

## Application of Computerized Switch for Domestic and Industrial Appliances

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### ABSTRACT

This study was conceived out of the curiosity to appreciate automation and harness the possibility of controlling numerous appliances with a single remote control. It aimed at developing a computerized wireless switch using Infrared Technology capable of controlling the bi-directional flip-flop and push-pull switches of some household and industrial appliances such as fans and energy bulbs in order to reduce the stress associated with manual switching of these appliances. This study is designed based on the working principle and properties of Infrared Light, the ground on which remotes for home electronics are built. To achieve this objective, an ATMEG328p microprocessor was used to interface the TSOP1738 Infrared Receiver and the other components of the circuit on a breadboard or project board as a prototype. The whole system is composed of three units which are independently built as the Object-Oriented Programming paradigm is employed. The units are: the transmitter (a handheld universal remote); Control or Receiver (embedded processor) and the household or industrial appliances to be controlled. Emphasis was on the Receiver and controller unit because they formed the pillar of the automation. The system's implementation showed higher performance in terms of effectiveness, precision, and dependability, and controlled the household and industrial appliances at a distance of 10 meters.

**Keywords:** Computerized switch, remote-control, automated home appliances, domestic and industrial appliances.

### Introduction

Every existing technology ought to simplify human specific responsibilities seamlessly. Hence, the motivation behind man's quest for technology is to simply simplify tasks with enhanced efficiency, speed and reduced risk of infections and accident. In homes, manual operations of electrical appliances have rigorously exposed users more especially the elders, physically challenged and kids to stress, risks of electrocutions, inconvenience and fire outbreak; and this has made

some people to be generally electro-phobic when switching operation becomes frequent. Thus, telling such persons to utilize the manual-switch to turn ON or OFF an electric bulb, ceiling fan, wall socket and generator, creates tension. Similarly, industrial appliances like power generators, operation machines, power change over, and many other processes constitute stress to the industry. To solve these problems, a remote-controlled switching system for household and industrial appliances was proposed in this study to make life

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easier and comfortable to the users of these appliances.

Remote control is a wireless handheld device that transmits digitally encoded pulses to regulate various equipment's settings for things like power, volume, tuning, temperature, fan speed, etc. (Mbunwe, 2017). The earliest remote-control system was wired (Bellis, 2020), and depending on the length of the wires used, these remotes-controlled appliances at varied distances. However, the wired remotes constituted much distraction to the users as one had to run a length of wire to a particular appliance from the remote. Consequently, a home that uses five appliances, requires five distinct visible Ethernet tethering cables to operate these appliances. This method could possibly cluster a room with wires. Alternative to that is the common use of appliances with switch buttons attached to the devices. Here, manual operation is used. Thus, this conventional manual switching method has to be overcome by an easier wireless switch (Longinus, 2019). The introduction of wireless remote-control system meant an end to the challenges of wired-remotes and manual switch. Mbunwe (2017) noted that *"various technologies have evolved in the past: controlled by radio waves; used to execute commands transmitted by electromagnetic waves; and also, the use of battery-operated low frequency radio transmitter remote control for consumer electronics"*. At this point, it became essential to develop the concept of an electronic remote control that operated wirelessly by shining a light beam over a photoelectric (Mbunwe, 2017).

It is evident that efforts have been made by researchers to build a computerized switch control system that can use a wireless-remote to control household and industrial appliances. These studies and some of their methods and working principles are discussed (Ekeh, et al., 2021). Among them are Laurentius and Yuan (2017) that designed a Node MCU which was used to manage the old type of Alternating Current (AC) split appliance through

the internet using Wi-Fi connections. The medium of propagation of the designed system was through the internet and users were able to control devices through android application and the web. Mbunwe (2017) designed a switching device that uses a remote control for household appliances. The system made use of radio frequency, a form of electromagnetic wave with higher wave-length than infrared. The receiver has three portions that work to receive and process the received signals and carry out switching operation. The components of the power supply include: 220/12V transformer, bridge rectifier, capacitors, 7805, 7812 and AC plug. It includes the rectification of AC voltage to DC and the regulation of this DC to a voltage as required by the ICs. The bridge rectifier performs full wave diode rectification while the transformer reduces the AC voltage to 12 volts to provide the output voltage determined by equations. The design of the power source allows for a plug-in connection to the main supply. As a result, power surge may cause serious damage to the system. Moreso, Ajibola and Balogun (2019) designed and implemented a computerized household electrical switching system which utilized a web-based technology. The system aimed to monitor and control energy consumption in households by subsequently conserving the energy use. The users and administrators of the system can remotely use a local area network or wide area network to activate and deactivate a desired appliance. Likewise, Salako (2019) designed a time switching system with an Atmega328 microcontroller to regulate when an electrical appliance attached to its output switches ON and OFF. The technology was created to cut down on electrical waste and save energy. Unlike Ajibola and Balogun (2019) that utilized computer network system, Salako (2019) used the microcontroller (ATMEGA328) to achieve timing operation. Rather than regulating the appliances that we specify to make life easier for the consumers, these systems were made to conserve energy. Furthermore, Luh, et al (2019) developed a wireless remote control switching

system and it was made to remotely control the switching of electrical and electronic devices. Luh, et al utilized a radio frequency module (RF433) to transmit signals while the Receiver module (IC HT12E) decoded the signals. The results showed that the system was able to switch on and off appliances at a distance of 18 meters. We used infrared technology because radio frequency is expensive, its usage requires fewer frequencies and it still experiences interference from other radio frequency devices. Ashraf et al (2020) designed and implemented a home automation system using a Raspberry Pi and relay circuits to remotely control electrical appliances. The system used a local network and remote access to control the appliances, and a Microsoft Azure cloud database was used for data logging to restore any lost data records. The use of any household appliance requires periodic notifications to optimize the device and to communicate between the raspberry pi and the android app, while HTTP web interface and Apache server were used. This system is very expensive and out of the reach of the middle class. If you incorrectly connect a pin in Raspberry pi, the board is damaged. Unlike the Arduino, there is no built-in Analog-to-digital converter on the general-purpose input/output pins

From the reviews, there is need for something better, cheaper and simpler. Existing technologies of GSM Remote Controls, Customized Remotes, Raspberry pi, and Infrared WLAN with Wi-Fi are still complex and unable to meet the primary needs of the end user. The systems described above are very expensive, difficult to operate, require more coding, and easily damaged. Universal Infrared remote control is cheaper, lighter in weight, easier to replace and user friendly. However, the design of the external receiver of this proposed system can make the system support all devices. The utilization of multiple relay modules in this research entails simultaneous supports for many devices. With a universal remote of 21 buttons, 21 different appliances can be supported. This is achieved by expanding the relay module.

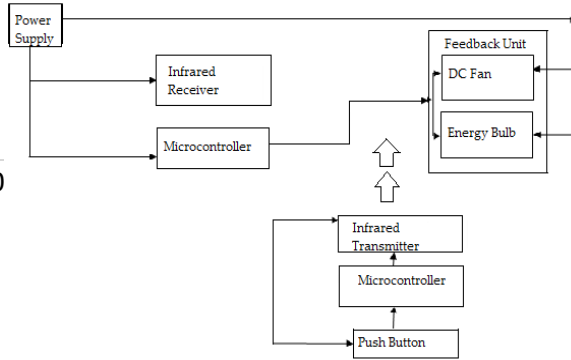
## Materials and Methods

The study was conducted in Abakaliki and the devices were assembled in the computer laboratory of the Department of Computer Science and Informatics, Alex Ekwueme Federal University Ndufu Alike Ikwo, (AE-FUNAI) Nigeria. The study targeted the elderly, physically challenged individuals, kids, and few staff of AEFUNAI and Royal Salt Company. The responses gathered from the study gave us insight into the design of the system. The methodology utilized in designing the system was the Unified Process method which involves incremental and iterative approach to development. Iteration involves components such as the receiver, the transmitter (remote), and the appliances (Fan, Energy bulb, refrigerator, etc.), each completed component is integrated into others incrementally.

The system is designed with an Infrared-based remote-control switch technology that uses a single remote to control different electrical appliances which serves to make switching of domestic and industrial appliances easy for the users. Its distinctiveness is the usage of an ATMEGA328p microprocessor to direct the remote control's functional keys to turn electrical appliances ON and OFF from a distance of 10 meters.

## System Design

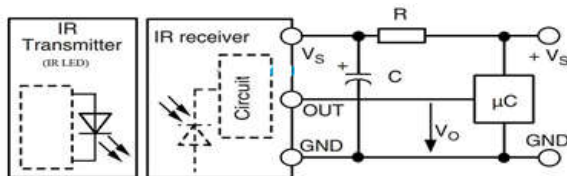
The figure 1 below shows the different parts of the system such as the detection unit, control unit and feedback unit. The detection unit receives infrared signals which is responsible for detecting the users IR signals from the remote. The control unit consists of the microcontroller (ATMEGA328P) which is responsible for the control of signal execution. The feedback units are the electric fan and energy bulb. These devices are switched on and off depending on the buttons pressed by the user on the remote control.



**Figure 1:** The Proposed System Structure

**Logic control unit**

The figure 2 shows the circuit of the system. The Voltage Common Collector (VCC) and the ground (GND) pins of the IR sensor are linked to the positive and negative rails of the breadboard, respectively, while the OUT pin is attached to D4. The VCC and GND for the relay module are connected to the positive and negative terminals of the breadboard's power rail, while the IN1 and IN2 pins are connected to pins D7 and D8, respectively. The DC fan is connected to a 12-volt power adapter, while the energy bulb is connected to an AC power source. On the relay module, however, each of them is connected to a different channel for automatic power switching when the relay is switched high or low. A 9v battery or power bank with a 5v output voltage is used to power the system. The microcontroller's VIN and GND pins are each linked to one of the battery's positive and negative terminals. The controller then supplies 5v, which is utilized to power all of the component parts that are connected.



**Figure 2:** The Circuit of the System

**Microcontroller programming**

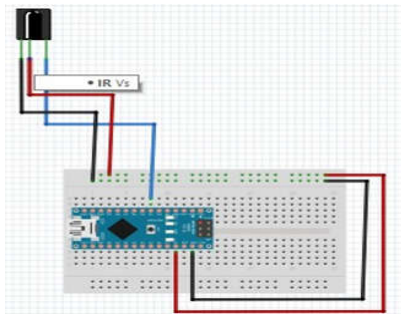
Figure 3 shows the microcontroller programming which is connected to a USB cable. A 5v USB cable is used to connect the microcontroller to the computer for programming. Once the connection is made, the microcontroller circuit was detected by the computer system and the correct port is selected for programming operations.



**Figure 3:** Microcontroller programming with USB cable

**Interfacing Modules**

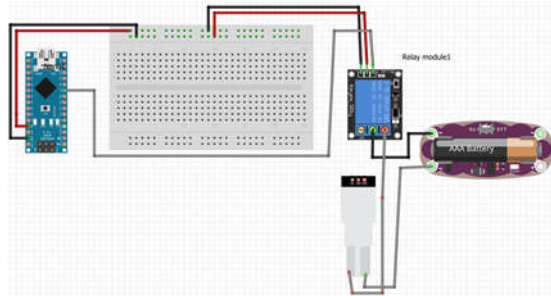
Figure 4 below shows the infrared receiver interfacing with the microcontroller. The infrared sensor is responsible for detecting IR signals from the user's remote. It has three (3) connection pins: GND, VCC, and OUT. The GND pin is connected to the 0v rail while the VCC pin is connected to the +5v rail. The Arduino Nano's pin D4 was then linked to the OUT pin.



**Figure 4:** Infra-red receiver interfacing with the microcontroller

**Relay and bulb interfacing module** – figure 5 interfaces relay and bulb with Arduino. The energy bulb connects to the AC power source while the DC fan connects to 12v power adapter.

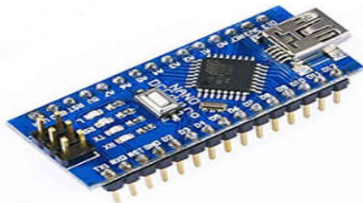
On the relay module, however, each of them is connected to a different channel for automatic power switching when the relay is switched high or low.



**Figure 5:** Interfacing relay and bulb with the arduino

### Hardware Components

**The Arduino Nano** – figure 6 shows the Arduino Nano board. The ATMEGA328p microcontroller board was utilized in the creation of this system. This component controls all the input signals from the IR Sensor. Once the IR sensor reads any input, the microcontroller which is programmed in C++ will perform all the arithmetic and logics.



**Figure 6:** Arduino Nano board

**Detection unit** – figure 7 below shows the Infrared Sensor. This component is in charge of recognizing an infrared signal from the remote control and transmitting a corresponding signal to the control unit for additional processing and computation. It uses a TSOP1738 infra-red receiver, with a high-speed PIN phototransistor and the full wave band preamplifier. It contains three pins: GND, which connects to the ground terminal; VCC, which connects to the 5v power source, and OUT, which connects to a digital pin for sending the output to the Arduino board.



**Figure7:** Infrared Sensor

**IR Transmitter** – figure 8 shows the remote control. The primary purpose of the IR receiver is to receive IR signals from IR transmitters often found in remote controls, and in this system, the user's remote is used as one of those transmitters.



**Figure 8:** Remote control (IR Transmitter)

**Dual-channel relay** – figure 9 depicts the dual-channel relay of the system. With a few added capabilities, such optical isolation, this module is essentially a single-channel relay module with some additional functionality. A microcontroller's pins can be utilized to switch mains-powered loads using the dual-channel relay module.



**Figure 9:** Dual-channel relay

### Software Development

The Arduino IDE was used in the design of this system as depicted in figure 10. This IDE enabled us to design a sketch (Write code) for the system. The programming was done in Embedded C/C++. The ATMEGA328P Microcontroller, which was

uploaded to the chip, serves as the primary component of the suggested system.



```

// This sketch will turn on and off a light emitting diode(LED) connected to digital pin 13,
// when pressing a pushbutton attached to pin 2.

// The circuit:
// - LED attached from pin 13 to ground through 330 ohm resistor
// - pushbutton attached to pin 2 from +5V
// - one resistor attached to pin 2 from ground

// Note: on most Arduino boards it already is LED on the board
// attached to pin 13.

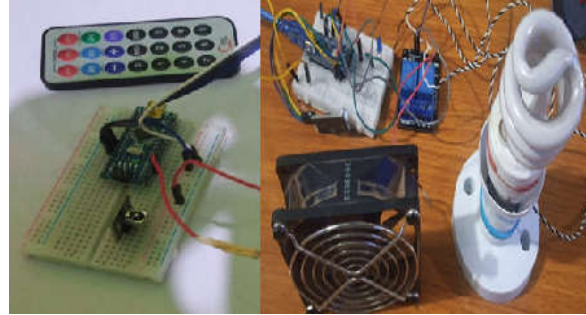
// constants won't change. They're used here to set pin numbers:
const int buttonPin = 2;    // the number of the pushbutton pin
const int ledPin = 13;     // the number of the LED pin

// variables will change:
int buttonState = 0;        // variable for reading the pushbutton status
  
```

**Figure 10:** Arduino IDE

## Results and Discussion

Figure 11 shows the developed system's screenshot. The technology uses a remote control to turn on and off household appliances like fans and lights. In order to enable home automation, the system used IR transceiver technology. The IR receiver searches for an IR signal when all the components are powered by a 9v battery. The active buttons on the remote were pressed once the signal was picked up, and the bulb, fan, or other household appliances were turned ON/OFF in accordance with the designation. We implemented Arduino with Infrared as a medium of communication without internet services or mobile phone to overcome the challenges of using a Raspberry pi. Infrared technology is preferred over the Radio Frequency (RF) because RF is more expensive and still experiences interference from other radio frequency devices. In order to prevent power upsurge from causing serious damage to the system, we used Direct Current from 9-volt battery which makes this research good for both AC and DC bulbs and fans.



**Figure 11:** Screenshot of the developed system

## Conclusion

The study proposes an efficient means of controlling both the domestic and industrial appliances with a single remote control. The system was especially designed to assist the physically challenged individuals, the elderly, youths and kids who frequently control home or industrial appliances with one remote without much stress. The system uses a remote control to operate home appliances including fans, lights, air conditioners, televisions, refrigerators, etc., or industrial appliances ON and OFF. In order to enable home automation, the IR Transceiver technology has been implemented in the system. Most people's activities in their homes, workplaces, places of worship, and other places can be made simple and comfortable with the help of this system.

## Acknowledgment

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## Conflict of Interest

The authors affirm that there were no financial or commercial ties that might be viewed as having a potential conflict of interest on this research.

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