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Design and construction of microcontroller finger-base attendance system

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ABSTRACT

The academic attendance of students greatly influences their acquired knowledge, grades, and skills. The present study aimed to reinforce a fingerprint identification system to be applied in a database. Fingerprinting is an efficient and rapid technique for attendance checks as it represents the uniqueness of humans and is easily available. Fingerprint sensors have benefited from this exclusivity for the automatic identification or recognition of individuals. To this end, we designed and developed an attendance system, the main components of which were a Fingerprint reader and Arduino board (microcontroller) for the insertion of the records into the database. As a result, the performance evaluation of students was facilitated by the recorded attendance in an accurate, efficient manner with the least possible error, as the results of testing this system was with an average of 98.833 %, as well as the improved academic performance of students as they must attend all the sessions and cannot avoid classes.

***Keywords*:** Fingerprint sensors, automatic identification, microcontroller

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1. INTRODUCTION

The recent attendance System in institutions has proved to have failed to achieve its' major purpose which was to ensure that the right statistics of students that attended the class can be taken.

The major reason for its failure among its shortcomings is the ability for a student to sign up for another student. Many educational institutions are trying to identify accurate, safe, and reliable techniques to protect access rights to their existing services or operation.

Fingerprint based attendance system is an answer to these concerns. Biometrics, especially in information technology, encompasses methods to analyze physical and behavioral identities to extract unique features for identification or monitoring purposes. Various physical features including faces, eyes, fingers, hands, veins, ears, and teeth can be used by this technology, and characteristics such as gaits or voice patterns are still being investigated and analyzed as part of the wider biometrics field. Biometrics offers secure methods of access to sensitive services and obviates the need to carry a token, card, remember several passwords.

Biometric techniques also reduce the risk of lost, forgotten or copied passwords, stolen tokens or over the shoulder attacks, yet despite all this obvious advantages there is still one major reasons why a specialisten implemented in many organizations which is that the biometric technique is expensive and the level of standardization differs within systems, numerous health hazards, requirement for a specialist analytical software and availability of machines with the computing power to run it. Fingerprint identification is one of the most well-known and common Biometric identification system, Because of their uniqueness and consistency over time, fingerprint has been used for identification for many years, more recently becoming automated due to advancement in computing capabilities. The fingerprint system seems to be the most cost effective and easy to use among all the biometric systems with no health side effects.

Survey and analysis of the current attendance methods has shown that most lecturers use a paper-based attendance method to keep attendance in Enugu State University of Science and Technology. Problems that have been discovered with the paper-based registers are paper based registers are not uploaded to a centralized system, so the data is lost for analysis, Time Taken for data collection impacts on lecturing time, The system can be fooled by students' buddy-signing in other to ensure that their friends scale through the 75% attendance benchmark. Consequently, this project proposes Fingerprint recognition as a method to overcome these problems in Enugu State University of Science and Technology. Several similar works exist on the implementation of different methods and principles to effectively monitor the attendance of students; Related systems using electronic cards only takes the attendance of the system when the student swipes in the card, this system is not mobile and still encourages buddy-signing as one student can still sign for his friend.

In this study, it was demonstrated that the difference between the method proposed in this study and the normal paper method is that this is more accurate and just a bit faster, Related systems using R.F.I.D cards are efficient and can be set to take attendance for every class by setting it to take attendance at certain times of the day but the system still allows buddy-signing and a student can just leave his RFID cards in class While he is away, Related systems using Ear Recognition has a very high efficient, development time is minimal, it offers reporting and ability to query its database but it is not mobile, the students have to queue up to take the attendance and do the same for the next class and also it needs to be connected directly to a

system for each device so if it was to be implemented in a school, computers will have to be bought for each class. The knowledge gap that was filled are making the system portable, less time consuming and less power consuming, Plug and play system, Incorporating display and user interface button.

2. MATERIALS AND METHODS

2. 1. Analysis of the block diagram

The power supply section of this circuit consists of a 6V rechargeable battery and a 12v step-down transformer whose voltage is regulated using a voltage regulator (LM7805 regulator) to 5V which supplies power to the rest of the circuit. The display used is a 20*4 Liquid crystal display (LCD) unit, which displays the output of the microcontroller. Port PB of the ATMEGA 1284p microcontroller is connected to the LCD display and it is used for getting the data or information that is meant to be displayed to the user.

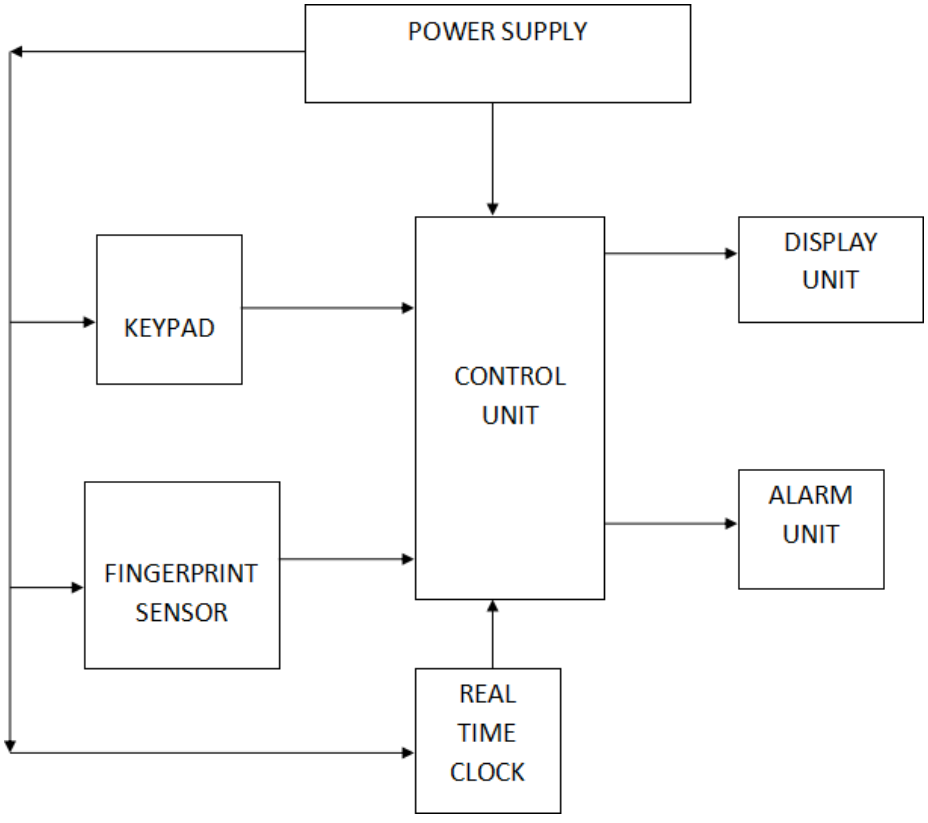

Figure 1. Design block diagram

The microcontroller used in the implementation of the project is the Arduino uno. The controller ensures that each action being performed by the buttons is displayed on the LCD display. The microcontroller saves the data gotten from the Fingerprint to its EEPROM, ensures that the Real Time Clock time is displayed and stored the moment a fingerprint is accepted. It

also controls the displays of the LCD, by transmitting the character strings to be displayed on the LCD screen.

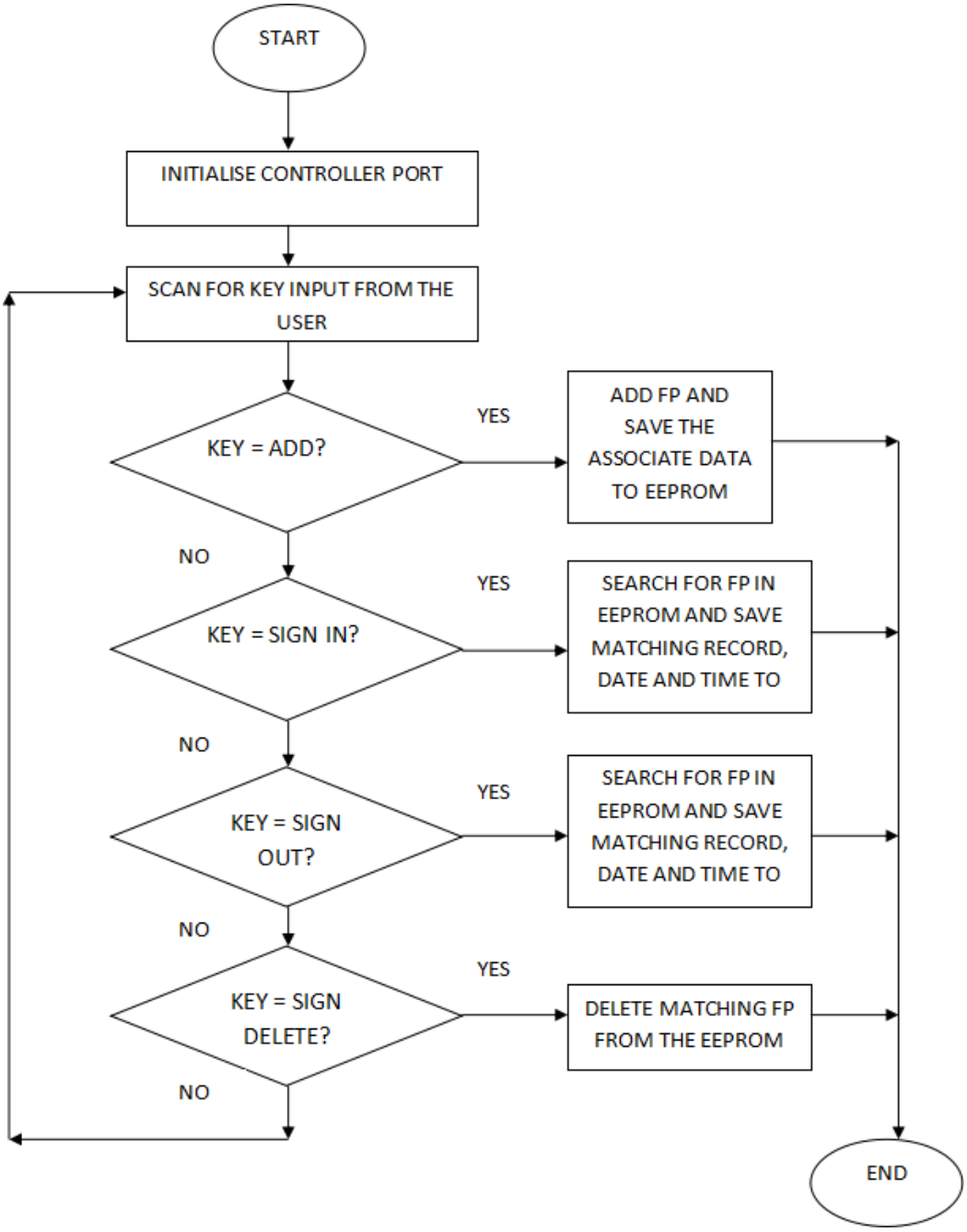

Figure 2. System operational flowchart

The DS1307 RTC is the real time clock used in the project. The RTC was used to keep track of time and date. Details concerning the RTC were gotten from its datasheet. The DS1307 Serial Real Time Clock is a low–power, full BCD clock/calendar plus 56 bytes of non-volatile

SRAM. Address and data are transferred serially via the 2–wire bi–directional bus connected to the SDA and SDL pins of the microcontroller. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with less than 31 days, including corrections for leap year. The clock operates in either the 24–hour or 12–hour format with AM/PM indicator. The DS1307 has a built–in power sense circuit which detects power failures and automatically switches to the battery supply.

The fingerprint module (AS608) device captures the fingerprint of the user and stores it in its memory. It operates at 57600 baud rates. AS608has four pins Vcc, Gnd, Tx and Rx. The microcontroller is connected to the Fingerprint Module and communicates with it through one of its Serial ports UART (Universal Asynchronous Transmitter and Receiver). The Tx of AS608 is connected to the serial receive input of the microcontroller which is the PD0 pin. Similarly, Rx of AS608 is connected to serial transmit pin of microcontroller which is pin PD1.

2. 2. Mathematical design of individual blocks

The entire circuit is powered by a standard +5 volts DC power supply since most of the components are digital logic components. Before the power supply unit was designed, the total power requirement of the circuit was analyzed as follows: The ARDUINO UNO datasheet specified that the maximum voltage to be 5 volts and the minimum voltage to be 4.5Volts.
The H-bridge fingerprint sensor required 5 volts. The LCD also required 5Volts to be supplied to its pins. The RTC also required 5Volts to be supplied to its pins. Therefore, the circuit can adequately run on a 5 volts DC supply. However, to obtain the 5 volts DC supply from the public mains, the following circuit configuration was used.

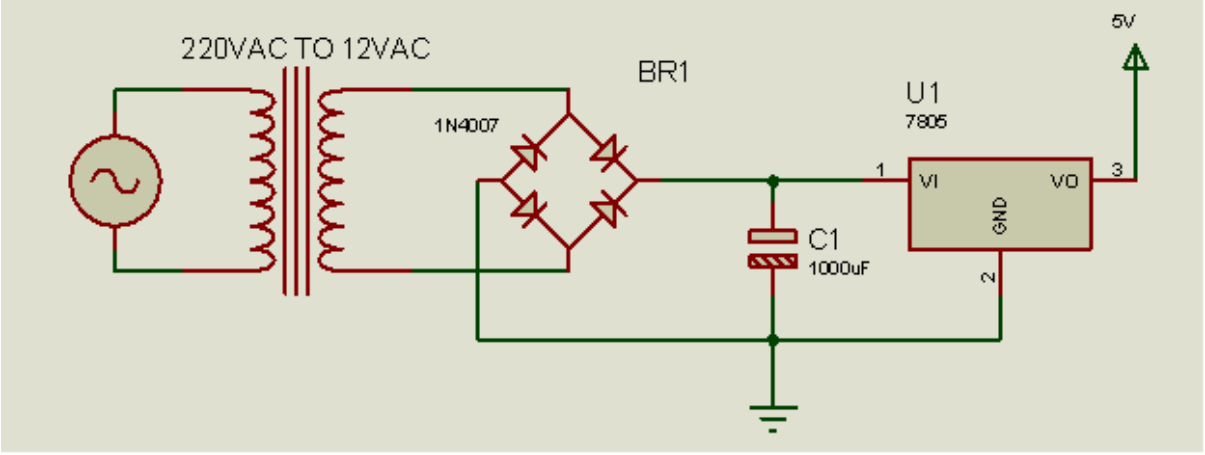

Figure 3. Power supply circuit

The transformer is a step-down transformer rated 220 V/12 Vac at 500 mA: since the expected output voltage is 5volts, any value above this is suitable. So, a 12 V transformer is chosen to step down AC voltage from 220 Vac to 12 Vac at 500 mA. A full wave rectification was employed in this work using a bridge rectifier. The four diodes of the bridge rectifier are so chosen that their peak inverse voltage (PIV) can withstand twice the peak voltage (Vp) of the transformer output with a forward current 1.5 times the output current of the transformer.

The Vp from the transformer is given as:

$$V_p = \sqrt{2} \times V_{rms} \quad \text{.....1.0}$$

V_{rms} is the measured voltage from the step-down transformer; V_{rms} = 9V.

Vp = $\sqrt{2} \times 9$ = 12.728 volts

The chosen diodes must be able to withstand twice this value i.e 2

D_{piv} = 25.46V and $D_{current}$ = 1.5 × 500mA = 0.75A.

where $D_{current}$ is the Diode forward current. Therefore, the required device must have a: $D_{piv} \geq 25$ V and $D_{current} \leq 0.75$ A. From diode catalogue (datasheet), the IN4007 has the following characteristics: D_{piv} = 50V and $D_{current}$ = 1A, this makes it more than suitable. Hence the four diodes of the bridge rectifier are IN4007.

The filter stage consists of two capacitors. The function of the capacitor is to remove the fluctuations or pulsation (called ripples) present in the output voltage supplied by the rectifier. Capacitors C1 and C2 are filter capacitor and improvement capacitor respectively [2,3]. The voltage rating of the capacitors is chosen such that it is at least 1.5times the Vp from the rectifier output.

The Vp from the rectifier output is:

$$V_{p(in)} - V_d = V_{p(out)} \quad \text{.....2.0}$$

where $V_{p(in)}$ is the Vp from the transformer; V_d is the voltage drop across the rectifier diodes; and $V_{p(out)}$ is the Vp from the rectifier output.

Thus, $V_{p(in)}$ = 12.728V; V_d = 1.4V (voltage drop across each diode arm is 0.7V),

$V_{p(out)}$ = 12.728 − 1.4 = 11.328V,

The voltage of the capacitor should be $V_{p(out)}$ × 1.5 = 11.728 × 1.5 = 16.99V.

A capacitor that has a voltage of 35V was chosen. For effective filtering of the ripple from the pulsating DC, the capacitance value chosen should be high enough to eliminate the ripple voltage (Vr) to about 20% of the peak voltage (Vp). The ripple voltage is given by:

$$V_r = I_o \div (2 \times F \times C) \quad \text{.....3.0}$$

20% of Vp = 0.2 × 12.728 = 2.546V

where I_o is maximum current from supply = 500 mA; F is frequency of supply = 50 Hz; C is the expected capacitance of the capacitor, hence

$C = I_o/(2 \times F \times V_r)$ ……..4.0

C = 500 mA ÷ (2 × 50 × 2.546) = 1963.86 uF.

However, the manufacturer specified that if the distance between the capacitor and the regulator is up to 6 inches, the inductance of the connecting cable may interfere with regulation [Richard Blum 2001], therefore a capacitor of capacitance value of 2200 uF is recommended for C1. Therefore, C1 is rated 2200 uF at 35V. C2 is mostly specified in rectifier circuits and its value is 0.01 uF.

The fixed voltage regulator is the 78xx series. 78 indicates that it is a positive voltage output regulator while xx signifies that value of the voltage; 09 for 9V, 12 for 12V. 7805 was used in this work to ensure that a 5V output voltage is obtained. To carry out effective voltage regulation, the minimum input voltage to the regulator is gotten from the manufacturer formula:

Vout = Vmin - Vref ……5.0

where Vout is the output voltage = 5 Volts.
Vref is the reference voltage given by the manufacturer = 2 or 3 Volts.
Vmin = Vout + Vref = 5 +3 or 5+2 = 8V or 7V

The minimum required input voltage for effective regulation is 8 to 7 V. Since we are getting a Vrms of:

Vrms = 0.707 Vp = 0.707 × 12.728 = 8.99 ≅ 9V

The power supply is adequate for proper regulation, hence the voltage regulator required is 7805. The series connected components are to indicate that there is power on to the circuit.

The resistor protects the LED from damage and it value is given as:

R1 = (Vs − Vd) ÷ Id ……6.0

where Vs is supplied voltage = 5V; Vd is voltage of diode = 1.25V; and Io is current of the diode = 10 mA.

R1 = (5 − 1.25) ÷ 10mA = 375Ω

The input keypad allows the user to enter passwords and act as an interface for the user to communicate with the device. The keypad is a matrix arrangement of pushbuttons arranged in such a manner that each of the sixteen buttons enables any of the external interrupts when depressed. This makes the circuit very responsive. The schematic diagram below was used to design the input keypad.

Table 1. Software tools used in the course of implementing the project

S/N	NAME	USAGE
1	Proteus 8 professional	For circuit schematic design and simulation
2	ARDUINO IDE studio	For coding, in order to generate hex file and control the system operations

The resistors R1 and R2 act as pull up resistors for the external interrupt pins of the AT89C52 micro-controller. The typical sink current allowed on any of the microcontroller pins is 2.5 mA. Therefore, appropriate resistor values for the pull up resistors can be derived from the formula below:

$$R = \frac{V_{cc}}{I_{sink}} \quad \text{.....7.0}$$

where R = pull up resistor; Vcc is the supply voltage = 5.0V; and I_{sink} is sink current = 2.5 mA

$$R = \frac{5.0V}{2.5mA} = 2000\ \Omega$$

Nearest preferred value for R1 and R2 is 2200Ω

Table 2. Hardware tools used while implementing the project

S/N	NAME	USAGE
1	Soldering iron (60 watts)	For welding the components together
2	Soldering Lead	As a paste to hold the components during soldering/welding of the components
3	Vero board	For putting the circuit together
4	*Linking* wire	To help in connecting two or more components that are not close to each other
5	Digital multi-meter	For testing the components and system parameters like; input voltage, continuity, resistance and shortcircuit.

2. 3. Materials used in Implementation

A switch was deployed in this construction, which is any device used to interrupt the flow of electrons in a circuit. Resistor a device having resistance to the passage of an electric current. Jumper wire is an electrical wire, or group of wire in a cable, with a connector or pin at each end, which is normally used to interconnect the components in a circuit. Transistor basically acts as a switch and as an amplifier. Also, a transistor is a miniature device that is used to control or regulate the flow of electronic signals.

A button is a momentary or non-latching switch which causes a temporary change in the state of an electrical circuit only while the switch is physically actuated/pressed and when the button is released, the circuit is broken. This type of switch is also known as a Normally Open (NO) Switch. A capacitor is a device used to store an electric charge, consisting of one or more pairs of conductors separated by an insulator. Voltage regulator is a component designed to automatically maintain a constant voltage level in electronic circuit. Fingerprint scanner is an optical device that captures the fingerprint of any user.

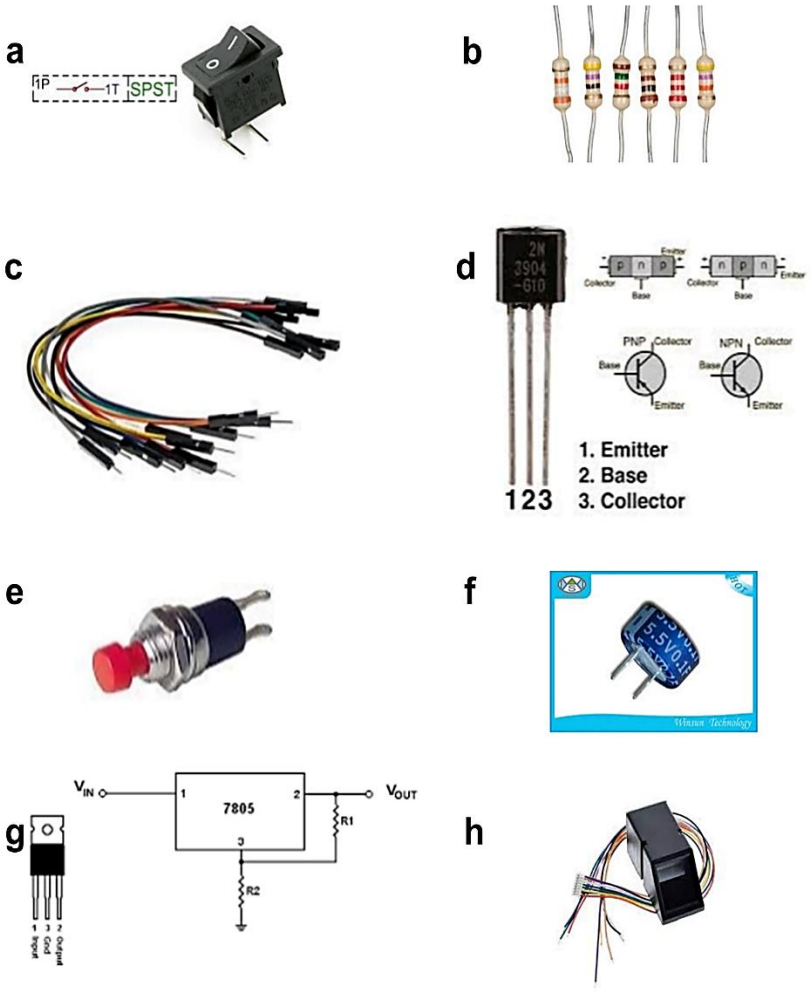

Figure 4. (a) Image and symbol of a simple pole simple throw (SPST) switch. **(b)** Image of a resistor. **(c)** Image of a jumper wire. **(d)** Image and symbol of a transistor. **(e)** Image of a button. **(f)** Image of a capacitor. **(g)** Image and symbol of a voltage regulator. **(h)** Fingerprint module

3. RESULTS AND DISCUSSION

3. 1. Testing of the Power Supply

It happens to be that the transformer steps down the 220 VAC to 12vac and the bridge rectifier converted the AC to DC, with the help of the capacitor, the ac ripples were filtered out, the voltage regulator convert the 12 vdc to 5vdc.

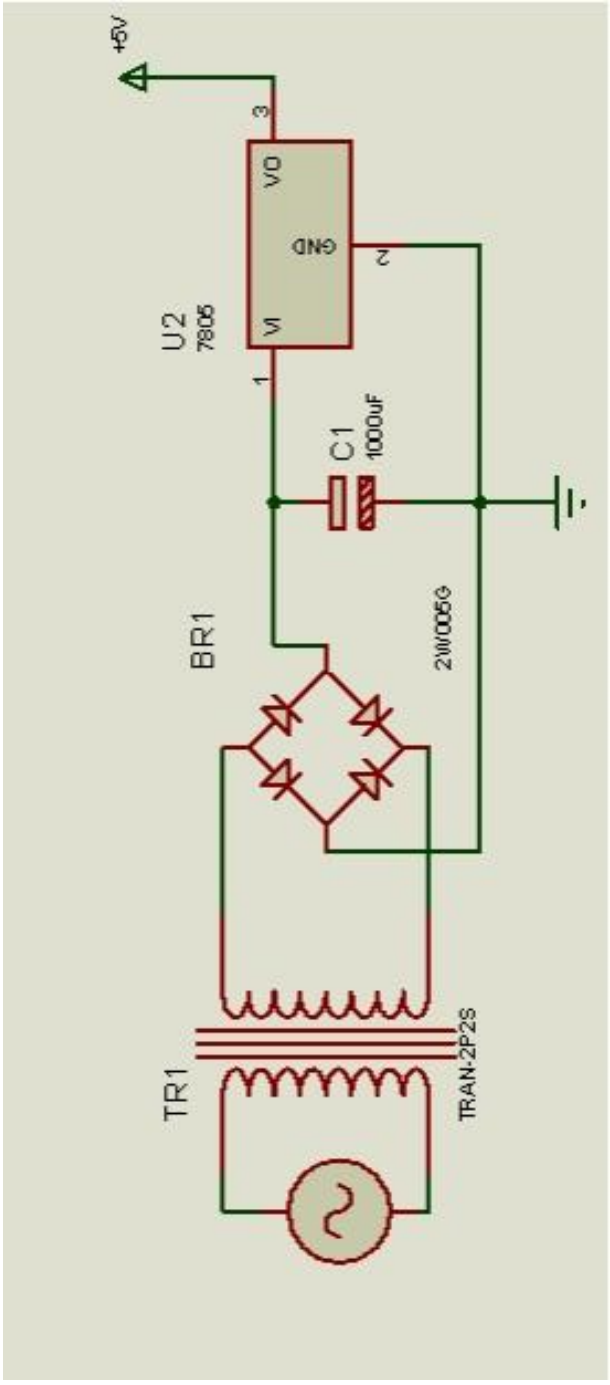

Figure 5. System power supply diagram

3. 2. Testing of the RTC Module

The circuit Fingerprint Attendance System using Arduino also utilizes a RTC (Real Time Clock) module for storing date and time of attendance. In this project we used DS1307 RTC, it is a serial real-time clock IC with inbuilt various types of functions like calendar, 24-hour and 12-hour time format with AM and PM indication. Two-line SDA and SCL of DS1307 module are connected to analog pin A4 and A5 of arduino uno board as shown in figure 1. The module has an inbuilt 3V button cell which helps RTC module to run internally for few days (approx. 10 days) even external power supply is not connected, and all these features are well functioning.

3. 3. Testing of the Key-Pad Unit

The keypad is wired to send a negative signal to the microcontroller and when the button is pressed, the microcontroller executes operation in respect to the button pressed. The four switches SW_1 to SW_4 connected to four analog pin A0 to A3 of arduino uno board respectively. Switch SW_1 and SW_2 are multiplexed i.e., various operations are performed by single switch. Table show below explains the operation of switches uses in circuit diagram.

Table 3. Operation of switch

S.N.	Switch	Operations
1.	SW1	ENROLL/BACK/DOWNLOAD
2	SW2	Delete/Ok/Reset
3.	SW3	UP
4.	SW4	DOWN

To enroll new user, the following steps should be followed: Power on the circuit, Press the Enroll switch (SW_1), and follow the message displayed in LCD, User input the ID by using UP and Down switch (SW_3 and SW_3), Press the OK switch (SW_2), a message on LCD screen displayed and ask user to put finger on fingerprint module, follow the message as shown in LDC i.e. remove finger and again put finger on module. The system stores the fingerprint image in memory i.e., user is registered and can take attendance.

To delete existing user, the following steps should be followed: Press DELETE switch (SW_2), LCD ask for user ID to delete, User ID is selected by sculling UP and DOWN using switch SW_3 and SW_4, if ID is selected press OK switch (SW_2), confirmation message is displayed on LCD, glowing LED_1 is used to indicating either system is ready or not where piezo buzzer is used for sound alert.

3. 4. Testing of the 16 X 2 LCD Display Unit

The 16×2 alphanumeric LCD is used to display messages during operation like name, authentication etc. The higher order data pin of LCD (pin 11, 12, 13 and 14) are connected to digital pin 8, 9, 10 and 11 of Arduino uno board. The RS and E pin of LCD is connected to pin

12 and 13 of arduino uno board. RW pin of LCD is grounded because we only perform write operation in LCD. Preset VR_1 is used to adjust contrast of LCD. Pin no 15 and 16 of LCD not shown in circuit diagram is used to glow backlight LED.

3. 5. Testing of Fingerprint Sensor Unit

Fingerprint sensor module AS608 (connected across CON1) has UART interface with direct connection with Arduino UNO board. The user can store fingerprint samples in the module and can be configured in 1:1 or 1: N mode for identification for the right user.

The fingerprint sensor module AS608 is power with +5V power supply which is connected to 5V pin of arduino board. Tx and Rx pin of fingerprint sensor module is connected to arduino digital pins 2 and 3 as shown in circuit diagram. This connection is used for serial communication because only one individual pin is used for transmitter and receiver thus parallel communication is not possible.

3. 6. Integration of all the individual blocks to form the system

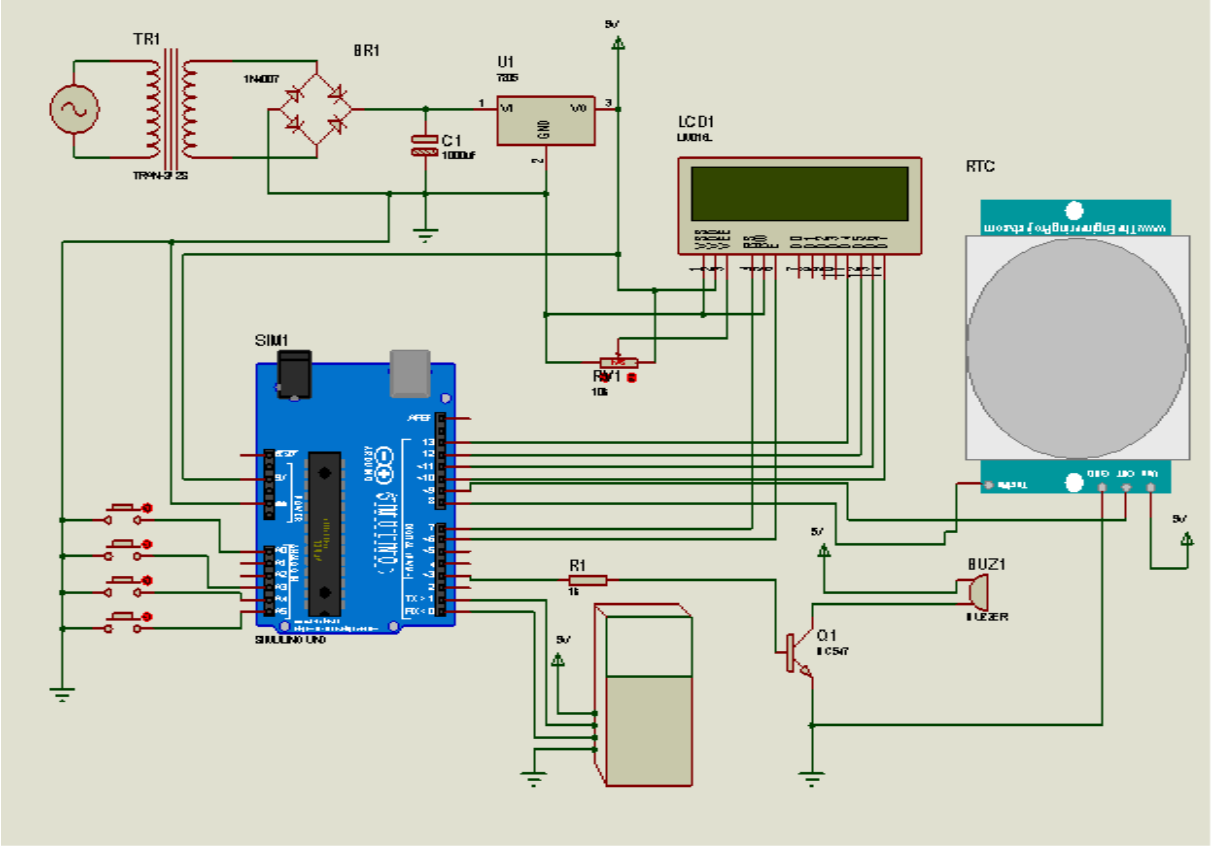

Figure 6. Complete system circuit design diagram

The power supply unit creates the power that powers the entire system, it powers the control unit, the fingerprint sensor, the RTC, and the LCD. The keypad unit is wired to send signal to the control unit to be able to control the systems function while the fingerprint sensor

is used for capturing the biometrics of individual users and the captured biometrics has been sent to the control unit for storage and further function.

The RTC (Real Time Clock) is connected to the control unit to help in keep the record of time when user thumbprint. While the display gets the system status from the control unit and show out visually through a liquid crystal display (LCD)

3. 7. Testing of the system and display

A continuity test was carried out between individual components to ensure that they link together as required. A short circuit test was also carried out on the microcontroller to see if there was existence of Wrong connection. The short circuit test was conducted between vcc and GROUND to ensure that they were not linked together. The test was also conducted between Components connections to ensure that individual components are connected as supposed.

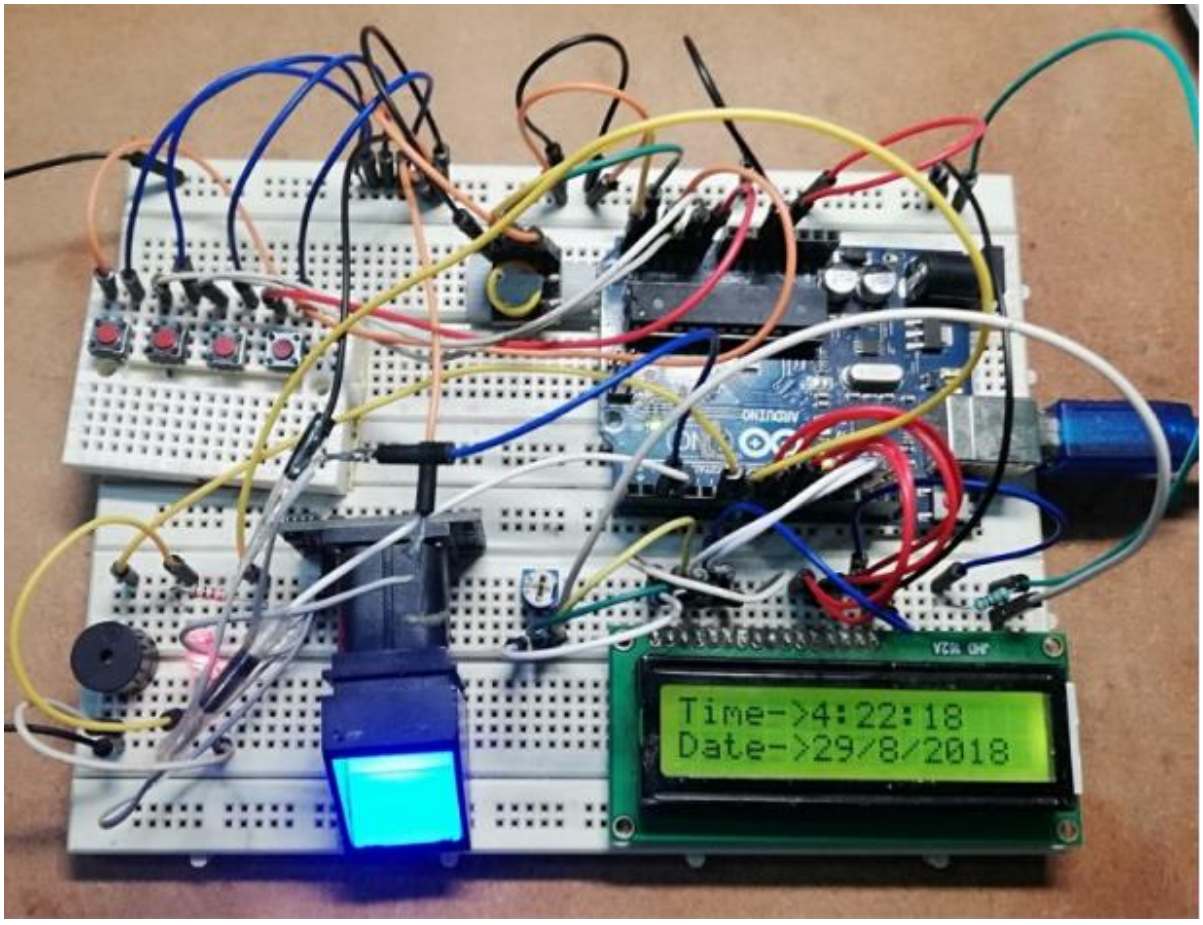

Figure 7. Testing of the entire system and its display

When the system is switched on, the microcontroller initializes, and displays the corresponding “SYSTEM READY”, waiting for a fingerprint to be placed on the sensor to sign in/out. A test was carried out on the RTC to ensure that the time and date is in order as shown in Figure 7 and the buttons were also pressed severally to ascertain a normal function while in

the presence of a non-registered user, the buzzer beeps to indicate that. The microcontroller was also confirmed to be working as the entire system operation is working as designed.

4. CONCLUSION

The Implementation of Fingerprint Based Attendance System has been designed, constructed, and tested/trusted by us. It is suitable for domestic, industrial, and commercial purposes. This Fingerprint Based Attendance System is thus very good for economic keeping and normality. It can be used in place of human/manual means of taking attendance in other to avoid mistakes and impersonation. Enabling real time monitoring: The proposed system can be further enhanced by using a WIFI system so updating is automatic. That way the lecturers don't need to even return the handheld device for the attendance to be in personal computer. Lecturer's alert system: The proposed system can be improved by enabling the lecturer to get an SMS or email update of the day's attendance immediately after the last attendance is taken. Guardian alert System: A student misses a specified number of classes; an SMS/email is sent to his/her parent or Guardian to alert them of their ward's truancy. Automatic Exam door opener: I can be installed to the door whereby the door only opens when one has attained 75% of the attendance.

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