SECURE OFFICE LOCKER ACCESS WITH RFID CONTROLLED SMART LOCKER

AN INTERNSHIP PROJECT REPORT

Submitted by

MUTHUKUMAR R **910021106302**

in partial fulfilment for the award of the degree

of

BACHELOR OF ENGINEERING

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

ANNA UNIVERSITY REGIONAL CAMPUS MADURAI-625019

ANNA UNIVERSITY: CHENNAI 600 025

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BONAFIDE CERTIFICATE

Certified that this project report **“SECURE OFFICE LOCKER ACCESS WITH RFID CONTROLLED SMART LOCKER”** is the Bonafide work of **MUTHUKUMAR R** who carried out the project work under my supervision.

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ABSTRACT

This project presents the design and implementation of a Secure Office Access System using RFID-controlled digital lockers, aimed at automating and managing personal storage access for office staff. The system integrates STM32 microcontroller, RS-485 communication, and RFID authentication to control and monitor up to eight electronic lockers via a single PCB platform. Each locker's access is managed through a MOSFET-based driver circuit, replacing traditional relays for improved space efficiency and reliability. Optocouplers are employed to ensure electrical isolation and protect sensitive components. An RFID reader enables staff authentication, while a priority encoder setup collects locker status and occupancy feedback efficiently, allowing the STM32 controller to process inputs with minimal GPIO usage. The system also features a watchdog timer for reliability, and utilizes regulated power supplies including 12V, 5V, and 3.3V converters to power various modules. Communication between the central controller and peripheral locker nodes is handled through RS-485 transceivers (SN65176BDR), ensuring robust and long-distance data transmission. This solution enhances security, simplifies locker management, and exemplifies a compact, scalable approach to smart infrastructure in corporate environments. The system supports Free RTOS to manage real-time tasks efficiently, ensuring responsive and stable operation under varying loads. A centralized PCB layout optimizes component placement, minimizing wiring complexity and electromagnetic interference. Modular design allows easy expansion to accommodate more lockers without major hardware changes. Overall, the project demonstrates a cost-effective and intelligent storage access solution tailored for modern office environments.

ACKNOWLEDGEMENT

I would like to thank the almighty god for all the blessings he bestowed on us, which drove us to the successful completion of this project.

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MUTHUKUMAR R

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LIST OF ABBREVIATION

ABBREVIATIONS	EXPANSIONS
SMPS	Switch Mode Power Supply
SMD	Surface Mount Components
UART	Universal Asynchronous Receiver Transmitter
I2C	Inter Integrated Circuits
RFID	Radio Frequency Identification
RTC	Real Time Clock
CTRL	Control
USB	Universal Serial Bus
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
IR	Infrared
LED	Light Emitting Diode
LDO	Low Dropout
TX	Transmit
RX	Receiver
NFC	Near Field Communication
GPIO	Input Output
TP	Test Point
NC	No Connection
CIS	Component Information System

CHAPTER 1

INTRODUCTION

This project presents the design and implementation of a Smart Locker System integrated with RFID-based access control and a feedback mechanism to ensure enhanced security and user interaction. Traditional lockers using mechanical keys are increasingly being replaced by intelligent, electronically controlled systems for improved security and convenience. The smart locker developed in this project eliminates the dependency on physical keys by employing RFID cards for secure, user-specific access. Central to the system is a microcontroller that governs all operations, supported by RS485 communication for reliable data transmission and multi-locker control in noisy environments. To further enhance system robustness, a watchdog timer is implemented, ensuring recovery from potential system faults. Fast switching of electronic locks is achieved using MOSFETs, while optocouplers and 8:3 encoders provide electrical isolation and stable signal processing. The lock status is monitored through IR sensors, and the locking mechanism operates on a regulated 12V DC supply. A key feature of this smart locker is the integration of a feedback system that provides real-time confirmation of lock and unlock actions, helping users and administrators ensure that operations are successfully completed. This feedback may include visual indicators (LEDs), buzzer alerts, or status messages on a display, thereby reducing errors and improving user trust in the system. The power supply design optimizes energy consumption while supporting reliable operation across components. The inclusion of the Modbus protocol over RS485 allows easy scalability for larger locker networks in office or industrial environments.

1.1 PROJECT OVERVIEW:

In modern office environments, secure and streamlined access to personal storage is essential, especially with the growing emphasis on workplace automation and staff convenience. Traditional lockers often fall short in providing real-time monitoring, centralized control, and tamper-proof access, which are critical in today's fast-paced and security-conscious settings. To address these challenges, this project introduces a smart digital locker system titled “Secure Office Access with RFID-Controlled Digital Lockers,” which leverages RFID technology and embedded systems to offer contactless, user-specific access to electronic lockers. The solution is powered by an STM32 microcontroller, which coordinates communication, access control, and real-time status tracking.By integrating components such as RS-485 transceivers for robust data transmission, priority encoders for efficient signal management, and MOSFET-based lock drivers for reliable operation, the system achieves both scalability and compact design.Enhanced with optocouplers for signal isolation and watchdog timers for system stability, the architecture is suitable for high-demand environments. The system uses IR-based occupancy detection to monitor locker usage in real time.

Status signals from multiple locks and sensors are encoded and processed efficiently using SN74HC148 priority encoders. By replacing bulky relays with MOSFETs, the PCB design achieves space optimization while ensuring reliable 12V, 2A electronic lock control.Unlike conventional systems, this solution provides not only security but also operational insights through feedback sensors and programmable logic. This project lays the foundation for intelligent locker systems that align with the future of smart office infrastructure.

CHAPTER 2

LITERATURE SURVEY

[1] In this study, an attempt has been taken to design and prototype a cost effective security locker system to ensure the safety of the valuable objects and belongings of people in public places. To combat unfortunate cases of thefts or loses at public places, this paper aims to represent a Radio Frequency Identification (RFID) based security locker system that can protect the valuable belongings in individual boxes of the system. A microcontroller is the heart of the system, with a stored database. An RFID reader reads information from RFID tags to match with the stored data in the microcontroller to allow access. Users of this system can use the RFID tags to lock their belongings inside the locker and take them out after completing their respective businesses in the public places. The proposed security system can be a major step in preventing valuable item stealth or losses in public places as this system has been designed in such a way that only the authorized owner of the locker or the admin of the system can access the locker.

[2] As mankind leads into a new age of modernization, security issues and measures have become exceedingly important. Considering an educational institute or workplace, keeping one's belongings safely with a minimal interface is the need of the hour. The traditional lock and key method of keeping personal items safe is clumsy and inconvenient. The recent developments in technology have provided innovative solutions to this problem. Gone are the days of the troublesome key and lock. Radio Frequency Identification (RFID), along with Internet-of-Things (IoT), is a secure, user-friendly and efficient method to safeguard things. This combination comes with advantages such as high security, simplicity, cost-effectiveness and 'misplace-proof' methodology. This paper proposes a Smart RFID-IoT based Locker system. The locker works on RFID authentication technology, which is unique to every identity card of the user.

[3] The advancement in communication and information technology has played a significant role in the development of the Internet of Things (IoT).Nowadays, IoT is essential in various fields such as healthcare, smart cities, engineering, and more. Security plays a crucial role in our daily lives, and this project focuses on enhancing security. As technology continues to advance at a rapid speed and the need for college automation solutions grows, there is one particular innovation that stands out-the smart door lock system. This system not only provides improved security but also offers convenience and control over access to both residential and commercial properties. Traditional locks in colleges and businesses have their drawbacks when it comes to security and convenience. Losing or having keys stolen can be a hassle, and keeping track of who has access can be difficult. This project introduces a Smart Door Lock System that utilizes Arduino Uno, ESP-01 Wi-Fi module, LCD Display, Relay, and a Solenoid Lock. The main objective of this system is to improve security and convenience by enabling remote access control and monitoring capabilities. The Arduino Uno acts as the central control unit, facilitating communication between different components.

CHAPTER 3

METHODOLOGY

3.1Existing system:

The traditional locker systems commonly used in offices, educational institutions, and industrial environments rely on mechanical locks that require physical keys for access. These systems pose several limitations in terms of security, convenience, and scalability. Key-based lockers are prone to unauthorized access, key duplication, and theft. Managing keys for multiple users becomes cumbersome, especially in organizations with a large number of employee.

Additionally, lost or stolen keys require costly replacements or re-keying of locks. Some existing systems may use basic digital locks with PIN codes, but these are often standalone and lack centralized control or access logging capabilities. There is generally no way to monitor locker status remotely or identify which user accessed a locker and when

.

Furthermore, traditional systems do not support features like multi-user authentication, real-time feedback, or integration with office automation systems. Due to these limitations, there is a growing demand for smarter, more secure, and efficient locker systems that can overcome the drawbacks of existing technologies.

3.2 PROBLEM STATEMEMT

In many existing digital locker systems, especially those built using Arduino development boards, control is limited to simple relay-based actuation. While this allows basic open and close functionality, it lacks the intelligence needed for real-world office environments. There is no provision to monitor which lockers are in use or when they were accessed, making it difficult to manage or audit usage effectively.

Moreover, the use of only relays offers no feedback on whether the locker actually opened or encountered a fault. Without current sensing or feedback signals, these systems cannot detect malfunctions or unauthorized access attempts. Communication errors are also common, especially in systems that attempt to scale without robust protocols like RS-485. These limitations make existing locker prototypes unreliable and unsuitable for smart office applications, where real-time monitoring, secure access, and centralized control are essential. Hence, there is a pressing need for a more intelligent, feedback-enabled, and communication-stable locker system for modern workplaces.

3.3 PROPOSED SYSTEM

1. RFID-Based Secure Access

The core of the proposed system is RFID-based authentication, enabling contactless, secure access to lockers. Each user is issued an RFID card that, when scanned, is verified by the system to grant or deny access. This eliminates the problems associated with traditional key-based systems, such as loss, duplication, or unauthorized use. The RFID module is externally placed and communicates with the microcontroller to validate user credentials in real-time.

2. Microcontroller-Centric Operation

An STM32 microcontroller serves as the brain of the system, coordinating all functions including authentication, lock control, sensor monitoring, and communication. It manages data input from RFID readers and sensors, and issues control signals to actuate the locks. It also integrates a watchdog timer, which ensures the system automatically resets in case of software faults, enhancing overall system reliability and uptime.

3. Intelligent Locking Mechanism

The locking system is driven by MOSFETs instead of mechanical relays, offering faster switching speeds, lower power consumption, and better durability. Each electronic lock operates on a 12V DC supply and includes a current sensing circuit to monitor the lock's status. This feature detects abnormalities like short circuits or jammed locks. IR sensors are also used to detect locker occupancy, enabling real-time tracking of which lockers are in use.

4. Efficient Input and Isolation Handling

To manage multiple inputs efficiently, the system uses SN74HC148 priority encoders, reducing the number of GPIO pins required on the microcontroller. This conserves hardware resources and simplifies wiring. Optocouplers are integrated to electrically isolate the control and power sections, safeguarding the microcontroller from voltage surges and improving overall system robustness.

5. Robust Communication and Scalable Design

Communication across multiple lockers is enabled via RS-485 transceivers using the Modbus protocol. This ensures stable, noise-resistant, and long-distance data transmission, which is ideal for scalable office installations. All system components are designed for integration on a compact PCB, supporting a modular and scalable approach that allows easy deployment in environments with multiple lockers.

3.4 BLOCK DIAGRAM OF PROPOSED SYSTEM:

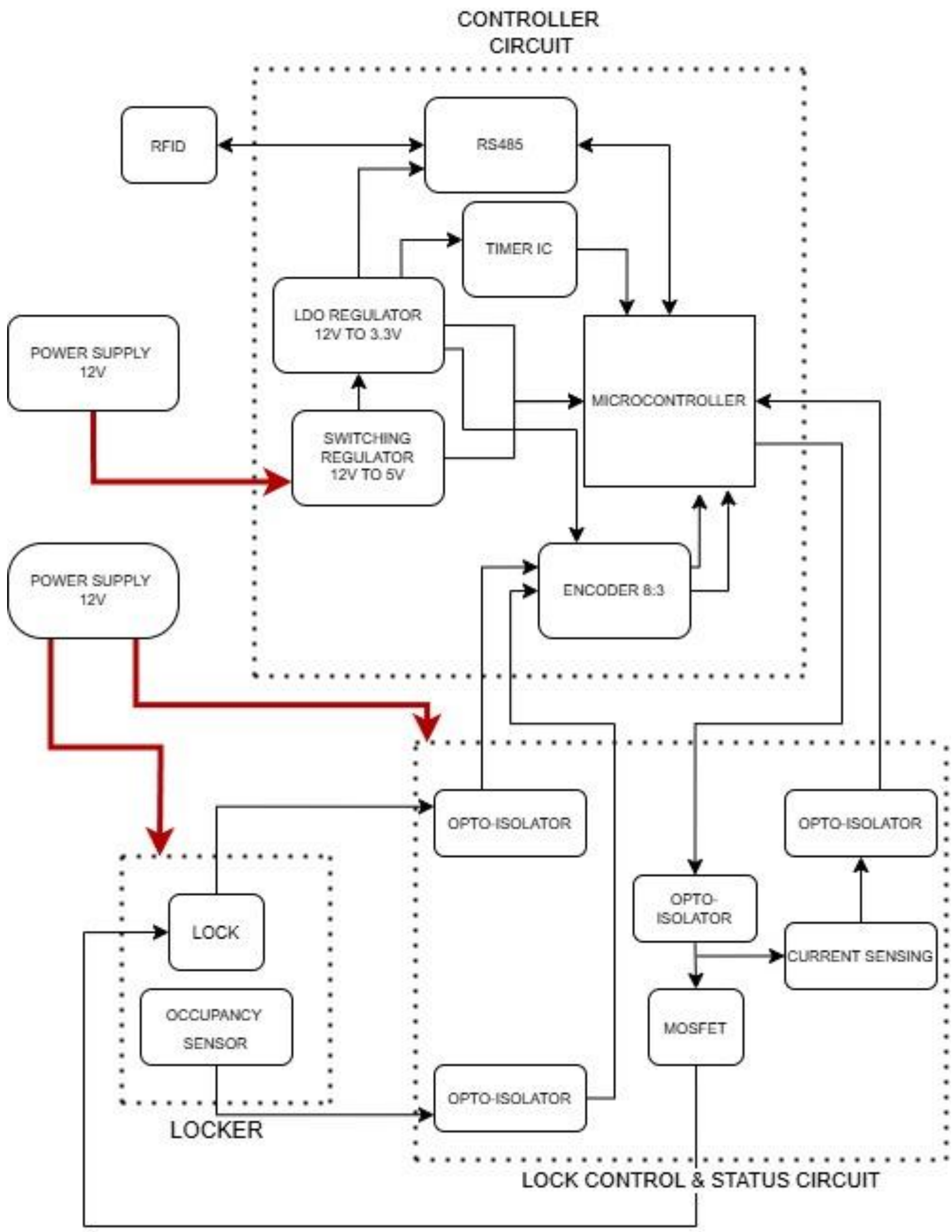

Figure 3.1: Block diagram

CHAPTER 4

HARDWARE DESIGN AND IMPLEMENTATION

4.1 HARDWARE REQUIREMENT:

- POWER SUPPLY 12V(SMPS)
- MICROCONTROLLER (STM32F103C8T6TR):
- SWITCHING REGULATOR (LM2596R-12V TO 5V)
- VOLTAGE REGULATOR (SPX3819M5 5V TO 3.3V)
- NFC MODULE (PN532 V3)
- RS485 COMMUNICATION (SN65HVD75DR)
- WATCHDOG TIMER IC
- ENCODER 8:3(SN74HC148DR)
- LOCK STATUS AND OCCUPANCY SENSOR (IR SENSOR) STATUS AND LOCK CONTROL SECTION
- CURRENT SENSING FOR LOCK
- LOCK
- PROJECT 3D MODULE

4.1.1 POWER SUPPLY 12V (SMPS):

Figure 4.1. SMPS

The input power supply used in this project is a Switched-Mode Power Supply (SMPS) that delivers a regulated 12V DC output. SMPS is preferred over traditional linear power supplies due to its higher efficiency, compact size, and reduced heat generation. It converts high-voltage AC mains into a stable 12V DC output using high-frequency switching and filtering. This 12V supply is used to power the electronic locks directly and also serves as the main input for voltage regulators such as the LM2596, which further steps down the voltage for other components like microcontrollers and sensors.

The SMPS provides sufficient current to drive all connected modules, including high-power loads like the 12V, 2A electronic locks. It ensures stable and reliable operation of the entire system even under varying load conditions. Its compact design and plug-and-play functionality make it ideal for embedded and industrial applications. Thus, the 12V SMPS is a critical part of the power architecture in the proposed digital locker system.

4.1.2 MICROCONTROLLER (STM32F103C8T6TR):

Figure 4.2. STM32F103C8T6TR

4.1.2.1KEY FEATURES:

Processor Core

- Based on Arm® 32-bit Cortex®-M3 core
- Operates up to 72 MHz
- Delivers 1.25 DMIPS/MHz performance (Dhrystone 2.1)
- Includes single-cycle multiplication and hardware division
- Incorporates patented ST technology for enhanced efficiency

Memory

- Flash memory: 64 KB or 128 KB
- SRAM: 20 KB

Power and Clock Management

- Operating voltage: 2.0V to 3.6V for core and I/O s
- Power-on reset (POR), power-down reset (PDR), and programmable voltage detector (PVD)
- External crystal oscillator: 4 to 16 MHz
- Internal oscillators: 8 MHz (factory trimmed) and 40 kHz
- 32.768 kHz oscillator for RTC with calibration support

Low-Power Modes

- Supports Sleep, Stop, and Standby modes
- Backup battery support (VBAT) for RTC and backup registers
- Dual sample-and-hold capability
- Integrated temperature sensor

Communication Interfaces

- 2x I2C (with SMBus/PMBus support)
- 3x USART (with LIN, IrDA, modem control, ISO 7816 support)
- 2x SPI (up to 18 Mbps)
- 1x CAN interface (2.0B Active)

4.1.2.2 WORKING PRINCIPAL OF MICROCONTROLLER IN SCHEMATIC:

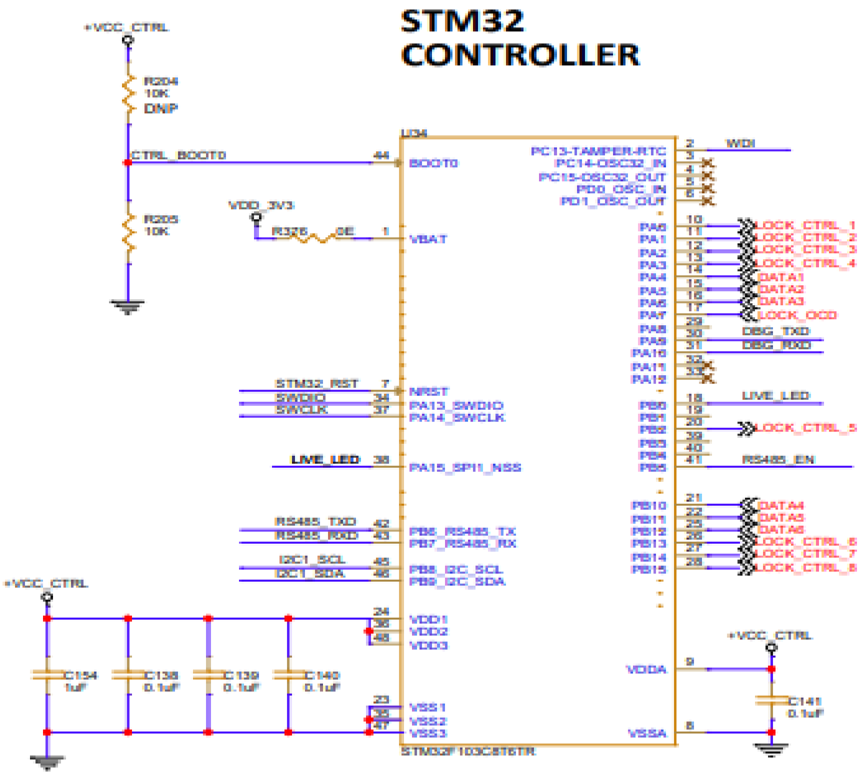

Figure 4.3 Schematic for Microcontroller

This STM32 controller schematic shows the core of a microcontroller-based system, with the STM32F103C8T6 at its heart. The microcontroller handles various digital signals, peripherals, and power regulation. Power to the MCU is supplied via VDD and VDDA pins, filtered by decoupling capacitors (C154–C141), ensuring stability and reducing noise. The BOOT0 pin, pulled low via R205, determines the boot mode—typically set to boot from flash memory. A control signal CTRL_BOOT can override this setting for programming or firmware updates.

The NRST pin is for hardware reset, while SWDIO and SWCLK are for programming/debugging via Serial Wire Debug (SWD).The microcontroller communicates with external components using UART, SPI, and I2C interfaces. PA9 and PA10 are used for UART TX/RX, ideal for serial debugging or connecting to modules like GSM/GPS. SPI pins such as PA15 (NSS) and PB13 (SCK) are used for high-speed peripheral communication like memory or sensors. The I2C lines (PB6 and PB7) allow interfacing with I2C sensors or IO expanders. GPIOs such as PA0–PA7 and PB0–PB15 control or read various devices.

Some pins are labelled LOCK_CTRL_1 to LOCK_CTRL_8, likely controlling or monitoring security systems or locks in the project. DATA1–DATA4 are general data lines, probably for inputs from sensors ENCODER.LIVE_LED connected to PA8 serves as a heartbeat indicator to show system status. RS485_TXD and RS485_RXD on PB10 and PB11 support robust, long-distance communication with industrial devices via the RS-485 protocol, enabled by RS485_EN. LOCK_OCD and DBG_TXD help with system diagnostics or status feedback. VBAT supports real-time clock operation when main power is off. Capacitors on the power rails smooth out voltage fluctuations. The MCU is central to decision-making, controlling locks, gathering data, and enabling communication. This system could be used in an access control system, combining lock management, sensor inputs, and RS485 communication for remote control and monitoring.

4.1.2.3 TOTAL CURRENT CONSUMPTION:

The STM32F103C8T6TR microcontroller core draws approximately 22 mA during active operation. The RS-485 transceiver consumes around 2.3 mA, while the indicator LED adds about 3.3 mA. The general-purpose input/output (GPIO) pins account for an estimated 2 mA, and the timer IC, being a low-power component, contributes only about 50nA, Approximately the total current consumption is 40milli amps.

4.1.3 SWITCHING REGULATOR (LM2596R-12V TO 5V):

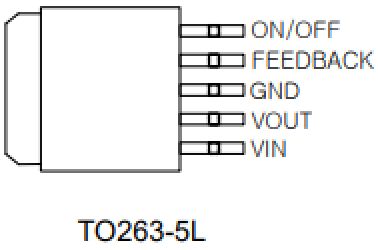

Figure 4.4. Switching Regulator

The LM2596 is a monolithic integrated step-down (buck) switching regulator capable of delivering up to 3A output current with high efficiency. It is available in 3.3V, 5.0V, 12V, and adjustable output versions with an adjustable range from 1.2V to 37V. Internally, the LM2596 uses a 150kHz fixed-frequency oscillator, which drives a high-speed switching transistor.

This transistor rapidly turns on and off, supplying current through an external inductor to the load. The energy is stored in the inductor during the "on" phase and released during the "off" phase, maintaining continuous current flow. A Schottky diode provides a path for this current when the switch is off, ensuring smooth output.To stabilize the output, a feedback pin (FB) senses a portion of the output voltage via a resistor divider network.

This signal is fed into an error amplifier, which compares it to an internal reference and adjusts the duty cycle accordingly, ensuring tight line and load regulation within ±4%.

The LM2596 includes thermal shutdown and current limiting for protection. Additionally, it has a TTL-compatible shutdown pin, allowing the regulator to be turned off via logic control, reducing quiescent current to as low as 100μA in standby mode.This regulator requires only four external components: an inductor, two capacitors (input/output), and a diode, making it compact and easy to implement.

It is available in TO-220 and TO-263 packages for through-hole and surface-mount applications. The internal circuitry includes a moisture sensitivity rating of level 3, ensuring reliable performance under standard soldering and handling conditions.

The LM2596 is widely used in power supply designs due to its combination of efficiency, protection features, and simple implementation, making it ideal for embedded systems like your RFID-controlled locker system.

Table 4.1. Pin Description

PIN NO	SYMBOL	DESCRIPTION
1.	VIN	The input pin of the LM2596 step-down regulator receives the positive supply voltage. A bypass capacitor is required to reduce voltage transients and support switching currents.
2.	VOUT	This pin is the emitter of the internal switch with a typical saturation voltage (V_{sat}) of 1.5 V.
3.	GND	Circuit ground pin.
4.	FEEDBACK	This pin senses the output voltage for feedback; in adjustable versions, external resistors set the output voltage.
5.	ON AND OFF	This pin enables shutdown of the regulator via logic signals, with operation off above 1.3V and on when below 1.3V or left open.

4.1.3.1 WORKING PRINCIPLE IN THE SCHEMATIC:

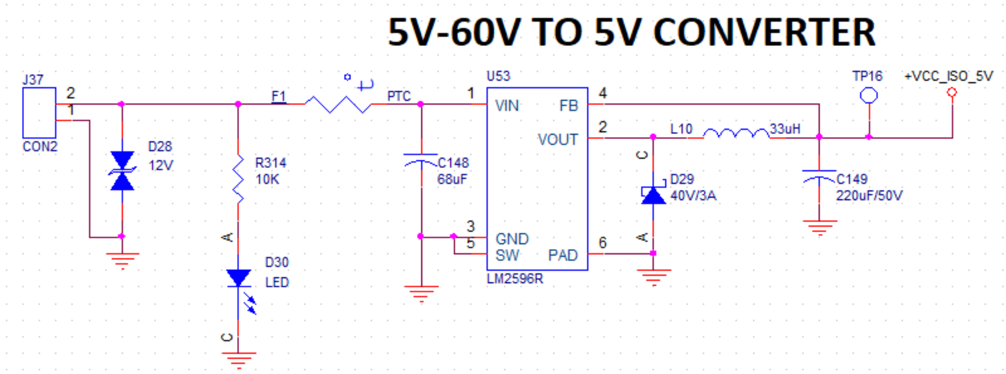

Figure 4.5. Schematic For Switching Regulator

Table 4.2 Function of the Component

Component	**Reference**	**Function**	**Typical Value / Range**
Inductor	L10	Stores energy and smooths current in buck converter	33µH(Range: 22 µH – 100 µH)
Input Capacitor	C148	Filters input voltage and suppresses noise and surges	68uF/50v
Output Capacitor	C149	Reduces output voltage ripple and stabilizes DC output	220 µF /50v
Schottky Diode	D29	A freewheeling path during switch-off cycle	40V / 3A (SS34)

Component	**Reference**	**Function**	**Typical Value / Range**
TVS Protection Diode	D28	Protects circuit from voltage spikes and transient surges	15V 600W BI-DIR (P6SMB15CA)
PTC Fuse	PTC	Limits input current to protect LM2596 from overcurrent	PTC 12V 500mA (WT-0805-050/12)
Feedback Resistors	Internal / External	Sets the output voltage via FB pin in adjustable mode	Depends on VOUT (e.g., 3.3kΩ/1.1kΩ)

In this system, the LM2596R step-down regulator is used exclusively for generating a stable 5V power rail from a higher input voltage ranging between 5V and 60V. However, this 5V output is not directly supplied to any sensitive components such as the STM32 microcontroller, RS-485 transceiver, or logic circuits. Instead, the LM2596R is connected to a secondary low dropout linear regulator, the SPX3819M5, which converts the 5V output to 3.3V. This design ensures that the STM32 and other peripherals operate safely within their required voltage levels. The use of the LM2596R as a pre-regulator improves overall power efficiency by handling high voltage input with minimal heat generation, while the SPX3819M5 provides a clean, low-noise 3.3V output ideal for digital logic. This two-stage regulation architecture allows the system to benefit from both switching efficiency and linear precision.

4.1.4 VOLTAGE REGULATOR (SPX3819M5 5V TO 3.3V):

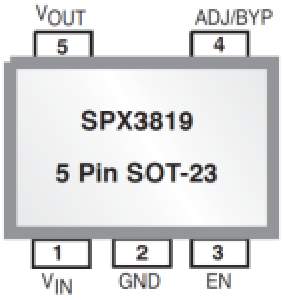

Figure 4.6. Voltage Regulator

The SPX3819M5 is a low-dropout (LDO) voltage regulator known for its high performance and low quiescent current. It delivers a fixed output voltage of 3.3V with a maximum output current of 500mA, making it ideal for

Table 4.3. Pin Description of SPX3819M5

Pin No.	Pin Name	Description
1	VIN	Input voltage pin. Connects to the 5V supply (e.g., output of LM2596).
2	GND	Ground pin. Common return path for input/output power and control signals.
3	EN	Enable pin. High to enable the regulator; low or floating disables output.
4	VOUT	Regulated output voltage (3.3V in this circuit). Powers logic-level components.
5	BYP	Bypass pin for noise filtering. Connect a capacitor to ground to reduce output noise.

powering low-power digital circuits. One of its key features is low dropout voltage, typically around 340mV at full load, ensuring stable regulation even when the input is just slightly higher than the output. The regulator includes an enable pin (EN) for shutdown control, reducing current consumption to less than 1µA in standby mode. Its low output noise can be further minimized by connecting a bypass capacitor to the BYP pin.The device offers excellent line and load regulation, ensuring consistent voltage under varying conditions. It is internally protected with current limiting and thermal shutdown to prevent damage during faults. The SPX3819M5 operates over a wide input voltage range of 2.5V to 16V, making it flexible for various power designs.

It is available in compact SOT-23-5 packages, supporting space-efficient PCB layouts. These features make it highly suitable for use in microcontroller-based systems, like your RFID-controlled digital locker application.

4.1.4.1WORKING PRINCIPLE OF SCHEMATIC:

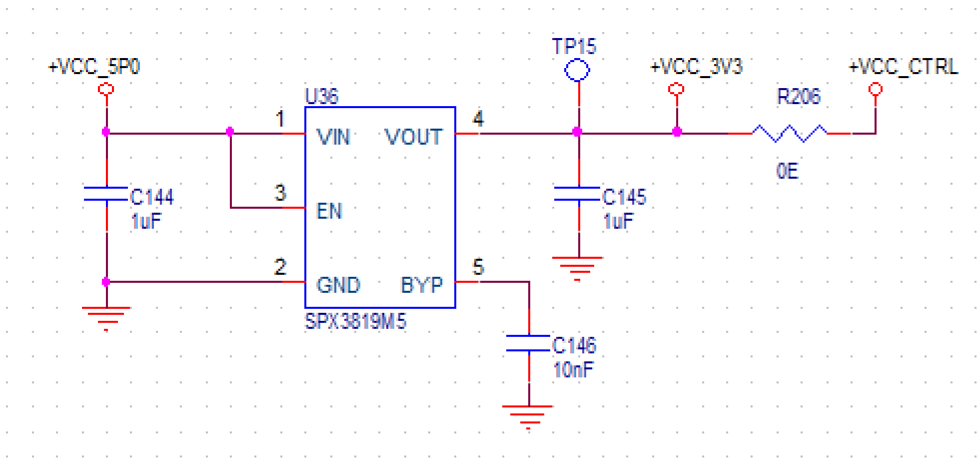

Figure 4.7. Schematic For Voltage Regulator

1. **Input Voltage Supply**

- +VCC_5P0 is the regulated 5V output from the LM2596 buck converter.
- C144 (1μF) is placed near the VIN (Pin 1) of the SPX3819M5 to filter high-frequency noise and ensure stable input.

2. **Enable and Ground Connections**

- EN (Pin 3) is tied directly to VIN, which keeps the regulator always enabled.
- GND (Pin 2) is connected to the system ground to complete the circuit.

3. **Output Voltage and Filtering**

- VOUT (Pin 4) provides the regulated +VCC_3V3 output.
- TP15 is a test point for monitoring the 3.3V output.
- C145 (1μF) is placed at the output to maintain voltage stability and reduce output noise.

4. **Bypass Capacitor for Noise Rejection**

- Pin 5 (BYP) is connected to C146 (10nF), which improves Power Supply Ripple Rejection (PSRR) and minimizes output noise.

5. **Current Path and Jumper Resistor**

- R206 (0Ω) acts as a jumper or a current-sensing resistor between the regulator output and the VCC_CTRL rail.
- This VCC_CTRL rail powers logic circuits and controllers.

6. Load Current and Efficiency

- The SPX3819M5 can deliver up to 500 mA of current.
- The estimated load current in this application is around 60 mA, including STM32, RS-485, opto- isolators, encoder, and timer IC, allowing efficient and safe operation.

7. Importance of Stable Power

- The LDO ensures a clean 3.3V supply, critical for stable digital logic, preventing glitches or unpredictable behaviour in sensitive components.

4.1.4.2 POWER CALCULATION:

INPUTVOLTAGE -5V

OUTPUT VOLTAGE -3.3V

LOAD CURRENT -66mA

POWER LOSS IN LDO= (5V-3.3V) x 66mA

= 0.1122w

4.1.5 NFC MODULE (PN532 V3):

NFC is a popular technology in recent years. Almost all the high-end phones in the market support NFC. Near field communication (NFC) is a set of standards for smartphones and similar devices to establish radio communication with each other by touching them together or bringing them into close proximity, usually no more than a few centimetres.

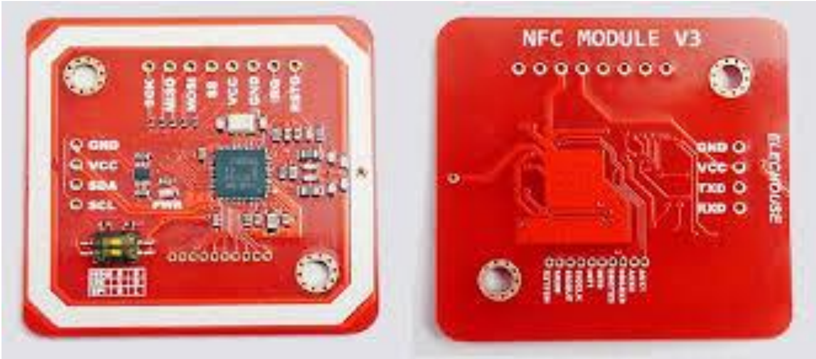

Figure 4.8. NFC Module

4.1.5.1 KEY FEATURES:

- Support I2C, SPI and HSU
- RFID reader/writer mode support
- Built in PCB Antenna, with 7cm communication distance
- On-board level shifter, Standard 5V TTL for I2C and UART, 3.3V TTL SPI
- Work as RFID reader/writer
- Work as 1443-A card or a virtual card

Table 4.4. Power Supply

Parameter	**Min.**	**Max.**	**Unit**
Voltages	3.3	5	V
Current consumption Idle (waiting command)	35	50	mA
Active (reading/writing NFC tag)	60	80	mA

4.1.6 RS485 COMMUNICATION (SN65HVD75DR):

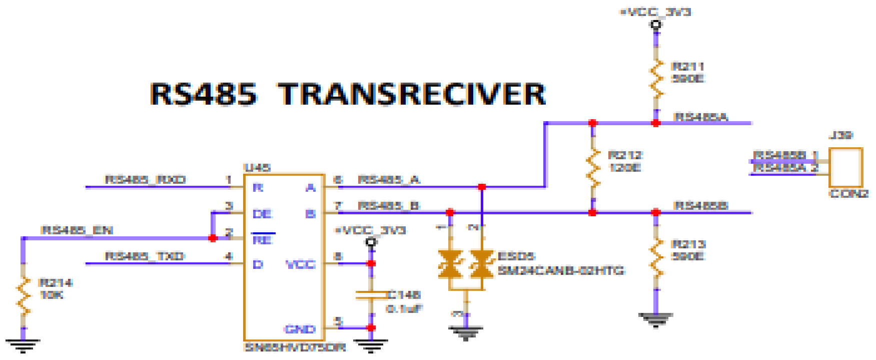

Figure 4.9. Schematic For RS485

The SN65HVD75DR is a high-speed, differential RS-485 transceiver designed by Texas Instruments. It is ideal for long-distance, noise-immune serial communication, making it perfect for industrial and embedded systems. In this project, it forms a reliable communication link between the STM32 microcontroller and networked digital lockers using RS-485 protocol.

1. Advantages of RS-485 in This Project

- Supports communication over long cables (up to 1200 meters)
- Excellent immunity to EMI (Electromagnetic Interference)
- Allows multi-drop configurations with multiple devices
- Half-duplex operation using only two wires (A and B)

2. Electrical Characteristics

Table 4.5. Electrical Characteristics

Feature	**Value**
Operating Voltage	3V – 5.5V
Data Rate	Up to 250 kbps
Bus Type	Half-duplex (2-wire)

3. Circuit Description

The RS-485 transceiver connects the UART lines of the STM32 to the differential RS-485 A and B bus lines. It includes:

- D pin (TXD): Transmit input from STM32
- R pin (RXD): Received output to STM32
- RS485_EN: Controls the direction of data flow by driving:
- DE (Driver Enable)
- RE (Receiver Enable)

4.Control Signal Functionality

RS485_EN Logic:

Table 4.6. RS485_EN Logic

RS485_EN	**Mode**	**De (Driver Enable)**	**RE(Receiver Enable)**	**Function**
HIGH	Transmit	ENABLED (1)	DISABLED (0)	Send data to bus
LOW	Receive	DISABLED (0)	ENABLED (0)	Receive from bus

When RS485_EN is HIGH, the device transmits data from STM32 to the RS-485 bus. When LOW, it listens to incoming signals from the bus and relays them to STM32.

5. Supporting Components

- **0.1μF capacitor**: Bypass between VCC and GND to filter high-frequency noise
- **R211, R212 (Pull-up/Pull-down Resistors)**: Maintain line stability when idle
- **R213 (120Ω Termination Resistor)**: Matches cable impedance to reduce reflection
- **ESD5S Diode**: Prevents damage from electrostatic discharge

4.1.6.1 POWER REQUIREMENT:

BIASING RESISTOR:

R1=590E, R2=590E

IR1=3.3V/590E=5.59Ma

I bias total=IR1+IR2

=11.18mA

LINE CURRENT:

Terminator resistor =120E

Differential voltage =1.5V

I LINE=V/R=1.5V/120E=12.5mA

TOTAL TRANSFER CURRENT:

I TOTAL=1mA+12.5mA+11.18mA

=24.68Ma

POWER RATE CALCULATION:

P=3.3V ×24.68mA

= 0.0814W

4.1.6.2 MODBUS PROTOCOL:

Modbus is a serial communication protocol developed by Modicon (now Schneider Electric) in 1979 for use with its programmable logic controllers (PLCs). It is a master-slave (or client-server) protocol that allows multiple devices to communicate over the same network, commonly used in industrial and embedded systems.

Start Frame	Slave Add	Fun_Type	REG_ADDR		Qantity		Checksum		END_FRAME	
3A	1	4	1	0	1	0	F9	0	0D	0A

Fun_Type	
4	Read
6	Write

Start Frame	Slave Add	Fun_Type	REG_ADDR		Data		Checksum		END_FRAME	
3A	1	6	1	0	1	0	F7	0	0D	0A
3A	1	6	1	0	2	0	F6	0	0D	0A
3A	1	6	1	0	3	0	F5	0	0D	0A
3A	1	6	1	0	7	0	F1	0	0D	0A

Figure 4.10. Modbus RTU communication frame

Table 4.7. Modbus RTU "Read Input Registers".

Field	Description
3A	Start Frame (indicates beginning of the frame)
1	Slave Address (slave device ID = 1)
4	Function Code (04 – Read Input Registers)
1 0	Register Address (starting register = 0x0100)
1 0	Quantity of Registers to Read (1 register)
F9	Checksum (for error checking)
0D 0A	End of Frame (carriage return and line feed)

This table represents Modbus RTU "Write Single Register" commands with different data values

Table 4.8. Modbus RTU "Write Single Register

Field	**Description**
3A	Start Frame
1	Slave Address
6	Function Code (06 – Write Single Register)
1 0	Register Address (0x0100)
1/2/3/7	Data to be written to the register
F7/F6/F5/F1	Checksum values for each respective command
0D 0A	End of Frame

Table 4.9. Locker Access Logic Table

Event	**Action**	**Result**
RFID tag scanned	PN532 reads tag ID	Sends ID to master controller
Tag ID processed	Master determines device & locker ID	Sends command via RS-485
RS-485 message received	Slave compares device ID	If match, continue
Locker ID checked	If locker ID matches assigned range	Activate lock (via MOSFET)

Lock energized	Locker opens	Timer starts / wait for open confirmation
Optocoupler feedback	Detects lock status	LOCK_STAT_RET_G is read by STM32
Feedback = Open	STM32 logs success / notifies master	Lock deactivated
Feedback = Closed	STM32 may retry / notify error	Lock remains closed

4.1.7 WATCHDOG TIMER IC:

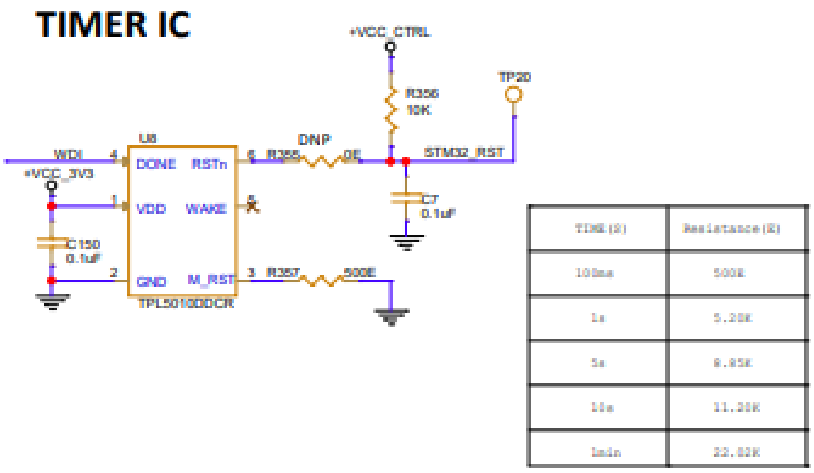

Figure 4.11. Schematic For Watchdog Timer ic

The TPL5010DDCR is an ultra-low-power programmable watchdog timer from Texas Instruments, designed to monitor system health and reset microcontrollers in case of software failure. In this project, it is used to enhance the reliability of the STM32-based smart locker controller by preventing it from hanging or freezing during operation.

Table4.10 Logic for Timer ic

WDI Pin	DONE Pin Toggled?	Timer Status	WAKE Output	Effect on STM32
HIGH	YES (Within timeout)	Timer resets	NO PULSE (HIGH)	STM32 continues running
HIGH	NO (Timeout elapsed)	Timer triggers reset	LOW PULSE	STM32 reset via RST line
LOW	N/A	Watchdog disabled	NO PULSE (inactive)	No watchdog action

The circuit shown uses the TPL5010DDCR, a low-power watchdog timer IC from Texas Instruments, designed to provide periodic wake-up or reset signals to the microcontroller (STM32). It ensures that the system can automatically recover if it hangs due to a software malfunction.The IC is powered by a 3.3V supply (+VCC_3V3) and uses a 0.1µF capacitor for power stabilization.

In this setup, the WDI (Watchdog Input) pin is tied high, meaning the system is always considered alive unless a timeout happens.The DONE pin is connected to the microcontroller; the microcontroller must pull this pin high within a preset timeout to inform the timer that it is functioning correctly. If not, the timer triggers a pulse on the WAKE pin, which is connected to the STM32_RST line, forcing a system reset.The time interval after which a reset will be triggered is set by the resistor R306 connected to the RT pin. The relation between resistance and timeout is given by the formula:

$$\text{Time (seconds)} = \text{Resistance (K}\Omega\text{)} \times 2$$

For example, using a 5.28kΩ resistor results in a 1-second timeout, while a 22.02kΩ resistor results in a 1-minute timeout. A table is provided alongside the circuit showing different resistor values and corresponding timeouts.After power-up, the TPL5010 starts an internal countdown based on the RT resistor value.

During this countdown, if the microcontroller successfully toggles the DONE pin (pulling it HIGH and then LOW), the timer resets its countdown and starts over. If the DONE pin is not toggled before the countdown finishes, the IC asserts a LOW pulse on the WAKE pin, resetting the microcontroller.

This ensures that if the firmware gets stuck or stops operating properly, the hardware watchdog brings the system back to a working state without manual intervention.In my smart locker project, this watchdog timer is critical because it guarantees that the STM32 controller stays responsive at all times. If any unforeseen issue like software crash, infinite loop, or communication failure occurs, the timer will automatically reset the controller, thus restoring locker control and system stability.

The use of the TPL5010 enhances the reliability, safety, and maintenance-free operation of the overall system, especially for 24x7 unattended environments where manual resets are not feasible.

4.1.8 ENCODER 8:3(SN74HC148DR):

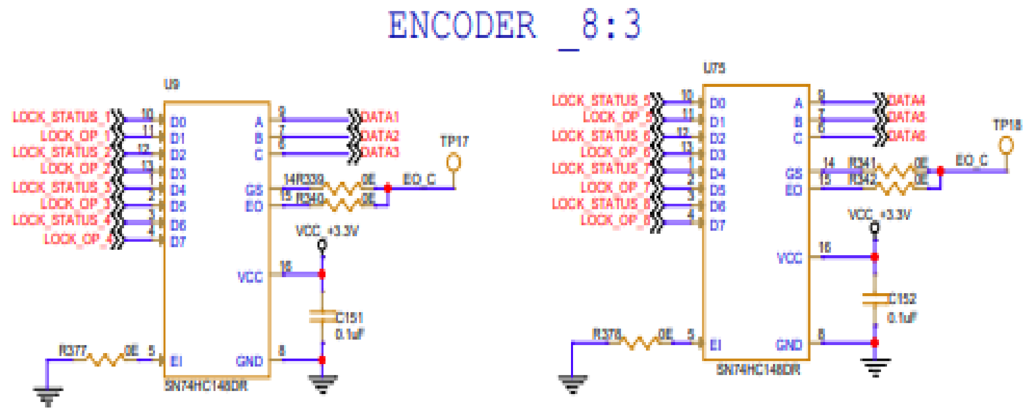

Figure 4.12. Schematic For Encoder 8:3

Table4.11. Pin Description of Encoder 8:3

Pin No.	Pin Name	Type	Description
1	A2	Output	MSB of binary-coded output
2	A1	Output	Middle bit of binary-coded output
3	A0	Output	LSB of binary-coded output
4	EI	Input (Active LOW)	Enable Input – must be LOW for Device to function
5	I7	Input (Active LOW)	Highest-priority input (most significant)
6	I6	Input (Active LOW)	
7	I5	Input (Active LOW)	
8	GND	Power	Ground

9	I4	Input (Active LOW)	
10	I3	Input (Active LOW)	
11	I2	Input (Active LOW)	
12	I1	Input (Active LOW)	
13	I0	Input (Active LOW)	Lowest-priority input (least significant)
14	GS	Output	Group Select (Active LOW when Any input is LOW and EI is LOW)
15	EO	Output (Active LOW)	Enable Output – goes LOW when any input is LOW and EI is LOW
16	VCC	Power	Supply voltage (typically 2V – 6V)

1. Introduction to Priority Encoding

The circuit uses two 8-to-3 line priority encoders, implemented using the SN74HC148DR ICs (U9 and U75). These components are responsible for compressing 8 active-low input signals into a 3-bit binary output based on signal priority. In this design, the input signals represent the lock status (LOCK_STATUS) and locker occupancy (LOCK_OP) of 8 individual electronic lockers.

2. Working Principle

Each encoder accepts eight active-low inputs (D0 to D7). When one or more inputs go LOW, the encoder outputs a corresponding 3-bit binary code (A, B, C) that identifies the highest-priority active input. The priority is fixed, with D0 having the highest priority and D7 the lowest. This enables the system to detect and respond to the most important event among multiple simultaneous signals.

3.Input and Output Signals

- Inputs: D0–D7, connected to lock and occupancy status lines.
- Outputs: A, B, C — representing a binary code corresponding to the triggered locker.

4. Signal Conditioning and Stability

- Pull-up resistors (R377, R378) are used on input lines to hold them HIGH when inactive.
- Decoupling capacitors (C151, C152), each 0.1μF, are placed near the VCC pins of the ICs to filter out noise and stabilize power delivery.

5. Enable and Control Pins

- The Enable Input (EI) pin is tied LOW to enable the encoder operation.
- GS (Group Select) and EO (Enable Output) pins provide cascading and system-wide control when combining multiple encoders (as done in your project with two encoders).

6. Encoder Logic and Priority

The encoder outputs the binary code corresponding to the highest-priority LOW input:

- If multiple inputs go LOW at the same time, only the highest-priority one is encoded.
- This logic allows the system to respond deterministically even in the presence of simultaneous locker events.

7. GPIO Optimization

This encoding mechanism significantly reduces the number of required GPIO pins on the STM32 microcontroller:

- Instead of needing 8 I/O pins for 8 locker lines, only 3 output lines plus control signals are required.
- Using two encoders, the system handles 16 input lines (8 LOCK_STATUS and 8 LOCK_OP) using only a few microcontroller pins.

8. Application in Smart Locker System

In the smart locker controller:

- The encoders provide real-time monitoring of locker events.
- The system becomes more scalable, as additional encoders can be added for more lockers without overloading the microcontroller.
- The design improves space efficiency, response speed, and pin count optimization, all critical for compact and reliable embedded system design.

4.1.9 LOCK & OCCUPANCY SENSOR STATUS & LOCK CONTROL SECTION:

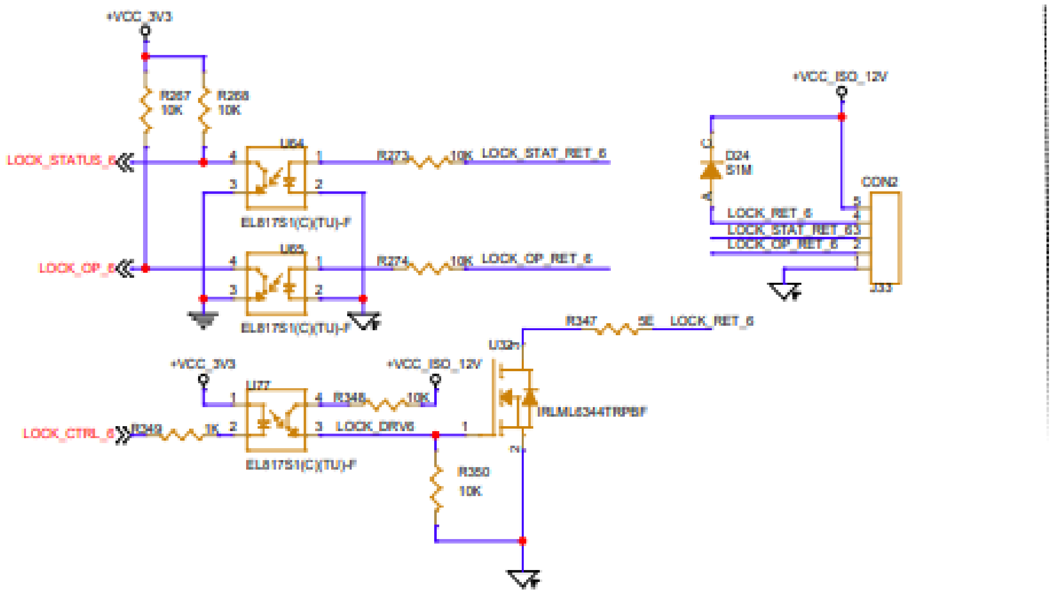

Figure 4.13. Schematic For Lock Stat &Lock Cntrl

4.1.9.1 EL817S Optocoupler:

Figure 4.14. Optocoupler

This table represents a pin description of the optocoupler

Table 4.12. Pin Description Of Optocoupler

Pin	Name	Function
1	Anode	LED input (positive side)
2	Cathode	LED input (negative side)
3	Emitter	Phototransistor emitter (output side)
4	Collector	Phototransistor collector (output side)

4.1.9.2 KEY FEATURES:

- **Manufacturer**: EVERLIGHT (or equivalent brands)
- **Type**: Phototransistor optocoupler
- **Package**: Available in 4-pin DIP or SMD form
- **Isolation Voltage**: 5000 Vrms between input and output
- **Current Transfer Ratio (CTR)**: Ranges from 50% to 600% depending on model
- **Input Forward Voltage (Vf)**: Typically, 1.2V (LED side)
- **Input Forward Current (If)**: Operates typically between 5 mA to 20 mA
- **Output Collector-Emitter Voltage**: Maximum 80V
- **Output Collector Current (Ic)**: Maximum 50 Ma

4.1.9.3 WORKING PRINCIPLE IN SCHEMATIC:

- Provides electrical isolation between the high voltage (12V) lock side and the 3.3V microcontroller side.
- It has an internal LED and phototransistor. When the LED turns ON (input side LOW), the phototransistor pulls the output LOW.

4.1.9.4 CURRENT CONSUMPTION:

Forward Current=2.2Ma

collector current=1.2Ma

CTR=(IC÷IF) ×100

=54%

4.1.9.5 IRLML6344TRPbF MOSFET:

The IRLML6344TRPbF is an N-channel logic-level MOSFET designed for low-voltage control and efficient switching of medium to high currents. It is used extensively in embedded circuits where a 3.3V or 5V microcontroller needs to control a higher voltage device (like 12V electronic locks) without using large relays or mechanical switches.In this circuit, the IRLML6344TRPbF acts as the main electronic switch to control the flow of 12V power to the electronic lock, based on a control signal (LOCK_CTRL_G) from the STM32 microcontroller

4.1.9.6 Key Features:

Very low R ds(on):

When ON, the resistance between drain and source is very low (~30 m Ω), allowing high current (up to ~5A) with very little heat generation.

Logic Level Drive:

Can fully turn ON even with a gate voltage (Vgs) as low as 2.5V to 3.3V, making it ideal for direct control from microcontrollers.

Small Package (SOT-23):

Compact size saves PCB space, perfect for dense layouts like your smart locker system.

Fast Switching:

It can switch ON and OFF very fast, reducing power losses and allowing efficient, quick response to control signals.

4.1.9.7LOCK STATUS CIRCUIT

The Lock Status circuit is designed to indicate whether the electronic lock is in a locked or unlocked state using an optocoupler-based isolation method. The LOCK_STATUS signal controls the LED inside the EL817S optocoupler. When this signal is HIGH, the LED turns ON, causing the optocoupler's phototransistor to conduct. This conduction pulls the LOCK_STAT_RET_G line LOW, indicating that the lock is currently engaged or locked. Conversely, when LOCK_STATUS is LOW, the LED is OFF, the phototransistor does not conduct, and a pull-up resistor (R228) pulls LOCK_STAT_RET_G HIGH, indicating the lock is open or inactive. This configuration allows the STM32 microcontroller to safely detect the lock state using LOCK_STAT_RET_G, which operates at 3.3V logic, while isolating it from the higher 12V side. The circuit ensures safe interfacing, reliable status monitoring, and noise immunity. It also helps prevent accidental damage to the microcontroller due to voltage mismatch.

Table 4.13. Logic Of Lock Status

Lock State	**LOCK_STAT_RET_G (Opto- Input)**	**LOCK_STATUS (To Controller)**
Closed (Locked)	HIGH	LOW
Open (Unlocked)	LOW	HIGH

4.1.9.8 OCCUPANCY STATUS FUNCTION

The Occupancy Status circuit detects if a locker is occupied. The LOCK_OP input drives an LED inside another EL817S optocoupler.

When the locker is occupied (sensor active), the LED turns ON, and the phototransistor pulls LOCK_OP_RET_G LOW. A pull-up resistor ensures that when the optocoupler is OFF, the output remains HIGH. This setup allows the STM32 to detect locker occupancy accurately.

Table 4.14. Logic Of Occupancy Status

LOCK_OP	LOCK_OP_RET_G	Locker Status
LOW	LOW	Occupied
HIGH	HIGH	Empty

The optocoupler ensures safe signal transfer and avoids MCU damage due to external surges or faults in sensor wiring.

4.1.9.9 LOCK CONTROL FUNCTION

Based on the provided schematic, the circuit is used to control an electronic lock using a 3.3V microcontroller signal through an opto-isolated MOSFET driver stage. The input signal LOCK_CTRL_3 comes from the STM32 and is active LOW. When LOCK_CTRL_3 is pulled LOW, current flows through R329 (10k) and the LED inside the EL817STU optocoupler (U72), turning it ON. This activates the phototransistor side of the opto-isolator, allowing current to flow from VCC_ISO_12V through R328 (10k) to the gate of the MOSFET (DMN31D5L-13).

This turns the MOSFET ON by pulling its gate HIGH, allowing current to flow through the load (likely a solenoid or actuator inside the lock) connected between LOCK_RET_3 and GND. A pull-down resistor R330 (10k) ensures the MOSFET gate discharges when the opto is OFF, turning the lock OFF. This configuration isolates the microcontroller from the 12V lock power domain and ensures safe control.

Table 4.15. Logic Of Lock Control

LOCK_CTRL	**Opto State**	**LOCK_DRV**	**MOSFET State**	**Lock State**
LOW	ON	HIGH	ON	OPEN (Active)
HIGH	OFF	LOW	OFF	CLOSED (Inactive)

4.1.10CURRENT SENSING FOR LOCK:

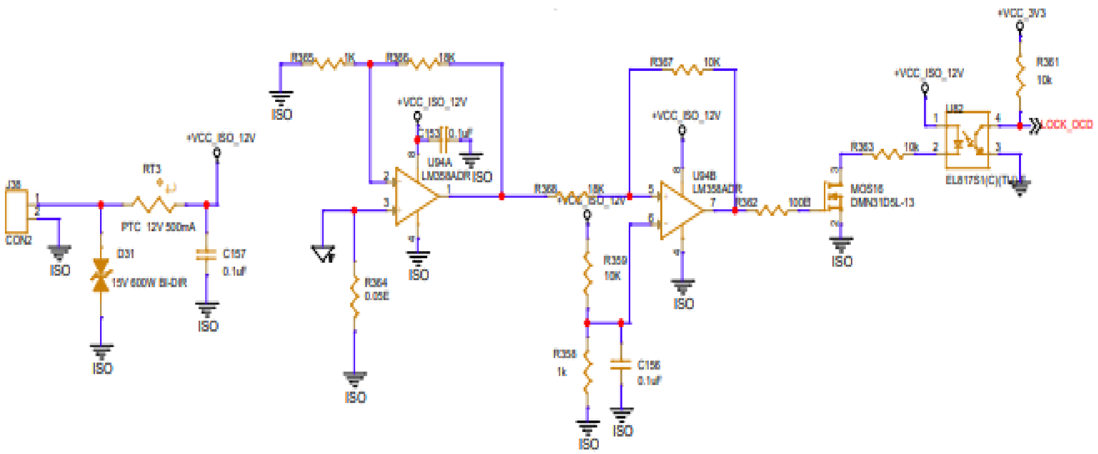

Figure 4.15. Schematic For Current Sensing

The above circuit is a 12V DC load protection, monitoring, and fault detection circuit designed mainly for locker electronic locks. It uses a combination of protection elements, current sensing, amplifiers, and optocouplers to detect overcurrent, short circuits, or system faults and safely isolate or alert the controller. The power enters through CON2 and first passes through a PTC (RT3), which is a resettable fuse rated for 500mA. This protects the system by increasing resistance during an overcurrent event. Additionally, a TVS diode (D31) clamps any transient voltages above 18V to ground, protecting the circuit from surges.

The current through the load is monitored by a low-side shunt resistor (R254, 0.05Ω). The small voltage drop across this resistor is proportional to the load current.The formula used here is V = I × Rshunt, where Rshunt = 0.05Ω. For example, if 1A flows through the lock, the voltage across Rshunt will be 50mV. This voltage is then fed into a high-gain differential amplifier U54A (LM324ADR), which amplifies the small voltage signal for better detection by the microcontroller or comparator circuits. A pull-up resistor and filtering capacitors (C157, C158) help clean the signal.

Following the first stage, the amplified signal is passed to another op-amp, U54B (LM324ADR), configured as a comparator. Here, a reference threshold voltage is set using a resistor divider (R255 and R256).

- When the load current exceeds the threshold, the comparator output changes state. The logic behind this is simple: if V_SENSE > V_THRESHOLD, fault condition is detected.
- In normal operation, the comparator output stays LOW; when a fault like overcurrent or short occurs, it goes HIGH.
- The output of this comparator is then fed into an optocoupler (U49, EL817S(C)) to isolate the fault signal from the main control board.
- The optocoupler output pulls the "LOCK_OCD" signal LOW in case of a detected fault, informing the microcontroller to stop further operations or

to alert maintenance. The MOSFET (M6, DMMT5401-13) acts as a switch for stronger drive if needed for signalling.

Ground (GND) is critical here:

- ISO_GND (ISO) is the isolated ground reference for all 12V circuits.
- The main microcontroller ground is separate and connected only through the optocoupler output, maintaining system protection.

Logic Summary:

- Normal current → Comparator output LOW → Lock operates normally.
- Overcurrent/short → Comparator output HIGH → Optocoupler signals fault → MCU takes protective action.

Table 4.16. Logic Of Current Details

(A)	**(V)**	**Comp Input > 1.1V**	**Comp Output**	**Opto Output**	**Fault Condition**
0.50	0.55	No	LOW	HIGH	No
0.80	0.80	No	LOW	HIGH	No
1.00	1.00	No	LOW	HIGH	No
1.18	1.10	Yes	HIGH	LOW	Yes
1.20	1.12	Yes	HIGH	LOW	Yes
1.50	1.35	Yes	HIGH	LOW	Yes
2.00	1.80	Yes	HIGH	LOW	Yes

This complete circuit ensures robust protection for your smart locker system, avoiding damage to locks or power supplies during fault conditions. It provides real-time feedback, fault isolation, and system safety, making the locker control highly reliable.

4.1.11 LOCK(PRO3524):

Figure 4.16. Lock

- PRO3524 typically refers to a professional 12V/24V electromagnetic lock.
- It is controlled electronically (by relay or transistor from a microcontroller like STM32).
- Designed to secure doors, lockers, or cabinets in places like offices, labs, smart buildings.
- Can handle high holding force (e.g., 300-600 lbs), suitable for secure access systems.
- It operates on external control signals (like LOCK_CTRL_1, LOCK_CTRL_2, etc. in your schematic).
- May include fail-safe or fail-secure modes

4.1.12 PCB LAYOUT:

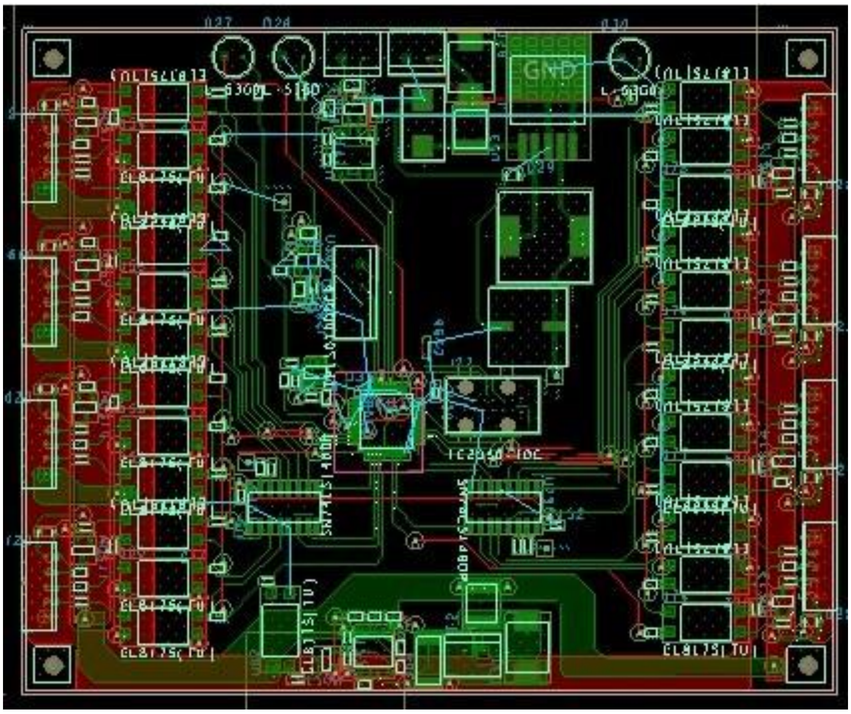

Figure 4.17. PCB Layout

The PCB layout for your RFID-controlled smart locker system is designed using a standard **2-layer board architecture**, where the **top layer (red)** primarily handles component placement and signal routing, while the **bottom layer (green)** serves as a ground plane and carries power return paths and additional signal traces. **Track widths are carefully differentiated** based on function: wider tracks are used for **high-current paths**, particularly those carrying 12V to the electronic locks via the MOSFET drivers, ensuring minimal voltage drop and thermal buildup, while **narrower tracks** are reserved for low-current digital signals between the STM32 microcontroller, optocouplers, encoders, and RS-485 transceiver.

The **power traces**, especially those routed to drive multiple 2A electronic locks, are strategically kept short and thick on the top layer to minimize resistance and improve reliability. Where necessary, **vias (blue circles)** connect high-current or ground lines between layers, ensuring sufficient current-carrying capacity and proper thermal distribution.

These vias are also used extensively to transition signal traces between the STM32 and peripheral components, especially in areas where pin breakout density is high.

A **solid ground plane is likely present on the bottom layer**,Each functional zone—power supply, logic control, communication, and output drivers—is kept logically and physically separate to **isolate noise-sensitive areas from power-intensive sections**. Routing appears optimized for clean signal flow, with minimal crossovers and short trace lengths, which supports high-speed signal stability and reduces parasitic capacitance. Overall, the PCB layout demonstrates a well-planned balance between **electrical performance, physical space optimization, and functional clarity**, suited for a high-reliability smart locker system.

4.1.13 PROJECT 3D MODULE:

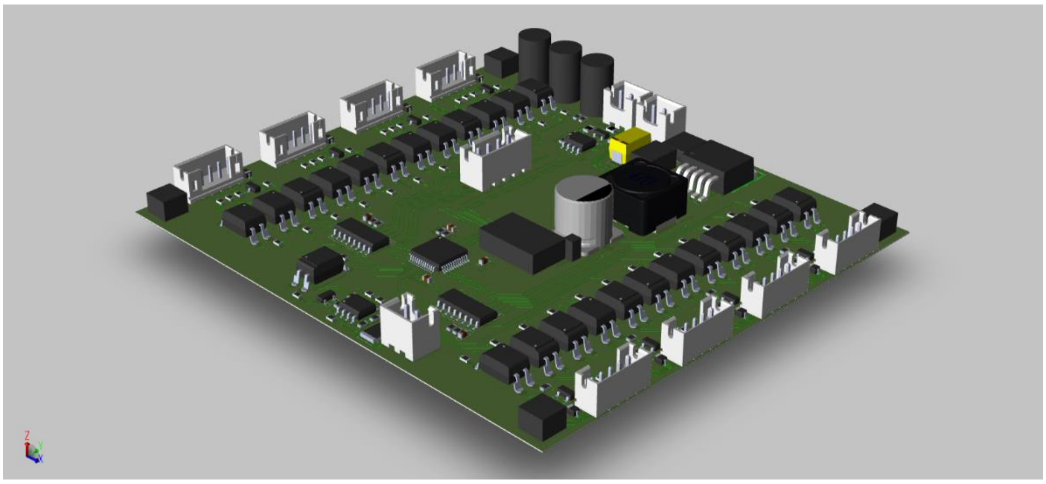

Figure 4.18. 3D Module

The image displays the 3D model of a custom-designed PCB developed for the RFID-controlled smart locker system. At the center of the board is the

STM32 microcontroller, which acts as the main processing unit for handling RFID inputs, lock control, and communication. Surrounding the MCU are several MOSFETs used to drive electronic locks, providing fast switching and reduced power consumption. Optocouplers are placed strategically to provide isolation between the control logic and power section, protecting the system from voltage spikes. Large electrolytic capacitors and voltage regulators ensure stable and clean power delivery to all components. The board includes multiple connectors to interface with RFID modules, IR sensors, and locking devices. SN74HC148 priority encoders are used to minimize GPIO usage while managing multiple inputs. RS-485 transceivers are integrated to enable long-distance, robust communication using the Modbus protocol. The PCB layout is compact and well-organized, promoting efficient signal routing and minimal electromagnetic interference..The image displays the 3D model of a custom-designed PCB developed for the RFID-controlled smart locker system. At the center of the board is the STM32 microcontroller, which acts as the main processing unit for handling RFID inputs, lock control, and communication. Surrounding the MCU are several MOSFETs used to drive electronic locks, providing fast switching and reduced power consumption. Optocouplers are placed strategically to provide isolation between the control logic and power section, protecting the system from voltage spikes. Large electrolytic capacitors and voltage regulators ensure stable and clean power delivery to all components.The board includes multiple connectors to interface with RFID modules, IR sensors, and locking devices. SN74HC148 priority encoders are used to minimize GPIO usage while managing multiple inputs. RS-485 transceivers are integrated to enable long-distance, robust communication using the Modbus protocol. The PCB layout is compact and well-organized, promoting efficient signal routing and minimal electromagnetic interference. This design is ideal for scalable deployment in smart locker applications across office and industrial environments.

CHAPTER 5

RESULT &B DISCUSSION

5.1 SIMULATION OUTPUT:

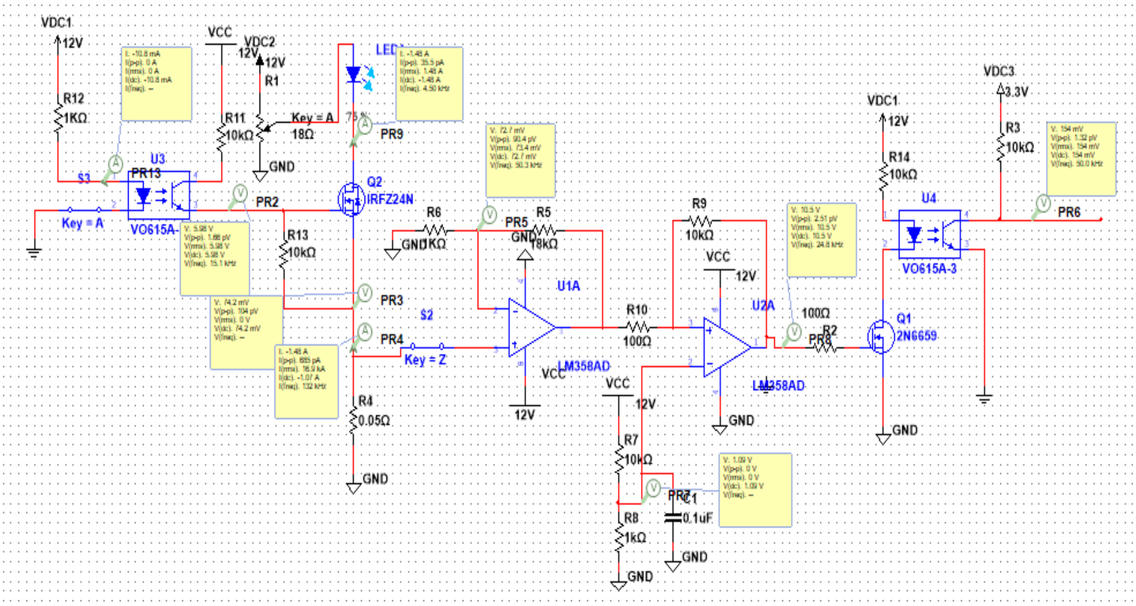

Figure 5.1 Circuit of the Simulation

This circuit controls a dual-stage electronic lock system with safety verification. Pressing Key A triggers optocoupler U3, activating MOSFET Q2 to power the first lock (LED1). A shunt resistor senses current, which is amplified and compared to a threshold by U1A and U2A. If the current confirms activation, optocoupler U4 and transistor Q1 power the second lock. Test points (PR3–PR9) assist in monitoring each stage's performance.

5.2 OUTPUT:

The image above illustrates the hardware setup for our embedded system project, which incorporates an RFID-based access control system. The system includes an RFID module interfaced via UART communication to authenticate users. Upon successful RFID tag detection, the system controls a solenoid-based electronic locker mechanism, A 4-channel relay module is also integrated to manage the switching of high-power devices, A USB-to-serial converter connects the system to a laptop for programming and monitoring. This prototype demonstrates an effective and scalable solution for secure access control using RFID technology.

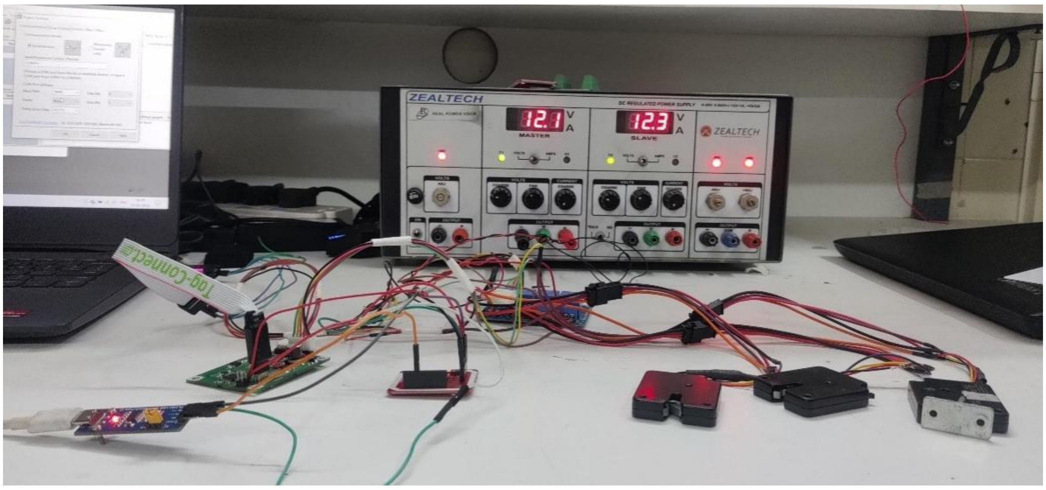

Figure 5.2(a). output

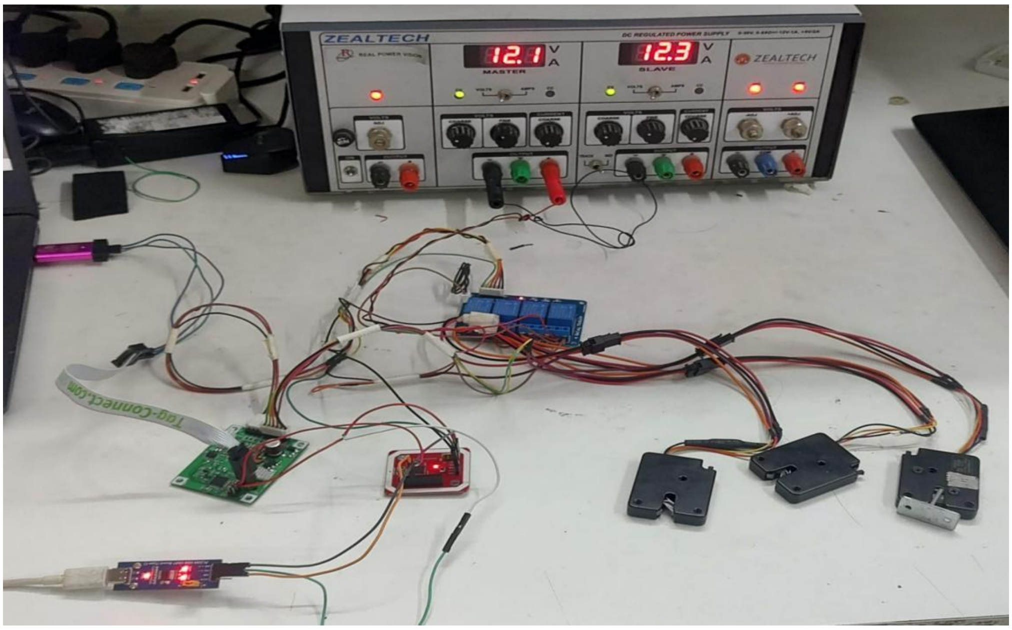

Figure 5.2.(b) Output

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

CONCLUSION:

The project has successfully reached a significant milestone with the completion of the PCB layout and finalization of the Bill of Materials (BOM). All core logical designs and functionalities, including lock control operations, feedback monitoring, power management, and RS485 communication, have been thoroughly implemented and verified at the schematic level. The design is now fully prepared for the manufacturing phase, with clear, tested logic and a well-organized component list. This sets a solid foundation for the next steps, including PCB fabrication, assembly, and full system testing, ensuring a high level of reliability and scalability for future enhancements.

FUTURE SCOPE:

1. Integration of Biometric Authentication

Future versions of the system can include fingerprint or facial recognition in addition to RFID cards, offering multi-factor authentication for enhanced security and user verification.

2. Cloud Connectivity and Remote Access

By enabling cloud integration, the system can allow remote monitoring, real-time notifications, and centralized data management through web or mobile applications.

3. Enterprise System Integration

The locker system can be linked with employee databases, attendance systems, or corporate access control software, streamlining operations and automating access rights.

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ATTENDANCE CERTIFICATE FOR INDUSTRIAL TRAINING /INTERNSHIP

The Student Mr. **MUTHUKUMAR R** (Reg.No.) **910021106302,** studying **Bachelor OF Engineering** programme at **Anna University Regional Campus Madurai** College in semester **8th** at Department of **Electronics and Communication Engineering** has attended Internship from **28-01-2025** to **15-05-2025**. It is certified that he has completed the Internship in our **Veeron Energy India Private Limited** organization.

Signature

BHANU PRASAD
(HR Admin)

For VEERON ENERGY INDIA PRIVATE LIMITED
Authorised Signatory

VEERON ENERGY INDIA PVT LTD.

Date: 15/05/2025

TO WHOME IT MAY CONCERN

This is to certify that **Mr. MUTHUKUMAR R** (Reg.No.) 910021106302 has done his internship in Veeron Energy India Private Limited, Bengaluru from 28-01-2025 to 15-05-2025.

He has worked on a project titled **"Secure Office Locker Access with RFID Controlled Smart Locker".** As part of the project, he was having hands on experience in design and development devices by understanding the design briefs and product specifications.

During the internship he demonstrated good skills with a self-motivated attitude to learn new things. His performance exceeded expectations and was able to complete the project successfully on time.

We wish him all the best for his future endeavors.

Warm regards,

J. Bhanu Prasad
15/05/2025

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