

## **Android-Based Electric Fan Remote Control Unit for Smart Healthcare and Assisted Living Environments**

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### **ABSTRACT**

The research focus on the design of an electric remote fan control (RFC) using android mobile phone. The fan automation system is divided into nine parts. 9V DC battery was used to power the Arduino board. Code was uploaded on microcontroller through the Arduino board using Arduino IDE. Proteus professional software was used to simulate the fan control circuit workability prior to soldering. A 5V, 10A DC relay was used. Trigger current for the relay was computed using Ohms law. A BC 337 transistor was used to boost the arduino current output order to trigger the relay. Limiting resistor was used to protect HC-05 bluetooth module. Multi meter was used to test against phase to neutral. Measuring tape was used to determined operational distance of the module. Locally fabricated metallic case was used to protect the designed module against mechanical damages. The existing fan without inbuilt remote facility was upgraded to use the developed RFC in this work to powered 130W fan and 100W light. Distance of operation is 15m maximum. The remote control using android phone can be used for control conveniency.

**KEYWORDS:** Arduino board, Android phone, Bluetooth module, and microcontroller.

### **1. INTRODUCTION**

Automation is defined as a technology used in performing a process by means of programmed commands combined with automatic feedback control to ensure proper execution of the instructions [1]. Automation makes it possible for a system to produce output without human intervention or complement human's input to a system. This technology finds application in various works of life such as home, hospital, firm and the likes.

Home automation is the controlling of home appliances and equipment automatically and remotely, safely and controllability [1]. Home automation is also referred to the process of controlling or operating automatically both home equipment in residence and everything we use for our day to day activities or purpose such as vehicles, telephones and the likes [2]. Automated controls can turn equipment on and off, or adjust operating settings at anytime and anywhere within the home without having to press the physical electrical controls and switches.

The invention of mobile phone has now made it possible for people to move about with their phones due to its portability. It is of great advantage in using phone in controlling electrical appliances installed in various home. Home automation gives its user access to control devices in their home from a mobile device anywhere in the world. Home automation may also allow many vital functions to be controlled remotely from anywhere in the world using a device connected to the internet. The fundamental components of a well-designed home automation system (HAS) include a computer with the appropriate programming, the various devices and systems to be controlled, interconnecting cables or wireless links, a high speed internet connection and essential home systems. This research is aimed at designing an android controlled Electrical Fan that can be used in home, office, shop and the likes.

The idea of home automation or smart home started with invention of microcontroller in the early 20<sup>th</sup> century, with the intention that people would operate domestic equipment cheaply and easily [2]. This technological advancement gave rise to the implementation of embedded systems within home appliances. [3], in their work developed a home automation by using Field Programmable Gate Array controller (FPGA), PIC microcontroller, and an Android mobile phone with Bluetooth feature. The FPGA controller is as the central

controller and communicates with Bluetooth module through a serial interface, which was achieved through a Universal Asynchronous Receiver/Transmitter (UART) used on the FPGA. The speech recognition application on the Android mobile phone was developed using Java software, which is used for controlling all the devices that are connected to the FPGA controller via Bluetooth. The number of devices that are connected depends on the rated value of the FPGA controller. The PIC microcontroller receives data from the Bluetooth receiver serially, the data received is converted into digital form using the PIC microcontroller and the data is transmitted parallel to the FPGA [3].

In another development home automation was implemented using Android app and cloud network [4]. The system comprises cloud server, Android app and home system, the cloud server serves as a central storage of data for the

system, this cloud server provides interface for both the Android app and the home system and analyses the data receives from home and sends it to the Android application and vice-versa. The mobile Android application gives room for users to access every appliance at home so to monitor and control them. The home server provides a graphical user interface that allows the user to select an input[4].

[5], developed a classroom automation using Arduino Uno microcontroller and Passive Infrared (PIR) sensor. The PIR sensor senses the presence of a person at a particular range and amount of change in infrared rays that takes when a person of temperature value different from that of the surrounding moves.

It is good to note that there are existing fan remote control in the market. Instead of procure another fan in the market, the remote fan control of this work is adaptable to work with any fan remotely with the maximum load of 10A, the cost of 70W remote fan in the open market is #18,000 ( \$49). It will be economical in use at a cost of #12,000 (\$33).

### 1.1 Elements of an Electrical Fan Remote Control

The elements of an Electrical Fan Remote Control is as presented in Figure 1.

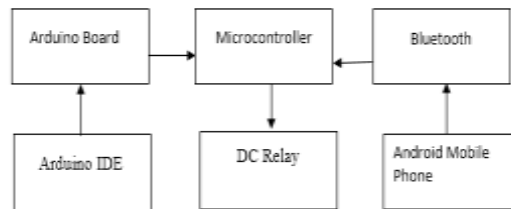


Figure 1: Elements of an Electrical Fan Remote Control

#### 1.1.1 Interfaces Software

The interface software in this work is Arduino Integrated Development Environment (IDE) is a special program that runs on computer which allows codes to be written for the Arduino Board in a simple language modeled after the processing language. The script of Arduino IDE is called Sketch; this sketch is written in C language.

The IDE allows user to edit, debug, and upload Sketch to the Arduino board which serves as a programmer to the atmega328p microcontroller.

Installation of Arduino IDE software for a particular project required the following steps:

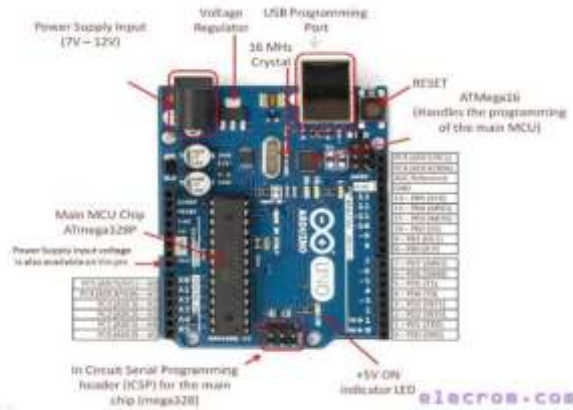
- i. the software is downloaded based on the specifications of ones' personal computer from the website.
- ii. Having downloaded the software then the Arduino IDE can be installed on android handset

#### 1.1.2 Arduino Development Kits

The Arduino development consist of Arduino development board, sensors, microcontroller and connecting wires. Sensors is not used in this research. Arduino board's design was invented in the year 2005 to overcome the problems encounter by electronics hobbyists, students, and professionals in building or implementing

electronics projects by providing an inexpensive microcontroller that can easily be used to interact with the environment using sensors and actuators [6].

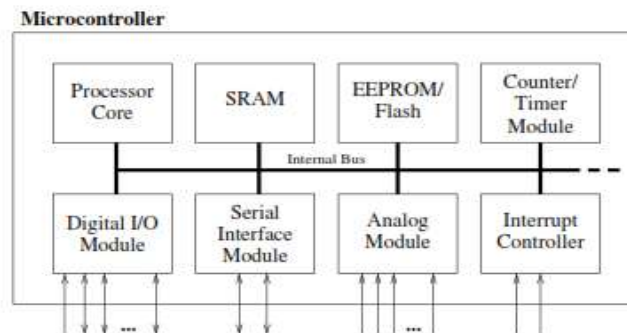
Arduino board is made of an Atmel AVR reduced instruction set computer (RISC) microprocessor, a crystal or oscillator that sends time pulses at a specified frequency to enable it operate at the correct speed and 5volts regulator. The board comes in different versions depending on the bit of the microprocessor and number of input and output pins on the board, these include Uno, Duemilanove, Due Leonardo, Mega 2560, Mega ADK, Fio, Arduino Ethernet, Mini, Nano, Lilypad and Bluetooth Arduino. The most commonly used version is the Arduino Uno and the latest version Arduino Due Leonardo that make use of ARM processor instead of AVR architecture processor, a 32bit processor, 512KB flash memory and run at 84MHz [7].



**Figure 2: Arduino development board**

**1.1.3 Microcontroller**

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory and programmable input or output peripherals [8]. They are specially designed for embedded applications use in automatically controlled products and devices such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. The various types of microcontrollers manufacture or produce such as Microchip (PIC series), Atmel (AVR series), Actel, Motorola (MPC series), Maxim integrated products, Texas instruments, Sharp (ARM series) and the likes are classified as general purpose microcontrollers and signal processing microcontrollers. The general purpose microcontrollers as the name implies are useful in different applications and are available in various configurations such as 8-bit, 16-bit and 32-bit word sizes, examples of these microcontrollers include Atmel and Microchip. Signal processing microcontrollers combine the built in memory and simple instruction sets of microcontrollers with the signal processing arithmetic circuits found in digital signal processors [8]. The microcontroller block diagram is presented in Figure 3



**Figure 3: Microcontroller Layout**

**1.1.3.1 Atmega328 Microcontroller**

Arduino Atmega328 microcontroller Figure 4, acts as a processor for the Arduino Board it consists of 28 pins out of which the inputs can be controlled by transmitting and receiving the inputs to the external device.



**Figure 4: Atmega328p Microcontroller**

The pulse width modulation (PWM) pins of the microcontroller are used to transmit the entire signal in a pulse modulation. This IC mainly consists of analog and digital inputs which are used for specific applications. The high performance Atmel 8-bit AVR RISC based microcontroller combines 32KB ISP flash memory with read while write capabilities, 1KB EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer or counter with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter, programmable watchdog timer with interval oscillator and five software selectable power saving modes. The device operates between 1.8 to 5.5 volts [9].

### 1.1.4 Bluetooth Technology

Bluetooth technology is a global wireless standard ability, convenient, secure connectivity for an expanding range of devices and services. This technology is to eradicate RS-232 data cable. It makes use of radio transmission frequency in exchange of data over short distances. This frequency operates within the unlicensed Industrial Scientific and Medical (ISM) band at 2.4 to 2.485 GHz using a spread spectrum, frequency hopping and full-duplex signal at a nominal rate of 1600 hops per second. The ISM frequency band of 2.4 GHz is available and unlicensed in most countries [10].

#### 1.1.4.1 HC-05 Bluetooth Module

HC-05 Bluetooth module, Figure 5, is an easy to use Bluetooth (Serial Port Protocol) SPP module designed for transparent wireless serial connection setup. The Bluetooth module is a short range device of around 10 meters which provide both sound and data transmission. The Bluetooth transmits and receives at a frequency band of 2.4 GHz which is globally available. The Bluetooth device uses a IEEE 802 standards wherein the connections can be point-to-point or point-to-multipoint. The data transfer rate is 3mbps and the maximum range of a Bluetooth device can be 10 to 100 meters. The default baud rate is 38400 [11].



Figure 5: HC-05 Bluetooth Module

### 1.1.5 Relay

A relay is an electrically operated switch, Figure 6, Relays are used where it is necessary to control a circuit by a low power signal with complete electrical isolation between control and controlled circuits or where several circuits must be controlled by one signal. A type of relay that can handle the high power required to directly control an electric motor or other loads is referred to as a contactor. However for this relay to work effectively resistor and diode are used as protective devices. The resistor is used to limit the current in accordance to the rated value, and a diode is used to prevent reversed voltage



Figure 6: A DC Relay

## 2. MATERIALS AND METHODS

### 2.1 Materials

The materials used for this research include bluetooth module, android hand set, distance meter, FTIKE MAS830L (F.M) digital multimeter, Atmega 328p microcontroller and Arduino board are present in Figure 4 to 9.



*Figure 7: YUE BAO*



*Figure 8: F M. Meter*

### 2.2 Cable sizing

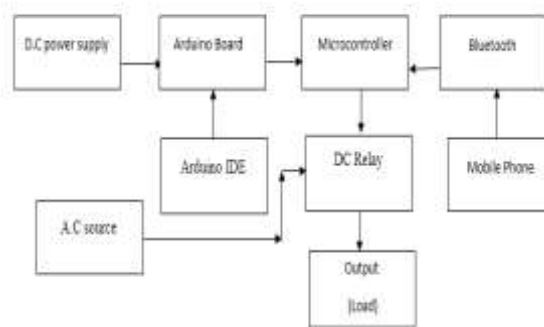
The rated current output of the load used will be obtained from the fan name plate. The rated output will then be used to size cable for this work using kabel metal catalogue [12]

### 2.3 Mechanical Protection

Metallic device is used to protect the module to be designed against mechanical damage. The mechanical protective box will be punctured using chisel in order to protect the component of the assembled module against heat

### 2.3 Block Diagram of Fan Automation System

The fan automation system is divided into nine parts as presented in Figure 9



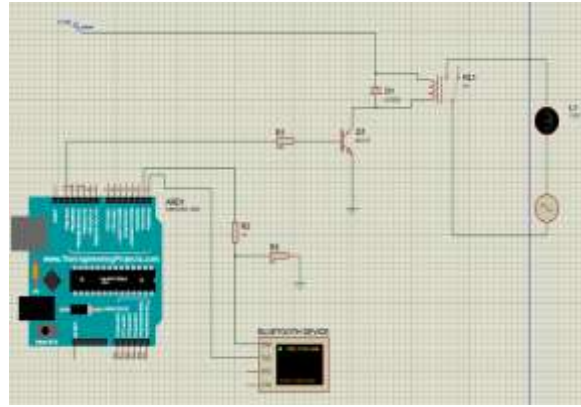
*Figure 9: Complete Block Diagram of Fan Control*

To power the Arduino Board, 5V DC supply is needed but for this project a 9V DC power supply will be used because Arduino board has an inbuilt voltage regulator that reduces the 9V DC power source to the required 5V DC. The code will be uploaded on microcontroller through the Arduino board.

The Android mobile phone communicates with the microcontroller through bluetooth feature or device. The Bluetooth receiver receives the signal from the mobile phone based on user input and processing unit that reads and processes the received signal that triggers the relay to turn ON or OFF the Fan.

### 2.3 Circuit Design

The Circuit design is presented in Figure 10.



**Figure 10: Circuit Design of Fan Control**

Proteus professional software was used to design and simulate the circuit as presented in Figure 10. A 5V DC relay (minimum available relay) with a maximum DC load current of 10A (since the price of 2A and 10A are the same) for further expansion. To calculate the current needed to switch or energize the relay. The trigger or nominal current of the relay is computed using Equation 1 and the data sheet will also be used to confirm the alignment or agreement of computed current value.

$$I = \frac{V}{R} \quad (1)$$

Where I is the current to energize the relay, v is the source voltage of the relay and R is the coil resistance of the relay.

If the output current from the Arduino is less than what is needed to energize the required relay, a transistor (BC 337) will be used to boost the value to the required value in order to bias the base of the transistor Equation(2) will be used to calculate the base resistance,  $R_1$ .

$$R_1 = \frac{(V_{cc} - V_{be})}{I_b} \quad (2)$$

Where  $V_{cc}$  is the collector voltage and  $I_b$  is the base current  $V_{be}$  is the base emitter voltage which is 0.7 V as obtained from its data sheet [13]. A diode will also be used to protect the transistor against reverse voltage. The bluetooth module (HC-05) RX terminal will also be connected across resistor  $R_2$  and  $R_3$  using voltage divider rule initializing  $R_2$  as 1k and  $R_3$  (limiting Resistor) will be obtained using Equation (3).

$$R_3 = \frac{R_2(V_{out} - V_{rx})}{V_{rx}} \quad (3)$$

Where  $V_{out}$  is voltage output of the Arduino,  $V_{rx}$  is the voltage at the terminal rx of the bluetooth module,  $R_2$  is the resistor across the bluetooth module.

### 2.3 System Software Code Development

The embedded system was developed with Arduino IDE; the Arduino IDE script or sketch is written in C++ Program. The algorithm used is highlighted below:

- i. open the Arduino IDE and check the port of connection between the Arduino board and PC.
- ii. create an object of the Serial Class.
- iii. declaration of variables for the Arduino board pins.
- iv. establish serial communication.
- v. setup the Arduino pins.
- vi. check if there is a serial communication on the software serial object pins.
- vii. read the communication value.
- viii. if value is "0", switch off the source
- ix. if value is "1", switch on the source.

### 2.4 Android Bluetooth design and Arduino bluetooth controller downloaded

#### **Android Bluetooth design**

The Android app is designed with the use of MIT App Inventor platform. The design is made up of two parts, the (Graphical User Interface) GUI design and the coding section. The Android app displays two Screens, an introductory screen and a main screen that comprises the control and feedback components.

### ***Arduino bluetooth controller Application***

The Arduino bluetooth controller application will be downloaded from Google play store into an android mobile phone by searching for Arduino bluetooth controller.

## **3. RESULTS AND DISCUSSIONS**

### **3.1 Results**

The result of this research are presented in Figure 11-16.



***Figure 11: Assembled Module***



***Figure12: Protective Unit***



***Figure 13: OFF Mode Light***



***Figure14: ON Mode Light***



***Figure 15: OFF Mode Fan***



***Figure16: ON Fan + Light***

### **3.2 Result Verification**

The accuracy of the computed nominal current value of the relay which is 70mA was verify using the relay specification from its data sheet.

From Equation (2) the calculated value for the bias resistor (R1) of the transistor is 107.5 Ohms. Since there is no single resistor of 107 Ohms, the designed make used of 100 Ohms. From Equation (3) the limiting resistor (R3) value is obtained as 2K in order to connect the RX terminal of HC-05 bluetooth module in accordance to its voltage specification.

### **3.3 Discussions of the Designed Circuit**

From Figure 14 the multi meter was used to test the phase to neutral voltage output of the designed Fan Control module as 224 volts. From Figure 14 to 16 the designed module was tested using 100 watts bulb and 130 watts standing fan and it worked perfectly, it means that the developed fan control can carry load current of 1A. From the relay rated value it will carry load up to 10A. It worked at Maximum distance of 15m and it failed to operate above 15 m away from the system, it worked against obstruction of non-transparent objects (cemented 9 inches block wall and Iron door). It implies that the system is not a function of obstruction.

## 4 CONCLUSIONS AND RECOMMENDATION

### 4.1 Conclusions

- i. It allows modification of existing fan (standing, wall or ceiling) to be remotely controlled.
- ii. It is economical or otherwise save cost in modification
- iii. The maximum distance for the system to perform effectively without using a repeater was found to be approximately 15 m.
- iv. The system can work effectively when obstructed by non-transparent object within a range of 15m.
- v. This type of control can be very beneficial to the elderly ones, sick people and the physically challenged.
- vi. The HC-05 bluetooth module used is of upward 50% tolerance compared to the data sheet specification.

### 4.2 Recommendation

It is recommended that the developed fan control can be used in light control or any other control apart from fan for the end users comfort ability, especially hospitals, physical challenge people and aged people

## 5 ACKNOWLEDGEMENT

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