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Research Article

Artificial Intelligence-Powered Four-Wall Intrusion Prevention System using PIC Microcontroller: Suggestions for Further Development and Growth

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Abstract

Today's society relies heavily on digital electronics, particularly in the security sector, and is highly integrated. In order to protect the north wall, south wall, east wall, and west wall, a security system was created for this study. A light-emitting diode (LED) and a light-dependent resistor (LDR) are used in the sensor that is installed on each wall. The light-dependent resistor (LDR) is prevented from receiving light from the light-emitting diode (LED) whenever someone or something passes the wall. This means that the peripheral interface controller, which serves as the brain of this study, receives a 0-volt output from the light-dependent resistor (LDR). The system instantly rotates the DC motor that holds the closed-circuit television (CCTV) camera to stop at the crossed wall in order to record a real-time video and send it to the buzzer whenever the peripheral interface controller detects 0 volts. This signals the liquid crystal display (LCD) to indicate that the specific wall has been crossed. The purpose of the buzzer is to alert others to an infringement. All of the walls are not being crossed if the peripheral interface controller (PIC) senses 5 volts from each light-dependent resistor (LDR) on the wall. The peripheral interface controller (PIC) will show "all walls ok" on the liquid crystal display (LCD) if every wall's light-dependent resistor (LDR) produces 5 volts. Because life depends on it, the system also shows a calendar (time and date) on a liquid crystal display (LCD). Approximately 96% of the system is predicted to be dependable based on calculations. To further develop and grow an Artificial Intelligence (AI)-powered four-wall intrusion prevention system using a PIC microcontroller, focus should be on integrating advanced sensor technology, incorporating more sophisticated AI/ML models, enabling Internet of Things (IoT) connectivity, and enhancing the system's ability to reduce false alarms.

Keywords: *Machine Learning, Artificial Intelligence (AI), Recommendations, Home security system, microcontroller, CCTV, LCD.*

I. INTRODUCTION

A security system is defined as a system 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, school areas, university 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 are important parts 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 one of the world's richest countries, which is the United States of America (USA), we can see that it is placed 6th in auto theft and 9th in break-ins [4]. Their investigation also indicates that most of the break-ins happened in banks and residential areas, as well as an office. Non-automated home alarm security systems were found to be unreliable. Doors were fitted with a 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 vulnerable [6]. Our home is a place where security is a must-need to keep all the appliances and vulnerable people safe. You as the homeowner should have the full assurance to step out from your house with the feeling that nothing is going to happen 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]. In 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 a light-dependent resistor (receiver). The light beam is pointing at the light-dependent resistor (receiver). The system also has a real-time clock that is used to save the time of when a particular wall was last crossed and can be viewed 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 rotates the CCTV camera is by default located at the north wall [9]. Whenever a wall (say the east wall) is crossed by an intruder, the system will alert the user (through a 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 the east wall in order to capture the real-time video of the area using a closed-circuit television (CCTV) camera that is mounted on the motor [10]. The system will remain at the east wall and keep alarming the user with the help of the 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 number of the walls crossed [11].

II. MATERIALS AND METHODS

2.1. Materials

The materials used in this research are shown in table I

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 and all or most of the parts needed to perform an application control function. The PIC (peripheral interface controller) is an integrated circuit (IC) that 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 a 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. Ashas been mentioned earlier, there are about 40 pins on 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 detail.

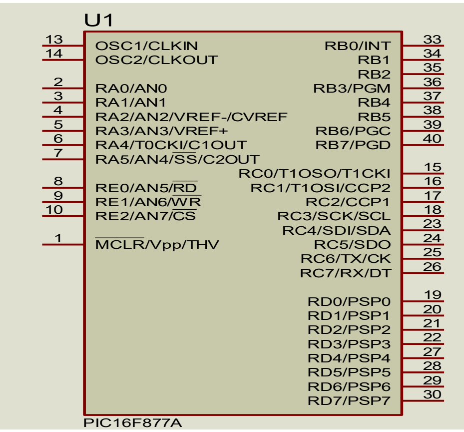

Figure_1: Microcontroller PIC16F877A

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 act as physical connections 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, however, be reconfigured by the program [5].

   i. **PORTA**
   It is a 6-bit-wide bidirectional port. RA0–RA5 are purely bi-directional I/O pins, while RA0–RA3 can be used as analog-to-digital conversion pins. RA4–RA5 can be used as free-run timers or counters in addition to the input/output function [5].

   ii. **PORTB**
   It is an 8-bit-wide bidirectional port. RB0–RB7 are bidirectional input/output pins. RB0 has an interrupt-on-change feature. RB1 to RB3 are purely bidirectional 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 assembling it is made easy by the availability of a group of software known as the MPLAB IDE with an assembler called the MPASM assembler.

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.

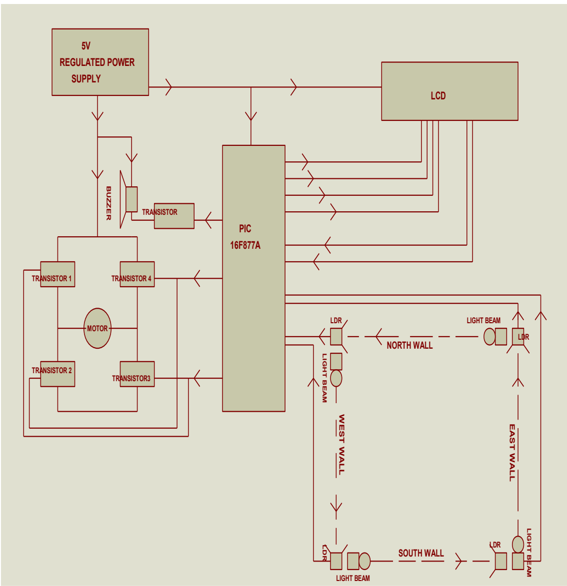

Figure 3: System block diagram

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 displays on the liquid crystal display (LCD) that all four walls are ok. That is, if none of the four walls were crossed, but if one of the walls was crossed, that is, if there is an 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 rotate 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 an alarm alerting the house owner until the system is reset. If all the walls were crossed at the same time, the system would 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, the light-dependent resistor is close to the light beam and is not moving away from it, and the negative sign means an intruder is 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].

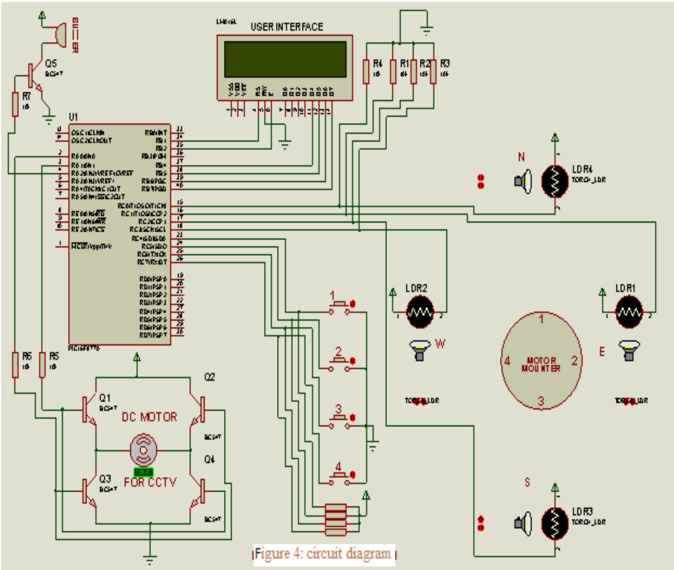

Figure 4: Circuit diagram

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 and similarly C0-C7 and 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 bases Q2 and Q3 through 10-kilohm resistors R5. Pin 3 is also connected to the base transistor Q1 and Q4 through the 10-kiloohm resistor R6. These two pins, 2 and 3 of the microcontrollers, are responsible for turning the motor clockwise or anticlockwise since the closed-circuit television is mounted on the motor in case there is intrusion or interruption between the light-dependent resistor (LDR) and its light beam (LDR TORCH). Pin 4 is connected to the transistor Q5 through a 10-kilo-ohm resistor, which is responsible for switching the buzzer for notifying of an intrusion through the 10-kilo-ohm resistor R7. Pins 15, 16, 17, and 18 are connected to a light-dependent resistor (LDR) through a pull-down resistor of 10 kiloohms. Pins 23, 24, 25, and 26 are connected to push buttons through 10-kiloohm 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 the east LDR, 3 to the south LDR, and 4 to the west LDR. If the closed-circuit television is pointing in the south direction and the 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. Pins 40, 39, 38, and 37 are connected to the 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 is the formula used in designing the system and their values obtained

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

I_B is the transistor base current

I_C is the transistor collector current

β is the transistor gain

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

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

R_B is the transistor base resistor

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

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

2.2.2. 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) be in darkness. Therefore, the calculation is going to be in two parts;

i) When the LDR is in darkness, it sees no light; that is, the light beam is blocked or moved away from it.
ii) When the LDR is in light, that is, there is no interruption between the light beam and the 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, 5 volts is the voltage supplied by the microcontroller, and 200 ohms is the resistance 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 flow 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 sees this current showing that it is not active, it will output 0 volts, which is a sign of interruption between the LDR and the light beam (LED).

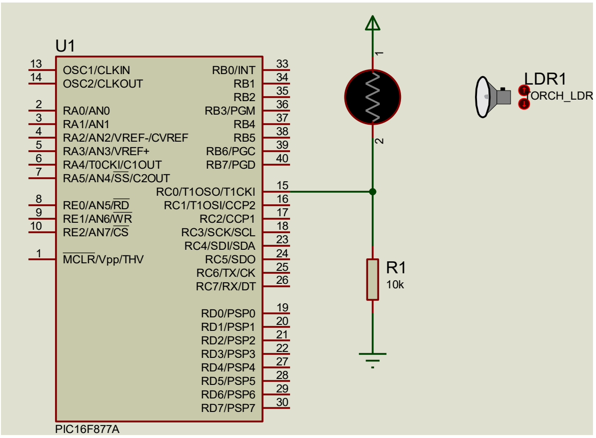

Figure 5: Is one of the lights dependent resistors (LDR) interface and how is calculated

2.2.3. Light 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.

2.2.4. 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)

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

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)

$5 = 299\times10^{-6}\times R_B + 0.7$

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 the voltage, and 8 ohms is the resistance of the buzzer that comes with it. And 625 mA 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 there is any interruption between the LDR and its light beam.

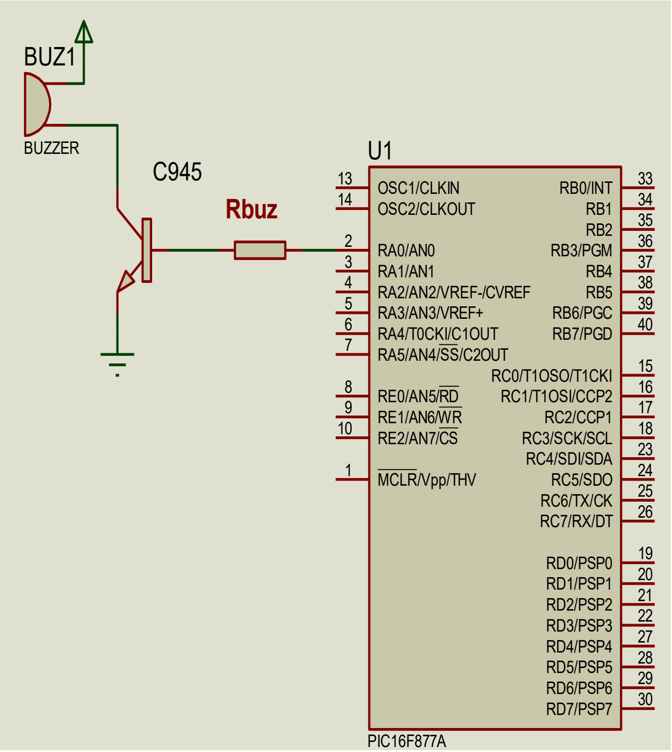

Figure 6: Transistor driven Buzzer

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 25 mA; therefore, we need to calculate the 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 10 kΩ resistor was used to meet the requirements set by the microcontroller manufacturers on the PIC sinking current.

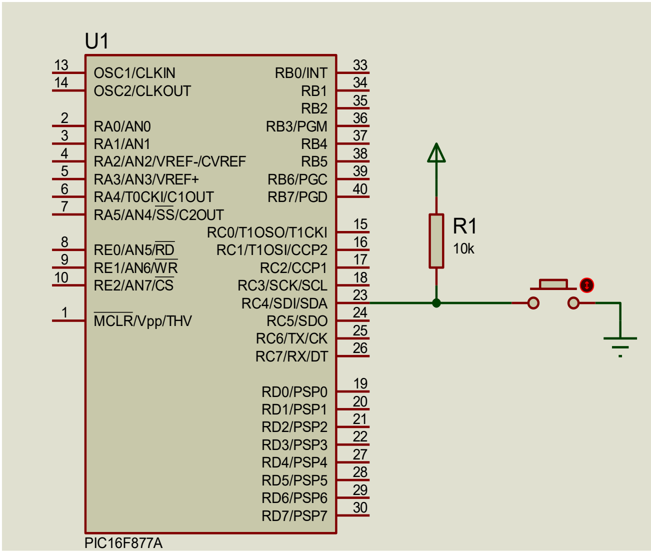

Figure 7: Push Button Sinking current

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.

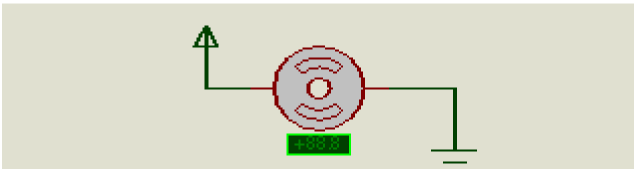

Figure 8: shows the current passing through the dc motor.

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 results, as well as the result of the overall system. The system is purposely made to improve the effectiveness and reliability of wall-crossed detecting security systems. Being something on which human life will depend. The test was carried out on the system as a whole, and during the simulation process, the results were 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, which 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 were obtained.

Table 2: Shows the simulation testing and results obtained

S/No	Test Conducted	Result obtained
1	Press the play button	Ports, LCD, and sensors initializing & LCD display "time and date & "ALL WALLS OK" (shown in figure 9)
2	If the north light-dependent resistor is blocked from the light beam or moved away from it by pressing the negative sign of the LDR torch	The LCD display "north wall crossed" system rotates the motor until it makes contact with the north point (north button pressed); it then stops to capture a real-time video by CCTV (shown in figure 10).
3	If the south light-dependent resistor is blocked from the light beam or moved away from it by pressing the negative sign of the LDR torch.	The LCD display "south wall crossed" system rotates the motor until it makes contact with 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 is blocked	The LCD display "west wall crossed" system rotates the motor

	from the light beam or moved away from it by pressing the negative sign of the LDR torch.	until it makes contact with the west point (west button pressed); it then stops to capture a real-time video by CCTV (shown in figure 12).
5	If the east light-dependent resistor is blocked from the light beam or moved away from it by pressing the negative sign of the LDR torch	The LCD display “east wall crossed” system rotates the motor until it makes contact with the east point (east button pressed); it then stops to capture a real-time video by CCTV (shown in figure 13).

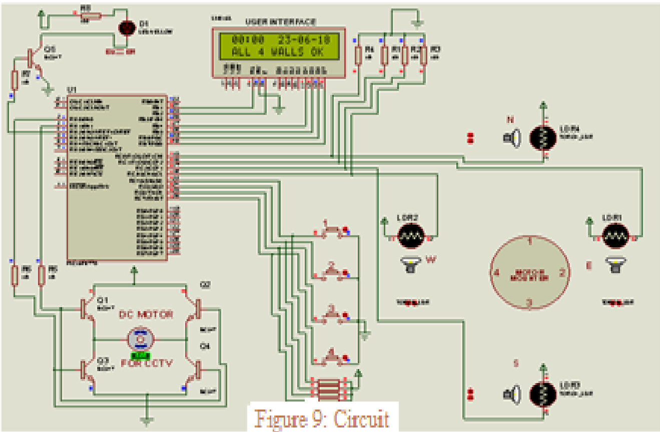

Figure 9: Circuit diagram

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

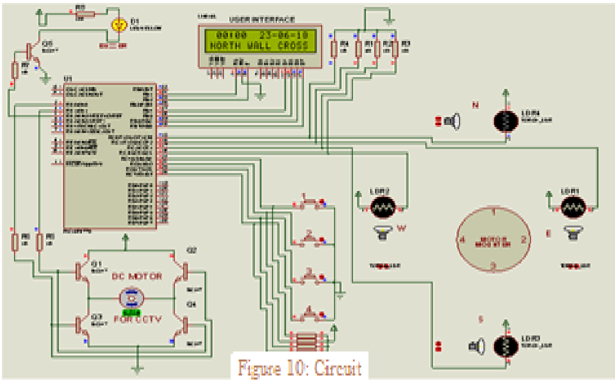

Figure 10: Circuit diagram

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

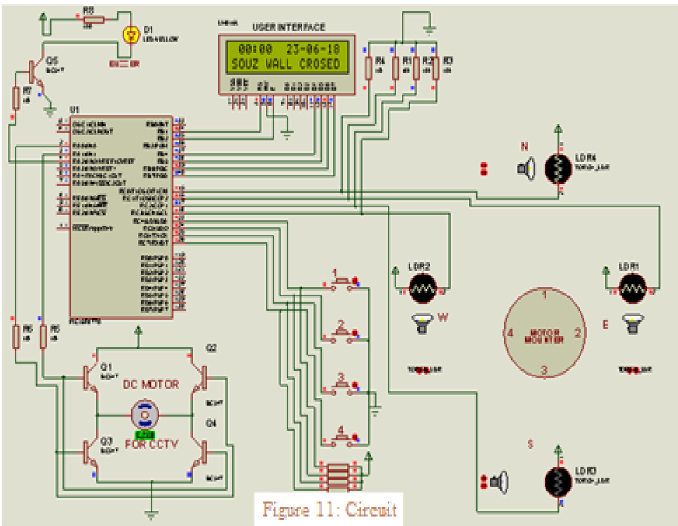

Figure 11: Circuit diagram

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

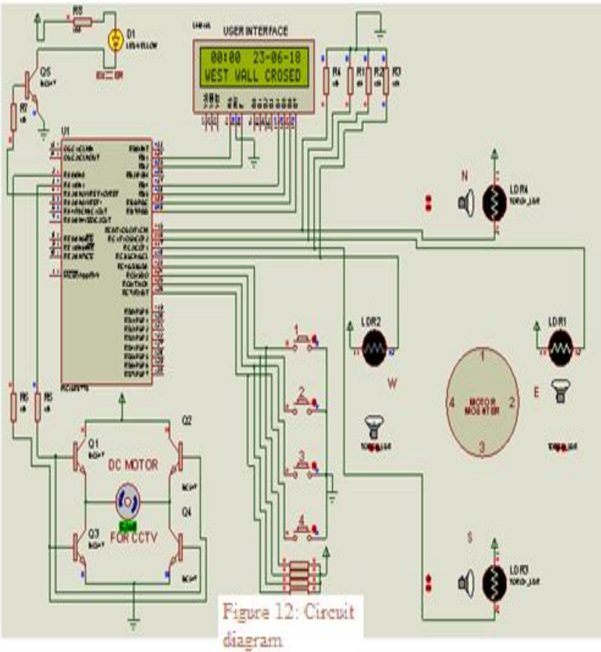

Figure 12: showing the simulation result displayed on LCD that west wall is cross(interrupted)

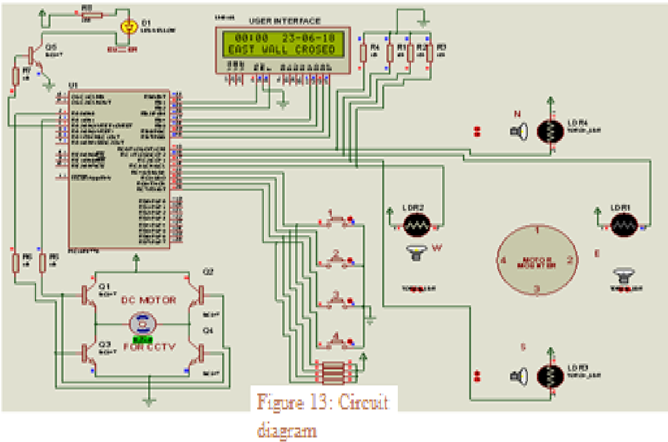

Figure 13: showing the simulation result displayed on LCD that east wall is cross(interrupted)

IV. CONCLUSIONS

It has been seen in this study that the simulation model functions well and without any fundamental errors [18]. Therefore, this research has practical applications. Furthermore, this research is not very costly. As you can see, it is nearly impossible for an intruder to access the restricted area without the owner's knowledge because one closed-circuit television has increased protection in this case compared to utilizing four. Some features, such as SMS notifications, can still be incorporated for future study. It will immediately send the home owner an SMS if someone breaks into the secured area rather than setting off an alarm. The entire study process was reproduced, and the anticipated outcomes were attained. Additionally, the system was found to be adequately dependable and capable of carrying out its purpose following reliability tests. Thus, it may be said that the research's goal—simulating a security system against every type of intrusion—has been accomplished [19-32].

Future development and expansion recommendations

i. **Cloud integration:** Explore cloud-based services for storing event logs and video footage. This provides redundancy and access to data from anywhere.

ii. **IoT integration:** Make the system compatible with other smart home devices. For example, the system could automatically turn on lights or lock doors upon intrusion detection.

iii. **Machine learning for anomaly detection:** For a more advanced project, integrate a small, low-power machine learning model to learn normal behavior patterns and detect anomalies, reducing false positives [17, 33-35].

REFERENCES

1. Hossain, M. K., Biswas, P., Mynuddin, M., & Morgalin, S. (2014). Design and implementation of smart home security system. *International Journal of Modern Embedded Systems, 2*(6), 7–10.
2. Olarewaju, I. K., Ayodele, O. E., Michael, F. O., Alaba, E. S., & Abiodun, R. O. (2017). Design and construction of an automatic home security system based on GSM technology and embedded microcontroller unit. *American Journal of Electrical and Computer Engineering, 1*(1), 25–32. https://doi.org/10.11648/j.ajece.20170101.14
3. Zungeru, A. M., Kolo, J. G., & Olumide, I. (2012). A simple and reliable touch sensitive security system. *International Journal of Network Security & Its Applications, 4*(5), 149–165. https://doi.org/10.5121/ijnsa.2012.4512
4. British Security Industry Association (BSIA). (2005, April). *Journal on security system section strategy for intruder alarm system* (pp. 1–3). https://www.thenbs.com/PublicationIndex/documents?Pub=BSIA
5. History of security alarms. (n.d.). http://www.icee.org/organization/historycenter/firealarm.html
6. Koenig, J. A., & Taylor, L. (n.d.). *Perimeter security sensor technology handbook* (pp. 67–86). Electronic Security Systems Engineering Division, North Charleston, U.S.A.
7. Karri, V., & Lim, J. S. D. (2005). Method and device to communicate via SMS after a security intrusion. In *1st International Conference on Sensing Technology* (pp. 21–23). Palmerston North, New Zealand.
8. Bing, Z., Yunhung, G., Bo, L., Guangwei, Z., & Tian, T. (2001). Home video security surveillance. In *Info-Tech and Infonet, ICII Beijing International Conference* (Vol. 3, pp. 202–208).
9. Mahmud, S. A., & Mohammed, G. A. (2006). Development of a simple sound activated burglar alarm system. *Leonardo Journal of Sciences, 9*(July–Dec).
10. Elfasakhany, A., Hernández, J., García, J. C., Reyes, M., & Martell, F. (2011). Design and development of a house-mobile security system. *Scientific Research, 3*, 1213–1224. https://doi.org/10.4236/eng
11. Khan, S. R., Al Mansur, A., Kabir, A., Jaman, S., & Chowdhury, N. (2012). Design and implementation of low-cost home security system using GSM network. *International Journal of Scientific & Engineering Research, 3*(3).
12. Kaur, S., Singh, R., Khairwal, N., & Jain, P. (2016). Home automation and security system. *Advanced Computational Intelligence: An International Journal (ASCII), 3*(3), 17–23.
13. Hasan, R., Khan, M. M., Ashek, A., & Rumpa, I. J. (2015). Microcontroller based home security system with GSM technology. *Open Journal of Safety Science and Technology*, 55–62. http://www.scirp.org/journal/ojsst
14. Nwalozie, G. C., Aniedu, A. N., Nwokoye, C. S., & Abazuonu, I. E. (2015). Enhancing home security using SMS-based intruder detection system. *International Journal of Computer Science and Mobile Computing, 4*(6), 1177–1184. http://www.ijcsmc.com
15. Adeline, I. N., Innocent, E. O., & Nkechi, A. (2017). Insecurity question and crime statistics in Nigeria: A case of Anambra State, 1999–2015. *Specialty Journal of Humanities and Cultural Science, 2*(1), 30–45. http://www.sciarena.com
16. Galadanci, G. S. M., Tijjani, A., & Muhammad, A. (2016). Automatic time-based street light control system. *Journal of the Nigerian Association of Mathematical Physics, 33*, 251–258. http://www.nanohub.org
17. https://www.google.com/search?q=recommendations+of+Design+and+Simulation+of+Four+Walls+Crossed+Security+System+against+Intrusion+Using+Pic+Microcontroller&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIGCAEQIxgnMgYIAhAjGCcyBwgDEAAYgAQyBwgEEAAYgAQyBwgFEAAYgAQyBwgGEAAYgAQyBwgHEAAYgAQyBwgIEAAYgAQyBwgJEAAYgATSAQoxMzEyOGowajE1qAIIsAIB8QUBvBk0nJ75GvEFAbwZNJye-Ro&sourceid=chrome&ie=UTF-8&udm=50&fbs=AIIjpHxU7SXXniUZfeShr2fp4giZ1Y6MJ25_tmWITc7uy4KIeoJTKjrFjVxydQWqI2NcOha3O1YqG67F0QIhAOFN_ob1xGdzU5Cnyn-oUzTul2B5TXRzAeIy3FI7wzggwHPeZE6A_YjAVf9uE0nNdQlAcGqqj5AFYH9gBj6Gco72idWfDSHyBqtc2Mn9Wkv0Fc0g3se9_tqrCpEpg1Mk49vFKkgil7s-SQ&ved=2ahUKEwixxqyF0MaQAxV4QEEAHSxjB1sQ0NsOegQIBBAB&aep=10&ntc=1&mstk=AUtExfASinvDECKtKGy-e2BKJm2O5ZoONI7R0HSTarUcizBW3Y9bbGc_RiCmCUsSvUO-3PKTeGSzu_sIpOra3n0U24Ayui0BQblOXyDGkX3mYIAnVUW8Dq7Eo-4AubiubQGIqEt3hLwwRjfB6MsxeT65O9hq6U9nLRi1T_vK9slyAH5j8dwY4b7ardjBbq416zg_UZCMURNPkB4eoyt_ro_p-OLS8G695fFGdV2VyGIDVGBu0_6ahiyezCMJdS1lv4wAclUZZpKT4AfFV68_j1mWlWgtw7NiuHLaKRhpewBBiTr-R5Q_JLGdgqm6cRf44bi6lmI8oTYrOH3jew&csuir=1&mtid=_5IAaYzcB5CjhbIPw--rwQ8
18. Cavas, M., & Ahmad, M. B. (2018). Design and simulation of four walls crossed security system against intrusion using PIC microcontroller. *American Journal of Engineering Research, 7*(12), 233–244.
19. Ibrahim, I. A., Abdurrahman, I. A., & Muhammad, A. B. (2025). Artificial intelligence enhanced wireless medical alert systems: Overcoming challenges, mitigating effects, and addressing limitations. *Global Journal of Research in Engineering & Computer Sciences, 5*(3), 53–58. https://doi.org/10.5281/zenodo.15521486
20. Ibrahim, I. A., & Baballe, M. A. (2024). Essential elements required for a successful AI application in the healthcare industry. *Global Journal of Research in Engineering & Computer Sciences, 4*(5), 46–51. https://doi.org/10.5281/zenodo.13755067

21. Ibrahim, I. A., & Baballe, M. A. (2024). Bidirectional people counters as a catalyst for smart cities in the technological singularity era. *JETIR, 11*(10).
22. Ibrahim, I. A., & Baballe, M. A. (2024). Developing a user-friendly smart blind stick for visually impaired individuals in the digital era. *JETIR, 11*(9).
23. Isa, A. I., & Muhammad, A. B. (2024). Overcoming facility management challenges using IoT-based smart energy management systems. *Global Journal of Research in Engineering & Computer Sciences, 4*(5), 95–99. https://doi.org/10.5281/zenodo.13823585
24. Ibrahim, I. A., & Abubakar, Y. (2016). The importance of identity management systems in developing countries. *International Journal of Innovative Research in Engineering & Management (IJIREM), 3*(1).
25. Ibrahim, I. A., Mohammed, I. B., & Saidu, B. (2015). Fraud management system in detecting fraud in cellular telephone networks. *International Journal of Innovative Research in Computer Science & Technology (IJIRCST), 3*(3).
26. Ibrahim, I. A. (2018). Nigeria's ethical issues in the use of ICT. *ITNOW, 60*(2), 12–13. https://doi.org/10.1093/itnow/bwy035
27. Lawal, L. S., et al. (2022). Digital health inclusion: A pilot study of health services deployment using communication satellite for the underserved in Nigeria. https://doi.org/10.2139/ssrn.4141456
28. Lawal, L. S., et al. (2022, November 16–18). Overview of satellite communications and its applications in telemedicine for the underserved in Nigeria: A case study. *Proceedings of the International Conference on Electrical, Computer, Communications and Mechatronics Engineering (ICECCME)*, Maldives.
29. Ibrahim, I. A., et al. (2025). Bluetooth smart attendance system design and simulation with SMS alert: Considerations and limitations. *JETIR, 12*(10), 404–412.
30. Ibrahim, I. A., & Abubakar, M. (2015). Technological adoption of e-commerce in Nigeria. *International Journal of Innovative Research in Engineering & Management (IJIREM), 2*(6).
31. Ibrahim, I. A., et al. (2025). Recommendations and future directions: A bidirectional visitor counter and gate control. *JETIR, 12*(10), 257–263.
32. Ibrahim, I. A., et al. (2025). Smart home control and management system design and development: Future directions. *JETIR, 12*(10), 404–412.
33. Ibrahim, I. A., et al. (2025). Harnessing the power of RFID tags technology with artificial intelligence: Enhancing efficiency and innovation. *JETIR, 12*(6), 648–653.
34. Ibrahim, I. A., et al. (2025). Sustainable power planning in the Kano zone through accurate long-term demand forecasting using machine learning. *JETIR, 12*(6), 107–110.
35. Ibrahim, I. A., Abdurrahman, I. A., & Muhammad, A. B. (2025). Navigating the challenges of artificial intelligence in healthcare: Overcoming barriers in the 4th industrial revolution and beyond. *Global Journal of Research in Engineering & Computer Sciences, 5*(3), 81–87. https://doi.org/10.5281/zenodo.15538505

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