Chapter 3

Methodology of Proposed Electronic Voting System

3.1 Introduction

In this chapter the design methodology that we have chosen in our implementation of "Biometric Voter Authentication, Vote Casting and Counting & Ensuring Vote Verifiability" in Electronic Voting System will be explained. Before discussing the methodology different biometric authentication techniques will be discussed in brief. The source codes are given in appendix.

3.2 Biometric Authentication

The term authentication refers to an electronic process that allows for the electronic identification of a natural or legal person. Additionally, authentication may also confirm the origin and integrity of data in electronic form. Such as the issuance of a voter authenticate to his information using fingerprint. The overall purpose of authentication is to reduce the potential for fraud, especially in the event of an individual purposely misrepresenting their identity or through the unauthorized use of another person's credentials.

First, some of the possible biometric properties need to be overlooked that can be used for the authentication of individual persons. In this paper, we will restrict ourselves to present just a subset of different biometric properties. We explicitly do not focus on their feasibility, but rather try to show the wide spectrum of "theoretically" possible human properties that can be used in biometric systems.

The terms authentication synonymously refer to the process where the confidence in user identities is established and presented electronically to an information system. Possible biometric identifications are as follows:

- **Fingerprint:** Fingerprint scanners are probably the most commonly used biometric system; as and replace the pin code entry to unlock the card, especially in the area of smartcard readers. Similar systems include hand geometry or palm prints [45].
- **Iris:** Another static property of individuals is eyes. One can either use pictures of the person's iris or use a retina scanner that scans blood vessels to create an individual data set.
- **Face:** The human face is also a feature that can be used by biometric systems. Human face recognition by analyzing the size and position of different facial features is being

pushed for use at several airports to increase security. Another possible approach is to make infrared recordings and analyses the resulting facial thermo gram [46].

- **Voice:** A more behavioral individual aspect of humans is their voices. Everybody has a special mode and tone while speaking. Voice recognition tries to analyses these features and uses them to identify a person [45].

- **Signature:** Another behavioral aspect of a person usable by biometrical analyses is the signature. Not only the form but also the dynamic aspects can be seen as a set of unique features of a person. Other possible movable biometric input could be the rhythm and pattern of a person's walk.

- **DNA analysis:** Now this is a rather more theoretical idea for biometric identification. Imagine a DNA reader that can create a full DNA analysis within seconds from just a few cells of a person's body. Such a device would surely be a match to, e.g. a finger print reader, when comparing the quality of the results the fingerprint authentication process presents a technical challenge due to the necessity of authenticating individual people or entities remotely. Its level of security depends on the applied type of authentication, the authentication factors used, as well as the process of authentication applied.

We have used biometric authentication in our proposed device. Biometric identification refers to metrics related to human characteristics. Identify individuals in groups that are under surveillance. Different fingerprint templates are as shown in Figure 3.1. These three 3 fingerprint templates are different that is why we have used biometric identification in our project.

Figure 3.1: Biometric identity template for different voters.

3.3 Design Proposal

Our proposed E-Voting system has been divided into several sectors. The sectors are as follows:

1. **Voter Access:** First a voter needs to show his/her smart card on smart card reader to get access in the voting room. Now, we have done it by RFID (Radio Frequency Identification) card and reader as a sample version. In future, we can do it by using smart card.

2. **Biometric Voter Authentication:** After getting access to give vote, a voter needs to put his/her finger on fingerprint module. If fingerprint is authenticated then a voter will be able to give his/her vote to their desirable candidate.

3. **Vote Casting & Counting:** After fingerprint authentication, a voter can cast his/her vote. After completion the entire voting process, counter unit counts the stored votes for different candidates and it is also responsible for publishing result.

4. **Vote Verifiability:** After completion the entire voting process, voters will be able to verify of their voting with the vote reference number. A random vote reference number will produce for every voter while casting their vote and it will store in the SD card according to the sequence of their vote casting along with their NID, phone number and the candidate name for which the voters will vote. The vote reference number will be sent to every voter with the help of a GSM Module after one/two days of election. Election Commission will publish a cart/table showing the candidate wise vote reference number on their website. By checking this, voters will be able to verify of their voting with the vote reference number.

5. **Display:** This sector shows the voter information, casting vote and results at the end of the vote casting period.

We also believe that, we will be able to ensure privacy of a voter to some extent by our proposed E-Voting system.

3.4 Block Diagram

Design is the creation of a plan for the construction of the project. Our project design plans are shown in Figure 3.2 & 3.3.

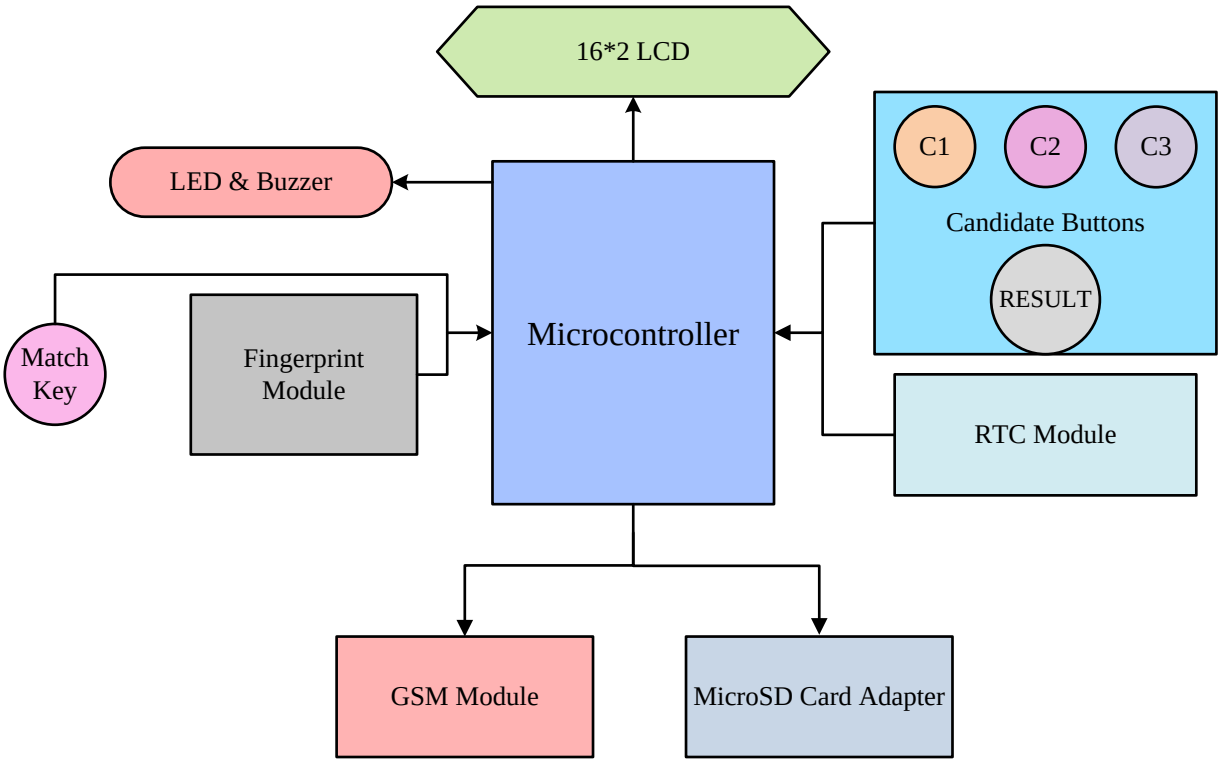

Figure 3.2: Block diagram of EVM for vote casting, counting & verifiability.

By pressing the match key button, a voter can place his/her finger on the fingerprint module. After fingerprint authentication, a voter can cast his vote to their desirable candidate. A voter can cast vote for once. Here are three buttons for three candidates. Result button for showing the final result and it only works with the fingerprint of a specific authority in the election center. LCD display will show all the information about voter authentication, casting vote and results. MicroSD Card Adapter along with a SD card will store voter NID number, phone number, a vote reference number and the candidate name according to the sequence of their vote casting. Actually, vote reference number is nothing but a random number which will produce by arduino programming. Here we use GSM module to send the vote reference number to every voter after one/two days of election. Election Commission will publish a cart/table showing the candidate wise vote reference number on their website. By checking this, voters will be able to verify of their voting with the vote reference number.

At the gate of pooling booth a voter need to place his/her smart card or RFID card where a microcontroller will identify the voter and enable the main EVM for vote casting.

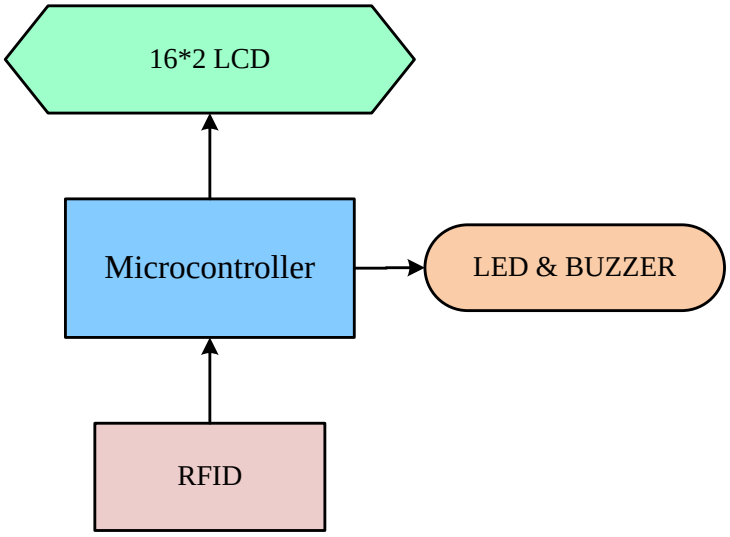

Figure 3.3: Block diagram for voter access.

3.5 Hardware Description

The hardware part of this project contains microcontrollers, fingerprint module, GSM module, RTC module, MicroSD card adapter, RFID reader and many other components which are described below in brief.

- Fingerprint Sensor [FPM10A]
- ATmega 328P/Arduino Uno
- ATmega 2560/Arduino Mega
- GSM Module [SIM800L]
- RFID (Radio Frequency Identification) Card & Reader
- RTC (Real Time Clock) Module [DS3231]
- MicroSD card Adapter
- 16*2 LCD
- LEDs & Buzzers
- Push Buttons

3.5.1 Fingerprint Sensor

A fingerprint sensor is an electronic device used to capture a digital image of the fingerprint pattern. The captured image is called a live scan. This live scan is digitally processed to create a biometric template (a collection of extracted features) which is stored and used for matching.

The fingerprint sensor [FPM10A] which has been used in this project is shown in Figure 3.4.

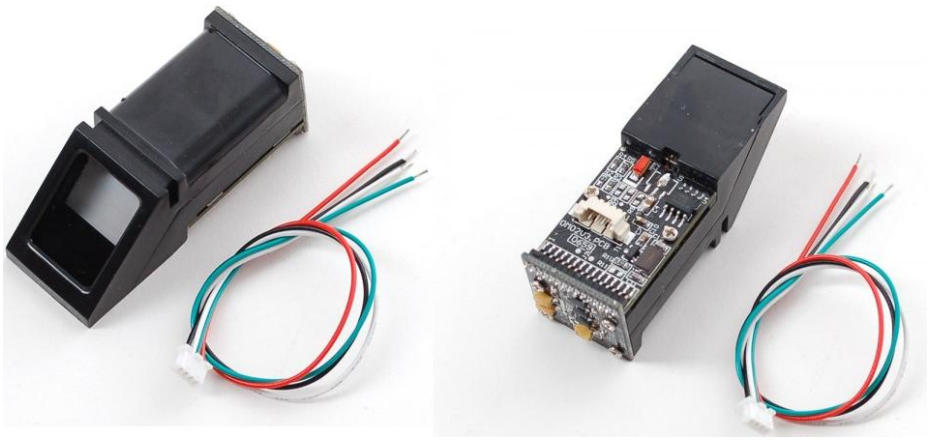

Figure 3.4: Fingerprint Sensor [47].

Fingerprint sensor module, made fingerprint recognition more accessible and easy to add to our project. This means that it is super easy to make fingerprint collection, registration, comparison and search. These modules come with FLASH memory to store the fingerprints and work with any microcontroller or system with TTL serial. Some specifications of fingerprint module are given below:

- Supply voltage: 3.6 - 6.0V DC
- Operating current: 120mA max
- Peak current: <140mA max
- Fingerprint imaging time: <1.0 seconds
- Window area: 14mm x 18mm
- Signature file: 256 bytes
- Template file: 512 bytes
- Storage capacity: 1000 templates
- Safety ratings (1-5 low to high safety)
- False Acceptance Rate: <0.001 % (Security level 3)
- False Reject Rate: <1.0% (Security level 3)
- Interface: TTL Serial
- Baud rate: 9600, 19200, 28800, 38400, 57600 (default is 57600)
- Working temperature rating: -20C to +50C
- Working humidity. 40% - 85 % RH
- Full Dimensions: 56 x 20 x 21.5mm
- Exposed Dimensions (when placed in box): 21mm x 21mm x 21mm triangular
- Weight: 20 grams

The sensor has six pins. The fingerprint sensor module used in this project came with really thin wires, so soldering breadboard-friendly wires was needed.

- VCC – Red wire
- TX – Green wire
- RX – Yellow wire
- GND – Black wire

The following table shows how to wire the sensor to the Arduino.

Fingerprint Sensor	Arduino Mega
VCC	5V (it also works with 3.3V)
TX (Green wire)	RX (digital pin 12, software serial)
RX (Yellow wire)	TX (digital pin 13, software serial)
GND	GND

The easiest way to control the fingerprint sensor module with the Arduino is by using the Adafruit library for this sensor.

3.5.2 Enroll a Fingerprint

Having the fingerprint sensor module wired to the Arduino, the next steps to enroll a new fingerprint. We have to make sure that we've installed the Adafruit Fingerprint Sensor library previously.

- We have to go to File > Examples > Adafruit Fingerprint Sensor Library > Enroll from Arduino IDE.
- We have to upload the code, and open the serial monitor at a baud rate of 9600.
- We should enter an ID for the fingerprint from 1 to 127 (shown in Figure 3.5).

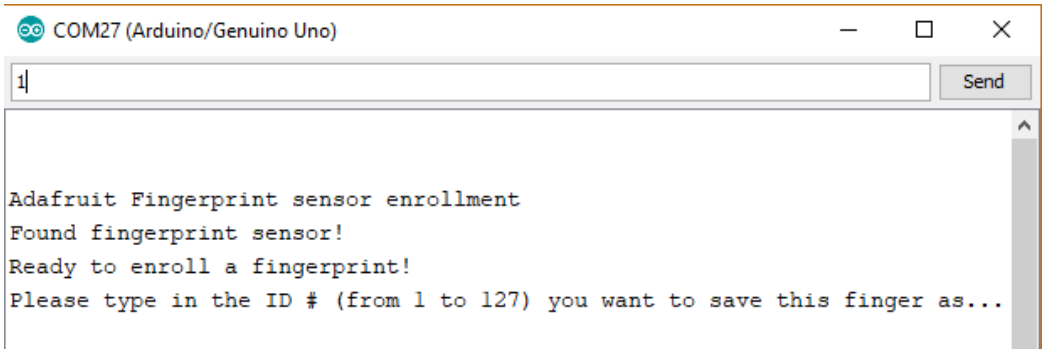

Figure 3.5: Arduino IDE Serial Monitor for enrolling fingerprint.

- After pressing the enter button, we need to wait for valid fingerprint (shown in Figure 3.6)

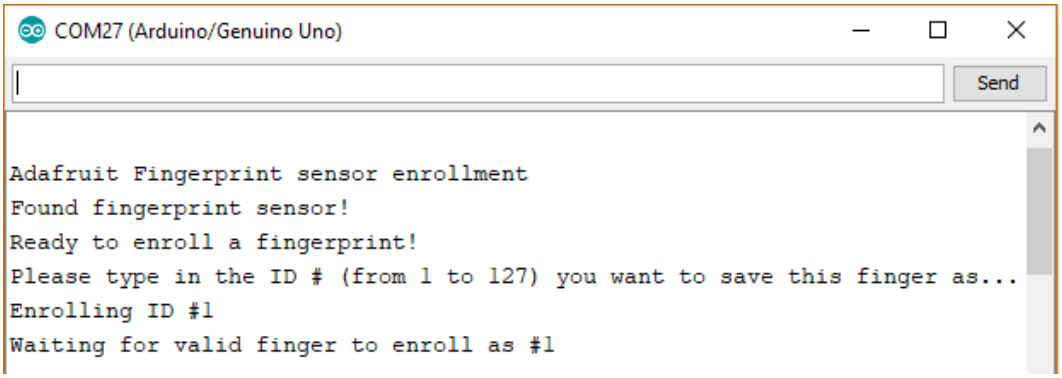

Figure 3.6: Waiting for valid fingerprint as ID #1.

- We have to place our finger on the scanner and follow the instructions on the serial monitor.
- At last we'll be asked to place the same finger twice on the scanner. If we get the "Prints matched!" message, as shown below, our fingerprint was successfully stored (shown in Figure 3.7). If not, we have to repeat the process, until we succeed.

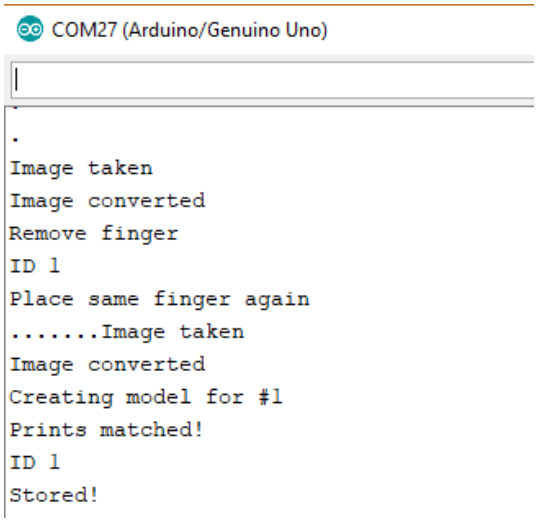

Figure 3.7: Fingerprint enrollment as ID #1 is stored.

3.5.3 Finding Match

We now should have several fingerprints saved on different IDs. To find a match with the Fingerprint sensor, we have to follow the next instructions.

- We have to go to,
  File > Examples > Adafruit Fingerprint Sensor Library > Fingerprint and upload the code to our Arduino board.
- We have to open the Serial Monitor at a baud rate of 9600.

- We have to place our enrolled finger to be identified on the scan.
- On the serial monitor, we can see the ID that matches the fingerprint (shown in Figure 3.8). It also shows the confidence – the higher the confidence, the similar the fingerprint is with the stored fingerprint.

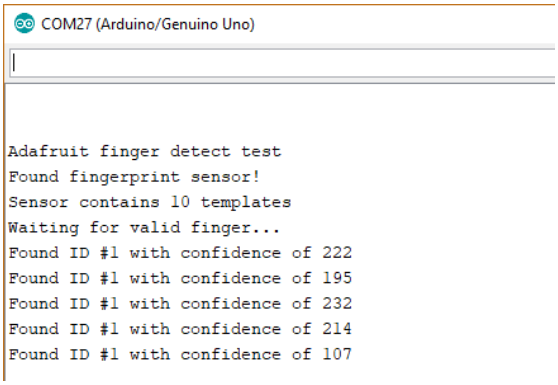

Figure 3.8: Fingerprint detect test for ID#1.

3.5.4 ATmega 328P/Arduino Uno

Arduino Uno (shown in Figure 3.9) is a microcontroller board based on 8-bit ATmega328P microcontroller. Along with ATmega328P, it consists other components such as crystal oscillator, serial communication, voltage regulator, etc. to support the microcontroller. Arduino Uno has 14 digital input/output pins (out of which 6 can be used as PWM outputs), 6 analog input pins, a USB connection, A Power barrel jack, an ICSP header and a reset button[48].

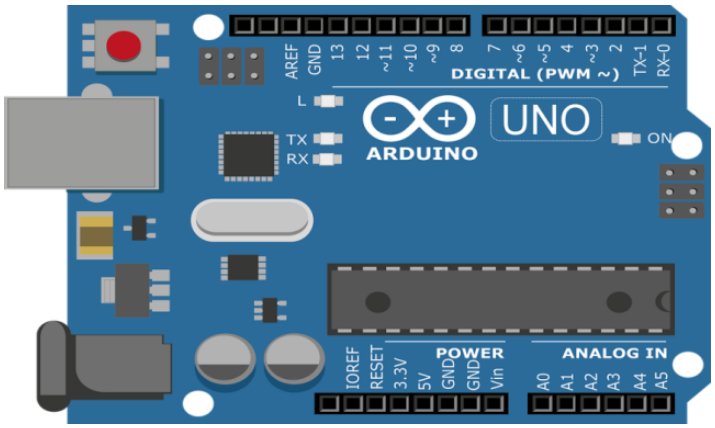

Figure 3.9: Arduino Uno Board [49].

3.5.5 ATmega 2560/Arduino Mega

The Arduino Mega 2560 (shown in Figure 3.10) is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal

oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

Figure 3.10: Arduino Mega Board [50].

3.5.6 GSM module (SIM 800L)

SIM800L (shown in Figure 3.11) is a minuscule GSM module that offers 2G GSM/GPRS data, and supports SIMCOM enhanced AT commands. Because it uses the serial communication method, it's easy to interface with the UART of almost all popular microcontrollers. SIM800L is support only 2G services. Check it by another 2G card if it’s not getting network so connect GSM antenna [53]. SIM800L has 88pin pads of LGA packing and provides all hardware interfaces between the module and customers boards.

- Support 5*5*2 keypads.
- One full modem serial port, user can configure two serial ports.
- One USB, the USB interfaces can debug, download software.
- Audio channel which includes two microphone input, a receiver output, and a speaker output.
- Programmable general purpose input and output.
- A SIM card interface.
- Support FM.
- Support one PWM.

SIM800L is designed with power saving technique so that the current consumption is as low as 0.7mA in sleep mode [54]. Specifications of SIM 800L modules are as follows:

- Supply voltage: 3.8V - 4.2V
- Recommended supply voltage: 4V
- Power consumption:
  - Sleep mode < 2.0mA
  - Idle mode < 7.0mA
  - GSM transmission (avg): 350 mA
  - GSM transmission (peek): 2000mA
- Module size: 25 x 23 mm
- Interface: UART (max. 2.8V) and AT commands
- SIM card socket: microSIM (bottom side)
- Supported frequencies: Quad Band (850 / 950 / 1800 /1900 MHz)
- Antenna connector: IPX
- Status signaling: LED
- Working temperature range: -40 do + 85 ° C [52].

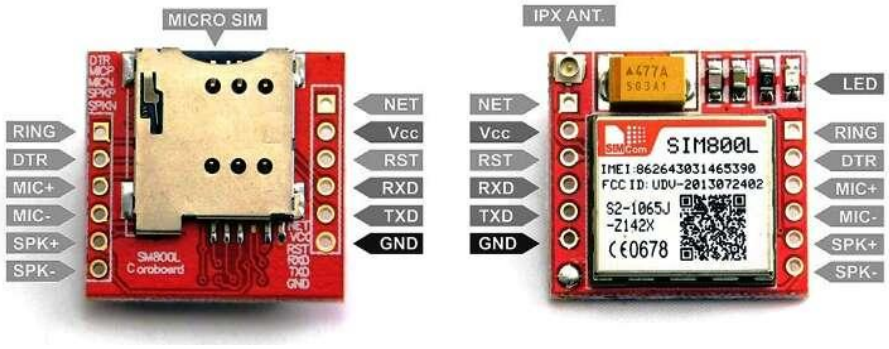

Figure 3.11: SIM800L GSM Module [55].

The SIM800L module has total 12 pins that interface it to the outside world. The connections are as follows:

- **NET** is a pin where you can solder Helical Antenna provided along with the module.
- **VCC** supplies power for the module. This can be anywhere from 3.4V to 4.4 volts. Remember connecting it to 5V pin will likely destroy your module! It doesn't even run on 3.3 V! An external power source like Li-Po battery or DC-DC buck converters rated 3.7V 2A would work.
- **RST (Reset)** is a hard reset pin. If you absolutely got the module in a bad space, pull this pin low for 100ms to perform a hard reset.
- **RXD (Receiver)** pin is used for serial communication.
- **TXD (Transmitter)** pin is used for serial communication.

- **GND** is the Ground Pin and needs to be connected to GND pin on the Arduino.
- **RING** pin acts as a Ring Indicator. It is basically the 'interrupt' out pin from the module. It is by default high and will pulse low for 120ms when a call is received. It can also be configured to pulse when an SMS is received.
- **DTR** pin activates/deactivates sleep mode. Pulling it HIGH will put module in sleep mode, disabling serial communication. Pulling it LOW will wake the module up.
- **MIC±** is a differential microphone input. The two microphone pins can be connected directly to these pins.
- **SPK±** is a differential speaker interface. The two pins of a speaker can be tied directly to these two pins [57].

3.5.7 Radio-Frequency Identification

Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically stored information. Passive tags collect energy from a nearby RFID reader's interrogating radio waves. Active tags have a local power source (such as a battery) and may operate hundreds of meters from the RFID reader. Unlike a barcode, the tags don't need to be within the line of sight of the reader, so it may be embedded in the tracked object. RFID is one method of automatic identification and data capture (AIDC) [56]. RFID technology may be used in a variety of applications including:

- Passports
- Smart cards
- Airplane luggage
- Toll booth passes
- Home appliances
- Merchandise tags
- Animal and pet tags
- Automobile key-and-lock
- Monitoring heart patients
- Pallet tracking for inventory
- Telephone and computer networks
- Operation of spacecraft and satellites

RFID technology uses digital data in an RFID tag, which is made up of integrated circuits containing a tiny antenna for transferring information to an RFID transceiver. The majority of RFID tags contain at least an integrated circuit for modulating and demodulating radio frequency and an antenna for transmitting and receiving signals. Frequency ranges vary from low frequencies of 125 to 134 kHz and 140 to 148.5 kHz, and high frequencies of 850 to 950 MHz and 2.4 to 2.5 GHz. Wavelengths in the 2.4 GHz range are limited because they can be absorbed by water.

While each system will vary in terms of device types and complexity, every RFID system contains at least the following four components:

- Readers
- Antennas
- Tags
- Cables

The simplest system can be comprised of a mobile handheld RFID reader (with an integrated antenna) and RFID tags, while more complex systems are designed using multi-port readers,

GPIO boxes, additional functionality devices (e.g. stack lights), multiple antennas and cables, RFID tags, and a complete software setup. Pinout of RC522 RFID Module is shown in Figure 3.12.

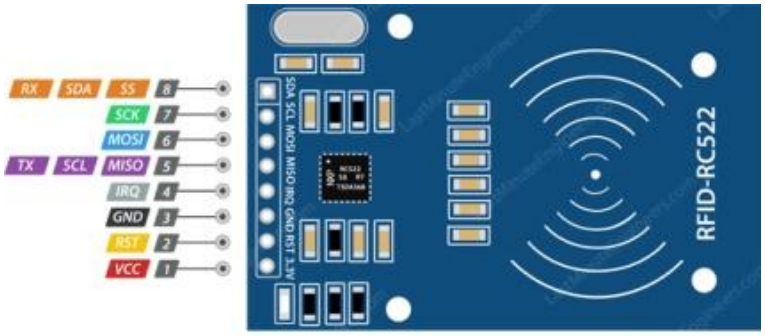

Figure 3.12: RC522 RFID Module Pinout [61].

The RC522 module has total 8 pins that interface it to the outside world. The connections are as follows:

- **VCC** supplies power for the module. This can be anywhere from 2.5 to 3.3 volts. You can connect it to 3.3V output from your Arduino. Remember connecting it to 5V pin will likely destroy your module!
- **RST** is an input for Reset and power-down. When this pin goes low, hard power-down is enabled. This turns off all internal current sinks including the oscillator and the input pins are disconnected from the outside world. On the rising edge, the module is reset.
- **GND** is the Ground Pin and needs to be connected to GND pin on the Arduino.
- **IRQ** is an interrupt pin that can alert the microcontroller when RFID tag comes into its vicinity.
- **MISO / SCL / TX** pin acts as Master-In-Slave-Out when SPI interface is enabled, acts as serial clock when I2C interface is enabled and acts as serial data output when UART interface is enabled.
- **MOSI (Master Out Slave In)** is SPI input to the RC522 module.
- **SCK (Serial Clock)** accepts clock pulses provided by the SPI bus Master i.e. Arduino.

- **SS / SDA / RX** pin acts as Signal input when SPI interface is enabled, acts as serial data when I2C interface is enabled and acts as serial data input when UART interface is enabled. This pin is usually marked by encasing the pin in a square so it can be used as a reference for identifying the other pins [57].

3.5.8 RTC module (DS3231)

The DS3231 is a low-cost, highly accurate Real Time Clock which can maintain hours, minutes and seconds, as well as, day, month and year information. Also, it has automatic compensation for leap-years and for months with fewer than 31 days. The module can work on either 3.3 or 5 V which makes it suitable for many development platforms or microcontrollers. The battery input is 3V and a typical CR2032 3V battery can power the module and maintain the information for more than a year. Main Features of DS3231 RTC Module are given below:

- RTC counts seconds, minutes, hours and year.
- Accuracy: +2ppm to -2ppm for 0ºC to +40ºC , +3.5ppm to -3.5ppm for -40ºC to +85ºC
- Digital temperature sensor with ±3ºC accuracy.
- Two Time-of-day alarms.
- Programmable square wave output.
- Register for Aging trim.
- 400 KHz I2C interface.
- Low power consumption.
- Automatic power failure battery switches circuitry.
- CR2032 battery backup with two to three year life.
- Potable size.

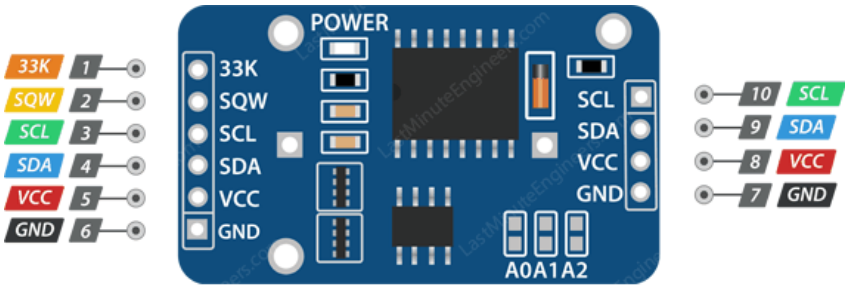

Figure 3.13: DS3231 RTC Module Pinout [61].

DS3231 RTC Module Pinout is shown in Figure 3.13. The DS3231 RTC module has total 6 pins that interface it to the outside world. The connections are as follows:

- **33K** pin outputs the stable (temperature compensated) and accurate reference clock.

- **SQW** pin outputs a nice square wave at 1 Hz, 4 kHz, 8 kHz or 32 kHz and can be handled programmatically. This can further be used as an interrupt due to alarm condition in many time-based applications.
- **SCL** is a serial clock pin for I2C interface.
- **SDA** is a serial data pin for I2C interface.
- **VCC** pin supplies power for the module. It can be anywhere between 3.3V to 5.5V.
- **GND** is a ground pin [58].

3.5.9 Micro SD Card Reader Module

The Micro SD card Module is an SPI Communication based device. It is compatible with the TF SD cards used in mobile phones and can be used to provide some sort of external storage for micro controller and microprocessor based projects, to store different kind of data types from images to videos. SD cards generally are 3.3v logic level based devices, but with the aid of the Micro SD card module, the signals are converted to 5v via a logic level converter implemented on the SD card Module [59]. Main Features of MicroSD Card Adapter are given below:

- Working voltage: VCC 4.5~5.5V
- Current: 0.2~200mA
- Interface electrical level: 3.3V / 5V
- Onboard 3.3V voltage regulator circuit
- Supports Micro SD up to 2GB
- Micro SDHC up to 32GB
- 4 M2 2.2mm screw installation holes[60]

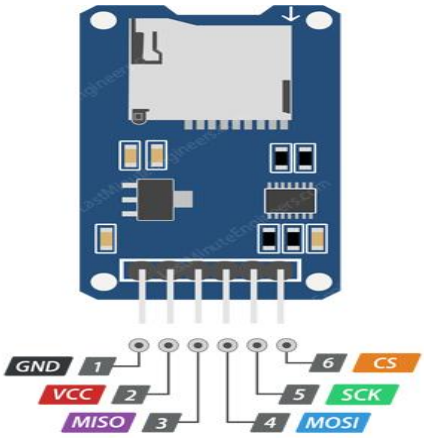

Figure 3.14: Micro SD Card Module Pinout [59].

Pinout of Micro SD Card Module is shown in Figure 3.14. The micro SD card module is fairly simple to connect. It has six pins:

- **VCC** pin supplies power for the module and should be connected to 5V pin on the Arduino.
- **GND** should be connected to the ground of Arduino.
- **MISO (Master In Slave Out)** is SPI output from the Micro SD Card Module.
- **MOSI (Master Out Slave In)** is SPI input to the Micro SD Card Module.
- **SCK (Serial Clock)** pin accepts clock pulses which synchronize data transmission generated by Arduino.
- **SS (Slave Select)** pin is used by Arduino (Master) to enable and disable specific devices on SPI bus.

3.6 Circuit Diagram

Overall Circuit diagram are shown in Figure 3.15 & 3.16. The corresponding design specification is achieved through the Fritzing tool. Figure 3.15 illustrates the circuit diagram for Voter Access which will be placed at the gate of pooling booth whereas Figure 3.16 illustrates the circuit diagram of our proposed EVM.

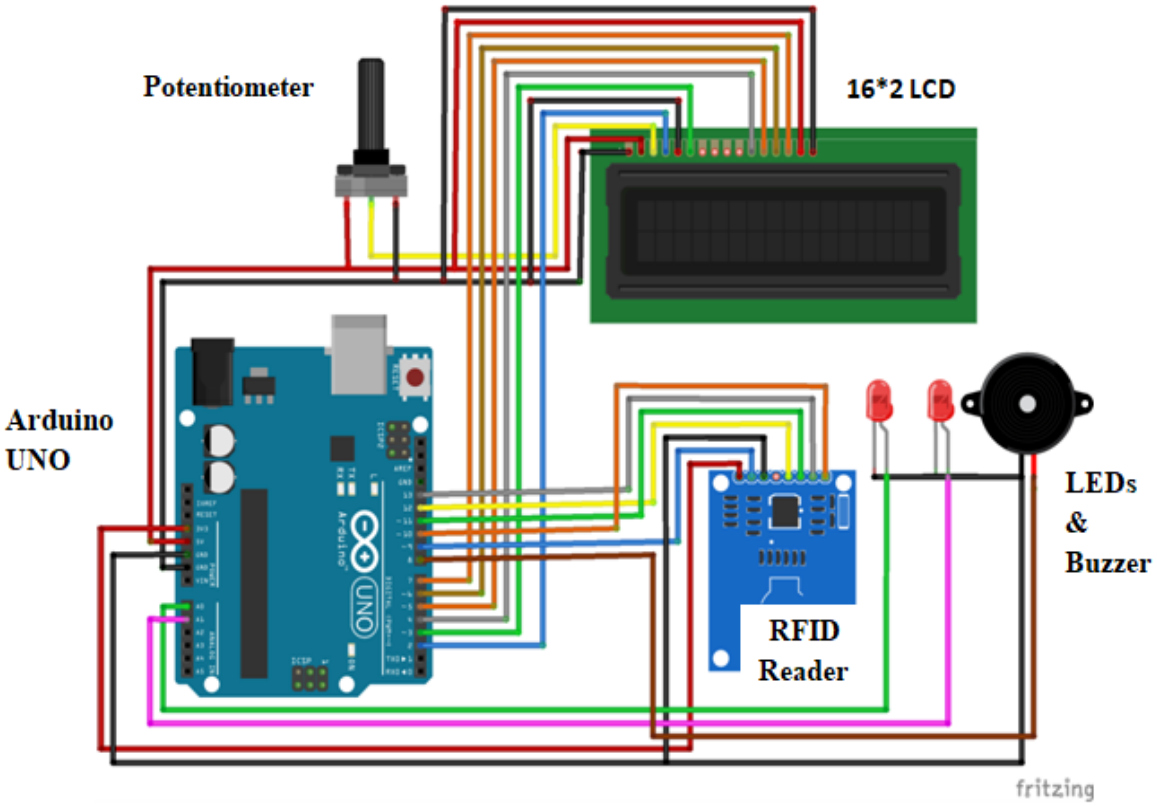

Figure 3.15: Circuit Diagram for Voter Access.

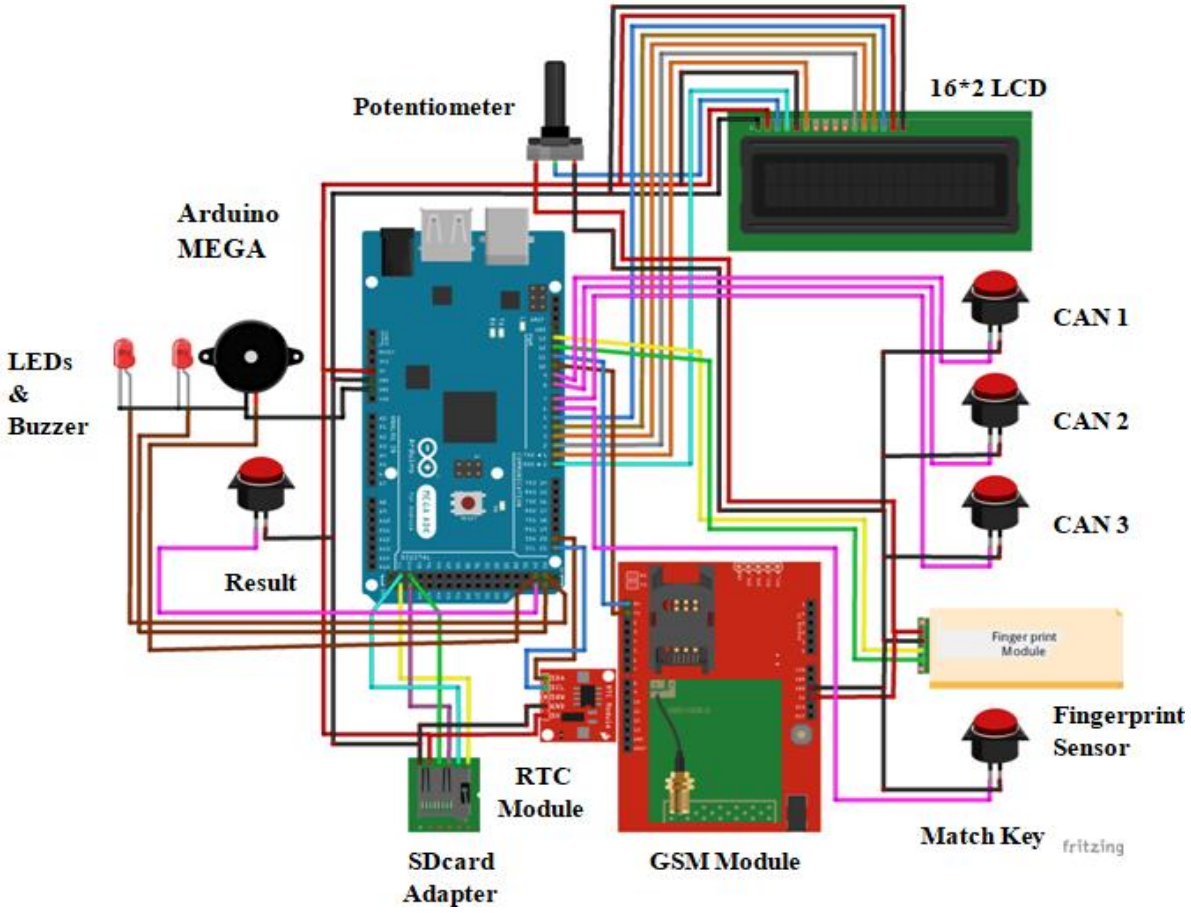

Figure 3.16: Circuit Diagram of our proposed EVM.

3.7 Demo Device

The demo device of "Biometric Voter Authentication, Vote Casting and Counting and Ensuring Vote Verifiability" in Electronic voting system is shown in Figure 3.17.

Figure 3.17: Demo version of our voting machine.

3.8 Advantages of Proposed EVM

Though there are several advantages of our e-voting machine yet following are the most important advantages:

- Checks whether the voter is valid or not.
- One cannot cast other's vote.
- A valid voter can cast vote for once.
- Not possible to cast vote after the specific time.
- Result is fair & accurate.
- No delay for result announcement.
- Result will publish after a specific time (No partial Result)
- Rejected vote will not be counted.
- Result cannot be manipulated by seizing the center/EVM machine.
- Same device can be used in many elections.
- Voters can verify their vote was counted for their desired candidate.
- This system ensures the receipt-freeness to some extent.