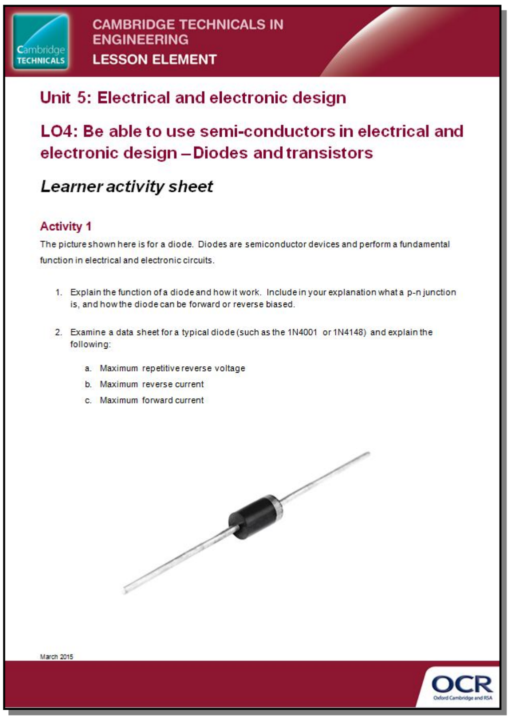
Unit 5: Electrical and electronic design

LO4: Be able to use semi-conductors in electrical and electronic design – Diodes and transistors

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Be able to use semi-conductors in electrical and electronic design – Diodes and transistors' *activity which supports Cambridge Technicals in Engineering Level 3.*


CAMBRIDGE TECHNICALS IN ENGINEERING
LESSON ELEMENT

Unit 5: Electrical and electronic design

LO4: Be able to use semi-conductors in electrical and electronic design – Diodes and transistors

Learner activity sheet

Activity 1

The picture shown here is for a diode. Diodes are semiconductor devices and perform a fundamental function in electrical and electronic circuits.

1. Explain the function of a diode and how it work. Include in your explanation what a p-n junction is, and how the diode can be forward or reverse biased.
2. Examine a data sheet for a typical diode (such as the 1N4001 or 1N4148) and explain the following:
   a. Maximum repetitive reverse voltage
   b. Maximum reverse current
   c. Maximum forward current

March 2015

The Activity:

In this task the students are tasked with familiarising themselves with diodes and transistors.

This activity offers an opportunity for English skills development.

This activity offers an opportunity for maths skills development.

Suggested timings:

1 hour

Activity 1

Learners could use the internet to research how a diode works. Alternatively, they might use reference texts. Only a simple explanation is required. Learners could use diagrams. Presentation of findings could be in the form of a poster.

1. A diode is a semiconductor device. It is made of material with varying ability to conduct electricity (e.g. it is not a conductor or an insulator).

   It consists of two materials – one termed p-type and the other n-type. There is a junction between the materials (the p-n junction).

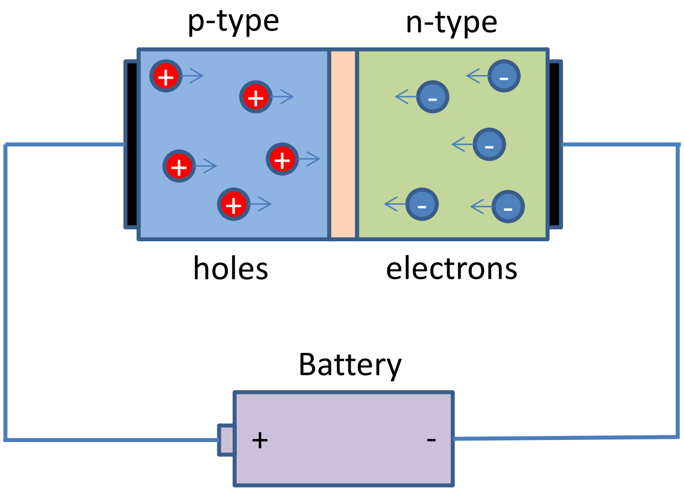
   The n-type material has extra electrons that are free to move as it is positively charged.

   The p-type material has extra holes as it is negatively charged. Free electrons can jump from hole to hole.

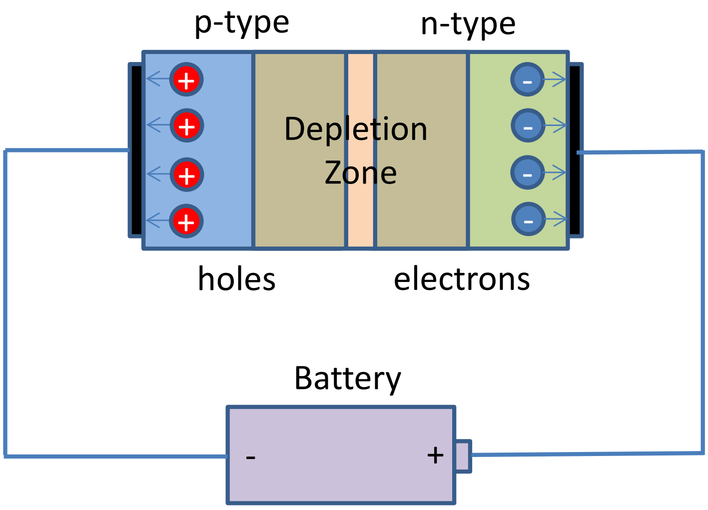
   The diode consists of n and p type material bonded to each other (the p-n junction) with a contact electrode at each end.

   When no voltage is applied to the diode, free electrons from the p-type material fill all the holes in the n-type material. The area in which all the holes are filled at the junction is called the depletion layer. This section now acts as an insulator.

   If a voltage is applied to the diode (p-type end positive and n-type end negative) positive electrons now move away from the p-type electrode and negative holes from the n-type electrode. The diode is now **forward biased** and the diode conducts.



If a voltage is applied to the diode (n-type end positive and p-type end negative) positive electrons now move towards the p-type electrode and negative holes towards the n-type electrode. The diode is now **reverse biased** and the diode blocks the flow of current.



So – the diode conducts current in one direction and blocks the flow of current in the other direction. The positive terminal (p-type end) of the diode is called the **anode** and the negative terminal (n-type end) the **cathode**.

2. Learners could investigate datasheets for real diodes – investigating the following key terms. Datasheets are available freely online at the following website: http://www.datasheetcatalog.com/

Maximum repetitive reverse voltage	The maximum amount of voltage the diode can withstand in reverse-bias mode.
Maximum reverse current	The amount of current through the diode in reverse-bias operation. It is sometimes referred to as the leakage current.
Maximum forward current	The maximum average amount of current the diode is able to conduct in forward bias mode.

Learners could investigate further characteristics of commercial diodes using datasheets.

Activity 2

1. The circuit diagram for a typical transistor switch circuit is shown below.

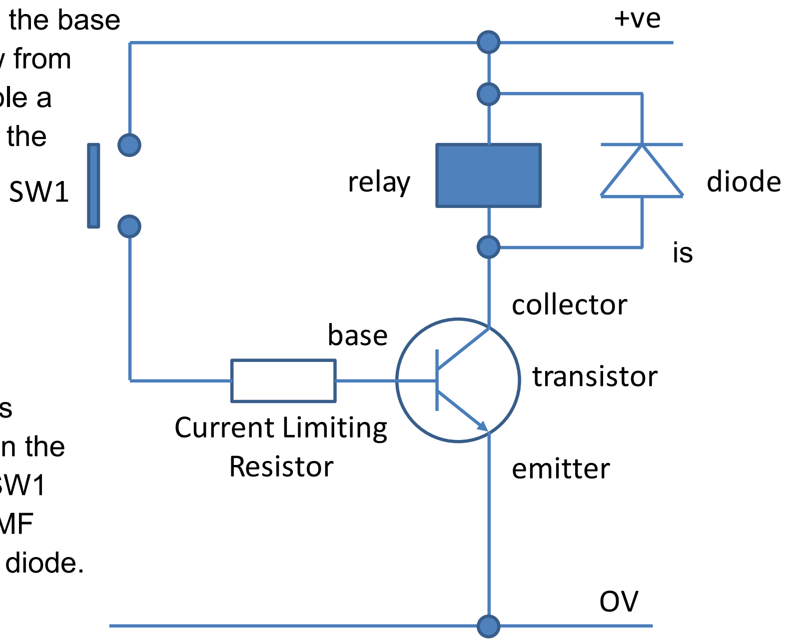
   Learners may be able to build and test a physical circuit, or undertake a circuit simulation to investigate how the circuit works.

   With no connection to the transistor base terminal, there is no current flowing into the base. The transistor will be 'off' with no current following from collector to emitter – and the relay is not energised.

   When SW1 is closed a voltage is applied to the base terminal of the transistor. A current will flow from emitter to base. This base current will enable a much larger flow of electrons (current) from the emitter to collector.

   The relay will now energise. The transistor is said to be in a saturated state.

   The function of the diode in the circuit is to protect the transistor as a large back-EMF is generated by the collapsing magnetic field in the relay when the transistor is turned off (i.e. SW1 opened). This diode dissipates the back-EMF and is often termed a flywheel or freewheel diode.



2. The circuit diagram for a typical common emitter single transistor amplifier is shown below. This is termed a class-A amplifier.

   Unlike the transistor switch circuit, an alternating input signal is applied to the base terminal of the transistor. The transistor does not saturate but operates in an unsaturated mode.

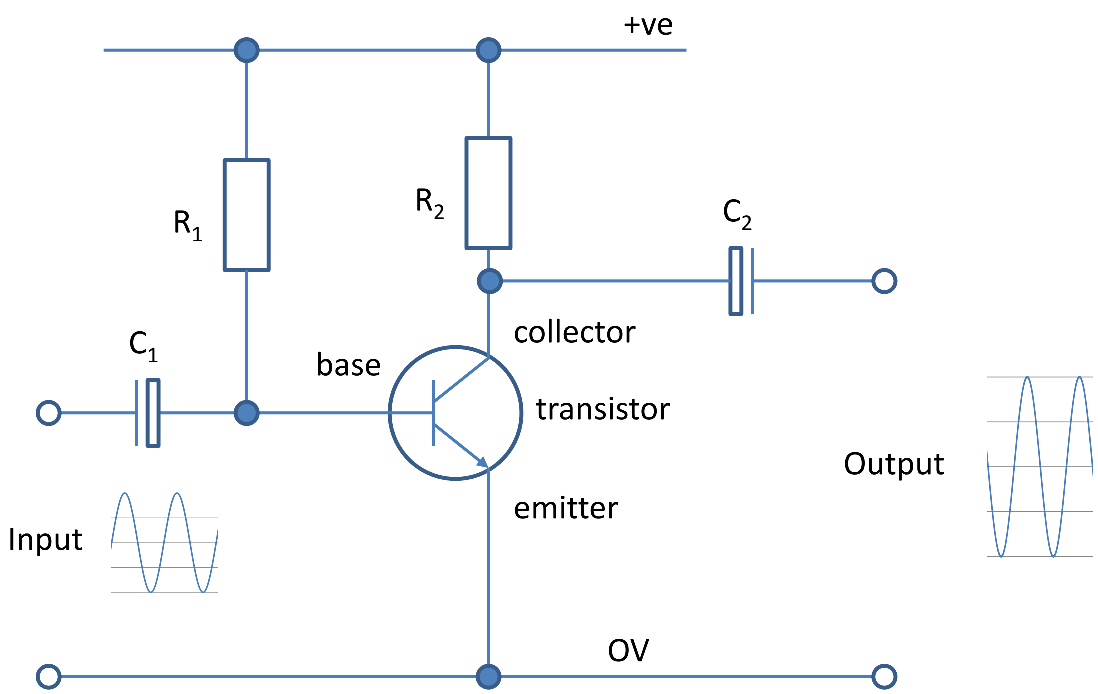
   Again, this will cause a corresponding (larger) current to flow from emitter to collector.

   R_1 is termed a bias resistor, and holds the base at a certain voltage. The input signal causes the base voltage to rise and fall above and below this bias voltage.

   R_2 is the collector load resistor, and provides a voltage output point with voltage corresponding to current flowing in the resistor (from Ohm's Law).

   C_1 and C_2 are termed coupling capacitors, and allow AC to pass through them (alternating voltage) but no DC voltage.

   In summary – a small alternating voltage at the input terminals to the amplifier will case a larger (amplified) alternating voltage at the output terminals.



3. Learners could investigate datasheets for real transistors – investigating the following key terms. Datasheets are available freely online at the following website: http://www.datasheetcatalog.com/

Maximum collect current (I_c max)	The maximum allowable collector current.
Maximum voltage collector-emitter (V_{CE} max)	The maximum voltage that can be applied to the collector-emitter.
Total power (P_{TOT} max)	The maximum amount of power the transistor can dissipate without being damaged.
Gain (h_{FE} typical)	The gain is the current 'amplification ratio' for the transistor. This specifies the amount of collector current that flows for a given base current. It is the ratio of collector current to base current.

Learners could investigate further characteristics of commercial transistors using datasheets.