A PROJECT REPORT
ON

DESIGN AND CONSTRUCTION OF DOMESTIC FIRE ALARM USING SMOKE AND HEAT DETECTOR

BY

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CERTIFICATION

This is to Certify that this work was carried out by Ajakaiye D. Adekunle of the Department of Electrical and Computer Engineering, School of Engineering and Technology, Federal University of Technology Minna.

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Supervisor's Signature

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ABSTRACT

This project is on the design and construction of Domestic fire alarm usable by both urban and rural dwellers and affordable by the general populace.

It's been powered by 6 volts battery supply so as to care of rural areas where there are no public power supply.

The alarm detects both smoke and heat by the use of light dependent resistor (L D R) and thermal resistor respectively.

The work is started by introduction to the general premise followed by literature review, design analysis, construction and testing discussion of result, conclusion and recommendation.

ACKNOWLEDGEMENT

My Appreciation goes to my mother and all my junior one's who have contributed greatly in diverse ways to the success of my University career.,

I will also like to appreciate the support of my friends in which it might not be convenient to mention all their names here

Most of all is the love of my God towards me, He has be in all to me, to Him be all the glory forever and ever.

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CHAPTER ONE

1.0 INTRODUCTION

Statistic shows that over 50% of fire accidents are from homes and only about 10% of fire accidents are brought under rescue; 90% unrescued leading to heavy loss of lives and properties worth millions of Naira annually hence the need for safer precautionary measure to reduce this life disaster. Table 1.0 on the next page shows the static of fire/rescue incident for Niger state for the year 1996 and 1997 gotten from Niger state Fire Service.

Seeing that it is just about 10% of the fire accidents that is brought under control, it is taught wise that a system or device like an alarm system to alert people early enough of fire incidents or outbreak we be of great help in reducing the loss caused by the incident. The system adopted for this project is the one that detects both smoke and heat, and alert the people nearest to the place. This is designed to make it reliable and cheap as much as possible by using the most reliable and cheapest available materials and also making it possible to be used anywhere by making its source of power from dry cells.

1.1 LITERATURE REVIEW

Owing mainly to the fact that homes consist of different materials such as fabrics, wood, life electric cables, cooking gas, kerosine, inflammable liquids like pressurised insecticides etc that serves as fuel for combustion during accidental fire out break and each exhibit different properties in the production of heat and smoke during combustion(some produce a lot of smoke while some produce a lot of heat) it is most suitable to use both smoke and heat sensors simultaneously as detectors for domestic fire alarm systems.

1:1.1 SMOKE DETECTORS

Smoke is a dispersion of finely divided solids in gaseous medium which could come from incomplete combustion of organic matter such as tobacco, wood and coal soot or carbon block; oil vapour mists [4]

It is produced from smouldering and flaming combustion. The smoke from smouldering tends to have bigger particles compared to that from flaming combustion, so the detector must be able to detect both types of the smoke. There are two types of smoke detectors

(1) Ionisation detector

(2) Optical detectors.

The ionisation detector is known to be very sensitive to smoke so that one could expect false alarm in homes. For example in a house where you have a cigarette smoker or where you have little smoke here and there in the kitchen either due to incomplete combution of cooking fuel like kerosene or even accidental burning of paper etc. Hence they are too good or appropriate as smoke detectors for the domestic fire alarms. They are very good and useful in location such as computer suites that are air conditioned and no smoking areas like petrol stations, electric power stations, telecommunication gadgets, gas plants etc. where just little fire or smoke can cause an enormous damage to the whole system.

2. **Optical detectors**

Photo cells like photodiodes, photoresistors, phototransistors etc. are used as detectors.(Precisely for this project, the photoresistor is used as the detector) The physical phenomena that affects this method is obscuration and scattering. The size of smoke particles is very important for optical detection systems. The size of the smoke particles should be comparable with the wave length at the light passing through the smoke. In practice this means that only the larger particles of 500nm or more have any appreciable effect.

Obscuration system:

These are the earliest types of smoke detectors and are sensitive to attention of beam of light shinning across a space caused by scattering and absorption of the light by smoke particles.

This is described by the Beer Lambert' Law:

$I = I_0 e^{-kcl}$

Where I is the intensity of a length e of a light path through smoke laden air

I_0 is the initial intensity of the light source

c = concentration of smoke particles.

k = a constant

In this system, a current flows from the photocell detectors always but is reduced by smoke which scatters and absorbs some of the light.

The scattering type:

This type depends on scattered light from suspended smoke particles the physical law governing the scattering of light from smoke particles is a complex one being described for very small particles by Rayleigh theory also for the particles of the order of the wave length of light by Mies theory. These theories however can not be used to describe the light scattering of smoke particules despite the fact tahat the amount of scattering produce by smoke has been shown to be proportional to the wavelength. The general construction of this is such that shields are included to protect the detecting elements from light paths. This labyrinths can resist the flow of smoke velocity. Dirt tends to block this channel and once the light output source is very low the response of the photocell becomes low. Light emitting diodes are used to produce more reliable light.

Optical beam type

This type uses a beam of light to detect any fire at any point along its path. It consists of a pulsed light source producing a focused beam which possibly after reflection of the light beam by smoke or irregularly deflected by air convention (excessive refraction) due to the presence of fire causes an attenuation of the beam and is detected by the detector

1:1.2 **HEAT DETECTORS**

There are two classes of heat detectors:

1. **Point detector.**

The point detector protects a small area around itself. These must operate within specified for rates of temperature rise between 1°C per minute and 30°C per minute. And when rise between the rate of rise in temperature is less than 1°C per minute also at fixed temperature between 54°C and 62 to 78°C.

2. **Line detector.**

The detectors are sensitive elements present in a continuous tine either in the form of a long wire or a long tube containing fluid. They are responsive to heating arising from a developing fire.

TYPES OF HEAT DETECTORS

There are two types of head detectors.

1. **Fixed temperature heat detectors.**

This type of heat detector makes use of the temperature dependent change in physical property of material eg. the bimetallic strip which is made up of two metal strips of different coefficient of expansion and with an increase in temperature. Or a temperature dependent resistor (thermistor) whose resistance changes with a corresponding change in temperature.

2. **Rate of rise detectors.**

These types of detectors make use- of the rate at which the temperature of the environment increases. When this rate exceeds a minimum rate. It can be obtained by using two elements that responds to temperature change at different rate. When there is high rise in temperature, the low thermal capacity element will heat up faster than the high thermal capacity element and the low thermal capacity element will eventually catch up with the high thermal capacity element which then close up the alarm circuit. Whereas when the rate of rise in temperature is low, the effect of the two elements cancels each other.

For this project I have chosen the fixed temperature type owing to the fact that some domestic fire outburst are accompanied by low rise in temperature.

Heat sensitive detectors all have a nominal operating temperature usually some 30°C above ambient temperature of their surrounding which ensures non-operation under normal conditions. [3]

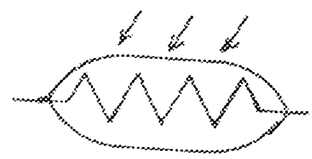
CHAPTER TWO

2.0 DESIGN ANALYSIS

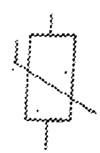
The sensors (the photoresistor and the thermistor) are connected across a voltage source for supply of currents and the current output signal from the sensors are as a result of change in their resistances due to change in properties in which they depend (light intensity for the photo resistor and heat for the thermistor) is amplified with the use of transistor to trigger on the alarm.

2.1 COMPONENTS USED AND THEIR SYMBOLS

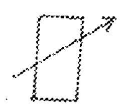
Light dependent resistor (photoresistor)



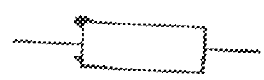
Thermistor or thermal resistor



Variable resistor

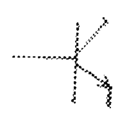


Fixed valued resistor



Light source

Bipolar junction transistor (BJT)



Light Dependent Resistor (LDR) or photoresistor

The LDR which is also called photoconductive cell is a two terminal device which has its resistance decreasing with increasing light intensity.

Thermistor

The thermistor (another name for the thermal resistor) is a temperature sensitive resistor which are of two types:

(1) The negative temperature coefficient type (NTC) and

(2) The positive temperature coefficient type (PTC)

<u>The Negative Temperature Coefficient Type (Ntc)</u>

This type has its resistance decreasing with increase in temperature. They are made from sintered mixture of the oxides of nickel, zinc, copper and manganese.

<u>The positive temperature coefficient type (PTC)</u>

This type has its resistance increasing with increase in temperature. They are made of current semiconductor material barium titanate. This compound has a transition temperature known as the curie point at which the crystallites of barium titanate change from the tetragonal to cubic structure. The transition is accompanied by a marked change in electrical properties, in particular the resistance which increases by several powers of 10 when the temperature reaches the curie point (12°C) the range of resistance increases can be selected by suitable doping of the barium titanate. [1]

Variable resistor

The resistance of this type of resistor can be varied to a desired resistance within a specified limit. The value attached to the resistor tells of the maximum resistance attainable by that particular resistor. For example a 10 KΩ variable resistor means its resistance can be varied from 0- 10KΩ

Fixed value resistor

These are resistors that have their resistance value permanent.

Light source

This is a 6 Volts Tungsten filament bulb.

Bipolar Junction transistor (BJT)

A bipolar junction transistor (BJT) is a three terminal device with a base, a collector and emitter legs. It can be represented by two diode n-p-n, p-n-p structure shown below. In fig. 2.1.a which also defines the symbols and the terminals of the devices (emitter base and collector).

FIG. 2.1.a

The arrow on the emitter leg serves the purpose of distinguishing between the emitter and the collector terminals which cannot be interchanged and also the arrow denotes the direction of conventional current flow through the devices providing discrimination between the symbol for the n-p-n transistor and its p-n-p counterpart.

$I_E = I_C + I_B$

Where I_E, I_C and I_B are the emitter collector and base current respectively.

BJT current gain

The fraction of the emitter current appearing as collector current is given the symbol α. The common base current gain of the both transistor - common base since the base terminal is common to both the input port emitter-base and the output port (collector-base) thus,

$$\frac{\text{collector-current}}{\text{Emitter current}} = \frac{I_C}{I_E} = \alpha \text{ ----------------------------- } (2.1.2)$$

The ratio (β) of the collector current to base current can be determined by combining equation 2.1.1 and 2.1.2 as follows.

Since $I_E = I_C + I_B$

$I_B = (1-\alpha)I_C$

$$\frac{\text{collector current}}{\text{base current}} = \frac{I_C}{I_B} = \frac{\alpha}{1-\alpha} = \beta \text{ --------------------- } (2.1.3)$$

β is termed the common emitter current gain, with it's input at the base.

and it's output at the collector. The symbols hf_b and hf_a are widely used as alternatives to α and β

Rearranging equation 2.1.3 we have an expression for α in terms at β and hence determine α to BJT whose measured β is 100

$\alpha = \beta/(1+\beta)=0.99$ [2]

2:2 CIRCUIT ANALYSIS

2:2.1 SMOKE DETECTING CIRCUIT

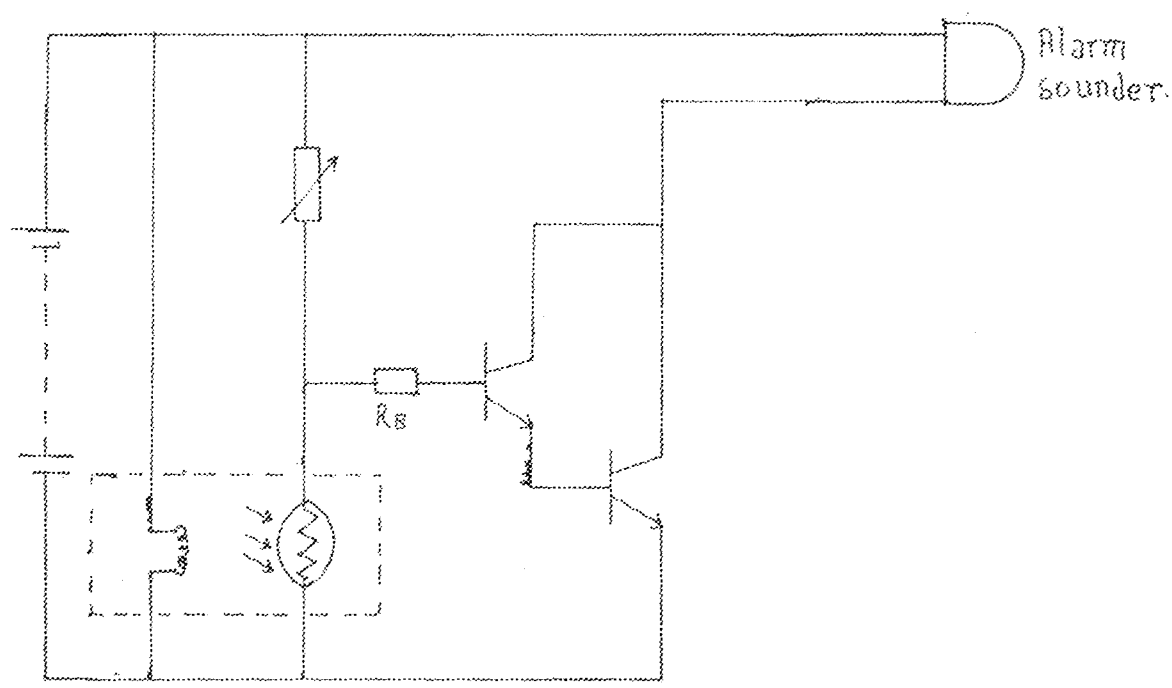


Figure 2.2.1

The light dependent resistor has low resistance in the presence of light and high resistance in the absence of light that is it increases its resistance with reduction of light intensity.

The LDR is illuminated with a constant light from the Tungsten filament as shown in the circuit diagram fig. 2.2.1 So as to maintain a constant resistance for the LDR even in the dark. Taking care of night and day of illuminated rooms and dark rooms.

As the LDR is illuminated, the resistance is so low as 0.5KΩ lower than the value of the resistor at the base of transistor 1 which value of base resistor is 2.2 KΩ meaning that a lot of current will flow through the LDR and there will be an insufficient base current to the transistor. So no signal to trigger on the alarm. But when there is smoke, it produces a shield to the LDR which increases its resistance above that of the base resistor of transistor 1 therefore there sufficient base current for the transistors which in turn trigger on the alarm. The current that flows across the variable resistor is also determined by the value of its resistance, if too high it allows very little current therefore the alarm can not trigger even when there is smoke. If too low the alarm comes on even when there is no smoke. So it has to be adjusted to a value such that the alarm comes on only when there is smoke.

2.2.2 **HEAT DETECTING CIRCUIT**

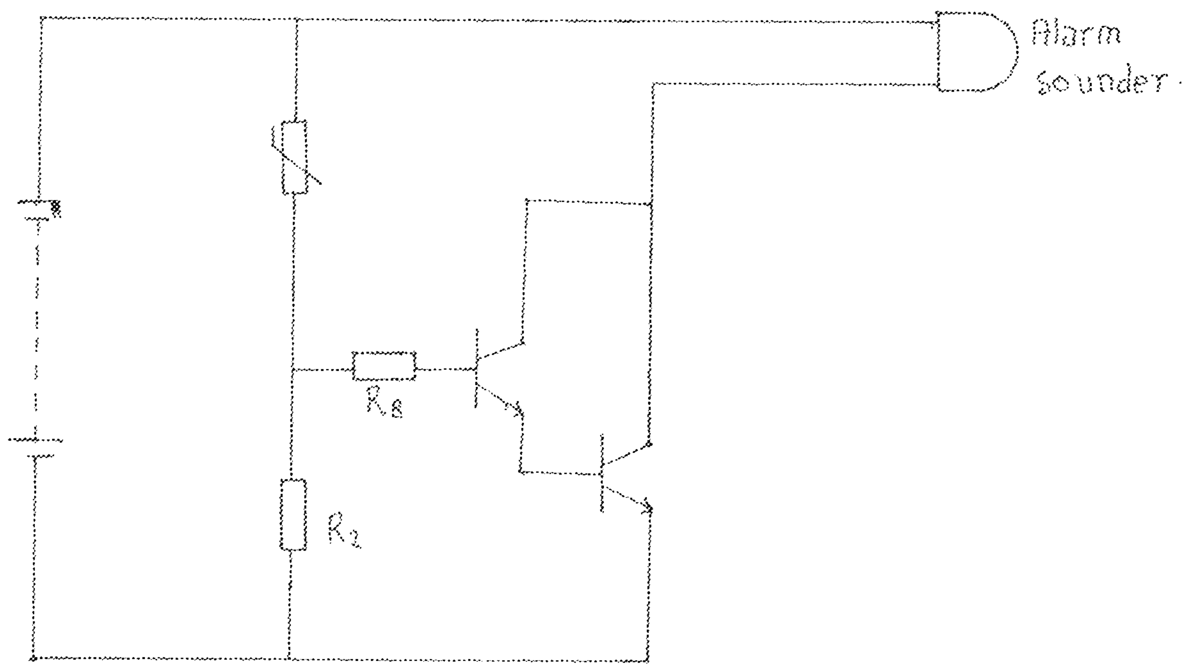


Figure 2.2.2

The thermistor used is the NTC type decreasing in resistance with increase in temperature.

Looking at the circuit diagram above in figure 2.2.2, Resistor R_2 has such a resistance value that is lower than the resistance value of the thermistor at normal room temperature but becomes higher at abnormal room temperature (say 30°C above normal room temperature) due to the fact that the resistance of the thermistor decreases with increase in temperature. So when R_2 is lower in resistance to the thermistor, there is no sufficient base current to the transistor therefore the alarm is off. But when R_2 becomes higher in resistance at the abnormal temperature because the resistance of the thermistor has reduced, these is now sufficient base current to the base of the transistor which in turn turns on the alarm.

2:3 CONSTRUCTION AND TESTING

CONSTRUCTION

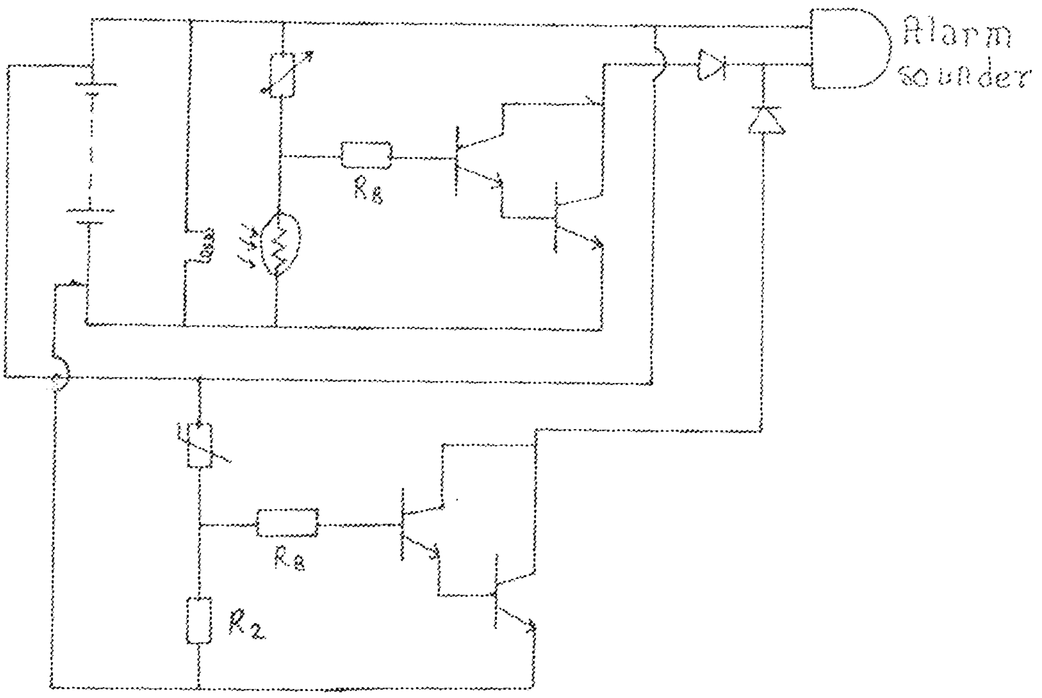


Fig. 2:3.1 a CIRCUIT DIAGRAM OF THE SMOKE AND HEAT DETECTOR

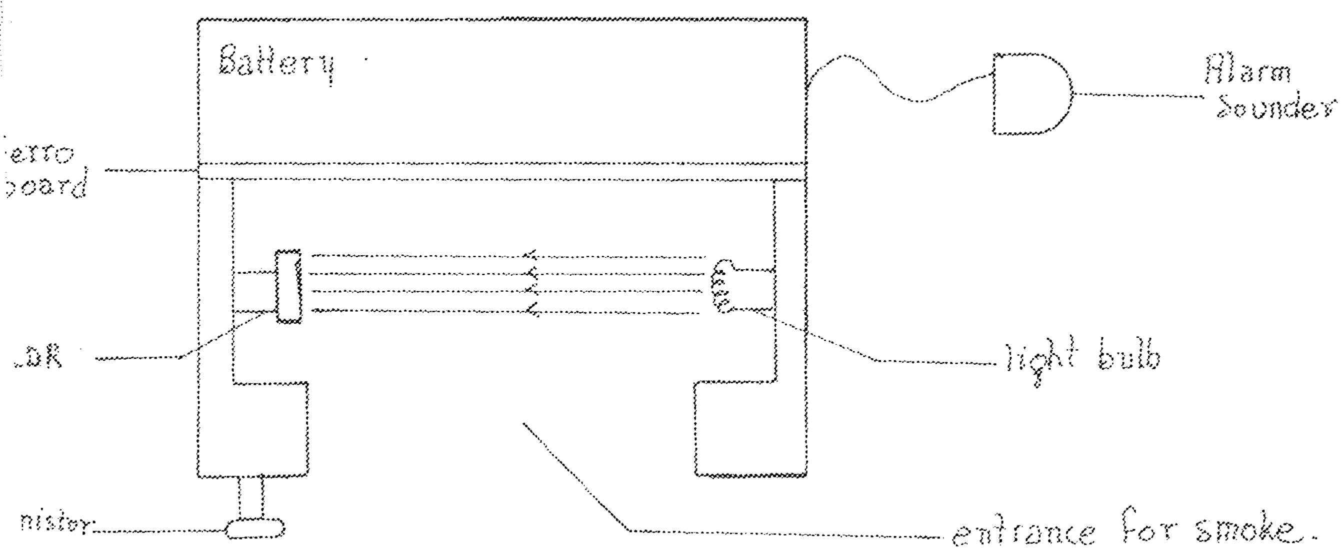


FIG 2:3.1 b CROSS SECTION OF THE FINISHED PRODUCT

Smoke detector

Only the transistor Darlinton pair, the base resistor and the variable resistor are soldered to the ferro board as shown in the circuit diagram (fig 2:3.1a) with two points on the board as the power supply input points (positive and negative points). The bulb which is the light source with the LDR are fitted inside a black box as shown in figure 2:3.1b so as to prevent natural light or external light variation from affecting the operating point of the LDR, but the box is with such an opening that allows the entrance of smoke easily. The box is also made from a highly heat resistance material because of the heat generated by the light bulb. The terminals of both the LDR and the light bulb are connected to the power supply point on the ferro board with wires. The power supply point are then linked to the dry cells through wires too. And the output collector current of the darlinton pair connected to the alarm with wires long enough to make provision for the alarm to be placed at convenient points away from the detector if wanted. The diodes at the alarm inputs are to prevent current signals coming from the heat detector circuit from entering into the smoke detector circuit and vis-versa.

Heat detector

The construction of the heat detector is similar to the one described for the smoke detector above except that it has its own separate circuit from that of the smoke detector on the same ferroboard and it is only the thermistor that is exposed as shown in fig 2:3.1 b and its circuit shares the same power supply with the smoke detector circuit and the output collector current of the transistor darlinton pair is connected to the same alarm sounder via a diode as shown in fig. 2:3.1a due to the reason stated above earlier.

2:3.2 TESTING

Test is carried out for alarm signal given with the various resistances of the photoresistor in different states listed below;

STATE	RESISTANCE VALUE
(1) Dark	= 17KΩ
(2) Under bulb illumination	= .002KΩ
(3) When smoke is present	=≥.004KΩ

and also for various resistances of the variable resistor for .002kΩ and .005kΩ

CHAPTER THREE

3.0 RESULT .

Symbol used in the table of Result

V_s - - - Supply Voltage

V_R - - - Resistance of Variable resistor

B - - - Result under Bulb illumination

B_s - - - Result under Bulb illumination with the presence of Smoke

D - - - Dark

X - - - No Signal

✔– - - - Poor Signal

✔ - - - Good signal

Table 3a

V_s (v)	V_R (Ω)	B	B_s	D
3	200	x	x	x
4.5	200	x	✔–	✔
6. V	200	x	✔	✔

Table 3b

V_s (v)	V_R (Ω)	B	B_s	D
3	500	x	x	x
4.5	500	x	✔	✔
6. V	500	x	✔	✔

3.1 DISCUSSION OF RESULT

From the table 3a and 3b above, there are good Signals at 6v Voltage supply when smoke is present for both 200Ω and 500Ω of V_R but 500Ω is prefferable owing to the fact that resistance of the photo resistor at B (resistance under Bulb illumination) is about 200Ω so that if V_R is made 200Ω, any little reduction in the intensity of light will give an alarm signal and this increases the probability of false alarm.

enough to power it. And a relay will be used so as to be to make use of the small current at the collector of the transistor darlington pair to trigger on the alarm. This means that the alarm will only make use of its power source when triggered by the relay. This also saves lot of energy.

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DESIGN AND CONSTRUCTION OF A MICROCOMPUTER BASED, 14 PINS DIGITAL IC TESTER.

BY

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96/5111EE

SUBMITTED TO

THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING,
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