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MICRO-CONTROLLER BASED WIRELESS REMOTE CONTROLLED LIGTHING SYSTEM USING RADIO FREQUENCY

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Abstract: **The remote-controlled lighting system is a system that can facilitate a convenient, flexible and easy way of controlling our lighting points and sockets. This study describes the design and implementation of an effective remote control lighting system which uses radio frequency (RF) transmitter and receiver module as its sensing device, HT12D as the decoder IC which converts its input serial data received from the RF transmitter to 12 bit parallel data, HT12E as the Encoder IC which transmit and receive 12 bit of parallel data serially, and the 74LS04 IC that invert the signal to the microcontroller through its six NOT gate pins. A 12v Relays was used to creates a magnetic field which attracts a lever and changes the switch contacts to display the operations of the system. It also employs atmega 328p microcontroller to execute its instruction. This system provides low cost and flexible home automation & intelligent light control system. The test results shows that the system works fine and covered relatively wide are of up 50 ft distance. This can be used both domestically and in industries, as it helps the disable and sick users to control the system from a far and wide distance. This RF remote controlled system when fully implemented will go a long way in ease the rigorous efforts to be applied in usage and control of lighting system.**

Keywords: Transmitter, Receiver, Microcontroller, Wireless, Encoder, Relays

1. Introduction

Remote control of lighting system in residential and industrial settings has become certainly an important utility. The ease in controlling the lighting system from a distant is enhanced with this type of system. Moreover, controlling lighting system remotely has improved safety in industrial and residential settings [15]. Wireless communication technology actually led to the rise in the remote control of lighting system. Wireless communication technology is a channel for conveying data or information commencing from one gadget to another [8]. The wireless communication technology comprises Bluetooth, microwave radio, satellite communication, ZigBee, broadcast radio, Global System for Mobile Communication (GSM), wireless fidelity (Wi-Fi), and Global Positioning System (GPS). In choosing the type of wireless communication technology, researchers always focus on the cost, efficiency, and the size of the system. This research work concentrate on a micro-controller based wireless remote controlled lighting system which utilizes radio frequency wireless network.

2. Literature Review

2.1. Communication Technology.

In this paper some essential communication technologies employed in designing a wireless controlled lighting system were discussed. The wireless technologies reviewed in this segment comprise Bluetooth, Zigbee, GSM module, and IoT.

2.1.1. **Bluetooth**.

Bluetooth remains a fast-speed small-range technology, that links electronic gadgets, portable equipment and phones together for the purpose of sharing information and resources [9, 20]. It works within 2.45 GHz frequency band. The key merit of Bluetooth is its low power consumption (around 0.3 mW). Nevertheless, the effective distance of coverage which can be used to control the lighting system remotely is very short compare to other wireless technology.

2.1.2. ZigBee Technology.

ZigBee which operates on IEEE 802.15.4 at a frequency of 868 MHz, 902–928 MHz, and 2.4 GHz is a type of wireless personal area network (WPANs) technology [10]. The ZigBee technology employs the usage of digital radio in order to boost the transmission of data or information from one gadget to another. This type of wireless technology is mostly employed by so many people because of its low cost and low power consumption. Furthermore, it possesses the capability to conceive equal to 65,000 nodes per network. Conversely, in comparison to the wireless fidelity (Wi-Fi) technology, ZigBee is not protected. Also, this technology has a restricted area coverage, compared to the Global System for Mobile Communication Module (GSM) technology.

2.1.4. **Global System for Mobile Communication Module (GSM).**

Global System for Mobile Communication (GSM) remains a digital cellular wireless technology, that is employed to transmit data services and mobile voice [25]. This kind of wireless communication technology functions at a frequency band of 1900 MHz, 1800 MHz, 900 MHz, and 850 MHz. Current GSM technology allows a high-speed data transfer. Yet, pulse-based burst transmission which form the bases for Global System for Mobile Communication (GSM) technology do interferes with certain electronics. Hence, places such as airplanes, hospitals and petrol bunks, do discourage the use of GSM mobile devices in their territories.

2.1.3. Internet of Things (IoT).

Internet of Things (IoT) denotes the combination of gadgets around the world, that are linked to the Internet for purpose collecting or sharing of data and instructions [18]. ESP8266 element is commonly connected to the Arduino Uno to ensure Internet connection. The practise of IoT enriches the loading of information on the cloud. Nevertheless, the problem associated with Iot is high risk of insecurity and privacy. There is possibility of leakage of significant documents or data to a third party when IoT is employed. Furthermore, hackers can also get into the cloud to reclaim vital documents.

2.2. Related Works.

Gokoza and Tastana developed air conditioning and lighting control system for smart homes using Internet of things (IoT) [24]. The effort was put in place to provide a smart and relaxed way of operating lighting and air conditioning system. This was implemented with NodeMCU embedded system microcontroller, Blynk iOS/Android interface developer and Arduino Pro Mini. This study flourished in operating domestic devices and appliances with a tablet or mobile phone. However, this system is more costly and require internet network to function all the time [2].

Some researchers also designed a proficient smart home management system using IoT [13]. This work cantered on improving the efficiency and security of a smart lighting system which was based on IoT. This was realized with the help of Secure Hash Algorithm 256 (SHA-256). The researchers add to existing knowledge by realizing the device with a web application, a piece of hardware, and server with high security. Though this research work was fruitful, but cannot function without presence of internet [2].

Swamy et al. also worked on a smart home lighting system [23]. This research work was done to developed a faultless smart home assistant to control domestic appliances effortlessly via speech instruction. The research work was accomplished with software and hardware modules that has speech recognition module. Natural language processing (NLP) was used to implement the speech recognition module. Though this system enhanced working mode of wireless lighting system, however accuracy in absence of an audible voice is actually a great challenge [19].

Lee et al. worked on a domestic lighting automated system using Zigbee wireless technic [14]. This work was done to reduce the energy consumption of domestic lighting system. Incorporating Zigbee wireless technology

into the lighting control system form the bases of the work. The proposed system produced by the research work was capable of saving up to around 11.81%. of the electrical energy. However, the system uses ZigBee technology that suffers Channel Noise and Low Transmission Rate [5].

A group of researchers developed an unmanned control and lighting system for schoolrooms [22]. This work was done to reduce the effect of leaving the appliances ON when no one is around in the classrooms, which has become the attitude of many students. The research was implemented with voice-controlled module, Arduino Uno and Bluetooth and was tested and used in a classroom. However, the system makes use of Bluetooth technology which suffers has short range communication and low bandwidth [17].

Hence radio frequency technology is employed in this work which is more stable, cheaper and cover considerable large area.

3. Methodology

3.1 Components Used

1. XFMR Step down Transformer
2. LM7805 Voltage regulator
3. 12mhz Crystal oscillator
4. 12v Relays
5. UNL2003
6. HT12D Decoder and HT12E Encoder IC for Remote Control Systems
7. 74LS04 Hex Inverting Gates
8. RF Transmitter and Receiver Module
9. Atmega328p Microcontroller

3.1.1 XFMR Stepdown Transformer

This is an inductive electrical device used for varying an alternating current (A.C) voltage, transformer comprises of dual magnetically coupled coils. A changing magnetic field created by alternating current in one (primary), induces a current in the second coil (secondary). The transformer was use to step down the 230 AV input voltage.

Figure 1: Diagram of an XFMR transformer [16]

3.1.2 7805 Voltage Regulator

7805 Voltage Regulator deliver a positive constant voltage of 5v for a diverse voltage on the input pin.

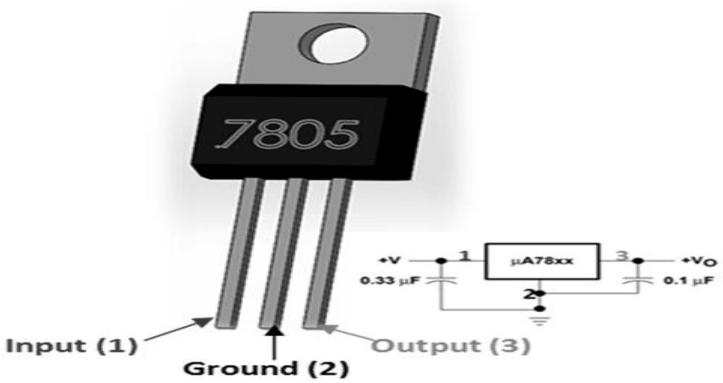


Figure 2: Diagram of a 7805 voltage regulator [6]

3.1.3 12MHZ Crystal Oscillators

This Oscillator which is an electronic oscillator circuit which employs mechanical resonance of an oscillating crystal of piezoelectric substance to form electrical signal that has a specific frequency. The frequency possess the capacity to provide a stable clock signal for digital integrated circuits, keep track of time, as in quartz wristwatches, and to stabilize frequencies for radio transmitters and receivers.

Figure 3: 12MHZ Crystal Oscillator [7]

3.1.4 12V Relay

A relay happens to be an electrically controlled switch. A magnetic field created by current flowing through the coil of the relay attracts the lever and alternate the switch contacts. The current in the coil can be on or off, this make relays to possess dual switch points and most have **paired throw (changeover)** switch contacts as shown in the figure below.

Figure 4: 12V Relay [3]

3.1.5 UNL2003

ULN2003 a contains seven open collector Darlington pairs with common emitters with high-voltage, high-current Darlington arrays. The rating of each channel is at 500 mA and can withstand up to 600 mA peak

currents. It also contains suppression diodes for inductive load driving and the inputs are held in opposite to the outputs to streamline board design. The ULN2003A was employed to drive circuits for relays in this research work.

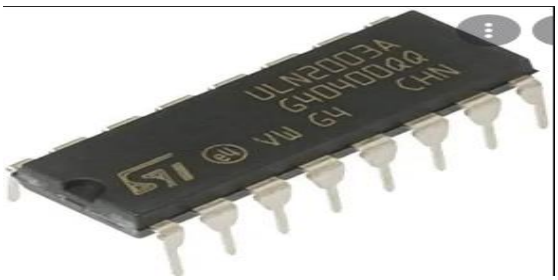
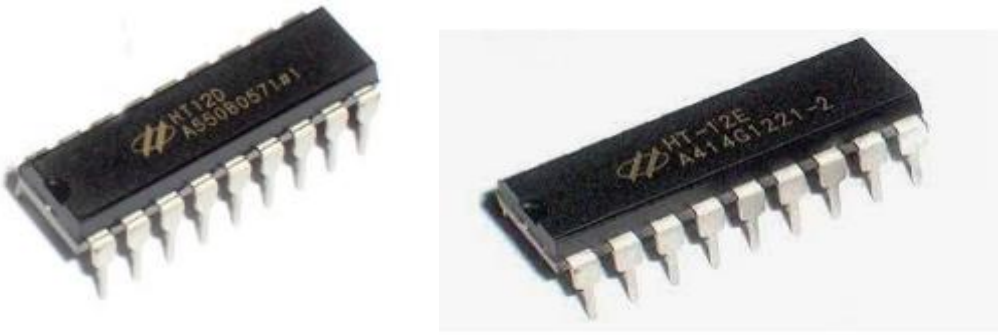


Figure 5: UNL2003 [4]

3.1.6 HT12D Decoder and HT12E Encoder IC for Remote Control Systems

HT12D is actually a 2^{12} series decoder IC (Integrated Circuit) for remote control applications. Is usually employed in radio frequency (RF) wireless applications. **HT12D** solely changes serial data to its input (may be received through RF receiver) to 12-bit parallel data. While HT12E is a 2^{12} series encoder IC (Integrated Circuit) used in remote control applications especially in radio frequency (RF) applications. By employing the paired HT12E encoder and HT12D decoder we will be able to transmit and receive 12 bits of parallel data serially.



a b

Figure 6: HT12D Decoder and HT12E Encoder IC for Remote Control Systems [21]

3.1.7 74LS04 IC

74LS04 a member of 74XXYY IC series, is a 14 PIN IC. It has a sequence of digital logic integrated circuits and has six NOT gates, which perform inverting function, hence the name **hex inverting gates**.

Figure 7: diagram of 74S04 IC [12]

3.1.8 RF Transmitter and Receiver Module

The RF modules which are 433 MHz RF receiver and transmitter modules operate over a certain distance and transmit precise volume of information around a data rate. This RF modules possess wide range of operating voltage i.e. 3V to 12V and are very small in dimension. There is no power consumption when transmitting logic zero while completely suppressing the carrier frequency thus using considerably low power in battery operation. When logic one is sent carrier is fully on to about 4.5mA with a 3volts power supply. The data is sent serially from the transmitter which is received by the tuned receiver as shown in figure below.

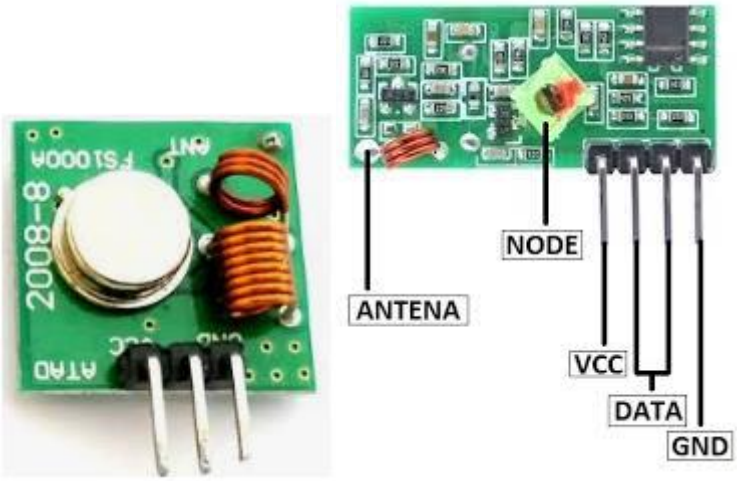


Figure 8: RF Transmitter and Receiver Module [11]

3.1.9 Atmega328p Microcontroller.

Atmega328p though based on modified Harvard architecture is an 8-bit RISC processor core microcontroller. This microcontroller has the principal function to control the relay in response to the input signal from the user. Additionally, it also helps in monitoring current flow of the power supply which result in detecting faults, as well as monitoring the light intensity of the lamp. The microcontroller converts the proportional analog voltage signal been received from the current sensor to a digital signal by the principle of the following equations:

$$V_{p-p} = \frac{ADC_{max} - ADC_{min}}{2^{10}} \times V_{ref} \quad (1)$$

$$V_{rms} = \left(\frac{V_{p-p}}{2}\right)\left(\frac{1}{\sqrt{2}}\right) \quad (2)$$

$$I_{rms} = \left(\frac{V_{rms}}{R}\right) \quad (3)$$

where

V_{p-p} = peak-to-peak voltage

V_{rms} = RMS voltage

I_{rms} = RMS current

V_{ref} = analog reference voltage input

R = sensitivity of current measured in ohms

ADC_{max} = maximum ADC value based on the input of the current sensor

ADC_{min} = minimum ADC value based on the input of the current sensor [1]

3.2 Constructional Units of The System

The development of the System under study comprises of four main units as follows;

1. The power unit
2. The input unit
3. The output unit
4. The processing unit

3.2.1 The Power Unit

The power unit energize the system to come up and get it ready for action or other processes. This comprises of XFMR step-down transformer, 100µf/25V capacitor, 7805 voltage regulator and 1kΩ resistor. In the power section, a voltage supplied to the system from the main supply is stepped down, rectified, filtered, regulated and applied to the system by switching on the system using the power button to the system.

3.2.2 The Input Unit

The input unit consists of a RF transmitter and a switch button. The RF transmitter module (remote) is a primary input unit as it helps the user to send the signal to the system either to activate or deactivate the light bulbs.

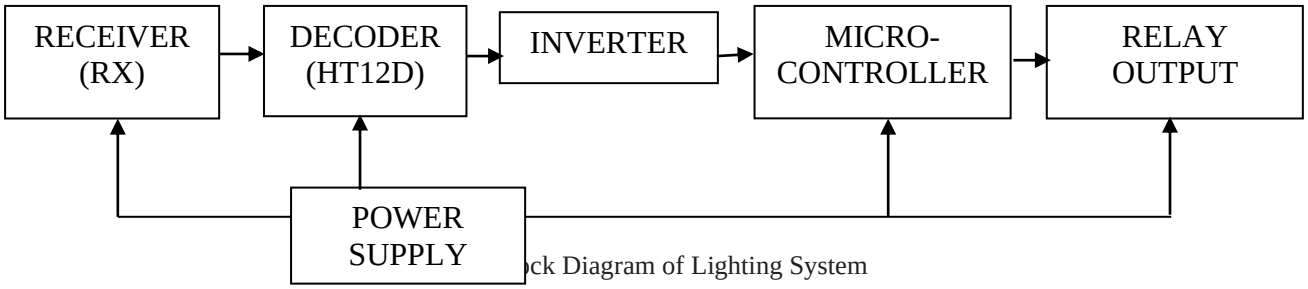
3.2.3 The Processing Unit

The processing unit is made up of elements that are capable of reading the signals sent from the input components, process them and sends appropriate signal to the output components. The main component here is the microcontroller.

3.2.4 The Output Unit

Light bulb socket is the output unit of the system. Socket allow bulb to be safely and conveniently inserted and replaced. This light bulb can be control by the remote/switch button through the radio frequency (RF) wireless technology.

3.3 Block Diagram



ock Diagram of Lighting System

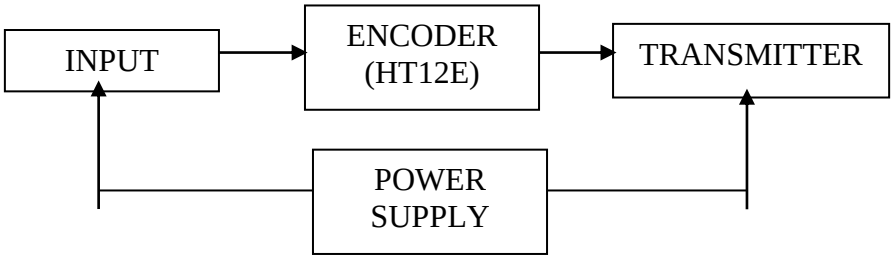


Figure 10: Block Diagram of Remote-Control Lighting System

3.5 Circuit Diagram of The System

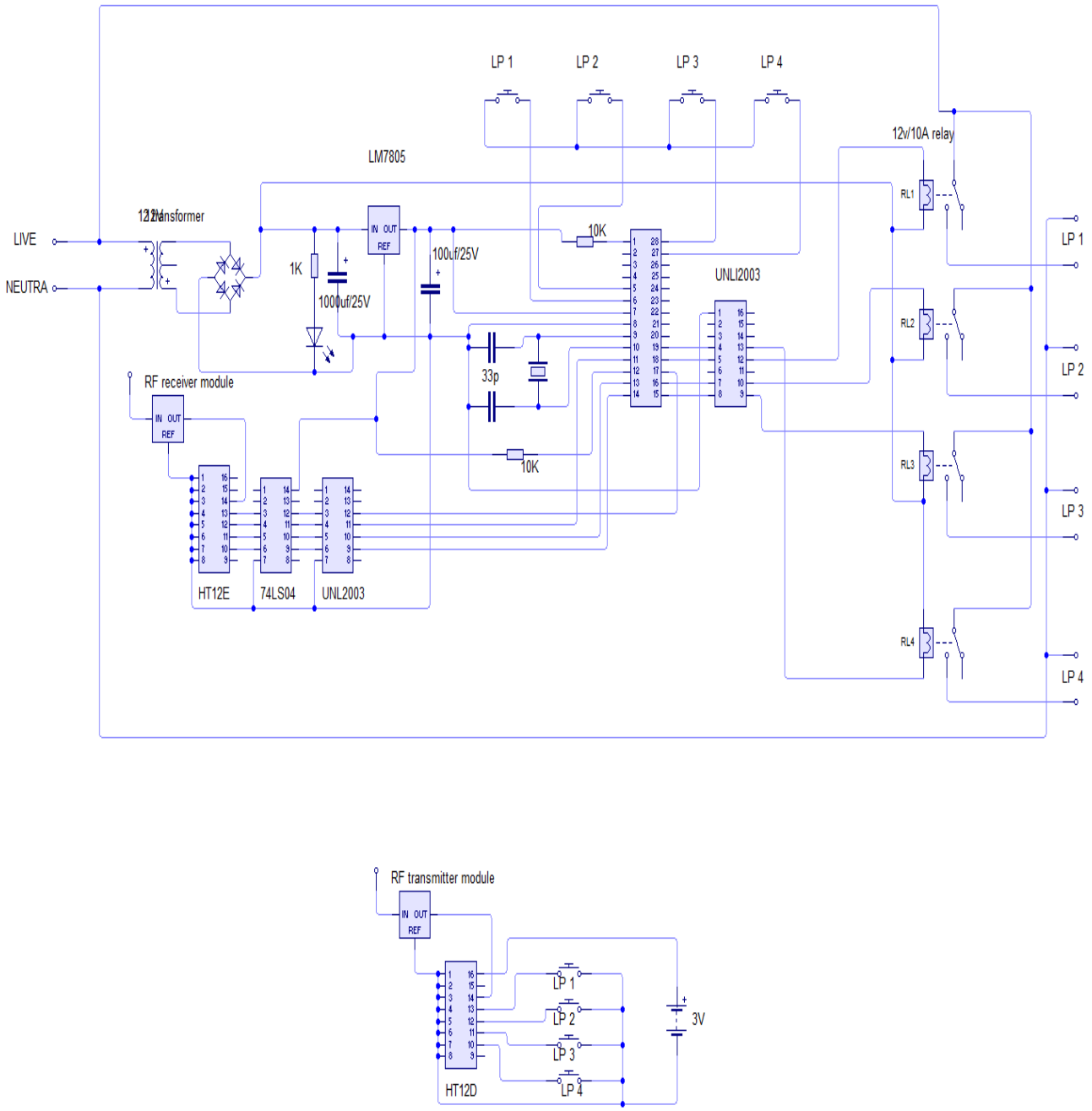


Figure 11: Circuit diagram of Remote-Controlled Lighting System

From figure 9,10 and 11 above the 220V from the main supply is been stepped down to a much lower 13.5voltage. The stepped down AC voltage from the XFMR is been rectified to a much stable DC voltage by the Bridge rectifier, the 100µF capacitor filters out all the remnant AC voltage in the rectified DC voltage before the DC voltage gets into 7805IC where it is been regulated and ready to be used by the microcontroller, decoder, encoder and other components that use 5Volts for their operation. The 7805IC provide a 5v constant output voltage for a varied input voltage. In the course of this project 7805 IC was used for some purposes.

A 12MHZ Crystal Oscillator circuit is use to create an electrical signal with a precise frequency. This frequency is often used to keep track of time, to provide a stable signal for system circuits, and to stabilize frequencies for RF transmitters and receivers.

The RF modules are 433 MHz RF transmitter, it transfer the signal to the RF receiver module and it must operate over a certain distance and transfer a certain amount of information within a data rate. It also has a wide operating voltage range i.e. 3v to 12v.

After sending the signal to the RF receiver module, the HT12D IC simply converts the serial data to its input (may be received through RF receiver) to 12bit parallel data.74LS04 IC receives the series data/data line. It has a series of digital logic integrated circuits. 74LS04 IC has six NOT gates, these NOT gates perform inverting function and send the signal to the microcontroller.

A 12v relay is an **electrically operated switch**. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have **double throw** (**changeover**) switch contacts and it was connected to the circuit to energies the signal to a more stable form.

4. Results and Discussion

The testing and analysis of this system was basically done in two parts; testing and analysis of the working and operation of the various component used for the design and the general testing analysis of the working and operation of the system at large.

4.1 Result from XFMR5 Stepdown Transformer

The XFMR5 transformer was tested using multimeter, the input and output voltage was tested by turning the multimeter to the ac volt meter section and also the input and output current was tested by turning the multimeter to the ammeter section. The result in the table 4.1 below shows that this transformer is ok for use in this research work.

Table 1: Showing XFMR5 Stepdown Transformer

1. Input Voltage (Vp)	2. 230v
3. Input Current (Ip)	4. 0.13A
5. Output Voltage (Vs)	6. 14.6v
7. Output Current (Is)	8. 2A
9. Transformer Power	10. 29.2 watt

From the table 4.1 above that the transformer will be able to drive easily the voltage regulator IC i.e. 7805 IC which require minimum of 5v respectively.

4.2 Input Voltages, Output Voltage and heat dissipation of the Voltage Regulator

A DC power supply panel equipped with a voltmeter, a multimeter, regulator IC 7805, and the black and red wires was used in the testing. The multimeter was place in the DC voltage setting while the Red and black wires were used as a link between positive polarity (+) and negative (-) of the voltage source to the input pin (1) and ground (2) of the regulator IC. Output pin (3) and ground (2) of the 7805 IC was also connected to the positive polarity (+) and negative (-) on the voltmeter.

Several input voltage was applied to the voltage regulator and the output voltage was also measured on the pin3 (output pin). The output of the multimeter confirmed that the output voltage of 7805 IC was nearly a constant value of 5v with little variation of ±0.2v which shown that the IC is working efficiently.

The heat generated by the voltage regulator was also tested by subjecting the IC to various input voltages. The result from table 2 below shows the heat dissipated when various input voltages were applied. Also the heat generated increases as the input voltage increase which indicates that the efficient of the 7805 IC also decreases and this implies that the greater the difference between the input and output voltage, the more the heat generated.

Table 2: Heat dissipated by 7805IC

Voltage in (Vin)	Current (Io)	Heat Dissipated (w) 7805
5	1.5	0.00
6	1.5	1.50
7	1.5	3.00
8	1.5	4.50
9	1.5	6.00
10	1.5	7.50
11	1.5	9.00
12	1.5	10.50
13	1.5	12.00
14	1.5	13.50
15	1.5	15.00
16	1.5	16.50
17	1.5	18.00
18	1.5	19.50
19	1.5	21.00
20	1.5	22.50
21	1.5	24.00
22	1.5	25.50
23	1.5	27.00
24	1.5	28.50
25	1.5	30.00
26	1.5	31.50
27	1.5	33.00
28	1.5	34.50
29	1.5	36.00
30	1.5	37.50
31	1.5	39.00
32	1.5	40.50
33	1.5	42.00
34	1.5	43.50

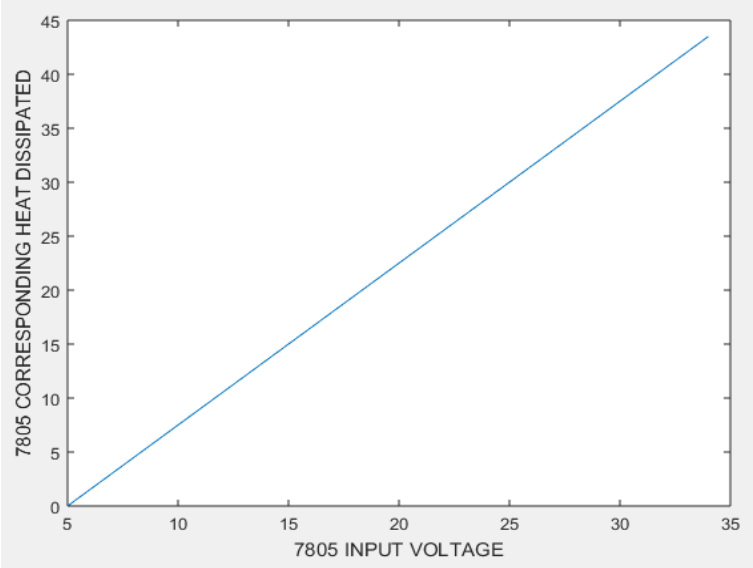


Figure 12: Input Voltage versus Heat Dissipated

The figure 12 above shows the graph of the input voltages of the 7805 IC against the heat dissipated , the graph as shown is linear and shows that the amount of heat dissipated increases as the input voltage increases.

4.5 The System Testing

The wireless controlled lighting system was tested by pressing a corresponding button on the remote control, the corresponding bulb lights up or OFF at the instance of the received signal, which shows that the system satisfied the requirement. As shown in figure 13 below all the four bulbs get activated when the four button the remote control was pressed.

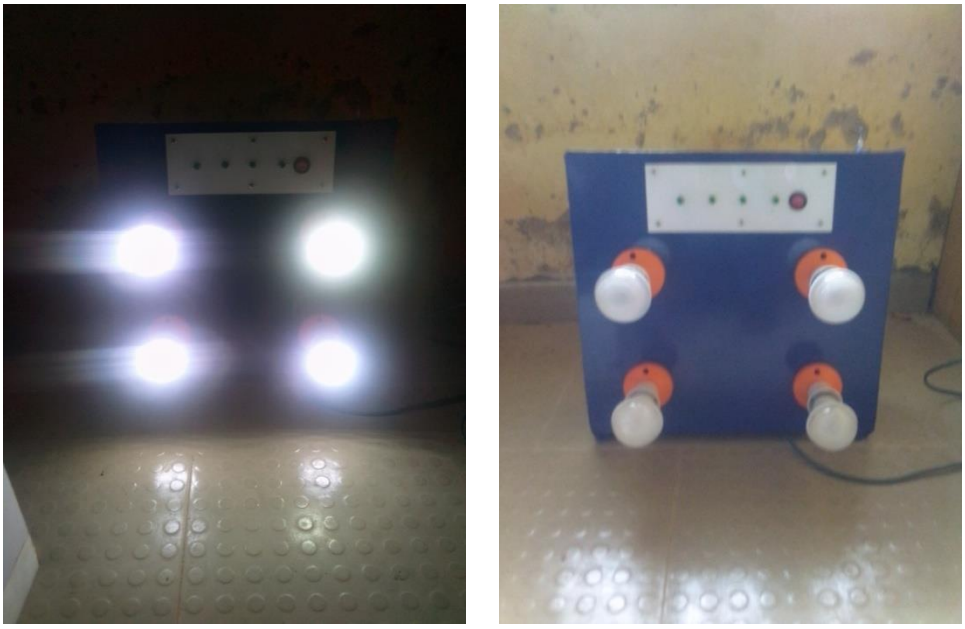


Figure 13: diagram of lighting system when all the lighting points are ON/OFF

Figure 14, 15, 16 and 17 shows that the lighting system respond to the remote control as the light bulb get activated when the corresponding button was pressed even from a far.

Figure 14 diagram of lighting system when the first button is pressed

This is when the first button was pressed on the remote control, the first lighting point goes ON as shown in the figure 14 above.

Figure 15 diagram of lighting system when the second button is pressed

When the second button was pressed on the remote control, the second lighting point goes ON as shown in the figure 15 above.

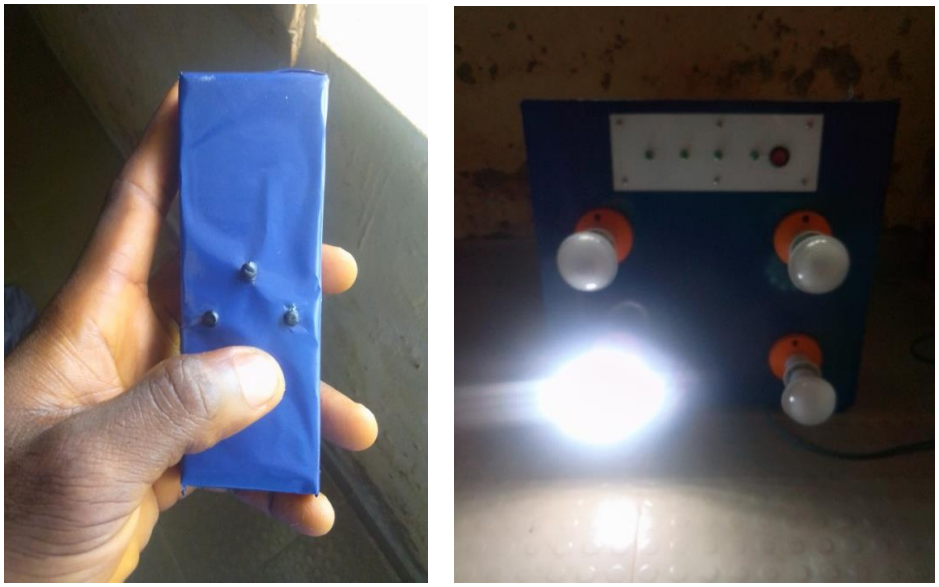


Figure 16: diagram of lighting system when the third button is pressed

When the third button on the remote control was pressed, the third lighting point goes ON as shown in the figure 16 above.

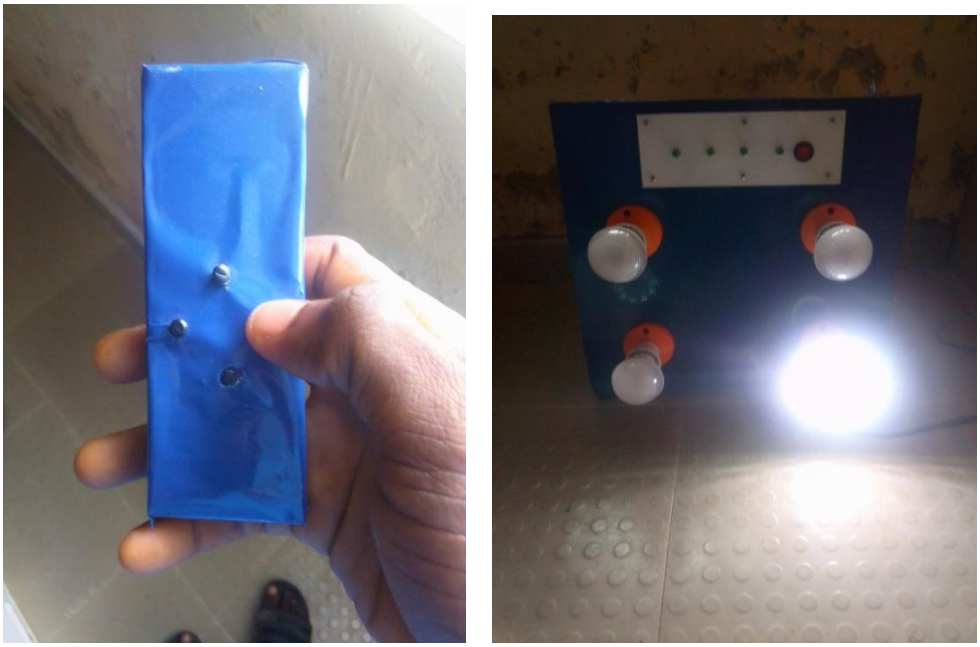


Figure 17: diagram of lighting system when the fourth button is pressed

When the fourth button on the remote control was pressed, the fourth lighting point goes ON as shown in the figure 17 above.

From the series of testing carried out on this constructional research work, it was observed that both the components used and the entire system function as expected and the designed produced the expected result. It can also be deduced that the system can work on any area where there is presence of radio frequency (RF).

5. Conclusion

The application of radio frequency wireless technology in operating domestic lighting system has really improved the lighting system as the wireless technology is stable, consume less power and covers a wide area of operation. This research work is actually an improved remote controlled lighting system at it employs RF transmitter and RF receiver module as its sensing device, HT12D and HT12E as the decoder and encoder ICs respectively which converts serial data to 12 bit parallel data and vice versa. It also uses an atmega 328p microcontroller to activate appropriate decision and 12v Relays to creates a magnetic field which attracts a lever and changes the switch contacts to display the operations of the system. The RF technology and rechargeable battery used in the implementation this device makes it operative even in the absent of the telecommunication network and power supply from national grid respectively. The testing and operation of the system gives more hopes in the field of controlled lighting system as the precision and accuracy levels was high, with effective and efficient management of power and other resources.

6. **Recommendation**

Though the implementation of thisresearch work has actually proven that it works according to its specifications and is convenient to use. Yet the following improvements if effected will make the lighting system a better version.

1. Incorporation of human sensor so as to off itself in the absence of human being thereby conserving the energy.
2. Incorporation of GSM module to allow the user to control the system from a relatively anywhere in world.
3. Commercialization of this product to benefit the real end user.

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