



Development and Implementation of a Microcontroller based Remote Control of a Single Phase Induction Motor Using Radio Frequency

Joseph Ailenokhuoria OGBEKHIULU, Emmanuel Ighodalo OKHUELEIGBE

Abstract— In this paper the development and implementation of speed control of a single phase induction motor through radio frequency module is presented. The proposed speed control method enables the user to operate an induction motor remotely. In this scheme any button on the remote can be used for the speed control of the induction motor. Whenever any push button switch of remote controller is pressed on the remote control, the transmitter transmits the wireless signal to the receiver module. Subsequently, this signal was decoded by the decoder and the firing angle of ac voltage controller can be controlled.

Keywords— Induction Motor, Microcontroller, Infrared, Control, Efficiency

I. INTRODUCTION

Single phase induction motors are the most widely used motors for domestic appliances. The AC induction motor has a simple rugged design. Other advantages include low cost, low maintenance and the fact that it can be connected directly to an AC power source. When power is supplied to the motor at the recommended name plate specifications, it runs at the rated speed [1]. Basically, a single phase induction motor consists of three main parts viz- the main winding in the stator, the rotor winding, which is usually made of a squirrel cage type and the starting mechanism. The single phase induction motor is not self-starting hence the starting mechanism incorporates a capacitor and a centrifugal switch connected in series with the starting winding to cut off the starting winding after starting [2]. The principle of operation of a single phase induction motor is very simple. When the supply voltage is applied to the motor, the supply voltage in the main winding leads the current due to the main winding impedance while current in the starting winding may lead or lag the supply voltage depending on the starting mechanism impedance. The interaction between the magnetic fields generated by the main winding and the starting mechanism produces a resultant magnetic field rotating in the specific direction depending on the resultant magnetic field [3]. The single phase induction motor of interest here is the fan used both at home and in the offices. Majority of them

incorporate either a mechanical push button switch, a regulator of five speed or by pulling a chain. Each of these mechanical switches corresponds to one speed that is selected by either pushing a button at a time or the regulator or pulling a chain. The use of an android phone to regulate the speed of a single phase induction motor via a bluetooth is presented in [4]. The disadvantage of this system is that when there are network issues with the network providers, there will be problem operating the system. Some people who are incapacitated will find it very difficult to operate the system. It is not cost effective as it involves phone gadget. The system proposed here can be operated by anybody using the remote control of the system. Automatic speed control of single phase induction motor with the variation of ambient temperature was proposed in [5]. The author aimed at the design of Automatic Speed Control of Single Phase Induction motor with variation of ambient temperature. It is very clear that the device controls the load with the variation of the temperature. It reduces human effort and as TRIAC is used for controlling the voltage so as to save power. Despite the fact that it is user friendly and as well monitors the temperature of a room or office and automatically gives it a normal/room temperature, it still has some weaknesses as this cannot be used in the hospital where the variation of temperature varies with the speed of a single phase induction motor (fan) which might not be conducive to the patients. Secondly, the body temperature of the user might not be the same with the room temperature and the device itself works with the principle that, the speed of the fan is the function of ambient temperature. In that case, it is not the appropriate device to be used in controlling the speed of a fan so as to give maximum conduciveness to the user. Microcontroller Based infrared (IR) Remote Control Signal Decoder for Home Applications has been proposed. The author proposed a design and implementation of an infrared (IR) remote control signal decoder which can be used for various home control applications. The entire system is based on microcontroller that makes the control system smarter and easy to modify for other applications. It enables the user to operate or control a fan regulator and operate the mains power switch from about 10 meters away. The control setting and output AC voltage of fan regulator has been observed [6]. The drawback of this work lies in the fact that it covers only small range of distance and as well does not pass through a wall which makes it limited to be used within a very short range of distance. In the use of radio frequency in speed control of an induction motor presented in this paper, a wider range of distance can be covered and it can pass through wall. Speed Control of Single Phase Induction Motor Using Android Phone was proposed in

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[7]. The authors concentrated on controlling the speed of induction motor using Android phone remotely by the help of the Bluetooth technology interfaced with the microcontroller. The Microcontroller decodes the signal and sends it to the relays. Then, the respective relays operate to change the speed of Induction motor from zero percent to 100 percent. This device does not only control the speed of an Induction motor, but it also uses feedback network to detect the over temperature, high voltage, low voltage, miniature circuit breaker (MCB) tripping on account of any faults and also monitors the phase lines of the motors. Because these types of uncertainties are likely to happen in Industries, this design will be very helpful in industries, households, shopping malls etc. However, this design has some drawbacks such that, the Bluetooth wireless technology only supports for limited distance and that the system is not cost effective because it makes use of global system for mobile communication (GSM) which is very costly compared to the use of radio frequency module. A Microcontroller based remote control of single phase induction motor using Radio frequency is therefore considered the most reliable, efficient, cost effective, low power consumption and user friendly to be used in controlling the speed of a single phase induction motor for homes and offices.

The generalized block diagram of the microcontroller based remote control of the single phase induction motor is shown in figure .1

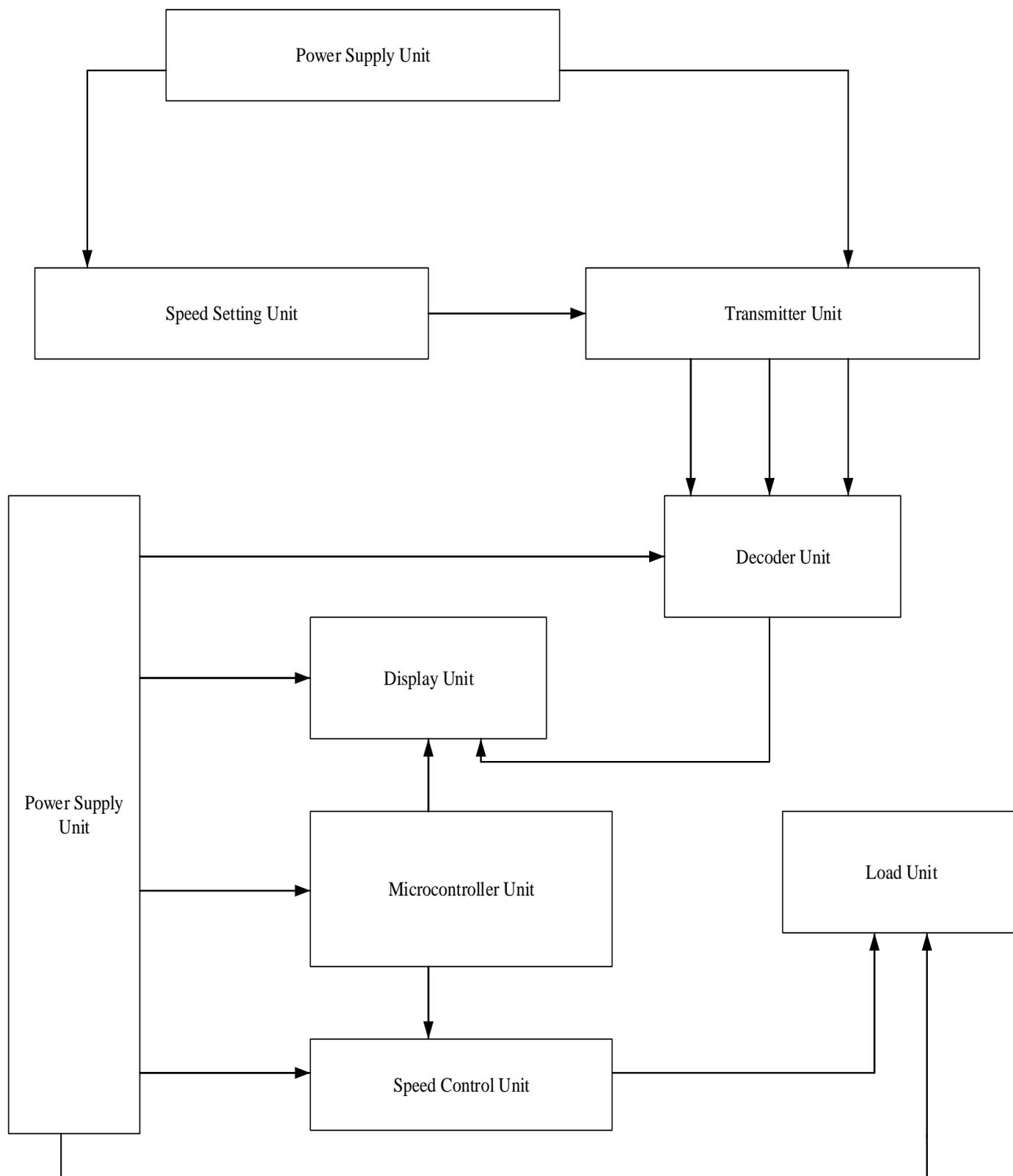


Figure.1 Block diagram of microcontroller based remote control of single phase induction using radio frequency.

The flowchart of how the design operates is shown in figure2.

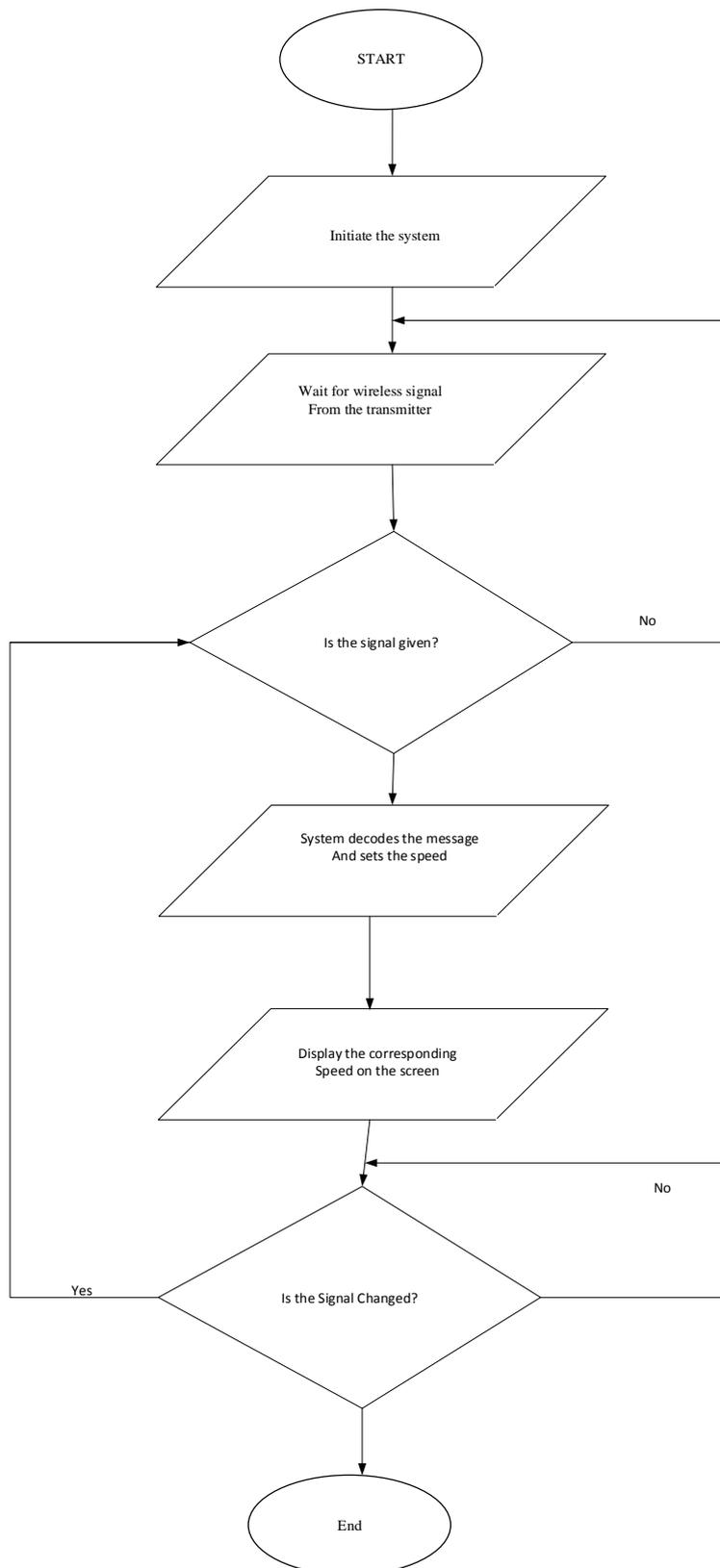


Figure.2 The Flowchart of Microcontroller Based Remote Control of Single Phase Induction motor using radio frequency.

II. METHODOLOGY

The method of the design of the entire circuitry is outlined below.

A. Design Calculation of the Power Supply Unit

AC mains voltage = 220VAC Volts.

The transformer used is a Step down transformer 230V/15VAC

Primary voltage, E1 = 230VAC

Secondary voltage, E2 = 15VAC

Transformer turns ratio, n; as in equation (1)

$$N = \frac{N_p}{N_s} = \frac{E_p}{E_s} \dots \dots \dots (1)$$

$$n = \frac{230}{15} = 15:1$$

Primary current calculation as in equation (2)

$$\frac{N_p}{N_s} = \frac{E_p}{E_s} = \frac{I_s}{I_p} \dots \dots \dots (2)$$

Secondary current, Is = 2A

$$I_p = \frac{2A}{15} = 133.33mA.$$

So, the current flowing through the primary side of the transformer is 133.33mA

TRI: Is the step down transformer with 15Vac at 2A. D₁ - D₄ is the full wave rectifier. The diodes chosen have a peak inverse voltage (PIV) that must be able to withstand twice the peak voltage V_p of the transformers output and a forward current (DC) of 1.5 times the output current of the transformer.

$$V = (\sqrt{2})V_{rms} \dots \dots \dots (3)$$

Where,

V_p is the peak voltage of the transformer output

V_{rms} = actual voltage from the transformer = 15Vac

$$V = \sqrt{2} \times 15 = 21.21Vac$$

$$D(PIV) = 2 \times V_p = 2 \times 21.21 = 42.42Vac \text{ and } Dc = 1.5 \times 2A = 3A$$

Therefore, the required diode must have PIV ≥ 42.42V and DC ≥ 3A.

From diode catalogue, the 1n4007 has the following characteristics

$$PIV = 50V, DC = 1A$$

Where, PIV is the peak inverse voltage of diode.

So 1n4007 diode is chosen.

C1: This is the filter capacitor otherwise called electrolytic capacitor. It comes with a capacitance and voltage ratings.

B. Voltage Rating

The voltage of the capacitor (V_c) must be able to withstand 150 percent of the output voltage from the diode.

$$V = 150\% \text{ of } V_{DP}$$

$$V_{DP} = V_p - V_D \dots \dots \dots (4)$$

Where V_p = the peak voltage of the transformer

V_D = the voltage drop of the diode (0.7 x 2 = 1.4)

$$V_{DP} = \frac{150}{100} \times 21.21 - 1.4 = 19.81$$

$$V_c = 1.5 \times 19.81 = 29.7V$$

C. Capacitance Rating

The capacitance of the capacitor must be such that it can reduce the ripple voltage (VR) to about 30 percent of the output peak voltage from the diodes.

$$V = 30\% \text{ of } V_{DP}$$

But V_{DP} is calculated as 19.81V.

$$V_R = \frac{30}{100} \times 19.81 = 5.94V$$

Now, from the ripple voltage equation, we can calculate the capacitance of the capacitor.

$$V_R = \frac{(\text{Maximum current})}{2fc} \dots \dots \dots (5)$$

Where VR is the ripple voltage and I_{MAX} is the maximum current from the diodes = 2A

f = frequency in Hertz (50Hz).

C = the capacitance of the capacitor.

$$\text{from equation (3.5), } C1 = \frac{I_{\text{maximum}}}{2fVR}$$

$$C1 = \frac{2}{2 \times 50 \times 5.94}$$

$$C1 = 3360\mu F$$

But 3300μF at voltage of 50V were chosen.

D. LM7805 Voltage Regulator

U1: The voltage regulator has the following specifications

- Maximum input voltage = 32V
- Maximum output voltage = 5.5V
- Operating temperature = (0-150)°C

For effective voltage regulation, the minimum input voltage is given by:

$$V_{\text{MIN}} = V_{\text{OUT}} + V_{\text{REF}} \dots \dots \dots (6)$$

Where V_{MIN} = Minimum input voltage

V_{OUT} = Required output voltage

V_{REF} = Reference voltage (from data sheet given as 3V)

$$V_{\text{min}} = 5v + 3v = 8V$$

So the range of voltage at the input of voltage regulator is (8V-32V). Therefore, LM7805 voltage regulator can be used comfortably.

E. Design Calculation of the Power Supply Unit of the transmitter

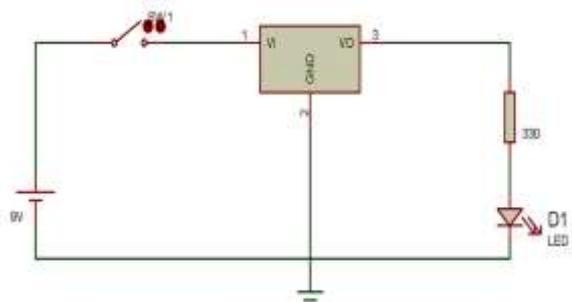


Fig.3 The power supply unit of the transmitter circuit.

$V_{MIN} = V_{REF} + V_{OUT} \dots \dots \dots (7)$
 $V_{MAX} = 32v$
 $V_{REF} = 2v$ and $V_{out} = 5v$
 But $I_F = 10mA$
 $V_{MIN} = 2 + 5 = 7v$
 $V_{RANGE} = 7v$ to $32v$
 $\therefore R = \frac{V_S - V_D}{I_D} \dots \dots \dots (8)$
 $V_S =$ Supply voltage
 $V_D =$ voltage drop across LED
 $I_D =$ current drop across LED with the range 10mA – 20mA
 $I_F =$ forward current
 $\therefore R = \frac{5v - 2v}{10mA} = 300\Omega$ from equation (8)
 Although 300Ω resistor was calculated, 330Ω preferred.

F. RF Transmitter and Receiver

Here I have constructed a simple 434MHz ASK based wireless remote control capable of transmitting 4-bits of information. It is directly interfaced with the motor driver to control the speed of the motor. These transmitter and receiver modules use 434MHz. The ones that are found suitable with the microcontroller AT89C52 are 434MHz Transmitter and 434MHz Receiver. The frequency of operation of these modules is from 315MHz to 434MHz bandwidth. They work with 5V. The transmitter accepts serial data at a maximum speed of 4800 bauds/sec. Bauds /second means symbols per second and a symbol may consist of varying number of bits, generally, 8-bits. They can be interfaced to a Microcontroller or can be directly interfaced with the encoder and decoder ICs at the transmitter and receiver side respectively as shown below.

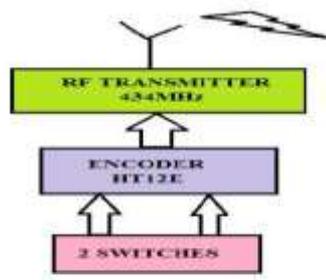


Figure 4a Transmitter unit

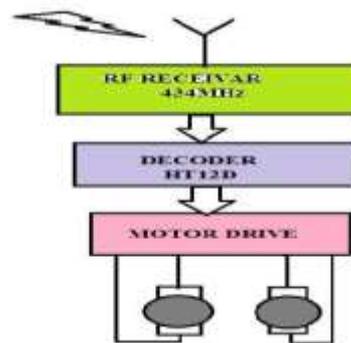


Figure 4b Receiver unit

G. Design Calculation of the Transmitter Unit

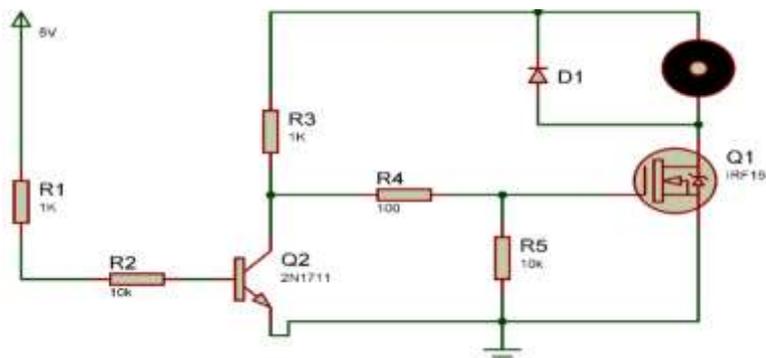


Figure 5 shows the circuit diagram of the transmitter unit of the proposed system.

$R_a =$ Pull up resistor
 $R_b =$ Base resistor, $R_c = 1k\Omega$ while, $R_3 = R_4 = 100\Omega$ and $R_2 = R_5 = 10k\Omega$ (chosen from the IRF150N datasheet)
 But $R_b = 10R_c$, Therefore, $R_b = R_2 = 10 \times 1000 = 10k\Omega$

H. Display unit

This displays the speed status of the motor using seven segment display. Fig.6 shows is the circuit diagram of the display unit. The microcontroller is programmed to display the speed level of the motor on the seven segment display.

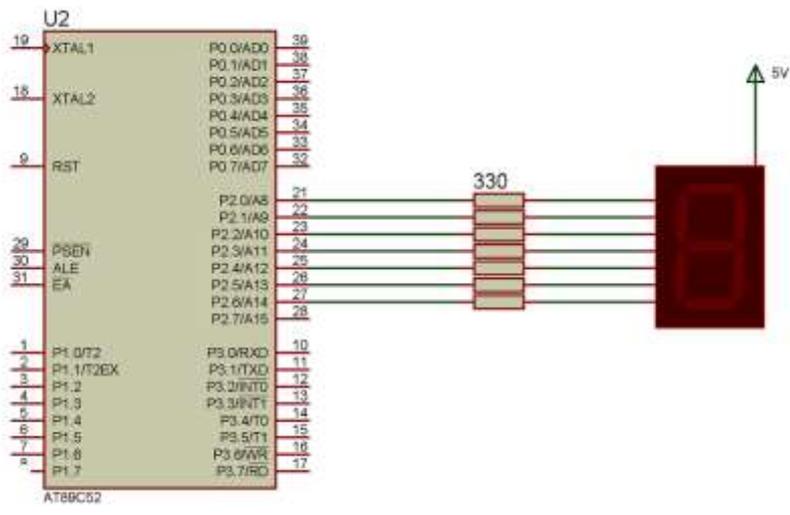


Figure 6 The display circuit

$$R = \frac{(V_s - V_d)}{I_d} \dots \dots \dots (9)$$

Where, I_d is the safe operating current of the resistor which is equal to 10mA.

V_s = input voltage = 5v.
 V_d = voltage drop across diode = 2v

$$\text{So, } R = \frac{5v - 2v}{10mA} = \frac{3v}{10mA} = 300\Omega.$$

But R is chosen to be 330Ω.

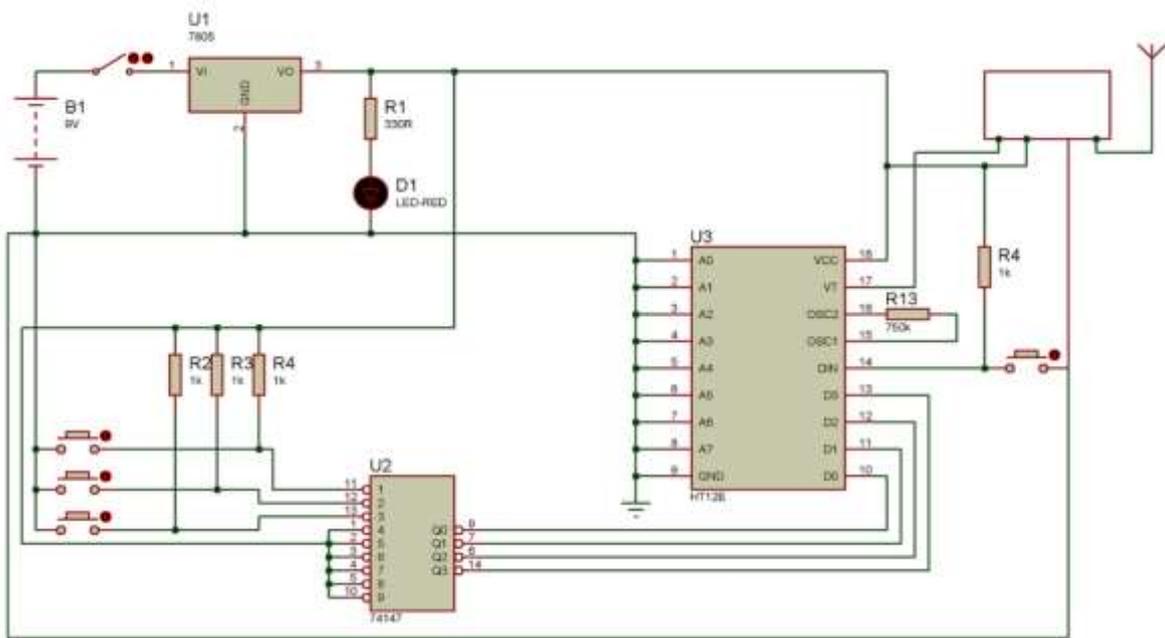


Figure 7 Complete Circuit Diagram of the Transmitter Unit

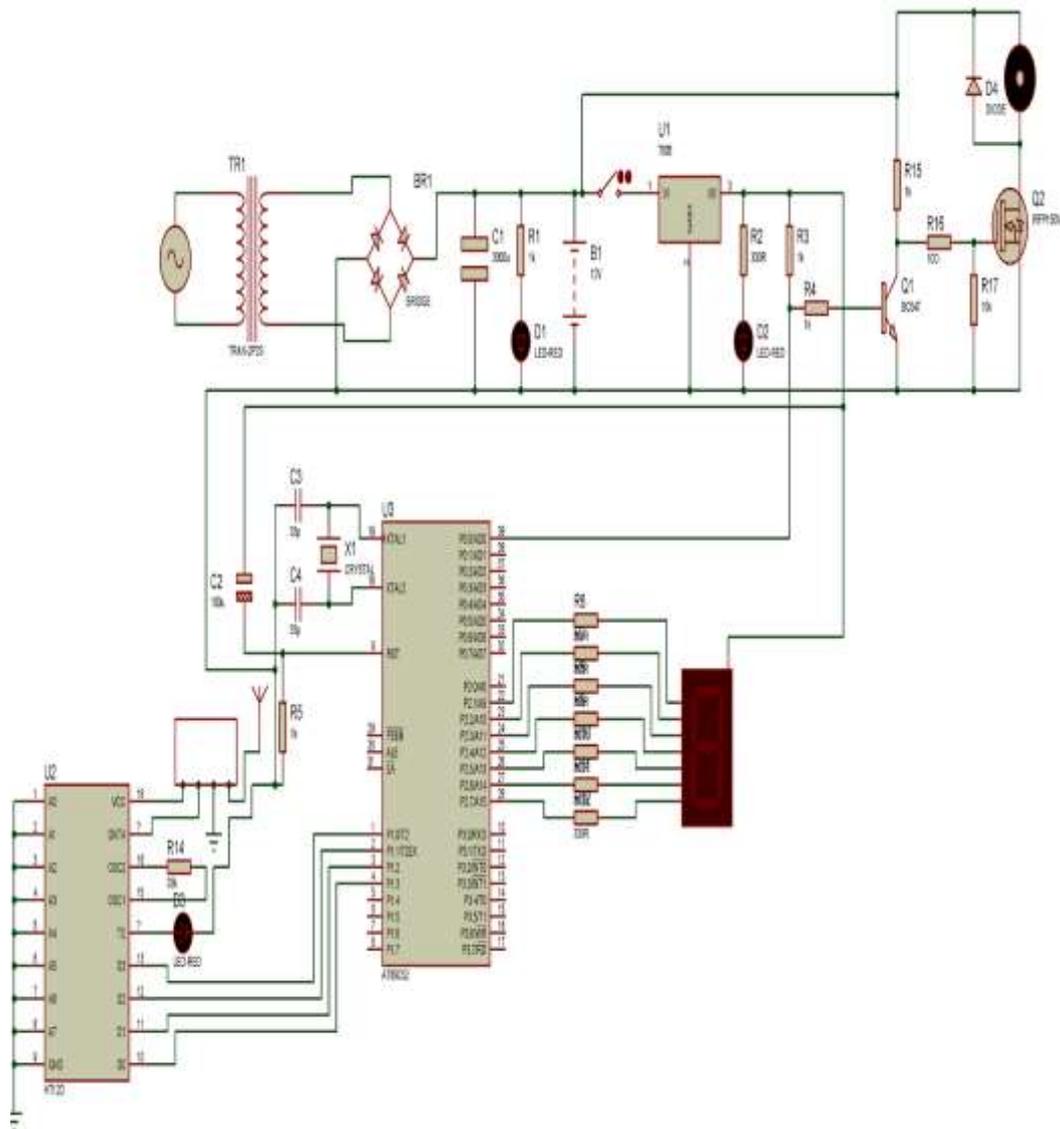


Figure 8 Complete Circuit Diagram of the Receiver Unit

I. The Principle Operation of the Circuit Design

When the user presses a specific key the RF Generator generates the Corresponding analogue output. This analogue output is fed to the RF Transmitter. The RF Transmitter is initially tuned to work in the RF range 315MHz to 434MHz. The options are provided to vary the frequency depending on the RF Receiver. The RF provides an output that is a combination of two different Frequencies of the specific key pressed. So the output from the RF Transmitter will be the Combination of the carrier frequency and analogue frequency generated by the HT12E IC. At the other end the RF Receiver picks up the signals by tuning in to the carrier frequency of the RF Transmitter. The output of the RF Receiver is fed to the HT12D Receiver; the Receiver accordingly generates the BCD (Binary coded Decimal) output from this IC. The Output that

is digital is fed to the Microcontroller (89C52). The Microcontroller identifies the BCD output from the HT12D Receiver whose output is fed to the Induction Motor which is given in serial through the power supply. Depending on the button pressed by the user, the Microcontroller generates PWM (Pulse Width Modulation) that helps to drive the circuit and hence control the speed of the induction motor. The smaller the pulse width, the faster the speed of the Induction Motor.

III. HARDWARE IMPLEMENTATION OF THE PROPOSED DESIGN

The hardware implementation of the circuit design was carefully constructed stage by stage as presented in the design calculations and the accompanying circuit diagrams.



Figure 9 The hardware of the transmitter circuit



Figure 10 The Hardware of the Receiver Circuit

A. The Simulations of the Circuit

The simulation circuit above, was performed on Proteus Simulation 7.7 software with the help of the program burnt on the microcontroller AT89C52 so as to confirm its working possibility of the hardware. This is done to save time, energy and to avoid wastage of components. This circuit consist of speed selector, the encoder, the microcontroller, the seven segment display, resistors and the motor. Whenever speed selector 1 is pressed, the encoder displays the inverted binary equivalent of one and send it to the microcontroller. The microcontroller displays the speed selected at the seven segment display. The microcontroller (AT89C52), as it was programmed as well send the same speed level imputed to the motor so, in this way the motor speed is regulated. But in practice, a transmitter is used to send signal wirelessly to the receiver via radio frequency. The receiver circuit which is incorporated with the microcontroller and the seven segment displays the speed and regulate the motor speed as required by the user.

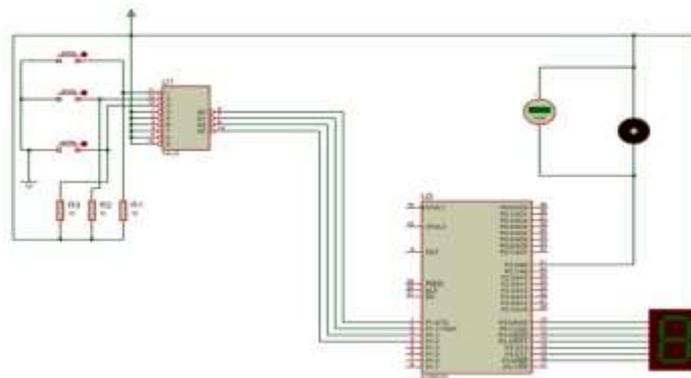


Figure 11 The Proteus Simulation of Circuit

IV. TESTS AND RESULTS

The design was sectionalized and then tested separately before it was integrated into the whole system before final assembly.

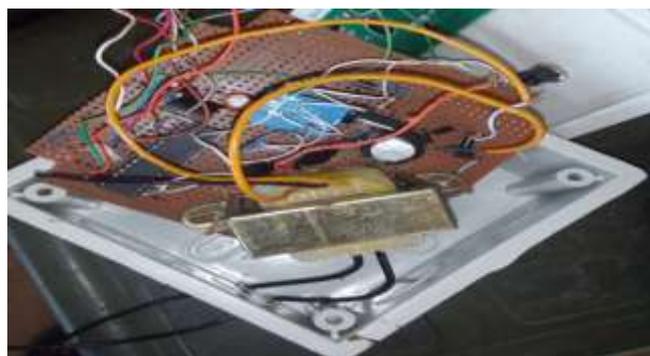


Figure 12 The Proteus Simulation of the Circuit

TABLE 1. Illustrating the Voltage and Amperage Values at Different Speed Levels.

| S/N | SPEED(rev per min) | VOLTAGE (V) | CURRENT (A) |
|-----|--------------------|-------------|-------------|
| 1 | 0.00 | 0.00 | 0.000 |
| 2 | 680 | 3.43 | 1.175 |
| 3 | 1380 | 7.08 | 2.674 |
| 4 | 2040 | 11.87 | 5.450 |

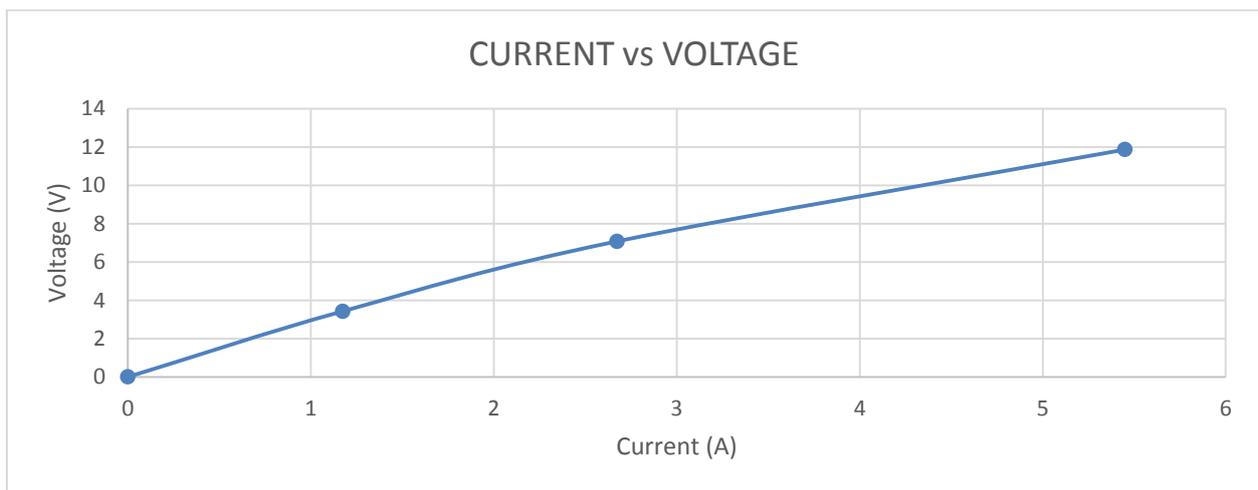


Figure 13 Graph of Current against Voltage

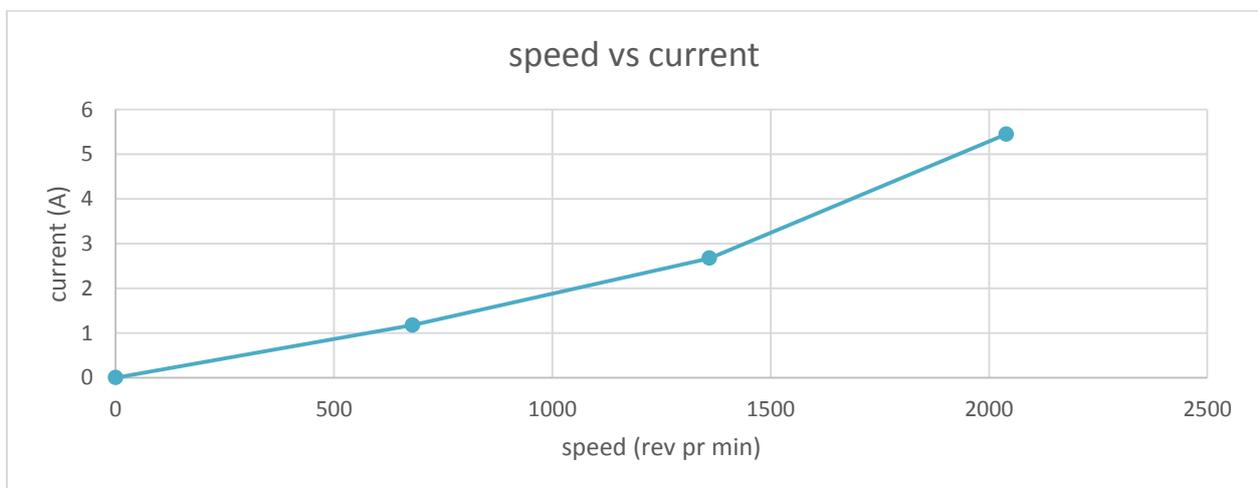


Figure 14 Graph of Speed against Current.



Figure 15 Complete Assembly of the work

CONCLUSION

The objective of this paper which is the development and implementation of a microcontroller based remote control of single phase induction motor using radio frequency as a medium of controlling motors at homes and offices has been successfully achieved. The remote/keypad was able to control the speed of single phase induction motor (fan). The transmitter was able to send a signal at a frequency of 315-433MHz to the receiver and the receiver implemented the signal sent to it. The microcontroller was able to understand the command sent by the user through the transmitter and then displayed it through the seven segment display and finally, ON/OFF, increase or decrease the speed of the motor.

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