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Design and Simulation of Four Walls Crossed Security System against Intrusion Using Pic Microcontroller

Mehmet Çavaş[1], Muhammad Baballe Ahmad[2],
[1,2,](Department of mechatronics engineering, Firat University, Elazig, Turkey)
Corresponding Author: Mehmet Çavaş

ABSTRACT: *The world of today is highly integrated and depends on digital electronics especially in securities. In this research, a security system was developed to look after four square walls north wall, south wall, east wall and west wall. Each wall has a sensor designed using light dependent resistor(LDR) and light emitting diode(LED) whenever somebody or something crossed the wall he/she blocked the light-dependent resistor(LDR) from receiving light from light emitting diode(LED) that makes the light dependent resistor(LDR) to output 0 volt to peripheral interface controller (the peripheral interface controller function as the brain of this research) whenever the peripheral interface controller detects 0 volt it send signal to liquid crystal display(LCD) to display that, that particular wall has been crossed, and the system will immediately rotate the dc motor that carries closed-circuit television(CCTV) camera to stop at the crossed wall in order to capture a real-time video and send to the buzzer, the function of the buzzer is to sound an alarm informing an intrusion. If the peripheral interface controller(PIC) detects 5 volts from all the walls light dependent resistor(LDR) that means that all the walls are not being crossed, if all wall light dependent resistor(LDR) output 5 volts the peripheral interface controller(PIC) will display on the liquid crystal display(LCD) "all walls ok". The system also displays a calendar (time and date) on liquid crystal display(LCD) because life depends on it calculations are made to show how reliable the system is going to be which is about 96% reliable.*
KEYWORDS -: *Home security system, microcontroller, CCTV, LCD.*

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I. INTRODUCTION

A security system is defined as to identify trespass, illegal entry into a protected area or a building and disagree with such unauthorized access to protect property and personnel from damage or harm[1]. Nowadays Security systems are mainly used in commercial areas, residential areas, industrial areas, schools areas, universities areas, hospital areas and military belongings for protection against theft or property damage, as well as personal protection against burglars. Car alarms also protect automobiles and their contents[2]. The security system is also used in prisons in order to watch over the prisoners and their movements. Today, the home alarm security system and closed-circuit television(CCTV) system is an important part of any modern programmed home security system. The simple design of any home security system starts with considering the needs of the residents, measuring existing hardware and technology, reviewing the costs of the system, taking into account the watching choices and lastly scheduling the installation[3]. Now if we are going to look at the worlds one of the richest countries which are united states of America (USA) we can see that they are placed 6th in auto theft and 9th in break-in[4]. Their investigation also indicates that most of the break-in happened in banks, residential area, as well as an office. Non-Automated home alarm security systems were found non-reliable. Doors were fitted with lock and key system which can be opened easily[5]. Even with the help of human presence as a security watchman may not be absolutely reliable. Every system from the past has been found to be very much vulnerable[6]. Our home is a place where security is must need, to keep all the appliances and vulnerable safe. You as the homeowner should have the full assurance to step out from your house with the feeling that nothing is going to happened to your Home[7]. This feeling will only arise when the house is fully equipped with a reliable home alarm security system. For this purpose, in this research, it has focused on the upkeep of home security[8].

This work, the liquid crystal display (LCD) is used as a user interface. Each one of the four walls has a light beam (transmitter) and light dependent resistor (receiver) the light beam is pointing at the light dependent resistor (receiver) the system also has a real-time clock that use to save the time of when last a particular wall crossed and can be view by the user when pressing the view mode button. When the system is powered on, it displays on the liquid crystal display (LCD) 'ALL 4 WALLS OK' and the motor that rotating the CCTV camera is by default located at the north wall[9]. Whenever a wall (say east wall) is crossed by an intruder the system will alert the user (through buzzer) and display on the liquid crystal display(LCD) 'EAST WALL CROSSED' the system will also save the time at which the east-wall was crossed and will automatically control the motor to rotate and stay at east-wall in order to capture the real-time video of the area using closed circuit television(CCTV) camera that is mounted on the motor[10]. The system will remain at the east wall and keeps alarming the user with the help of buzzer until another wall is crossed at the same time if all the walls are crossed it will still notify the house owner by displaying on the LCD the amount of the walls crossed[11].

II. MATERIALS AND METHODS

2.1. Materials

The materials used in this research are shown in table I

Table 1: Materials

S/N	Components	Number of used
1	Resistor	11
2	Liquid crystal display(LCD)	1
3	Peripheral interface controller	1
4	Light dependent resistor(LDR)	4
5	Light emitting diode(LED)	4
6	Buzzer	1
7	Transistor	5
8	Oscillator	1
9	Connections	21

2.1.1 Microcontroller (Pic16F877A)

A microcontroller is an extremely combined device, which includes one chip, all, or most of the parts needed to perform an application control function. The PIC (peripheral interface controller) is an integrated circuit (IC) which was established to control peripheral devices, improving load from the central processing unit (CPU). It also has a low memory capacity, it is also used in performing calculations and is controlled by software just like central processing unit (CPU). It is used in the designs where a local resolution needs to be taken. The PIC16F877A is a high performance, low-cost CMOS, 8-bit microcontroller with RISC (Reduced instruction set computer) architecture as it has been mentioned earlier before, there are about 40 pins of this microcontroller IC. It consists of two 8 bit and one 16 bit timer. Compare and capture modules, serial ports, parallel ports, and five input/output ports are also present in it[12]. Figure 1 shows the pin configuration of the pic16f877a microcontroller. Also, the pins functions are explained in details.

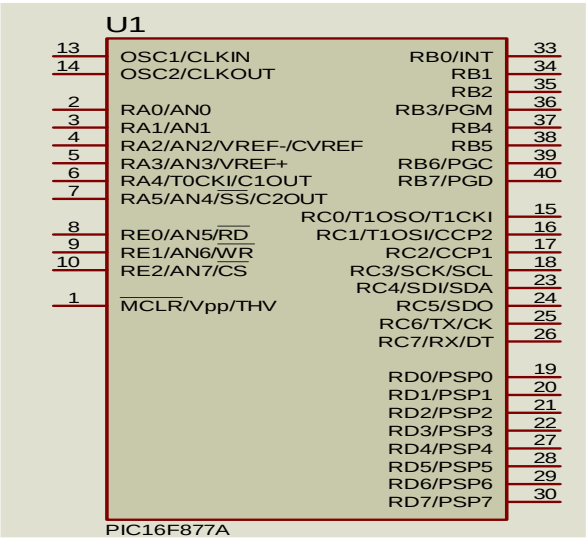

Figure1: Microcontroller PIC16F877A

2.1.2. Pin description of the microcontroller

1. Vss and Vdd

The Vss and Vdd are pins 11 and 12, 31 and 32 respectively. They are power supply pins. Vss is the negative supply while the Vdd is positive supply [4].

2. OSC1/CLKIN and OSC2/CLKOUT

The external clock is connected to these pins. The clock provides the required timing for the microcontroller.

3. MCLR

The MCLR is used to erase memory locations inside the PIC whenever there is the need to reprogram it. It is connected to the positive power supply in normal use.

4. The Input/output PORTS

These are a group of pins that can be simultaneously accessed. The PIC16F877A has 5 ports; portA, portB, portC, portD and portE which acts as physical connection of the central processing unit(CPU) to the outside world. On power up and reset, all the pins are configured as input pins by default. They can be however be reconfigured by the program [5].

i. PORTA

It is a 6 bits wide bi-directional port. RA0 – RA5 are purely bi-directional I/O pins while RA0 – RA3 can be used as an analog to digital conversion pins. RA4 – RA5 can be used as free run timers or counter in addition to Input/output function [5].

ii. PORTB

It is an 8 bits wide bi-directional port. RB0 – RB7are bidirectional Input/output pins. RB0 has an interrupt on change feature. RB1 to RB3 are purely bi-directional I/O pins while RB4 – RB7 also have the interrupt on change feature. The interrupt on change feature can be enabled only when the given pin is configured as an input pin [5].

iii. PORTC

It is an 8 bits wide bidirectional port. RC0 – RC7are bidirectional I/O pins.

iv. PORTD

It is an 8 bits wide bidirectional port. RD0 – RD7are bidirectional I/O pins.

v. PORTE

It is a 3 bits wide bi-directional port. RE0 – RE2are bidirectional I/O pins.

2.1.3. Microcontroller programming process

The software actually refers to the program code that is loaded onto the microcontroller's program memory. It is the execution of the instructions contained therein that aids the microcontroller in carrying out its primary function of controlling the peripheral devices attached to it. The program is usually written in assembly language and then assembled to generate a hexadecimal code file (machine code). Writing the program and assemble it is made easy by the availability of a group of software known as the MPLAB IDE with assembler called the MPASM assembler. The figure below shows the programming process of the microcontroller.

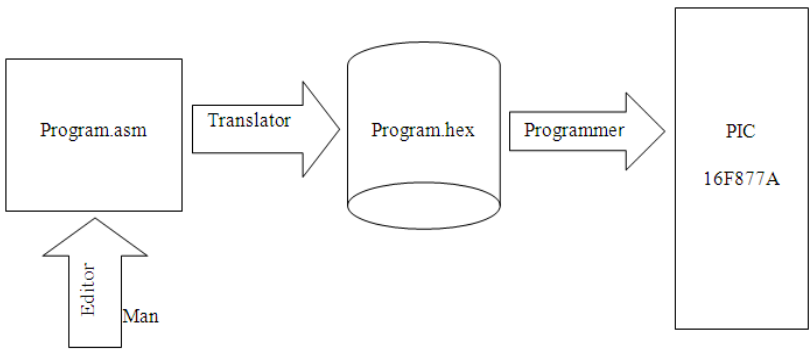

Figure 2: Microcontrollerprogramming process

2.2. Method

This section of the research handled the calculation and theoretical part of the design of the wall-crossed detecting security system against intrusion.

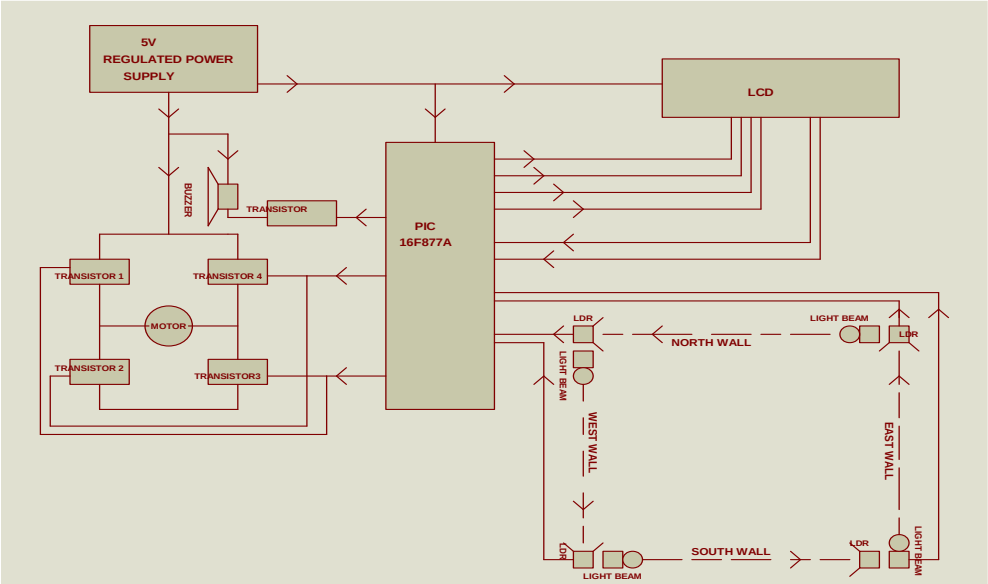

Figure 3: System block diagram

The above figure 3, is the system block diagram of this research, showing the method of operation. If the system is switched on, it displays the time and calendar on the liquid crystal display (LCD) and also display on the liquid crystal display (LCD) that all four walls are ok, That is if none of the four walls was crossed, but if one of the walls was crossed that is if they is interruption between the light dependent resistor(LDR) and the light emitting diode(LED) or light beam the system will immediately display the name of the crossed wall and rotating the motor that is carrying the closed-circuit television (CCTV) camera in order to start a real-time video recording while the buzzer will be on for alarm alerting the house owner until the system was reset. If all the walls were crossed at the same time, the system will be able to display them on the liquid crystal display (LCD) screen. In this simulation, the positive sign of the light dependent resistor (LDR) light beam means no intruder (wall not crossed) that is if the light dependent resistor is closed to the light beam and is not move away from it and the negative sign means intruder in between the light dependent resistor (LDR) and the light beam that is the light beam is moved away from the light dependent resistor by pressing the negative sign of the light beam(torch)[13].

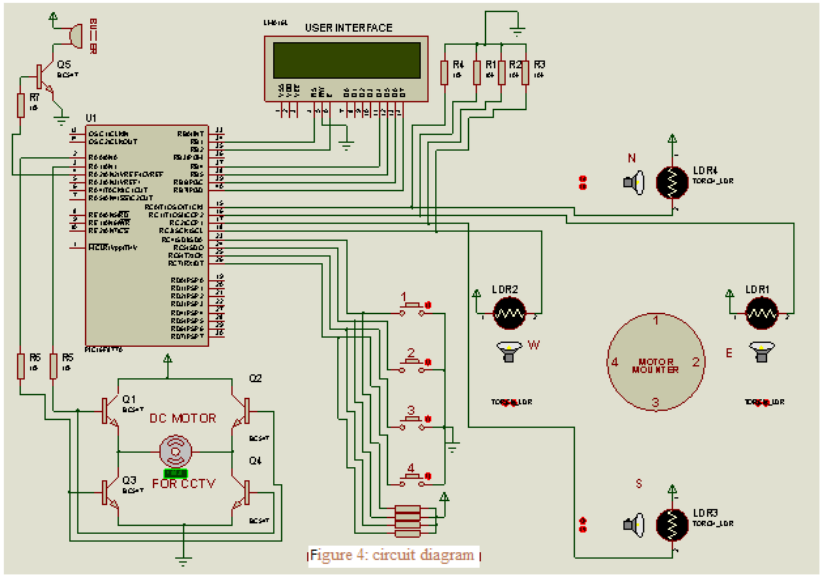

Figure 4: Circuit diagram

The above figure 4, is showing the complete circuit diagram of this research. Here the (PIC16F877A) microcontroller has five ports. Port A, Port B, Port C, Port D, and Port E. Almost every port has eight pins such as B0- B7 similarly C0-C7, D0-D7, except Port E, which has 3-pins E0-E2 and port A which has 6 pins A0-A5. Pin 2 is connected to transistor base Q2 and Q3 through 10 kiloohms resistors R5. Pin 3 is also connected to the base transistor Q1 and Q4 through 10 kiloohms resistor R6. This two pins, 2 and 3 of the microcontroller are responsible in turning the motor clockwise or anticlockwise since the closed-circuit television is mounted on the motor in case they are intrusion or interruption between the light dependent resistor(LDR) and its light beam(LDR TORCH). Pin 4 is connected to the transistor Q5 through 10-kilo ohms resistor which is responsible for switching the buzzer for notifying of an intrusion through 10 kiloohms resistor R7. Pin 15, 16, 17 and 18 is connected to a light dependent resistor(LDR) through a pull-down resistor of 10 kiloohms. Pin 23, 24, 25 and 26 are connected to push button through 10 kiloohms pull-up resistors. The push buttons are not physically to be used in the main simulation. They were just a contact that the motor has to stop when making a contact at one of the walls that crossed. The push button 1 is allocated to the north LDR, 2 to east LDR, 3 to south LDR and 4 to the west LDR. If the closed-circuit television is pointing to the south direction and north wall is crossed the motor will rotate the CCTV camera until it has contact with push button 1 which is allocated to the north wall and stop and take real video and images. Pin 40, 39, 38 and 37 is connected to liquid crystal display (LCD) data line which is responsible for displaying alphanumeric characters on the liquid crystal display when you press the play button in the simulation or if any wall is crossed.

2.2.1. Design equation

Below are the formula used in designing the system and their values obtained

$$I_B = \frac{I_C}{\beta} \quad (1)$$

I_B is the transistor base current

I_C is the transistor collector current

β is the transistor gain

$$V_C = I_B R_B + V_{BE} \quad (2)$$

V_{BE} is the transistor base-emitter voltage = 0.7v, for silicon

R_B is the transistor base resistor

$$\beta = \sqrt[2]{\beta_{max} \times \beta_{min}} \quad (3)$$

$$I_{sinking} = \frac{V_{CC}}{R_{pull-up}} \quad (6)$$

2.2.2. C945 is selected and used for switching. The following values were obtained from the data of the transistor shown in table 2 below.

Table II: Datasheet of the C945 transistor

Parameter	Symbol	Test condition	Min	Max	Unit
Collector-base breakdown voltage	$V_{(BR)CBO}$	I_C=1mA, I_E = 0	60		V
Collector-emitter breakdown voltage	$V_{(BR)CEO}$	I_C = 100uA, I_B = 0	50		V
Emitter-base breakdown voltage	$V_{(BR)EBO}$	I_E = 100μA, I_C = 0	5		V
Collector cut-off current	I_{CBO}	$V_{CB = 60v}$, I_E = 0		0.1	μA
Collector cut-off current	I_{CEO}	$V_{CE = 45v, R = 10M\Omega}$		0.1	μA
Emitter cut-off current	I_{EBO}	$V_{EB = 5v}$, I_C = 0		0.1	μA
DC current gain	$H_{FE(1)}$	$V_{CE = 6v}$, I_C = 1 mA	70	700	
DC current gain	$H_{FE(2)}$	$V_{CE = 6v}$, I_C = 0.1mA	40		
Collector-emitter saturation voltage	V_{Cesat}	I_C =100mA, I_B = 10mA		0.3	V

Base-emitter saturation	V_{BE}	$I_C = 100mA, I_B = 10mA$		1	V
Collector output capacitance	C_{ob}	$V_{CB} = 10V, I_E = 0, f = 1MHZ$		3.0	pF
Transition frequency	Fr	$V_{CE = 6v}$, I_C=10 mA F = 30MHz	200		MHz

the values below are obtained from the datasheet of the transistor C945.

$\beta_{min} = 70$ (4a)

$\beta_{max} = 700$ (4b)

$I_C = 100mA$ (5)

2.2.3. Light dependent resistor(LDR)

The light dependent resistor (LDR) is used to detect the crossing body, that is anything that will interrupt or block the light beam which is also known as the light emitting diode (LED) that makes the light dependent resistor (LDR) to be in darkness. Therefore, the calculation is going to be in two parts;

- When the LDR is in darkness, it sees no light, that is the light beam is blocked or moved away from it.
- When the LDR is in light, that is they are no interruption between the light beam and light dependent resistor.

In the presence of light

$$I_{LDR} = \frac{V_{LDR}}{R_{LDR}}$$

$I_{LDR} = \frac{5}{200}$= 25mA is the expected current passing through the LDR and 5volts is the voltage supplied by the microcontroller and 200ohms is the resistor of the light dependent resistor provided by the manufacturer. The light dependent resistor will be active at this stage indicating no walls crossed if all the walls are having a follow of such currents.

In the Absent of light

$$I_{LDR} = \frac{V_{LDR}}{R_{LDR}}$$

$I_{LDR} = \frac{5}{20000000}$= 0.000025mA, very low value, if the light dependent resistor see this current is showing that is not active it will output 0 volts which is a sign of interruption between the LDR and the light beam(LED).

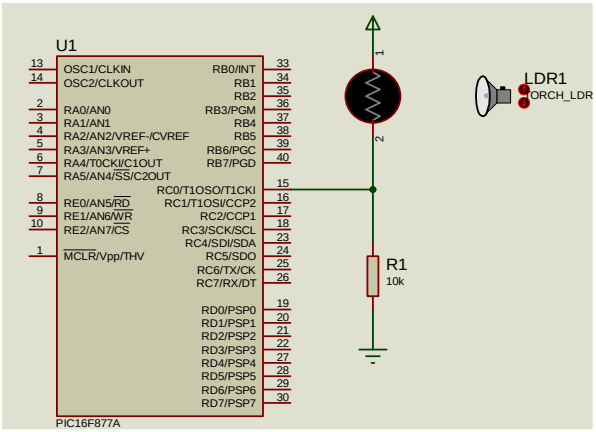

Figure 5: Is one of the lights dependent resistor(LDR) interface and how is calculated

2.2.4Light emitting diode (LED)

The following data are gotten from the datasheet of the LED

I_{LED} = 25mA, which is the current of the LED from the datasheet

V_{LED} = 1.8v, which is the voltage of the LED also obtained from the datasheet

$R_{LED} = \frac{V_{CC} - V_{LED}}{I_{LED}} = \frac{5-1.8}{25\times10^{-3}} = \frac{3.2}{0.025}$ =128Ω, is the resistor obtained using the above values of the LED.

2.2.5.Transistor driven buzzer

Substituting Equation (4a) and (4b) in Equation (3)in order to obtain the DC current gain of the transistor (β)

$\beta = \sqrt[2]{(700 * 70)} = 221.4$

Substituting β and equation (5) in equation (1)
Therefore,

$I_B = \frac{I_C}{\beta}$ (1)

$I_B = \frac{I_C}{\beta} = \frac{100\times10^{-3}}{221.4}$ = 0.0004517=451.7µA

And

V_{BE} = 0.7 (for voltage drop across a silicon transistor)

Substituting the above values in equation (2)

$V_C = I_B R_B + V_{BE}$ (2)

5 = 299×10^{-6}× R_B + 0.7

V_C is the voltage supplied to the microcontroller, which is 5 volts.

$R_B = \frac{5-0.7}{451.7\times10^{-6}} = \frac{4.3}{0.0004517} = \frac{9519.59}{1000}$

R_B = 9.52kΩ, is the base resistor obtained

2.2.5.For 8 ohms buzzer

$I_{BUZZER} = \frac{V_{BUZZER}}{R_{BUZZER}} = \frac{5}{8}$ = 625mA, 5 volts is voltage and 8 ohms is the resistor of the buzzer that comes with it. And 625mA is the value of the current obtained from the calculations and is the current passing through the buzzer that is going to make the buzzer active in case they is any interruption between the LDR and its light beam.

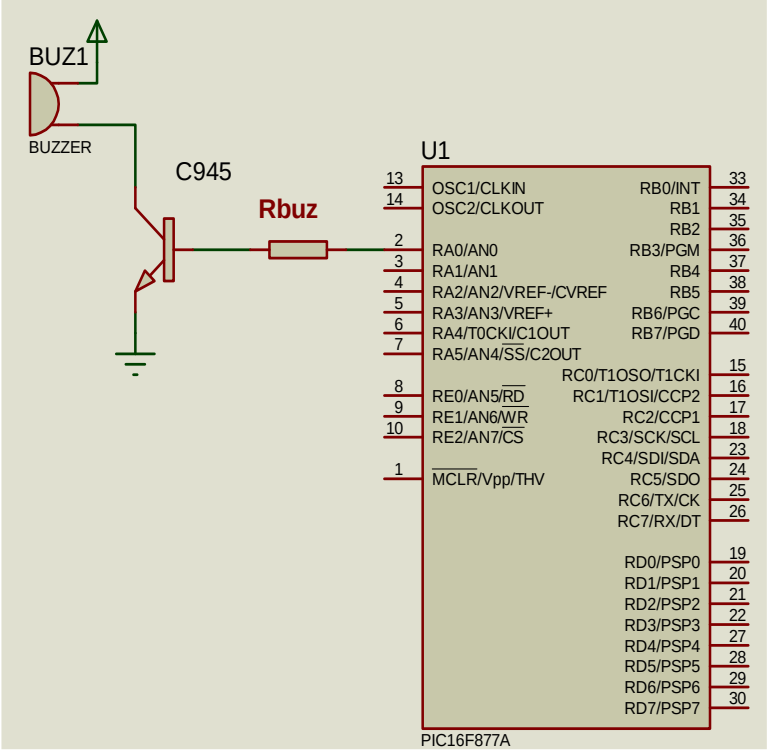

Figure 6: Transistor driven Buzzer

2.2.6. Push button

The push buttons are not physically to be used in the main simulation. They were just a contact that the motor has to stop when making a contact at one of the walls that crossed, that is if you want the motor to stop rotating you have to press the specific switch attached to that wall. The maximum sinking current of PIC is 25mA, therefore we need to calculate sinking current to be much less than the maximum sinking current.

$I_{sinking} = \frac{V_{CC}}{R_{pull-up}}$ (6)

$I_{sinking} = \frac{V_{CC}}{R_{pull-up}} = \frac{5}{10}$ = 0.5mA

Therefore, a 10kΩ resistor was used to meet the requirements set by the microcontroller manufacturers on the PIC sinking current.

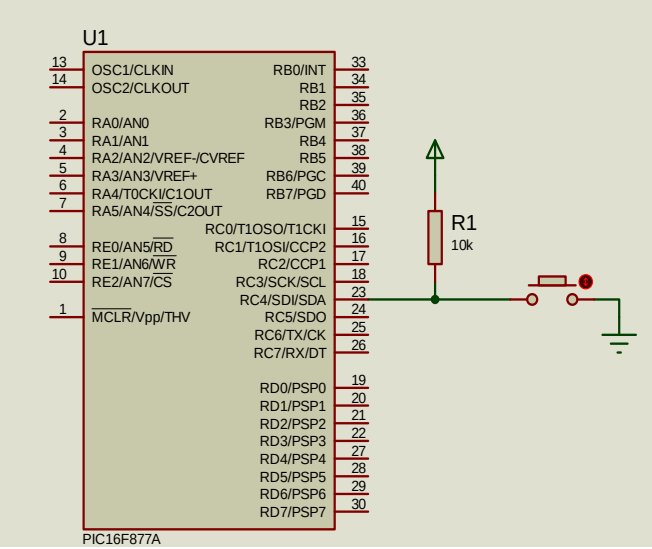

Figure 7: Push Button Sinking current

2.2.7. Dc motor

$I_{motor} = \frac{V_{motor}}{R_{motor}} = \frac{5}{8} = 625\text{mA}$

I_{motor} is the current drawn by the motor

V_{motor} is the voltage of the motor which is 5v

R_{motor} is the resistance of the motor 8Ω

The calculation of the transistor driven motor is the same with the transistors driven buzzer.

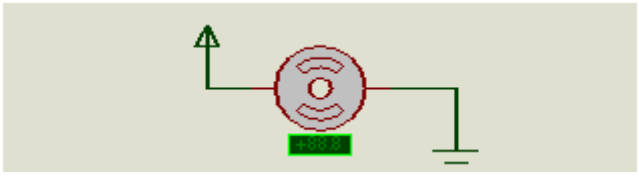

Figure 8: shows the current passing through the dc motor.

III. RESULTS AND DISCUSSIONS

This section is to deal with the description of the test performed on the various sections of the overall system and their corresponding result as well as result of the overall system. The system is purposely made to improve the effectiveness and reliability of wall-crossed detecting security system. Being something in which human life will depend on. The test carried out on the system as a whole and during the simulation process, the results obtained. The program for the wall-crossed detecting security system was written using MPLAB IDE. After the program was written, it was simulated using MPLAB SIM that is part of the MPLAB software. This was done to ensure that the program performed as expected and to detect any bugs that exist in the program. The circuit diagram was drawn using Proteus ISIS which is an electronics design software and the respective programs for the peripheral interface controller (PIC) were loaded into the designed diagram. The circuit was then simulated to see if it performed the desired function. All necessary corrections were made to the software at this stage until the desired results are obtained.

Table 3: Shows the simulation testing and results obtained

S/No	*Test Conducted*	*Result obtained*
1	Press the play button	Ports, LCD, sensors initializing & LCD display “time and date &“ALL WALLS OK”(shown in figure 9)
2	If the north light dependent resistor blocked from the light beam or moved away	LCD display “north wall crossed” system rotate the motor until when it makes contact to the north point (north button pressed) it then stops

	from it by the pressing the negative sign of LDR torch	to capture a real-time video by CCTV(shown in figure 10)
3	If the south light dependent resistor blocked from the light beam or moved away from it by the pressing the negative sign of LDR torch	LCD display "south wall crossed" system rotate the motor until when it makes contact to the south point (south button pressed) it then stops to capture a real-time video by CCTV(shown in figure 11)
4	If the west light dependent resistor blocked from the light beam or moved away from it by the pressing the negative sign of LDR torch	LCD display "west wall crossed" system rotate the motor until when it makes contact to the west point (west button pressed) it then stops to capture a real-time video by CCTV(shown in figure 12)
5	If east light dependent resistor blocked from the light beam or moved away from it by the pressing the negative sign of LDR torch	LCD display "east wall crossed" system rotate the motor until when it makes contact to the east point (east button pressed) it then stops to capture a real-time video by CCTV(shown in figure 13)

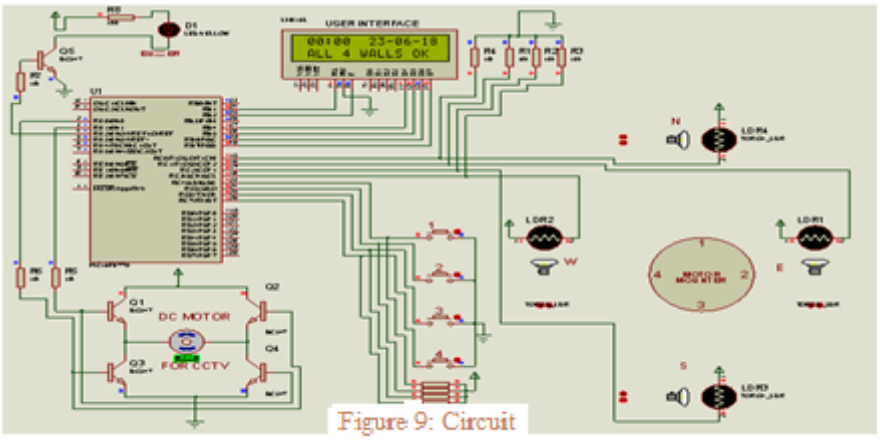

Figure 9: Showing the simulation result display on the liquid crystal display "All 4 walls ok"

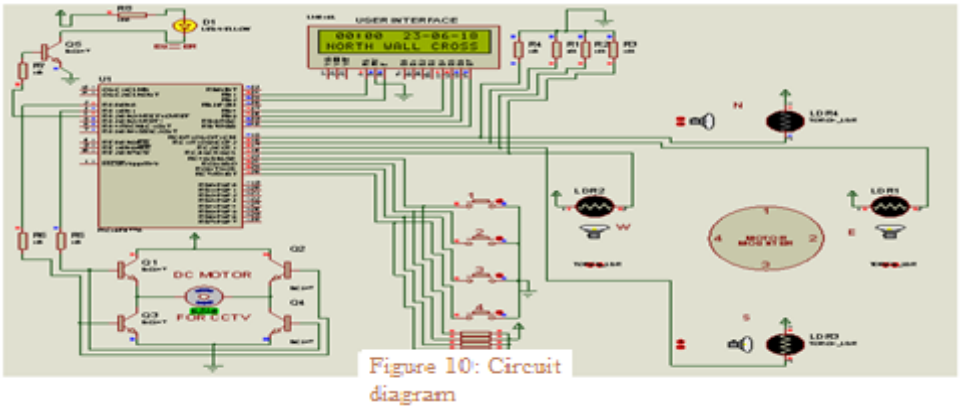

Figure 10: showing the simulation result displayed on LCD that north wall is cross(interrupted)

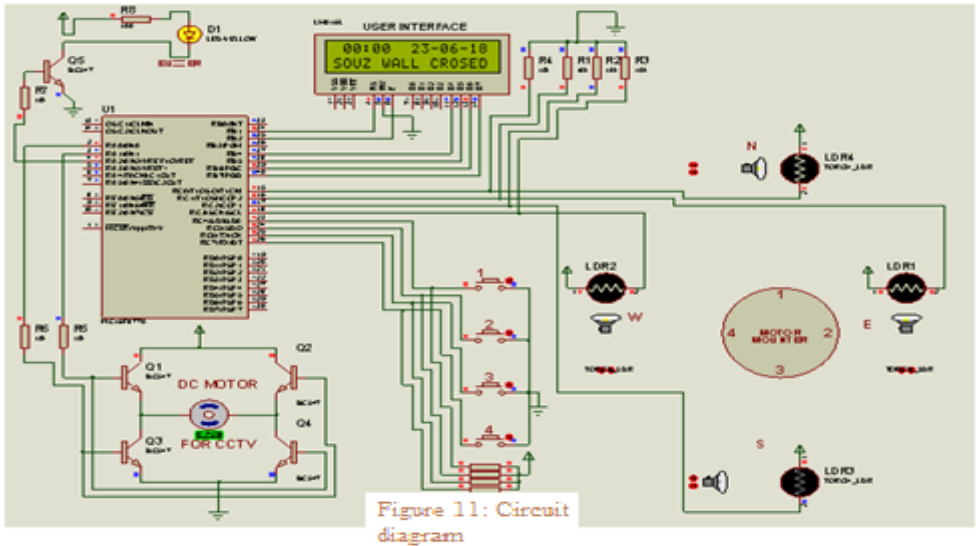

Figure 11: Circuit diagram

Figure 11: showing the simulation result displayed on LCD that south wall is cross(interrupted)

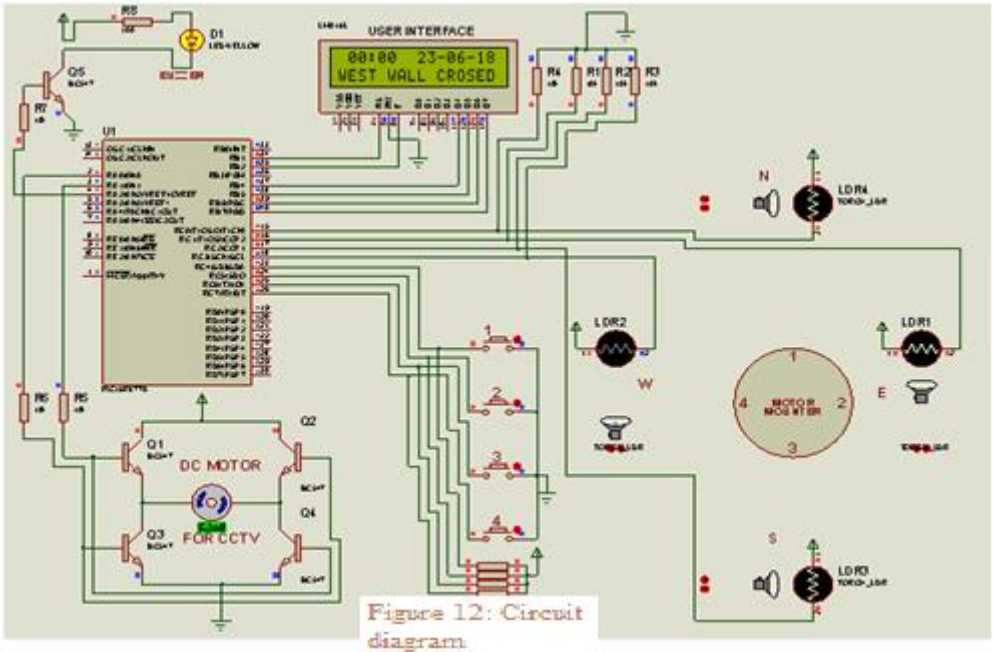

Figure 12: Circuit diagram

Figure 12: showing the simulation result displayed on LCD that west wall is cross(interrupted)

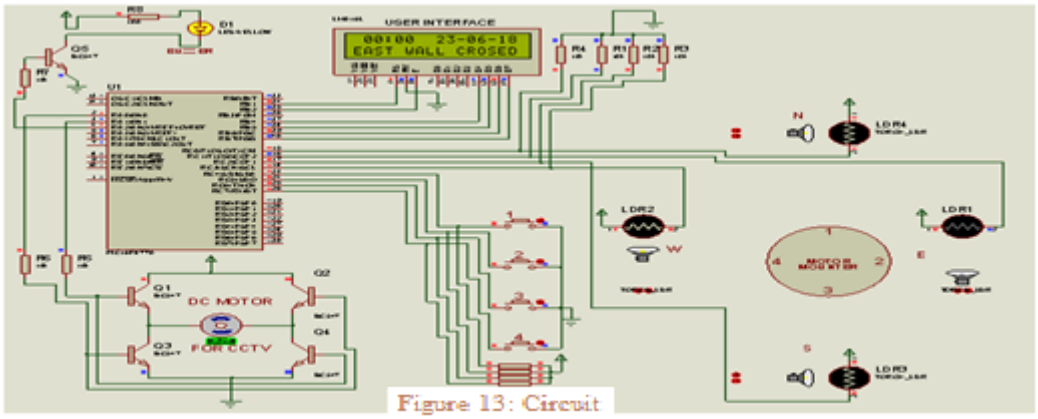

Figure 13: Circuit diagram

Figure 13: showing the simulation result displayed on LCD that east wall is cross(interrupted)

Reliability testing

The reliability of every system is very important. Especially a system like the one under consideration on which human life developed. In this section of the report will deals with how reliable this system will be seen. The reliability of a system falls within the range of 0 and 1or if calculated in percentage, within the range of 0% to 100%. It is not likely to have the extreme values of either 0 or 1 but lies between two extreme values. The reliability assessment procedure consists of the following:

1. List of component parts of the equipment,
2. State the basic failure rate for each part,
3. Multiply by the number of similar parts,
4. Multiply by all available weighting factors,
5. Add up all the products from steps (1) through (4) to give overall failure rate,
6. Determine the equipment reliability R, for a given operating time t, using the expression, R = e-πt

Table 4: Gives the reliability assessment of the research at 40°C operating temperature. The failure rate is given in percentage per 1000hours (%/1000hrs). The rating factor Wr is taken for operation in a normal office, laboratory or home.

Components	Number used	Basic failure rate,λi (%/10-3hrs)	The weighting factor due to the environment	Weighting factor due to temperature	Weighting factor due to Wr	Overall failure rate, λoi
Resistor	11	0.003	1.0	1.5	1.0	0.0495
LCD	1	0.02	1.0	1.5	1.0	0.03
PIC	1	0.02	1.0	1.5	1.0	0.03
LDR	4	0.002	1.0	1.5	1.0	0.012
Buzzer	1	0.002	1.0	1.5	1.0	0.003
Transistor	5	0.03	1.0	1.5	1.0	0.225
Oscillator	1	0.005	1.0	1.5	1.0	0.0075
LED	4	0.01	1.0	1.5	1.0	0.06
Connection	21	0.001	1.0	1.5	1.0	0.0315

The overall failure rate of the system is the summation of the failure rates, λoi is given by

$\sum \lambda oi = \lambda T = 0.0495 + 0.03 + 0.03 + 0.012 + 0.003 + 0.225 + 0.0075 + 0.06 + 0.0315 = 0.4485\%/1000hrs = 0.4485 \times \frac{1}{100000} = \frac{0.4485}{100000} = 4.485 \times 10^{-6}$

For the operating time of one year, that is 365 days

t = 24hrs x 365 = 8760

Therefore, the failure rate of the device for a year, $\lambda_T \times t = 4.485 \times 10^{-6} \times 8760 = 0.03929$

The reliability, R(t) =e^(-λ_T×t)=e^(-0.03929)= 96%. From the value obtained, it can be seen clearly that the system would be quite reliable under favorable conditions and is going to be dependable for its operation.

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IV. CONCLUSIONS

In this research, it has been seen that the simulation model works successfully without any basic error. So this research can be applied in the practical field. Besides the cost of this research is not too much expensive. Here the one closed-circuit television has provided utmost security than using four closed-circuit television, so you can see it is quite impossible for any intruder to enter the secured environment without concern of the owner. Some features can still be added for further research like SMS notification in case if an intruder enters the secured environment instead of to sound an alarm it will automatically send an SMS to the house owner. The operation of the complete research was simulated and expected results were obtained. Also after conducting reliability tests, the system was seen to be sufficiently reliable and capable of performing its function. Therefore, it can be concluded that the aim of this research has been achieved, which is a simulation of a security system against any kind of intrusion.

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