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DESIGN AND DEVELOPMENT OF A PASSWORD- BASED DOOR LOCK SECURITY SYSTEM

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ABSTRACT

This work is a design and development of a micro-controller based, password enabled door lock for home security. The work involved building a working model of a security door lock that is password protected with an AT89C52 microcontroller which operates by sending control signals to a H-bridge that controls the opening and closing of a model door connected to a stepper motor. Accessing and changing various information and settings are done via an electronic system that allows the user to enter secret pass codes via a 4×4 keypad and a 16×2 LCD display. The design incorporated a serial EEPROM that can retain the information during power outages and runs on available power from the mains supply. Once the circuit is plugged to the mains supply, the LCD displays the different menu functions and waits for data input from the keypad, the illustrative door slides open and close when a valid pass code is entered.
The work was designed, developed, and tested and found to perform according to design objectives.

Key words: Security system, Microcontroller (AT89C52), Keypad access, EEPROM

INTRODUCTION

Security is a serious problem in Nigeria that calls for a proactive measure by all stakeholders and owners of residential buildings. Buildings in Nigeria (residential and organizational) do not have adequate security systems that monitor intruders and prevent access to sensitive files and products. The increasing rate of crime, attacks by thieves, intruders and vandals despite all forms of security gadgets and locks still need the attention of researchers to find a permanent solution to the well being of lives and properties of individuals [Adamu M.U. 2009]. To this end, this work uses the model of a keypad enabled access and seeks to further simplify and solve the problem of security in places where unauthorized access to organization materials and files are to be prevented.

As technology advances, the need for security also is increased considerably. Security has now become one of the most sensitive issues in organizations and the demand for higher security for storing company databases, files (most times on computers) has become higher. An access control for doors forms a vital link in a security chain. This work consists of a code lock system, an alarm system and a driver circuit to open and close a door.

The goal of this work is to design a door-latch opening using a password that is entered through a keypad. The lock system makes use of a pass code to grant access to authorized individuals. The pass code is chosen by the individual who wants to secure the door and it has the advantage that multiple users can access the door each with their unique user I.D and Pass Code. In other applications, mobile technology can be utilized to control various units of the houses, industries and also provide security system. The various doors can be utilized by managing them remotely by using GSM technology, which enables the user to remotely control the operations of the doors. Just by pressing keypad of remote telephone the user can perform OPEN/CLOSE operations on the doors [Arpita M. etal 2014]. This work exhibits low cost home security system which is widely employed in our daily life. The system is designed to prevent the opening of the door by unauthorized persons. The system consists of an illustrative door, a matrix keypad interfaced to a microcontroller. The keypad is used as the password entry system to open/close the door. When an authorized user enters a valid pass code, the illustrative door connected to a stepper motor that is controlled by a H-bridge slides open. If the pass code entered is incorrect, the door remains close and a buzzer sounds an alarm for multiple entries of incorrect pass codes.

Review of Previous Work

In 1958, the first electronic combination lock was invented [Koenig J.A, Taylor L.1998 and Robert L.B and Louis N 2009]. As subsequent developments were along the lines, the locks were improved upon by the improvement of materials and increasing complexity of the working mechanism including the increasing use of automatic electronic alarm and safety devices [Mehta V.K.1993] worked on a password based security lock system that uses GSM technology to remotely control the opening and closing of a door as well as an interfaced keypad. The deviation of this work from that of (Arpita M et al 2014) is that it utilizes low cost security system without an added complexity of the GSM technology and works with a simple stepper motor instead of a relay that is prone to electromagnetic interference.

MATERIALS AND METHOD

I. The password-based door lock security system was designed in the following stages:

II. Design of the Power supply unit.

III. Design of the Input Keypad.

IV. Design of the Drive Mechanism

V. Design of the Micro-controller unit

The block diagram of the password-based door lock system is shown in Figure 1.

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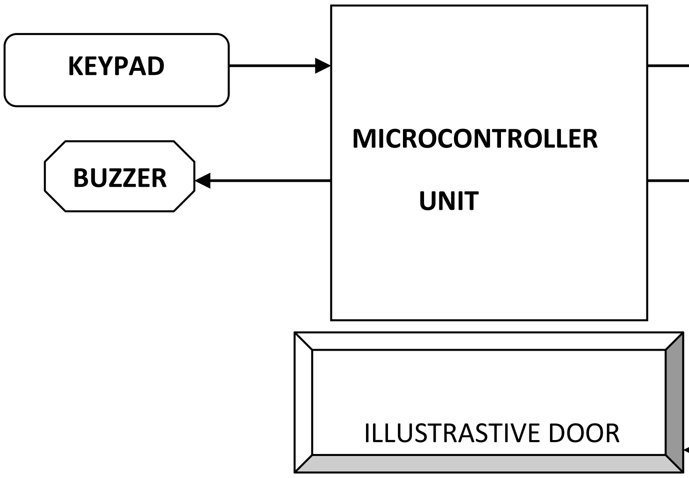

Figure 1: Block diagram of the security system.

Design of the Power Supply Unit
The entire circuit is powered by a standard +5Volts DC power supply since most of the components are digital logic components. Before the power supply unit was designed, the total power requirements of the circuit was analyzed as follows:

- The AT89C52 datasheet specified that the maximum voltage to be 6.6Votls and the minimum voltage to be 4.5Volts.
- The H-bridge driver for the stepper motor required 5Volts
- The LCD also required 5Volts to be supplied to its pins

Therefore, the circuit can adequately run on a 5Volts DC supply. However, in order to obtain the 5Volts DC supply from the public mains, the following circuit configuration was used;

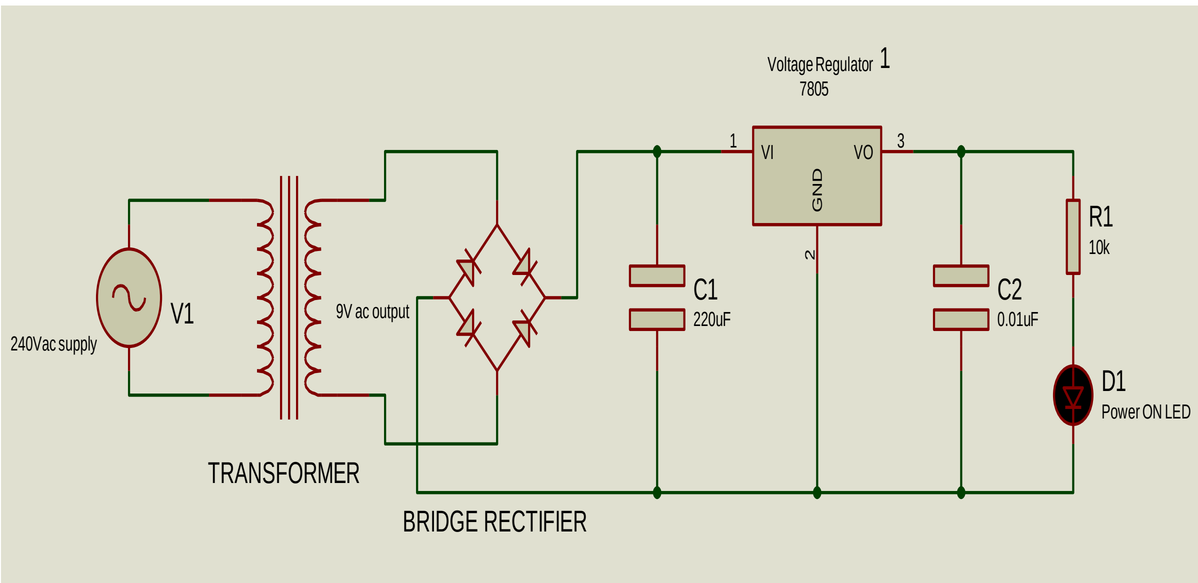

Figure 2: Power supply circuit

The transformer is a step down transformer rated 240V/9Vac at 500mA: since the expected output voltage is 5volts, any value above this is suitable. So a 9V transformer is chosen. This steps down AC voltage from 240Vac to 9Vac at 500mA.

Rectifier Stage:
A full wave rectification was employed in this work using a bridge rectifier. The four diodes of the bridge rectifier are so chosen such that their peak inverse voltage (PIV) can withstand twice the peak voltage (Vp) of the transformer output with a forward current 1.5times the output current of the transformer. The Vp from the transformer is given as:

$V_p = \sqrt{2} \times V_{rms}$ …………1.0

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

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

the chosen diodes have to be able to withstand twice this value i.e $2 \times 12.728 = 25.456V$

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: $D_{piv} \geq 25V$ and $D_{current} \geq 0.75A$. From diode catalogue (datasheet), the IN4001 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 IN4001.

Filtering Stage:
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 [Rashi M.A 1986 and Richard B.2001]. 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
$V_{p(in)} - V_d = V_{p(out)}$………………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 $V_{p(out)} \times 1.5 = 11.728 \times 1.5 = 16.99$V.

A capacitor that has a voltage of 35V was chosen. For effective filtering off 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:

$V_r = I_o \div (2 \times F \times C)$ ……………3.0

20% of Vp = 0.2 × 12.728 = 2.546V

Where I_o is maximum current from supply = 500mA; F is frequency of supply = 50Hz;

C is the expected capacitance of the capacitor, hence $C = I_o \div (2 \times F \times V_r)$ …………………4.0
C = 500mA ÷ (2 × 50 × 2.546) = 1963.86uF.

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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 [www.aldata sheet.com 2012], therefore a capacitor of capacitance value of 2200uF is recommended for C1. Therefore C1 is rated 2200uF at 35V. C2 is mostly specified in rectifier circuits and its value is 0.01uF.

Voltage Regulator Stage:
The fixed voltage regulator is the 78xx series. 78 indicate 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 = 5volts;

Vref is the reference voltage given by the manufacturer = 2 or 3volts;

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.

Current Limiting Resistor and Power on Light Emitting Diode:
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 supply voltage = 5V; Vd is voltage of diode = 1.25V; and Io is current of the diode = 10mA.
R1 = (5 – 1.25) ÷ 10mA = 375Ω

Design of the Input Keypads
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 push-buttons 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. 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 micro-controller pin is 2.5mA. Therefore appropriate resistor values for the pull up resistors can be derived from the formula below:

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

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

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

Nearest preferred value for R1 and R2 is 2200Ω

Design of the Drive Mechanism
In this work, the door was illustrated using a mechanism that allows a model door to open and close. It involved a DC motor, connected to a mechanism that can be powered to rotate either in a clockwise or anti-clockwise direction. The circuit used to achieve this is shown in Figure 3.

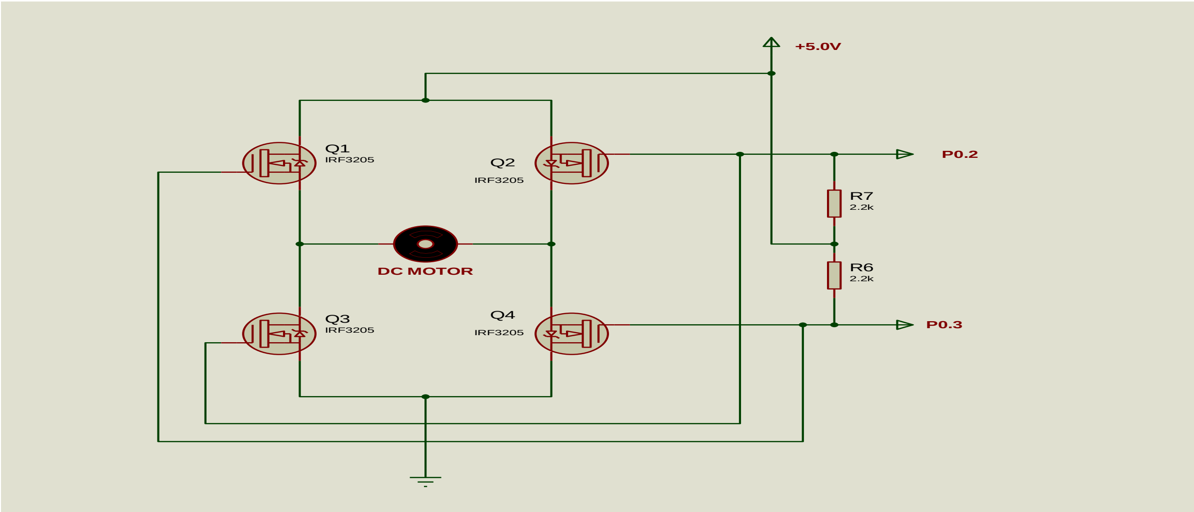

Figure 3: H-bridge circuit for driving DC motor.

In the design, an H-bridge is realized using a network of MOSFETs. The H-bridge and a DC motor are used to model the opening and closing of the door. The gates of alternate MOSFETs are tied together and connected to pins 2 and 3 of PORT0 of the AT89C52 micro-controller. The voltage states at the pins then determine the direction of rotation of the DC motor and thus the opening and closing of the model door.

Port States

Table1. A table showing logic state of the Pins 2 and 3 of PORT0 and the corresponding motor state.

Port 0, Pin 2	Port 0, Pin 3	Motor State
LOW	LOW	Stationary
LOW	HIGH	Clockwise Rotation
HIGH	LOW	Anti-clockwise Rotation
HIGH	HIGH	Forbidden

The forbidden state can destroy the MOSFETs in matter of seconds. Therefore care should be taken to ensure that any possible software error that is likely to generate this state is avoided. 375Ω is not readily available. The closest suitable substitute is 470 Ω.

Design of the Micro-Controller Unit

The 40-pin AT89C52 micro-controller is the central control of the circuit. All other components are interfaced to it. The micro-controller receives data and manipulates them according to the code programmed into it. For various results, it outputs from specific pins. The circuit keypad matrix, liquid crystal display (LCD) and motor drive are all interfaced to the AT89C52 and the pin configuration of the digital input/output is done in the assembly language code burnt into the micro-controller. In other for the AT89C52 to

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execute the instructions programmed into it, a clock signal is provided with an 8MHz crystal oscillator connected across it oscillator pins (pins 18 and 19). The oscillator provides the instruction cycle which is the primary unit of time in the actions of the micro-controller; that is, it determines how long an instruction takes to execute [Peter A. 1987]. The sequence of calculations is used to determine the instruction cycle of the AT89C52.

Clock cycle = 1/oscillator frequency

= 1/8000 = 0.125mSec

Instruction cycle = 12 × Clock cycle

= 12 × 0.125mSec = 1.5mSec

Pins 40 and 20 provide +5volts and 0 volts needed by the micro-controller respectively. The following flow chart shown below was adopted for the design and an assembly language program was written to implement it. The assembly language progam algorithm is as shown in Figure 4.

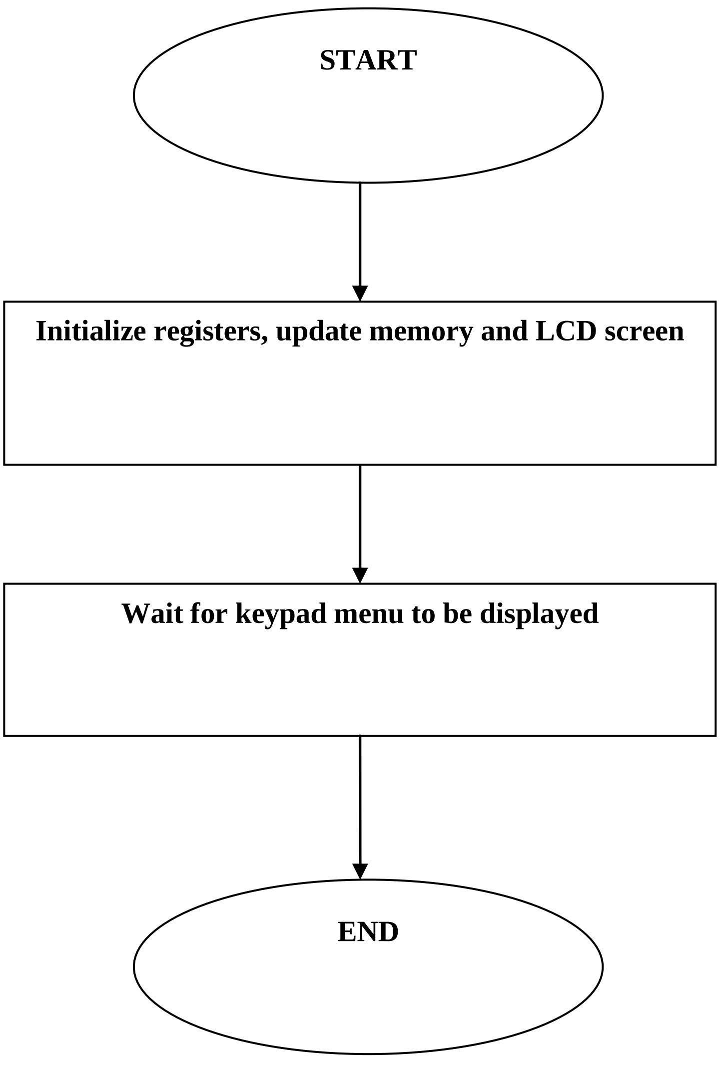

Figure 4: Flow chart for main program body showing how the program runs inside the micro-controller.

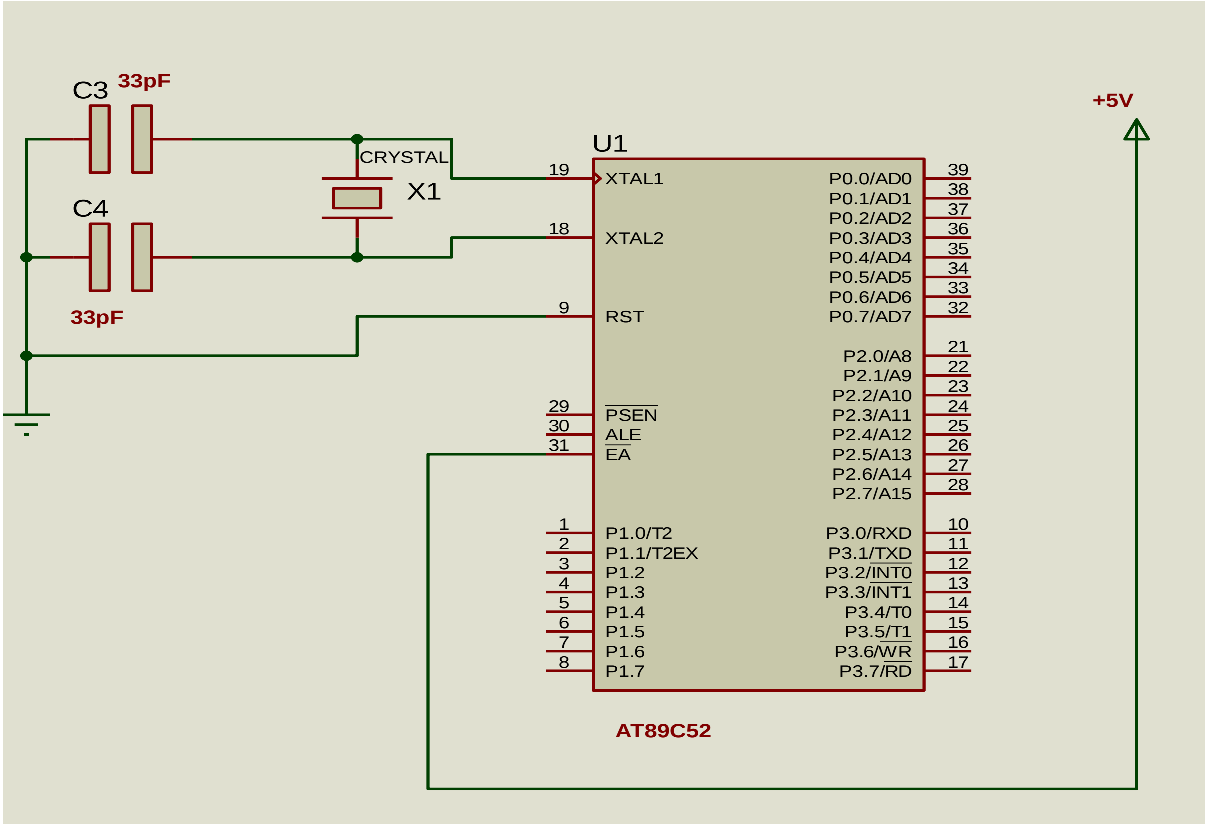

Figure 5: Essential Circuitry to the AT89C52 Micro-controller

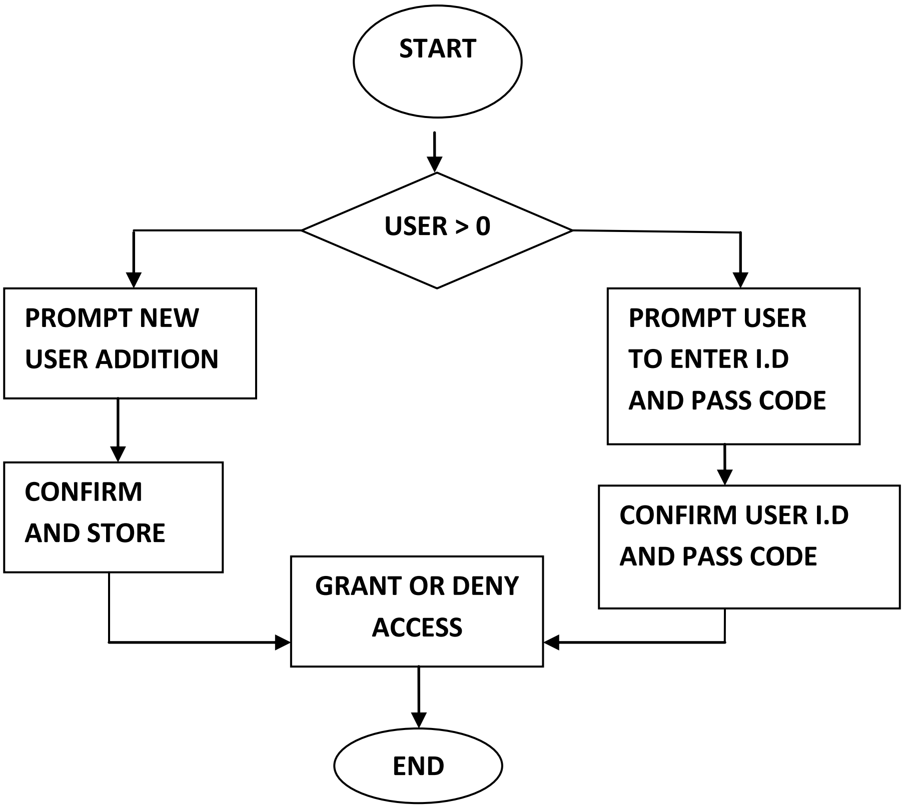

Figure 6: Flow chart for keypad interrupt

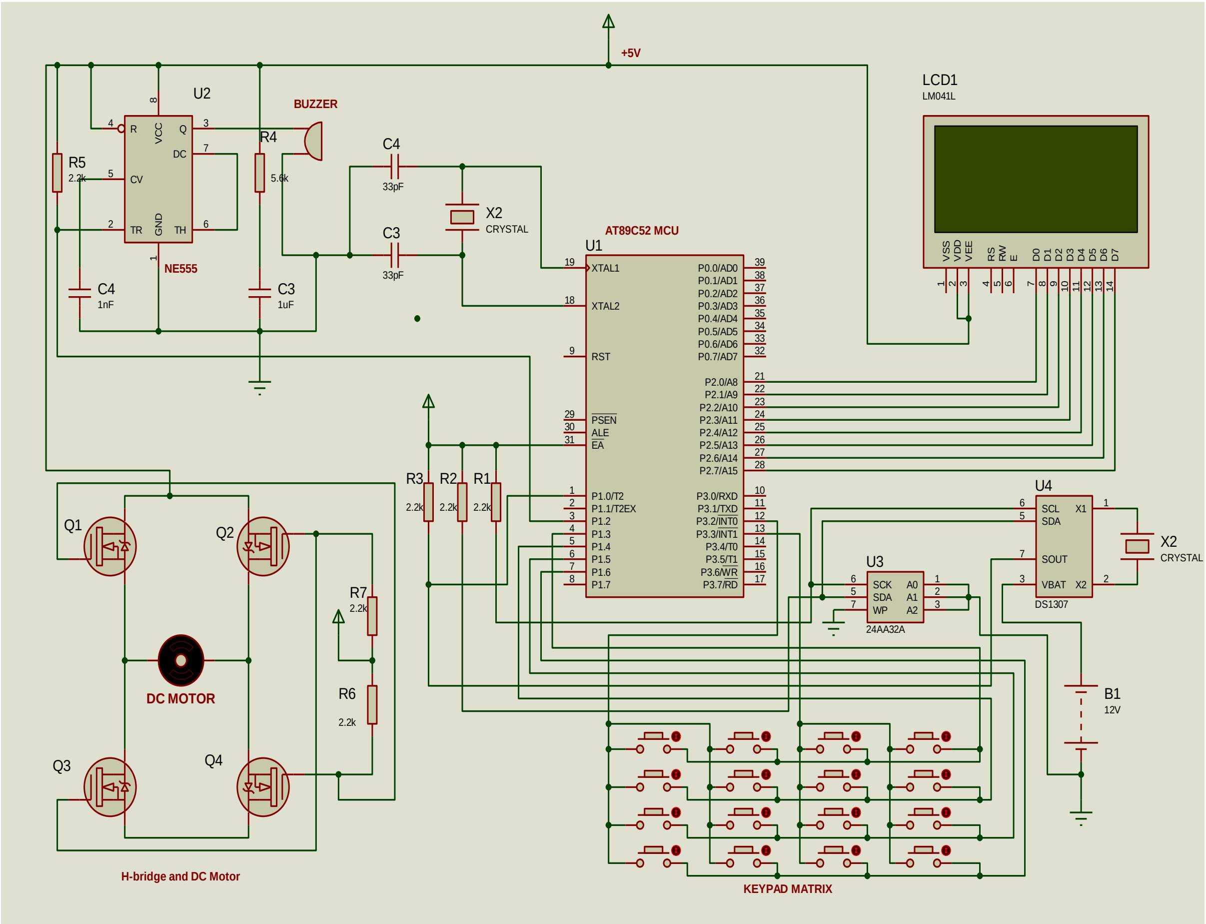

Figure 7: Circuit diagram for a password based door lock security system.

Principle of Operation

The circuit is designed to operate using the supply from the mains. The 240Vac from the supply mains is stepped down and regulated to 5Vdc which used to power the micro-controller circuit and the door mechanism. When the circuit is plugged to the supply, the POWER ON LED comes on indicating the presence of supply to the circuit. The micro-controller registers are initialized, memory and LCD screen are updated and control signals are sent which causes a voltage state of logic 0 to be present at pins 2 and 3 of PORT 0 of the micro-controller. This logic 0 output causes the MOSFETs of the H-bridge to conduct and consequently the motor is stationary. Shortly after, the micro-controller goes into POWER DOWN MODE and waits for the keypad to be depressed. The micro-controller uses external interrupt to accept data input from the keypad and sequential logic to move from one state to the next. When a key is pressed, the micro-controller reads an active high (logic 1; 5V); and at each key press, the pass code count is incremented by 1 and the key value is stored in the array and compared with those store in the EEprom. If these data entries agree with the stored data, opposite logic states result on pin 2 and 3 of PORT 0 which causes the motor to turn and hence opens the door and an authentication message is printed on the LCD showing that access has been granted.

Construction Procedure

In the design of the project, three stages were undertaken. The first involved assembling of materials, components and tools required, the second stage involved soldering of components and the last stage is placing the composite circuit into a suitable case. The circuit diagram was gotten after a careful design and calculation had been done. The complete project was first simulated with an electronic workbench (Proteus 7.5) and

Bill of Engineering Measurement

Table 2: Bill of Engineering Measurement and Evaluation (BEME)

Components	**Unit Price(Naira)**	**Quantity**	**Total (Naira)**
Transformer	300	2	600
Diodes	50	8	400
Capacitors	20	10	200
Regulator	60	2	120
LCD	1000	1	1000
Resistor	10	15	150
LED	10	2	20
EEprom	100	1	100
555 Timer	100	2	200
Transistors	50	2	100
Real time clock	100	2	200
Vero board	100	1	100
IC holders	50	4	200
Wires	30	4yards	120
Oscillator	50	3	150
Casing	750	1 board	750
Screws	10	10	100
Miscellaneous	-	-	1500
TOTAL	-	-	6010

RESULTS

During the construction of this work, testing was carried out at different stages to determine if the results obtained at each stage met the desired specifications. The primary testing and simulation tool used is the Proteus 7.7 software. After simulation, the circuit was tested on a bread board before soldering was done.

After all necessary testing and adjustments have been carried out, the project worked according to the objectives. Once the circuit is plugged to the mains supply, the LCD displays the welcome message and waits for an interrupt by the keypad. After the user I.D and Pass code are inputted, they are compared with the default in memory and right action is taken. ASCII bytes, R and W are individually sent out to the serial port to log the date, time and right pass code entry or wrong pass code entry as the case may be.

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The password based door lock model was designed which enables the security access to a room was designed with minimum parts count and lowest cost possible as seen in the Bill of Engineering Materials and Evaluation of Table 2. The working model was constructed under various constraints like time and availability of materials. As such, the work stands not to be the best that can be realized as several modifications and improvements can be incorporated into the design, these include:

- Incorporating a PC interface to monitor and control activities at the door unit in real time through a logging system;
- Incorporating a motion sensor to automatically sense presence at the door unit and prompt for password; and
- Provision for rechargeable back-up batteries in case of power failure from the mains supply.

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