Hardware Specification #1

Define and document the hardware components required for the staff access monitoring system. This includes selecting the appropriate fingerprint sensor, ESP32 model, power supply, RTC module and any other necessary peripherals.

1. Micro-controller: ESP32 DevKit V1

Characteristics:

- Processor: Dual-core Tensilica LX6 microprocessor, up to 240 MHz
- Memory:
    - RAM: 520 KB SRAM
    - Flash: Varies (commonly 4MB)
- Connectivity:
    - Wi-Fi: 802.11 b/g/n (STA, AP and dual mode)
    - Bluetooth: Bluetooth v4.2 BR/EDR and BLE
- GPIO Pins:
    - Digital I/O: 34 GPIO pins (various multifunction)
    - Analog Inputs: 18 (ADC1: GPIO32-39, ADC2: GPIO0, 2, 4, 12-15, 25-27, 34-39)
- Communication Interfaces:
    - UART: 3 (UART0, UART1, UART2)
    - SPI: 4
    - I2C: 2 (HSI and HSI2)
    - PWM: Multiple channels
- Power Supply:
    - Input Voltage: 5V via USB or VIN pin
    - Operating Voltage: 3.3V (logic level)

Functionality in Project:

- Acts as the central controller managing data acquisition from the fingerprint sensor, LCD display, RTC module, and communication with the remote server via Wi-Fi.
- Handles user authentication and data storage operations.

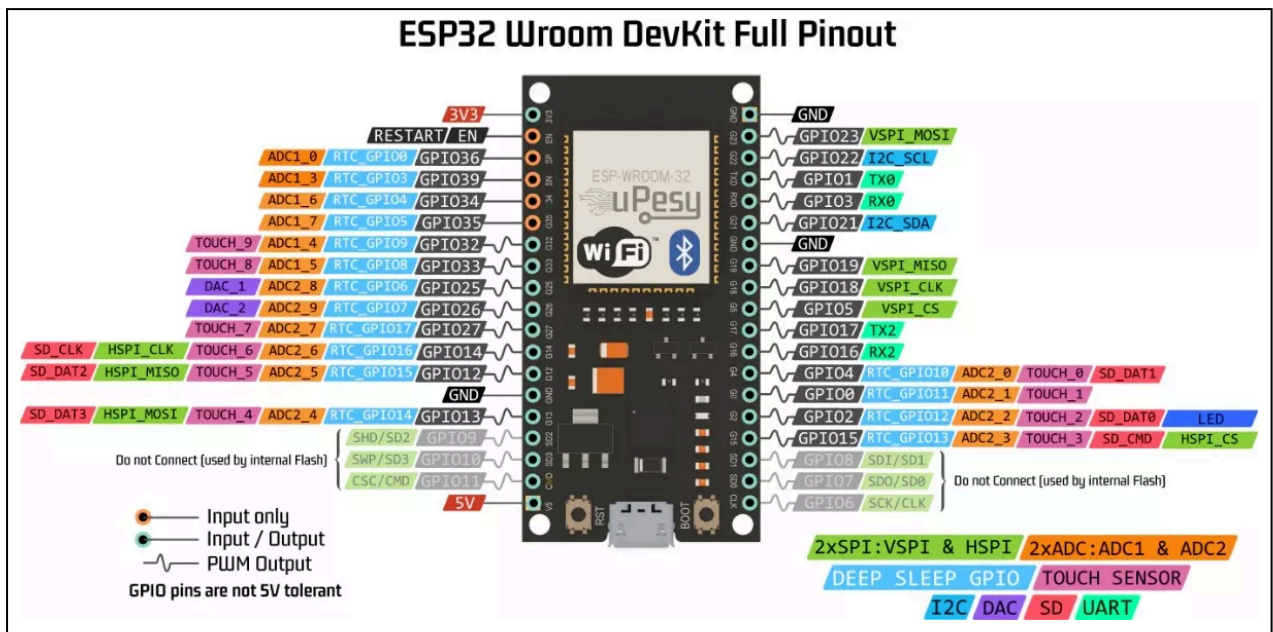*Figure 1: Functional Block Diagram ESP32*

Figure 2: Pinout connections ESP32

2. Fingerprint Sensor: R305

Key Specifications:

- Interface: UART (Serial Communication)
- Operating Voltage: 3.3V to 6V (compatible with ESP32's 3.3V logic)
- Resolution: 500 DPI (dots per inch)
- Precision :
    - FAR (False Acceptance Rate): < 0.001%.
    - FRR (False Rejection Rate): < 0.1%.
- Fingerprint Capacity: Up to 1000 fingerprints
- Capture Time: ~0.3 seconds
- Storage: Onboard memory for fingerprint templates
- LED Indicators: Status LEDs for operations (enrollment, verification)

Functionality in Project:

- Captures and reads users' fingerprint data for authentication.
- Sends fingerprint data to the ESP32 for processing and verification against stored templates.
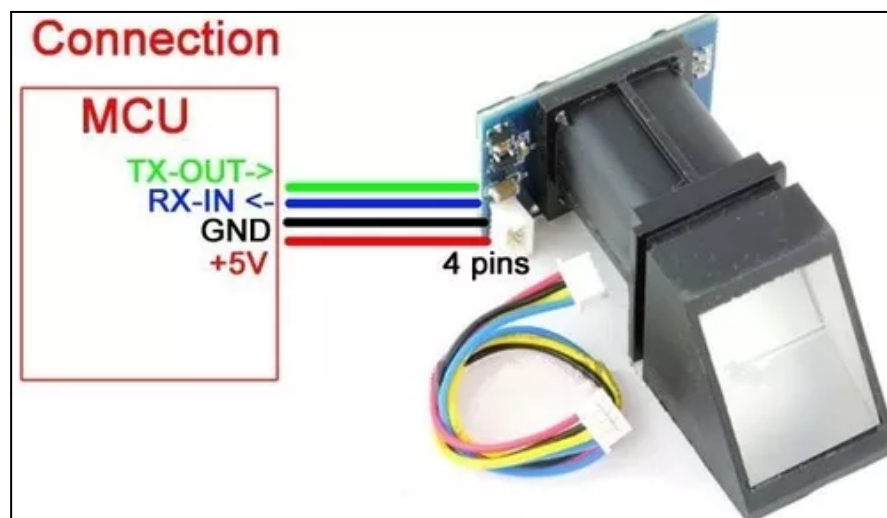

Figure 3: Pinout R305 module

3. Display LCD: 16x2 I2C

<u>Characteristics:</u>

- Type: Character LCD, 16 columns x 2 rows
- Interface: I2C via PCF8574 I/O expander
- Operating Voltage: 5V (logic levels are typically 5V compatible, but can work with 3.3V with proper configuration)
- Backlight: LED backlight (typically controlled via I2C)
- Contrast Control: Potentiometer or via I2C commands
- PINS:
    - SDA Pin: Data line
    - SCL Pin: Clock line
- Address: Common default is 0x27 or 0x3F

<u>Functionality in Project:</u>

- Displays system status, prompts, and other information.
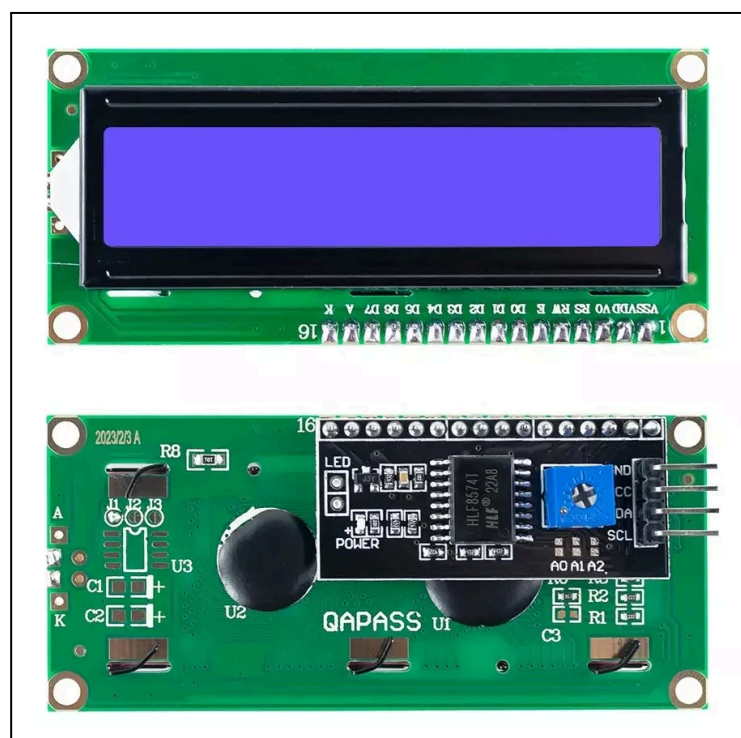- Provides real-time feedback to users during the authentication process.

Figure 4: LCD I²C module

4. RTC Module: DS3231

Characteristics:

- Interface: I2C
- Operating Voltage: 3.3V to 5V
- Accuracy: ±2 minutes per year
- Battery backup (for timekeeping when power is off)
- Timekeeping: Supports seconds, minutes, hours, day, date, month, and year.
- PINS:
  - SDA Pin: Data line
  - SCL Pin: Clock line
- Address: Typically 0x68

Functionality in Project:

- Keeps accurate real-time data for logging entry and exit times.
- Ensures time stamps are maintained even during power outages via the backup battery.
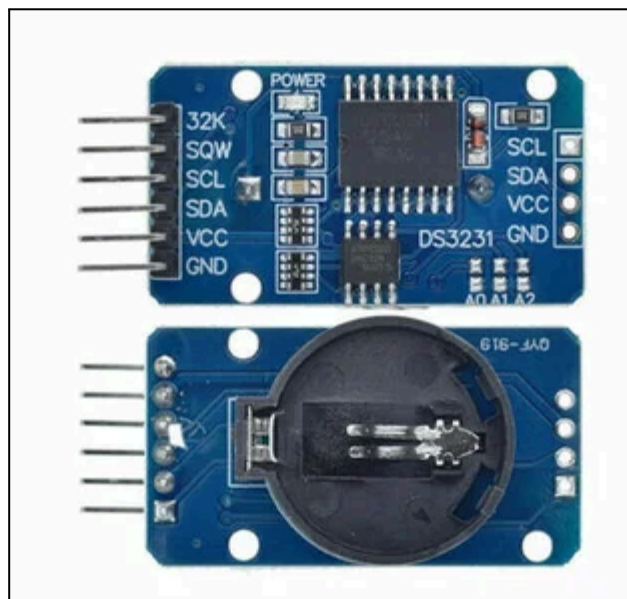

Figure 5: RTC DS3231 module

5. Power Supply: USB Current Adaptor

Characteristics:

- Output Voltage: 5V DC
- Current Rating: Minimum 2A
- Connector: USB Type-A or Micro/USB

Functionality in Project:

- Provides stable power to the ESP32 and connected peripherals.
- Ensures reliable operation of the system by maintaining adequate power supply.

Figure 6: Micro USB power supply

6. Ethernet interface: ENC28J60

Characteristics:

- Interface: SPI
- Communication Speed: 10 Mbps Ethernet
- Supported Protocols: TCP, IP, UDP, ICMP, ARP, HTTP
- Operating Voltage: 3.3V (often comes with a 5V compatible module)
- Power Consumption: Approximately 180 mA
- Ethernet Features: Full-Duplex or Half-Duplex operation
- Library Support: Compatible with libraries like UIPEthernet for Arduino/ESP32

Functionality in Project:

- Adds wired Ethernet communication to the microcontroller via SPI.
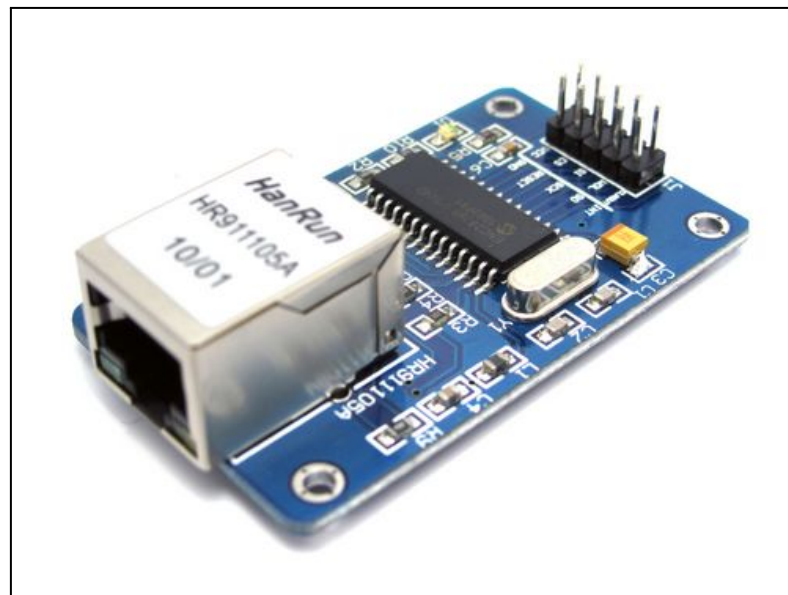- Enables sending and receiving TCP/IP, UDP, and HTTP packets over Ethernet.

Figure 7: Ethernet Module ENC28J60

7. Push buttons

<u>Characteristics:</u>

- Type: Momentary push buttons.
- Number: 2 buttons (one for entry, one for exit).
- Material: Plastic/metal.
- Debouncing: 10 ms - 50 ms to avoid multiple triggers when pressed
- Electrical Rating: 3.3V or 5V compatible

<u>Functionality in Project:</u>

- Entry Button:
    - When pressed, it informs the system that the next fingerprint is for an entry.
    - Once the button is pressed, the system activates the fingerprint sensor and waits for a fingerprint scan for a certain period of time.
    - Once the fingerprint is scanned and verified, the system records the event as an entry in the database.
    - The fingerprint sensor is deactivated after the scan, saving power.
- Exit Button:
    - This button lets the system know that the next fingerprint scan is for an exit.
    - After being pushed, the system turns on the fingerprint sensor, allowing the user to scan their fingerprint.
    - After verifying the fingerprint, the system logs the event as an exit in the database.
    - The sensor is powered down until the next button press.
- Advantages:
    - Users can clearly declare an entry or exit, avoiding any confusion and simplifying the software implementation.
    - The fingerprint sensor is only powered when necessary, conserving energy and prolonging the lifespan and durability of the sensor.

Figure 8: Push buttons

Hardware Schematics

The system will have the following connections as shown in the figure:

1. **ESP32:**
   - Power from USB.
2. **R305:**
   - VCC → ESP32 3.3V or 5V.
   - GND → ESP32 GND.
   - TX → ESP32 RX (pin 27).
   - RX → ESP32 TX (pin 28).
3. **LCD 16x2:**
   - VCC → ESP32 5V.
   - GND → ESP32 GND.
   - SDA → ESP32 GPIO21.
   - SCL → ESP32 GPIO22.
4. **RTC DS3231:**
   - VCC → ESP32 3.3V or 5V.
   - GND → ESP32 GND.
   - SDA → ESP32 GPIO21.
   - SCL → ESP32 GPIO22.
5. **ENC28J60:**
   - VCC → ESP32 3.3V or 5V .
   - GND → ESP32 GND.
   - SO → ESP32 VSPI_MISO.
   - SI → ESP32 VSPI_MOSI (pin 37).
   - SCK → ESP32 VSPI_SCK (pin 30)
   - CS → ESP32 VSPI_SS (pin 29)
6. **Push buttons:**
   - Entry button
     - Output → ESP32 GPIO27 (pin 11).
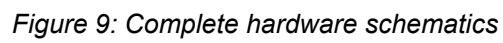   - GND → ESP32 GND.
   - Exit button
     - Output → ESP32 GPIO26 (pin 10).
     - GND → ESP32 GND.

Figure 9: Complete hardware schematics