DESIGN AND IMPLEMENTATION

OF

AN AUTOMATIC TEMPERATURE CONTROLLED FAN REGULATOR

BY

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EEE/12/0840

A PROJECT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICSENGINEERING

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE FEDERAL UNIVERSITY, OYE-EKITI

IKOLE CAMPUS.

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DEDICATION

This imperative project is dedicated to almighty God who has seen me through from conception till date, my strength in ages past.

I also dedicate this project to my parents for their care, love and support. Also to my siblings for which without them there will be no me.

I also dedicate this project to all those that believed in me and stood by me throughout the journey of my life.

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ABSTRACT

This project presents the Design and Implementation of a Temperature Controlled Fan Regulator. The main aim of this project is to develop a fan regulator that can change the speed level according to temperature changes. The regulator will help reduce extra effort and add comfort to human lives. The system comprises major components; thermistor, resistor, capacitor, transformer etc. but the entire system is based on temperature sensor known as thermistor, where the fan speed is dependent and controlled by temperature. As the temperature increases or decreases, the fan speed increases or decreases respectively. The thermistor used in the circuit here, decreases its resistance with increasing temperature, hence the electrical conductivity also increases, increasing voltage across it, resulting in an increment in the speed of the fan. Thus, it is possible to control the speed of the fan automatically when the device's temperature varies. The completion of this project work results in fan regulator that can be controlled by temperature.

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ACKNOWLEDGEMENT

Praise be to Almighty God for keeping me alive throughout my stay in this academic institution and also enabling me complete this project.

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It is my sincere prayer that God in his infinite goodness will continue to be with you all. I love you all.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Project

The electric fan is one of the most popular and populous electrical appliances to have graced the electrical appliance world. It has become the most popular electrical appliance as it's in use in many different parts of the world except the cold regions of the world taking different shapes and forms but still serving its main purpose which is to equally distribute the flow of air whether in the home or industry. These fans range from ceiling fans, to fans in automobiles to computer cooling fan to variable pitch fans etc.

All fans possess a regulator, without the regulator, the user cannot decide on his/her choice amount on air flow to be supplied by the fan. The fan component is a crucial component that serves to increase or decrease the speed of the fan according to the user's needs. There are conventional and electronic regulators. The conventional regulators are very large and are made up of a knob to set the fan to its desired speed and it's separate from the fan. Advancements into the electronic regulators have the regulators embedded in the fans.

The main intention of this project is to design and implement an automatic temperature controlled fan regulator, where the speed of the fan is controlled based on the temperature (i.e.as the temperature of the room increases the speed of the fan increases and as the temperature of the room decreases the fan speed decreases). The main element in this project is the thermistor with the regulating part of the fan embedded with the fan.

1.2 Statement of Problem

In the industrial field, machines that emit a lot of hot air put workers in the application area of such machines at risk as they try to the increase the speed of air produced by the fan to cool such machines using the regulator of the fan.

The normal fans in household create a few problems in terms of user comfort. For example, the speed of fan needs to be changed at regular time intervals as the temperature and weather conditions keep changing throughout the day. Also, in the mornings or at night, it might become cold. Hence, either the fan speed needs to be adjusted before sleeping or the consumer has to wake at the inappropriate time and manually set it. It can be difficult for people sensitive to changing temperatures and may cause sickness, especially small kids and babies.

Also physically challenged persons are mainly affected due to the inconveniences related with regulating the fan manually. In order to solve this problem, the design and implementation of automatic controlled fan regulator that will automatically change the speed level according to the room temperature is recommended.

1.3 Project Motivation

General purpose fan present in the society today possesses manual speed regulator control and a need for its automation as seen in industrial air conditioners and cold rooms is necessary. I was motivated to develop this device due to this pertinent problem in the society today because there is a need to automatically control the temperature of a room with the aid of a fan that will be beneficial to the society especially that with disabilities to curb the difficulty in manually regulating the speed of the fan. This device can be applied at homes, offices, poultry or industries.

1.4 Aims and Objectives

The aim of this project is to design an automatic temperature controlled fan regulator.

The following are the objectives of the project:

- To design a system that would regulate room temperature or temperature of where the fan is located.
- To design a system that would reduce human intervention which occurs with changing of the fan speed.
- To design a system that will keep room temperature balance if applied in at homes.
- To design a system that would keep device within their operating temperature if applied in the industries.
- To conduct simulation of an automatic temperature controlled fan regulator.

1.5 Scope of project

This project merely designs and develops a prototype of an automatic temperature controlled fan regulator, which will help reduce extra effort and add comfort to human lives. The entire system is based on temperature sensor known as thermistor, where the fan speed is dependent and controlled by temperature. This design controls the speed of the fan automatically when the device`s temperature varies.

1.6 Organization

Chapter 1 presents the introduction of this project. The rest of the work is organized as follows: Chapter 2 reviews all related work conducted by several researchers, chapter 3 describes the methodological approaches and design specification. Chapter 4 presents simulation results and analysis, followed by Conclusion, Recommendations and Future work directions of chapter 5.

CHAPTER TWO

LITERATURE REVIEW

2.0 Background

The home is usually the most habitable place in any society. The need to keep the home environment thermally conducive should be of paramount concern in any society that wants to maintain happy and healthy citizens. Areas in the home that are usually occupied by people, such as the living room and bedrooms need to be maintained within habitable temperature ranges. The human body has a set-point temperature of between 35°C- 37°C. Extremely higher or lower temperatures can result in damage to some body organs or tissues and eventual death. These issues become more pertinent in areas of the home that are occupied by infants. Adults could possibly find their way around "thermal discomforts", but infants may not. Other areas of the home that are used as storage areas for perishable food items also need to be thermally regulated in order to prevent accelerated decay of such items. This makes necessary the need for a Temperature Control System within the home. For instance, during winter in most parts of Europe, the atmospheric environmental temperature sometimes drops to as low as -15°C during the day. This temperature implies that few liquids can exist under such conditions (body fluids inclusive). Therefore, a Temperature Control System is needed to act as a "watchdog" to make sure that such a thermal condition never exists especially when people are in the house. So many researches have been conducted in relevance with this project

2.1 Review of Related Work

Ahmad (2009) developed an automatic room temperature control system with an added security system with the aim implementing it in server rooms so as to control the temperature in Server rooms, especially those that are poorly ventilated and have no cooling units. The automatic room temperature control system utilized temperature sensors to detect the temperature of the server room. When the current temperature exceeds the set-point temperature, the Controller triggers on a cooling system made up of a set of brushless fans. These fans would cool the server room until the current temperature fell below the set-point temperature. The added security system is perceived as an auxiliary system that regulates access to the server room door by demanding an access password to open the door. The system is built with a temperature sensor that is placed in the server room that detects the current temperature and displays the value on the LCD. A PIC Microcontroller reads the data from the temperature sensor which is in output voltage. The system will operate in three different conditions depending on the range of temperature. When the current temperature value reaches higher than the desired value, the fan will start functioning and the LED indicator for high temperature turns on. As the current temperature reaches the desired value, the fan stops functioning and the LED indicator for normal state temperature will come on. Finally, if the current temperature reaches lower than the desired value, the fan also stops functioning and the LED indicator for cold temperature comes on. Any changes in temperature in the room are continuously displayed on the LCD and the LEDs are used to indicate the current state and range of temperature in the server room. With the security system (which also acts as a door lock security), the user has to provide the correct access code/password to gain access to the server room. Ahmad (2009), if the correct password is inserted, the door unlocks. However, if the password provided happens to be the wrong password, the door remains locked and a buzzer alarm system is activated. The Temperature Control System and the Security System are designed to function independent of each other. Thus, the failure of one of the systems does not affect the functionality of the other. The hardware comprised a PIC Microcontroller Circuit, A Sensory Input Circuit, A Driver Circuit, An LCD Display Module, LEDs and an Output Circuit. The system board was designed using a Bootstrap Mode Connection due to the constraints of size and finance. The Microcontroller is the Microchip PIC18F4550 owing to its ease of use, built-in timers, and many digital inputs and outputs. The Temperature Sensor used was the LM35DZSensor. An Alphanumeric LCD was chosen having 2 lines of 16 characters each.

Another temperature control system was developed using an LM92 Temperature Sensor and an AVR microcontroller by Kira (2007). The control program was compiled using BASCOM. The system is comprised of two main parts: the half-sphere contained four LM92Temperature Sensors, which were connected to a small box containing an ATTiny2313controller. The controller reads the input from the four sensors and then sends the temperature string over a low-speed RS232 cable to a display box which is close to the DMX light controllers. The display box has an ATMega32 which reads the temperature string and displays the result on a 240x128 graphics display using large digits. The ATMega32 also reads a pot meter to be used as a trip value. When one of the temperature readings exceeds this value, the display is repeatedly switched from normal to inverse as an alarm signal.

Mustafa (2014) also developed an automatic fan speed control using microcontroller. In this circuit the microcontroller is used to control the fan according to the temperature variation. The voltage from the mains (220/240V AC) is stepped down by a transformer to 12V. Then the 12V DC passes through the voltage regulator to give a clean 5V DC. The LM35 function is to measure the changes of temperature that surround the area. All the operations are controlled by the PIC16F877A to produce the output. The LCD, fans are the output where they are set with the pseudo code of PIC. The LCD is used to measure and show the changes of temperature value. As working principle, the temperature sensor senses the room temperature and displays it on the LCD. The speed of the fan is controlled by using PWM technique according to the room temperature change. For processing analog signals microcontroller has analog to digital converter which converts analog signals to digital ones. The LM35 gives 10mv for each 1°c change in the temperature; this value is analog value and should be converted to digital. Any change in the temperature will be sent to the microcontroller via PORTA pin 2, which has been specified by researchers in the program using TRISA. The microcontroller used in this system has inbuilt PWM module which is used to control speed of the fan by varying the duty cycle. According to the readings from the temperature sensor, duty cycle is varied automatically thus controlling the fan speed. The microcontroller will send the PWM signal via pin RC2 in port C to the transistor which works as switch to the fan. Crystal oscillator is connected in between pin 13 (osc1) and pin 14 (osc2) of PIC16F877A, those are pins if we want to provide external clock to the microcontroller. 0.1 µF bypass capacitor is used on the output pin +5 V of the voltage regulator to smooth out the supply voltage to microcontroller and LCD. Vout pin of temperature sensor LM35 is connected on pin RA2 which is ADC0 of all ADC input pins. Pin 3 of LCD is connected to ground via 1Kohm resistor to set the contrast of the LCD to display temperature on LCD. Pins from RB2 to RB7 are connected to remaining LCD pins used for data and control signals between LCD and microcontroller PWM output is given to gate terminal of Transistor NPN KSP2222A from microcontroller. Transistor NPN KSP2222A is high switching speed power switch. This switches on and off at PWM frequency and controls the voltage across motor. When KSP2222A is on, the motor starts to gain speed and off then motor loses speed. The hardware circuits that have been designed for the controlled fan speed system in this research, which consists of the LM35, PIC microcontroller, BLDC motor and LCD, which also include the crystal circuit.

Cytron Technologies Limited (2008) built a commercial Temperature Control System using 2 LM35 Temperature Sensors. Other components in the system included a PIC16F876A Microcontroller, Dc brushless Fans, LEDs, Buzzer and a BD135power transistor. A difference in the design of this system over previously designed models by the company was that: in previous versions, the PIC was used to control the LEDs and Buzzers. In this project, the PIC doesn't have enough current to perform this function; hence, an NPN power transistor (BD135) is used to power the brushless fans. Two LM35 Temperature sensors are used to detect the temperatures of two different areas. The Control Program in the Microcontroller compares the temperature readings against a set-point that has been programmed into the micro-controller at the push of a button. When this set-point is exceeded, the buzzers are triggered on and the DC brushless fans are powered on to begin cooling the room. When the temperature normalizes, the DC Brushless fans switch off and the buzzers go off too.

S. Velusamy et al. (2005) have presented the design of a system that monitors the temperatures at various locations on the FPGA. This system is composed of a controller interfacing to an array of temperature sensors that are implemented on the FPGA fabric. Such a system can be used to implement dynamic thermal management techniques. They cross validate the sensor readings with values obtained from Hotspot, a pre-RTL architectural level thermal modeling tool. Growth in floating-point applications for FPGAs has made it critical to optimize floating-point units for FPGA technology. The divider is of particular interest because the design space is large and divider usage in applications varies widely. Obtaining the right balance between clock speed, latency, throughput, and area in FPGAs can be challenging. The studies of K.S. Hemmert and K.D.Underwood include range of performance, throughput, and area constraints. On a Xilinx Virtex4-II FPGA, the range includes 250-MHz IEEE compliant double precision divides that are fully pipelined to 187-MHz iterative cores. Similarly, area requirements range from 4100 slices down to a mere 334 slices. Color space conversion is very important in many types of image processing applications including video compression. This operation consumes up to 40% of the entire processing power of a highly optimized decoder. Therefore, techniques which efficiently implement this conversion are desired. F. Bensaali and A. Amira describe four different scalable architectures for efficient implementation of two such color space converters using an FPGA based system. Distributed arithmetic technique and systolic design have been exploited to implement the proposed structures on the Celoxica RC1000-PP FPGA development board. The implementation approaches exhibit better performances when compared with existing implementations.

Paul (2006) developed a remote controlled fan regulator. Remote control facilitates the operation of a regulator around the home or office from a distance. Remote control is a standard on other consumer electronic products, including VCRs, cable and satellite boxes, digital video disc players and home audio players. And the most sophisticated TV sets have remote with as many as 50 buttons. In year 2000, more than 99 percent of all TV set and 100 percent of all VCR and DVD players sold are equipped with remote controls. The average individual these days probably picks up a remote control at least once or twice a day. Basically, a remote control works in the following manner. A button is pressed. This completes a specific connection which produces a Morse code line signal specific to that button. The transistor amplifies the signal and sends it to the LED which translates the signal into infrared light. The sensor on the appliance detects the infrared light and reacts appropriately. The remote control's function is to wait for the user to press a key and then translate that into infrared light signals that are received by the receiving appliance. The carrier frequency of such infrared signals is typically around 36 kHz. Usually, the transmitter part is constructed so that the transmitter oscillator which drives the infrared transmitter LED can be turned on/off by applying a TTL (transistor-transistor logic) voltage on the modulation controlled input. On the receiver side, a photo transistor or photodiode takes up the signals. The approach used in this work is the modular approach where the overall design was broken into functional block diagrams, where each block in the diagram represents a section of the circuit that carries out specific function. The system was designed using 9 functional blocks. Hadji and Mollov, (2008) describe that temperature is among the most frequently measured analog parameters. This might be expected since most electrical, chemical, mechanical, and environmental systems are strongly affected by the temperature directly or use its value to control other relevant processes. Intuitively, temperature is a measure of how hot or cold something is, although the most immediate way in which we can measure this, by feeling it, is unreliable, resulting in the phenomenon of felt air temperature, which can differ at varying degrees from actual temperature. Here they present a prototype design of an engineering system for precise measurement of temperature based on Xilinx Spartan3Edeveloping kit. Kumari and Malleswaran,(2010) developed real time based equipment condition monitoring and controlling system using embedded web based technology which directly connects the equipment to network as a node. The embedded system consists of ARM7 based LPC 2148 microcontroller board, A/D, signal conditioning, sensors, and communications interface. The function of web based system is to collect the real time data information of the on-site equipment and remotely send the data in the form of user defined data transmission style.

The remote Computer collects the data and running status through the network and provides the comparison on the historical data. If the parameter value is different from the original set value, the corrected signal is sent to the control unit. The embedded remote monitoring system completes the data Collection in the embedded platform and provides the data to remote host through the TCP/IP protocol from Web server. It creates condition to realize unattended management through providing Web-based graphical management interface for the Internet or LAN users.

2.2 Thermistor

A thermistor is a type of resistor whose resistance varies significantly (more than in standard resistors) with temperature. They are widely used as inrush current limiters, temperature sensors, self-resetting over current protectors, and self-regulating heating elements.

Thermistors have the most sensitivity, but are the most non-linear. However, they are popular in portable applications such as measurement of battery temperature and other critical temperatures in a system. "Similar in function to the RTD, thermistors are low-cost temperature sensitive resistors and are constructed of solid semiconductor materials which exhibit a positive or negative temperature coefficient. Although positive temperature coefficient devices are available, the most commonly used thermistors are those with a negative temperature coefficient

A thermistor is an electronic component that exhibits a large change in resistance with a change in its body temperature. The word "Thermistor" is actually a contraction of the words "Thermal Resistor". The thermistors, which are to be described herein are ceramic semiconductors and have either large positive temperature coefficient of resistance (PTC) devices or large negative temperature coefficients of resistance (NTC). Both types of thermistors (PTC and NTC) have definite features and advantages which make them ideal for certain sensor applications.

Thermistor differ from resistance temperature detectors (RTD) in that the material used in a Thermistor is generally a ceramic or polymer, while RTDs use pure metals. The temperature response is also different; RTDs are useful over larger temperature ranges, while Thermistor typically achieve a higher precision within a limited temperature range. In this project NTC thermistor of 1k at 25°C is used.

2.2.1 Types of Thermistor

Thermistor is a kind of temperature dependent resistor and its resistance varies depending on the temperature in its vicinity. There are two types of Thermistors

- Positive Temperature Coefficient Thermistor (NTC)
- Negative Temperature Coefficient Thermistor (PTC)

Positive Temperature Coefficient Thermistor (PTC)

PTC thermistors are made from doped polycrystalline ceramic (containing barium titanate ($BaTiO_3$) and other compounds) which have the property that their resistance rises suddenly at a certain critical temperature. Barium titanate is ferroelectric and its dielectric constant varies with temperature. Below the Curie point temperature, the high dielectric constant prevents the formation of potential barriers between the crystal grains, leading to a low resistance. In this region the device has a small negative temperature coefficient. At the Curie point temperature, the dielectric constant drops sufficiently to allow the formation of potential barriers at the grain boundaries, and the resistance increases sharply with temperature. At even higher temperatures, the material reverts to NTC behavior.

Negative Temperature Coefficient Thermistor (NTC)

Many NTC thermistors are made from a pressed disc, rod, plate, and bead or cast chip of semiconducting material such as sintered metal oxides. They work because raising the temperature of a semiconductor increases the number of active charge carriers - it promotes them into the conduction band. The more charge carriers that are available, the more current a material can conduct.

The NTC thermistors are composed of metal oxides. The most commonly used oxides are those of manganese, nickel, cobalt, iron, copper and titanium. The fabrication of commercial NTC thermistors uses basic ceramics technology and continues today much as it has for decades. In the basic process, a mixture of two or more metal oxide powders are combined with suitable binders, are formed to a desired geometry, dried and sintered at an elevated temperature. By varying the types of oxides used, their relative proportions, the sintering atmosphere and the sintering temperature, a wide range of resistivity and temperature coefficient characteristics can be obtained.

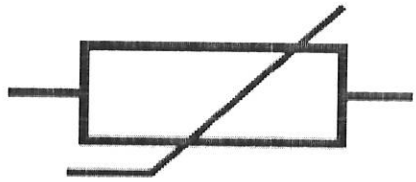

Figure: 2.1 Thermistor symbol (Wikipedia, 2010)

Assuming, as a first-order approximation, that the relationship between resistance and temperature is linear, then:

$$\Delta R = k\Delta T$$

Where

ΔR = change in resistance

ΔT = change in temperature

k = first-order temperature coefficient of resistance

Thermistor can be classified into two types, depending on the sign of k. If k is positive, the resistance increases with increasing temperature, and the device is called a positive temperature coefficient **(PTC)** Thermistor. If k is negative, the resistance decreases with increasing temperature, and the device is called a negative temperature coefficient **(NTC)** Thermistor. Resistors that are not Thermistor are designed to have a k as close to zero as possible (smallest possible k), so that their resistance remains nearly constant over a wide temperature range.

Instead of the temperature coefficient k, sometimes the temperature coefficient of resistance α (alpha) or α_T is used. It is defined as

$$\alpha_T = \frac{1}{R(T)}\frac{dR}{dT}.$$

The Thermistor used in this project is of NTC type with the value of 1KΩ.

2.3 Variable Resistor

The variable resistor known as potentiometer used in this project is of 1K Ω. Variable resistors consist of a resistance track with connections at both ends and a wiper which moves along the track as you turn the spindle. The track may be made from carbon, cermet (ceramic and metal mixture) or a coil of wire (for low resistances). The track is usually rotary but straight track versions, usually called sliders, are also available.

Variable resistors may be used as a rheostat with two connections (the wiper and just one end of the track) or as a potentiometer with all three connections in use. Miniature versions called presets are made for setting up circuits which will not require further adjustment.

Some variable resistors are designed to be mounted directly on the circuit board, but most are for mounting through a hole drilled in the case containing the circuit with stranded wire connecting their terminals to the circuit board. The standard spindle diameter is 6mm

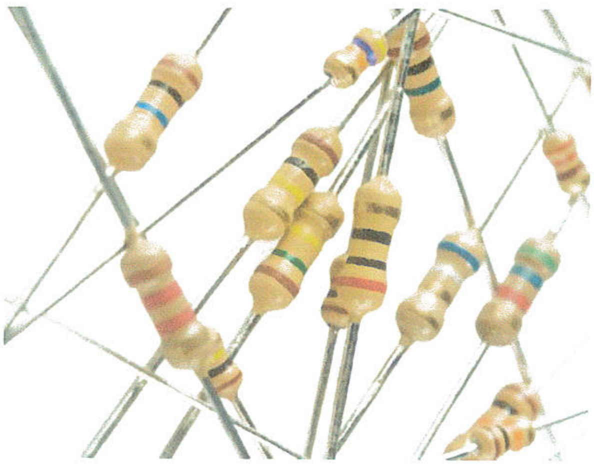

Figure 2.2 variable resistors (Bird, 2003)

2.4 Capacitor

A capacitor is a passive component which consists of a pair of conductors separated by a dielectric (insulator). Capacitors are used in the project to block alternating current from the system. It is also used for filtration and smoothing of unwanted A.C ripples in the power supply unit.

Figure 2.3: Symbol of a capacitor (Wikipedia, 2010)

2.5 Transformer

A transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed to electric power of the same frequency in another circuit. This design circuit uses a step-down transformer.

The voltage induced across the secondary coil may be calculated from Faraday's law of induction, which states that:

$$V_s = N_s(\frac{d\Phi}{dt})$$

Where Vs is the instantaneous voltage, Ns is the number of turns in the secondary coil and is the magnetic flux through one turn of the coil. If the turns of the coil are oriented perpendicularly to the magnetic field lines, the flux is the product of the magnetic flux density B and the area A, through which it cuts. The area is constant, being equal to the cross-sectional area of the transformer core, whereas the magnetic field varies with time according to the excitation of the primary. Since the same magnetic flux passes through both the primary and secondary coils in an ideal transformer, the instantaneous voltage across the primary winding is

$$V_p = N_p(\frac{d\Phi}{dt})$$

Taking the ratio of the two equations for Vs and Vp gives the basic equation for stepping up or stepping down the voltage

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Ns/N_p is known as the turn ratio, and is the primary functional characteristic of any transformer. In the case of step-up transformers, this may sometimes be stated as the reciprocal. N_p/N_s. Turns ratio is commonly expressed as an irreducible fraction or ratio: for example, a transformer with primary and secondary windings of, respectively, 100 and 150 turns is said to have a turn's ratio of 2:3 rather than 0.667 or 100:150.

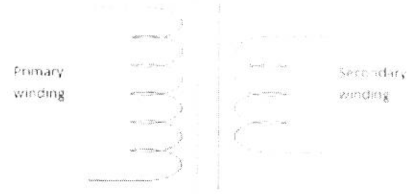

Figure 2.4: Symbol of a step-down transformer (Wikipedia, 2010)

2.6 Diode

A diode is a two-terminal electronic device that allows current to flow just in one direction. For a diode to conduct it must be forward biased with a voltage equal or above its bias voltage. That is the positive voltage is applied to the anode with respect to the cathode. At this point the barrier is overcome and current flow increases until it reaches saturation. If the input forward bias voltage exceeds the maximum forward voltage of the diode as stated in the data sheet of the diode it breaks down. If the diode is reversed biased, it acts as an open circuit.

In this project, four diodes were used in configuring a bridge rectifier circuit. The conversion of alternating current into direct current is called rectification. Here the property of a diode which only encourages a unidirectional flow of current is the physical basis why a diode or a number of diodes can be configured as a rectifier. Where a single diode is used the resulting type of rectification is called the half wave rectification. Subsequently, where four diodes are used the resulting type of rectification is called the full wave rectification. Following the fact that a relay is an inductive load, a diode was used to prevent back EMF from the coils.

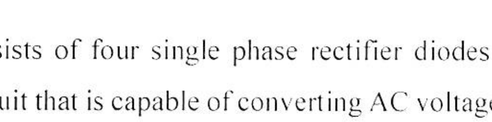

Figure 2.5: Symbol of a diode (Wikipedia, 2010)

2.7 Bridge Rectifier

The bridge rectifier consists of four single phase rectifier diodes connected together in a closed loop to form a circuit that is capable of converting AC voltage to DC voltage. A bridge rectifier circuit can be an IC or can be configured with four diodes as shown in figure 2.6 below.

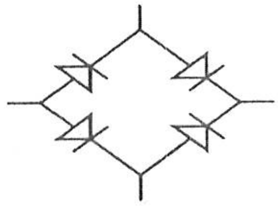

Figure 2.6: Symbol of a bridge rectifier (Bird, 2003)

It is called a full wave rectifier because two diodes must conduct for each cycle of an AC signal. That is the circuit employs the full use of an AC signal which is sinusoidal in nature. Most commonly, silicon rectifiers are used. When designing, the silicon diodes used should have a current rating greater than the current expected to be delivered to the circuit. The peak inverse voltage should also be taking into consideration. Considering both swings of the AC output from a transformer that is the positive and negative swings of the sinusoidal wave of the AC signal, there is always a conducting path through the bridge rectifier to be delivered to the load.

We find out that the current that flows through the load during both cycles is of same direction, thus it can be said that the polarity of the current at the output is of singular polarity, thus proving rectification has taken place.

CHAPTER THREE

DESIGN METHODOLOGY

3.0 Introduction

In this chapter, the design of the entire system (automatic controlled fan regulator) is presented. The entire system design comprise of the hardware aspect only. The hardware design relies on the knowledge of electronic component.

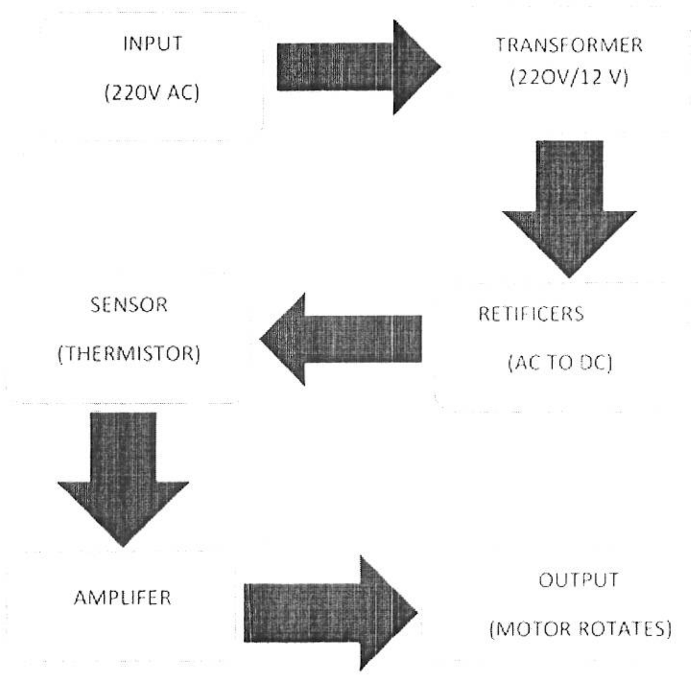

Figure 3.1 Block diagram of the system.

Figure3.1 shows the mode of operation of this project. When temperature changes, the fan regulator automatically change to suit the temperature, if it's a cold temperature the fan speed reduces and vice versa. In this project, whenever the sensor i.e. thermistor sensed temperature changes the motor starts rotating.

3.1 System Hardware Design

The project design consist mainly of the hardware design. The hardware is the physical part of the system; the basic units of the system are as follows

- Power supply unit
- Temperature sensing unit

3.1.1Power Supply Unit

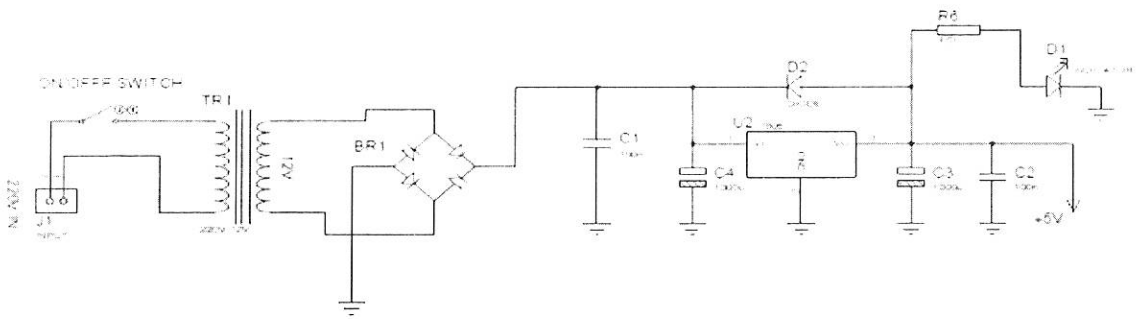

Figure 3.2: Diagram of power supply circuit

Fig 3.2 shows the diagram of the power supply unit which provides the desired 12 VDC and 5 VDC to run the circuit. The voltage obtained from the mains line is 220 VAC but the components require 12 VDC and 5 VDC, hence a step-down transformer is used to step the voltage down from 220 VAC to 12VAC. This 12 VAC is rectified to 12 VDC using a bridge rectifier circuit, and a filter capacitor is connected across the output of the bridge rectifier to remove ripples present in the output voltage. Then, the voltage regulator is used to supply the required voltage to the various components.

3.1.2 Choice of Transformer

A 220V/12V step-down transformer designated as TR1 in the circuit diagram, was chosen for the design of the power supply.

The turns-ratio of the transformer is given by;

$$N=\frac{E_p}{E_s}=\frac{N_p}{N_s}=\frac{I_p}{I_s}$$

Where:

N = transformer turn ratio. For this circuit the design specification is as follows:

Primary Voltage, E_p = 220VAC

Secondary voltage, E_s = 12VAC

Primary turn, Np

Secondary turn, NsSecondary current, I_s = 1A (as the maximum amount of current needed, which is in accordance to 7805 data sheet)

Primary current, $I_p = \frac{E_p \times I_s}{E_s} = \frac{220\times1}{12}$ =18.33A

Peak Primary voltage, E_p peak = $E_p\sqrt{2}$

E_pPeak = $220\sqrt{2}$

$E_p$peak = 311.13VAC

Peak Secondary voltage, E_s peak = E_p peak $\times (\frac{E_s}{E_p})$

$E_s$peak = $311.13\times(\frac{12}{220})$

E_sPeak = 13.67.

But recall, $V_m = V_{peak} = 2V_m = \frac{0.636\, V_m}{\pi}$

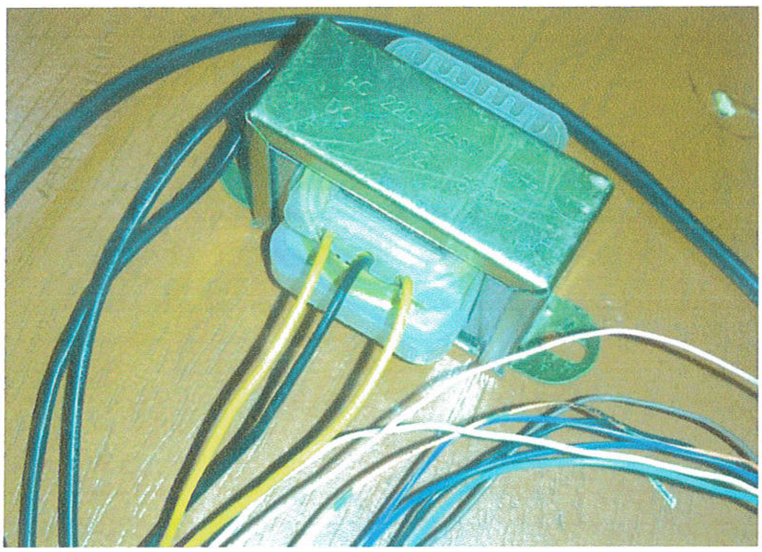

Figure 3.3 12v Step-down transformer

3.1.3 Choice of Diode Rectifier

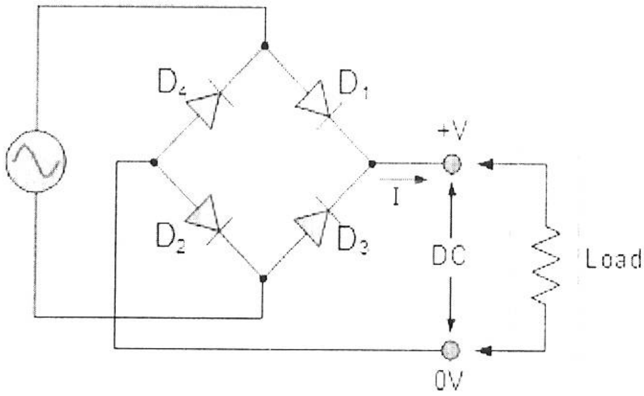

Figure 3.4: Diagram of a bridge rectifier (Wikipedia, 2010)

The bridge rectifier I.C, 2WGS (Composed of four IN4007 diodes) used for the design, has the following specification:

Forward voltage drops of 0.7V x 2 = 1.4V

Max current of the rectifier = 1A.

Since a voltage of 12Vrms AC is supplied by the transformer

The equivalent DC Voltage in R.M.S is given by

$V_{dc} = 0.636V_m - 2V_f$

$= 0.636 \times 12 - 2 \times 0.7$

$= 7.632 - 1.4$

$= 6.232$VDC. (Approximately 6VDC)

3.1.4 Choice of Smoothing Capacitor

In other to minimize ripple to at least 10%, an electrolytic capacitor was used for the filtering of the output voltage and its value was calculated using the formula. The capacitance of this capacitor is calculated below for a ripple voltage of 5.0V. The ripple voltage for a given capacitance is given by

$$V_R = \frac{I_{dc}}{2fc}$$

Which becomes equation 3.7 by making Capacitance (C) the subject of the equation

$$C = \frac{I_{dc}}{2fV_R}$$

Given the following specification;

I_{dc} - Rectifier output current (200mA)

F - Supply frequency (50Hz)

C - Capacitance

V_R - Ripple voltage (2v)

$$C = \frac{200 \times 10^{-3}}{2 \times 50 \times 2}$$

$$C = 1000\mu f$$

A capacitor of 1000μf, 50V was chosen and used for the construction of the filtering circuit.

3.2Temperature Sensor Unit

A temperature sensor is a device that gathers data concerning the temperature from a source and converts it to a form that can be understood either by an observer or another device. These sensors come in many different forms and are used for a wide variety of purposes, from simple home use to extremely accurate and precise scientific use. Thermistor as a main component has been chosen for sensing the temperature for designing the circuit.

3.2.1 Thermistor

Thermistor was chosen as temperature sensor for this project due to its high sensitivity and linearity. The ceramic NTC thermistor (Negative Temperature Coefficient Thermally Sensitive Resistor). This type of Temperature sensor exhibits a decrease in electrical resistance with increasing temperature. It is a semi-conductor based ceramic device. It generally has an operating temperature range of–50°C to +150°C and is accurate to ±0.1°C. The NTC Thermistor has a relatively large change in resistance with respect to temperature – of the order of -3% per °C to -6% per °C. This provides an order of magnitude of greater sensitivity or signal response than most other temperature sensors such as Thermocouples and RTDs. This sensor is well suited for sensing temperature at remote locations via long two-wire cables, because the resistance of the long wires is insignificant compared to its relatively high resistance. The diagram below shows the NTC Thermistor used in the construction of this project:

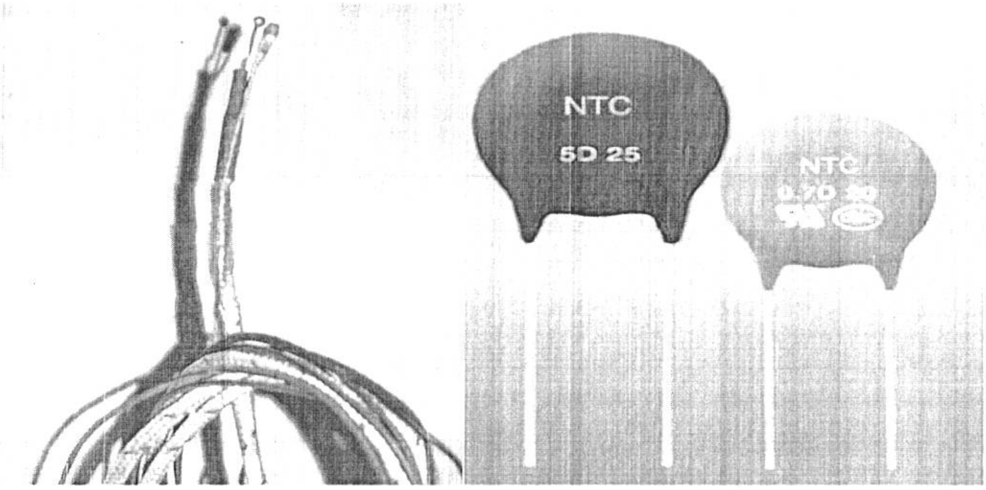

Figure 3.5 Negative temperature coefficient thermistor (Bird, 2003)

3.3 Requirements Specifications

S/N	NAME OFCOMPONENTS	SPECIFICATIONS	NO OF COMPONENTS USED
1.	Resistor	1k	3
2.	Variable resistor	(1-5)k	1
3.	Diodes	1N4001	5
4.	LEDS	1.8-2.2 v Dc	2
5.	NPN Transistors	BC548C	2
6.	Motor	Permanent Magnet DC, 12V, 6100 RPM, 0.06A	1
7.	Thermistor	1K at 25 degree Celsius	1
8.	Capacitor	1000μF, Electrolytic	2
9.	Transformer	220/12V, 600mA	1
10.	Vero board	Striped Board	1
11.	Propeller	3 bladed	1

Figure 3.6 shows a complete circuit diagram of an automatic temperature controlled fan regulator. The simulation was carried out with use of Proteus software.

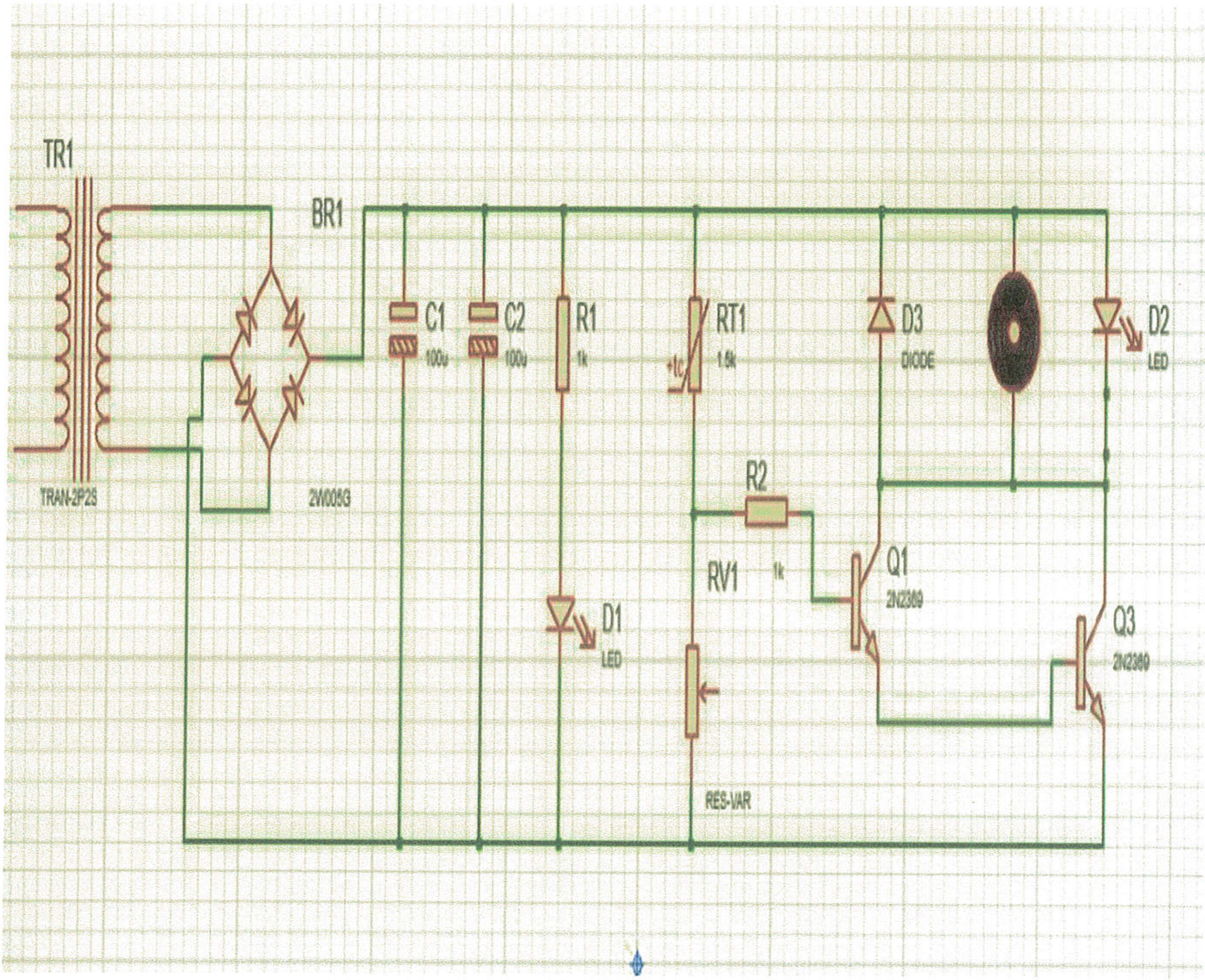

Figure 3.6 Complete circuit diagram of an automatic temperature controlled fan regulator

CHAPTER FOUR

TESTING, ANALYSIS OF RESULTS AND DISCUSSION

4.0 Introduction

This chapter covers the methods used to implement the circuit designed in the previous chapter and would be discussed alongside the various testing procedures carried at each stage in designing of the temperature controlled fan regulator.

The hardware worked properly as expected, the circuit is designed considering simplicity as the top priority. The purpose of this circuit is to vary the speed of a fan related to temperature with a minimum parts counting and avoiding the use of special-purpose ICs, often difficult to obtain. To do so, first of all, a number of Temperature Sensing Circuits are being developed and their characteristics were put into proper consideration. The circuit exploits the property of sensor to operate the DC Fan and the temperature sensor used is known as thermistor. Thermistor is a kind of temperature dependent resistor and its resistance varies depending on the temperature in its vicinity. NTC Thermistor1K (25°C) is used due to its ability to decreases its resistance when the temperature increases. A small DC fan increases or decreases its speed as per the temperature change. When the temperature decreases below a certain level, Fan automatically turns off. Several abnormities were observed in the behavior of the system, but was refined immediately the problem was figured out.

4.1 Testing

To ease the construction procedures, the circuitry was segmented into functional blocks. The construction included a prototype located on a breadboard followed by the final construction located on a Vero board. On completion of the construction, a thorough test and assessment of the component connection were carried out. The following steps were followed: The continuity and connectivity were taken using a multimeter while the circuit was not powered.

- The construction was tested block by block.
- The measurement of capacitance, current, resistances and voltage were taken and compared with design values.
- To operate the circuit, the switch, is held down

The aim is to design a temperature controlled fan regulator that is portable in size and a temperature sensor that responds only to the temperature. The system responds favorably and automatically changes the fan speed.

4.1.1Constructions Aids

The following tools and materials were used during the construction of this project:

- **Vero-Board:** The circuits were built on this board. It requires soldering and it has high connectivity which does not allow or enable two or more circuits to be placed on board.
- **Connecting cables:** These connectors are used to connect the various components together in the circuit.
- **Pliers and wire strippers:** These were used to cut the cables and remove their outer covering to prepare them for soldering and easy connection on the Vero-board.
- **Soldering iron and lead:** These were used to connect the cables together and to connect components to the copper layer of the Vero-board.
- **Multi-meter:** This was used to test values of the components used to ensure that certain.

Components were working efficiently and to test continuity in cables and components

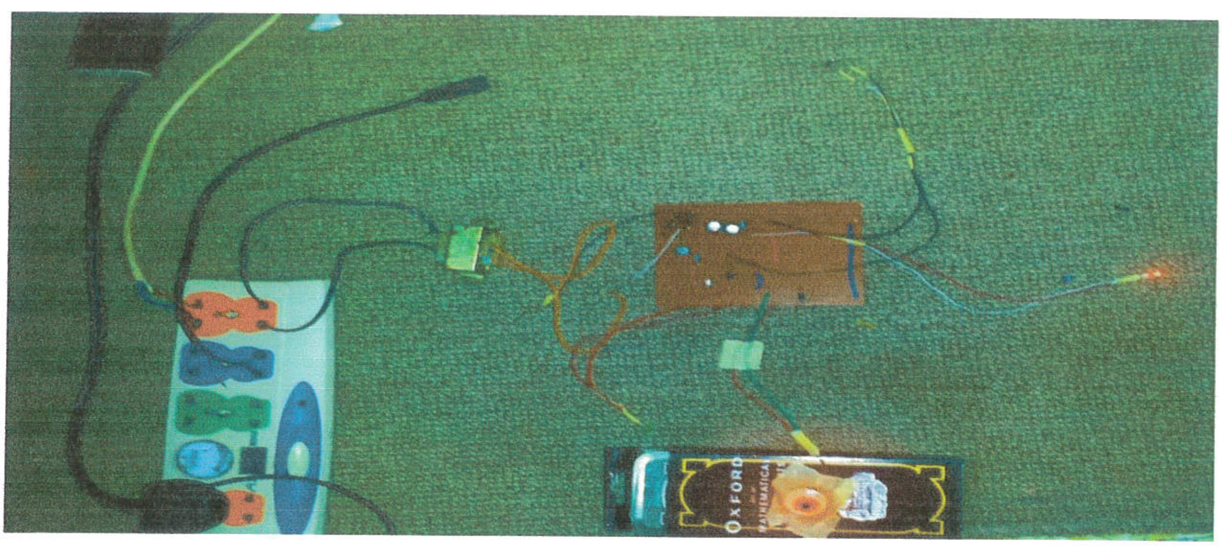

Figure 4.1 Increased fan speed and led brightness at 25°C and above

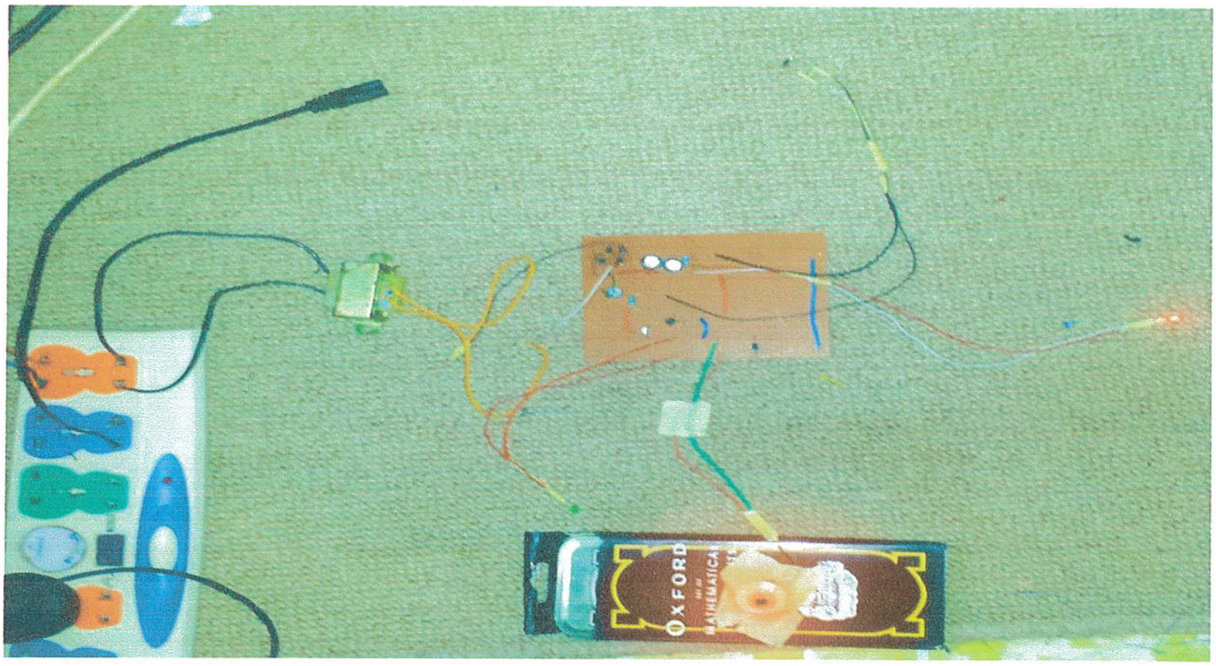

Figure 4.2 Decreased fan speed and LED brightness at 25°C and below

At figure 4.1, shows that at 25°C and above, the led glows brighter and the fan speed is faster, while at figure 4.2, shows that at temperature at25°C and below the led glows but the fan operates at a low speed.

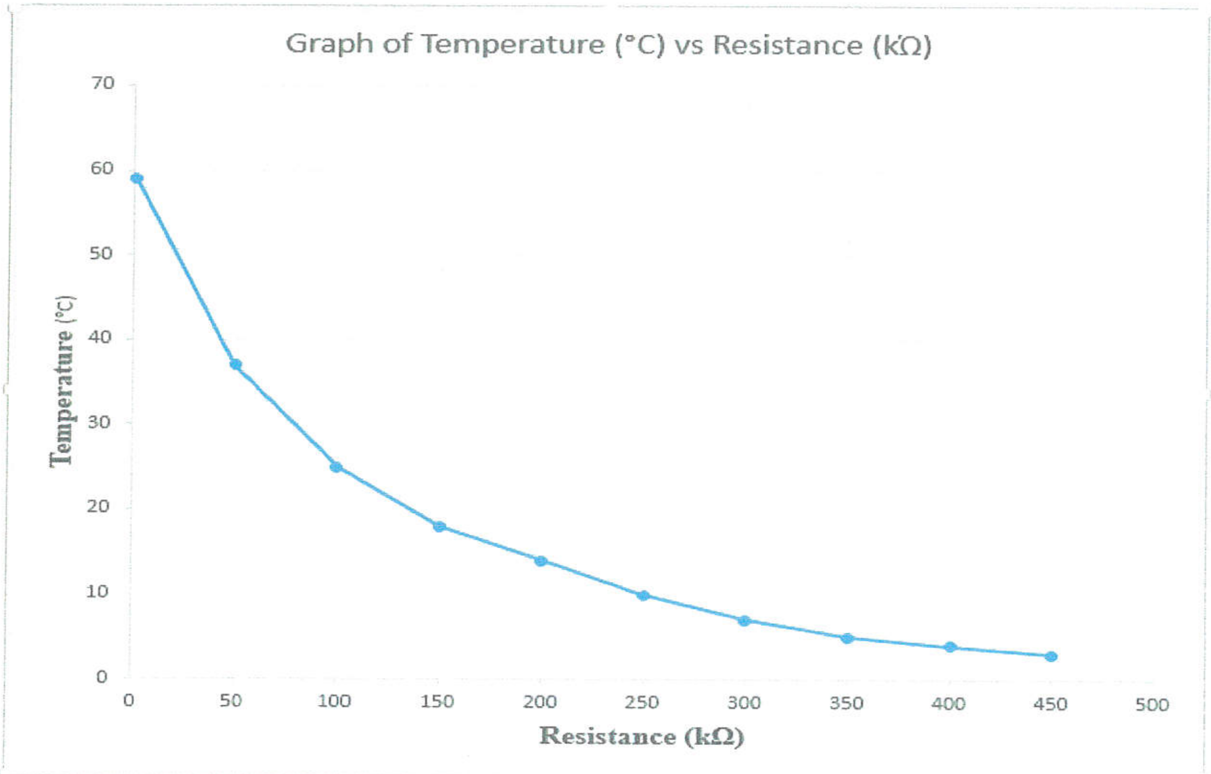

Figure 4.3 Graph of thermistor Temperature against Resistance

Figure 4.3 shows how increase in temperature around the thermistor affects the thermistor resistance. It shows that the thermistor resistance is inversely proportional to the temperature around the thermistor i.e. as the temperature increases the thermistor resistance decreases and vice versa.

4.1.2 System Functionality Requirements

For the temperature control system to operate optimally, there are some requirements that have to be met. These requirements include the following:

- The temperature sensor should be well positioned.
- The system should be protected from rain and even excessive heat that is generated from fire.

4.2 Analysis

The project is designed considering simplicity as the first priority. The purpose of this circuit is to vary the speed of a fan related to temperature with minimum parts counting and avoiding the use of special-purpose ICs, often difficult to obtain. To do so, first of all, a number of Temperature Sensing Circuits are being developed and their characteristics have been studied. Thermistor as a main component has been chosen for sensing temperature for designing the circuit. Development of the project included the use of a thermistor with simple peripherals, the opportunity to usefully apply introductory level modeling of physical system and the need for relatively simple experimentation for model validation and simulation for detailed performance prediction which shows that the device thrives better in societies with good power supply.

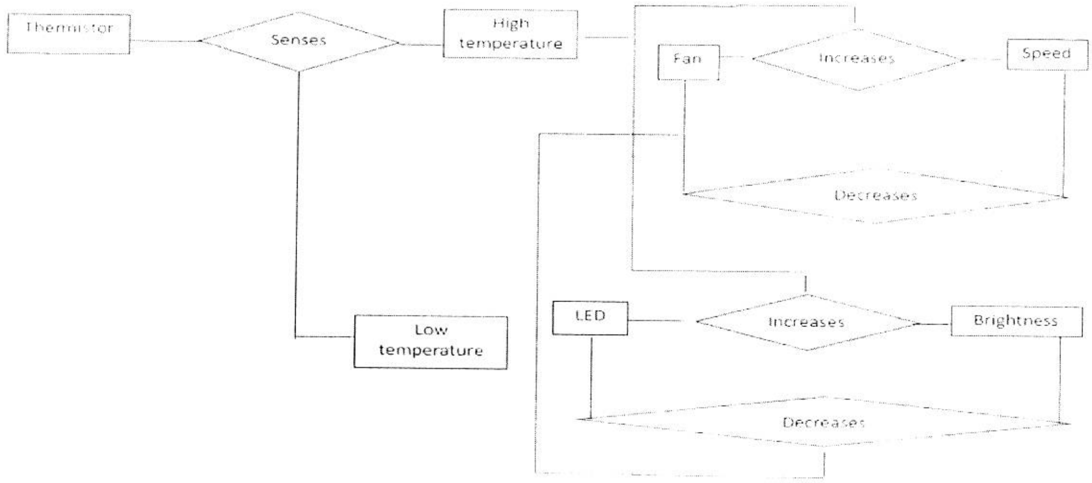

Figure 4.4 Entity – Relationship Diagram of project

4.2.1 CIRCUIT SIMULATION

The circuit is an open loop system. In this circuit initially 220V AC is stepped down to 12V AC. Then this AC is converted into DC by a rectifier circuit consisting of 4 diodes D1, D2, D3 and D4. Two electrolytic capacitors C1 and C2 are connected parallel to give more sensitivity to the circuit as they have the ability to smoothen the voltage across them. As the capacitor charges, the rate of change of voltage slows, and charge slows, as the charging current falls thus showing an exponential curve. An LED L1, through a resistance R1 is there across the capacitors to detect the flow of current. Now it is seen that, the thermistor's' and a variable resistor R2 (Potentiometer used here) is divided by R3 resistance of 1K. Initially R2 resistance and that of the Thermistor are almost same and there is no potential difference, so there is no voltage difference thus no current flows though the circuit. And hence the motor does not rotate. When thermistor senses the temperature, as it is NTC (Negative Temperature Coefficient), its resistance decreases with the increase of temperature. As a result the current and voltage also increase creating a voltage difference across thermistor and the potentiometer R2. Due to this potential difference, a current starts flowing through R3. But this current is not sufficient to start the motor as the rated current of the motor is of high value. In order to amplify the current to a desired value Darlington pair is used. The Darlington transistor (often called a Darlington pair) is constructed using two bipolar transistors (either integrated or separated devices) connected in such a way that the current amplified by the first transistor is amplified further by the second one. This configuration gives a much higher current gain than each transistor taken separately. The current output from the Darlington Pair has sufficient high gain to drive the motor. The second LED, L2 is used for the same purpose as L1. Diode D5 is used as a Suppression diode or Fly-back diode, to suppress the sudden voltage spike across the inductive load, i.e. the motor, when the voltage is suddenly increased or decreased, due to rapid temperature change sensed by thermistor. When the motor starts, the LED L2 glows. It glows more brightly as the speed of the motor increases and vice versa, and thus the increasing or decreasing speed can be identified.

Results displayed are not in values. Result of this simulation is just the rotation of the fan and the lighting up of LED, which is shown pictorially in this testing section.

Figure 4.5 shows the proteus user interface upon which the circuit of the automatic temperature fan regulator was simulated

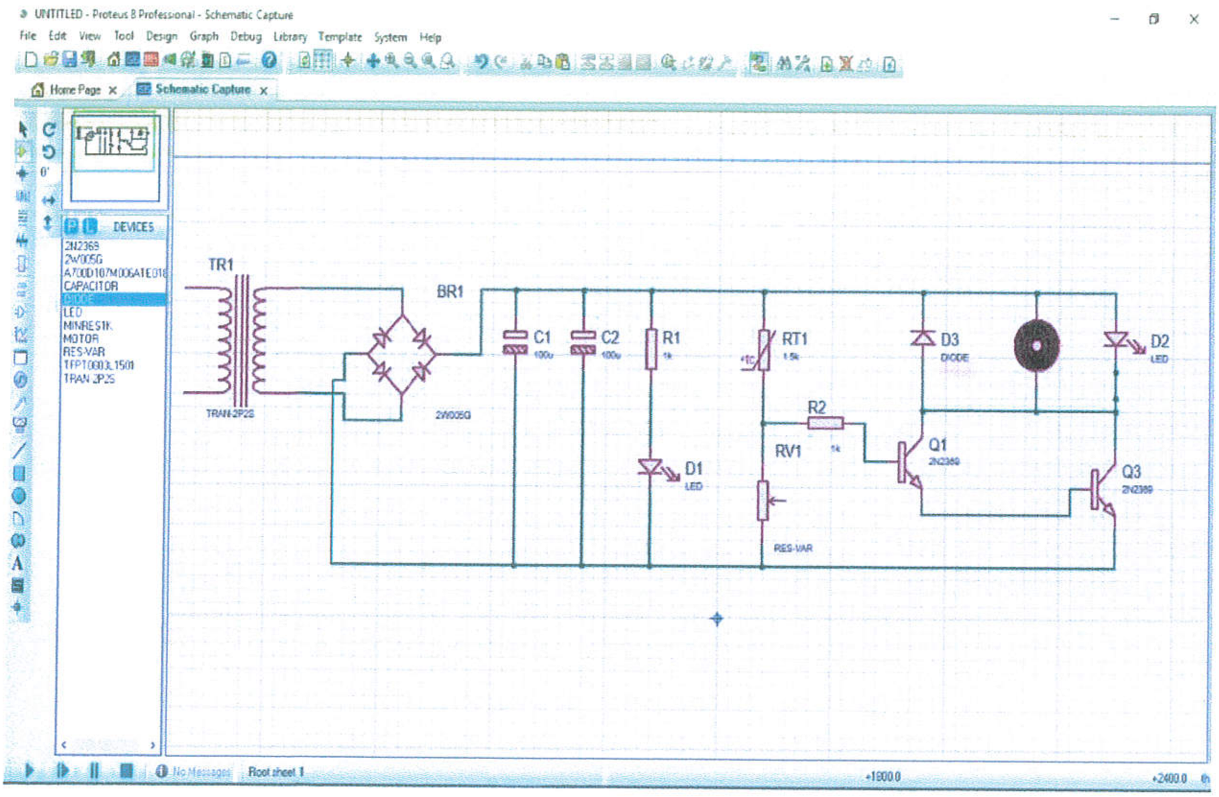

Fig. 4.5 Proteus interface showing simulation of automatic temperature controlled fan regulator.

4.3 Project Management

Implementation of the design was categorized into various hardware units with each unit comprising of various components connected together for the overall efficient performance of the system.

Vero board implementation: The Vero board is also called a strip board. It is a widely used type of electronic prototyping board characterized by a 0.1inch rectangular grid holes with parallel strips of copper cladding running in one direction all the way across one side of the board. The Vero board was first inspected to ensure there were no wrong linkages between the dotted lines. Components were placed on the plain side of the board, with their leads protruding through the holes. The leads were then soldered to the copper tracks on the other side of the board to make the desired connections. Tracks may be linked on the other side of the board using connecting wires for convenience.

The soldering of the components to the Vero board was achieved using soldering iron and lead. This was done by joining the terminals of two components together before soldering. And after soldering each unit, continuity test was carried out to ensure that proper soldering was done.

Housing: The casing of the system is made of a wooden material. This material was chosen because of its excellent properties such as; high resistance to corrosion, immune to common solvents such as sunlight and bacterial action, light weight and high insulation properties. It has a reasonable long life span. Necessary measurement such as the thickness, length and breadth of the project were taken into consideration.

4.3.1 Project Schedule

4.3.1.1 Gantt Chart

This chart shows the breakdown structure of the project by showing the starting and completion dates; it also shows various project activities

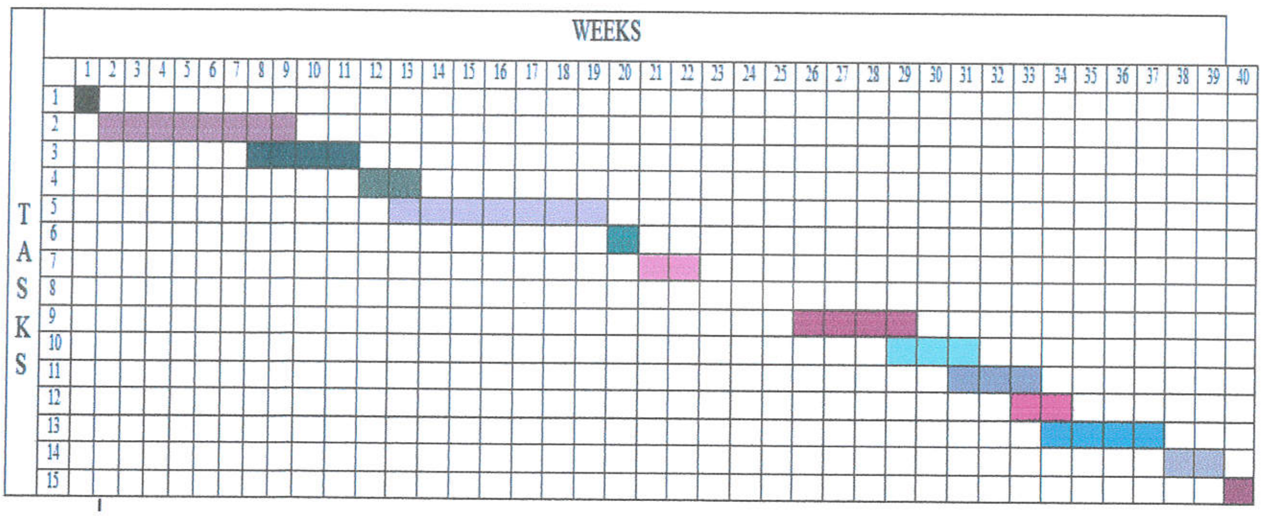

Figure 4.6 Gantt chart of the project

Task 1 - Proposal submission

Task 2 - Data gathering

Task 3 - Design consideration

Task 4 - Simulation

Task 5 - Hardware implementation

Task 6 - Testing

Task 7 - Introduction

Task 8 - Literature Review

Task 9 - Methodology

Task 10- Analysis and results

Task 11 - Discussion, conclusion and recommendation

Task 12- Supervisor check

Task 13- Proof reading

Task 14- Submission of draft

Task 15- Printing and binding of report

4.3.2 Risk Management

The risk involved in the design and implementation of a temperature controlled fan regulator is that of the fan blade which is not supposed to be exposed due to the rotating speed when powered on. This risk was mitigated by fixing the fan blade on a solid platform and creating a cover for it. Also another risk associated with this design is seen in the connections from the AC side of this device. This risk was effectively mitigated by using proper insulators.

4.3.3 Social, Legal, Ethical and Professional Considerations

This project is based on previous designs on projects related to temperature control fan and the thermistor with just few modifications to indicate its authenticity. Two LEDs were used instead of one, which other researchers used, LED one aided in detecting the flow of current in the circuit and LED two increases, or decreases it brightness according to the fan speed. This shows the authenticity of my work.

The speed in revolutions per minute of the fan used in the design of this project meets the required standard owing to the size of the blade when calculated.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.0 Conclusion

The design and construction of the project was a success, which was to develop the cheapest way to provide a near perfect automation system that can automatically switch to suit any temperature. The major components for the design and implementation of this project are transformer, variable resistor, capacitor, and NPN transistor and NTC thermistor that help to integrate the various units. A review of various past projects, components, strategies and brief explanation on the mode of operation of the different components used in the automatic temperature controlled fan regulator was documented as well as how they can be implemented and applied to solve impending challenges. The system was tested and results derived were presented in this chapter. The development of an automatic temperature controlled fan regulator can be used in both industrial and residential buildings which makes it very lucrative for developers on a large-scale production level affordable for people's well-being, security and protection.

5.1 Contributions to Knowledge

This project is a major improvement on other related based works. Power supplies used in this project use a step down transformer to reduce dangerous high mains voltage to a safer low voltage The project was requires a +12volts dc supply except thermistor which requires +5volts in order to create a linear power supply a 12volts step down transformer is used and the use of thermistor as the temperature sensor in this project, the problem encountered by other researchers of using other temperature sensor like resistance temperature detector(RTD) or thermocouples was solved. A light emitting diode (LED) was added to glow as the speed of the motor increases or decreases, it glows brightly when the speed of the motor increases, making it possible for the speed to be identified. The project was successfully completed and it's applicable to control the temperature devices, rooms, electronic components etc. by monitoring the temperature.

5.2 Challenges

The major challenges were encountered in the hardware implementation and construction, these problems were mitigated and solved. Some of the problems encountered are as follows:

- The components are not locally available.
- Difficulties in soldering due to the closeness of the components on the Vero board.
- Problem in the determination of the input and output of the transformer.

5.3 Future Work

In future, there are several improvements that can be made in order to upgrade the features of the system. The improvements are as follows

- The system can further be extended to an air conditioning system, laptop cooling system and larger work-space by adding additional sensor on request like light, rain, humidity etc.
- This circuit can be expanded by incorporating a passive infrared sensor along with the temperature sensor. The passive infrared sensor can include a Fresnel lens for sensing a 360° circumference beneath the fan so that the fan can be turned on and off based the motion of persons approaching and leaving a selected area.
- The system can be improve using image processing sensor to make it fully automatic system whereas the system can start automatically when user is inside the house.
- Fan can be controlled manually as well as automatically if a change over switch is added as an additional feature.
- Solar panels can be incorporated to ensure that the system is a stand-alone system as power supply is of a greatest importance.
- The fan speed can be done through internet, if the device information reaches the cloud.
- This temperature controlled fan with some modifications can further be used in other Heater Circuits to maintain the constant temperature of the device.
- Also mobile based monitoring can be added as an additional feature.
- With this circuit, an alarm circuit can be added and used effectively in large equipment where the risk of being overheated and explosions are the serious problems, in various industries.

5.4 Critical Appraisal

The design and construction of an automatic temperature controlled fan regulator, where the speed of the fan is controlled based on the room temperature is a prototype based project which are applicable to our homes to boost comfort and reduce stress, it can also be adopted by car manufacturers for use in their car-engine to reduce heat. Having in mind that this project is a prototype, it could have been done simple, but due to the fact of achieving a world class technology in homes or offices appliances, the project was built as a device that can be installed in homes and offices thus making life easy for humans. This project came with a lot of challenges especially the aspect of soldering done in the hardware implementation, but good knowledge was gained overcoming those challenges and as such increased my passion in developing other temperature controlled related works. One of the biggest challenges in this project is the issue of power, where electricity is not stable.

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APPENDIX A

Cost Analysis

COMPONENTS	COST	QUANTITY	TOTAL
RESISTOR	10	3	30
VARIABLE RESISTOR	20	1	20
DIODES	10	5	50
LEDs	20	2	40
NPNTRANSISTOR	50	2	100
MOTOR	300	1	300
THEMISTOR	100	1	100
CAPACITOR	50	2	100
TRANSFORMER	500	1	500
VEROBOARD	300	1	300
PROPELLER	50	1	50
BREAD BOARD	300	1	300
JUMPER WIRES	30	30	900
SOLDERING LED	700	1	700
SOLDERING IRON	1500	1	1500
CASING	3000		3000
TRANSPORTATION	5000		5000
MISCELLANOUS	3000		3000
TOTAL			15,900

APPENDIX B

The Project Operational Flow Chart