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Design and Construction of Security Lighting System in University of Port Harcourt using Mobile Phone

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ABSTRACT

The aim of this work is to design and construct a security lighting system at University of Port Harcourt using a mobile phone technology which will serve as the control switch. This work seeks to solve the challenges of fatigue due to the manual system of turning ON/OFF the switch. The system has four different stages; the mobile phone which is input, and serves as the transmitter for controlling the security lights from anywhere in Nigeria as long as there is GSM network, GSM modem is the second stage which serves as the receiver, the Arduino which contains the microcontroller processes the information and extracts the message from the GSM modem, the switching stage which is the relay that is responsible for switching ON/OFF the security lights on campus. Simulations of this design were carried out with proteus software while MATLAB/SIMULINK was used to process information from Aduino. The best result from simulations was analyzed based on inclusion of all the components required. Upon completion of this work, an effective and reliable developed security lighting control system using mobile phone (with the same and different Network Providers) was achieved and this system controls series of lightning points at different locations within the campus with an impressive performance. Irrespective of the distance of the transmitter, time it takes to turn ON the light remains constant when operating on the same Network Provider.

Key words: GSM Modem, Mobile Phone, Arduino, SMS Commands, Microcontroller

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INTRODUCTION

To provide a level of illumination that will clearly identify people and objects and create a psychological deterrent to criminal activity in specified area under protection, light security is needed [1]. Outdoor security light is important to provide a safe and secure home or work environment and also in the process of locking your doors and windows it can impede a burglar's attempt to break into homes and businesses, and however with well-placed security lighting it can deter potential criminals and then provide a very safe passage at night [1]. According to [2], Security lighting will be found to exist in many diverse forms and it is not possible to quote particular levels of illumination that are needed because these vary across the different applications. For the achievement of this design the Arduino with printed circuit board (PCB) designed to use a microcontroller chip and other input and outputs is embedded according to [3, 4]. The board has other electronic components which are needed for the microcontroller to function and they have an excellent way to program and control electronic devices. Microcontrollers are an excellent way to program and control electronic devices. Microcontroller boards have a microcontroller chip and other useful connectors and components that allow a user to attach inputs and outputs [5]. For the Arduino to work a code must be written in the Arduino software to tell the microcontroller what to do [5, 20]. The use of a mobile phone wireless remote control tends to eliminate the need for an operator to be in direct contact with manual switches [6]. The security personnel in charge of these lights can be allowed to freely operate the light from anywhere in Nigeria or any safe environment [7].

This work is informed by the following problems which it aims to solve; lack of higher efficiency and productivity of good security lighting control, lack of easy access and adjustability of the electrical billing system to save energy and trying to avoid fatigue due to the traditional and manual way of going to turn ON/OFF the switch.

The solution to these problems will Support the efficiency of other security and safety installations within the university community, improve the likelihood of detecting unauthorized personnel and intruders within the university community and deter crime by providing illumination in University of Port Harcourt [8]. [9] opined that a mobile network moving at high speed above ground with a wireless link will be the only means of transporting data to and from passengers because it is predicted that the use of computers will be less in the next ten years. [10] provided security in an establishment using an RFID card assigned to different personnel which allows only the authorized personnel to have access into the secure area. This work could be further enhanced by interfacing or programming a remote control assigned to the authorized individuals or with GSM technology. [11] in their work proposed an internet based wireless home automation system for multifunctional devices including the security light control. It is very cost effective, and has a high flexible web-based solution which strongly affected its use in public space. [12] designed an automatic gate control using infrared remote with password protection feature. The use of password in the opening of the gate and switching ON/OFF the security light leads to some sort of delay.

MATERIAL AND METHODS

The security lighting system presented in this work consists of different important stages: the power supply stage, the input stage, the control stage, the switching stage, and the output stage. However, listed below are the materials and equipment used in achieving this work:

i. Arduino
ii. SIM900A GSM modem
iii. Relay
iv. Bulbs
v. Connecting Wires
vi. Mobile Phone
vii. Bread Board
viii Resistors
ix Capacitors
x Diodes
xi Light Emitting Diodes (LED)
xii Digital Multimeter
xiii Digital Multimeter
xiv Proteus Software

The security lighting system of University of Port Harcourt in this work is shown in figure 1. It consists of three major run way at the Abuja campus. Light 1, from Ofirima roundabout to the Delta Gate, Light 2 from Ofirima roundabout to the school main Gate along the bank lane and finally Light 3 from same Ofirima round about through the school ICT along student's hostel road. The Electrical lighting networks are connected to the Arduino such that whenever there is a signal from the mobile phone through the GSM network to GSM modem interfaced to the Arduino, an automatic timing (AT) command through the relay will be issued to turn the light ON or OFF [13]. As soon as the mobile operation sends out SMS message to the GSM modem, and the microcontroller receives the signal from the GSM modem, it gives corresponding AT command to the ports where all the security lighting network are connected.

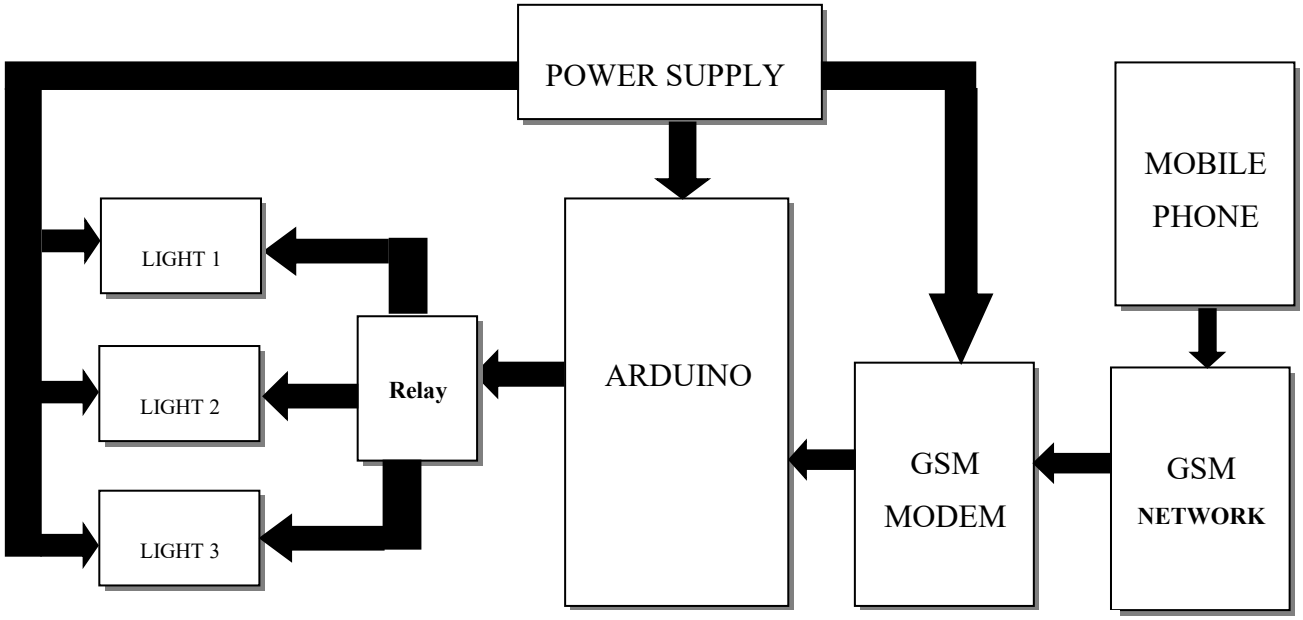

Fig. 1 Layout of the System in Block Diagram

The system design consists of hardware design, software design and fabrication. The hardware design is typically made up of initiating devices which is the mobile phone through the GSM modem, controlling device, and notification devices. These are the electrical security lighting network at University of Port Harcourt. Other part of the entire system is the

power supply section. The software aspect involves series of computer programs for interfacing each of the input and output devices with Arduino.

In order to overcome the disadvantages of bulky system, a transformerless power supply was used. It is a switch-based power supply. This transformerless power supply converts high AC input voltage (220V) to the desired output DC low voltage (12V) with low current output in milliamps. It is used in low power electronic applications with very low cost and takes less space. The concept of this power supply involves rectification, voltage division and regulation [14]. Figure 2 shows the basic circuit Diagram of a Power supply.

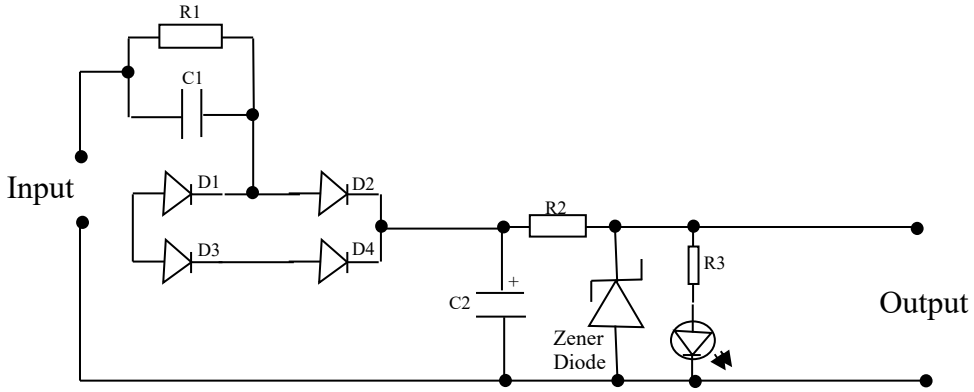

Fig. 2 Circuit Diagram of a Power Supply

The single-phase AC high voltage (220V) is converted into low DC voltage (12V). Diodes are used to rectify and regulate the desired DC voltage. The capacitor connected in series with the AC restricts the flow of AC current due to its reactance. It controls the flow of current to a specific value depending on its type [14]. Generally, an X-rated capacitor is used in this power supply. The resistor is used to dissipate the excess energy in the form of heat and the current. Diodes are used to rectify AC high voltage to DC low voltage [15]. The bridge rectifier circuit removes the negative voltage and stabilizes the peak voltage by the process of rectification. A Zener diode is used to remove the ripples and regulate the voltage. An LED is connected to test the circuit [16].

Working Principal of the System

When SMS command was sent to GSM module by the Mobile phone, GSM receives that SMS and sends it to Arduino. The Arduino reads the SMS and extract main command from the received string and store in a variable. After that, Arduino compares these strings with predefined string. If match occurred then Arduino sends signal to relay via relay driver for turning ON and OFF the security lights at different point. And relative result was seen on the point lights by using appropriate commands. This work comprised of three zeros of 5point light each of 6 watts bulbs.

Connecting GSM Module to Arduino

The communication between Arduino and GSM module were serial. The reason was because of serial pins of Arduino (Rx and Tx) used. With this, the Tx pin of GSM module was connected to Rx pin of Arduino and Rx pin of GSM module was connected to Tx pin of Arduino as shown in figure 3 [17]. Then the ground pin of Arduino was connected to ground pin of GSM module. The program objectives were described in figure 4.

1) To a specified mobile number inside the program, an SMS command was sent using Arduino and GSM Module
2) To the SIM card loaded in the GSM Module, an SMS was received using Arduino and GSM Module

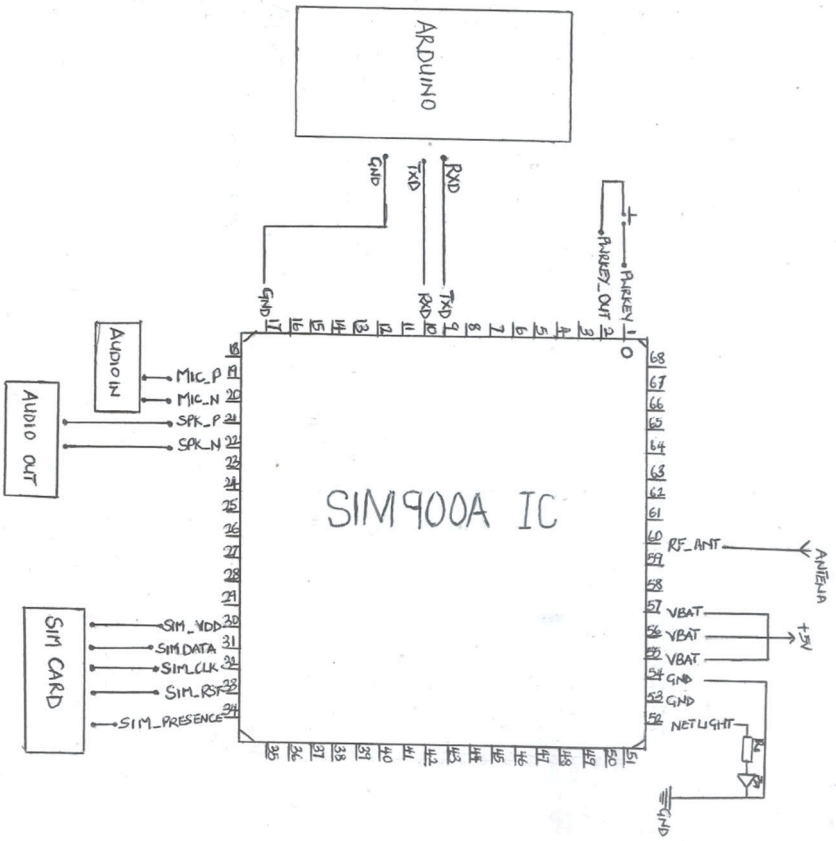

Fig. 3 A simple Circuit Diagram of SIM900 and Arduino [17]

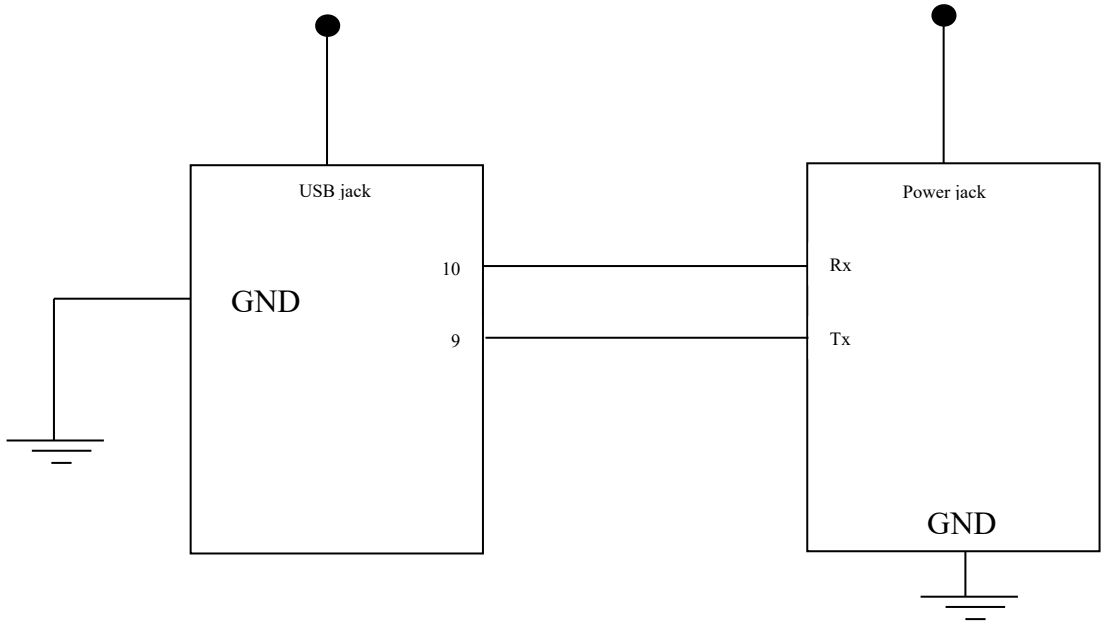

Fig. 4 Interface Diagram of Arduino to GSM module (Ogbonna BO& Okoye OE)

RESULTS AND DISCUSSION

The security Lighting system at University of Port Harcourt using a mobile phone is a very simple device which can be used for authorized switching of the entire University Security light remotely. Actually, this system can be used in place of the traditional switch which requires turning ON/OFF the light [18]. Performance evaluation for this device was carried out through simulation of a number of trials by generating various disturbances delay time [19] and was decided by observing the response time of the GSM modem. SIM cards of different network provider were inserted in both the transmitter (Mobile Phone) and the receiver (GSM Modem) to evaluate reliability of the network.

Result Analysis

Table 1 shows the response of the security light from the mobile phone with a full network coverage. The table indicates the number of sms sent, the distance at which it was sent (i.e., distance between the transmitter and the receiver) and the locations of the transmitters. From the table the time of turning ON of light is 1secs for all the locations despite the No of SMS sent.

Table -1 Response of the Security Light from the mobile phone with a full Network Coverage

No of SMS Sent	Turning ON of Light time (seconds)	Distance between the Transmitter (mobile Phone) and the Receiver (GSM Module) (KM)	Location of the Transmitter
1	1	4.1	Choba
2	1	11.8	Rumuokoro
3	1	17.3	Rumuola
4	1	34.6	Eleme
5	1	161.0	Asaba
6	1	228.8	Awka

Figure 4 shows the graph of No of SMS sent against the distance between the transmitter and receiver with a full Network Coverage. The graph indicates that as the No of SMS increases, the distance at which the receiver obtains signal from the transmitter changes gradually which implies a change of location of the transmitter. After about 4 SMS is sent, a sharp increase in the distance of the transmitter location is obtained. The distance (or location) further increases when more No of SMS is sent. This therefore implies that with a full Network Coverage the location of the transmitter determines the No of SMS that will be sent to turn ON the security light.

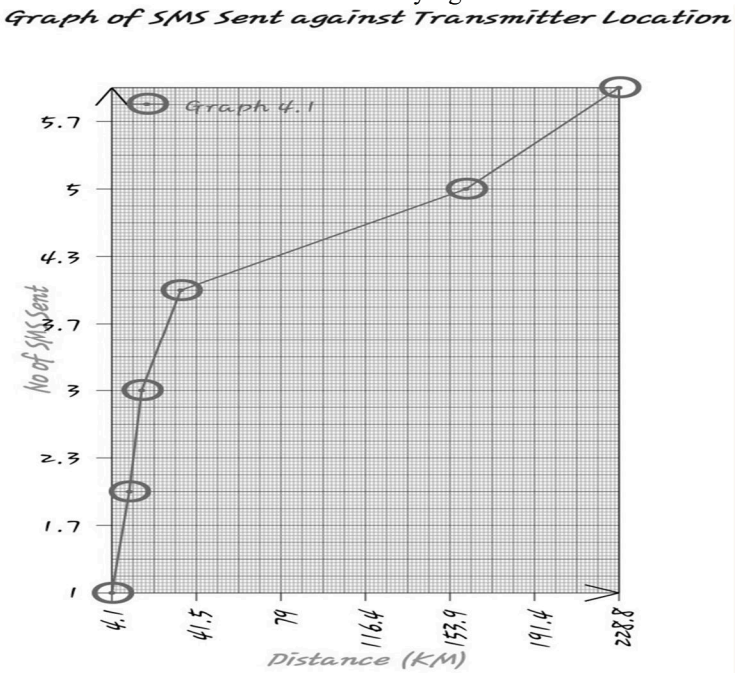

Fig. 4 Graph of No of SMS sent against the distance between the transmitter and receiver with a full Network Coverage

Basic statistics corresponding to Figure 4

Distance data peak	228.80
Distance data minimum	4.10
Distance data mean	76.27
Distance data Standard Deviation	86.62
Mean of Time to turn ON the light	7.19
Corresponding Standard deviation	1.93

Table 2 shows the response of the security light from the mobile phone with average network coverage. The table indicates the number of sms sent, the distance at which it was sent (i.e., distance between the transmitter and the receiver) and the locations of the transmitters. From the table the time of turning ON of light is 2secs for all the locations despite the No of SMS sent.

Table -2 Response of the Security Light from the mobile phone with an average Network Coverage

No of SMS Sent	Turning ON of Light time (seconds)	Distance between the Transmitter (mobile Phone) and the Receiver (GSM Module) (KM)	Location of the Transmitter
1	2	4.1	Choba
2	2	11.8	Rumuokoro
3	2	17.3	Rumuola
4	2	34.6	Eleme
5	2	161.0	Asaba
6	2	228.8	Awka

Table 3 shows the response of the security light from the mobile phone of different Network Providers (MTN for the Transmitter and Glo for the Receiver). The table indicates the number of sms sent, the distance at which it was sent (i.e., distance between the transmitter and the receiver) and the locations of the transmitters. From the table the time of turning ON of light changes for different locations of the transmitter with different No of SMS sent.

Table -3 Response of the Security Light from the mobile phone of different Network Providers (MTN for the Transmitter and Glo for the Receiver)

No of SMS Sent	Turning ON of Light time (seconds)	Distance between the Transmitter (mobile Phone) and the Receiver (GSM Module) (KM)	Location of the Transmitter
1	3	4.1	Choba
2	4	11.8	Rumuokoro
3	4	17.3	Rumuola
4	4	34.6	Eleme
5	5	161.0	Asaba
6	7	228.8	Awka

Table 4 shows the response of the security light from the mobile phone of different Network Providers (MTN for the Transmitter and Airtel for the Receiver). The table indicates the number of sms sent, the distance at which it was sent (i.e., distance between the transmitter and the receiver) and the locations of the transmitters. From the table the time of turning ON of light changes for different locations after No 1 SMS is sent. It remains constant until the No 4 SMS is sent. From Nos 5-6 SMS sent the time of turning ON of light changes for different locations.

Table -4 Response of the Security Light from the mobile phone of different Network Providers (MTN for the Transmitter and Airtel for the Receiver)

No of SMS Sent	Turning ON of Light time (seconds)	Distance between the Transmitter (mobile Phone) and the Receiver (GSM Module) (KM)	Location of the Transmitter
1	3	4.1	Choba
2	4	11.8	Rumuokoro
3	4	17.3	Rumuola
4	4	34.6	Eleme
5	6	161.0	Asaba
6	9	228.8	Awka

Table 5 shows the response of the security light from the mobile phone outside Port Harcourt and the Receiver inside University of Port Harcourt with the same Network Providers (MTN for the Transmitter and MTN for the Receiver). The table indicates the number of sms sent, the distance at which it was sent (i.e., distance between the transmitter and the receiver) and the locations of the transmitters. From the table the time of turning ON of light is 1secs for all the different locations despite the No of SMS sent.

Table -5 Response of the Security Light from the mobile phone outside Port Harcourt and the Receiver inside University of Port Harcourt with the same Network Providers (MTN for the Transmitter and MTN for the Receiver)

No of SMS Sent	Turning ON of Light time (seconds)	Distance between the Transmitter (mobile Phone) and the Receiver (GSM Module) (KM)	Location of the Transmitter
1	1	73.8	Umuagwo
2	1	87.7	Owerri
3	1	142.4	Orlu
4	1	162.2	Akokwa
5	1	177.3	Ekwuluobia
6	1	179.0	Oko

Figure 5 shows the graph of No of SMS sent against the distance of transmitter within Uniport Abuja Campus. The graph indicates that as the No of SMS increases, the distance at which the receiver obtains signal from the transmitter changes gradually which implies a change of location of the transmitter. After about 5 SMS is sent, a sharp increase in the distance of the transmitter location is obtained. This therefore implies that when the mobile phone is outside Port Harcourt and the Receiver is inside University of Port Harcourt with the same Network Providers (MTN for the Transmitter and MTN for the Receiver) the location of the transmitter also determines the No of SMS that will be sent to turn ON the security light.

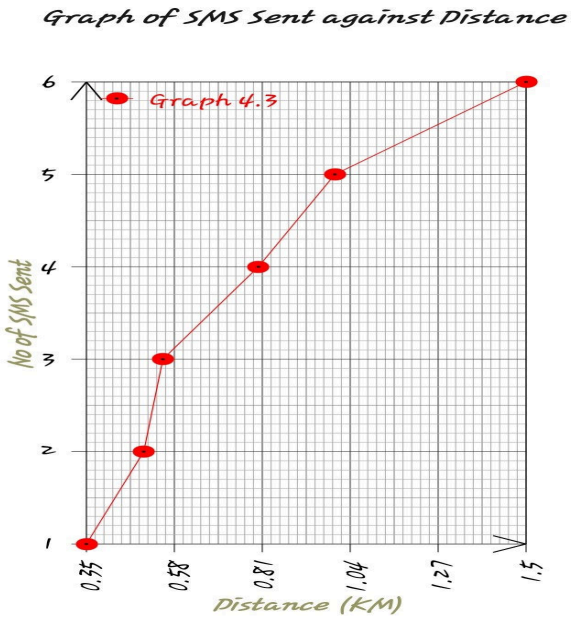

Fig. 5 Graph of No of SMS sent against the distance of transmitter within Uniport Abuja Campus

Basic statistics corresponding to figure 5

Distance data peak	1.50
Distance data minimum	0.35
Distance data mean	0.78
Distance data Standard Deviation	0.38
Mean of Time to turn ON the light	1.00
Corresponding Standard deviation	0.00

Table 6 shows the response of the security light from the mobile phone within the Abuja campus with the same Network Providers (MTN for the Transmitter and MTN for the Receiver). The table indicates the number of sms sent, the distance at which it was sent (i.e., distance between the transmitter and the receiver) and the locations of the transmitters. From the table the time of turning ON of light is 1second for all the different locations despite the No of SMS sent.

Table -6 Response of the Security Light from the mobile phone within the Abuja campus with the same Network Providers (MTN for the Transmitter and MTN for the Receiver)

No of SMS Sent	Turning ON of Light time (seconds)	Distance between the Transmitter (mobile Phone) and the Receiver (GSM Module) (KM)	Location of the Transmitter
1	1	0.35	Faculty of management sciences
2	1	0.50	Convocation Arena Round Abount
3	1	0.55	Ofrima Building
4	1	0.80	SSLT New Faculty
5	1	1.00	ICT Center Uniport
6	1	1.50	University Port Harcourt Main Gate

Figure 6 shows the graph of No of SMS sent against the distance of transmitter within Uniport Abuja Campus. The graph indicates that as the No of SMS increases, the distance at which the receiver obtains signal from the transmitter changes gradually which implies a change of location of the transmitter. After about 5 SMS is sent, a sharp increase in the distance of the transmitter location is obtained. This therefore implies that when the mobile phone is within Uniport, Abuja campus with the same Network Providers (MTN for the Transmitter and MTN for the Receiver) the location of the transmitter also determines the No of SMS that will be sent to turn ON the security light.

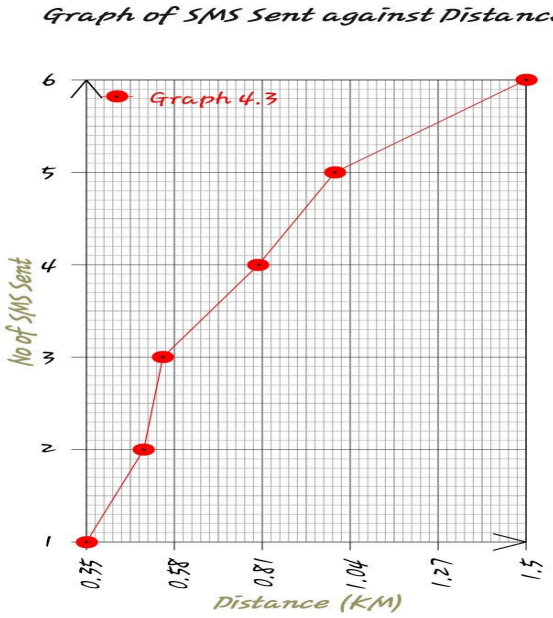

Fig. 6 Graph of No of SMS sent against the distance of transmitter within Uniport Abuja Campus

Basic statistics corresponding to Figure 6

Distance data peak	1.50
Distance data minimum	0.35
Distance data mean	0.78
Distance data Standard Deviation	0.38
Mean of Time to turn ON the light	1.00
Corresponding Standard deviation	0.00

Technical Specifications

Rated Voltage: 12V DC 1A
Working Temperature: -10^0C~ + 60^0C
Storage Temperature: -20^0C~ + 60^0C
Working Frequency: 850/900/1800/1900MHZ
Communication Protocol: GSM PHASE (Include data service)
Related Output Voltage: 3A/240V AC

The use of a mobile phone wireless remote control tends to eliminate the need for an operator to be in direct contact with manual switches. This means that whoever that is in control or in charge of the security lights can position themselves in safety, farther away from all the point lights within the institution community. The security personnel in charge of these lights can be allowed to freely operate the light from a safer environment. The following are the problems that this work solved;

i. This Mobile Phone wireless technology solved the problem of simplifying designs, installations and operation of lighting systems within Abuja Campus.
ii. This technology provided a solution in the way a user made a single environmental flexible enough to accommodate various visual needs.
iii. The other technologies are costly, they involve complicated hardwiring and even complex light management which uses the normal traditional light control protocols unlike this system.
iv. The problem of advanced interoperability which allows systems from different devices that has different functionalities to exchange data was totally solved with this system.
v. Lack of higher efficiency and productivity of good security lighting control.
vi. Lack of easy access and adjustability of the electrical billing system to save energy.
vii. Use of traditional and manual way can cause a lot of fatigue going to turn ON/OFF the switch at the right time.

Summary of Result

From the result analysis, the following were deduced:

1. Because the distance-time graph was a straight line, then the speed is uniform and since the time was constant, the speed of SMS was directly proportional to the distance covered. (speed= Distance/Time)
2. This showed that since the distance-time graph is given, the speed can be calculated using the slope of the graph.
3. The slope of the straight-line graph is the same irrespective of the interval that is chosen. This indicates that the speed of turning ON the light remains constant with the same Network Provider irrespective of the distance, but the time changes with change in distance when using different Network Provider.

CONCLUSION

Lighting is also an integral part of an effective home security system using the right tool and electronic components. Therefore, in practice:

1. Light provides an element of security lighting even though it may be quite marginal.
2. Arduino board is a printed circuit board (PCB) designed to use a microcontroller chip and other input and outputs. Arduino is made up of both hardware and software. The board has so many other electronic components which are needed for the microcontroller to function, which brought us to the world of mobile technology.
3. Mobile technology is the technology that goes where the user goes. This mobile technology has communications devices which are the computing devices and the networking technology that connects them.
4. Security lighting system using mobile technology is one them and it tends to give peace of mind to an occupant, a better sense of control to the occupant, adjustable electrical billing, unnecessary energy wastage, easy access to the functionality and easy access to be controlled from anywhere

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