Scott Jenkins

Fire Alarm

Aim:

The aim of this project is to create a fire alarm which will detect fire or the effects of fire and as a result, with a buzzer, aware any occupants and persons in the surrounding area. To do this, I have researched how to construct this particular circuit. Fire is a major hazard and without the proper warning indications, can lead to devastating consequences. This is a device that can solve this life-threatening problem.

Research

- From reading through a basic guide to fire alarms from www.firesafe.com, I have learnt that a minimum of 65 dB is required for a fire alarm in general areas or 5 dB above any background noise which persists for more than 30 seconds. If the alarm is to be placed where people are sleeping and are to be woken then 75 dB is required at the bedhead.

- A thermistor with a resistance of around 100 kilo-ohms at room temperature should be used to make it sensitive to the high temperatures of fire (about 100 C) but not anything much lower. When in high temperatures such as this, the resistance of the thermistor should drop to only a few ohms, drastically increases the current.

Investigations

Thermistor test

Resistance (KΩ)	Temperature
5.63	21
5.3	23
3.92	30
2.61	40
1.75	50
1.22	60
0.87	70
0.64	80
0.51	90

For the voltage comparitor of the thermistor, the trigger point must be about 0.55KΩ to be able to trigger at around 85 C

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Characteristic curve of the LDR and Thermisor

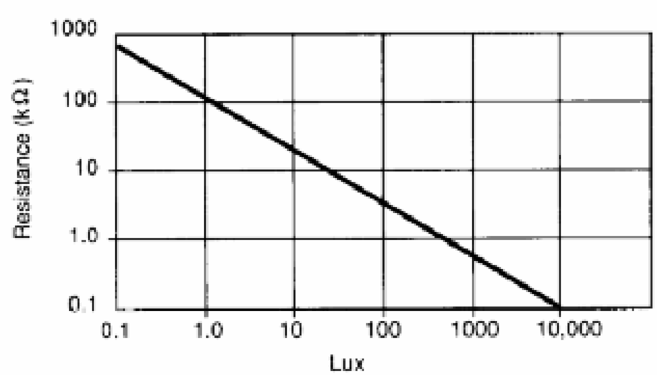
For a light sensor I am going to use a LDR, as I've used them before in my class work and know how to use them in circuits. To find details of the characteristic curve of the LDR, I searched it on the internet and found a data sheet for the LDR, type NOPRP12. A table of the electrical characteristics and a graph of resistance against illumination are shown below, as extracted from the data sheet. (Fig.2).

For a heat sensor I am going to use an NTC thermistor, as I've used them before in my class work and know how to use them in circuits. To find details of the characteristic curve of the thermistor, I searched it on the internet and found a data sheet for one. A table of the electrical characteristics and a graph of resistance against temperature are shown below. (Fig.3).

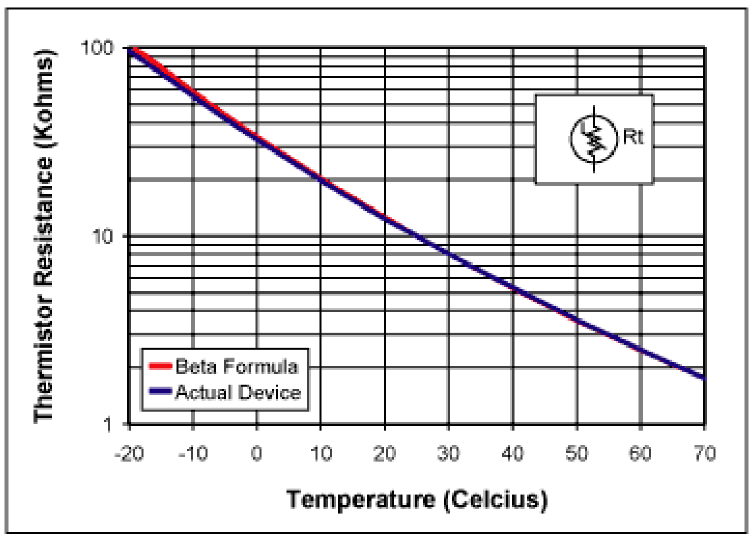
(Fig.2)

arameter	Conditions	Min.	Typ.	Max.	Units
ell resistance	10 lux 100 lux	20 -	- 5	100 -	kΩ kΩ
ark resistance	10 lux after 10 sec	20	-	-	MΩ
pectral response	-	-	550	-	nm
se time	10ftc	-	45	-	ms
ill time	10ftc	-	55	-	ms

Figure 4 Resistance as a function illumination



(Fig.3)



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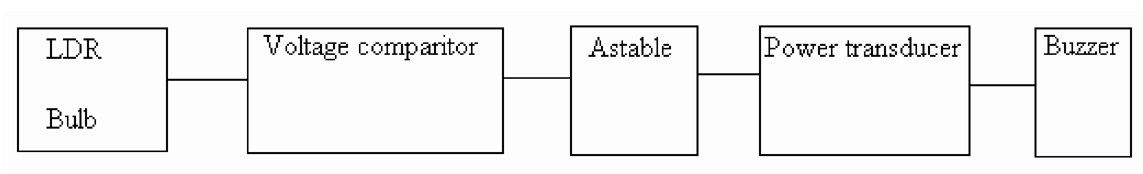
Specification

- My system must be able to reliably detect the high temperatures (about 80 C) and brightness from a nearby fire and not be affected by any ambient conditions.
- My system must operate from an 8 - 10 volts supply as this is a common voltage for similar fire alarms.
- It must also consume little power since fire alarms are easily forgotten about when checking the batteries and therefore a longer life can be much more reliable to last a long time.
- The buzzer must produce a sound of around 70dB of 1 meter distance, ON for 1.5 second period and OFF for 1.0 second period.

Possible Solutions

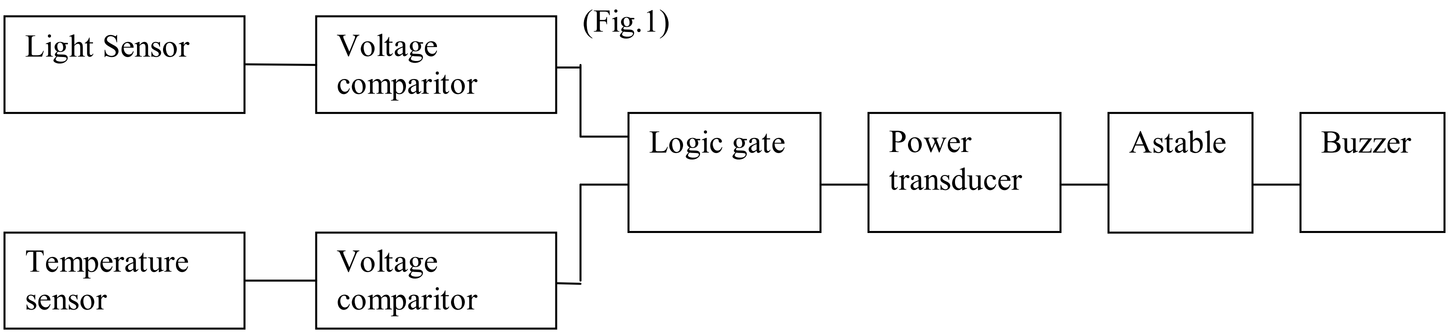
There is more then just 1 solution to solve the problem of fire detection.

(a) A device that relies on the smoke that is produced in the event of a fire. When this smoke passes between a bulb and an LDR, the amount of light falling on the LDR decreases. This causes the resistance of LDR to increase and the voltage at the base of the transistor is pulled high due to which the supply to the COB (chip-on-board) is completed. The sensitivity of the circuit can depend on the distance between bulb.



(b) A device that uses a thermistor and an LDR to detect the high temperatures and brightness of a fire. When the temperature reaches high, the resistance of the thermistor decreases dramatically and the voltage travelling across the thermistor is pulled high and is passed into an AND gate. The same thing happens with the LDR but as the brightness increases the resistance drops and the voltage travelling through the LDR is pulled high and is passed into the AND gate; switching on a \buzzer alarm. This is the system that I will investigate and use for my system.

(Fig.1)



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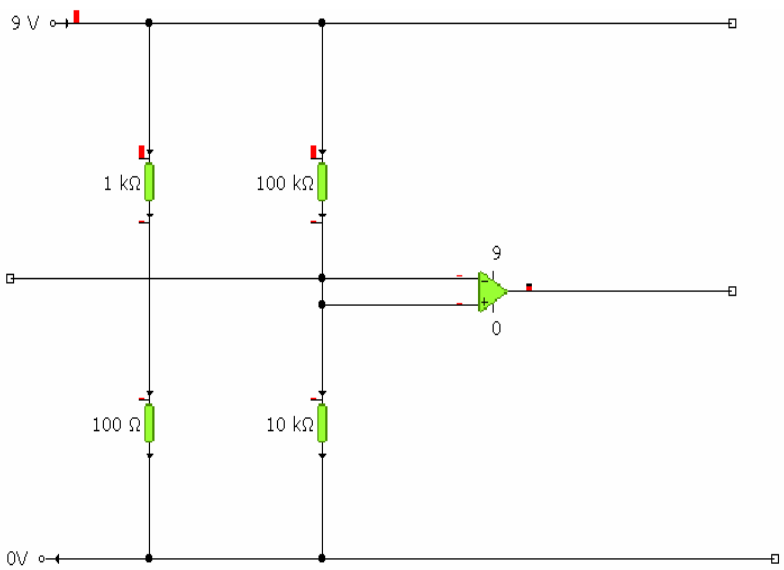
Reason for preferred choice

I decided to go with option B because I would like the circuit to be able to detect the heat and light of the fire, other then just the smoke as this can be accidently set-off by anything that may produce a little smoke but have no fire.

Sub-system Development

My complete fire alarm system will consist of the sub-systems previously shown in the block diagram (Fig.1).

The LDR voltage comparitor



Ratio 10:1
Therefore, trigger point = 100Ω

Using resistors 100KΩ and 10KΩ, a 10:1 ratio was formed to work out the trigger point. With the 1KΩ as R1 the trigger point was made to be 100Ω, which is enough light from a fire to trigger the circuit.

Resistor R1 forms a voltage divider with the LDR; the voltage to the non-inverting input being larger than the reference voltage when the LDR is in the light. When the LDR is in bright light, the non-inverting input is greater than the inverting input and so the output of the op-amp saturates at the positive supply voltage, +Vs. The output then goes into an AND gate. This circuit, therefore, gives a logic 0 output in the dark and logic 1 output in the light.

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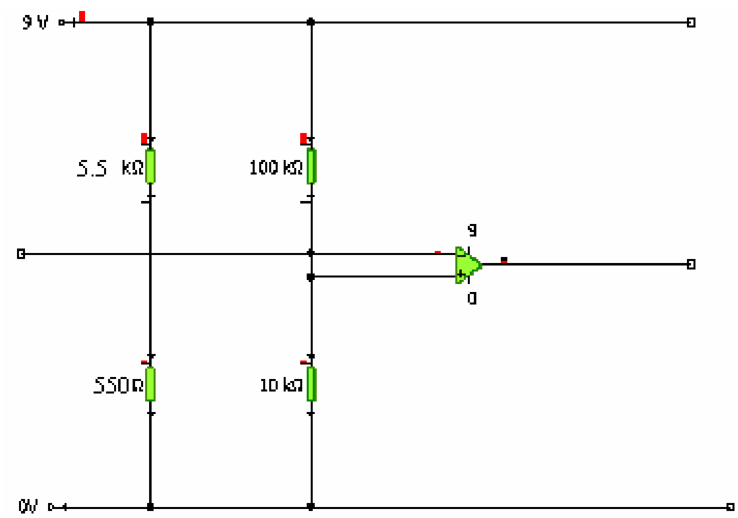
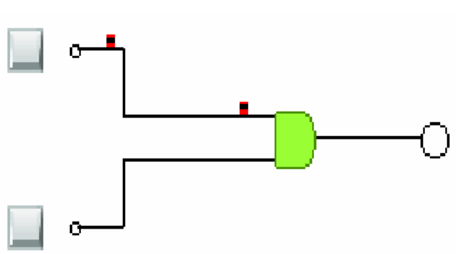
The Thermistor voltage comparitor



Ratio 10:1
Therefore, trigger point = 550Ω// 80 C

Using resistors 100KΩ and 10KΩ, a 10:1 ratio was formed to work out the trigger point. With the 5.5KΩ as R1 the trigger point was made to be 550Ω which is need for the circuit to trigger at around 80 C. Resistor R1 forms a voltage divider with the thermistor; the voltage to the non-inverting input being larger than the reference voltage when the thermistor is hot. When the thermistor is in high temperatures, the non-inverting input is greater than the inverting input and so the output of the op-amp saturates at the positive supply voltage, +Vs. The output then goes into the same AND gate. This circuit, therefore, gives a logic 0 output in the dark and logic 1 output in the light.

Logic AND gate



Truth Table

A	B	OUT
0	0	0
0	1	0
1	0	0
1	1	1

The output from both of the voltage comparitors are linked into an AND gate. When the logic outputs from the two sensors (A **AND** B) are a 1 (high), a single output is produced that also also becomes 1. This then goes on to the next part of the circuit.
When any one of the outputs of the two sensors is a 0 (low), the output of the AND gate is also a 0.

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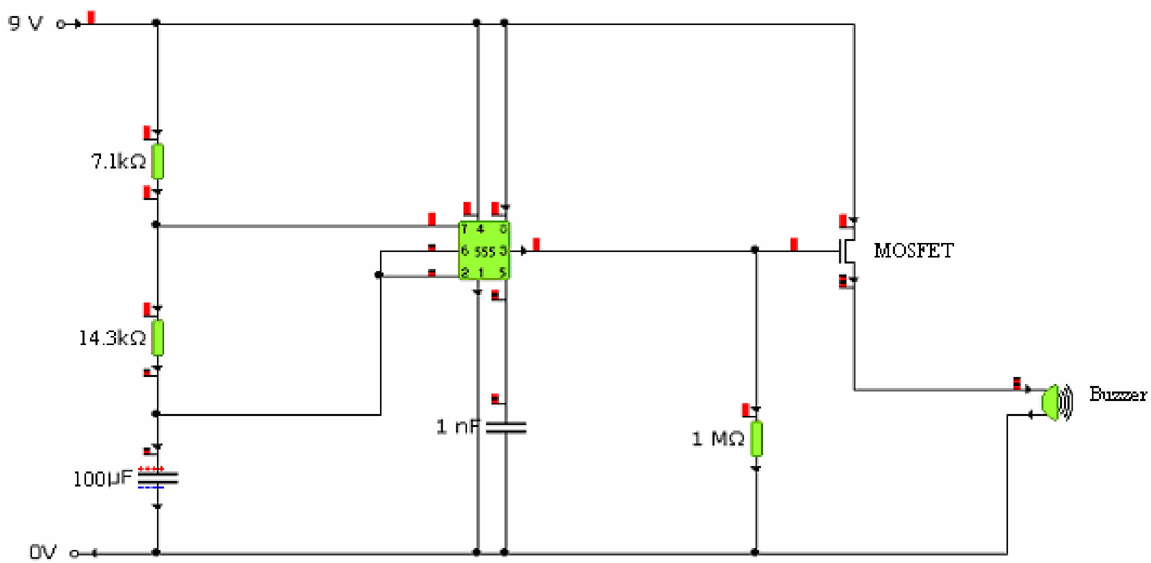
Power Transducer
This electrical component is voltage operated which has a very large input resistance and a large current gain. This will increase the power needed to sound the buzzer alarm.
555 Astable

The heart of the circuit is a 555 timer chip configured in astable mode
This means the out put at pin 3 is constantly changing, i.e. the output goes high (9V) for a specified time and then low (0V) for a specified time before again switching high. In my circuit the specified times are: 1.5 seconds HIGH and 1.0 seconds LOW.

The frequency is controlled by the size of R1, VR1, and C1

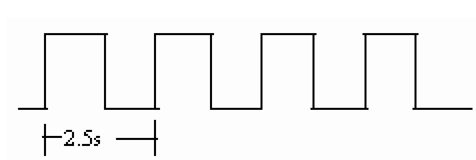


T-high = 0.7 (R1+R2) C
T-low = 0.7 R2 C

T-low = 1.5s (specified)
T-high = 1.0s(specified)
R1= 7.1KΩ (calculated)
R2= 14.3KΩ (calculated)
C= 100uF (no specific reason for this choice)

T-high = 0.7 (R1+R2) C
1.5s = 0.7 (R1 + R2) x 100uF
$R1 + R2 = \frac{1.5 \text{ seconds}}{0.7 \times 100uF}$ = **21.4KΩ** => **R1 = 7.1KΩ**

T-low = 0.7 R2 C
1.0s = 0.7 x R2 x 100uF
$R2 = \frac{1.0 \text{ seconds}}{0.7 \times 100uF}$ = **14.3KΩ** => **R2 = 14.3KΩ**



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Tests on Sub-Systems

Voltage comparitor – LDR

Inverting/non-inverting	Voltage with light ON (V)	Voltage with light OFF (V)
Inverting	0.72	0.79
Non-inverting	0.51	5.20
Output	7.42	1.34

This shows that when the light is on the output becomes high (7.42V) as the inverting voltage is higher than the Non-inverting voltage.The sub-system is therefore working.

Voltage comparitor – Thermistor

Inverting/non-inverting	Voltage with high temperature (V)	Voltage with low temperature (V)
Inverting	0.73	0.78
Non-inverting	0.70	1.60
Output	7.29	1.37

This shows that when the thermistor is in high temperature the output becomes high (7.29V) as the inverting voltage is higher than the Non-inverting voltage.The sub-system is therefore working.

AND Gate

Heat sensor input (V)	Light sensor input (V)	Output (V)
1.37	1.34	0
1.37	7.42	0
7.29	1.34	0
7.29	7.42	6.28

This shows that when both the inputs of the heat sensor and light sensor are HIGH the output voltage then also becomes HIGH. However, when either one of the sensors is LOW then the output voltage remains LOW. The sub-system is therefor working.