COMPARATORS

In this study file, we will consider a sophisticated type of electronic switch which is called a comparator. A comparator is made up of many transistors and resistors, all of which are manufactured on a silicon chip called an integrated circuit or IC. The comparator we shall be using is mounted on an eight pin dual in line (DIL) package.

A comparator has two inputs and one output. The voltage produced at the output (V_{out}) depends on how the two input voltages compare with one another.

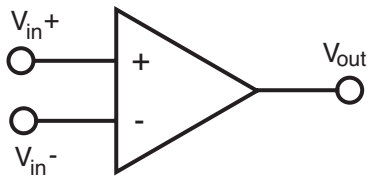
The terms high and low were mentioned in study files 4, 5 and 6. It is very convenient to consider the output voltage V_{out} in terms of high and low signals.

You should remember that:

A **low signal** is a voltage level which is very close to zero volts.

A **high signal** is a voltage well above zero volts and is likely to be very close to the value of the supply voltage.

The general symbol for a comparator is shown below:



CIRCUIT OPERATION

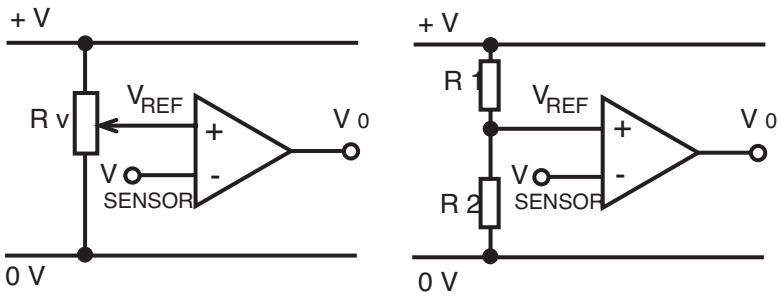
When V_{in} + is greater that V_{in} - then V_{out} is high (i.e., very close to the value of the supply voltage V).

When V_{in} + is less than V_{in} - then V_{out} is low (i.e., very close to zero volts).

Note:
The case when V_{in} + is equal to V_{in} - is not considered because there will always be a slight difference between the two values.

In practice a reference voltage is connected to one of the inputs and a sensing circuit to the other.

The reference voltage can be created by using a potentiometer or fixed resistor.



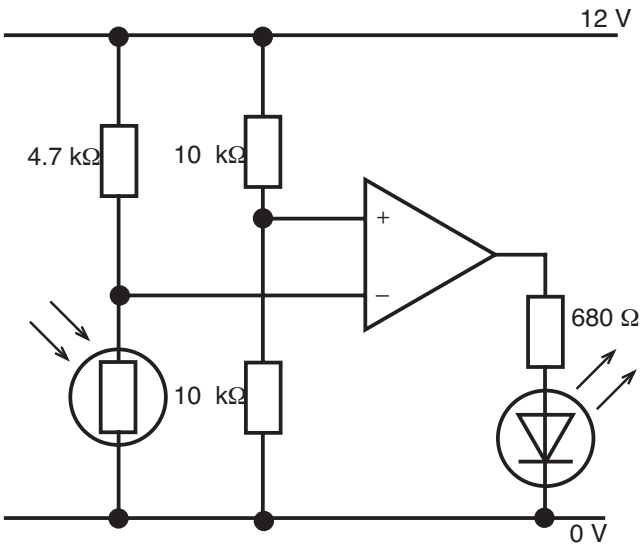
Using a potentiometer **Using fixed resistors**

The purpose of the pot in the left hand circuit is to enable us to vary the voltage (V_{ref}) to any desired voltage from 0 volts up to the full suppply voltage. The setting we choose determines at which level of light, temperature, sound, etc., the output switches from high to low and vice versa.

In the right hand circuit the two resistors form a potential divider chain and provide a fixed reference voltage. In this case the comparator output will always go high or low at the same level of light, temperature, sound etc.

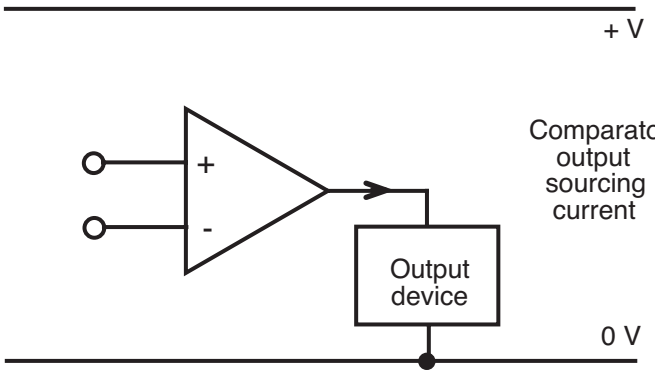
In the two circuits shown above the reference voltage is shown connected to V_{in} +. Therefore the output voltage will be high when V_{REF} is greater than V_{SENSOR} and low when V_{REF} is smaller than V_{SENSOR}. If the reference voltage was connected to V_{in}- the opposite effect would occur.

A typical comparator circuit as shown below.



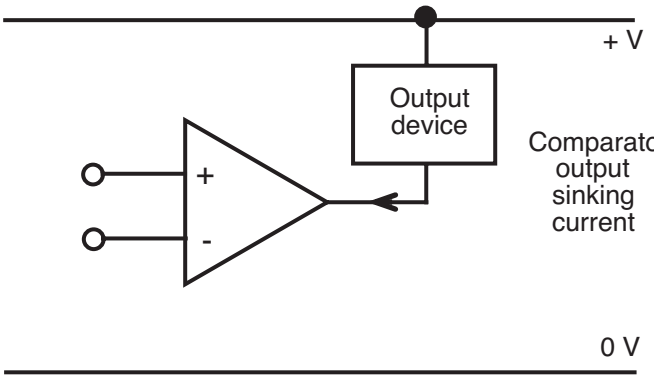
SOURCING AND SINKING CURRENT

If an output device is connected between the comparator output and the OV rail, the output device is activated when the comparator output is high. With the comparator output connected in this way the output is said to be sourcing current.



An output device can also be connected between the positive rail and the comparator output. The output device is now activated when the comparator output is low. Current travels from the positive rail through the output device and into the comparator output.

With the comparator output connected in this way the output is said to be sinking current.



ADVANTAGES OF A COMPARATOR

The main advantages of using a comparator rather than a transistor switch are:

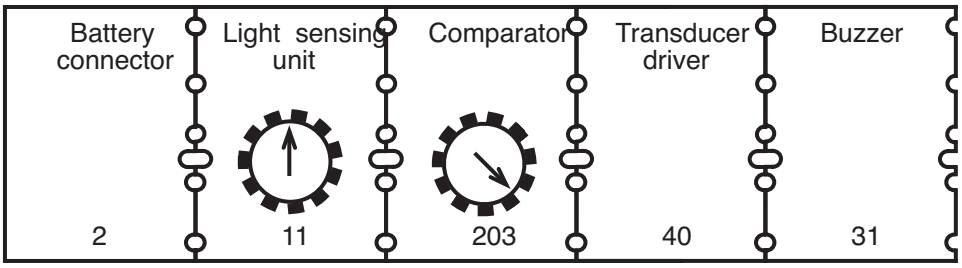
(i) a comparator is much more sensitive than a transistor switch, and this sensitivity is easily adjustable;

(ii) a comparator can switch on and off much faster than a transistor;

(iii) the comparator inputs draw a very small current from the input section and has a very high input impedance. It is a very good buffer.

(iv) it is easier to design circuits using a comparator, since the choice of resistors and potentiometers used in the input section of comparators is not as crucial as with transistors.

INVESTIGATION



Set up the following system using system boards such as Alpha, E&L, Omega etc. (The numbers on the diagram refer to Alpha)

Adjust the variable resistor dial on the light sensing unit until it is in its mid-position with the arrow pointing upwards. Adjust the potentiometer dial on the comparator board so that it is turned fully clockwise.

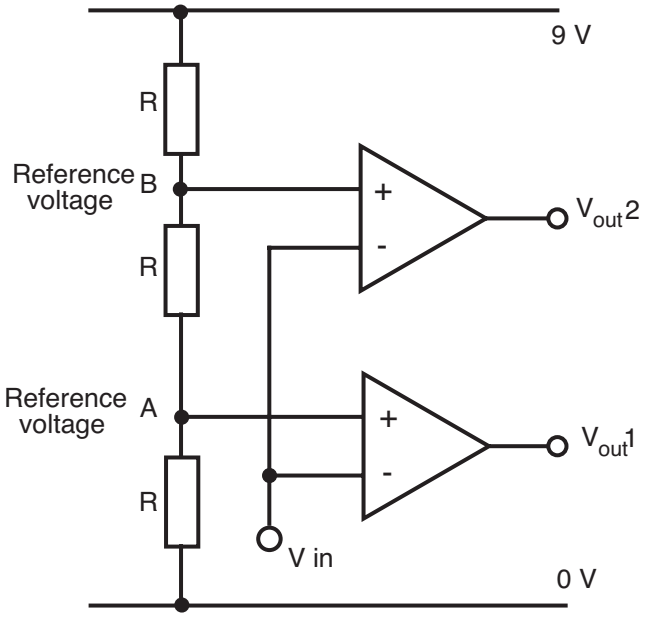
With the LDR uncovered slowly turn the dial on the comparator board anti clockwise until the buzzer just comes on.

Check the sensitivity of the system by placing your hand over the LDR from different distances.

ADDING MORE COMPARATORS

Several comparators may be interconnected to indicate a number of levels of input condition.

The circuit diagram below shows two comparators along with a potential divider consisting of three equal resistors.



From Study File 1 you should realise that if 3 equal resistors are connected across a 9V supply voltage then the voltage drop across each of the resistors will be equal and have a value of 3V. Therefore in the above diagram the reference voltage at point A will be at 3V and point B will be at 6V.

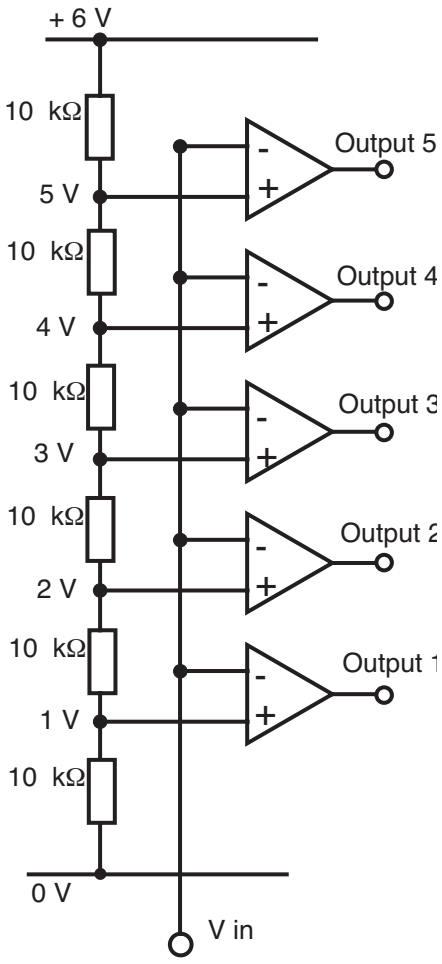
If V_{in} is slowly increased from zero then:-
when V_{in} is less than 3V both V_{out} 1 and V_{out} 2 will be high

When V_{in} is greater than 3V but less than 6V V_{out} 1 will be low and V_{out}2 will be high.

When Vin is greater than 6V both V_{out} 1 and V_{out} 2 will be low.

You can see that two comparators can indicate three different output states.

This idea can be extended to any number of comparators. A circuit showing how 5 comparators can be interconnected to indicate 6 different output states is show below



Complete the following table for the comparator circuit given on the previous page.

V_{in}	$V_{out}1$	$V_{out}2$	$V_{out}3$	$V_{out}4$	$V_{out}5$
Less than 1V	HIGH				
1V - 2V					
2V - 3V					
3V - 4V					
4V - 5V					
more than 5V					