

DESIGN OVERVIEW

**RFID based wireless inventory
management system**

TUE-02



Team Members :-

- Kadiyala Sai Susrush (210070038)
- Om Unhale (210070058)
- Prince Kumar (210070062)
- Soumyadeep Jana (21D070075)

Guided by :-

- Prof. V Rajbabu
- Prof. Siddharth Tallur

TA/RA reviewer :-

- Rohan Bagchi
- Alok Kumar

PROJECT OBJECTIVES

- Incorporating long antennas in RFID systems poses a challenge due to space constraints, leading to an increase in the overall size of the scanner.
- Human errors in data entry and management processes need to be reduced.
- Accurate inventory counts need to be maintained with some advanced technologies
- There is a need to track expiration dates and return records with alert SMS/email.



Image source: Freepic

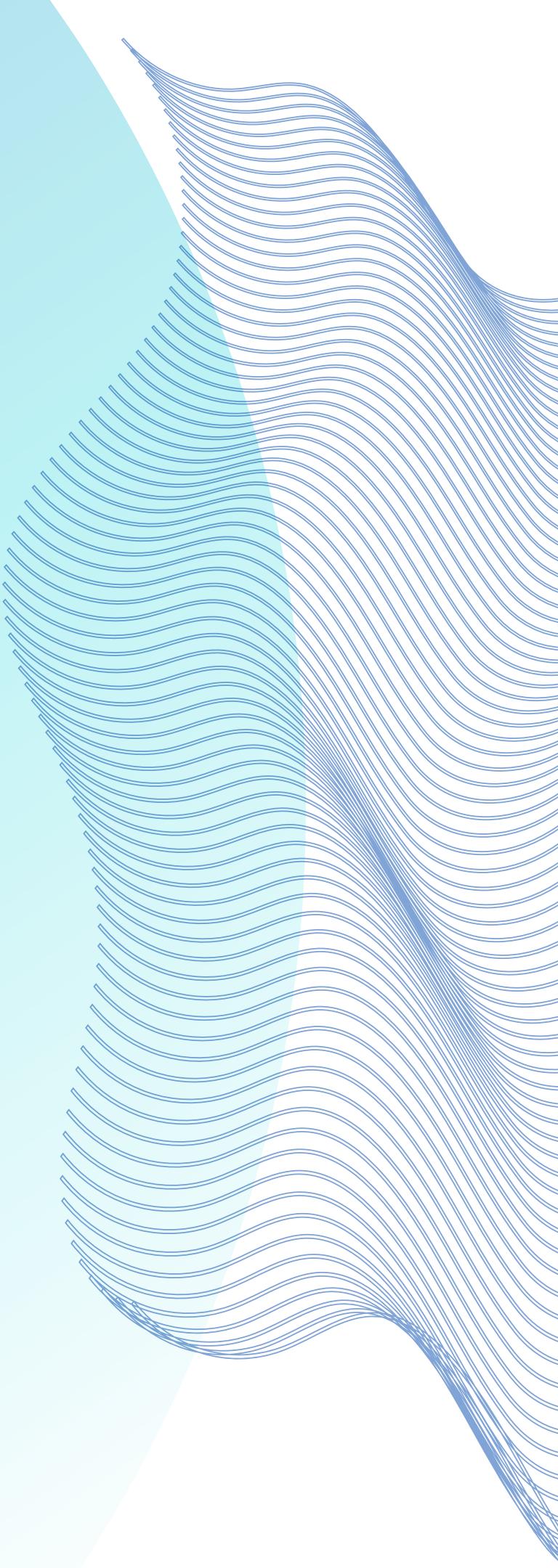
OUR PROPOSED SOLUTION

- Redesign the antenna loop to encapsulate all the extra components required to maintain the antenna, resulting in a visually appealing and compact design.
- Implement RFID reader base product scanning to minimize human errors in data entry and management processes.
- Utilize a web-based user interface to ensure the accurate maintenance of inventory counts.
- Implement a system to track expiration dates and return records, with automated alert notifications via SMS/email.



TARGET SPECIFICATIONS AND VALUE PROPOSITION

BOM



HOW ARE WE GONNA ACHIEVE THIS

1

Overview of methodology

2

Multiple option we had

3

How did we arrive at our solution

Overview of Methodology

- **Adopt phased approach:** Begin with comprehensive hardware testing, evaluating components, replicating antennas, and iteratively testing PCBs for optimal results.
- **Simultaneous development:** Initiate web development concurrently with hardware testing, referencing and addressing identified issues to ensure seamless alignment with software development.
- **Successful hardware implementation:** Implement the tested hardware components successfully.
- **Integrated testing and refinement:** Integrate both hardware and software components for final product testing, promptly rectifying any detected errors to achieve a refined and satisfactory output.

Multiple option we had

- Implement Plan A with the PN532 sensor in a compact design, prioritizing efficiency, size optimization, and space utilization.
- If Plan A encounters challenges or fails, switch to Plan B, incorporating the larger PC522 module as an alternative.
- Plan B provides a fallback option, leveraging the larger PC522 module if Plan A proves unfeasible.
- We also have a plan C where plan A and plan B have a power management system through batteries and intermediate components , in case it fails, the plan C is implemented in which power supply is done through USB type C OTG adapter from a smartphone

How did we arrive at our solution

- Initially considering the MF RC522 reader-writer system, we identified limitations such as inefficiency, substantial size, and a restricted operating frequency, leading us to reassess our approach.
- Subsequently, we shifted our focus to the PN532, recognizing its potential for a more efficient and compact design. This choice offers enhanced portability and a broader range of operating frequencies, allowing for increased versatility in mode selection.
- The new system's PCB design allows for flexibility, enabling potential replacements with readily available modules like RC522 and other RFID readers that operate at a frequency of 13.56 kHz.
- The strategic move towards the PN532 system aligns with our objective to create a compact, efficient, and highly portable solution while simultaneously expanding the operational capabilities through a diversified range of frequencies and modes.

Technical details

Principle of operation:

RFID (radio frequency identification) is a form of wireless communication that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency portion of the electromagnetic spectrum.

Basic principle of working:

- When there will be current through the coil of reader module it induce an Electromagnetic field which activate the passive RFID tag coil which then send back the signal(due to mutual effect) consisting of Unique ID of that Tag
- The signal received by the reader module is decoded to get the UID from the signal and then it is sent to the microcontroller through SPI/UART/I2C protocol. Then UID will be transferred to the database through its Wifi Module

Basic principle of RFID working

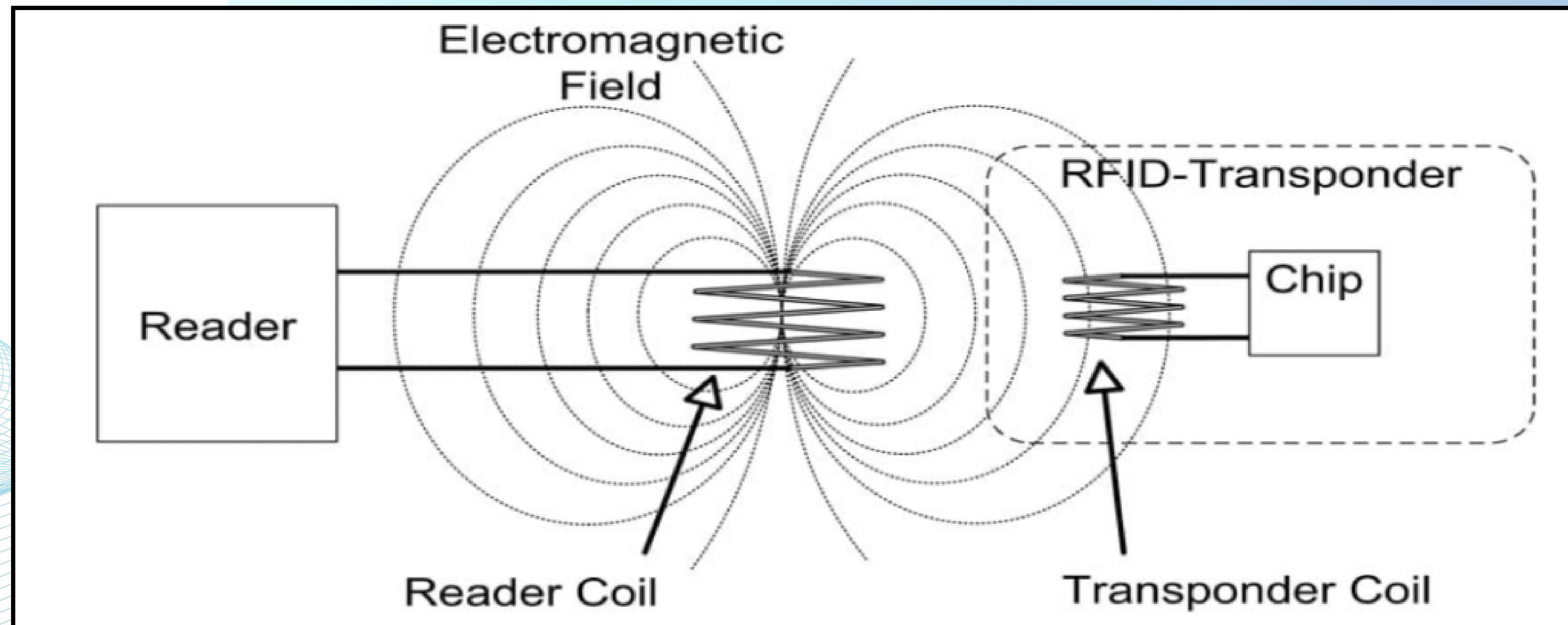
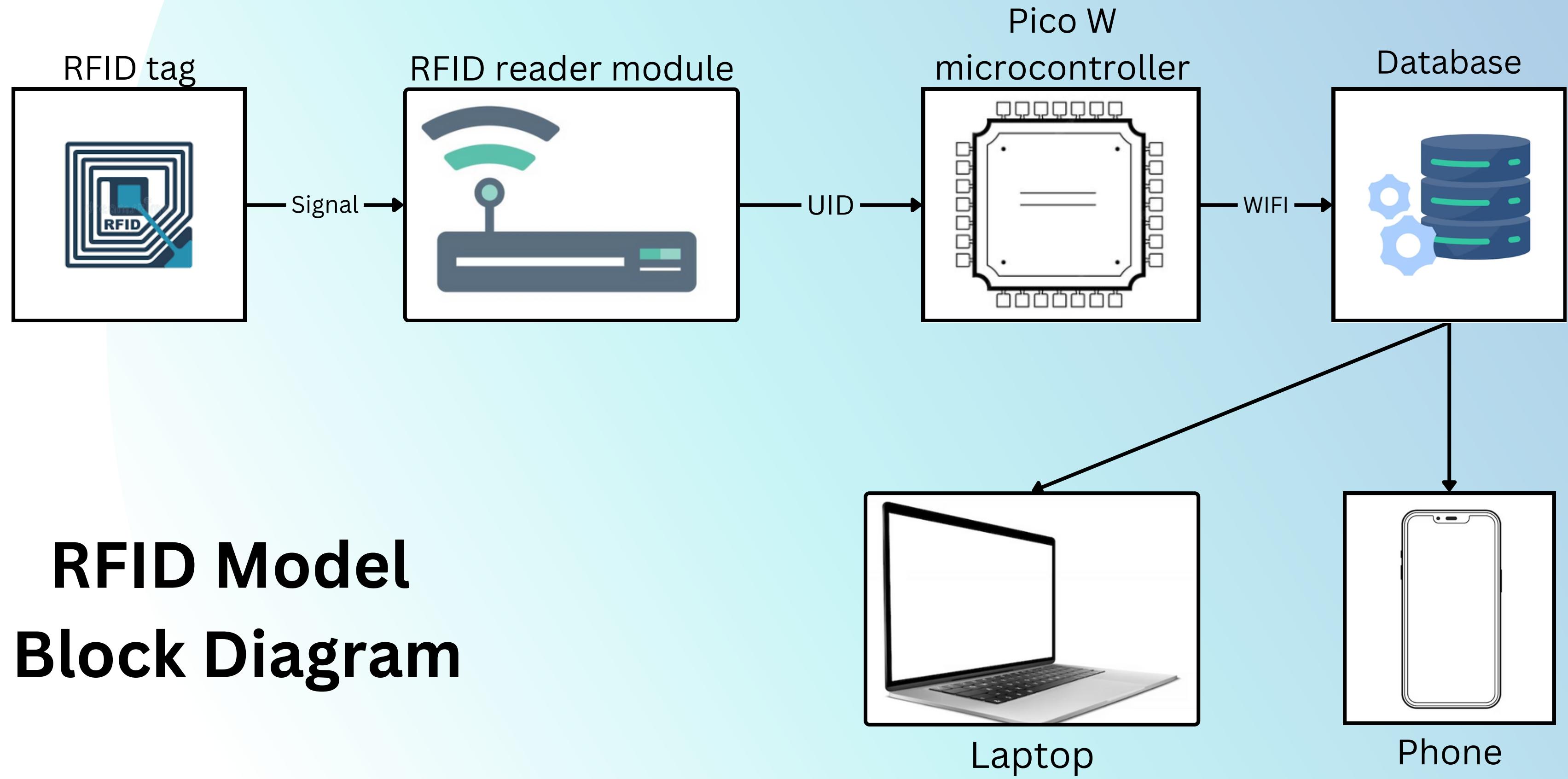
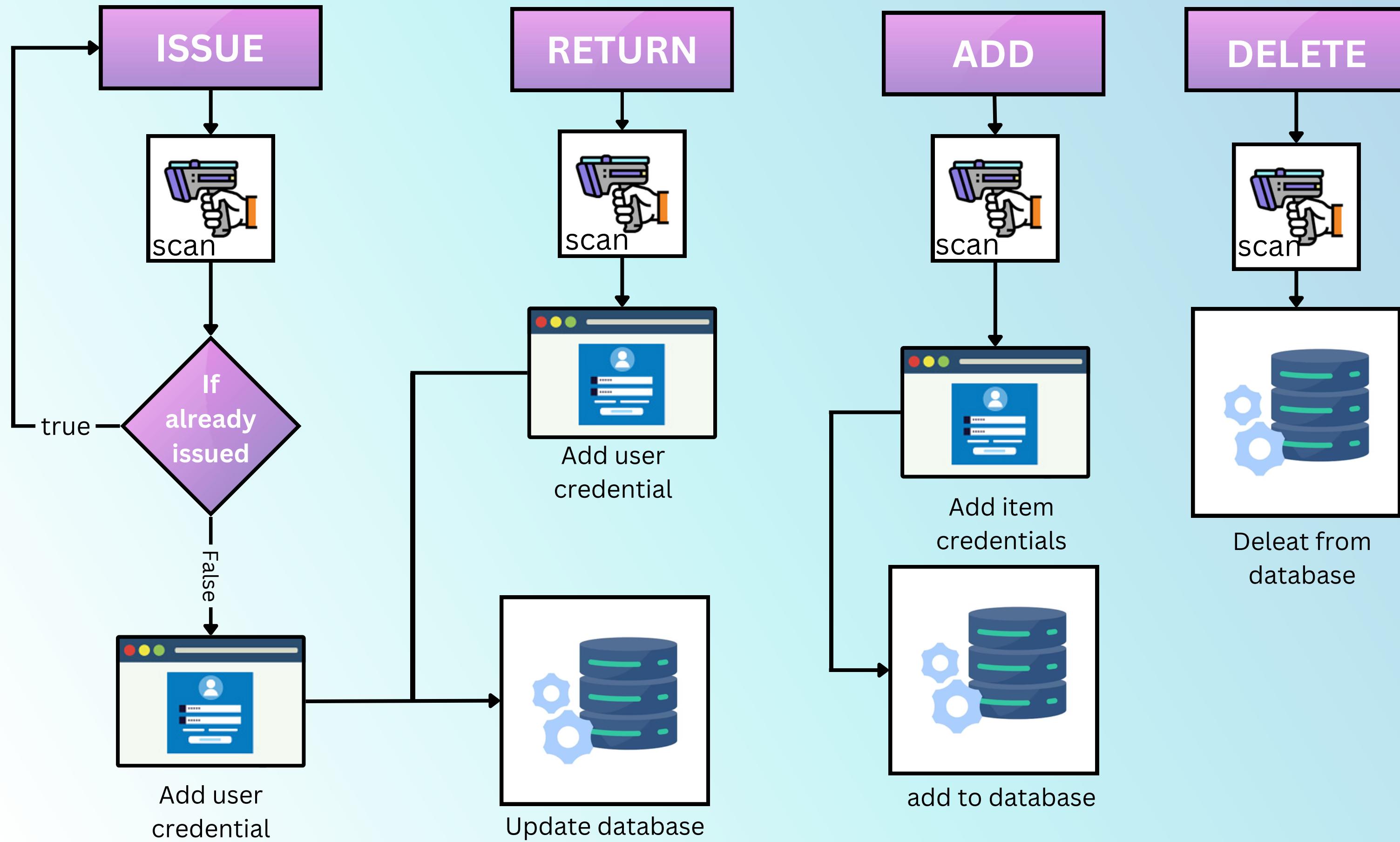


Image source: Google Images



Webpage Design



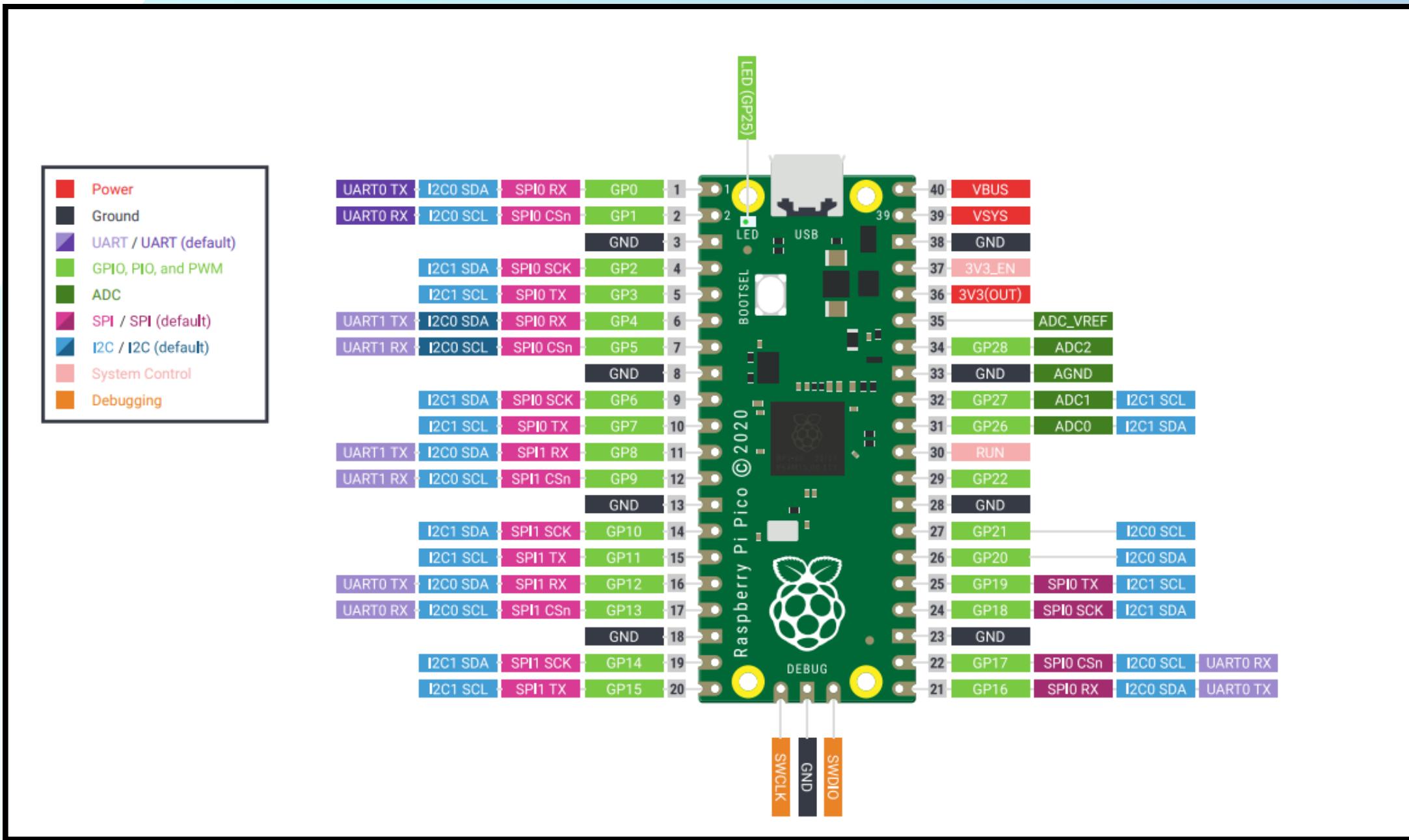
Components

1: Microcontroller

To send the UID related data to database with further processing We need a microcontroller

Raspberry Pi Pico W:-

- low-cost, high-performance microcontroller board with flexible digital interfaces
- Wireless (802.11n), single-band (2.4 GHz)
- WPA3
- Soft access point supporting up to four clients
- Bluetooth 5.2
 - Support for Bluetooth LE Central and Peripheral roles
 - Support for Bluetooth Classic



Raspberry Pi Pico w pin diagram

Image source: [raspberrypi.com](https://www.raspberrypi.com)

Why this?

We have another option of using Nucleo-F103RB board(STM32F103RB) but after doing some research we found that the board get update quite often with respect to its library.

2: Reader module

For Final implementation we will be using our own designed PCB, but before that for testing we need some reader modules

MFRC522 RFID Module:

- create a 13.56MHz electromagnetic field and communicate with RFID tags
- communicate with a microcontroller over a 4-pin SPI with a maximum data rate of 10 Mbps
- supports communication over I2C and UART protocols.
- 2.7 to 5.5 V power supply operating range

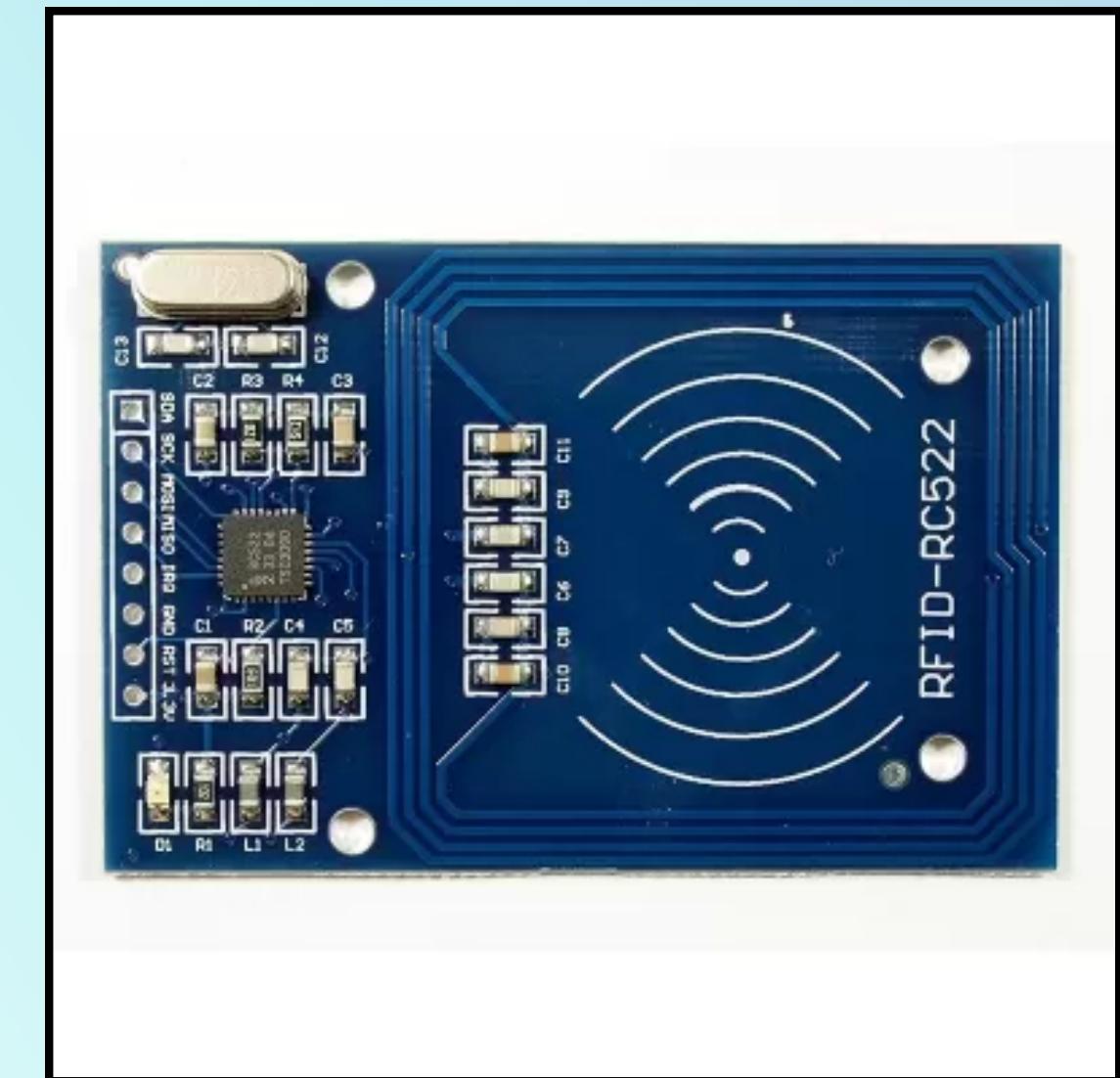


Image source: robu.in

PN532 NFC RFID Module:-

- Consume low power than the MFRC522 module
- higher transfer speeds up to 424 kbit/s
- Can be used in UART/I2C/SPI interface
- 2.7 to 5.5 V power supply operating range

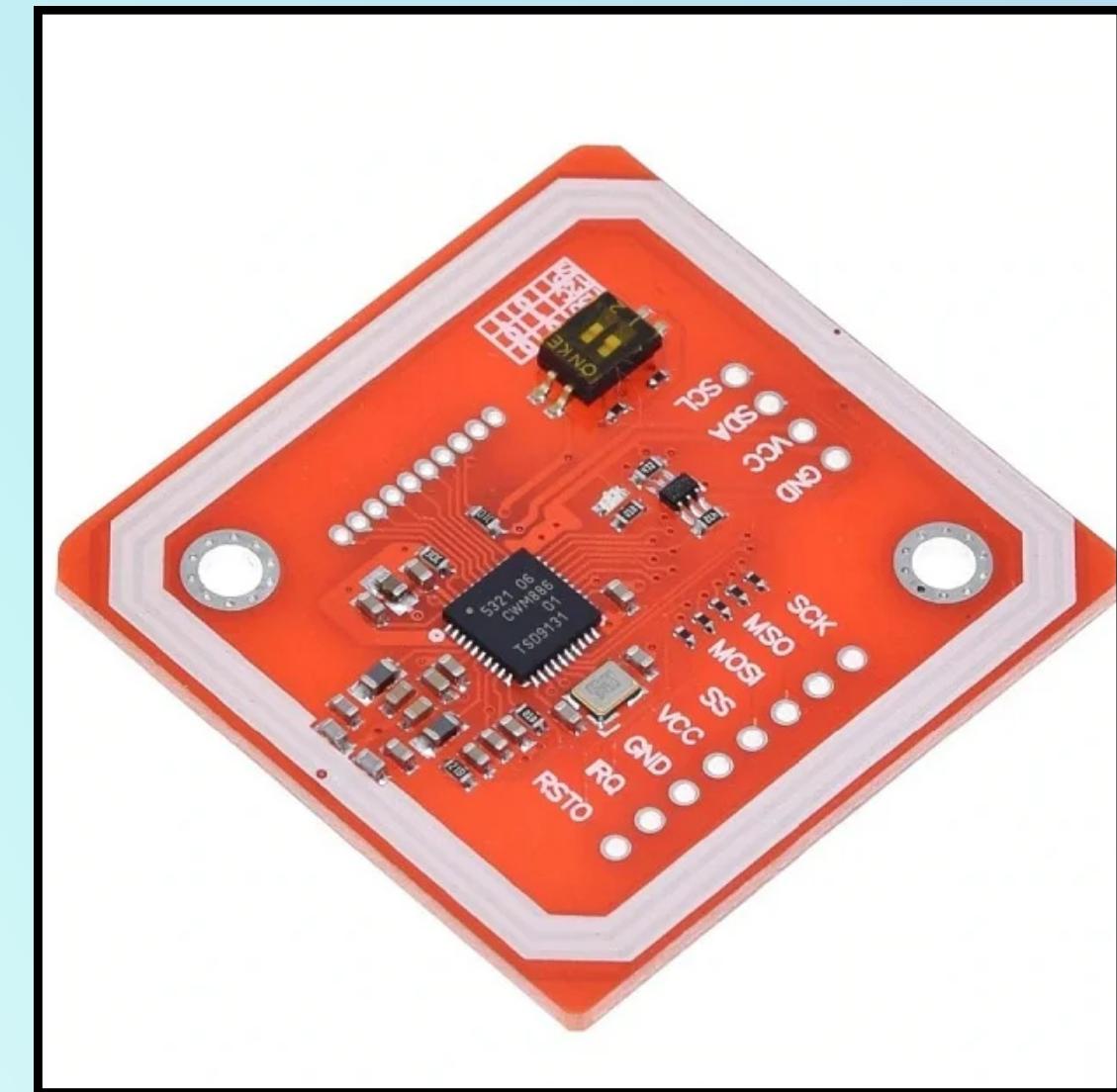


Image source: robu.in

3: RFID Tags:

RFID tags are made up of an integrated circuit (IC), an antenna and a substrate. The part of an RFID tag that encodes identifying information

There are two main types of RFID tags:

Active RFID: An active RFID tag has its own power source, often a battery.

Passive RFID: A passive RFID tag receives its power from the reading antenna, whose electromagnetic wave induces a current in the RFID tag's antenna.

3: RFID Tags:

Now in this project we are using passive RFID tags of high frequency(13.56 Mhz) which is ideal for inventory management system

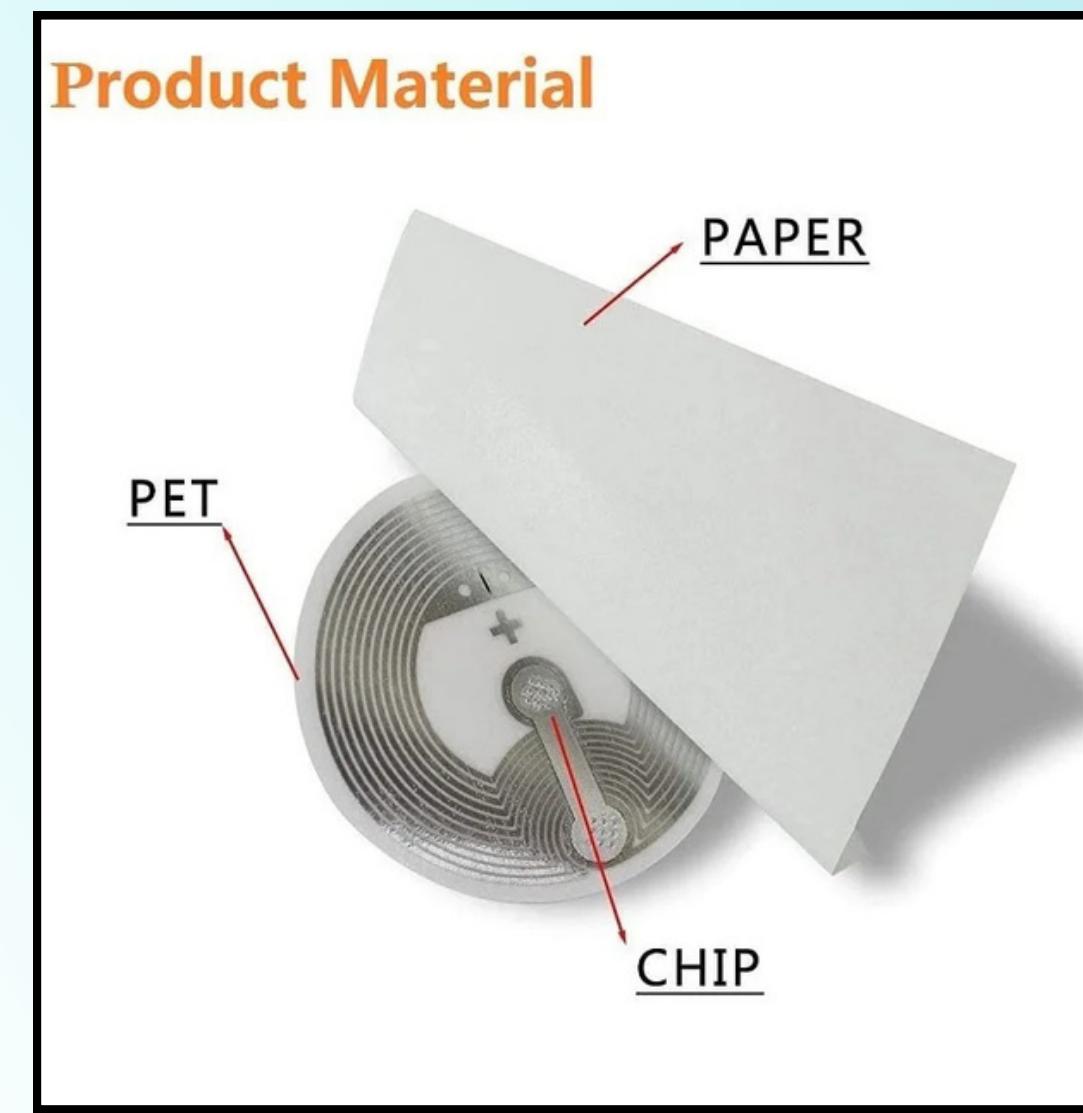


Image source: robu.in

4.Buzzer & LED:-

To get sound and visible feature in our scanner we using a buzzer and RGB Led(can get multiple color from one LED)



Image source: robu.in

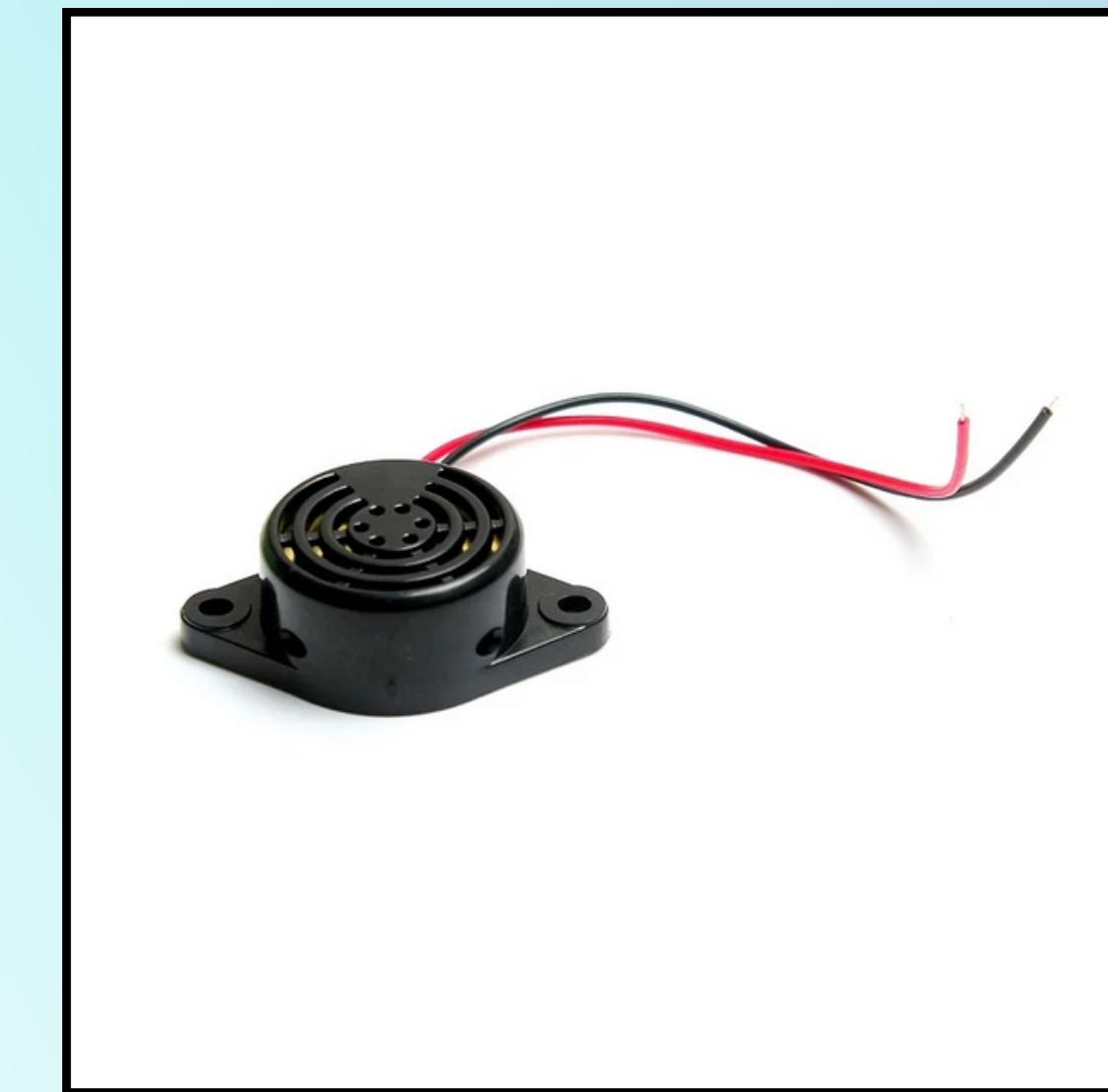


Image source: robu.in

5.Power Supply:-

We want to make our system portable so that there is a problem of continuous power supply to the microcontroller. For we two plans-

1.Using Cell and Buck Convertor:-

- Now for drawing 5v from a 9 v battery we will be using LM2596 Buck converter module which can convert input voltages up to 40 Volts to give an output voltage in the range of 1.2 V to 37 V.

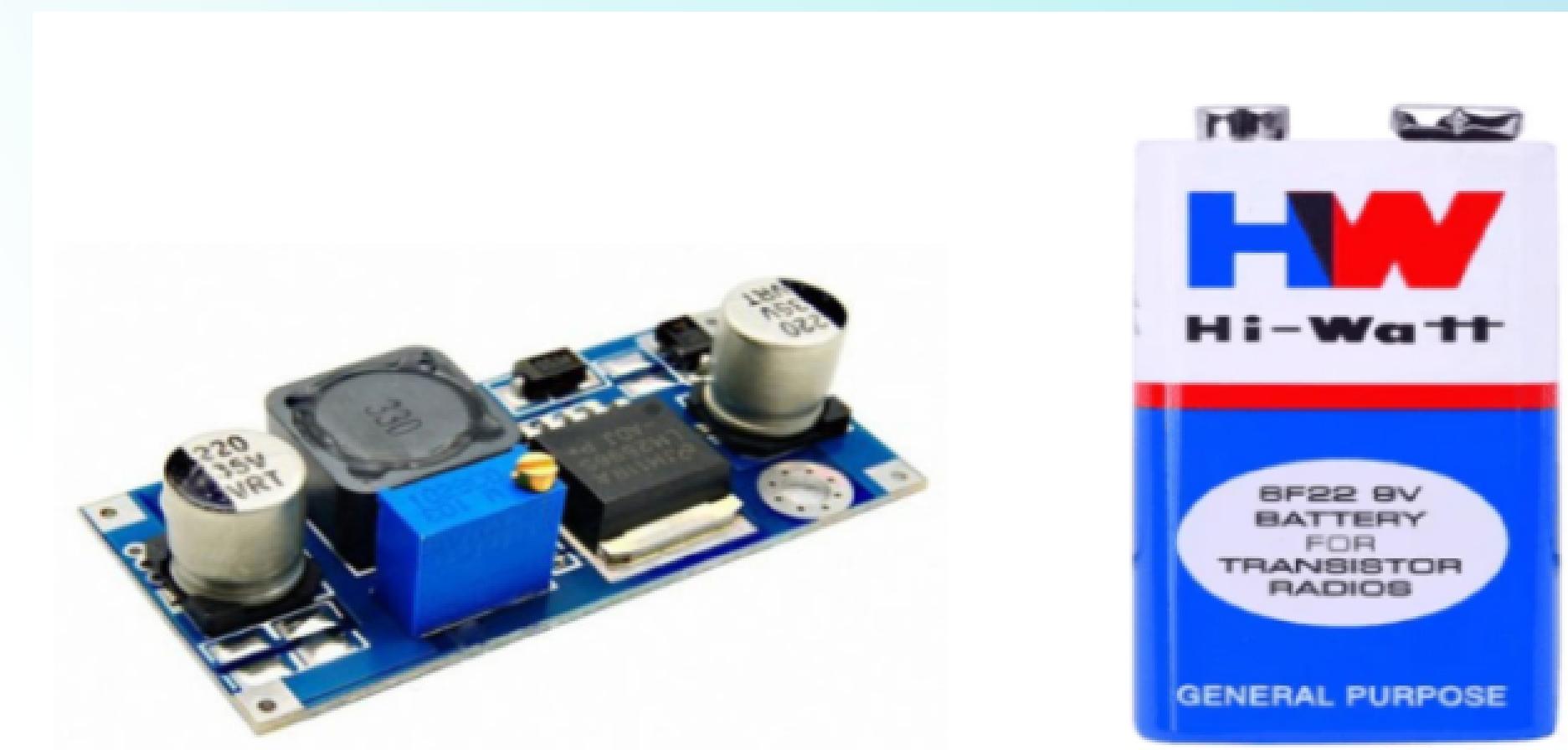


Image source: robu.in

- To avoid backfeeding from microcontroller we will use Schottky Diode, so that Whichever power source has the higher voltage will send power to the Raspberry Pi PicoW board



Image source: robu.in

2. Power From Phone:

Type C port of phone supply 5v, but for connection to microcontroller we need an USB Type C OTG Adapter



Image source: robu.in

6. .QFN40 SMD to DIP Adapter PCB:-

For testing with SMD components we can't do solder again and again it become cumbersome. So for that we will use QFN40 SMD to DIP Adapter so that we can do multiple testing with single IC

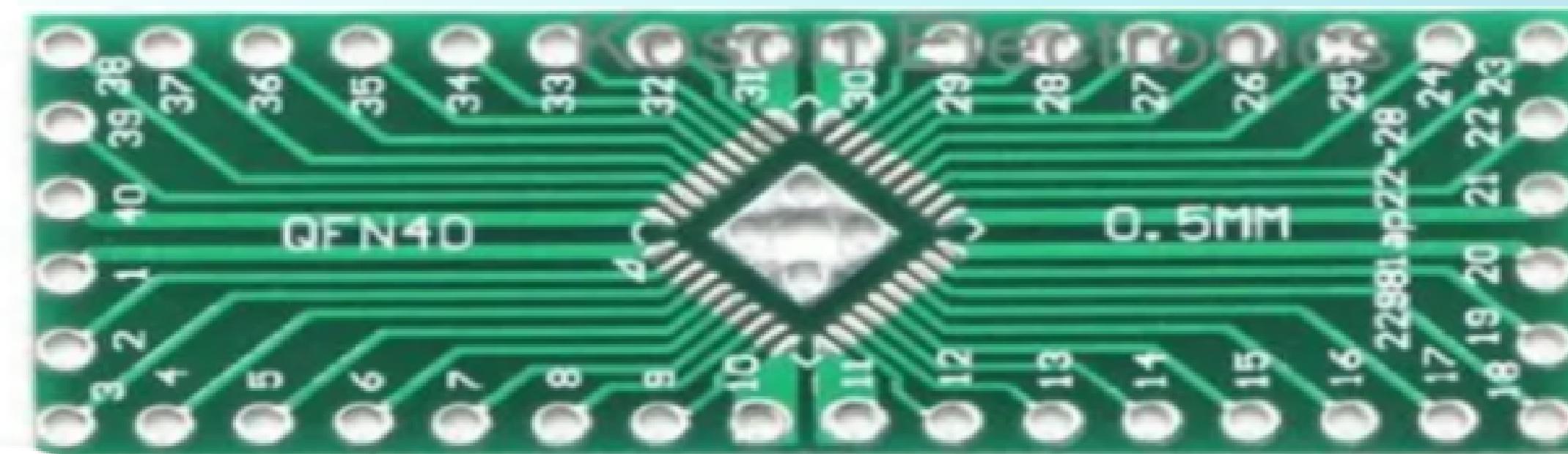


Image source: robu.in

GANTT CHART FOR PROJECT PLAN

Week ID	Task Title	Task Owner	Start Date	Due Date	Duration in Days	Target of the week	Pct of Task Complete	Phase One						Phase Two					
								Week 1			Week 2			Week 3			Week 4		
			M	T	W	F	M	T	W	F	M	T	W	F	M	T	W	F	
1	Project Conception and Initiation																		
1.1	understanding the working of RC522	Susrush	02-03-24	02-10-24	7	complete personal commitment	100%												
1.1.1	PCB design understanding	Om	02-03-24	02-10-24	7	complete personal commitment	100%												
1.2	HTML and CSS basics or front end	Prince	02-03-24	02-10-24	7	complete personal commitment	90%												
1.3	Study database management	Soumyadeep	02-03-24	02-10-24	7	complete personal commitment	40%												
2	Project Definition and Planning																		
2.1	Interfacing of WiFi with reader modul	Susrush	02-11-24	02-18-24	7	analysis	100%												
2.2	try to replicate the PCB designs for r	Om	02-11-24	02-18-24	7	schematics	100%												
2.3	connection of javascript with backend	Prince	02-11-24	02-18-24	7	personal commitment	80%												
2.4	work on web-development	Soumyadeep	02-11-24	02-18-24	7	personal commitment	100%												
	Evaluation2		02-19-24	02-20-24	1														
3	Project Testing review																		
3.1	Initial testing with the hardware syste	Susrush	03-03-24	03-10-24	7	debugging	100%												
3.2	wave interface testing and CAD layout	Om	03-03-24	03-10-24	7	CAD layout completion and review	100%												
3.2.1	Initial testing with the software syst	Prince	03-03-24	03-10-24	7	debugging	100%												
3.2.2	CAD layout	Soumyadee	03-03-24	03-10-24	7	CAD layout completion	100%												
4	Project Testing phase-I																		
	layout and CAD review																		
4.1	do the initial testing of whole system	Susrush	03-11-24	03-18-24	7	complete personal commitment	60%												
4.2	PCB review	Om	03-11-24	03-18-24	7	complete personal commitment	100%												
4.3	do the initial testing of whole system	Prince	03-11-24	03-18-24	7	complete personal commitment	60%												
4.4	PCB review	Soumyadeep	03-11-24	03-18-24	7	complete personal commitment	100%												
5	Project Testing phase-II																		
5.1	Testing again after debugging	Susrush	03-18-24	03-25-24	7	complete personal commitment	100%												
5.2	PCB review of new design	Om	03-18-24	03-25-24	7	complete personal commitment	100%												
5.3	testing again after debugging	Prince	03-18-24	03-25-24	7	complete personal commitment	100%												
5.4	PCB review of new design	Soumyadeep	03-18-24	03-25-24	7	complete personal commitment	100%												
6	buffer																		
6.1	rechecking everything and do the necc	Susrush	03-26-24	04-02-24	7	buffer week	just checking												
6.2	rechecking everything and do the necc	Om	03-26-24	04-02-24	7	buffer week	just checking												
6.3	rechecking everything and do the necc	Prince	03-26-24	04-02-24	7	buffer week	just checking												
6.4	rechecking everything and do the necc	Soumyadeep	03-26-24	04-02-24	7	buffer week	just checking												
7	Finalizing of the video and slide																		
7.1	combining the work	Susrush	04-03-24	04-15-24	6	co-ordinating to present final product	combine the work												
7.2	combining the work	Om	04-03-24	04-15-24	6	co-ordinating to present final product	combine the work												
7.3	combining the work	Prince	04-03-24	04-15-24	6	co-ordinating to present final product	combine the work												
7.4	combining the work	Soumyadeep	04-03-24	04-15-24	6	co-ordinating to present final product	combine the work												
8	Final checking																		
8.1	Final checking and error mitigation fo	Susrush	04-03-24	04-15-24	6	finalizing the product for presentation	product finalization												
8.2	Final checking and error mitigation fo	Om	04-03-24	04-15-24	6	finalizing the product for presentation	product finalization												
8.3	Final checking and error mitigation fo	Prince	04-03-24	04-15-24	6	finalizing the product for presentation	product finalization												
8.4	Final checking and error mitigation fo	Soumyadeep	04-03-24	04-15-24	6	finalizing the product for presentation	product finalization												

click [here](#) to get excel sheet

WORK PLAN AND DISTRIBUTION

WEEK1 (Feb 3 - Feb 10)

- Understanding of working of RC522 and PN532 module and learning C language for interfacing with microcontroller by Susrush
- Prince will work on HTML and CSS Basics for Frontend
- Soumyadeep will study database management.
- Om will work to understand the PCB designs of various modules.

WEEK2 (Feb 11 - Feb 18)

- Susrush will do Wifi interface with the reader module and do basic checks with tags.
- Prince will work Javascript to connect with backend
- Soumyadeep will work on web development.
- Om will try to replicate the PCB for reader module

18 Feb: Report 2 Submission(schematics and preliminary analysis)

19-20 Feb :Evaluation 2 :schematics and preliminary analysis

WEEK 3 (Feb 19 - Mar 2)

- Midsem

WEEK 4 (Mar3 - Mar 10)

- Susrush will do hardware testing of the whole system
- Prince will test web interface testing
- Soumyadeep will be in bug fixing
- Om will make Cad Layout

10 Mar : Report 3a Submission(layout and Cad review)

11-12 Mar: Evaluation 3a : layout and Cad analysis

WEEK 5 (Mar 11 - Mar 17)

- Testing 1
- Prince, Susrush will do initial testing of the whole system with PCB
- OM and Soumyadeep will do PCB review

WEEK 6 (Mar 18 - Mar 24)

- Testing 2
- Prince, Susrush will do initial testing of the whole system with PCB
- OM and Soumyadeep will do PCB review

22 Mar : Report 3b Submission of initial testing results

26-28 Mar: Evaluation 3b Submission of initial testing review

WEEK 7 (Mar 25- April 2)

- This last week will act as a buffer, as if we face any delays in our project, we can easily cover that up

WEEK 8 (April 3 - April 9)

- Finalising of the video and slide

7 April: Final Report : Video and Slide Submission

8-9 April: Evaluation 4 : Project Presentations

WEEK 9 (April 9- April 15)

- Final testing and small correction if needed before exhibition

15-16 April: Project demo

Key risks and mitigation strategies



Context: Our team needs to develop a mobile app for our inventory management system. Unfortunately, none of our teammates have experience in app development, and there's a concern that it may not be completed on time.

Risk: App development may not be achievable within the given timeframe.

Likelihood: Very likely

Mitigation strategy: To mitigate the risk associated with app development, we will initially focus on designing a basic webpage to meet our essential requirements. This approach allows us to make progress while exploring alternative options for app development, such as seeking external expertise or utilising user-friendly development platforms.

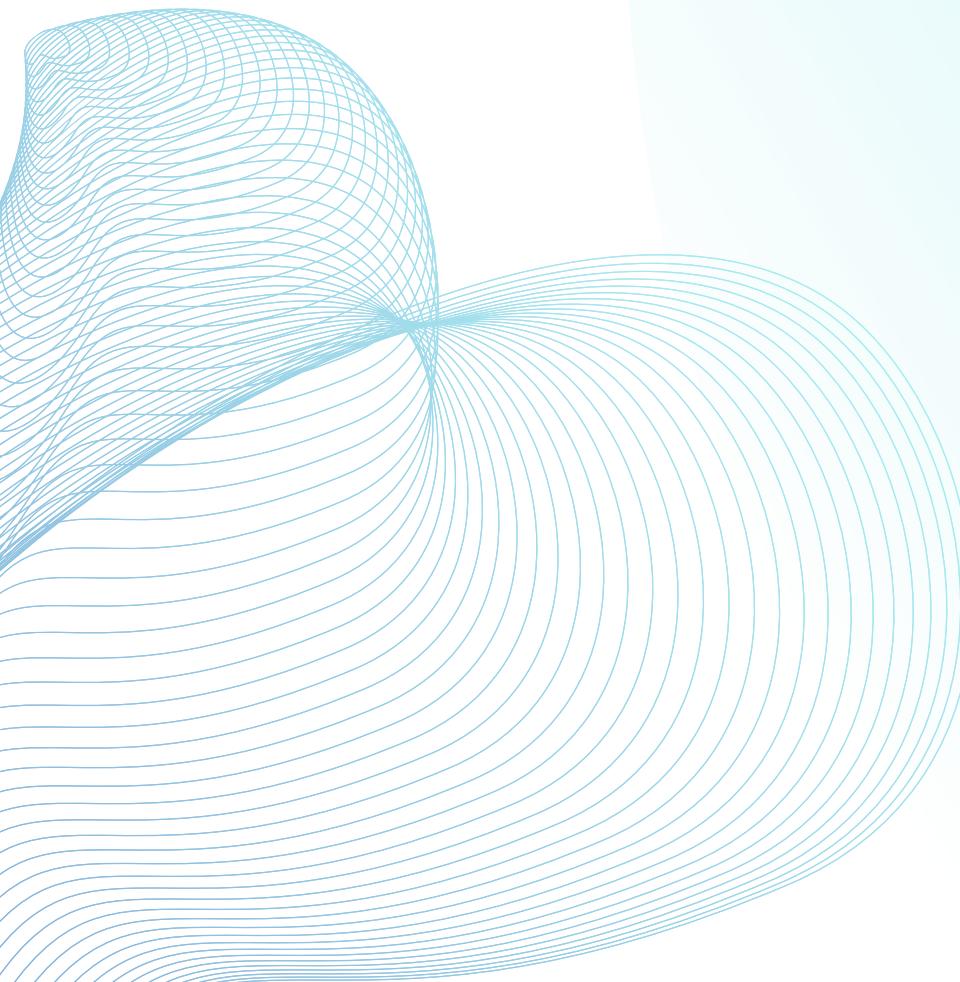
Context: We aim to design a proper structure for the mobile holder and RFID reader for the PCB through 3D printing. However, we do not have confirmation of the size and shape yet. If, after some time, it proves impractical to complete the 3D printing on time, we are considering the option of creating a rough shape using plastic sheets.

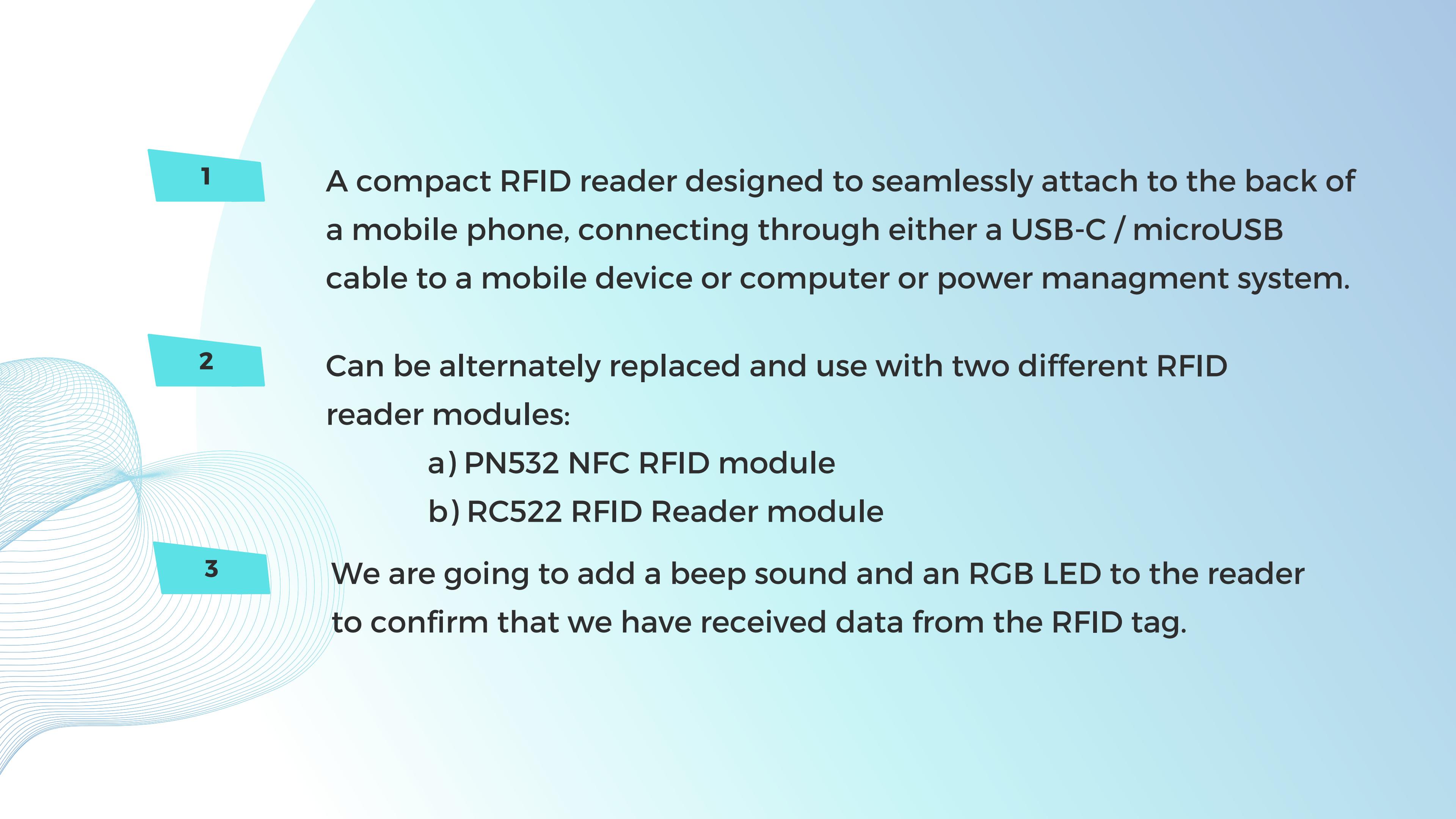
Risk: 3D printing for the mobile holder and RFID reader may not be achievable within the given timeframe.

Likelihood: Very likely

Mitigation strategy: To address this risk, we are contemplating an alternative approach of using plastic sheets to create a basic shape. We will also explore other materials and machining methods for the components. As we are still in the planning stages, the specifics of these mitigation techniques are yet to be determined, making the 3D printing a very high-risk component in the project. We welcome any help or suggestions in this matter.

EXPECTED OUTCOMES OF THE PROJECT





1

A compact RFID reader designed to seamlessly attach to the back of a mobile phone, connecting through either a USB-C / microUSB cable to a mobile device or computer or power management system.

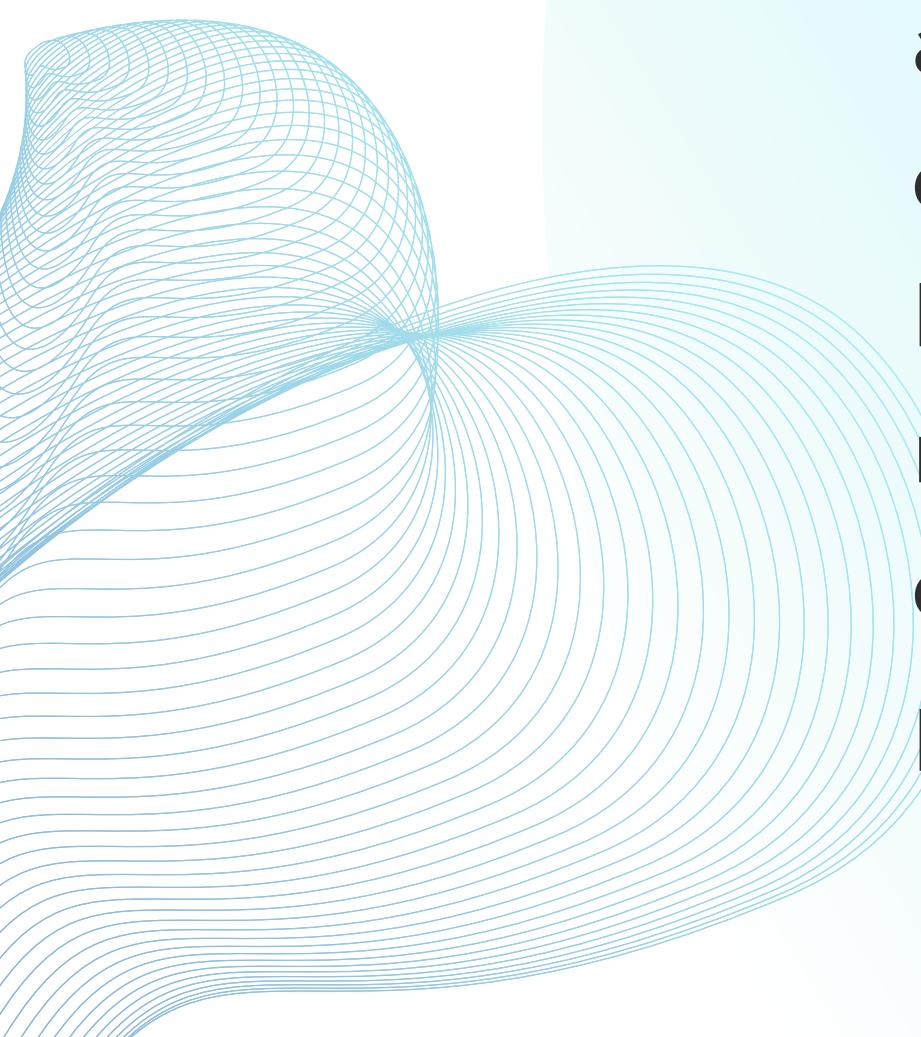
2

Can be alternately replaced and use with two different RFID reader modules:

- a) PN532 NFC RFID module
- b) RC522 RFID Reader module

3

We are going to add a beep sound and an RGB LED to the reader to confirm that we have received data from the RFID tag.



4

Primary focus on the PN532 NFC RFID module, with the development of a PCB design tailored to its specifications.

5

Development of a webpage for the functioning of an inventory management system, featuring:

- a) Issuance or return of a specific item through the scanning of its RFID tag.
- b) Ability to add or delete any item to the database as needed.
- c) Automated email notifications sent to borrowers three days prior to the due date for product returns.

Thank You