Umudike Journal of Engineering and Technology (UJET); Vol. 9, No. 1, June 2023, pp. 6 – 16; Michael Okpara University of Agriculture, Umudike, Print ISSN: 2536-7404, Electronic ISSN:2545-5257; http://ujetmoua.com; https://doi.org/10.33922/j.ujet_v9i1_2

INTELLIGENT CONTACTLESS IoT TIMER CONTROL SYSTEM FOR ELECTRICAL SOCKET USING WIRELESS INTERFACE

[1]Udeani, H. U., [1,2]Okey, D. O., [1]Udo, E. U., [1]Eze, P.

[1]Department of Computer Engineering,
Michael Okpara University of Agriculture,
Umudike, Abia State, Nigeria.

[2]Graduate of Information Engineering,
Federal University of ABC, Santo Andre,
São Paulo, Brazil

ABSTRACT

The conservation of energy is a significant problem that permeates every aspect of modern life. Over the course of the last few decades, there has been an increase in the rate of power consumption as well as the costs associated with it. This growth is often the consequence of excessively leaving electrical equipment on, even when they are not being used in the most effective manner. Having the capacity to remotely turn on or off a socket or to remotely establish a time restriction for how long an appliance may be powered on can both contribute to the reduction of energy use. This paper presents an internet of things (IoT) based timer controlled electrical socket system that uses micro-controller and relays to automatically control the usage of electrical appliances. The system features an IoT remote controlled device that can be programmed to control the power outlet's configuration, as well as real-time monitoring of the sockets status (either ON or OFF). This system can also be used to prevent overconsumption of energy and minimize the risk of electrical fires and accidental electrocutions. The system is developed with a wireless control web interface to enable the remote access to the controlled sockets. On evaluation, the proposed system presents an advantage to enhance energy usage and conservation.

Keywords: *Internet of Things (IoT), Automation Timer, Wireless fidelity (Wi-Fi), Atmega328 Microcontroller, Energy Conservation*

1.0 INTRODUCTION

Timers that schedule events according to predefined time value is an integral part of real-time embedded systems. They are applied in the control of sequential functions and used in industries, and laboratories to power up instruments for a specific time and perform process for a specific duration (Dunbar, 2020). Watches or other timing devices are also very important in tracking our daily activities. Timing control and alert system is significant in every aspect of our lives beyond just to tell what time of the day it is (Agbetuyi *et al*., 2011; Biswas & Mal, 2015). Clock has been designed in different architecture with functions to determine or solve many problems like day and night period, to control periodic events, to ring a bell every hour or minute, to open doors, run machinery and play music (Subero, 2018). Presently, humans are controlling actions within the environment in a programmed and predictable manner.

Power conservation and control have been a problem since the production of electrical socket outlets spread to underdeveloped nations like Nigeria (Ibitoye *et al*., 2022; Ibrahim & Ayomoh, 2022). It has not yet been possible to develop a reliable residential socket outlet for timing purposes. Lack of a functional timer for electrical outlets has resulted in several deaths and extensive property damage. Due to frequent power outages, homeowners are more likely to leave connected appliances on when they leave the house or to forget to turn them off altogether when they no longer need them. This results in a buildup of residual energy that, when allowed to expand out of control, can cause serious damage to the devices in question (Emovon *et al*., 2018; Olaniyan *et al*., 2018). Repeated exposure to these dangers has eroded resources. However, these issues may be effectively addressed via the use of an Internet of Things-based timer-controlled electrical socket outlet.

Since the cost of electricity has risen dramatically in Nigeria and other countries, many residents and businesses have begun looking into renewable energy sources (Helm, 2017). Conscious homeowners should monitor and reduce their energy use, but their hectic schedules may prevent them from performing necessary switching activities on time, resulting in significant power loss. Automating the on/off switching of electrical appliances is a viable alternative to manually managing this process, which is time-consuming and labor-intensive (Keles *et al*., 2015; Kevin, 2015; Zungeru *et al*., 2019).

Internet of Things (IoT) is a technology is has revolutionized the embedded system infrastructural network through the introduction of a suitable way to integrate technological devices (Things) into the Internet to permit fast and more efficient information gathering, processing, storage and transmission (Koohang *et al*., 2022). IoT enables the automation of devices with sensors and sensing systems, which acts as generators, receivers and/or both of information. Due to its unique features, IoT devices are widely applied to various automation systems (Udo, E.U. Egwu, A and Okey, 2021), including smart homes, agriculture, military, education surveillance (Okey *et al*., 2022), and waste management (Henrietta. U. *et al*., 2022).

According to (Shahzamal *et al*., 2013) a programmable timer that is based on a microcontroller including a digital display is proposed to control system switching. It has a manual mode and a programmed mode for use. Switchboard-like capabilities are available when operated manually. The user can select the maximum amount of time that the AC main line is allowed to remain plugged into the wall outlet in the programmable mode. The connection is then severed mechanically. Six seven-segment LEDs make up the display system, which shows the time in hours, minutes, and seconds. However, the limitation of the system is its manual operation method.

A technique for handling alerts and diagnostics in an automated management system and integrated information technology environment, using WBEM/CIM approach technologies, is provided in (Lee *et al.*, 2009; Lien *et a*l., 2007). Controlling the energy consumption of electrical appliances is as important as providing security to the energy systems. While the system provides security to the energy consumption by ensuring that only authorized individuals operate the energy sources, it failed to consider the cumbersome work operating the system. In this paradigm, (Okey *et al*., 2022) proposed a wireless robot to surveillance using Atmega328p microcontroller to remotely monitor various operating environment and provides visual alerts to administrators for control operations.

The Atmel AT89S52 microcontroller was used to develop an electric heating timer by Batra and Naidu (2016) for medical diagnostics. The authors developed a biomedical equipment for pain treatment that uses time-dependent heat therapy for detection and treatment of pains. The active time for the heat treatment is shown in real time on a four-segment display and can be counted down from 0 to 9999 minutes. Despite its usefulness in the application domain, the system's monitoring and alerting capabilities fall short once some amount of time has passed. In (Byun *et al*., 2013), authors propose an energy management system leverages the hierarchical relationship among home appliances, and intelligently manages their power usage. It prioritizes essential appliances over less critical ones, ensuring that power is allocated efficiently and in accordance with user needs. This approach optimizes energy consumption by reducing wastage and focusing resources where they are most necessary. The implementation was based on ZigBee technology. Other authors including, (Krishna & Nagendram, 2012), (Fernández-Caramés, 2015) (Dias *et al*., 2020), each used different IoT devices and techniques to propose an energy management system for households.

Ajao *et al*. (2016) designed and built a microcontroller-based digital timer and alarm system that allow speakers to rigorously adhere to time specifications and event management in conference arenas or events. The system consists of three major units: the system controller unit, which uses a PIC 16F887 microcontroller as the intelligence device to control and coordinate all system activities; the input unit, which consists of a 4x4 matrix keypad used as a data input device for the system timing or logical configuration of the system operation; and the output unit, which consists of a PIC 16F887 microcontroller. The output device, which comprises of a 16x2 LCD (HD44780), was used for display as the last step. The system consists of a digital clock implemented with software codes that enable time to be set and reset, an alarm system to inform the user when the preset times expire, and an indication light that displays the logical time situation.

This article proposes an IoT-based timer-controlled electrical socket that turns an appliance "on" for the chosen period, and then switches it off after the elapsed time, cutting off the appliance's power supply. This switch is preferable to a manual one since it eliminates the need for constant monitoring of the appliance. It is programmed to automatically turn on or off any electrical equipment in the house at a certain time. Using a mobile device that is wirelessly linked to the system, users may remotely set the time for how long they want their device connected to the power, and the timer can be terminated automatically from the switch, all without being physically there. The time is shown in 24-hour format (HH: MM). As a result, the longest period we can extend for is 23 hours and 59 minutes, and we can accomplish it using our mobile device. By turning appliances on and off at the appropriate times, you can extend their useful life and reduce your energy bills.

In order to promote residential energy savings, we have developed a novel timer-controlled socket system utilizing advanced components such as the programmable Atmega328p microcontroller and implementing it using the C++ programming language. The system incorporates a mobile device interface for convenient time setting, which is then synchronized with the hardware. A DS3231 module is employed to ensure accurate timing, while the mobile device's web interface provides real-time monitoring and tracking of the system's output. This eliminates the manual operation and on sight monitoring limitations identified in the literature.

2.0 MATERIALS AND METHODS

In this section, we provide a detailed description and analysis of the different components assembled together to achieved the proposed system as well as the various software packages used in the implementation.

2.1 Materials

The materials used for the project is grouped into the hardware and software components. For the hardware, we used the DS3231 integrated circuit (IC), Solid state Relays (SSR), Atmega328p Microcontroller, ESP-01 Wi-Fi module and AC-DC Power Converter as shown in Figure 1.

The DS3231 has a temperature-compensated crystal oscillator (TCXO) and crystal incorporated, making it a low-cost, very accurate I2C Realtime clock (RTC). It has a battery backup so it can keep time even if the power goes out. Integrating the crystal resonator improves the device's long-term precision and minimizes the number of individual parts required for production. SSRs are used for switching on and off applications without the use of movable contacts. They are usually modular in design and have a long life span. They are semiconductor equivalents of the electromechanical relay and can be used to control electrical loads without the use of moving parts. This is used to switch any connected device off/on by opening (*breaking*) or closing the circuit. The ATmega-328p is an 8-bit AVR micro-controller with over 20 pins. In total, it has 28 pins. ATmega328P is an eight bit micro-controller that can handle up to eight (8) bits of data. It has a built in 32KB internal memory. Its high performance and low power consumption make it an ideal choice for various applications. The ESP-01 is a low-cost, self-contained Wi-Fi module that has a full-fledged microcontroller and TCP/IP stack. It eliminates the need for an external microcontroller to control its outputs.AC-DC Power Supply 110/220v to 3.3v is used as a power supply to the DS3231 and the Atmega328p. It converts the AC power from the mains to 3.3v DC.

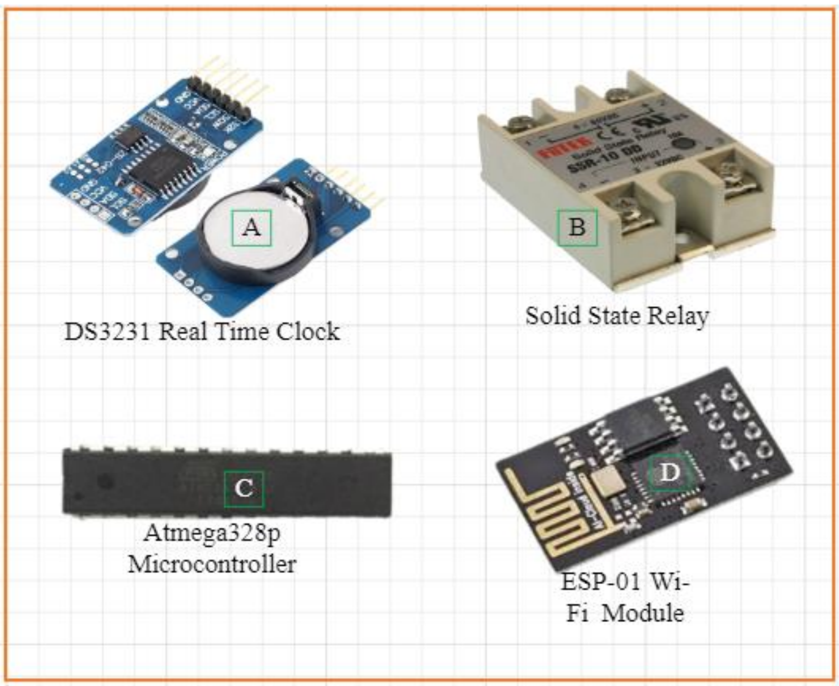

Figure 1: Hardware components used in the construction of the contactless IoT timer control system

2.1.1 Software Components

The physical components of an embedded system are controlled by software programs that are burned into microcontrollers. These applications are available in C, C++, JavaScript, and Python. In our suggestion, the C++ programming language is utilized to create the system's control software since it offers more flexibility and interoperability with embedded systems than other languages. An integrated development environment (IDE) is a form of software that converts high-level programming languages into machine code. It is often used to create applications for 32-bit and 64-bit architectures. The Arduino IDE will be used for this project since it has been designed and developed to convert C++ code into embedded hex format and connects with the Arduino AVR programmer, which is compatible with the Atmega328p microcontroller that will be used. Sketches are programs created using the Arduino IDE's text editor. They are stored as.ino files and may be used to change the text.

2.1.2 Description of the Modules of the System
The system will be constructed in modules consisting of various units which includes the, Power Unit., Microcontroller Unit and Monitoring, Control/Output Unit

Power Unit
Alternating current (AC) is used for power line transmission and for high power devices like appliances and lights. To power the microcontroller, ESP-01 and DS3231 real time clock a 3.3v AC to DC converter is built using a 12V transformer, IN4001 Diodes,16V 1000UF Electrolytic Cap, 50V 0.1UF Ceramic Cap, 50V 0.22UF Ceramic Cap IC Regulator 7805 +3.3V 1A .

Microcontroller Unit
This is the brain behind the system, the microcontroller is used to store the program which controls the system. The DS3231 real time clock is connected to the microcontroller this performs the timing function of the system. A crystal oscillator and a 10 KΩ resistor is connected to the microcontroller to regulate its timing. The input voltage of the microcontroller is 3.3v and it is gotten from the 3.3v AC to DC converter.

Monitoring, Control and Output Unit
This unit consist of a relay which switches or cuts the power entering the socket, a socket where the home appliance or device is plugged in, a buzzer which giver a sound output when the time programmed into the system elapses and a Wi-Fi enabled mobile device (e.g. android phone) for setting the time input of the system and monitoring the system countdown.

2.2 METHODOLOGY

2.2.1 Proposed System
The proposed system implements an IoT based timer controlled electrical socket system using Atmga328p, DS3231 real time clock and Wi-Fi module for connecting to the web user interface. This system is used to switch on/off an electrical appliance (load) through a relay switch after the specified time set in hours or minutes elapses. The timer can be set using buttons from the web user interface on a mobile device. The buttons is used to set, stop or reset the timer. The time elapsed or remaining is displayed on the screen and a buzzer sounds when the countdown finishes. The system aims to control and minimize the power wasted due to appliances and devices being plugged in and left unmonitored even after it has completed its purpose; conserve electrical power both domestically and industrially as well as reduce and subsequently prevent electrical hazards.

Prototyping: This method works by defining a system prototype that will be fully functional and not require modifications. This method is usually used since the system would be made fully functional with minimal modifications. A prototype is a conceptual model that shows the limited functionality of a proposed system.

2.2.2 Block and Circuit Diagrams of Proposed System
As shown in Figure 2, Atmega328p is interfaced to various components which includes the DS3231 real clock timer, Wi-Fi module, the relay, the buzzer and the AC to DC power converter which supplies the 3.3v that powers the microcontroller.

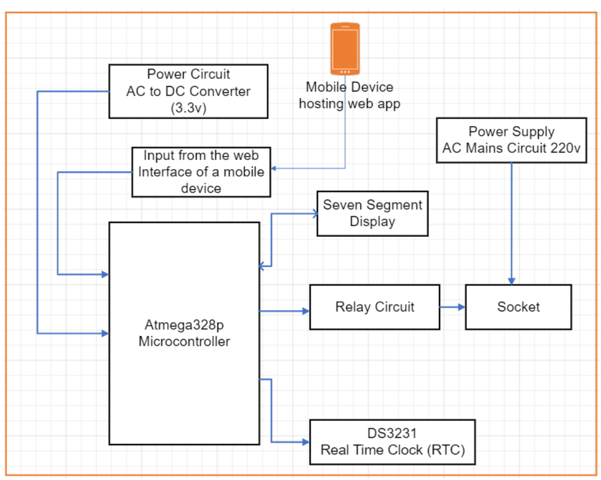

Figure 2: Block diagram of the system

The buttons on the web interface is used to set the input time on the screen. The DS3231 real clock timer is responsible for counting down the time set by the user. When this time elapses, the microcontroller sends a signal to the relay and the relay cuts the power entering the socket. A buzzing sound is also heard to indicate the elapsed time, this signal is also sent from the Atmega328p microcontroller. The schematic diagram for the implementation of the system is shown in Figure 3.

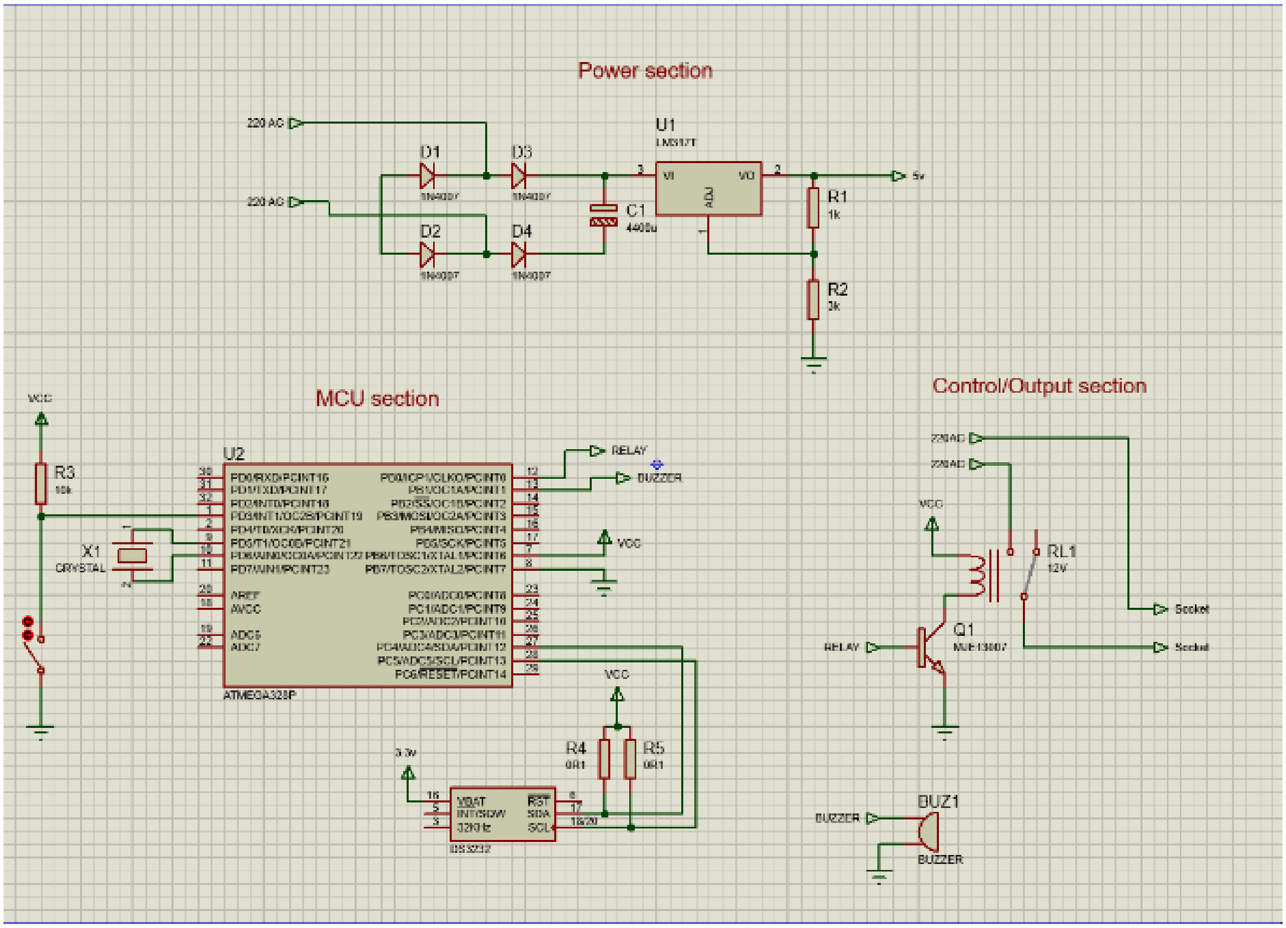

Figure 3: Circuit diagram of the proposed system

2.2.3 Flowchart of Proposed System

The program that operates the system is written in C and C++ language. An Arduino IDE is used for the software development. The program is burned to the microcontroller after it has been written. The control logic for the system operation is shown in Figure 4. The system is initiated and verified to be ON, if it is turned ON, the timer inputs are requested from the user, and the subsequent command is instantiated.

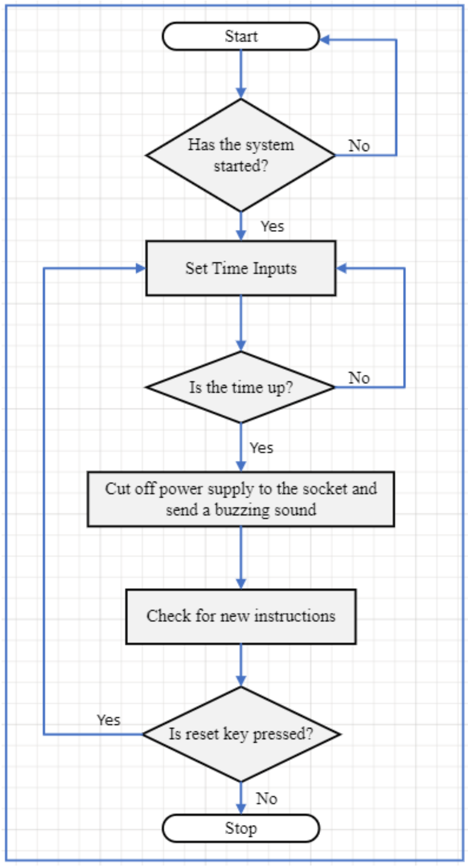

Figure 4: Flowchart of the proposed system

2.2.4 System Implementation and Testing

This system was constructed by soldering all the components to a dotted bread board. The system was constructed in modules for easy troubleshooting. These modules were later connected together and tested. The first module to be constructed was the power supply module. The power supply module is an important area that determines the stability of system. The availability of alternating current (AC) source which is 220 V, the Atmega328p controller which is used in this system operates at 5V and the ESP-01 WI-FI operates at 3.3V. A step down transformer is used to step down the voltage and then filtering was done using capacitors and inductors to reduce electromagnetic interference noise. The diode bridge rectifier is used to convert AC to DC supply and delivers 5V which serves the controller. The 5V is converted into 3.3V using voltage regulator and supplies to the ESP switch. The Wi-Fi device connected in series with relays which is used to interconnect the ESP switch (Wi-Fi switch) and Plug. From the main supply the plug is directly connected with plug. The microcontroller module consists of the controller chip and the ESP chip The VCC pin is used to give input supply to Wi-Fi module. TXD and RXD pins acts as Transmitter and Receiver pin of the switch. The switch can transmit a data to other device via TXD and receives a signal from the same device via TXD. The other pins are used to connect the external devices like relays and LED's and the completed circuit is shown in Figure 5.

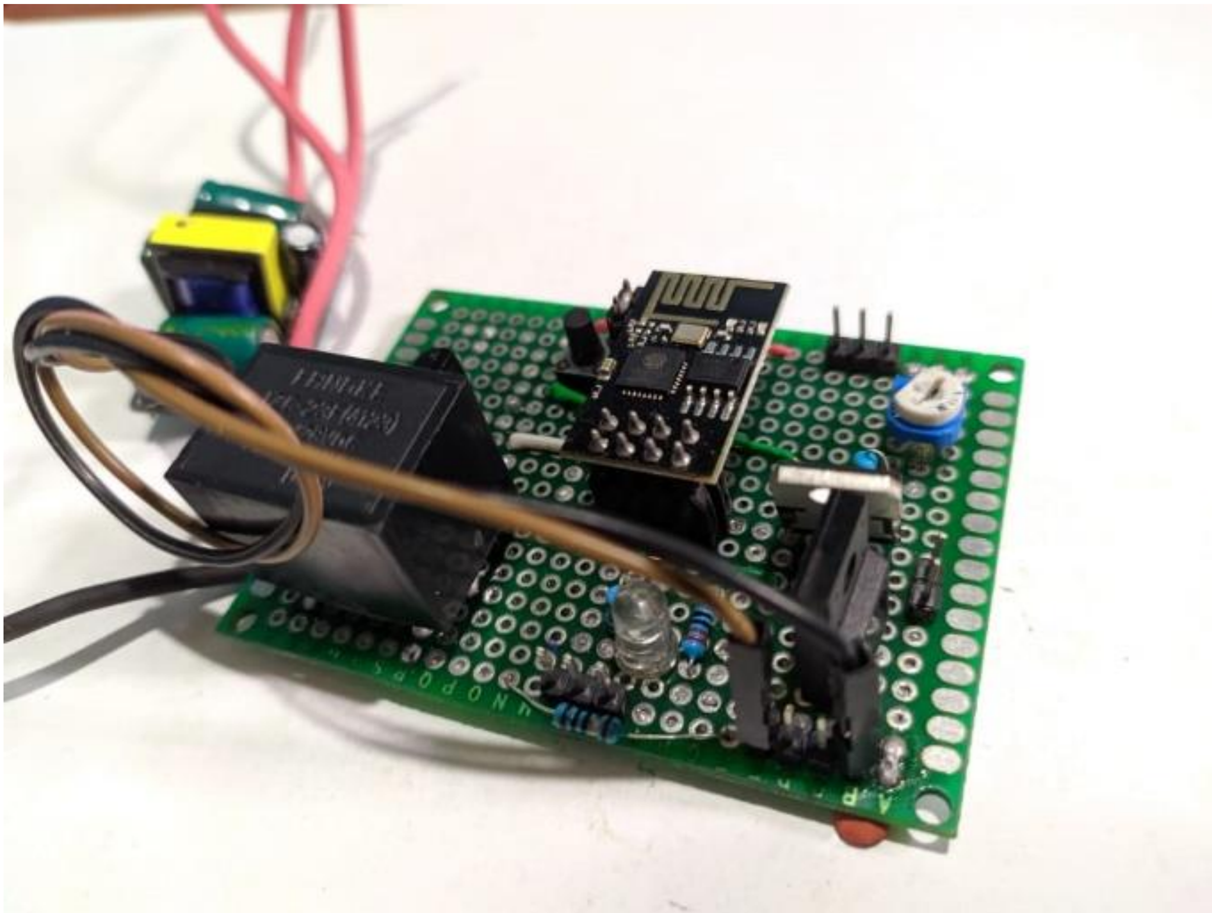

Figure 5: Assembled components of the remotely controlled electrical socket

3.0 RESULTS AND DISCUSSION

Figure 5 shows the connection of components of the remotely controlled electrical socket including, the power supply unit, Wi-Fi switch, Relay and the Microcontroller. The web application created to control the socket achieves control of the socket through relay via Wi-Fi switch, which determine the connection between power input and home appliances. ESP-01 Wi-Fi module is selected as it offers easy configuration and faster transmission compared to other models. The Wi-Fi allows a connection to be established between the socket and the web app for control operations.

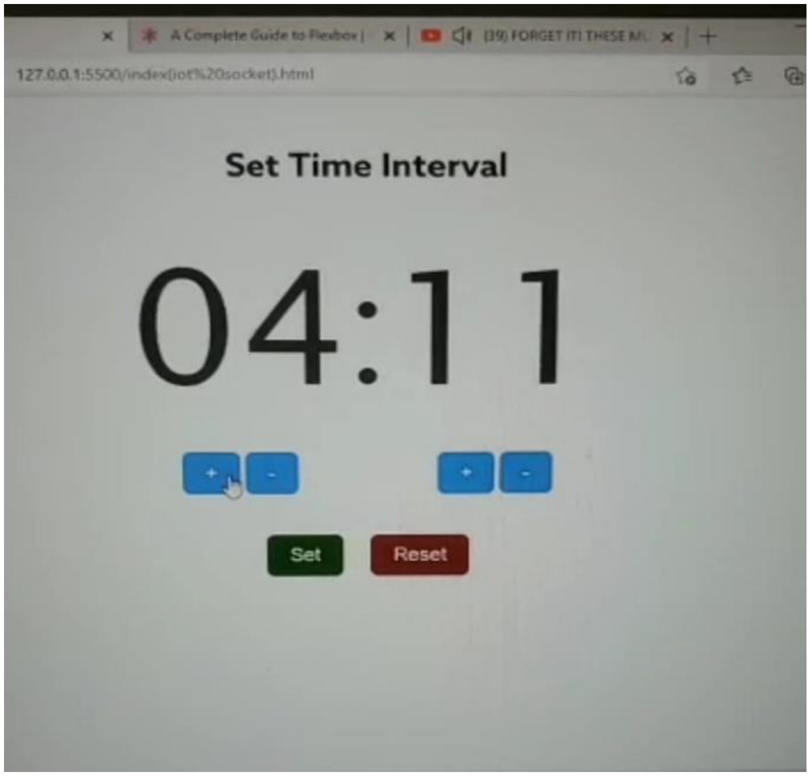

Figure 6: User interface of the web app created to control the switch system

The web application is designed and tested using JavaScript, HTML and CSS. The digitally based improved timer controlled electrical switch system web app is designed to disconnect and connect the power supply on each available socket depending on the time interval set from the web interface. Figure 6 shows the user interface display on main activity in the web application. In the Figure 6, when the web application is open, the plus and minus buttons are used to increase or decrease the timing intervals, the set button is used to set the time and the reset button used to stop the system or reset the time. To be able to control the system, set, and reset and stop time intervals, a server address is required. Once connected to an access point, the system has access to web app that was created for controlling it. This can be seen in the user interface of the web app as shown in Figure 6.

When the system is switched on, a connection is setup by the ESP-01 Wi-Fi and an IP is created that any mobile device can connect in order to control the system. A mobile device (android phone) is used to connect to the wireless connection set up by the system. After it has been connected, a browser is used to access the IP address 192.168.8.1. This accesses and displays the web page that will be used in controlling the system. In this test we controlled the system from a mobile android phone, the system can also be controlled using a laptop or any web enabled mobile device. Input commands are sent through the web page to the ESP-01, which is connected to the Atmega328p controller. The ESP-01 takes input from the web browser and according to input it gives output to the Atmega328p controller. Atmega328p controller then works according to the algorithms and performs the required action on the switch.

The buttons are used to increase and set the time interval required for the timer controlled electrical switch system to be on. When the set button is clicked, The ESP-01 communicates with the ATmega328p controller, which makes the pin high that is assigned to become ON. The time interval displayed on the screen is sent to the timer controlled switch system. The system activates and a countdown begins on the web page as shown in Figure 5. When the time is up, the timer controlled switch system automatically deactivates itself. The reset button is used to stop the countdown or reset the system.

For the purpose of development, the maximum time interval that can be set on the system is 2 hours. The system was tested and found to be fully functional providing improved work-efficiency and productivity. The performance evaluation procedure and the observation noticed during the system testing is shown in Table 1. We observe from Table 1 that the time required for the device to power on and connect to the internet is one (1) minute. However, this is influenced by the processing capacity of the android device. Devices with more cores connects in milliseconds.

Table 1. Performance Evaluation Procedures and Observation during System Testing

TIME	PROCEDURES	OUTCOME	REMARK
2021-07-27 4:00pm	Power switch of the system was turned on	The power indicator LED comes on.	This indicates that the system has been powered on.
2021-07-27 4:01pm	The Wi-Fi enabled android phone (mobile device) is connected to the Wi-Fi of the system. The IP address 192.168.8.1 is inputted into the browser of the mobile device.	The Wi-Fi of the mobile phone shows connected. The browser displays the user interface of the web application for controlling the timer controlled electrical switch system.	This indicates that the mobile phone and the system are now connected and the system can be controlled using the mobile phone
2021-07-27 4:05pm	The time interval is set to 00hh: 05mm and the set button is clicked	The socket switches on and a countdown begins on the web page.	This indicates that the web app is communicating very well with the hardware and that the system has received the command sent from the web page. The ON command given on the web browser was received and the instruction interpreted correctly by the Atmega328 microcontroller.
2021-07-27 4:10pm	The countdown rounds down to 00:00	The socket switches OFF and the appliance is disconnected from the socket	This indicates that the timing of the system is accurate and the system is working correctly.

In comparison with (Lien et al., 2007; Shahzamal et al., 2013), our system eliminates the limitations of manual operation and physical monitoring thereby saving the user's time and energy consumption. Integrating the Mobile App enhanced the efficiency of our system as almost every household currently uses at least one mobile phone, as opined in Olaniyi and Ismaila (2016). The user-friendly interface in the Mobile App makes it easy to use by inexperienced users. The integration of IoT technology and wireless communication in this intelligent timer control system highlights the potential of smart home automation and highlights the continuous evolution of the Internet of Things. As more devices become interconnected, the possibilities for creating smarter, more efficient, and convenient living spaces expand significantly. The contactless nature of the system indicates that it is highly advantageous in terms of hygiene and cleanliness. By eliminating the need for physical contact with electrical sockets, the system reduces the risk of contamination and the spread of germs, particularly in environments where maintaining hygiene is critical. This outcome supports the system's potential application in healthcare facilities, offices, and other public spaces where maintaining a sanitary environment is essential.

4.0 CONCLUSION

Energy consumption and the tariff associated with it has increased recently thereby making it impossible for some households to afford the cost of using electrical appliances. This research offers promising solution to enhance convenience, efficiency and safety. The innovation harnesses the power of IoT technology, eliminating the need for contact or manual operation while providing seamless control over electrical devices. By incorporating intelligent features, wireless connectivity and timer functionality, the systems offers the users the flexibility of activating and deactivating electrical sockets at ease, thereby optimizing energy consumption and promoting energy efficiency. In using the system, there will be reduction in domestic or industrial electrical accidents that previously results from carelessly leaving the electrical appliances on when they are not in use, reduce the high cost of energy consumption and thus improve standard of living. The successful implementation of the system's wireless communication, timer functionality, safety features, and contactless operation underscores its effectiveness and potential benefits in terms of convenience, energy efficiency, safety, and hygiene. These findings contribute to the growing body of knowledge on smart home automation, IoT technology, and their applications, emphasizing the significance of this system in smart city technology.

REFERENCES

Agbetuyi, A. F., Adewale, A. A., Ogunluyi, J. O., & Ogunleye, D. S. (2011). Design and construction of an automatic transfer switch for a single phase power generator. *International Journal of Engineering Science*, *3*(4), 1–7.

Ajao, L. A., Adegboye, M. A., Dogo, E. M., Aliyu, S. O., &

Maliki, D. (2016). *Development and Implementation of Microcontroller-based Improved Digital Timer and Alarm System*.

Batra, N. S., & Naidu, H. (2016). A Novel Method of Home Energy Management System Using Microcontroller for Increasing Load Factor. *Research Journal of Engineering and Technology*, *7*(3), 89.

Biswas, R. Sen, & Mal, S. (2015). Automatic power factor improvement using microcontroller. *2015 International Conference and Workshop on Computing and Communication (IEMCON)*, 1–6.

Byun, J., Park, S., Kang, B., Hong, I., & Park, S. (2013). Design and implementation of an intelligent energy saving system based on standby power reduction for a future zero-energy home environment. *IEEE Transactions on Consumer Electronics*, *59*(3), 507–514.

Dias, T., Sampaio, P., Cardoso, D., Prates, C., Jesus, R., & Costa, T. (2020). Open-Source Power Outlet System for IoT-based Smart Homes. *2020 International Conference on Smart Energy Systems and Technologies (SEST)*, 1–6.

Dunbar, N. (2020). ATmega328P Hardware: Timers and Counters. In *Arduino Software Internals* (pp. 417–492). Springer. https://doi.org/10.1007/978-1-4842-5790-6_8

Emovon, I., Samuel, O. D., Mgbemena, C. O., & Adeyeri, M. K. (2018). Electric Power generation crisis in Nigeria: A Review of causes and solutions. *International Journal of Integrated Engineering*, *10*(1).

Fernández-Caramés, T. M. (2015). An intelligent power outlet system for the smart home of the Internet of Things. *International Journal of Distributed Sensor Networks*, *11*(11), 214805.

Henrietta. U., U., Tochuwu. T., C., Daniel. O., O., & Eze, C. (2022). *Design and Construction of a Smart Dustbin System with Design and Construction of a Smart Dustbin System with Internet Of Things (IoT) Notification*. *5*(June), 63–75.

Ibitoye, O. T., Agunbiade, O. S., Ilemobola, T. W., Oluwadare, A. B., Ofodu, P. C., Lawal, K. O., & Dada, J. O. (2022). Nigeria Electricity Grid and the Potentials of Renewable Energy Integration: A Concise Review. *2022 IEEE 7th International Energy Conference (ENERGYCON)*, 1–4.

Ibrahim, H. A., & Ayomoh, M. K. (2022). Optimum predictive modelling for a sustainable power supply mix: A case of the Nigerian power system. *Energy Strategy Reviews*, *44*, 100962.

Keles, C., Karabiber, A., Akcin, M., Kaygusuz, A., Alagoz, B. B., & Gul, O. (2015). A smart building power management concept: Smart socket applications with DC distribution. *International Journal of Electrical Power & Energy Systems*, *64*, 679–688.

Kevin, Z. (2015). *Electrical Socket Switch Controlled Remotely Using Infrared Transceiver*. President University.

Koohang, A., Sargent, C. S., Nord, J. H., & Paliszkiewicz, J. (2022). Internet of Things (IoT): From awareness to continued use. *International Journal of Information Management*, *62*, 102442. https://doi.org/10.1016/j.ijinfomgt.2021.102442

Krishna, Y. B., & Nagendram, S. (2012). Zigbee based voice control system for smart home. *International Journal on Computer Technology and Applications*, *3*(1), 163–168.

Lee, M., Uhm, Y., Kim, Y., Kim, G., & Park, S. (2009). Intelligent power management device with middleware based living pattern learning for power reduction. *IEEE Transactions on Consumer Electronics*, *55*(4), 2081–2089.

Lien, C.-H., Bai, Y.-W., & Lin, M.-B. (2007). Remote-controllable power outlet system for home power management. *IEEE Transactions on Consumer Electronics*, *53*(4), 1634–1641.

Okey, D. O., Eze, C., & Ihekweaba, C. (2022). Computer-based Wireless Camera Robot For Mobile Surveillance. *FUNAI Journal of Science and Technology*, *5*(1), 27–36.

Olaniyan, K., McLellan, B. C., Ogata, S., & Tezuka, T. (2018). Estimating residential electricity consumption in Nigeria to support energy transitions. *Sustainability*, *10*(5), 1440.

Olaniyi, O. A., & Ismaila, O. K. (2016). Information and Communication Technologies (ICTs) usage and Household Food Security status of maize crop farmers in Ondo State, Nigeria: implication for Sustainable Development. *Library Philosophy & Practice*.

Shahzamal, M., Haque, M., Nasrul, H., Anzan-Uz-Zaman, M., Rana, S., Hoq, M., Akter, F., Farhana, H., & Mahmudul, H. (2013). Design and Development of Microcontroller Based Programmable Timer for Supply Control. *Institute of Electronics, Atomic Energy Research Establishment, Dhaka*.

Subero, A. (2018). Interrupts, Timers, Counters, and PWM. In *Programming PIC Microcontrollers with XC8* (pp. 165–207). Springer. https://doi.org/10.1007/978-1-4842-3273-6_8

Udo, E.U. Egwu, A and Okey, D. . (2021). Analysis and Computer Simulation of a Continuous Wave Radar Detection System for Moving Targets. *Uniport Engineering and Scientific Research (UJESR)*, *5*(2), 120–130.

Zungeru, A. M., Gaboitaolelwe, J., Diarra, B., Chuma, J. M., Ang, L.-M., Kolobe, L., David, M., & Zibani, I. (2019). A secured smart home switching system based on wireless communications and self-energy harvesting. *IEEE Access*, *7*, 25063–25085.