DESIGN AND CONSTRUCTION OF A TEMPERATURE INDUCED AUTOMATIC ROOM FAN REGULATOR

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DEDICATION

I dedicate this project to my beloved parents, Mr. and Mrs Rahman Adeyi

DECLARATION

I Adeyi Bashir declare that this work was done by me and has never been presented else where for the award of a degree. I also hereby relinquished the copyright to the Federal University of Technology, Minna.

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ABSTRACT

The fan was invented to produce air current to make man more comfortable especially in uncomfortably hot weather conditions. Control of the speed of the fan has hitherto been manual based on the discretion of man.

This project severs to offer an alternative by providing automatic fan speed control based on the direct sensing of the environment's ambient temperature. The design incorporates a thermistor as its temperature sensor

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CHAPTER ONE

INTRODUCTION

In a world where comfort and ease constitute some of man's basic desires, the electronic world has not in anyway been overwhelmed in its level of contribution to achieving these desires. This project is another step in the quest for the improvement of man's living conditions.

This project provides a circuit for the automatic control of a room fan speed using a temperature transducer. In other words, the circuit monitors the ambient temperature of the room and control the speed of the room fan in accordance with the room temperature. Thus, temperature changes of the room results in a proportionate change in the speed of the fan. The reference speed of the fan in relation to the ambient temperature can easily set by the user

Transducers form the interface between the world that we sense and the realm of electronics. In order for this circuit to act in temperature information, it must be converted into electrical signals by a transducer. The transducer used in this project is a negative-temperature coefficient (NTC) thermistor.

1.1 AIMS AND OBJECTIVES

The aim of this project work is to design and construct a temperature induced automatic room fan speed regulator that eliminates the manual speed regulator such that the speed increases automatically as the temperature increases and vice versa.

The objectives of this project are as follows:

1. To demonstrate how a thermistor can be use to control the action of temperature dependent appliance.
2. To demonstrate how DC power can be used to control A.C. power.

3. To construct an automatic regulation system that can efficiently regulates the speed of fan.

4. To provide an alternative to the manual fan speed control

1.2 METHODOLOGY

For ease of design and construction, this project work was carried out in modules Each module was carefully designed and constructed in a sequential order culminating to the assembly of all the modules to form the complete work. The major units of this project are briefly outlined as follows:

- The transducer unit converts temperature to proportional voltage.
- The comparator unit compares the input voltage with a reference voltage. The output from the comparator is coupled to the base of a transistor.
- The control unit consists of transistors, relays and an auto transformer. Each transistor switches On/Off the relay that is connected to it. And therefore, the A.C voltage delivered to the fan is regulated by means of the autotransformer through the relays

The major units are shown in the block diagram below.

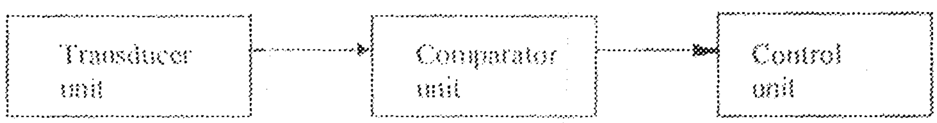


Fig 1.1 Block diagram of temperature induced automatic room fan speed regulator units

The compete circuit operation is explained in chapter three. Chapter four contains the procedure for construction of the device and the layout of the components.

1.3 SCOPE OF THE WORK

The areas covered include signal generation and its application to electrical system activation, transistor, operational amplifiers. temperature effects on eletronic compoent device switching.

CHAPTER TWO

LITERATURE REVIEW/THEORETICAL BACKGROUND

With fan use come usual fan headaches of mechanical failures, increased power consumption if the fan operation is at full speed when less cooling is required. Fan speed control can ease some of these headaches resulting in quieter more reliable fans that use less power. Fan speed and therefore cooling efficiency can slowly degrade or fail completely without adequate speed control.

2.1 TYPES OF FAN SPEED CONTROL

There are many ways to control the speed of a fan. Controlling the speed of a fan can range from as simple as regulating the input voltage to the fan to using more complicated digital micro processor unit.

2.1.1 LINEAR REGULATION

The linear regulation option is design for application where the input power may fluctuate at different voltage levels. As the term implies linear regulation adjusts the voltage across the fan by using a linear regulator [1].

Linear speed regulators work by controlling the voltage across the fan. They do this by dissipating power in the form of heat in the pass element [1].

2.1.2 DC – DC REGULATION

DC- DC regulation is similar to linear regulation in that it controls the speed of the fan by adjusting the dc voltage across the fan.

However, unlike a linear regulator a DC-DC regulation uses a switch mode power supply. DC – DCs are ideally 100% efficient and do not generate any heat. Although in reality, efficiencies tend to be around 75% to 95% [1].

The penalty for this efficiency is increased cost and complexity [1]

2.1.3 PROGRAMMABLE SPEED CONTROL

Programmable fans allow you to control the speed of the fan by developing simple circuits that can either pulse-width modulate, vary the voltage or the resistance [1].

Pulse-width modulating (PWMing) the fan directly involves turning the fan's power supply on/off at fixed frequency. Duty-cycle adjustments are made to control the speed of the fan. The larger the duty-cycle the faster the fan spins. The PWM rise and fall times most be sufficiently slow to ensure long-term reliability of the fan [1]. PWMing has its advantages and disadvantages. The advantages include a very simple drive circuit and, minimal heat dissipation in the past transistor. A major disadvantage is increased stress on fan.

2.1.4 THERMAL SPEED CONTROL

The thermal speed control option uses a thermistor or thermostatic switch to monitor the temperature and regulates the speed accordingly. As the name implies, the thermostatic switch turns the fan on and off depending on the temperature. This switching usually causes a sudden switching from peace to noise and vice versa which could be rather disturbing. The thermistor metal properties allow it to change its resistance at different temperatures, thus creating a variable voltage divider circuit [1].

2.2 BENEFITS OF FAN SPEED CONTROL

Fan speed control has many benefits some of which are briefly outlined below:

1. **Reduced Audible Noise**

One of the most immediately noticeable advantages of fan speed control comes in the form of relief for the human ear. Fans running at full speed cause turbulent air flow which is the most dominant sources of fan noise. This may be a significant source of annoyance especially in quite environment. Employing fan speed control eliminates the operation at full speed when not required and, hence noise is minimized [2].

ii. **Reduced Power Consumption**

In situations where minimization of power cost is of paramount importance, fan speed control is quite appreciated. Controlling fan speed ensures that fan speed is reduced when less cooling is required which eradicates power wastage. A 50% decrease in fan speed results in a 50% to 75% reduction in power. This results in significant power savings when much cooling is not required. [3]

iii. **Increased life Time**

Reducing fan speed when necessary also decreases the wear on the fan. Fan wear is a rough function of the absolute number of revolutions of the fan. Reduced wear translates into increased life times and therefore greater meantime between failures (MTBFs) because fans are mechanical; they tend to be one of the more common failures on a system [1].

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1 OVERVIEW OF CIRCUIT OPERATION

A 10kΩ negative-temperature coefficient is used as the transducer which senses the ambient temperature and decreases in its resistance as temperature increases and vice versa. It forms a voltage divider network with R2 (Fig. 3.2) and, hence change in ambient temperature causes a proportional change in voltage across it.

Three comparators (UA741) compare this varying voltage of the 10kΩ thermistor with their individual reference voltage (fig 3.3). The outputs from these comparators are coupled to the base of appropriate transistor through a current-limiting resistor.

Depending on the outputs of these comparators each transistor is turned on/off. This operates a relay connected to it. An auto-transformer with 3 tapings is connected to the relays through these tapings in which case each taping has different voltage output.

And as such each taping voltage can be fed to the fan motor (A.C) through the corresponding relay when the relay operates. Consequently, the fan speed is regulated between maximum and minimum speed based on ambient temperature.

3.2 CHOICE OF TEMPERATURE SENSOR

A variety of temperature sensor is available in the market today for various applications. The most common of which includes thermocouples, thermistors, resistance-temperature detectors (RTDs), pyrometers and I.C. Sensors. With an almost daily advancement in the field of electronics, newer series of these sensors are manufactured offering improved characteristics and features designed to meet the diversified individual needs of designers and engineers.

Thus, in handling any project a careful selection of the right temperature sensor has to be made with a view to meeting the requirements of the project and making efficient use of the sensor.

In choosing the sensor for this project, an analysis of the characteristics and features of the available sensors was carried out to choose the sensor that would most appropriately fit the needs of the project.

Due to the fact that every sensor has its advantages and disadvantage, a careful balance had to be made in choosing a sensor that had the maximum applicable advantages and minimum deterring disadvantages.

Thermocouples are not well suited for this project because the measurement must be relative to a fixed cold junction temperature making implementation impractical. The accuracy of the thermocouples has been found out to decrease over a long period of use and thus maintaining stability in thermocouples could be much of a burden. The materials which thermocouple wires are made are not inert and are subject to instability resulting from a variety of factors such as the atmosphere to which they are exposed [4] Also, if there is significant distance between the point in the process where the temperature measurement must be made and the electronic measuring instrument, the cost of the thermocouple wire connecting the two becomes an important consideration [5].

Resistance temperature detectors (RTDS) are made of platinum or nickel which are very expensive materials, culminating in expensive products. They are also susceptible to shock and vibration.

IC sensors are known to have low sensitivity to temperature changes [5]
Pyrometers are only applicable in radiation detection and will not be considered since the temperature range being considered is a little above and below room temperature [6]

Thermistors are well suited for use as component parts of this project. Their small size and mass means that they can be packaged in a wide variety of thermal sensing packages. Thermistors compared which other methods of temperature measurement provide simplicity and accuracy [7]

Thermistors provide higher resolutions than RTDs or thermocouples because their resistance versus temperature changes is significantly large [8]

The resistance of thermistor changes approximately three orders of magnitude in a 150^0C ranges. This provides a means to very accurately measure very small temperature variations. In comparison with other electrical temperature sensors, thermistors are the most sensitive devices available. This is shown in the table below for type K thermocouple 100 ohm , platinum RTD and a 10k ohm NTC thermistor @ 25^0C [9] – the thermistor used in this project work

Table3.1 Comparison of temperature sensors

	Kthermocouple	100ohm RTD	10Kohm Thermistor
Sensitivity	40µV/°C	0.392ohm/°C	438ohm/°C
For 1mk resolution	4×10^{-8} volts	4×10^{-4} ohms	4×10^{-1} ohms
Temperature Range	-200°C to1300°C	-200°Cto650°C	-80°C to 150°C

Their low mass and shall size give them quick response to temperature changes [10] Their higher resistance values allow them to be used with longer lead wires without requiring lead wire compensation[11]

3.3 DESIGN ANALYSIS

The temperature induced automatic room fan regulator is to be used in the room in the temperature range of a 25 °C to 40°C . The motor of the fan should be of A.C type and the fan should be of ratings 220V/100W. The design incorporates 3 fan speed selector which is automatic based on ambient temperature.

For better analysis the design is divided into modules. These are as follows.

I. Regulated power supply

ii. Transducer circuit

iii. Comparator circuit

iv. Indicator circuit

v. Control circuit

3.3.1 REGULATED DC. POWER SUPPLY

Virtually every piece of electronics equipment and their peripherals are powered from the D.C power source. Most of these equipments, this project not being an exception, required D.C sources for its operation.

More over this is a project that indirectly makes uses of DC power to control A.C power. Dry cells and batteries are one form of D.C source. They have the advantage of being portable and *ripple-free*. However their voltages are low and they need frequent replacement [12]. Since most convenient and economical sources of power is the domestic A.C supply, it is advantageous to convert this alternating voltage to D.C voltage.

This power supply performs the following functions at high efficiency and low cost.

1. Voltage transmission
2. Rectification
3. Filtering
4. Regulation

This is shown in the diagram below

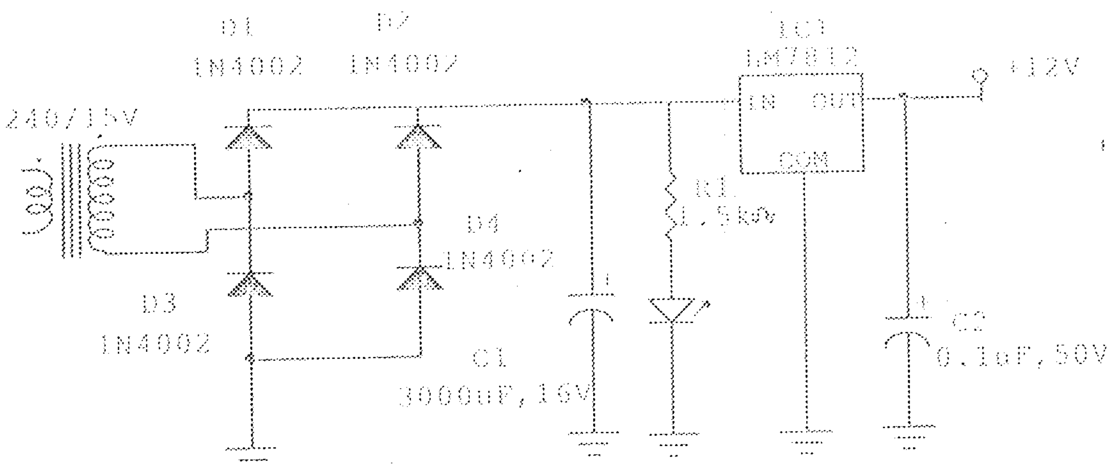


Fig 3.1 Regulated D.C power supply circuit diagram

From the above diagram, the transformer serves two main purposes.

- It isolates the equipment D.C. power lines from the mains supply and
- It changes the level of the mains voltage to a lower value.

The bridge rectifier converts the A.C voltage from the transformer secondary windings into pulses of unidirectional or D.C current.

Following the rectifier is the capacitor input filter (C1). It serves to smooth out the pulses received from the rectifier. Thereafter, a LED pilot-light with a current – limiting resistor (R1) follows immediately [13]

A linear voltage regulator is used. LM 7812 provides a fixed positive voltage of 12V. The linear voltage regulator behaves as a variable resistance between the input and the output as it provides the precise output voltage [14]. The output is continuously controlled to give good stabilization against mains input changes and good regulation against load current changes [15]. The capacitor (C1) connected across pin 3 of LM7812 and ground improves the transient response of the regulator [16]

Let V_{SM} = maximum value of transformer secondary voltage

V_S = r.m. s. of secondary voltage

V_{IP}=peak full wave rectified voltage at filter input

I_{SM} = maximum value of transformer secondary current

I_S = r.m.s. of secondary current

I_L= average value of load current

V_L= average value of load voltage

V_{IP} = V_{SM}_two diode drops (full wave rectification)

R.m.s value = maximum value/ √2 ……………….eqn. (3.1)

I_S = 1000mA (from transformer ratings)

From eqn (3.1),

$I_{SM} = I_S \times \sqrt{2}$

$I_{SM} = 1 \times \sqrt{2} = 1.414A$

$I_L = 2/3.14 \times I_{SM}$ ……………………………………eqn (3.2)

$= 0.6369 \times 1.414$

$I_L = 0.9$ A

V_S = 15V (from transformer secondary ratings)

From eqn (3.1),

$V_S = V_{SM} / \sqrt{2}$

$15 = V_{SM} / \sqrt{2}$

V_{SM} = 15 x 1.414 = 21.21V

V_{IP} = V_{SM} – two diode drops

IN4002 forward diode drop = 0.9V

Two diode drops = 2 x 0.9V = 1.8V

= 21.21 – 1.8

V_{IP} = 19.41V

I = C dv /dt.................. .... eqn (3.3) [17]

From eqn (3.2),

C1 = I dt /dv ....eqn (3.4)

Where C1 = filter capacitor

dt = 1 /2F (for full wave rectification) .... eqn (3.5) [17]

F= line frequency = 50Hz

dt = 1/2 x 50 = 0.01 sec.

dv = % ripple x V_{IP}................................. .... eqn (3.5) [17]

Choosing 15% ripple to ensure better filtering.

dv = 15 /100 x V_{IP}

= 0.15 x 19.41

=2.9 V.

Assuming a constant load current equal to maximum load current [6]

From eqn (3.2),

$I_L = 0.9A$

$C1 = Idt/dv$

From eqn (3.4),

$C1 = 0.9 / 2.9 \times 0.01 = 0.003103F$

$C1 = 3103\mu F$

$C1 = 3000\mu F$, 16V (preferred value)

The filter capacitor (C1) =3000μF

It is to be noted that V_L equals the d.c input voltage to the 7812 regulator.

$V_L = V_{IP} / (1 + 1/4FCV_{IP})$.......................................eqn (3.7) [18]

$C = 3000\mu F$

$V_{IP} = 19.41V$

$F = 50H_z$

$V_L = 19.41 / (1+1/4 \times 50 \times 0.003 \times 19.4)$

$= 19.41 / (1+1/11.646)$

$= 19.41/1.085866392$

$= 17.88V$

$V_L = 17.88V$

The input voltage to pin 2 of LM7812 = 17.88V which is to be fixed at 12V by the 7812 regulator irrespective of mains input changes.

3.3.2 TRANSDUCER CIRCUIT

The aim of this project work is centered on the transducer circuit. This circuit converts the changes in ambient temperature to proportional changes in voltage across the transducer due to the transducer's varying resistance with temperature. The transducer used as earlier mentioned is 10kΩ NTC thermistor. This forms a voltage divider network with a 5kΩ; this is shown in the figure bellow

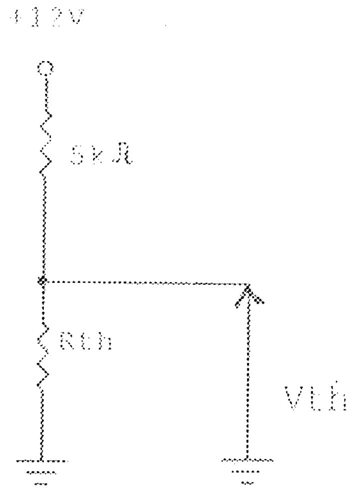


Fig 3.2 Transducer circuit diagram

Let Rth = Thermistor resistance

Vth = Voltage across thermistor

Vth = [Rth / (5 + Rth) x 12] V…… …………………… …… eqn. (3.8)

Case1 :(Maximum fan speed)

At 40°C, Rth=1kΩ (see Table4.1)

From eqn. (3.8)

Vth =1/ (5 + 1) x 12

Vth = 2V

Case 2: (Medium fan speed)

At 24°C, Rth = 15.4kΩ

Vth = 15.4 / (5 + 15.4) x 12

Vth = 9V

Case 3: (Minimum fan speed)

At 20°C,Rth = 40 kΩ

$Vth = 40/(5 + 40) \times 12$

$Vth = 10.67V$

Case 4: (Off state)

Temperature is below 20°C, Rth > 40kΩ

Therefore, Vth must be greater than 10.67V

3.3.3 COMPARATOR CIRCUIT

The integrated circuit used for comparator is the UA741. This is a high performance monolithic op-amp constructed on a single silicon chip [14]. It has high gain of up to 200,000 with a wide range of operating voltages. Its added features includes.

- Short circuit protection
- No frequency compensation is required [15]

The comparator function is realized by using the op – amp in its high gain differential mode – open loop. This ensures stability [6].

The comparator like any other one will be saturated fully positive if the voltage at the non-inverting input terminal is more positive than that at the inverting input terminal and saturated fully negative (in this project ground), if the voltage at the non-inverting input terminal is less positive than that at the inverting input terminal [15]. Thus the comparator compares the input from the non-inverting terminal with a reference voltage applied to the inverting terminal to produce an output

Three comparators U1, U2, U3, are used in this circuit. Vth is applied simultaneously to all the non-inverting terminals (pin3) of the comparators while individual reference voltage is applied to the inverting terminal (pin2) of each comparator (see Fig 4.1).

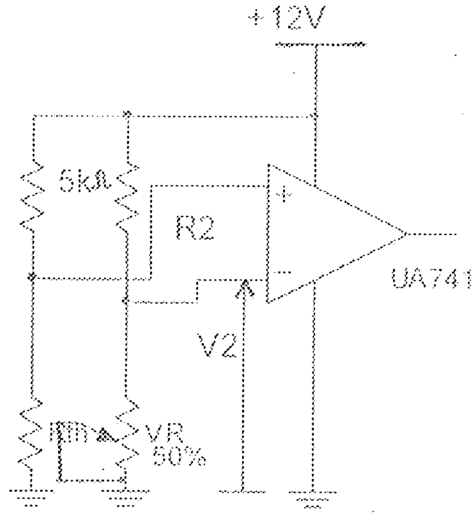


Fig.3.3 Comparator circuit diagram

Let V2=reference voltage across the pin2

From the diagram above,

$$V2 = \frac{\text{Preset value of VR}}{(R2 + \text{preset value VR})} \times 12\ V \quad \text{.........................eqn (3.9)}$$

For comparator U1,

R2 = 1kΩ, VR = 10KΩ (see fig 4.1)

With a preset value of 8.2KΩ and

From eqn (3.9),

$V2 = 8.2/(1 + 8.2) \times 12$

$= (8.2/9.2) \times 12$

$V2 = 10.7V$

For comparator U2,

R2 = 1kΩ, VR = 4.7kΩ

With a preset value of 3.5kΩ

$V2 = 3.5/(1 + 3.5) \times 12$

$= 3.5/4.5 \times 12$

V2 = 9.3V

For comparator U3,

R2 = 330 Ω, VR = 1k Ω

With a preset value of 100 Ω

V2 = 100/ (330 +100) x 12

=100/430 x 12

V2 =2 .8V

It can be seen from above that at the preset values of 8.2kΩ,3.5kΩand,100Ω the reference voltage to the comparators U1, U2, U3, are 10.7V 9.3V and 2.8V respectively. It is to be noted that Vth is applied simultaneously across pin 3 of U1, U2, and U3 so therefore, for Vth = 2V (section 3.3.2), pin2 voltage (V2) of each of U1, U2, and U3 exceeds their corresponding pin 3 voltage (2V) i.e. Vth < (2.8V, 9.3V, 10.7V) And hence, U1, U2, U3 have low outputs.

For Vth = 9V, pin 2 voltages of both U1 and U2 exceeds their pin 3 voltages (9V) i.e. 2.8V < Vth < (9.3V, 10.7V) and hence only U3 switches to high output with U1 and U2 remaining in their low output states.

For Vth = 10,67V, only pin 2 voltage (V2) of U1 exceeds its pin 3 voltage (10.67V) i.e. (2.8V, 9.3V) <Vth <10.7Vand hence U3 and U2 switch to high outputs with U1 remaining in low output state

For Vth > 10.7V, pin 2 voltage (V2) of U1 is less than its pin 3 voltage (Vth) and hence U1 also switches to high outputs making all of them (U1, U2, U3) to be in high outputs states,. The above is summarized in the table below.

Table3.2 Operational mode of temperature induced automatic room fan speed regulator

Thermistor resistance (KΩ)	Pin 3 voltage vth (V)	Comparator 1 U_1		Comparator 2 U_2		Comparator 3 U_3	
		Pin2 voltage V2 (V)	Output state	Pin 2 voltage V2 (V)	Output state	Pin2 voltage V2 (V)	Output state
1	2.00	2.80	Low	9.30	Low	10.70	Low
15	9.00	2.80	High	9.30	Low	10.70	Low
40	10.67	2.80	High	9.30	High	10.70	Low
>40	>10.7	2.80	High	9.30	High	10.70	High

3.3.4 INDICATOR CIRCUIT

In this project work, LEDs are used as indicators. As such, the number of LED that turns 'ON' indicate the level of fan speed i.e. maximum number of LED indicates maximum speed and vice versa.

For a voltage greater than 2V, there must be a resistance connected in series with the LED.

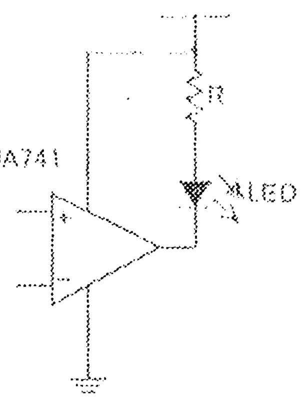


Fig 3.4 Indicator circuit diagram

The value of current – limiting resistor (R) can be calculated using the formula below.

$(+V - 2v) / I_{LED} = R$ ……………………………eqn (3.10) [16]

Where I_{LED} = current through the LED (mA)

From fig 3.4 above,

$+V = 12 - V_0$ ....eqn (3.11)

Where V_0 = output voltage of comparator (UA741)

For UA741, $V_H = (V_{CC} - 0.7)$ V

$V_L = 0.05$V (see appendix)

Where V_H and V_L are the high output and low output voltage of the comparator respectively and VCC is the supply voltage.

Therefore at high output state of UA741,

$V_H = 12 - 0.7$

$V_H = 11.3$V

At low output state of UA741, $V_0 = 0.05$V

Taking low state as reference,

$+V = 12 - V_0 = 12 - 0.05$

$+V = 11.95$V

For adequate brightness let I_{LED} = 25mA [16]

$I_{LED} = 0.025$

From eqn. (3.10)

$R = +V - 2V / I_{LED}$

$= (11.95 - 2)/0.025$

$R = 0.398 \times 103 = 398\Omega$

$R = 390\Omega$ (preferred value)

At low output state of UA741

$+V - 2V = 11.95 - 2$

$= 9.95$V

Therefore, the LED is forward biased and as a result it comes "ON".

At high output state,

$$+V - 2V = (12 - V_0) - 2$$

$$= (12 - V_H) - 2$$

$$= (12 - 11.3) - 2$$

$$= -1.3V$$

The LED is reversed biased and as a result goes "OFF"

3.3.5 CONTROL CIRCUIT

The transistors, the relays and the auto-transformer form the control circuit. As earlier explained, the transistors used in this project are in switching mode and hence they switch on the corresponding relays connected to them. A free- wheeling diode is connected across each relay to prevent the reverse voltage arising from the de-energizationof the relay from destroying the transistor [19].

The auto-transformer of three different voltage levels is used to regulate the A.C voltage (mains supply) delivered to the fan between a maximum, a medium and, a minimum value corresponding to 220V, 150V and 100V respectively.

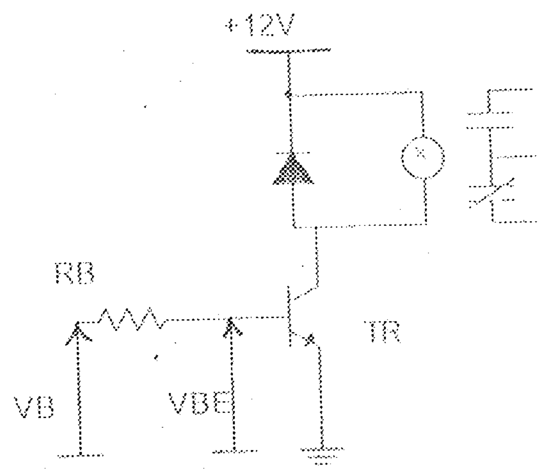


Fig 3.5 NPN transistor switching mode

Let R_C=relay coil resistance

I_B=base current

R_B=base resistor

I_C =collector current

V_B=base voltage

V_{BE}=0.6V (silicon transistor)

TR=BC337 (NPN transistor)

Ideally, in switching mode. V_{CE}= 0 [20]

From fig3.5 above,

$V_B - I_B R_B - V_{BE} = 0$ ....eqn (3.12)

$V_{CC} = I_C R_C + V_{CE}$.................................. eqn (3.13)

V_{CC} =12V, R_C = 400Ω

From eqn (3.13),

$I_C = (V_{CC} - V_{CE})/R_C$

$= (V_{CC} - 0)/400$

$I_C = (12 - 0)/400$

$= 0.03A$

$I_C = 30mA$

Also from the figure above, V_B equals output voltage of UA741 (V_0)

$V_B = V_0 = 11.3V$ (for high output state of UA741)

$\beta = I_B/I_C$ ....eqn (3.14)

$\beta = 163$ (BC337)

$I_B = I_C \times \beta = 0.03 \times 163$

$= 1.84 \times 10^{-4}$

$I_B = 0.184mA$

From eqn (3.12),

$R_B = (V_B - V_{BE}) / I_B$

$R_B = (11.3 - 0.6) / 1.84 \times 10^{-4}$

$= 10.7 / 1.84 \times 10^{-4}$

$= 58.1 k\Omega$

$R_B = 47k\Omega$ (preferred value)

For "OFF" state of the transistor, I_B equals zero (low output state of comparator).

It can be seen from above that the outputs of the comparators determine the relay to be operated through the corresponding transistor. Consequently, A.C circuit is closed through the autotransformer at appropriate voltage values and the speed is thus regulated. This can be briefly outlined below:

- maximum fan speed is achieved when all comparators' outputs are low
- medium fan speed when only U1and U2 outputs are low
- minimum fan speed if only U1 output is low
- fan goes off if all the comparators outputs are high

CHAPTER FOUR

TESTS, RESULTS, AND DISCUSSION

4.1 CONSTRUCTION PROCEDURE

The full schematic of the temperature induced automatic room fan speed regulator device is shown in figure 4.1.

List of components

Resistors

R1	-	1.5KΩ	¼ W
R2	-	5kΩ	¼ W
R3	-	330Ω	¼ W
R4	-	1 kΩ	¼ W
R5, R6	-	1kΩ	¼ W
R8	-	390 Ω	¼ W
R10	-	10KΩ	¼ W
R12	-	4.7kΩ	½ W
R13	-	330k Ω	¼ W
R9, R15	-	390Ω	½ W
R7, R11, R14	-	47kΩ	¼ W

Diodes

D1-D7 - IN4002 rectifier diode

Capacitors

C1 - 3000µF, 16V electrolytic

C2 - 0.1 µF, 50V electrolytic

Relays

K1 –K3 - 12V, 4088

Semi conductors

10kΩ NTC thermistor

U1, U2, U3 - UA741 operational simplifier

Q1 -Q3 - BC 337 (NPN transistors)

U4 - LM7812

Transformers

220V/100W Auto-transformer

240/15V transformer

8 pin IC socket

Vero board

Jumper wires

During the course of design and construction of this project, the following were taken into considerations.

1. Selection of suitable components to reduced bulkiness of the device.

2. Selection of reference voltages of the comparators.

The circuit was constructed on a breadboard taking note of polarities and pin numberings. Tests were conduct at different stages and readings recorded. This gave room for corrections and modifications.

.For soldering, an alloy of 60% tin, 40% lead was used. The solder both mechanically bind the components to the Vero board and provides electrical continuity between the devices on the board.

4.2 COMPONENT LAYOUT

Only one Vero board was used in the design. The Vero board takes care of all the units of the device and the power supply except the transformer which was placed directly in the casing.

Jumper wires were used to link points that the provision on the Vero board could not handle. Also the thermistor was placed away from the transformer so the temperature of the air is taken and not of the transformer.

4.3 TEST AND CALIBRATION

Test and calibration of negative temperature coefficient thermistor is usually referenced at 25° C (abbreviated as R25) [21]. This device is supposed to be placed in a room and it is expected that the temperature of the air in the room should be between 25°C and 40° C maximum.

Considering the above facts, a thermistor having an R25 value of 10kΩ was chosen. This implies that at temperature above 25°C, the resistance of the thermistor would be below 10KΩ.

A test was carried out to determine the resistance value of the thermistor at different temperatures.

The thermistor was place in a beaker containing water which had been cooled to 20° C and the temperature of the water was gradually increased by heating it to about 40° C. Readings were taken at an interval of 4 C by touching the leads of the thermistor with the multi-meter probes and monitoring the multi-meter display.

The result of the test is as shown below.

Table 4.1 Resistance versus temperature characteristics of 10kΩ NTC thermistor

T (°C)	R (KΩ)
20	40
24	15.4
28	9
32	7.3
36	5.6
40	1

The resistance versus temperature (R/T) characteristics of the NTC thermistor forms the "scale" that allows its use as a temperature sensor. This characteristic is a non-linear, negative exponential function [22].

4.4 DISCUSION OF RESULTS

The test was duly performed and results have been generated. From the results of the test, it could been seen that a change in ambient temperature causes a proportional change in the resistance of the thermistor i.e. a positive change in ambient temperature causes a proportional decrease in the 10KΩ (NTC) thermistor's resistance and vice versa. The proportional changes in the thermistor's resistance lead to changes in voltage drop across the thermistor and hence, the voltage across the pin 3 terminal of all the comparators. Thus comparators change their states – from high to low outputs, and these operate the control circuit.

Due to this above fact the results obtained from the test of the circuit as proved that the target goal of this project work, which is to design a regulator that is based on the temperature has been achieved.

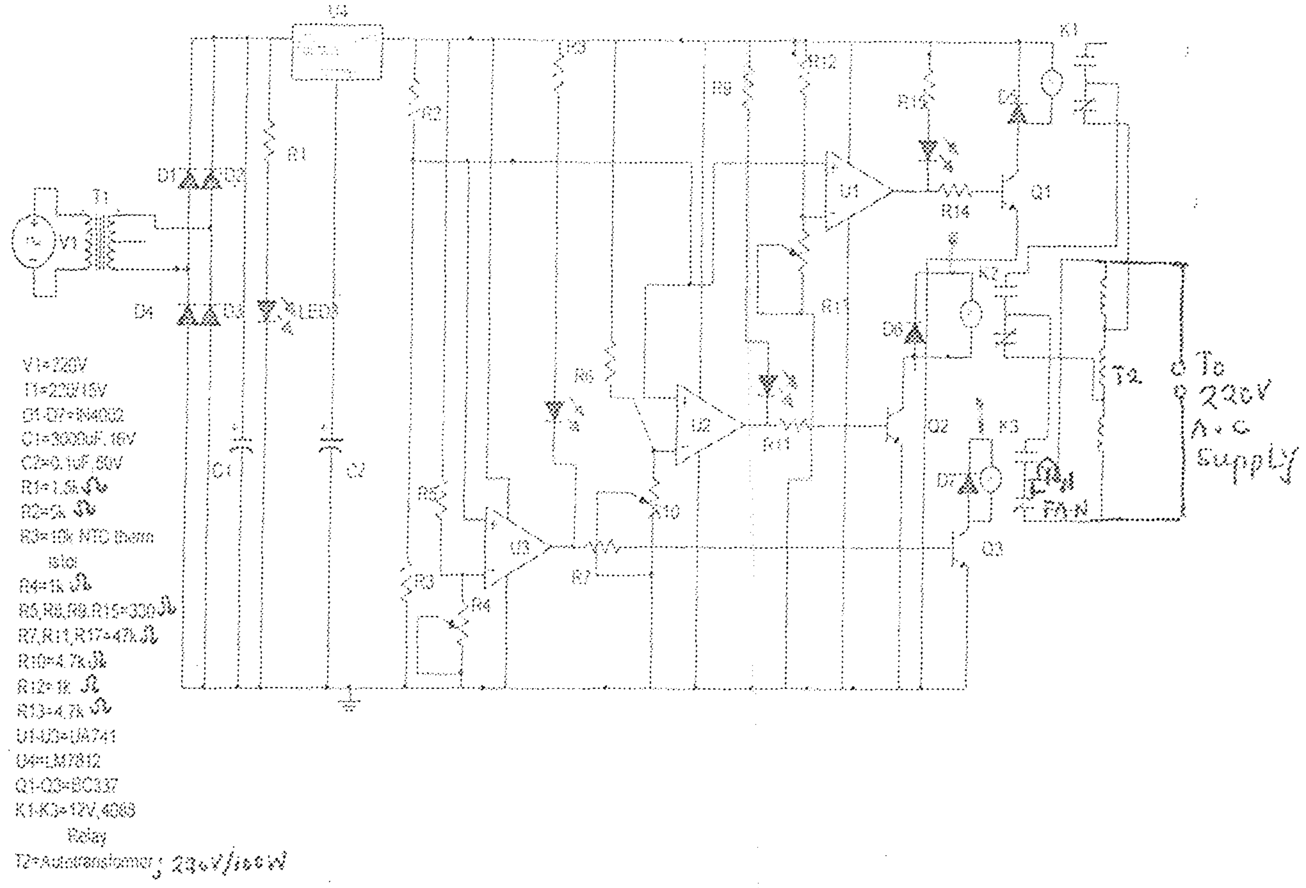
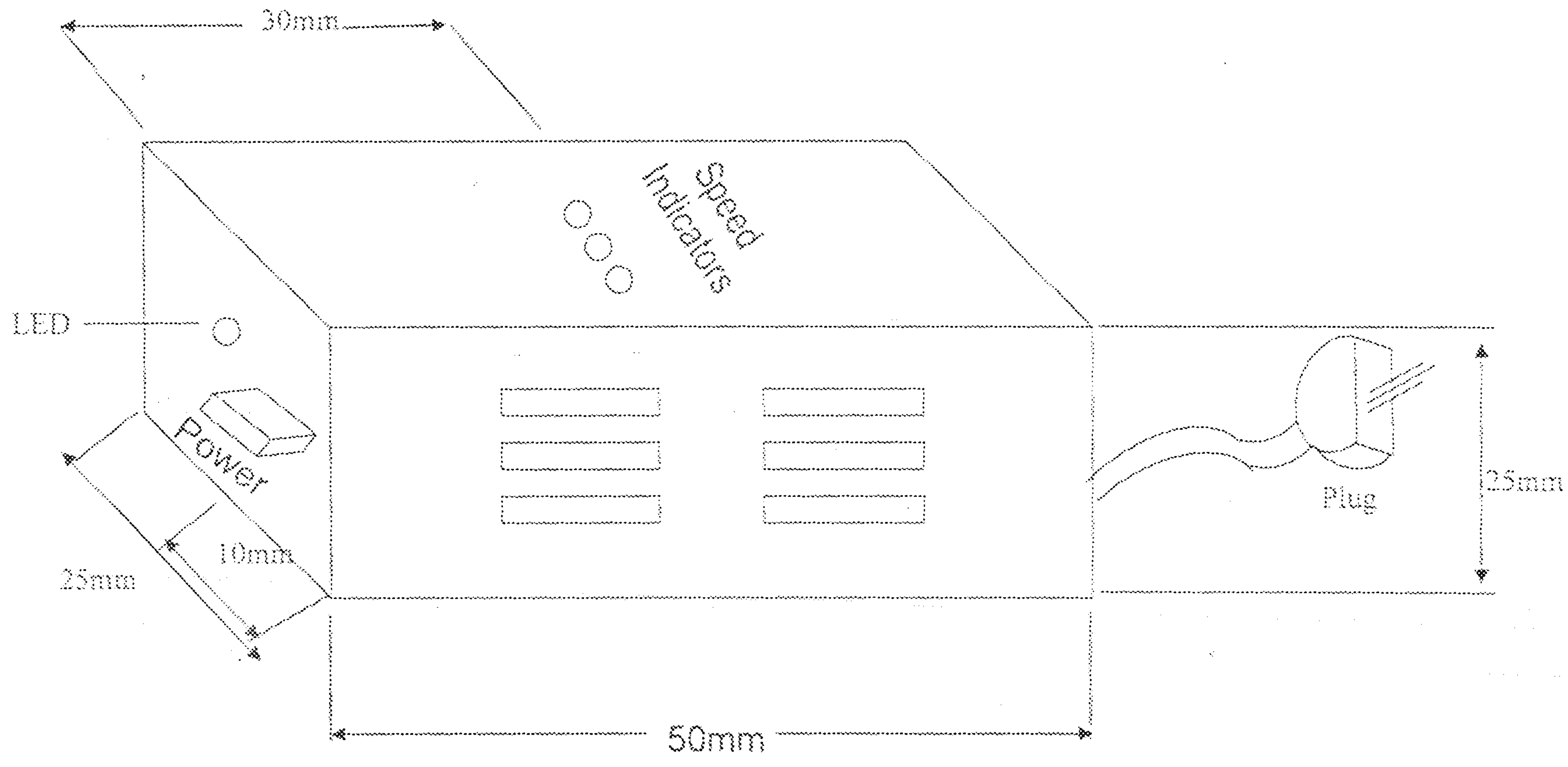


Fig. 4.1 The complete circuit diagram of temperature induced automatic room fan regulator



Scale: 1:2

Fig: 4.2 Casing diagram of a temperature induced automatic room fan regulator

CHAPTER FIVE

CONCLUSIONS

5.1. RECOMMENDATION AND CONCLUSION

5.1.1 RECOMMENDATION

In the course of design and construction, I discovered that this project could be further worked upon in future and enhanced to be of more benefits to the society. Thus, I recommend the following:

1. A circuit to handle automatic switching in response to presence or absence of people in the room.

2. A timing derive can be incorporated so that the duration of operation of the fan could be regulated also.

5.1.2 CONCLUSION

This project has successfully being used to control the power supply to room fan in direct response to the ambient temperature, thus doing away with manual fan speed control. It worked efficiently with a temperature range of 25°C to 40°C.

The usual characteristics and features of any project or assignment have not been lacking in this project. There were a few challenges and hitches which required deep thinking and reasoning.

This project has utilized DC-power to control AC-power supply and thus expanded the possibilities of power control.

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APPENDIX

UA741 Data sheet

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Total supply voltage	-18	18	V
Vid (max)	Maximum diff'l input	-15	15	V
Vo	Output Voltage	0.05	V_{CC} – 0.7	V

BC 337 NPN Transistor Datasheet.

Symbol	Parameter	Conditions	Min.	Max.	Unit
V_{CEO}	Collector – emitter voltage	Open base		45	V
I_C	Collector current		-	500	mA
hfe	DC current gain	I_C = 100mA V_{CE} = 1V	100	400	