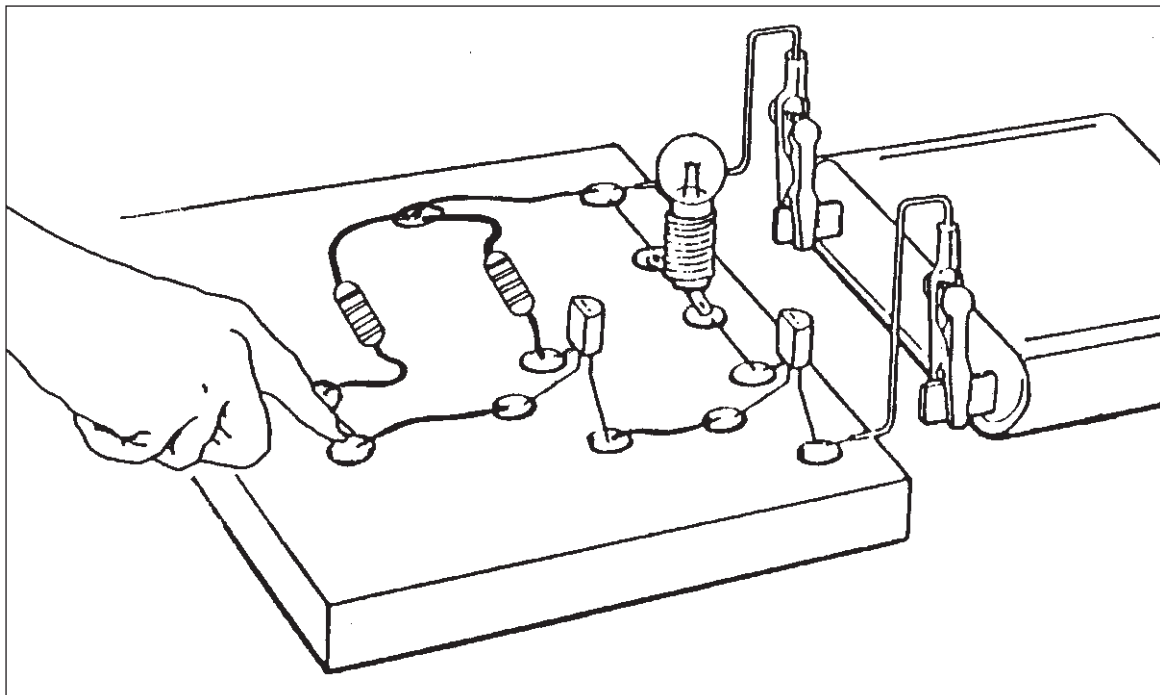


OPITEC

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Electronic Tutorial Program Part VI: Sensory Switching by way of humidity, contact, time, light and heat



Contents:

- Humidity sensor
- Contact sensor
- Time sensor
- Light sensor
- Heat sensor

Please Note

The OPITEC range of projects is not intended as play toys for young children. They are teaching aids for young people learning the skills of Craft, Design and Technology. These projects should only be undertaken and tested with the guidance of a fully qualified adult. The finished projects are not suitable to give to children under 3 years old. Some parts can be swallowed. Danger of suffocation!

Contents:

1 resistor	1,8 KOhm
1 resistor	6,8 KOhm
1 resistor	2,2 KOhm
1 thermistor	4,7 KOhm
2 transistors	BC 548
1 bulb	3,8 V/0,07 A
1 spring bronze band	50 mm long
1 plywood board	80 x 80
1 potentiometer	10 KOhm
1 Light Dependent Resistor (LDR)	
1 capacitor	1000 μ F
1 socket	E10
10 thumb tacks	
2 wires with crocodile clips	
1 wire	0,5 m

Please Note

Due to the manufacturing process of the bulb holders, the inner contact tab may stand a little proud. We recommend pressing the contact tab down with a small screwdriver, before inserting the bulb.

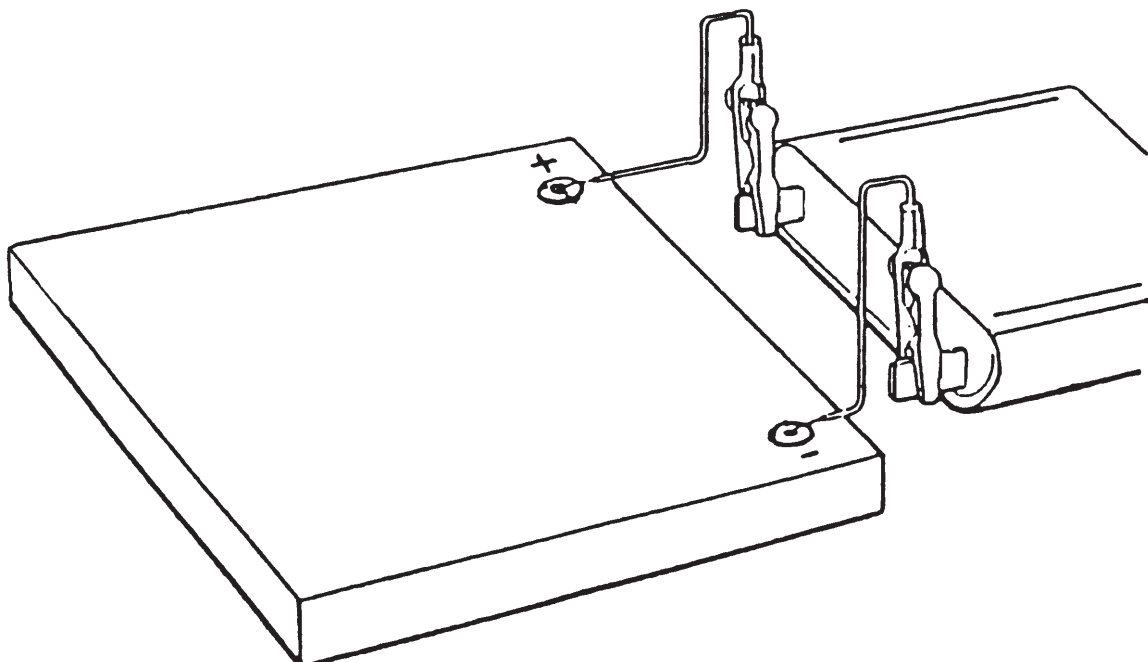
What are sensory applications?

With this term you can describe the technique which helps record and evaluate physical reactions. Such sensory circuits (detectors) react to liquids gases, light, heat, and other perceptible sources.

With this tutorial programme you will get to know the most commonly used sensors in both theory and practice.

Construction:

The constructions of the control is done onto the plywood board. Push the thumb tacks into the board as shown in the diadram and solder the parts onto it. The connection of the battery is done with the alligator clips.



THE LIQUID SENSOR

Sensing water

Tips for mounting the circuit

Firstly insert the drawing pins into the plywood board. Using the diagram identify the required components and solder them into position. Be careful to solder the transistor exactly as shown in the diagram.

The wires which are soldered to pins 1 and 2 and act as the sensors for the liquid. The distance between the ends of the wires should be about 1 cm

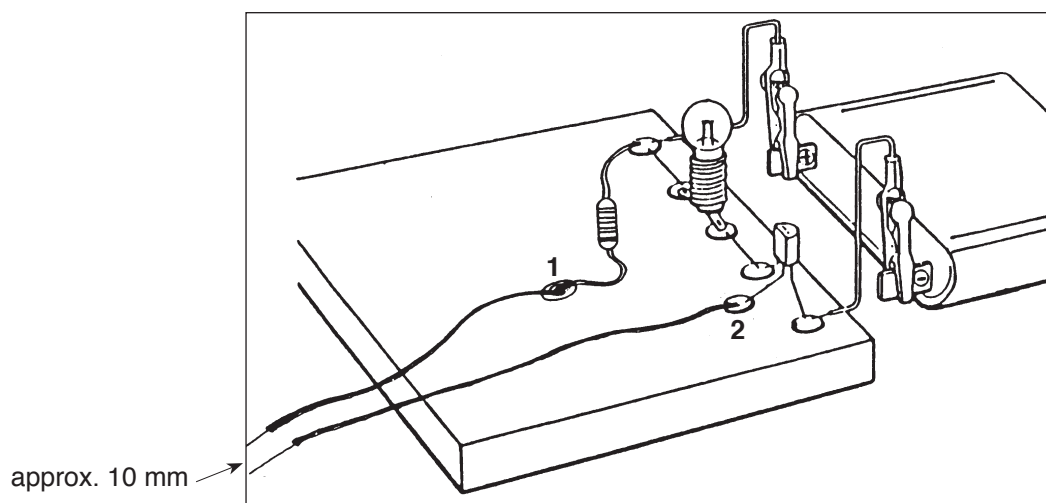


transistor BC 548 (or similar)

When soldering the transistor the flat side should face to the left.



resistor R1 = 1,8 kOhm (brown, grey, red)

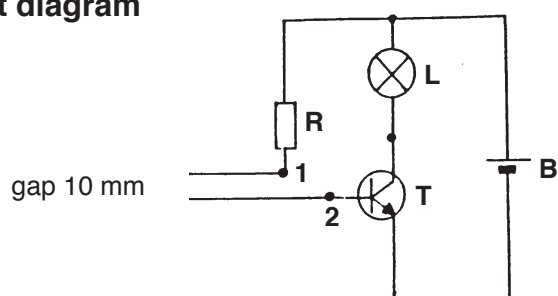


How the circuit functions:

When the battery (up to 6 Volts) is connected, the bulb does not light because there is no current reaching the base of the transistor. Once the ends of the sensor wires 1 and 2 are immersed in water, current can flow through the water into the base of the transistor and switches it on. This causes the bulb to light as the main flow of current passes through it. Without a resistor in the circuit the bulb would be brighter but the transistor could be easily destroyed if the two ends of the sensor wires accidentally touched each other.

When a pair of transistors are used (DARLINGTON pair) the sensitivity of the circuit is greatly increased.

circuit diagram



L = bulb 3,8 V/0,07 A

T = transistor BC 548

R = resistor 1,8 Ohm

B = battery 4,5 V

Uses for this type of control

This type of circuit is used to control the level of liquids. Practical applications of these type of circuits are found in washing machines to control the level of water, or for turning off the water should a hose break. You can use your circuit to electronically control the water level in a bath, or detect if water is present in the soil of a plant pot.

You may ask yourself why do you need a transistor circuit?

Why not use a bulb and battery on its own. Try it!

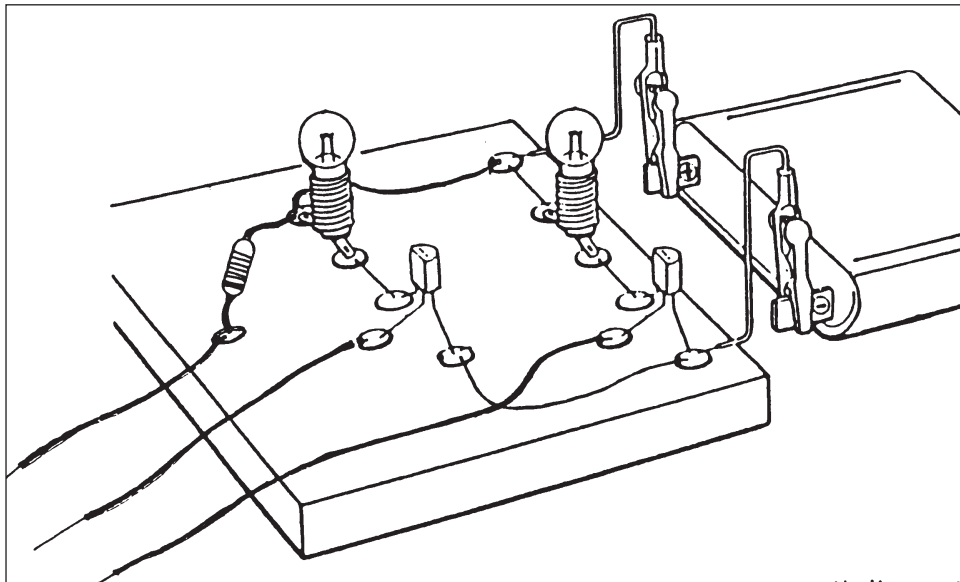
The bulb will not light because the resistance of the liquid is too high. The transistor serves as a current amplifier and a weak base current switches a strong collector current which lights up the bulb.

Expanding the moisture sensor

Tips for making the circuit

Insert the drawing pins into the plywood board and the solder the components in position as shown. Careful with the polarity of the transistors! Basically this circuit is double version of the first.

The advantage of this is that two positions can be controlled. One bulb lights when a certain level has been reached and the other indicates it dropping to a certain level. The implication of this is that it can be used to sense if a water container is full or empty.



The second bulb is not included in this programme

Tips for all the circuits

In all the circuits the bulb can be replaced with a relay (Order No.214016) This way more powerful buzzers or alarms can be added.

A diode has to be inserted in parallel with the relay in order to protect the transistors as the relay is switched off.

THE CONTACT SENSOR

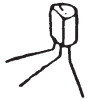
Use your finger to control a circuit!

Tips for making the circuit

Insert the drawing pins into the circuit as shown in the diagram.

Identify the components and solder them to the heads of the drawing pins. Be careful with the polarity of the transistors.

The drawing pins 1 and 2 serve as sensors. The distance between them should not be larger than your finger tips.



transistor BC 548 (or similar)

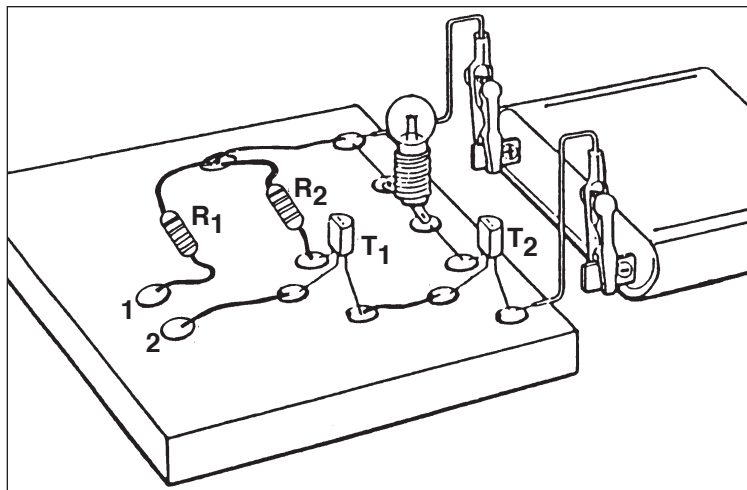
When mounting the transistors the flat side should face to the left.



resistor R1 = 1,8 kOhm (brown, grey, red)



resistor R2 = 6,8 kOhm (blue, grey, red)



How the circuit functions

When a finger is placed across the drawing pins 1 and 2 the bulb lights.

The resistance of the skin on your finger tip is not enough to stop a weak current from flowing. This weak current would not activate a single transistor circuit (moisture sensor 1). However we have connected two to make a DARLINGTON pair. This DARLINGTON circuit uses the effect of the emitter current of the first transistor to feed to the base of the second transistor. Each separate transistor amplifies the current. It has an amplifying factor of $\beta=8$. On a darlington circuit the amplification factor is not added but multiplied. A considerably higher factor is achieved compared to a simple circuit.

$$\text{Total of } \beta = \beta_1 \times \beta_2 \quad (80 \times 80 = 6400)$$

Now to our circuit

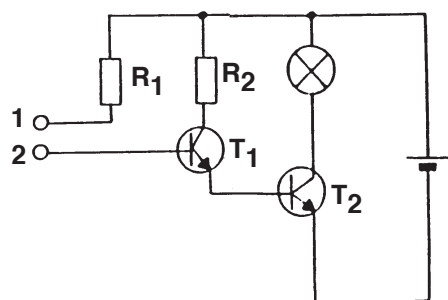
When the battery (up to 6V) is connected and a finger tip place on the sensor, a current flows via R1 and the finger tip to the base of T1.

This switches the transistor on and a collector current flows through.

The emitter passes it to the base of T2. R2 acts as control to ensure that T2 is not overloaded. T2 is switched on and the bulb lights.

Because of the amplification a weak current flowing through the finger tip can be used to activate a bulb or a relay.

circuit diagram



T_1 and T_2 transistors BC 548/547

$R_1 = 1,8 \text{ k}\Omega$

$R_2 = 6,8 \text{ k}\Omega$

Using this type of circuit

This type of touch sensitive circuit is used in lots of electronic appliances.

The touch of a finger is enough to change a TV channel. Devices which are used by handicapped people are often controlled this way.

The Time Sensor

More haste-less speed

Tips for making the circuit

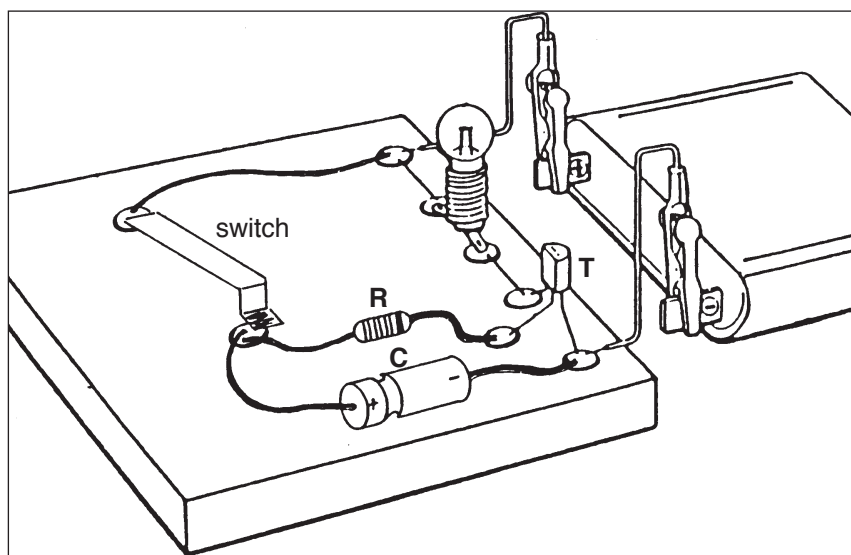
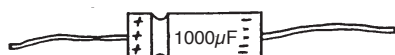
Insert the drawing pins into the plywood base as shown. Identify the components and solder them in position. Watch the polarity of the transistor! Watch the polarity of the capacitor! To make the switch bend the bronze metal strip as shown and solder one end to the head of the drawing pin. To switch the circuit simply press the strip on to the next pin, afterwards it will jump back on its own.



resistor $R_1 = 1,8 \text{ k}\Omega$ (brown, grey, red)



capacitor $1000 \mu\text{F}$
either one can be used, watch polarity



How it works:

When the battery (up to 6V) is connected the bulb does not light up. However, when the switch is pressed down a current flows into the base of the transistor and switches it on, lighting the bulb. At the same time the current flows into the capacitor charging it up. When the switch is released the bulb still stays on.

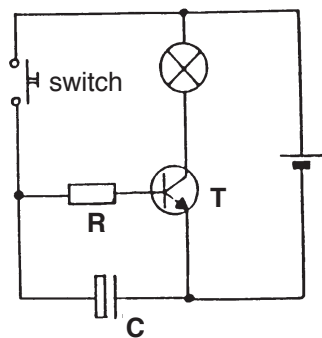
Why?

The capacitor continues to discharge itself via the resistor and the base of the transistor. Whilst discharging the current decreases and the bulb gets gradually dimmer as the transistor receives less input.

Finally the bulb goes out.

The length of time the bulb stays on is determined by the size of the capacitor and the resistor. The larger the capacitor the longer the bulb can stay lit, the smaller the resistor used with it, the quicker the bulb goes out as it can discharge quicker.

circuit diagram



T = transistor BC 548/547

R = resistor 1,8 kOhm

C = capacitor 1000 μ F

Uses for this type of circuit

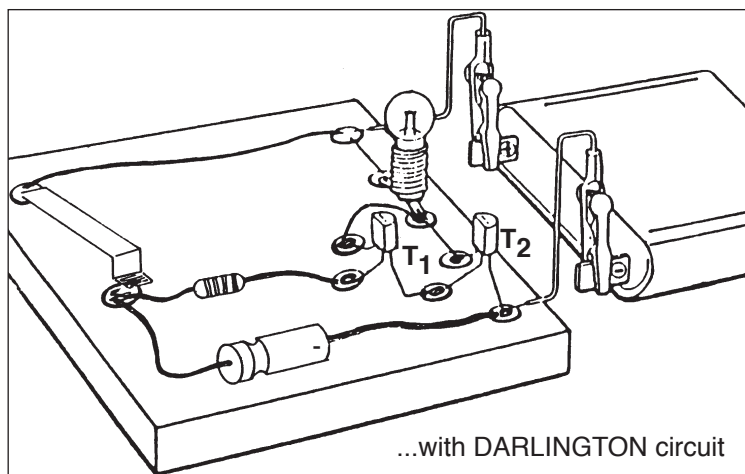
These types of circuit are used in applications where equal rythms are needed. e.g. impuses for flashing lights, automatic on/ off switching after a time delay (staircase lighting) or a timing circuit in a washing machine. You can also use it to operate a model boat or plane for a certain period of time.

An improved time sensor

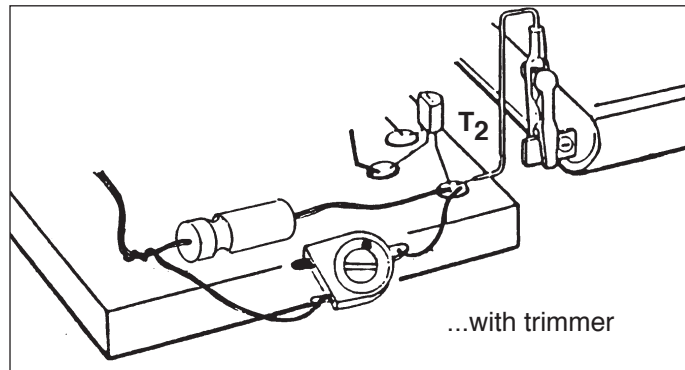
This is a DARLINGTON transistor based circuit. It is somewhat simpler as both the transistors are coupled together without a collector resistor.

The circuit reacts to a small amount of current at the base of T1. The discharging process of the capacitor can be used to count long periods of time as it feeds T1. Therefore the bulb will stay lit for longer intervals.

All the components to make this circuit are included, so you can make yourself an interval timer.



When a trimmer (adjustable resistance) is added in parallel with the capacitor further adjustment can be achieved, the bulb can be switched off when you want.



THE LIGHT SENSOR

Using light and shadow to control a circuit

Tips for making the circuit

Insert the drawing pins into the board according to the diagram.

Identify and solder the components in place. Be careful with the polarity of the transistor. Check that the resistors are correctly placed (check values)

Take care with the LDR



resistor $R_1 = 1,8 \text{ k}\Omega$ (brown, grey, red)

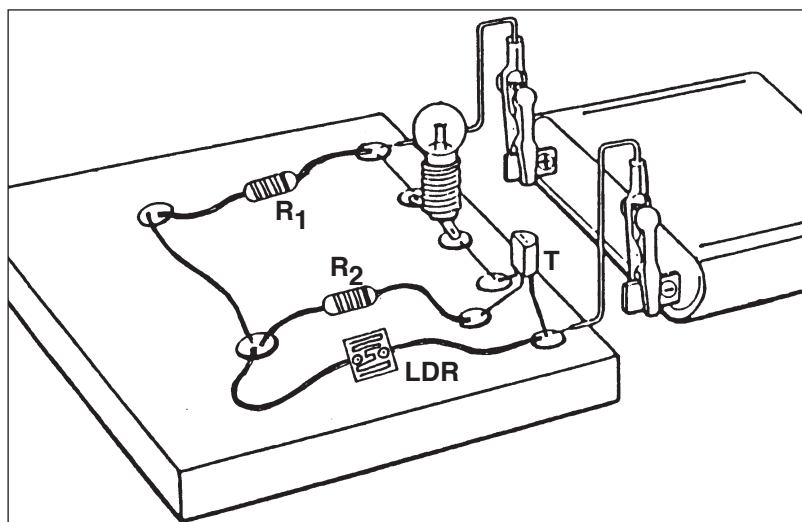


resistor $R_2 = 2,2 \text{ k}\Omega$ (red, red, red)



LDR

LDR is the abbreviation for light dependent resistor. Such a resistor is low resistant when exposed to light and high resistant when in the dark.



How the circuit functions

Light circuit

When a battery is connected (up to 6V) the bulb lights up.

Why?

The LDR is a light sensitive resistor. This means it has a HIGH resistance when it is in the dark and a LOW resistance when exposed to light.

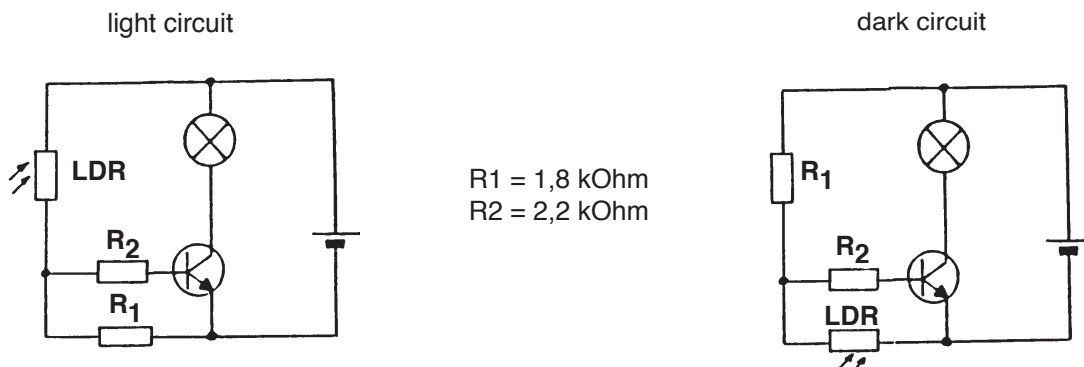
A positive current reaches the base of the transistor, this is because the LDR is exposed to daylight and has therefore a low resistance. The resistor R2 ensures that the transistor is not overloaded. The resistor R1 prevents too high a current flowing through the LDR when it is exposed to a bright light.

The Dark operated circuit

In this circuit the arrangement of the components has been changed. This time when the battery is connected the bulb does NOT light.

Why?

The LDR is exposed to light and has low resistance. The transistor does not receive enough current to activate the base. When the LDR is exposed to dark (a hand) the bulb will light as the current is forced to go along the base line, the resistance of the LDR being too high.



Uses for this type of circuit

On/off functions for automatic parking lights in cars. A house lights can be controlled by a sensor so that they come on automatically as it gets dark. As an alarm when a door or drawer is opened and the sensor exposed to light. All these circuits would of course need a relay and a buzzer or siren.

The LDR sensor can be made more sensitive by placing it in a tube so that the light has to be directed on it with a beam eg. a torch. This prevents it being activated by surrounding light.

THE HEAT SENSOR

Heat controls resistance

Insert the drawing pins into the plywood board. Solder the components in place ensuring that you identify the correct polarity for the transistor.

The thermistor (heat sensor) can be placed either way around.

Connect the trimmer as shown.



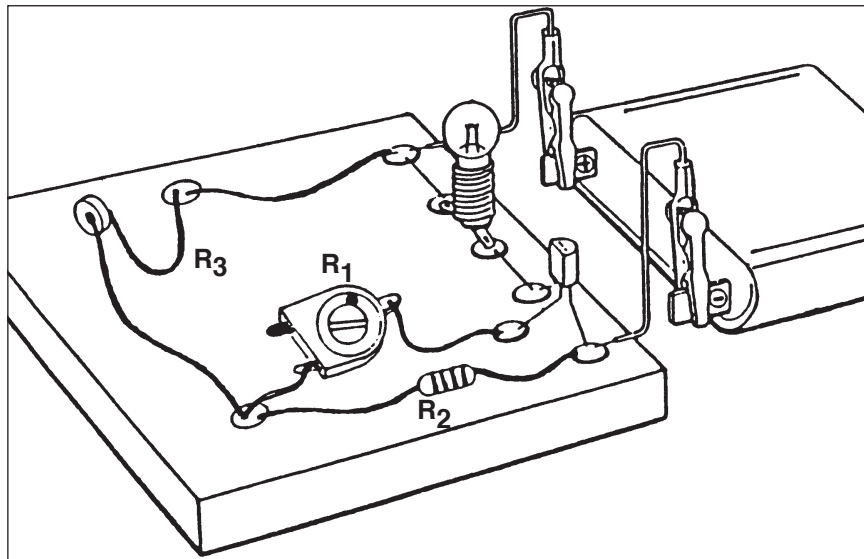
resistor = 1,8 kOhm (brown, grey, red)



hot conductor 4,7 kOhm



potentiometer 10 kOhm



How the circuit functions

When a battery is connected (up to 6V) the bulb does not light up

Why?

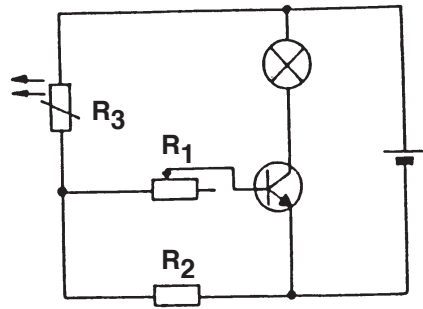
The thermistor is also a variable resistor. When it is cool it has a high resistance and when it is cold it has a low resistance. It is sufficient to hold the thermistor between your finger and thumb in order to change its resistance. Do not use an open flame on this type as it can destroy it.

Further heat sources could be hot water or hot metal.

When the thermistor is heated its resistance decreases allowing the current to flow via the trimmer to the base of the transistor. The transistor is then switched on and a greater current flows through the collector to the emitter thus lighting up the bulb.

The resistor R2 prevents a short circuit. The trimmer will make a certain amount of temperature adjustment possible.

circuit diagram



R1 = trimmer 10 kOhm

R2 = resistor 1,8 kOhm

R3 = thermistor

Uses for this type of circuit:

These kind of sensor circuits are used to active cooling fans or ventilation systems once a certain temperature has been achieved.

For example it can turn off a washing machine heater once the water has reached a predetermined temperature.

The thermistor can even measure liquids such as oil. When a tank is filled the level rises until it touches the thermistor and cools it down (oil is colder than air) and so switches the pump off.

Central heating systems use a thermistor circuit to control temperatures.

When the sun shines on your desk a fan can be activated.

A heat sensor can be put into a candle, when it burns down to a certain level a fan will turn on and put it out.

If a sensor is put into a drinkable liquid (coffee, tea, hot chocolate etc.) a bulb can indicate the correct safe temperature for drinking.