

FACTFILE: GCE TECHNOLOGY & DESIGN

1.17 ELECTRONIC SYSTEMS: PART 2



The Comparator

Learning Outcomes:

Students should be able to:

- demonstrate knowledge and understanding of the following system:
 - comparator
 - incorporate these devices into applications to meet specified criteria;

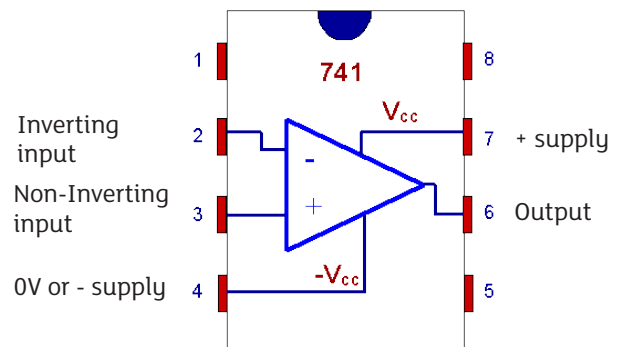
Course Content

The Comparator

An operational amplifier (op-amp) is an integrated circuit which may be configured to carry out a very wide range of functions. By making appropriate connections it is possible to configure it as a comparator. This is the only configuration required at AS level. The purpose of a comparator is to compare 2 analogue voltages and give a digital output to indicate which input voltage is the greater.

Connections

An operational amplifier is usually manufactured in an 8 pin Dual-in-line (DIL) package. For it to behave as a comparator, a minimum of 5 connections is required.

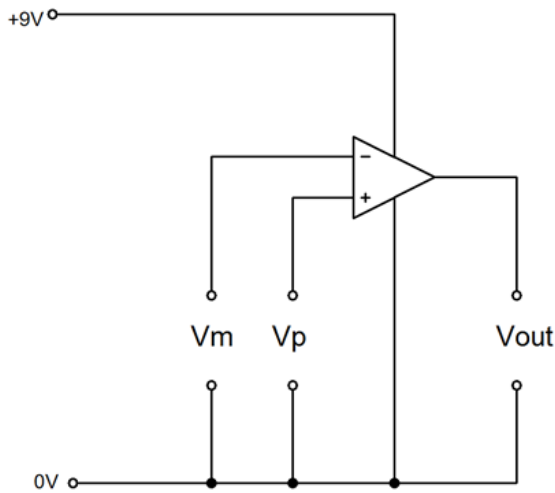


Source: <http://www.facstaff.bucknell.edu/mastascu/eLessonsHTML/Miscellaneous/Pinout741.html>

Pin	Function
2	Inverting input
3	Non-inverting input,
4	0V or - supply
6	Output
7	+ supply

Note that the comparator has 2 inputs, known as the Inverting and Non-inverting inputs. Let us call the voltage applied to the Inverting input V_m and the voltage applied to the Non-inverting input V_p . The op-amp works by amplifying the difference between its input voltages, $(V_p - V_m)$. When connected as a comparator, the gain or amplification of the operational amplifier is very large indeed.

Note that the supply connected to pin 4 can be 0V as in most circuits or can be -supply. This means that some comparator circuits have effectively three supply connections, +supply, 0V and -supply. This is a special power supply arrangement which applies only to op-amp comparators. See diagram below - alternative power supply configurations.



There are 2 possibilities:

Vp > Vm

This means that if Vp is greater than Vm by more than a few microVolts, the very large gain will amplify (Vp - Vm) to a voltage which would exceed the power supply voltage. This is sufficient to saturate the device, so that the output voltage equals Vsat+, a voltage level which is close to the +ve supply voltage. For calculation purposes, it could be assumed that the output voltage Vsat+ equals the + supply voltage.

Vm > Vp

Similarly, if Vm is greater than Vp by more than this amount, then Vout = Vsat-, again due to the large gain a voltage level which is close to the negative supply voltage or 0V. This is why a negative supply voltage has to be provided in some applications. Operational amplifiers are sometimes used with a dual power supply like the one shown. For calculation purposes, it could be assumed that the output voltage Vsat- equals the negative supply voltage or 0V.

This gives a precise method of comparing two voltages. In practice it is not possible for Vp to equal Vm, so there are only two possible output

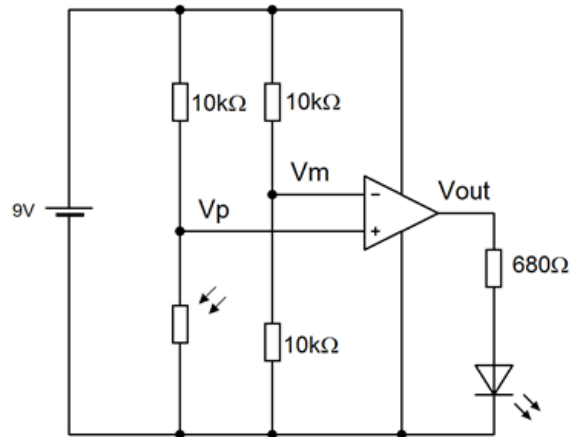
states. Hence the output of a comparator is digital – high or low.

Summary

If Vp > Vm Vout = Vsat+
 If Vm > Vp Vout = Vsat-

Worked Example

Explain the operation of the following circuit.



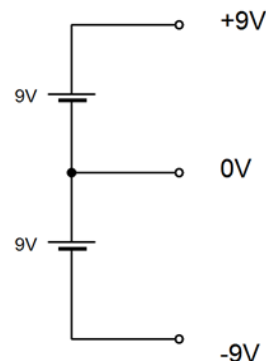
The circuit shows an example of the use of a comparator.

The inverting input is connected to a voltage divider which fixes Vm at +4.5 V.

The non-inverting input is connected to a voltage divider incorporating an LDR. The resistance of the LDR and hence this voltage will increase as it gets darker. When Vp > Vm, i.e. if Vp > 4.5 V the output voltage will be high and the LED will switch on. When Vp < 4.5V the output voltage will be low and the LED will switch off.

This circuit switches on an LED when it gets dark.

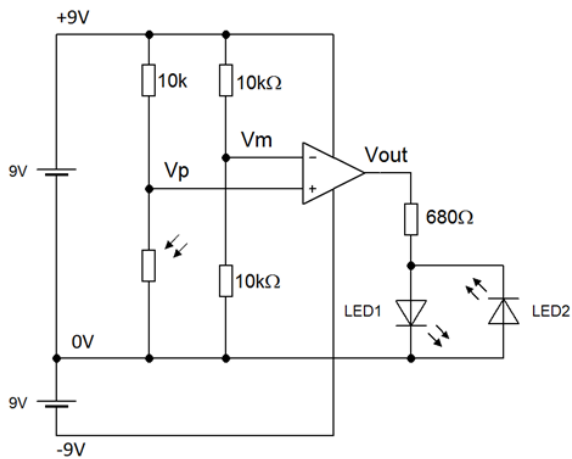
Alternative Power Supply Configurations



Worked Example

Design a circuit using an operational amplifier that will light an LED when it is dark and a different LED when it is light.

If the operational amplifier power supply connections are connected to the +9 V and -9 V battery connections, then the output voltage may either be V_{sat+} (+9 V) or V_{sat-} (-9 V).



In this circuit:

If $V_p > V_m$, $V_{out} = V_{sat+}$ and LED1 will light

If $V_m > V_p$, $V_{out} = V_{sat-}$ and LED2 will light

Revision Questions

1 Figure 1 shows part of a light sensing circuit.

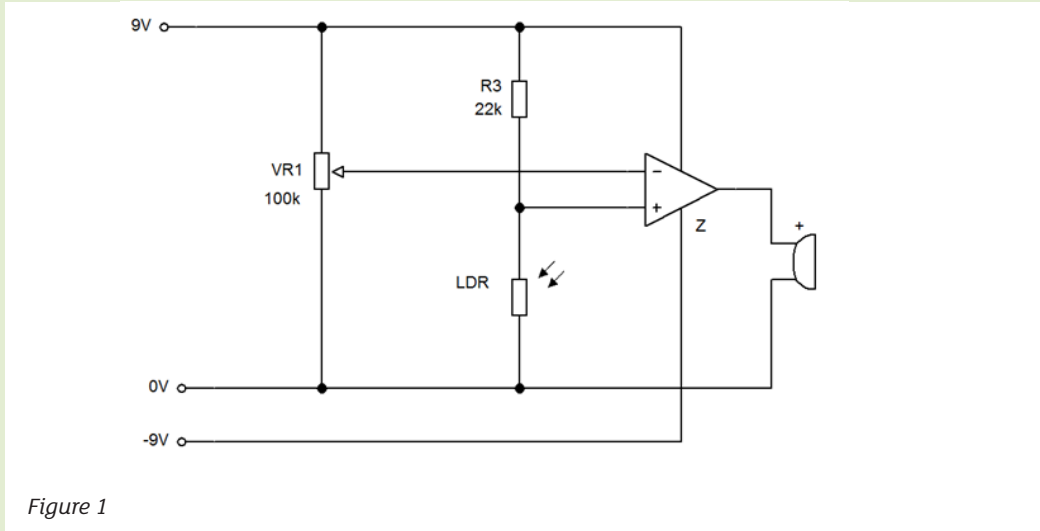


Figure 1

(i) Calculate the voltage at the Inverting input when the variable resistor VR1 on Figure 1 is adjusted to its mid position.

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(ii) Explain the function of component Z in the circuit shown in Figure 1.

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(iii) State whether the buzzer in Figure 1 will be turned on or off when the light level is high and justify your answer. Assume VR1 is adjusted to its mid position.

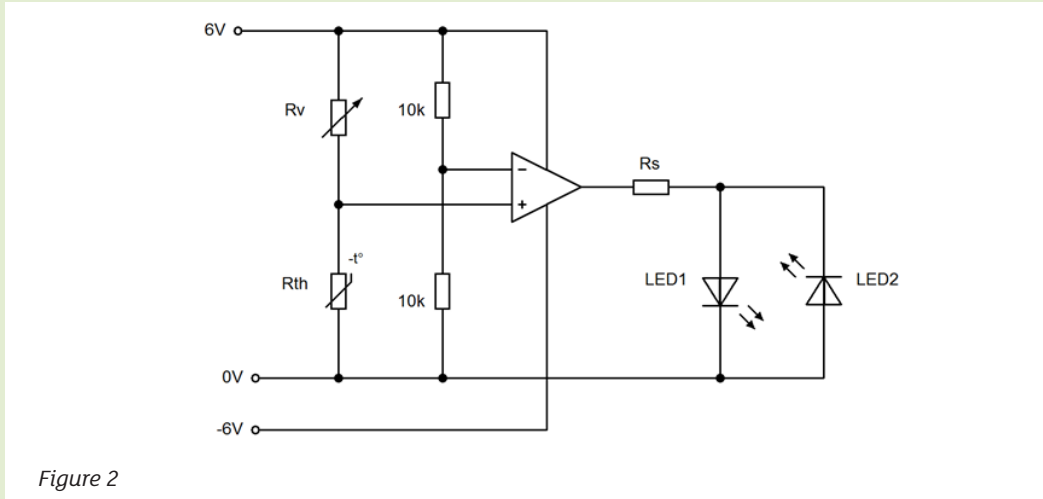
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Source: CCEA AS May 2009 Q10

? Revision Questions

2 Figure 2 shows a comparator circuit which is to be used as a frost warning system for a greenhouse.



(i) Name component Rv and state its function in the circuit shown in Figure 2.

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(ii) With reference to both hot and cold input conditions, describe the operation of the circuit shown in Figure 2.

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Source: CCEA AS June 2010 Q10

? Revision Questions

- 3 A voltage divider is to be used in conjunction with a comparator to make a circuit for a nightlight that will automatically switch on an LED when it is dark. Draw a labelled circuit diagram for the nightlight. The circuit should include a means whereby the level of light required to switch on the LED can be adjusted.

Source: CCEA AS June 2011 Q9

