



Solar-Powered Fingerprint Authentication based Voting Machine with Integrated Printing and SMS Acknowledgment

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Abstract : The Solar-Powered Fingerprint Authentication based Voting Machine with Integrated Printing and SMS Acknowledgment is designed to ensure secure, transparent, and reliable electronic voting. The system is powered by a solar panel with battery backup and regulated through DC-DC converters, making it highly suitable for rural and remote areas with limited grid access. A fingerprint module verifies the voter's identity against stored templates, ensuring only authorized individuals can vote and preventing impersonation. Once verified, the voter confirms their choice using a push button, after which the thermal printer generates a printed slip with the selected party name. Simultaneously, a GSM module sends an SMS acknowledgment to the voter's registered mobile number for added transparency. The Arduino Uno acts as the main controller, storing and managing the vote counts in memory. At the end of the voting process, the total number of votes secured by each party is displayed clearly on the LCD screen. This design integrates solar power, biometric authentication, and SMS communication to provide a sustainable, secure, and trustworthy voting solution.

IndexTerms - Solar-Powered Voting System, Fingerprint Authentication, Arduino Uno, GSM Module, Thermal Printer, LCD Display, Biometric Security, Renewable Energy, SMS Acknowledgment.

I. INTRODUCTION

Elections are a fundamental part of a democratic system, but traditional voting methods still face several challenges such as power dependency, chances of impersonation, lack of transparency, and manual errors. In the late 1970s, Election Commission of India sought a solution for the issues which resulted in the development of electronic voting machines (EVM).^{[1][2]} However, even with EVMs, issues like power availability in remote areas, voter verification, and transparency in vote confirmation still exist. Therefore, there is a need for an advanced voting system that is secure, transparent, and independent of continuous power supply. The Solar-Powered Fingerprint Authentication based Voting Machine with Integrated Printing and SMS Acknowledgment is designed to address these challenges by combining renewable energy, biometric verification, and real-time confirmation features.

This system uses a solar panel with battery backup and a DC-DC converter for continuous operation. A fingerprint sensor verifies the voter's identity to ensure only authorized voting. After authentication, the voter selects a candidate using push buttons. The Arduino Uno controls the system by processing inputs and managing vote data.

To improve transparency and trust in the voting process, the system provides instant confirmation through multiple methods. A thermal printer generates a printed slip showing the selected party name, while a GSM module sends an SMS acknowledgment to the voter's registered mobile number. An LCD display is used to show instructions and voting status, and a buzzer provides alerts during different stages of operation. At the end of the voting process, the total votes received by each candidate are displayed clearly on the LCD screen.

The main objective of this project is to develop a secure, reliable, and eco-friendly voting system that minimizes fraud, ensures accurate vote counting, and enhances voter confidence. By integrating solar power, fingerprint authentication, printing, and SMS communication, the system provides a modern and efficient solution for conducting elections, especially in areas with limited infrastructure.

II. BLOCK DIAGRAM

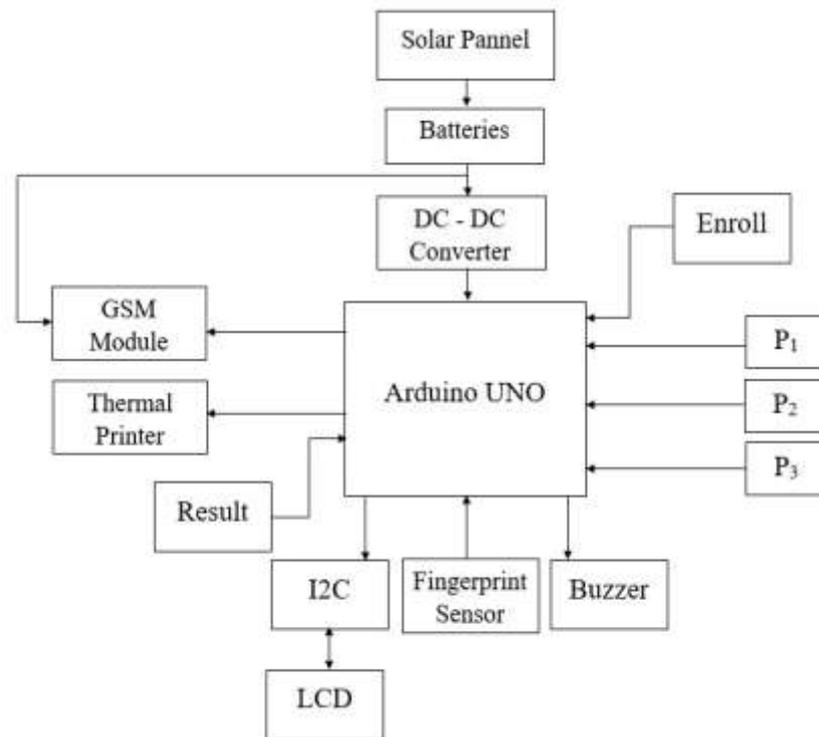


Fig. 1 : Block Diagram for Solar-Powered Fingerprint Authentication based Voting Machine with Integrated Printing and SMS Acknowledgment

The block diagram represents the working of a solar-powered fingerprint authentication-based voting machine. The solar panel provides power to the system, which is stored in batteries and regulated using a DC-DC converter to supply the Arduino UNO. The Arduino acts as the main controller, receiving inputs from the fingerprint sensor for voter verification and buttons (P1, P2, P3) for vote selection, along with an enroll option for registering voters. Once a fingerprint is verified, the user can cast a vote, and the result is processed by the Arduino. The LCD displays instructions and voting status through the I2C module, while the buzzer gives alerts during operations. After voting, the thermal printer prints a confirmation slip, and the GSM module sends an SMS acknowledgment, ensuring transparency and secure voting.

Description of Components

2.1 Solar Panel

A solar panel is a device that generates electricity from sunlight using multiple photovoltaic (PV) cells arranged in solar modules. PV cells are made of materials that release energized electrons when exposed to light. These electrons move through a circuit to generate direct current (DC) electricity, which can be used to operate devices or stored in batteries. Solar panels can be known as solar cell panels, or solar electric panels.^{[3][4]}

2.2 Lithium - Ion Battery

A lithium-ion (Li-ion) battery is a rechargeable battery that stores energy through the reversible movement of lithium ions (Li^+) between electrically conductive materials. Compared to other types of rechargeable batteries, they generally have higher specific energy, energy density, and energy efficiency and a longer cycle life and calendar life. They are also lightweight and compact, which makes them ideal for use in modern electronic devices and renewable energy systems.

2.3 DC – DC Converter

A DC-to-DC converter is a device that converts direct current (DC) power from one voltage level to another required level. It is a category of devices used to convert electrical power from one form to another. The power levels can vary from very low, such as in small batteries, to very high, as in high-voltage power transmission systems. They are widely used in electronic devices to provide stable and efficient voltage levels required for proper operation of components.

2.4 Arduino UNO

The Arduino Uno is an open-source microcontroller development board based on various microcontroller unit (MCU) architectures. It was initially developed and released by Arduino company in 2010.^{[6][7]} The microcontroller board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits.^[5] The word "uno" means "one" in Italian and was chosen to mark a major redesign of the Arduino hardware and software.^[8]

2.5 LCD Screen

An LCD (Liquid Crystal Display) screen is an output device used to display text and basic information in electronic systems. It works by controlling liquid crystals to show characters and numbers on the screen. In this project, the LCD is used to display messages such as instructions, voter verification status, and voting results. It helps users easily understand the system operation and improves overall user interaction.

2.6 I2C LCD Interface Module

The I2C LCD interface module is used to connect the LCD display with the Arduino using only two communication wires (SDA and SCL). It helps reduce the number of pins required compared to traditional LCD connections. This module simplifies wiring and makes the circuit more compact and organized. It also allows easy communication between the microcontroller and the LCD display. It improves overall system efficiency and is widely used in embedded systems for easy display interfacing.

2.7 Fingerprint Sensor Module

The fingerprint sensor module is a biometric device used to capture and identify an individual's fingerprint for authentication. It scans the unique ridge patterns of a finger and converts them into digital data for comparison with stored fingerprint records. It ensures that only authorized users can access or operate the system by verifying their identity accurately. This enhances security and prevents unauthorized or duplicate actions in the system.

2.8 GSM Module

A Global System for Mobile Communications (GSM), also known as a GSM modem or GSM module, is a device that allows electronic devices to communicate with each other. A GSM module is a communication device that allows electronic systems to send and receive data through the GSM mobile network. It enables wireless communication by using a SIM card and mobile signals to transmit messages or information. It uses an external antenna to transmit and receive mobile signals.

2.9 Thermal Printer

A thermal printer is a type of printer that produces printed output using heat on special thermal paper. It works by heating specific areas of the paper to create text or images without the need for ink or toner. It is widely used in applications like billing machines, ticket printing, and receipt generation due to its fast and quiet operation. In this system, it is used to print a confirmation slip after each vote, improving transparency and record keeping.

2.10 Buzzer

A buzzer or beeper is an audio signaling device,^[9] which may be mechanical, electromechanical, or piezoelectric (*piezo* for short). It is commonly used to provide sound alerts in electronic systems for notifications and warnings. In this project, the buzzer gives an indication during operations such as successful fingerprint verification or vote casting. It helps improve user interaction by providing immediate audio feedback for different system actions.

2.11 Push Buttons

A push button is a common electronic component that provides momentary contact closure when pressed. It is a simple input device used to send a signal to the controller when it is pressed. It works by completing an electrical circuit temporarily, allowing the system to detect user input. They are simple, reliable, and easy to interface with microcontrollers, making them widely used in various electronic applications. In this system, push buttons are used to allow the voter to select their preferred candidate during the voting process.

2.12 Perforated Board

A perforated board, also known as a perfboard, is a type of circuit board with a grid of small holes used for mounting and connecting electronic components. These holes are surrounded by round or square copper pads, although some boards are available without these pads. Low-cost perfboards typically have pads on only one side, while higher-quality ones feature pads on both sides with plated-through holes. It is commonly used for prototyping and assembling circuits without designing a printed circuit board (PCB).

2.13 Jump Wires

A jump wire (also known as jumper, jumper wire, DuPont wire) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.^[10]

III. CONTROLLER DESIGN & IMPLEMENTATION

The controller used in this Solar-Powered Fingerprint Authentication based Voting Machine is an Arduino Uno, which acts as the central processing and decision-making unit of the system. It continuously receives inputs from the fingerprint sensor, push buttons, and manages the overall voting process. The Arduino verifies the voter's identity using the fingerprint module and allows access only to authorized users. Based on the input received, it controls various components such as the LCD display for instructions, the buzzer for alerts, the thermal printer for printing vote confirmation, and the GSM module for sending SMS acknowledgment.

The Arduino controller is powered through a solar-based energy system, where the solar panel charges a battery, and the output is regulated using a DC-DC converter to provide a stable 5V supply. This ensures uninterrupted operation even in areas with limited or no electricity. The fingerprint sensor is interfaced with the Arduino using serial communication to capture and verify fingerprint data. The push buttons are connected to digital input pins for vote selection, while the LCD with I2C module uses two communication lines (SDA and SCL) to display system messages. The thermal printer and GSM module are also connected through serial communication for printing and message transmission.

The control algorithm is implemented using Arduino C/C++ programming, where logical conditions are defined for voter authentication, vote casting, and result management. When a voter places their finger on the sensor, the controller checks the fingerprint with stored data. If the fingerprint is valid, the system allows the voter to select their candidate using push buttons. Once the vote is cast, the controller records the vote, activates the thermal printer to print a confirmation slip, and sends an SMS acknowledgment through the GSM module. The LCD displays the voting status, and the buzzer provides audio feedback during operations. At the end of the voting process, the total votes for each candidate are displayed on the LCD. This structured control logic ensures a secure, transparent, and efficient voting system without manual intervention.

IV. RESULTS & DISCUSSION



Fig. 2 : Hardware Implementation of Solar-Powered Fingerprint Voting System

Figures 2, 3, and 4 show the implementation and results of the proposed voting system. Fig. 2 presents the complete hardware setup including the solar panel, Arduino Uno, and other connected components. Fig. 3 shows the SMS acknowledgment messages sent to voters after casting their vote, ensuring transparency and confirmation. Fig. 4 displays the LCD screen with the final vote count for each party, indicating accurate and reliable vote recording by the system.

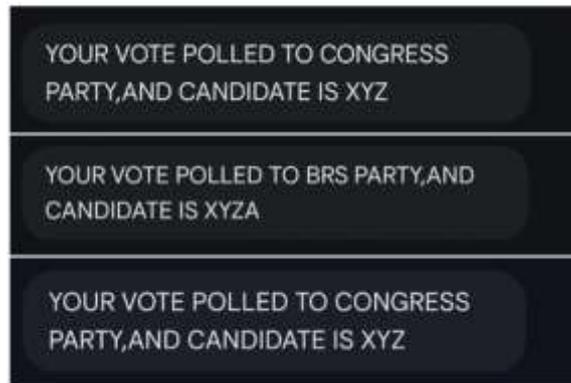


Fig. 3 : SMS Acknowledgment Messages for Vote Confirmation



Fig. 4 : LCD Display Showing Final Voting Results

V. CONCLUSION

The Solar-Powered Fingerprint Authentication based Voting Machine with Integrated Printing and SMS Acknowledgment provides a modern solution for secure and transparent electronic voting. By combining solar energy, the system ensures reliable operation even in rural and remote areas with limited power supply. The use of fingerprint authentication enhances security by allowing only authorized voters and preventing duplicate voting. The integration of a thermal printer and GSM module improves transparency by providing both printed and SMS confirmations. The Arduino-based control system efficiently manages all operations, ensuring smooth and accurate vote processing. The LCD display and buzzer make the system user-friendly by guiding voters during the process. Overall, this system reduces manual errors, increases trust in the voting process, and ensures accurate vote counting. Hence, it is a reliable, eco-friendly, and efficient solution for future voting systems.

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