ME1050 – Reflective Design Report & Portfolio

Note-To-Coin Convertor for Public Bus Transport – Group 07

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Executive Summary

This report begins by stating the project context and clearly defining the problem, followed by a detailed analysis of stakeholder needs, functional requirements, and design limitations. Several design concepts were generated and evaluated using different engineering methods which lead to the finalization of use an Arduino-based, color driven note-detection and gravity dependent coin-dispensing system.

A prototype of the note-validation system was assembled and tested. The results confirmed accurate note detection, reliable coin dispensing, and fast transaction times, verifying the system design. This design consists of electrical, mechanical components and user interface, which was supported by analysis and justification that requirements met the standards for performance, cost, durability, and reliability.

This project adopted a simple design, considering the following risks into consideration like coin jamming, sensor inaccuracies and excessive vibrations or force through specific improvements. More cases of sustainability, ethics and social impact enhanced the systems contribution to fairness, efficiency, and accessibility in public transport. Consistent communication and management ensured effective progress and development.

in conclusion, the Note-to-Coin converter successfully demonstrates all target objectives, offering a simple service to Sri Lankans public transportation system proving it to be an effective engineering solution while providing a strong base for future enhancements and large-scale implementation.

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1 Project Context & Problem Statement

1.1 Background and Context

Public bus transportation in Sri Lanka is one of the most used methods for daily travel, allowing passengers from all around the country to travel across the country. Despite its affordability and flexibility, fare collection on buses can still be a hassle as they still heavily rely on cash-based transactions, creating delays during daily operations. Bus fares in Sri Lanka often involve non-rounded values such as Rs.42, Rs.57, Rs.73 whereas passengers usually carry notes of more rounded values like Rs.20, Rs.50 and Rs.100.

In many situations passengers do not carry the exact fare to be paid, this results in frequent delays, disputes with the conductor and operational difficulties, more commonly when buses are crowded where the conductor must collect fares more quickly. Conductors are known to manage coins upon fare collection, which can lead to situations where they either run of change or have no change with them, complication transactions.

With increasing amount of passengers and consistent dependence on cash, there is a clear need of something low-cost, reliable and automated to assist in daily fare collections without needing to rely on digital or online transactions.

1.2 Problem Statement

The absence of an efficient and automated change dispensing mechanism in Sri Lankan buses leads to fare-related disputes and transaction delays. Passengers that always carry around notes of higher values where the fare requires smaller values, resulting in unnecessary tension between the conductor and passenger.

Currently, conductors must manually calculate change and manage with a limited amount of coin, this long and manual process is prone to human error, increases boarding times and cause impatience within passengers, especially when the exact change in unavailable. On the other hand, not every area has a reliable mobile connection, limiting cashless or online payment.

Therefore, the root problem is the lack of an offline system that allows passengers to exchange notes of higher value into coins of that same amount required for bus fares.

1.3 Aim of the project

The aim of this project is to design and develop a Note-to-Convert system specifically targeting Sri Lankan public buses, which allows passengers or conductors to convert notes into coins of that same amount quickly and accurately.

1.4 Objectives

The main objectives for the project are:

- Develop a low-cost, microcontroller-based system suitable for public bus environment.
- Allow the conversion of common notes (Rs.20, Rs.50, Rs.100) into coins.
- Ensure the system does depend on operation through internet/mobile network.
- Minimize fare-related disputes and transaction delays.
- Provide a simple and user-friendly interface using an LCD screen and buttons.
- Design a stable yet durable casing that can withstand vibrations and frequent usage.

1.5 Scope of the project

The project focuses on the design, prototyping and testing of a functional note-to-coin converter capable of being installed within buses or anywhere else. The system includes note detection, coin dispensing, user interface and electronic control.

The scope does not include:

- Integration with online payment systems.
- Automatic fare calculation based on route or distance.

The prototype is intended as a proof-of-concept demonstration technical feasibility and practical usefulness.

1.6 Significance of the Project

The proposed system has the capability of:

- Reducing disputed between passengers and conductors
- Improve transaction speed during busy travel hours.
- Enhance passenger and conductor travelling satisfaction.

Support Sri Lanka's transition to more efficient public transport systems

1.7 Stakeholder identification.

The primary stakeholders in this project are:

- Passengers: Users who require exact changes for bus fares.
- Bus conductors: Operators responsible for fare collection and managing transactions.

- Maintenance personnel: Individuals responsible for refilling coins, collecting notes, and servicing the device.
- Regulatory bodies: Authorizes concerned with safety, useability, and public transport standards.

Understanding stakeholders' needs are essential in making the system practical, safe and cost effective.

1.8 User Needs Analysis

based on observations and discussions we identified the following key user needs.

- Passengers need a fast and reliable way to obtain exact far.
- Conductors need to reduce disputes and speed up transactions.
- Easy to use system even for first time users.
- The machine must work offline without any internet network.
- The machine must be secure.

Requirements & Specifications

The success of the automated currency notes exchanger to coins is depends on its ability to perform accurately in the demanding environment of public transport. The following requirements have been identified stakeholder needs primarily passengers needing exact bus fares and coins shortages of conductors and passengers.

2.1 Functional Requirements

Functional Requirements

Functional requirement defines the core action the system must perform to meet its primary objective of fast and accurate currency conversion from currency notes to coins.

FR ID	Functional requirements	description
1FR	**Currency Recognition**	The system must identify and support all currently circulating Sri Lanka bank notes whether it is forged or valid.
2FR	**Value Identification**	The device must accurately identify the denomination of the inserted note
3FR	**Validity Verification**	the ability to identifying the validity of a note, ensuring counterfeit or heavily damaged notes are rejected
4FR	**Multi Coin Capacity**	The machine must be capable of holding and managing several coins at once to facilitate multiple transactions before requiring a refill.
5FR	**Security**	To protect the collected funds, a smart locking system must be installed for the and rob. Internal cast box by linking all the required authorities where no on one could remove and rob.
6FR	**User Feedback**	An LCD screen must be integrated to provide clear instructions and transaction status to the user.

Table 1 - Function requirement

2.2 Non-Functional Requirements

Nonfunctional requirements specify the performance and quality standards the system must adhere to.

NFR ID	Functional requirements	description
1NFR	Performance Speed	The system must provide a fast response time to ensure transaction do not cause delays at transport hubs or passenger on board point.
2NFR	Accuracy	High accuracy in both currencies note recognition and cion dispensing is essential to prevent financial discrepancies
3NFR	Durability and Maintenance	the machine must be durable and designed for low maintenance to ensure long term operational viability
4NFR	Physical Footprint	The unit must design be compact to fit within the limited space available at bs stop or within transport vehicles
5NFR	Sustainability	the machine should incorporate recyclable materials, such as mild steel for the wall mount bracket

Table 2 - Non-Functional Requirement

2.3 Technical Specifications

The following specifications represent the technical benchmarks **the prototype** was designed to achieve.

Feature	Specification
Note Inserter	Multi sensor array (Color, IR, UV) for detection and counterfeit rejection
Coin Handling	Automated coin ramp and barrier system with jam detection

Interface	Integrated LCD screen for user barrier system with jam detection
Protection	This machine, fixed with vibration isolation using rubber munts forholding and stability on empty roads. Also, to protect rob from thief where no one could easily remove.
Mounting	Sustainable mild steel wall mount bracket

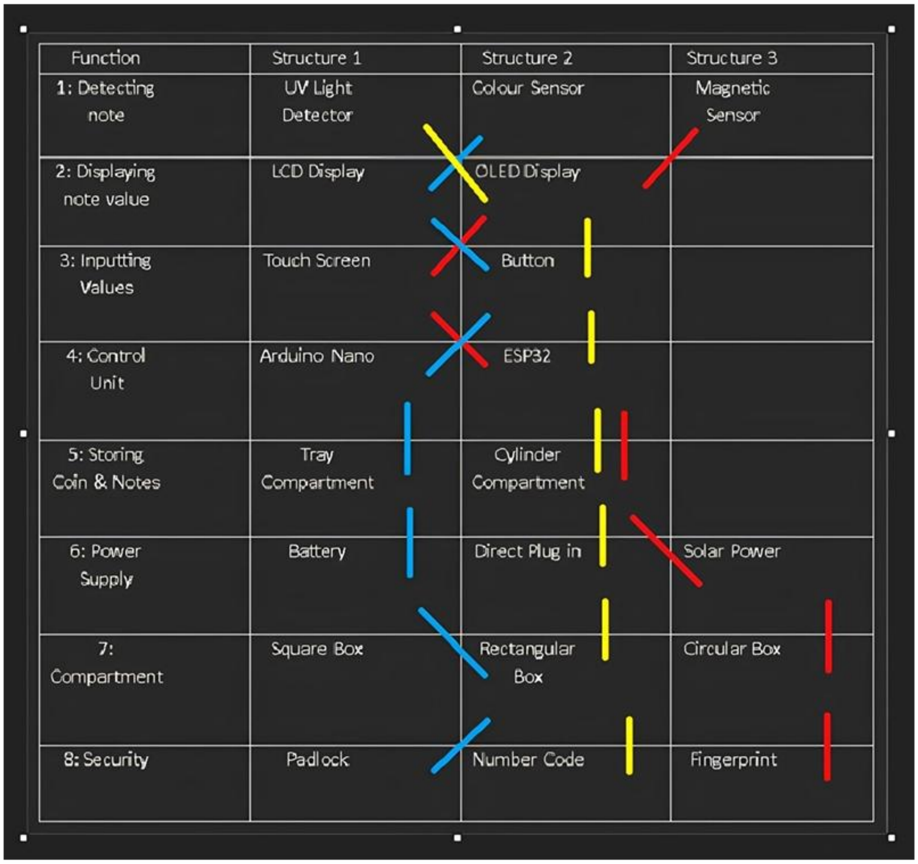
Table 3 - Technical Specifications

3 Concept Generation & Selection

To begin the design stage, our team listed all the main functions the note-to-coin converter must perform, such as detecting the note, identifying the value, letting the user select coin types, calculating the change, and dispensing coins safely. Using this functional breakdown, we created a Morphological Chart showing different possible solutions for each function. We then sketched several combinations of these options to form complete design concepts.

3.1 Concepts Considered

Morphological Chart



Function	Structure 1	Structure 2	Structure 3
1: Detecting note	UV Light Detector	Colour Sensor	Magnetic Sensor
2: Displaying note value	LCD Display	OLED Display	
3: Inputting Values	Touch Screen	Button	
4: Control Unit	Arduino Nano	ESP32	
5: Storing Coin & Notes	Tray Compartment	Cylinder Compartment	
6: Power Supply	Battery	Direct Plug in	Solar Power
7: Compartment	Square Box	Rectangular Box	Circular Box
8: Security	Padlock	Number Code	Fingerprint

Yellow – Structure 1
Blue – Structure 2
Red – Structure 3

Figure 1 - Morphological Chart

From the Morph Chart and sketching work, we formed three main design concepts:

<u>Concept A + structure 2 (selected concept)</u>

• Uses gravity-fed coin tubes with simple servo-based gates.

• LCD screen + push-button interface.

• Aluminum outer frame + PETG inner structure.
• Simple, low-cost, easy to build and maintain.

Figure 2 - Structure 2

Concept B + structure 1

• Conveyor moves coins from a main reservoir to the hopper.
• Higher capacity but more complex and expensive.
• Difficult to fabricate within our available time and tools.

Figure 3 - Structure 1

Concept C + structure 3

- Slim, modular components inspired by commercial changers.
- Very service-friendly but requires precision manufacturing.
- Not suitable for our beginner-level fabrication constraints.

Figure 4 - Structure 3

3.2 Screening and Selection

	Weight	Concept A + structure 2		Concept B + structure 1		Concept C + structure 3	
		Base	Weighted	Base	Weighted	Base	Weighted
Reliability & dispensing accuracy	5	4	20	4.4	22	3.8	19
Manufacturability	4	4.25	17	3	12	2.75	11
Cost	3	4.33	13	3.33	10	3	9

User experience	3	4.33	13	4	12	4	12
Sustainability	2	4.5	9	4	8	4	8
Maintainability	2	3.5	7	4	8	4.5	9
Schedule risk	1	5	5	3	3	4	4
Total/ 100	—	—	84	—	75	—	72

Table 4 - Screening and Selection

Concept A received the highest score overall, it was the most practical way to build with the tools and time we had.

3.3 Final selected concept

Concept A +structure 2 was selected because.

- It is easiest to manufacture using our sheet-metal and 3D-printing processes.
- Requires fewer moving parts, reducing failure points.
- Fits the size and layout established in our multi-sketch drawings.
- Best aligns with our materials, DfE considerations, and prototype timeline.
- Can incorporate improvements inspired by relevant patents.

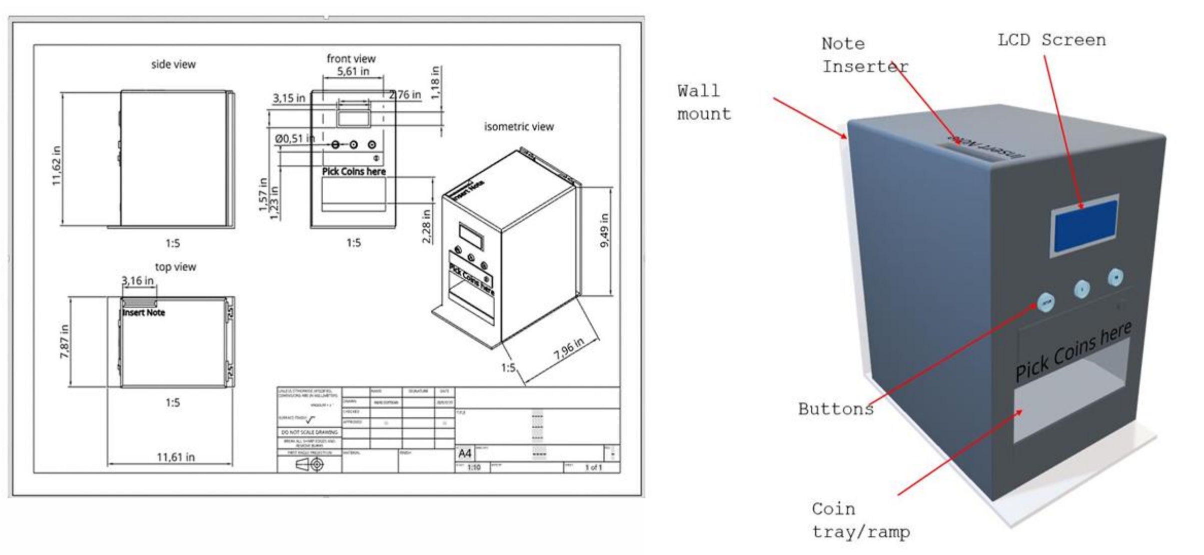


Figure 5

3.4 Outcome

We selected Concept A as our baseline for prototyping because it maximizes manufacturability and schedule confidence while still meeting the reliability, user experience, and sustainability targets established earlier. The choice is supported by the W5 weighted matrix, cross-checked against morph chart + sketches, assembly evidence, materials/DfE notes, and patent insights.

4 System/Design Description

4.1 System Overview

The Note-to-coin converter is a standalone **electromechanical system** designed to convert commonly used currency notes into suitable coin denominations for bus fare payments. The system integrates electronic sensing, microcontroller-based control, mechanical coin dispensing, and a simple user interface with a compact enclosure suitable for public transport environments.

the overall systems is divided into subsystems.

- Note detection subsystem.
- Control and processing subsystem.
- User interface + calculation subsystem.
- Coin dispensing subsystem.
- The mechanical structure of the design.

Each subsystem works in coordination to ensure accurate, fast, and reliable operation.

4.2 System Functional Flow

The system operates in controlled manner to ensure smooth transactions. The general flow of operation is as follow:

- Currency note (rs50, rs20) is inserted into the note inserting slot.
- The note is detected and identified.
- The detected value is sent to the microcontroller for processing.
- Note is taken in by a servo motor and stored.
- User interaction is handled by using push button and LCD displaying note value.
- The required coin value is calculated by the controller.
- Servo motors activate the coin dispensing system.
- Coins are pushed out and delivered into a coin tray.

This structured flow ensures accuracy and minimizes user error.

4.3 Note detection system

This is responsible for identifying the value of the inserted note. An optical sensing technique using a color sensor is fitted to analyze reflected light from the note surface (IR sensor, UV light sensor with camera, magnetic sensor can also be used but cost is greater).

- The system is in a closed environment to control illumination and reduce ambient light interference.
- It is pre-calibrated color intensity ranges for each note value (Rs 20-pink, rs50-blue)
- Real time comparison of sensed values with stored thresholds

Coste effective and more reliable method (security reason best to use IR + UV light +camera method)

4.4 Control and processing subsystem

An Arduino-based microcontroller functions as the central processing unit for the system. It continuously monitors inputs, processes sensor data, and controls system output. The code is run by Arduino IDE software.

The main functions of the microcontroller are:

- Reading data from the note detection sensor
- Identifying the note value
- Taking in note using servo motor
- calculating the required coin output
- controlling servo motos for coin dispensing
- updating LCD display
- reading user inputs from push buttons

The software is designed for real time operation to ensure a faster transaction.

4.5 User interface Subsystem

The user interface is designed to be simple and user friendly for public use.

LCD display (16x2)

- displays instructions and system messages.
- Shows detected note value and transaction status.
- Displays error messages for invalid notes or faults.

Push Buttons

- Rs 10 button.
- Rs 5 button.
- Enter button

4.6 Coin Dispensing Subsystem

Converts electronic control signals into physical coin output. Coins are stored in gravity-fed cylindrical tubes, each dedicated to a specific value.

Key characteristics include:

- Servo is controlled in push and pull mechanism.
- Coins are pushed one at a time.
- Servo motors spins 180 degrees and comes back to home angle of 0 degrees.
- Lower power consumption and it is simple.

4.7 The mechanical structure of the design

The mechanical structure is designed for durability, safety, and ease of installation inside a bus or outside a bus stand.

Design features include:

- Compact and fully closed housing
- It can wall mounted.
- Shock absorbing mounts to reduce vibration effects.
- Shielding of moving components to prevent user contact.

4.8 working principal.

The working principal of the system is summarized below:

- The system is powers on a display “INSERT NOTE”
- The user inserts Sri Lankan currency note into the note inserting slip.
- The color sensor detects and validates the note value.
- The detects note value is shown on the LCD.
- The user presses push button of what she requires. (Rs 5 or Rs 10 button)
- The note is taken in with a servo motor.
- Then press ENTER button.
- The Arduino calculates the relevant amount (if user inserted Rs 20 note and press Rs 5 button, the system calculates 20/4=5 coins)
- The LCD display the number of coins is going to be dropped.
- Then coins are dispensed using servo motor
- The systems automatically reset for the next transaction.

4.9 Interface of the total system

Subsystem/Device	Connected To	Interface Type	Arduino Pins	Power
Color Sensor (TCS34725)	Arduino	Adafruit	SDA = A4, SCL = A5	3.3V/5V module + GND
LCD 16×2	Arduino	I2C	SDA = A4, SCL = A5	5V + GND
Rs 5 Button	Arduino	Digital input (INPUT_PULLUP)	D2	5V logic + GND
ENTER Button	Arduino	Digital input (INPUT_PULLUP)	D3	5V logic + GND
Rs 10 Button	Arduino	Digital input (INPUT_PULLUP)	D4	5V logic + GND
Servo – Rs 5-coin dispenser	Arduino	PWM (servo signal)	D9	External 5V + GND common
Servo – Rs 10-coin dispenser	Arduino	PWM (servo signal)	D10	External 5V + GND common
Servo – Note storage / take-in	Arduino	PWM (servo signal)	D11	External 5V + GND common

Table 5 -Interface of total system

5 Analysis & Justification

5.1 Overview of engineering Analysis

Note to coin convertor system. The analysis focuses on electronic, mechanical, and operational aspects to demonstrate that were selected meeting the requirements from requirements and specifications.

5.2 Microcontroller selection

An Arduino uno based microcontroller was selected as the control unit due to the following reasons:

Arduin Uno –

- Operating voltage :5 V DC
- Clock frequency: 16 MHz
- Digital I/O pins: 14
- Current consumption: 50 mA (idle)

Thes specifications are sufficient as they are.

- Reading multiple sensors
- Driving servo motors via drivers
- Updating LCD and handling user inputs

Alternative controllers such as ESP32 were considered but rejected due to higher complexity and unnecessary features for offline operations.

5.3 Note detection method justification

Color based optical sensing (TCS34725) was chosen for note detection due to:

- Average RGB sensor response variance under controlled LED lighting ±5%
- Detection accuracy calibration ~80%
- Lower cost than other sensors

To mitigate issues caused by ambient lighting, controlled illumination and enclosure shielding were incorporated into the design. This ensures consistent sensor readings under varying bus lightning conditions. But UV light with infrared and camera is the most suitable for building the real model.

5.4 Coin Dispensing Mechanism Analysis

The gravity fed cylindrical 3D coin dispensing mechanism was selected after analyzing reliability and simplicity.

- Reduced mechanical complexity.
- Lower power consumption
- Fewer moving parts compared to hopper-based systems.
- Reduced likelihood of coin jamming.

  considerations:
- Coin tube diameter was selected based on coin dimensions with minimal clearance.

  Rs.5-coin diameter- 24 m
  Rs.10-coin diameter-26.5mm

- Dispensing speed was optimized to balance accuracy and transaction time.

  (Estimated ~0.45s per coin dispensed)

- Servo actuation angles were calibrated to release a single coin per cycle.

  (0 degrees home angle to +180 degrees)

The coin dispenser meets accuracy while maintaining low maintenance needs.

The diameter circular cylinder should be 0.1 mm greater than the dimeter of the rupee coin.

5.5 Structural and Mechanical Analysis

The mechanical aluminum housing was analyzed with respect to:

- **Vibration resistance**: Shock absorbing rubber mounts reduce stress on components.
- **Safety**: Enclosed thickness of roughly (4 mm) design prevents accidental contact with moving parts
- **Durability**: Rigid materials were selected to withstand daily public use.
- **Space efficiency**: Compact layout allows installation inside buses without obstructing passengers movement.

5.6 Power Consumption Analysis

The system operates using a low voltage DC supply compatible with bus power system (connect the system via USB port)

component	current
Arduino uno	50mA
LCD	20 mA
Color sensor	15 mA
Servo x 3	1.2 A (peak)

Table 6 - Power Consumption Analysis

total is around 2.05 Amperes maximum current is consumed. (other currents are negligible)

The system is compatible with a 12 V bus supply stepped down 5 V using a buck converter.

5.7 User Interface Design Justification

The selection of an LCD display with physical push buttons was justified by:

- Ease of use for users of different age groups and literacy levels
- Lower failure rate compared to touch screens.
- Clear feedback during operations by reducing confusions.

5.8 Reliability and Risk considerations

Key risks identified include:

- Coin jamming.
- Sensor misreading note value.
- Power fluctuations

Mitigation strategies implemented:

- Precision mechanical tolerances in coin tubes.
- Sensor calibration and controlled lightning
- Voltage regulators

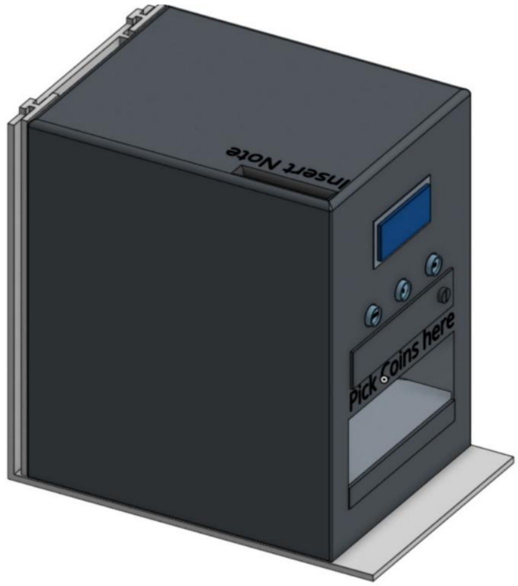


Figure 6

(Onshape 3D model (2025). Note to coin converter Figure 1.1)

5.9 Summary of design justification

The overall design choices were driven by a balance between performance, cost, reliability, and ease of use. This analysis confirms that the selected architecture satisfies all major requirements

6 Prototyping, Testing & Result

6.1 Prototype development overview

A functional prototype of the Note-to-Coin Converter was developed to validate the feasibility of the proposed design. The prototype integrates electronic components, mechanical dispensing mechanisms, and a user interface within a small and simple system suitable for a bus environment.

The prototyping phase focused on:

- Verifying correct note detection
- Ensuring accurate coin dispensing
- Testing system responsiveness
- Evaluating usability

The prototype represents a **proof-of-concept**, demonstrating the functions of the system under controlled conditions.

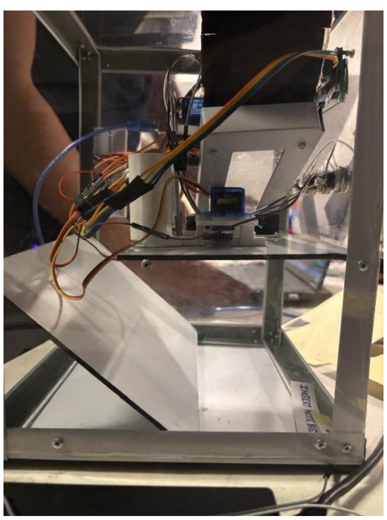


Figure 8

Figure 9

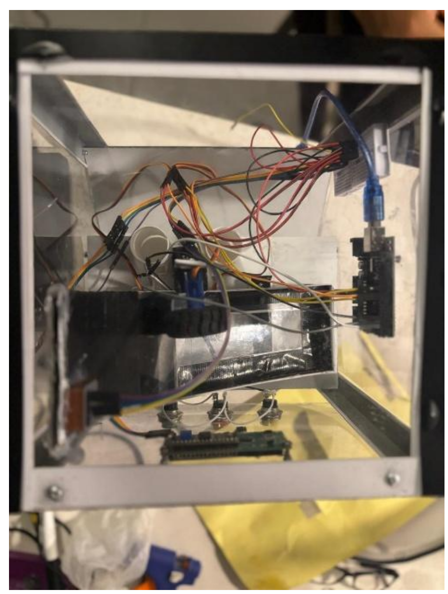


Figure 7

6.2 Prototype Assembly

The prototype assembly was carried out in different stages:

6.2.1 Electronic Assembly

- The Arduino microcontroller was mounted.
- Sensors were positioned within the note input path.
- Servo motors were connected.
- The LCD display and push buttons were wired to the control unit.
- Power regulation components such as a battery was added to ensure stable operation. / Or via USB cable connected to laptop

6.2.2 Mechanical Assembly

- Coin storage tubes were aligned vertically to make coins fall off when pushed.
- Servo-controlled release mechanisms were installed at the base of each tube.
- The note collection compartment was positioned below the detection unit.
- All components were enclosed within a rigid housing to protect against vibration and accidental contact.

6.3 Software Implementation

The system software was developed using Arduino IDE software. Key software modules include:

- **Sensor Reading Module:** Acquires and processes note detection data.
- **Decision Logic Module:** Identifies note denomination and validates input.
- **User Interface Module:** Controls LCD messages and button interactions.
- **Dispensing Control Module:** Manages servo motor activation and timing.
- **Error Handling Module:** Detects and responds to invalid notes or faults.

The software was repeatedly tested and refined during development.

6.4 Testing Methodology

Test Description	Expected Outcome
Insert valid Rs. 20 notes	Correct detection and coin dispensing

Test Description	Expected Outcome
Insert valid Rs. 50 notes	Correct detection and coin dispensing
Insert invalid note	System rejects note and displays error
Button interaction	Correct system response
Coin dispensing cycle	Accurate number of coins dispensed

Table 7 - Testing Methodology

6.4.1 Performance testing

Tests were performed under real conditions.

- Transaction time was measured from note insertion to coin output. (average 6–8 seconds)
- Servo response time was evaluated. (coin dispensing time around 0.4s per coin)
- LCD message clarity and readability were assessed. (negligible)

6.4.2 Reliability Testing

- Repeated dispensing 10 cycles were performed to observe consistency. (out of 10, 6 were accurate)
- Coin jamming frequency was monitored. -(2 jamming incident)
- Sensor readings were checked repeatedly for stability. -(60 % success rate)

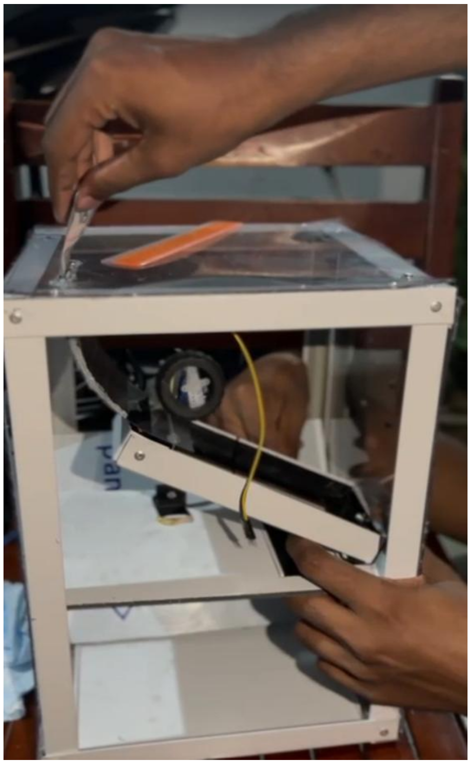
6.5 Test Results

The prototype demonstrated satisfactory performance in most test cases:

- Overall detection accuracy was 60 %.
- Coin dispensing accuracy was 80%.

Minor issues such as occasional **coin misalignment** and **note false detection** was observed during testing.

- Mainly due **to servo motor issues**
- **Color sensor detecting** issue due to change in ambient light readings.



Note Detection Testing

Figure 11

Coin Dispensing Testing

Figure 10

6.6 Discussion of Results

The testing results indicate that the system successfully meets the core functional requirements. The prototype demonstrated that automated note-to-coin conversion is feasible using low-cost components.

Observed limitations include:

- Sensitivity of optical detection to extreme lighting changes.
- Limited coin storage capacity in the prototype.

These limitations highlight design improvements.

6.7 Validation Against requirements

The prototype performance was evaluated against all the functional requirements. Most requirements were met, confirming the effectiveness of the selected design approach.

7 Iteration & Risk Management

7.1 Design Refinement & Iterations

Note to coin converter system based on observations made during prototyping and testing. Feedback from test results and practical considerations in a bus environment

• **Banknote Recognition Tuning**: To increase the system's precision in detecting damaged or worn Sri Lankan currency, several design iterations were conducted.

• **Coin Dispensing Optimization**: To guarantee reliable operation, the dispensing mechanism needed to be improved over a number of cycles.

• **Mechanical Reliability**: To reduce physical jamming, motors and coin guides underwent numerous modifications and improvements.

• **Testing Findings**: The results of final prototyping and testing demonstrated that these iterations produced dependable response times and high accuracy.

7.2 Strategies for Risk Management and Mitigation

Potential failures are described on this slide along with the engineering fixes put in place to stop them.

• **Detection Risks**: Using a combination of color, infrared, and ultraviolet sensors reduces the possibility of incorrect recognition brought on by note condition or illumination.

• **Mechanical Jams**: Auto-reverse features and jam-detection software mitigate the risks of dust accumulation or motor wear.

• **Environmental Factors**: Rubber mounts for vibration isolation are incorporated into the design to manage bus vibrations on uneven roads.

• **User Error & limited coin storage**: The system offers LCD alerts for low coin inventory and confirmation feedback to avoid confusion during peak hours.

• **System Integrity:** Regular calibration and the use of protective enclosures lower electrical and software risks.

7.3 Limitations of current prototype

Despite improvements, some limitations remain:

- Limited coin and note storage capacity.
- Sensitivity of optical sensors to light conditions as a closed environment is needed.
- Prototype scale to optimal for mass production.

- Programming errors when notes are detected, and right values are calculated.

7.4 Future improvements

- Integration of coin level sensors for dispensing verification
- Improve note validation using multi sensor’s such ad UV and infrared sensor.
- Increasing coin storage capacity and coin refilling compartment
- More accurate coin dispensing modules

8 Sustainability, Ethics & Societal/Environmental Impact

8.1 Environmental Impact & Sustainability

Evaluating the Note to coin convertor system in terms of environmental sustainability that would impact on society within the Sri Lankan public transport.

• **Recyclable Materials**: To reduce its environmental impact, the machine's design places a high priority on completely recyclable materials. Such as aluminum framework of the machine and inner wall of PETG plastic

• **Mild Steel Construction**: The wall mount bracket is made of mild steel, which is very recyclable and uses a lot less energy to recycle than it does to make from scratch.

• **Minimal electronic waste Reduction**: use widely available components that can be reused or replaced individually

• **Energy-Efficient Manufacturing**: Production-related scrap is recycled (aluminum and PETG plastic), and energy-efficient procedures like drilling and cutting are maintained.

• **End-of-Life Reuse**: The bracket is made to be recycled or used again after its useful life is over, as opposed to ending up in a landfill while the electronic go to E-waste the others get recycled in a circular economic way

8.2 Economic Sustainability

The note to coin convertor is designed to be affordable and economically viable:

- Low-cost components which result in increase in scalability
- Reduce transaction time improves operational efficiency.
- Low maintenance requirements minimize long term costs.

8.3 Ethics & Societal Impact

This project provides a solution for one of the key social friction points in public transport system in Sri Lanka.

- **Minimizing Conflict**: A key goal is to minimize friction between customers and bus Conductors who create problems due to an inability to give change.
- **Financial Accuracy**: The machine will ensure speed and automation in solving the problem at hand. Accurate transactions that do not make the passengers lose money because of incorrect change.
- **Accessibility and Efficiency**: The system will be easy for users to navigate,
- **Safety and public use:** Enclosed electronics prevent user contact, and rounded edges reduce risks of injuries while having a secure mounting preventing the device unnecessary movements.
- **Local Innovation**: From an ethical viewpoint, this project meets the needs of a local community by resolving a need that is unquiesces with Sri Lanka's market where no such solutions are found.
- **Anti-Counterfeit Measures**: For ethical financial transactions to take place, the machine UV includes UV, IR, and color sensors that detect counterfeit and/or invalid.

9 Project Management & Communication

9.1 Introduction to management

During the Note-to-Coin Converter project, the effective project management and communication skills were crucial for achieving the final outcome within the assigned academic timeframe. The present work followed a multi-disciplinary approach which include electronics, programming, mechanical fabrication, and testing. Hence a structured plan was necessary to coordinate tasks, manage resources, and maintain consistent quality. This chapter explains the strategies carried out in the planning stage of the project, scheduled activities and how team assigned the responsibilities, monitored progress, made decisions, documented the development process to ensure a successful final outcome.

9.2 Team Structure and Roles

The project was carried out as a collaborative group activity. To ensure efficiency and accountability of the project development, the task responsibilities were distributed among the team members by accounting their strengths and the technical needs of the system.

Typical roles and responsibilities included:

- Project coordination and planning
- Electronic circuit design and programming
- Mechanical design and fabrication
- Testing and validation
- Documentation and report preparation

The task and role allocation were enormously helped to minimize the possible overlaps and ensured that all aspects of the project were addressed effectively. Although each member had specific task and responsibility, team members regularly supported each other, especially during integration and troubleshooting stages where electronic and mechanical systems had to function together.

9.3 Project Planning and Scheduling

The project was planned by using a staged development approach aligned with the course timeline. Breaking down the work into well-defined phases made the process easier to manage and allowed to track down the progress systematically. Each stage had clear assigned benchmarks, enabling the team to confirm readiness before moving forward as illustrated in the Figure 1.

The major phases were:

- Problem identification and requirement analysis
- Concept generation and selection
- Detailed design and analysis
- Prototype development.
- Testing and iteration

- Final documentation and submission

Realistic milestones were set for each phase. It helped to team members to evaluate whether progress matched the schedule and enabled early detection of delays or technical issues.

Role / Task	Role					
	Task	Project Manager	Electronics & Control Lead	Mechanical Design Lead	Software / Integration Lead	Testing & Documentation Lead
Identification and objective of problem	A	C	C	C	C	I
Function and features of device	A	R	R	R	C	C
Layout configuration	A	C	R	R	C	C
Design and selection of parts	A	C	R	C	C	I
3D model and 2D sketch	I	C	R	R/A	C	I
Material selection	A	C	R	C	C	I
Building the prototype	A	R	R	R	C	C
Testing	I	C	C	R/A	C	R
Report and presentation	A	I	I	I	I	R

C Consulted R Responsible A Accountable A Accountable I Informed

Figure 12

9.4 Time Management

Time management was critical due to the limited access to tools and materials, and academic deadlines, as necessity to balance coursework with project development. Hence, team applied some practical strategies to remain on the schedule as illustrated by Figure 2:

- Carried out weekly or regular progress reviews to get an clear understanding on what was completed and what remained.
- Buffer time allocation near key deadlines to allow for unexpected errors during integration and testing.

- Tasks were re-prioritized to maintain overall progress in the perspective of possible delays. This adaptive approach ensured that finish the work by the deadlines without reducing quality of the outcome.

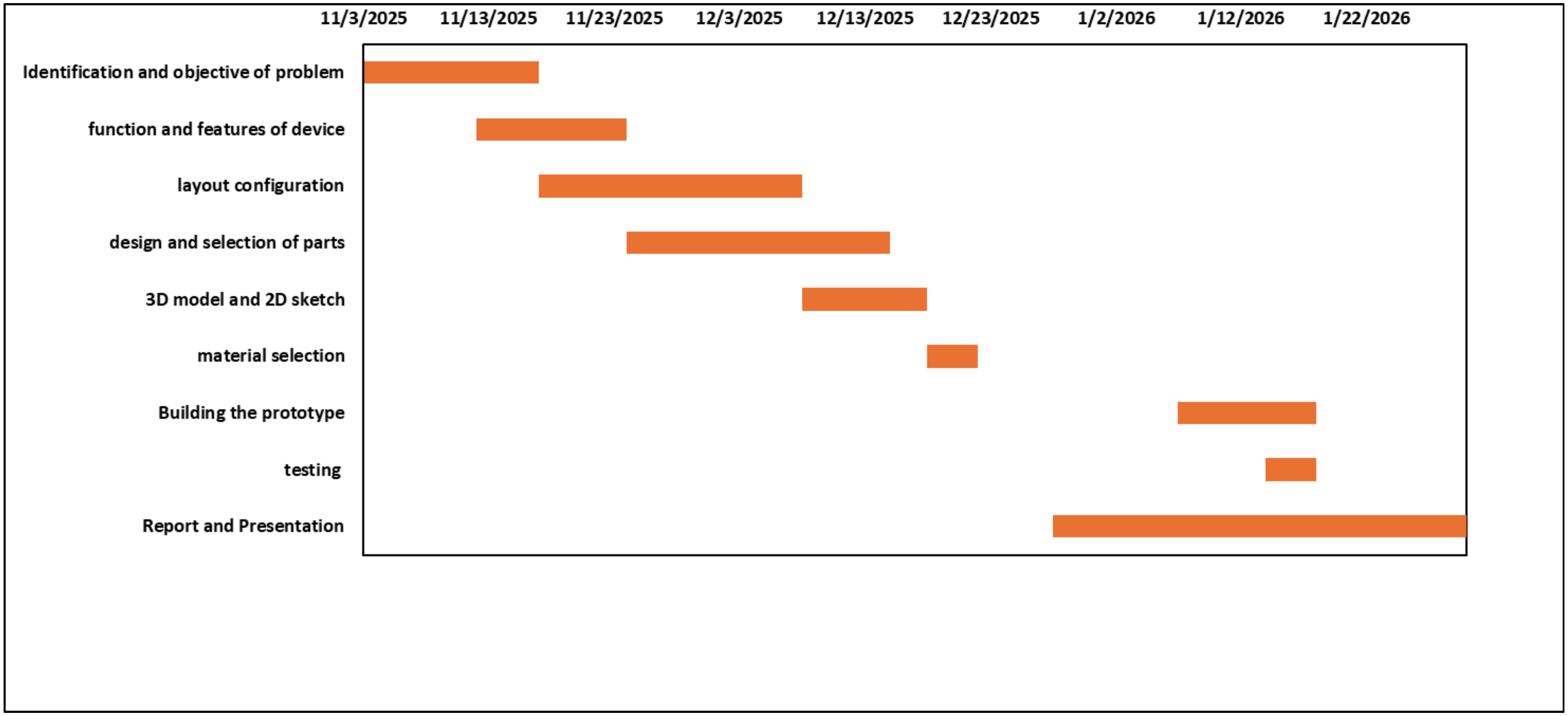


Figure 2: The time schedule that we followed.

Figure 13

9.5 Communication Strategies

Effective communication was maintained during the work for effective coordination and to ensure that all members shared the same understanding of the design goals and current progress. Communication methods that we used are:

- Regular group meetings
- Informal discussions during development
- Sharing design files and test results
- Coordinated report writing.

Clear communication allowed to resolve issues quickly and quick responses to technical problems. Ultimately, it helped to team members to align well with the project goals.

9.6 Decision-Making Process

Design decisions were made collaboratively to ensure the final prototype met the required objectives. The team aimed to make decisions in respect to the engineering evidence rather than personal preferences. Generally, the key decision criteria are based on:

- Technical feasibility
- Cost considerations
- Testing feedback
- Alignment with project requirements

When there were any disagreements, the decisions were merely supported by practical testing, calculations, or by based on the comparisons of alternatives. This adjusting approach encouraged the objective thinking and ultimately, improved the overall quality of the design.

9.7 Documentation and Record Keeping

Accurate documentation was maintained throughout the project to easier traceability, make the decisions based on the progress and technical issues, demonstrate the engineering process, and simplify report preparation. Hence the team recorded:

- Design sketches and diagrams.
- Test results and observations.
- Iteration records
- Final report drafts

This documentation process helped the team to track the progress and improve the transparency and present a well-supported final submission with clear technical justification.

9.8 Challenges in Project Management

Several challenges were encountered during the project, which are listed as follows.

- Coordinating schedules among team members
- Managing limited resources
- Balancing academic workload with project demands

These challenges were addressed through flexibility, transparency, and cooperation. The team was able to maintain realistic short-term goals and adjusted the timeline when any uncontrollable circumstances come up. Moreover, we maintained active communication whenever a task risked delaying the overall schedule.

9.9 Summary

Project management and communication played a key role in the successful completion of the Note-to-Coin Converter project. The team was able to ensure a steady progress from the preliminary conceptual stage to ultimate prototype stage by assigning clear roles, following a staged development plan, managing time carefully, and maintaining consistent communication. Collaborative decision-making and detailed documentation further strengthened the quality of the outcome, which are demonstrating an organized engineering process and achieving the project objectives within the required timeframe.

10 Reflective Journal (Individual)

1.Description

As a team, we built a "note-to-coin exchanger for public transport system" for the group project of the "Introduction to engineering design and communication" module. The project aimed to make a functional device that could accept notes and dispense the same value in coins, allowing a smooth transaction process for the user.

My role in the present study was multifaceted, connecting the space between design, material selection, and documentation. In the technical phase, I did 3D design and material selection for the model's input button, a critical user interface component. Moreover, I was heavily involved in assembling and managing space more efficiently for components to prototype from start to finish. Although in the testing phase, I identified mechanical weaknesses. Finally, I contributed to the final group report by writing Chapter 9 (project management and communication).

2. Feelings

My enthusiasm for our project was at its peak level from the beginning. The concept of a note-to-coin exchanger for public transport is more practical, and it solves a real-world problem that happens in the Sri Lankan transport system. However, as we moved from the conceptual design to the physical prototype, I became curious. We immediately encountered spatial constraints that we had not fully anticipated during our initial sketches.

There was a frustrating moment; our planned mechanism for storing notes is too large for our prototype case. However, these frustrations eventually turned into satisfaction. When I suggested an alternative solution using a gravity-aided roller system and saw it work in practice, I felt pride in my own. At the end of the project, writing Chapter 9 (project management and communication) gave a lot of experience about how we document all the project information for external parties.

3. Evaluation

Looking back at the project, there were clear successes and significant barriers.

What went well:

The teamwork was the main reason for the success of the project. My contribution was the 3D design of the input button and the material selection for the input button of our model. It was very effective. Moreover, our ability to troubleshoot instantly was a huge point. When we faced challenges while assembling the prototype, I was able to suggest alternative placement ideas that saved the design.

What was challenging:

The biggest challenge was space management for components. We didn't care much about the volume required for the internal components (sensors, rollers, coin dispenser, note container, and especially for the Arduino board). This led to a crowded assembly process where components interfered with each other. Moreover, the complexity of the note intake process led to mechanical malfunctions during early testing.

4. Analysis

This section analyzes the specific challenges that I faced and the actions I took to solve them.

Challenge 1- The Note Storage Mechanism

The note storage system was one of the most critical issues that we have faced. we designed a more complex and effective method to move the accepted note into the storage container for the model. But, we figured the prototype case did not have enough space for the components.

Action: I analyzed the issue and proposed a solution by replacing a single roller and a note storing container that guides the note naturally using gravity.

Result: This saved internal space, demonstrating the effectiveness of simpler engineering solutions.

Challenge 2 - Component Placement & Space Constraints

Action: During assembly, I paused the process and restructured the internal layout by prioritizing large components and then routing smaller ones around them.

Skill Developed: Systems integration and spatial planning.

Challenge 3 - Input Button Design

Action: I designed the button in ONSHAPE and selected suitable materials, ensuring correct tolerances and reliable spring reset.

Skill Developed: ONSHAPE design and material selection.

Challenge 4 - Documentation (Chapter 9)

Action: I documented technical work into formal academic writing for Chapter 9 of the report.

Skill Developed: Technical communication.

5. Conclusion

In summary, the Note-to-Coin Exchanger project gave a significant learning experience in understanding the gap between idealized designs and practical, functional solutions. I got the chance to learn real-world constraints, such as limited space, friction, and component interactions, often have a greater influence on the final design than the original concept.

My contributions to the project included simplifying an increasingly complex mechanism (for example, implementing a gravity-assisted roller system) and ensuring quality of the model through active involvement in assembly and testing. Nevertheless, some challenges, included those related to spatial constraints, could have been decreased by investing more time in developing a detailed 3D assembly model before fabrication.

6. Action Plan

I would implement the following improvements if I had to work on a similar project again in the future:

Digital Prototyping: I will develop a full "Digital Twin" of the assembly in CAD software before cutting any material. This will enable me to identify collisions and spatial issues virtually, rather than discovering them during physical assembly.

Iterative Testing: I will give priority to conduct unit testing, assessing the note intake and coin dispenser individually before combining them, rather than testing the machine solely at the end.

Documentation: I plan to maintain a daily project log to systematically record design changes, decisions, and progress throughout the construction phase. While writing Chapter 9, I had to rely heavily on recalling past activities, which proved challenging and stressful. Keeping a daily log would allow for more accurate documentation, improve the clarity of the final report, and significantly reduce pressure during the writing stage.

Overall, this project represented an important stage in my development as an engineer. It reinforced the value of adaptability and critical thinking, demonstrating that these skills are just as essential as technical knowledge when solving real-world engineering problems.

11 Conclusions

11.1 – Overall Summary

Our project successfully managed to design and develop a working Note-to-Coin converter targeted towards Sri Lankan public buses. The system provides the solution to a daily problem faced by both passengers and conductors when the exact bus fare is not provided due to non-rounded fare values and the more common use of notes with higher value.

Through a simple process, the project started through problem identification and solution analysis to concept generation, design, prototyping, testing and improvement. Each stage was achieved by referring to real-time events allowing us to determine the cost, reliability, ease of use and sustainability for a public transport environment.

11.2 – Achievement of Project Objectives

The primary objects listed have all been successfully achieved:

- A low-cost, offline system that converts notes to coins.

- The ability of detecting notes and dispensing that same amount in coins
- Create a simple user-interface using LCD screen and buttons.
- Perform accurate and fast transactions.
- Build a strong and durable casing capable of withstanding consistent vibrations.
- Reduce unnecessary disputes between conductors and passengers.

The achievement of these objects makes our project capable of performing its role if it were to be produced to a large-scale level.

11.3 – Significance and Limitations

This project displays the effective use of electronics, mechanical design and programming to create a solution to a common issue. The use of easily obtainable circuit components and simple design principles strengthens the systems potential.

While the system achieved its objectives, some limitations remain, such as the limited coin and note storage capacity, sensitivity of the note detector being disrupted by external lighting and the inability to calculate the coins needed for very large notes.

These limitations provide opportunities for future improvements such as an enlarged coin and note storage compartment, stronger note detection system and more advanced fare calculation program and an improved casing if necessary.

11.4 – Final Remarks

In conclusion, the Note-to-Coin converter system presents a simple yet useful solution to a consistent challenge in Sri Lankan public transport. By improving transaction efficiency, fairness and passenger experience. The system makes a positive contribution to the quality of public transport servers and showcases the value of engineering solutions in real problems.

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(Sommerville, 2016) (Pahl, et al., 2007) (Programme, 2020) (IEEE, 2022)
(Ashby, 2011) (Ulrich & Eppinger, 2016) (International Organization for Standardization, 2018)

Annexes (Portfolio of Evidence)

Annex A: Project Proposal

Background – Public bus transportation in Sri Lanka is used daily by everyone. Bus fares usually consist of non-rounded values whereas passengers usually possess currency of higher, rounded value. This creates a frequent issue during fare collection when the exact fare is not provided. This issue is commonly encountered during the peak travel hours, leading to delays, disputed and inconvenience to both passenger and conductor.

Problem Statement – Due to not being able to provide the exact fare among passengers and limited coin availability with conductors, fare collection in buses become inefficient. Conductors are forced the manually calculate and provide change where errors can happen, leading to disputes and delays. Current solutions like online transactions are not reliable as it is limited to internet access, larger implementation cost and user unfamiliarity, creating the need for an offline, more user-friendly solution.

Objectives – to design and develop an affordable, reliable and offline Note-to-Coin converter system that allows anyone to convert notes into coins of that same amount required for paying the proper bus fare, eliminating delays and disputes during transaction.

Significance – Solving this problem improves the efficiency of transactions and enhances passenger satisfaction. By providing the exact change quickly and accurately, it reduces the chances of conflict between conductor and passenger, minimizes delays and supports smoother travel experience.

Annex B – Requirement Table & Traceability

Note to coin converter

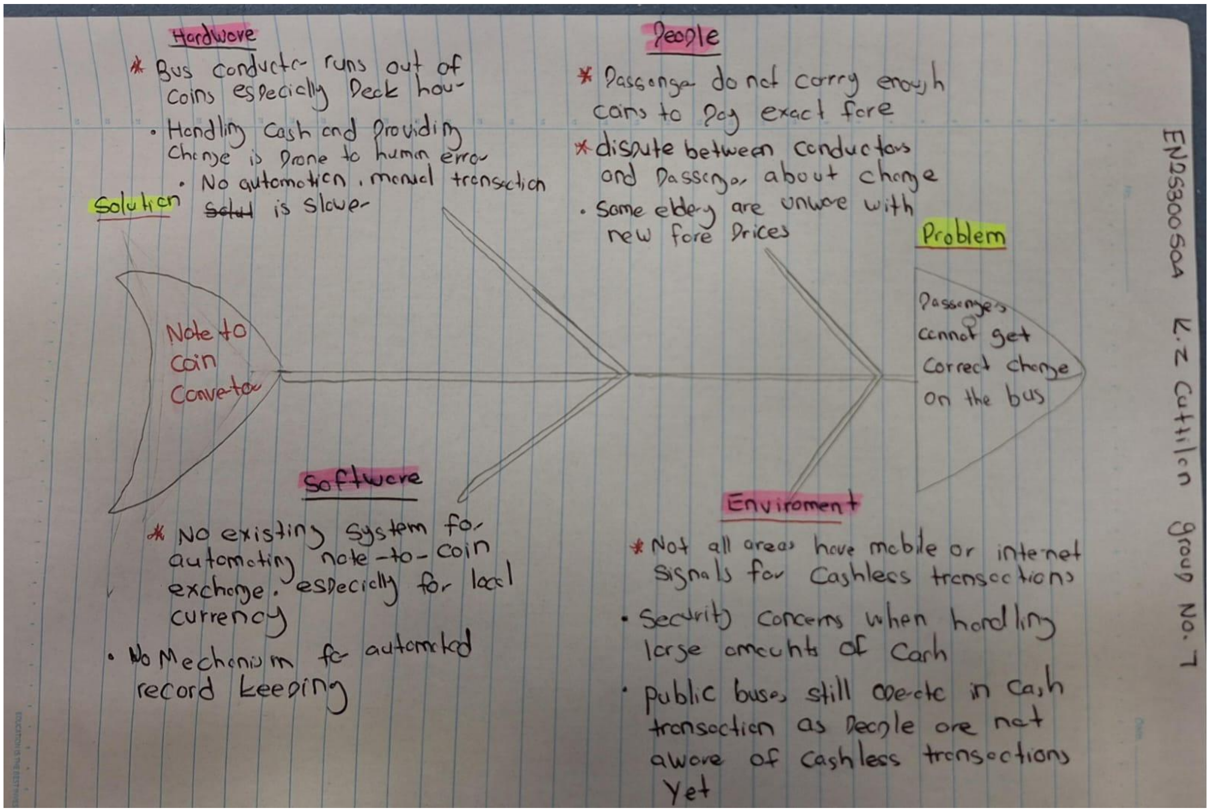
Requirements

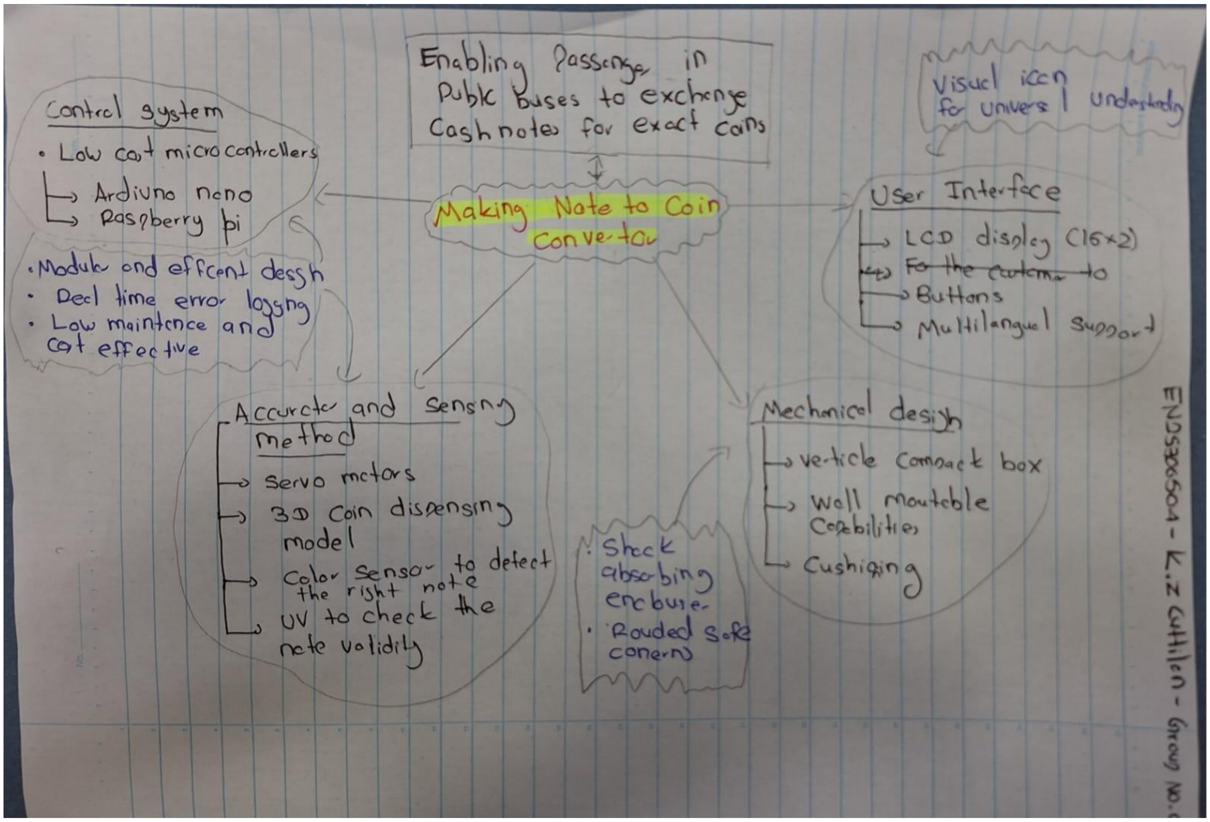
1. Functional Requirements

- Detect and accept paper currency notes
- verify note authenticity
- Identify the value of the inserted note
- Convert the note value into equivalent coins
- Dispense correct quantity of coins
- Automatic operation after note insertion

2. Physical Requirements

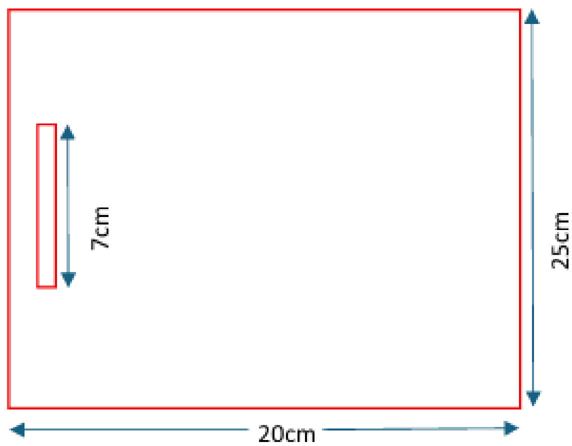
- Compact and durable outer casing
- Secure note insertion slot
- Coin dispensing outlet
- Internal Storage for coins
- Stable base to prevent tipping
- Clearly labeled user interface


Hardware
* Bus conductor runs out of coins especially peak hour
• Handling cash and providing change is prone to human error
• No automation, manual transaction is slower
People
* Passenger do not carry enough coins to pay exact fare
* dispute between conductors and passenger about change
• Some elderly are unaware with new fare prices
Solution
Note to coin Converter
Problem
Passengers cannot get correct change on the bus
Software
* No existing system for automating note-to-coin exchange, especially for local currency
• No Mechanism for automated record keeping
Enviroment
* Not all areas have mobile or internet signals for cashless transactions
• Security concerns when handling large amounts of cash
• public buses still operate in cash transaction as people are not aware of cashless transactions yet
Group No. 7

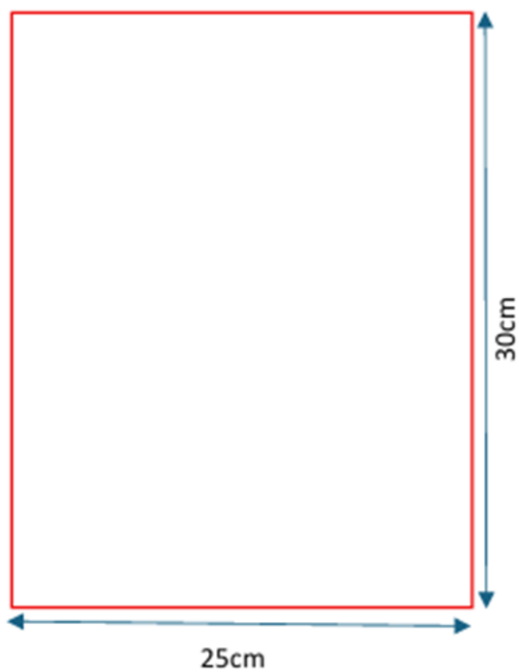


Annex C – Concept Sketches and Trade-off Tables

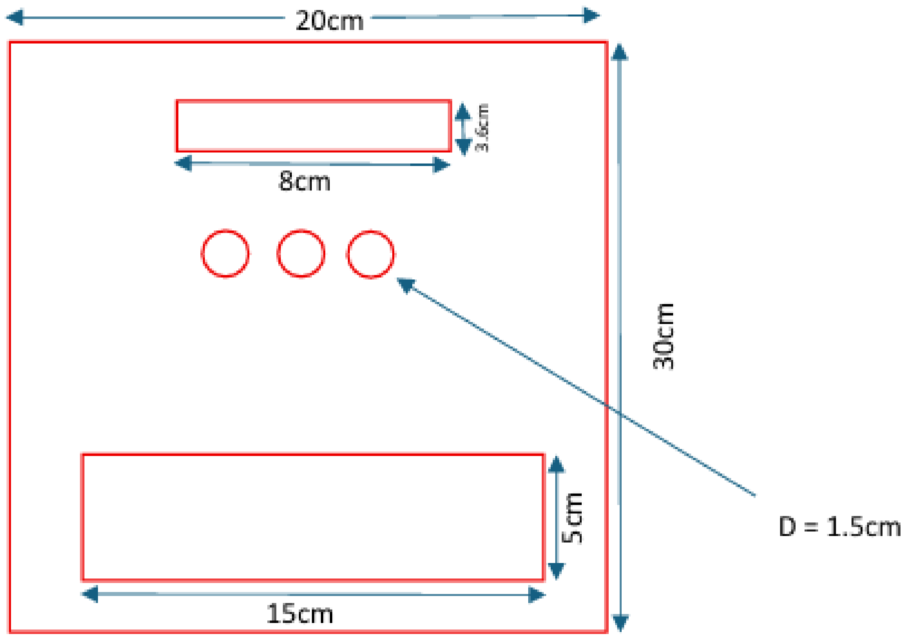
TOP VIEW

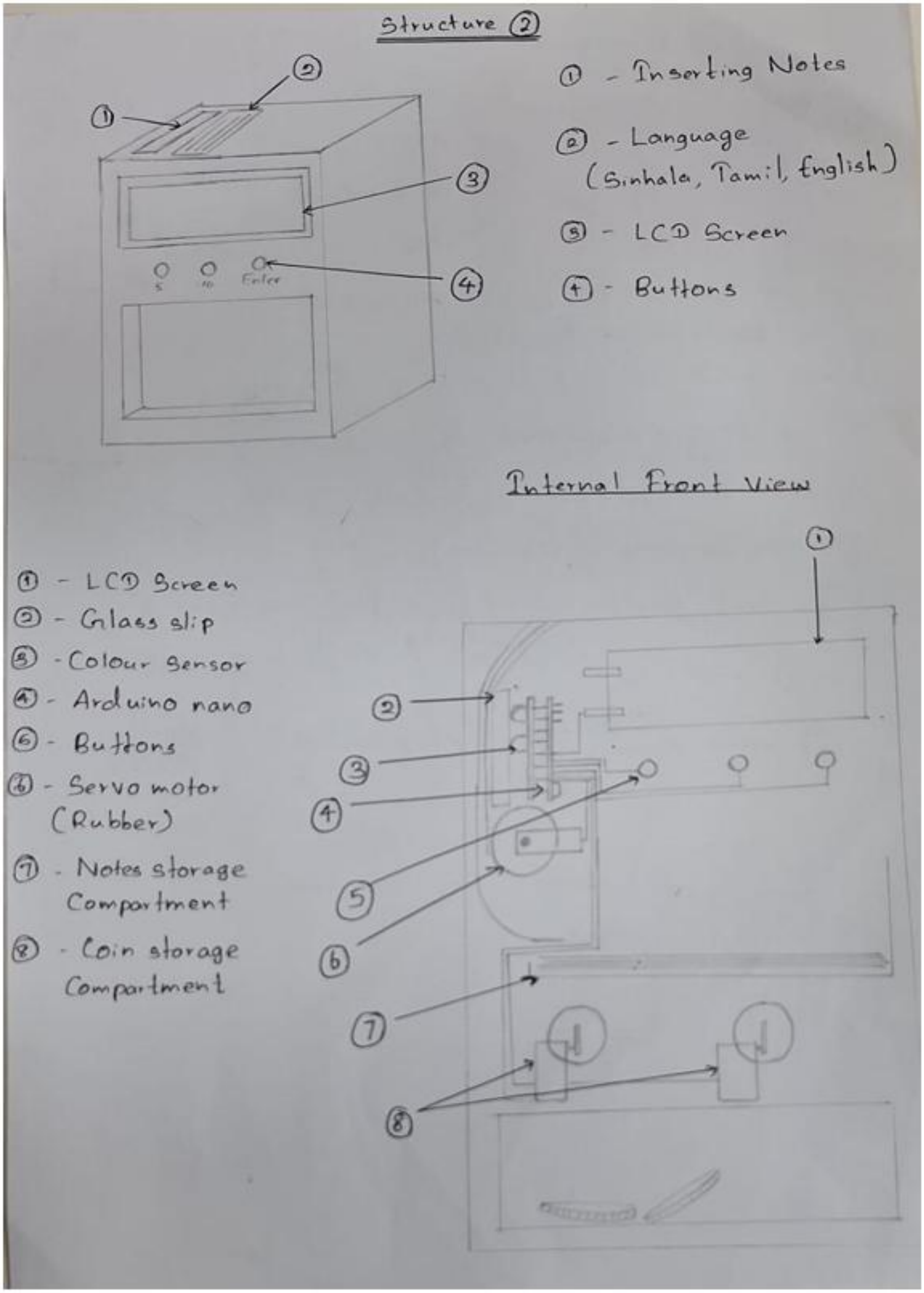


SIDE VIEW



FRONT VIEW



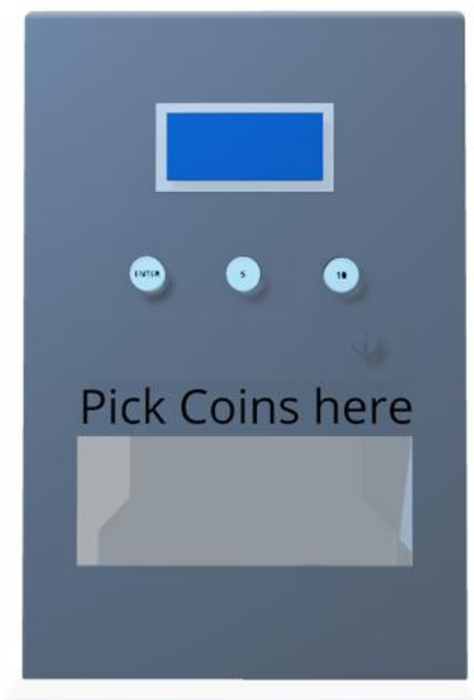

Structure ②
① - Inserting Notes
② - Language
(Sinhala, Tamil, English)
③ - LCD Screen
④ - Buttons
5
10
Enter
Internal Front View
① - LCD Screen
② - Glass slip
③ - Colour Sensor
④ - Arduino nano
⑤ - Buttons
⑥ - Servo motor
(Rubber)
⑦ - Notes storage
Compartment
⑧ - Coin storage
Compartment

Function	Structure 1	Structure 2	Structure 3
Detecting Note	UV Light Detector	Colour Sensor	Magnetic Sensor
Displaying Note Value	OLED Display	LCD Display	OLED Display
Inputting Values	Button	Button	Touch Screen
Control Unit	ESP32	Arduino Nano	ESP32
Storing coins & notes	Cylinder Compartment	Tray Compartment	Cylinder Compartment
Power Supply	Direct Plug-in	Battery	Solar Power
Compartment	Rectangular Box	Square Box	Circular Box
Security	Number Code	Padlock	Fingerprint

Selected – Structure 2

Annex D – CAD Drawings

FRONT VIEW



TOP VIEW

RIGHT VIEW

LEFT VIEW

OVERALL VIEW

Annex F – Power Calculation and Time drop

Component	Operating voltage
Arduino Nano	5 V
Servo motor (x3)	5 - 6 V
LCD display	5 V
Colour sensor	3.3 - 5v

- Current Consumption

1. Arduino nano = 30mA
2. Servo motors (3 Units) = 3 × 700mA = 2100mA
3. LCD Display = 20mA
4. Colour Sensor = 20mA

Total Current = 30+2100+20+20 = 2170mA = 2.17A

- Total power required

$P = VI$

using 5v supply
$P = 5 \times 2.17 = 10.85$ W

20 rupees → 4 coins drop

Total coin dispensing time = 2 s

for 1 coin = $\frac{2s}{4}$ = 0.5 s

Annex H – Risk Register, Safety Forms and Ethics Checklist

Main patent-Automatic validating farebox system (US6039164A)

The technology outlined in US Patent 6039164A is an automatic validating farebox used in buses that processes coins and banknotes. The farebox will authenticate the coin and banknote while also checking the value of the denomination. The deposited coin or banknote is automatically stored securely without the need for constant supervision by the bus driver. The key element of the invention is the use of a single central controller that combines the coin and banknote validators into a single device. The controller keeps a cumulative total of all fares validated, displays that total on an illuminated screen viewable by the passengers in the bus, and prevents any unvalidated money from being stored in the safe compartment of the farebox. Coins are processed using the single-coin processing technique where coins are allowed to enter the farebox at a controlled speed through the use of an electronic sensor. By using this method, the size and other dimensional features of the coin are precisely measured. Banknotes are measured by lengths and other dimensional features. As a direct result of this patent, there has been an adjusted design of the note-to-coin converter. Like the farebox, the converter uses UV and IR/colour sensors, along with a microcontroller such as an Arduino to determine the denomination of each piece of currency deposited. The note-to-coin converter is also equipped with a secure storage compartment for banknotes that have been validated. However, unlike the farebox, the note-to-coin converter will not only count the number of fares validated but will also calculate the amount of change that the bus should return to the passenger and activate a separate mechanism to dispense that change in the form of coins. This project also uses a basic sensor, and the note-to-coin converter will be constructed with a gravity-fed coin tube configuration as opposed to the more complicated coin and banknote validators used in the patent. Because of this construction style, the note-to-coin converter is felt will suit the low-cost buses in.

Annex I – Gantt Chart