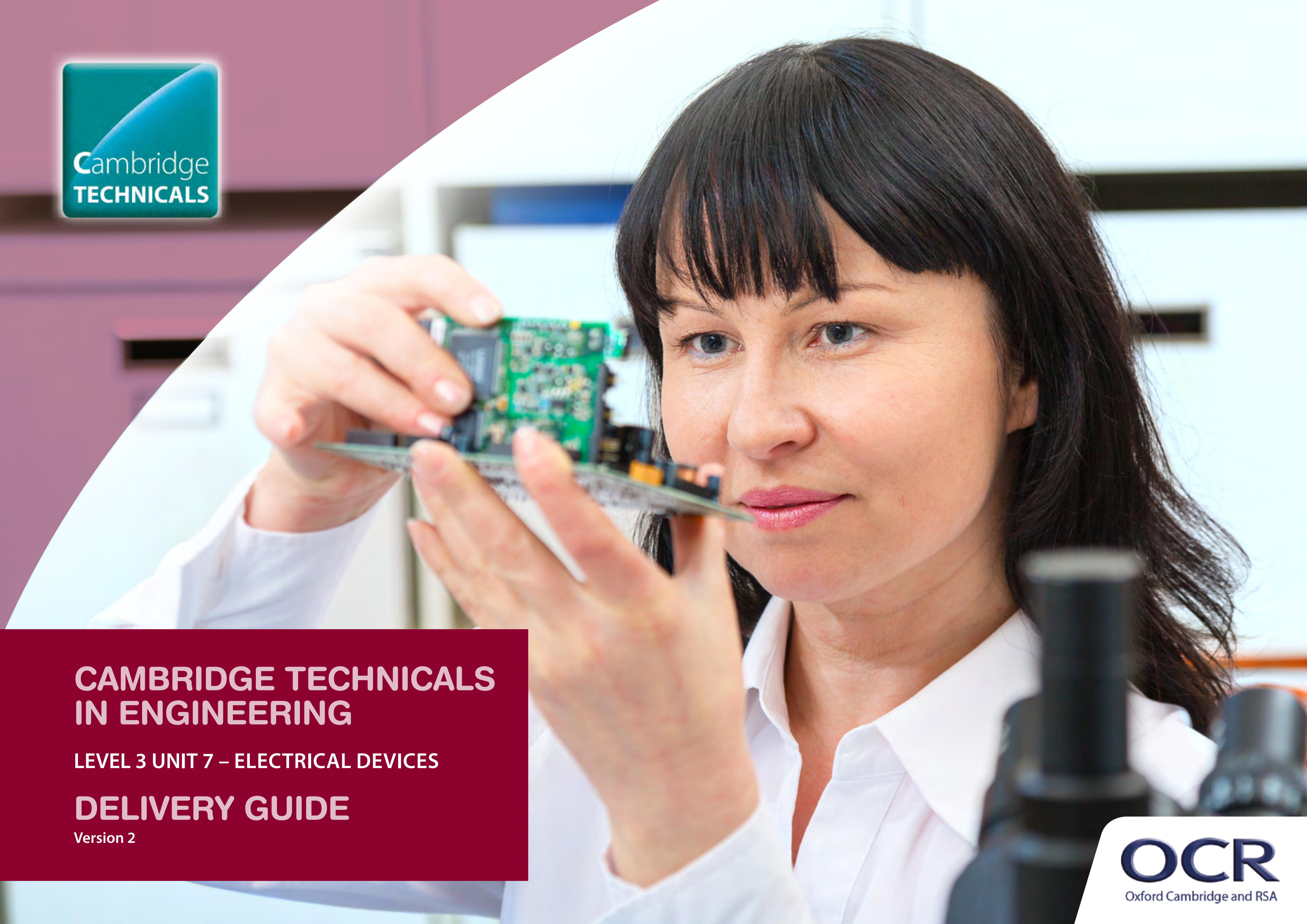

Cambridge TECHNICALS

CAMBRIDGE TECHNICALS IN ENGINEERING

LEVEL 3 UNIT 7 – ELECTRICAL DEVICES

DELIVERY GUIDE

Version 2

OCR
Oxford Cambridge and RSA

CONTENTS

INTRODUCTION

This Delivery Guide has been developed to provide practitioners with a variety of creative and practical ideas to support the delivery of this qualification. The Guide is a collection of lesson ideas with associated activities, which you may find helpful as you plan your lessons.

OCR has collaborated with current practitioners to ensure that the ideas put forward in this Delivery Guide are practical, realistic and dynamic. The Guide is structured by learning outcome so you can see how each activity helps you cover the requirements of this unit.

We appreciate that practitioners are knowledgeable in relation to what works for them and their learners. Therefore, the resources we have produced should not restrict or impact on practitioners' creativity to deliver excellent learning opportunities.

Whether you are an experienced practitioner or new to the sector, we hope you find something in this guide which will help you to deliver excellent learning opportunities.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resourcesfeedback@ocr.org.uk.

Unit aim

Electrical devices in engineering companies are used for many purposes, from sensors and actuators used in robotic manufacture to programmable logic controllers (PLCs) which can control automated assembly lines.

The aim of this unit is for learners to develop knowledge and understanding of electrical devices including semi-conductor and programmable devices and sensors and actuators. They will also develop an understanding of their applications within electrical and electronic engineering companies.

Learners will also develop understanding of signal conditioning techniques and signal conversion devices, and on the use of smart and modern materials in electrical devices.

Unit 7 Electrical devices	
LO1	Understand semiconductor and programmable devices
LO2	Understand electrical sensors and actuators
LO3	Understand how to use signal conditioning techniques and signal conversion devices
LO4	Understand the application of smart and modern materials in electrical devices

Opportunities for English and maths skills development

We believe that being able to make good progress in English and maths is essential to learners in both of these contexts and on a range of learning programmes. To help you enable your learners to progress in these subjects, we have signposted opportunities for English and maths skills practice within this resource. These suggestions are for guidance only. They are not designed to replace your own subject knowledge and expertise in deciding what is most appropriate for your learners.

English

Maths

Please note

The timings for the suggested activities in this Delivery Guide **DO NOT** relate to the Guided Learning Hours (GLHs) for each unit.

Assessment guidance can be found within the Unit document available from www.ocr.org.uk.

The latest version of this Delivery Guide can be downloaded from the OCR website.

RELATED ACTIVITIES

The Suggested Activities in this Delivery Guide listed below have also been related to other Cambridge Technicals in Engineering units/Learning Outcomes (LOs). This could help with delivery planning and enable learners to cover multiple parts of units.

This unit (Unit 7)	Title of suggested activity	Other units/LOs	
LO1	Thyristors	Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
	MOSFETS	Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
	IGBTs	Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
	Programmable devices – PLA, PAL and FPGA	Unit 4 Principles of electrical and electronic engineering	LO6 Understand digital electronics
	Programmable devices – SRAM, EPROM and flash memory	Unit 4 Principles of electrical and electronic engineering	LO6 Understand digital electronics
	Internal architecture – microprocessor, microcontroller and PIC	Unit 4 Principles of electrical and electronic engineering	LO6 Understand digital electronics
	Internal architecture – programmable logic controllers	Unit 4 Principles of electrical and electronic engineering	LO6 Understand digital electronics
LO2	Sensors – light	Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
	Sensors - temperature	Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
	Sensors – force and pressure	Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
	Sensors –position and speed	Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
	Sensors – flow and sound	Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles

This unit (Unit 7)	Title of suggested activity	Other units/LOs	
LO2	Linear and solenoid actuators	Unit 1 Mathematics for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
		Unit 2 Science for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 4 Principles of electrical and electronic engineering	LO6 Be able to apply statistics and probability in the context of engineering problems
	Rotary actuators	Unit 1 Mathematics for engineering	LO4 Be able to use trigonometry in the context of engineering problems
		Unit 2 Science for engineering	LO3 Understand fundamental scientific principles of electrical and electronic engineering
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
		Unit 4 Principles of electrical and electronic engineering	LO3 Understand electric motors and generators
LO3	Sensors and their outputs	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 2 Science for engineering	LO1 Understand applications of SI units and measurement
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
	Sensor calibration and scaling	Unit 1 Mathematics for engineering	LO2 Be able to use geometry and graphs in the context of engineering problems
		Unit 2 Science for engineering	LO1 Understand applications of SI units and measurement
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
	High and low pass active filters	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
		Unit 4 Principles of electrical and electronic engineering	LO5 Understand analogue electronics
	Analogue to digital and digital to analogue conversion	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
		Unit 4 Principles of electrical and electronic engineering	LO6 Understand digital electronics
	Parallel to serial and serial to parallel conversion (including bit and baud rate)	Unit 1 Mathematics for engineering	LO1 Understand the application of algebra relevant to engineering problems
		Unit 4 Principles of electrical and electronic engineering	LO1 Understand fundamental electrical principles
		Unit 4 Principles of electrical and electronic engineering	LO6 Understand digital electronics

KEY TERMS

UNIT 7 – ELECTRICAL DEVICES

Explanations of the key terms used within this unit, in the context of this unit	
Key term	**Explanation**
4-20 mA loop	The 4-20 mA loop is a robust signalling standard in which the sensor alters the current flowing in a circuit. It is more robust than using a sensor with a voltage output, and is suitable for harsh electrical environments.
A to D converter	An Analogue to Digital converter is a device that converts an analogue signal to a digital signal. It is often used to interface a sensor to a digital system, such as one using a microprocessor or microcontroller.
Baud rate	Baud is the unit (unit symbol Bd) for symbol rate, in symbols per second or pulses per second. It is can be the same as bit rate if each symbol is a single bit, or different if each symbol (or data element) is more than one bit. Bit rate and baud rate are often confused.
Bit rate	Bit rate is the number of bits per second that can be transmitted along a digital network. Bit rate and baud rate are often confused.
Bridge circuit	A bridge circuit is a type of electrical circuit, in which two circuit branches (usually in parallel with each other) are 'bridged' by a third branch connected between the first two branches at some intermediate point along them. When used with a sensor, the sensor is usually connected in one branch of the bridge, and the other branches adjusted to 'balance' the output signal from the bridge. It is often termed a Wheatstone bridge.
Calibration	Calibration is a comparison between measurements. Sensor calibration is a method of improving sensor performance by removing errors in the sensor outputs. Errors are differences between a sensor's expected output and its measured output, which show up consistently every time a new measurement is taken.
Conductive polymer	Conductive polymers are polymers that conduct electricity. They are generally difficult to process, so have relatively few applications at present.
D to A converter	A Digital to Analogue converter is a device to convert a digital signal or information to an analogue signal. It is often used to interface a digital system, such as one using a microprocessor or microcontroller, to an actuator.
Electroluminescent material	Electroluminescent materials give out light when an electric current is applied to them. They work on the principle of phosphorescence.
Electrorheological (ER) material	An electrorheological (ER) material (or more commonly a fluid) is a material whose apparent viscosity changes reversibly in response to an electric field.
Electrochromic material	Electrochromic material is a material whose optical properties alter when an electric current is applied. This property enables the ECD to be used for applications like smart-window, electrochromic mirror, and electrochromic display devices.
Electrostrictive material	An electrostrictive material is a material that, when an electric field is applied, will either stretch or shrink. Applications include actuators such as the 'bionic muscle'.
EPROM	EPROM (Erasable Programmable Read Only Memory) is a type of a read-only memory whose contents can be erased by ultraviolet light or other means and reprogrammed using a pulsed voltage. The EPROM will retain its programming with power removed, and so is termed non-volatile.
Flash memory	Flash memory is a type of constantly-powered non-volatile memory that can be erased and reprogrammed in units of memory called blocks. It retains its memory when power is removed.

Explanations of the key terms used within this unit, in the context of this unit	
Key term	**Explanation**
FPGA	A field-programmable gate array (FPGA) is an integrated circuit designed to be configured by a customer or a designer after manufacturing – hence "field-programmable".
High-pass filter	A high-pass filter is an electronic filter that passes signals with a frequency higher than a certain cut-off frequency and attenuates signals with frequencies lower than the cut-off frequency. It can be built using operational amplifiers – when it is termed an active filter.
IGBT	The insulated-gate bipolar transistor (IGBT) is a three terminal power semiconductor device primarily used as an electronic switch. It is used in high efficiency and fast switching applications.
Linear actuator	A linear actuator is an actuator that creates motion in a straight line, in contrast to the circular motion of a conventional electric motor.
Low-pass filter	A low-pass filter is a filter that passes signals with a frequency lower than a certain cut-off frequency and attenuates signals with frequencies higher than the cut-off frequency. It can be built using operational amplifiers – when it is termed an active filter.
LVDT	The linear variable differential transformer (LVDT) is a type of electrical transformer used for measuring linear displacement (position).
Microcontroller	A single chip that contains: the microprocessor (the CPU), non-volatile memory for the program (ROM or flash), volatile memory for input and output (RAM), a clock and an I/O control unit. Also called a 'computer on a chip', microcontroller units (MCUs) are embedded in products from toys to domestic appliances to automobiles.
Microphone	A microphone is an instrument whereby sound waves are caused to generate or modulate an electric current usually for the purpose of transmitting or recording sound (as speech or music).
Microprocessor	The microprocessor is a multipurpose, programmable device that accepts digital data as input, processes it according to instructions stored in its memory, and provides results as output. Unlike a microcontroller, it does not contain other functions such as memory or I/O control.
MOSFET	A MOSFET (metal oxide semiconductor field-effect transistor) is a three terminal semiconductor device commonly used as a switch. It has a thin layer of silicon oxide between the gate and the channel.
Optical encoder	An optical encoder is an angular position sensor. It has a shaft mechanically coupled to an input driver which rotates a disc rigidly fixed to it. A succession of opaque and clear segments is marked on the surface of the disc. These are detected using a optical sensor.
PAL	Programmable array logic (PAL) is a family of programmable logic device semiconductors used to implement logic functions in digital circuits.
Parallel to serial converter	A parallel to serial converter is a circuit or device to convert a serial digital signal into a parallel set of digital information.
Photodiode	A photodiode is a semiconductor diode which, when exposed to light, generates a potential difference or changes its electrical resistance.
Phototransistor	A phototransistor is a transistor that responds to light striking it by generating and amplifying an electric current.
PIC	PIC microcontrollers (programmable interface controller) are a family of trademarked specialised microcontroller chips produced by Microchip Technology in Chandler, Arizona. They are a form of microcontroller.

Explanations of the key terms used within this unit, in the context of this unit	
Key term	**Explanation**
Piezoelectric material	Piezoelectric materials are materials that exhibit the piezoelectric effect when mechanically stressed. This means that they can generate a voltage which is generally proportional to the stress applied to material. They can also work in reverse, generating a signal when a voltage is applied to them. Sensor applications include accelerometers and force transducers.
PLA	Programmable Logic Array (PLA) is a kind of programmable logic device used to implement combinational logic circuits. The PLA has a set of programmable AND gate planes, which link to a set of programmable OR gate planes, which can then be conditionally complemented to produce an output.
PLC	A Programmable Logic Controller (PLC) is an industrial computer control system that continuously monitors the state of input devices and makes decisions based upon a custom program to control the state of output devices.
PLD	A Programmable Logic Device (PLD) is an electronic component used to build reconfigurable digital circuits. Unlike a logic gate, which has a fixed function, a PLD has an undefined function at the time of manufacture. Before the PLD can be used in a circuit it must be programmed, that is, reconfigured.
Potential divider	A potential divider consists of two or more resistors connected in series, which are used to scale a voltage signal.
QTC	A Quantum Tunnelling Composite (QTC) is a flexible polymer which contains tiny metal particles. It is normally an insulator but if it is squeezed it becomes a conductor.
R-2R ladder	A method for D to A conversion which employs a ladder-shaped resistor array composed of two resistor values: R and 2R.
Rotary actuator	A rotary actuator is an actuator that produces a rotary motion or torque.
Scaling	Scaling (for a sensor) means increasing, reducing or altering its output signal in order to match the signal or signal range required by the electronic circuit it is connected to.
Serial to parallel converter	A serial to parallel converter is a circuit or device to convert a parallel set of digital information (1s and 0s) into a serial digital data stream.
Servo motor	A servo motor is a rotary actuator that allows for precise control of angular position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback.
Shift register	A shift register is a series combination of digital storage devices, such as flip flops, which allow the bits of its stored content to be moved left or right. It is often used to convert a parallel set of digital information into a serial data stream, and vice versa.
SMA	Shape memory alloy (SMA) is an alloy that can be bent out of shape, but will return to its original shape once heated above a certain temperature. The material can be heated by passing an electric current through it.
Solenoid	A solenoid is a type of electromagnetic actuator that converts an electrical signal into a magnetic field. This is in turn converted into mechanical energy in a straight line (i.e. a linear actuator)
SRAM	Static random access memory (SRAM or static RAM) is a type of semiconductor memory that uses bi-stable latching circuitry to store each bit. Information will be lost once power is removed, and so the memory is termed volatile.

Explanations of the key terms used within this unit, in the context of this unit	
Key term	**Explanation**
Strain gauge / Load Cell	A strain gauge is a sensor whose resistance varies with applied force. A load cell is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured.
Tachogenerator	A tachogenerator is a form of DC motor used to measure speed. Output voltage of the tachogenerator is roughly proportional to shaft speed.
Thermistor	A thermistor is an electrical resistor whose resistance changes by heating, used for measurement and control. Resistance may be a positive or negative change.
Thermocouple	A thermocouple is a thermoelectric device for measuring temperature, consisting of two wires of different metals connected at two points, a voltage being developed between the two junctions in proportion to the temperature difference.
Thermoelectric material	A thermoelectric material is a material whose properties (sometimes electrical properties) change when subjected to a rise or fall in temperature.
Thyristor	A thyristor is a three terminal semiconductor device commonly used as a switch in DC and AC circuits.
Vane-controlled potentiometer	A vane-controlled potentiometer is commonly used to measure mass (air) flow. It consists of a spring-loaded air flap/door attached to a variable resistor (potentiometer).

MISCONCEPTIONS/AREAS OF DIFFICULTY

Some common misconceptions and guidance on how they could be overcome		
What is the misconception/area of difficulty?	**How can this be overcome?**	**Resources which could help**
Understanding of the operation of thyristor, MOSFET and IGBT	Learners often have difficulty in understanding the operation of semiconductor devices. Practical experiments using physical devices in simple switching circuits may be a way to overcome this.	Practical experiments
Operation of servo control systems	Rotary actuators often work on the principle of servo motor control (e.g. a motor having some form of feedback).	Practical experiments http://electrical4u.com/servo-motor-servo-mechanism-theory-and-working-principle/
Operation of analogue to digital (A to D) and digital to analogue (D to A) converters	Practical experiments (using simple model remote control servos) may be a way in which to improve understanding.	http://www.allaboutcircuits.com/vol_4/chpt_13/1.html http://www.youtube.com/watch?v=wIKNRzjMZcs
Operation of parallel to serial and serial to parallel converters	The operation of simple A to D and D to A converters might be explained using the R-2R ladder principles. Learners could build (or simulate) and test the operation of the R-2R ladder.	http://www.allaboutcircuits.com/vol_4/chpt_12/1.html
Difference between bit and baud rate	Learners often confuse the terms bit rate and baud rate. This online article explains the difference between bit and baud rate. Learners could practice solving problems where both are identical, and non-identical.	http://www.circuitstoday.com/bit-rate-vs-baud-rate-the-common-misconception

SUGGESTED ACTIVITIES

LO No:	1		
LO Title:	**Understand semiconductor and programmable devices**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Thyristors	Thyristors are semiconductor devices that commonly function as switches. They are often used in both DC and AC circuits. Teachers could begin by explaining the basic operation of the thyristor. Web-based resources may be useful – with the following explaining the basic function and application of the thyristor: https://en.wikipedia.org/wiki/Thyristor http://www.explainthatstuff.com/how-thyristors-work.html Learners could explore operation in further detail, including applications (see http://www.electronics-tutorials.ws/power/thyristor.html) It may be possible to construct a physical circuit using a single thyristor, or to perform a circuit simulation in order to reinforce understanding.	2 hours	Unit 2, LO3 Unit 4, LO1
MOSFETS	MOSFETs (metal–oxide–semiconductor field-effect transistors) are another form of semiconductor device used as a switch. They are controlled by a voltage being applied to their gate terminal. Web resources, such as the following video, may prove a useful introduction to the MOSFET (http://www.youtube.com/watch?v=Te5YYVZiOKs) Learners could investigate the operation and application of the MOSFET in detail (see http://www.electronics-tutorials.ws/transistor/tran_6.html). Again, it may be possible for learners to construct or simulate the operation of a MOSFET in a circuit. Learners might also investigate parameters of MOSFETs using manufacturer data sheets. See Lesson Element MOSFETS (metal–oxide–semiconductor field-effect transistors).	2 hours	Unit 2, LO3 Unit 4, LO1
IGBTs	The Insulated Gate Bipolar Transistor (IGBT) is another form of semiconductor devices typically used as a switch in high-power applications such as inverter drives. It is a voltage controlled device. Learners could investigate the function, operation and applications of the IGBT in further detail, including its application in a simple single IGBT switch circuit (see http://www.electronics-tutorials.ws/power/insulated-gate-bipolar-transistor.html) Learners might also build a simple single IGBT switching circuit and test operation.	2 hours	Unit 2, LO3 Unit 4, LO1
Programmable devices – PLA, PAL and FPGA	Programmable logic devices (PLDs) are semiconductor devices that can be designed or programmed to perform combinational logic functions. They include the programmable logic array (PLA), programmable array logic (PAL) and the field programmable gate array (FPGA). Learners could investigate the operation and application of PLDs. Web resources could prove useful with the following giving a good introduction to PLDs - http://www.instructables.com/id/A-Beginners-Guide-to-Programmable-Logic-Devices/ Learners could compare the features and benefits of a range of devices, and present their findings as a poster.	2 hours	Unit 4, LO6

Title of suggested activity	Suggested activities	Suggested timings	Also related to
Programmable devices – SRAM, EPROM and flash memory	Static Random Access Memory (SRAM) is commonly found in modern computers. It is a form of volatile memory used to store information. Electrically Programmable Read Only Memory (EPROM) devices are devices that, once programmed, retain their computer code (i.e. non-volatile). Flash memory is another form of non-volatile programmable memory that will retain information once power is removed. Learners could investigate SRAM, EPROM and Flash memory – comparing their function, operation and application. Web resources may again prove useful e.g. SRAM (http://www.eeherald.com/section/design-guide/esmod15.html), EPROM (http://www.youtube.com/watch?v=uKk7fVIZPE4), and Flash memory (http://www.explainthatstuff.com/flashmemory.html) Learners could present a comparison as a presentation.	2 hours	Unit 4, LO6
Internal architecture – microprocessor, microcontroller and PIC	Teachers might begin with the following video which shows the history of the microcontroller, and how it has developed from the microprocessor (http://www.youtube.com/watch?v=CmvUY4S0UbI) Learners might then be tasked to investigate the developments in the internal architecture of the microprocessor, microcontroller and programmable interface controller (PIC). The PIC is another form of microcontroller. Learners could also focus on the differences in typical system configurations using these devices (e.g. input ports, output ports and peripheral devices such as memory). Web-based resources including manufacturer data sheets could be used e.g. http://www.electronicshub.org/difference-between-microprocessor-and-microcontroller/	3 hours	Unit 4, LO6
Internal architecture – programmable logic controllers	The Programmable Logic Controller (PLC) is a form of computer typically used in industrial applications, or applications where a robust device is required. The PLC uses a microcontroller to process information. Learners could investigate the internal architecture and peripheral configuration for a typical PLC. The following shows the internal architecture including peripherals (e.g. input and output ports) for a PLC - http://www.ti.com/solution/programmable-logic-controller-diagram	2 hours	Unit 4, LO6

SUGGESTED ACTIVITIES

LO No:	**2**		
LO Title:	**Understand electrical sensors and actuators**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Sensors – light	Sensors form an important part of many electronic circuits and systems that are required to measure (and often control) physical quantities. Sensors that can measure light include the photo-diode and phototransistor. Other types of sensor include the light-dependent resistor (LDR). Learners could be tasked to instigate the operation of a range of light sensors, and to suggest applications. The following explains how the phototransistor operates - http://www.radio-electronics.com/info/data/semicond/phototransistor/photo-transistor-circuits-symbols.php It may be possible for learners to construct and test circuits using physical devices, or to perform a circuit simulation using software. Manufacturer data sheets could also prove useful. Learners could undertake a comparison between electronic devices that measure light.	3 hours	Unit 2, LO3 Unit 4, LO1
Sensors - temperature	Temperature can be measured with devices such as the thermistor and thermocouple. Teachers could develop an experiment for learners to perform, in order to measure the characteristics of a thermistor. Learners could compare their findings against manufacturer data, presenting their findings in the form of a short laboratory report. This comparison of results may prove an opportunity to plot calibration graphs using ICT. The following explains the thermistor in detail - http://www.technologystudent.com/elec1/therm1.htm Further devices such as the thermocouple might also be investigated. See Lesson Element Sensors – temperature – the thermistor.	3 hours	Unit 2, LO3 Unit 4, LO1
Sensors – force and pressure	Force and pressure can be measured with devices such as the strain gauge, and load cell. Learners could explore devices in detail such as the strain gauge (http://www.ni.com/white-paper/3642/en/). It may be possible for learners to experiment with using physical devices to measure pressure (or strain) in a simple component or beam loaded with a force.	2 hours	Unit 2, LO3 Unit 4, LO1

Sensors – position and speed	Position sensors include devices such as the optical encoder, linear variable differential transformer and hall effect sensor. Speed can be measured using a tachogenerator, optical encoder and Doppler effect sensor. Learners could investigate the operation of a range of position and speed sensors, comparing their advantages,disadvantages and applications. The following explains the LVDT (http://www.macrosensors.com/lvdt_tutorial.html) and the tachogenerator (http://www.tachogeneratorsguide.com/whatis.html) It might be possible for learners to experiment with some physical devices to investigate their characteristics and forms of sensor output. Learners could present their comparison in the form of a poster.	3 hours	Unit 2, LO3 Unit 4, LO1
Sensors – flow and sound	Flow rate can be measured using a vane controlled potentiometer) and sound using a microphone. Learners could investigate how flow can be measured using different types of sensor (see http://www.engineershandbook.com/Components/flowratesensors.htm) and how sound can be measured using different types of microphone (see http://www.youtube.com/watch?v=kwE9lXbs3Rg). Learners could perform an experiment using a microphone and an oscilloscope to investigate the typical waveform generated by someone speaking.	2 hours	Unit 2, LO3 Unit 4, LO1
Linear and solenoid actuators	Actuators work in conjunction with sensors in an electronic control system in order to be able to control some aspect of the system. Linear actuators are available in many forms such as ones controlled by a motor (e.g. using a DC motor or servo motor) or by a solenoid. Learners could begin by exploring a range of commercially available electric linear actuators (e.g. http://www.techdrives.co.uk/linear_actuators.html) and how the solenoid works to provide linear motion (e.g. http://www.electronics-tutorials.ws/io/io_6.html). Teachers could develop an experiment using a solenoid for learners to perform, in order to determine operation of the device.	3 hours	Unit 1, LO4 Unit 2, LO3 Unit 4, LO1 Unit 4, LO3
Rotary actuators	Electric rotary actuators provide control of rotary motion. They are often controlled using a motor, and servo motor control. Learners could begin by exploring the range of rotary actuators commercially available, their operation and their application. Manufacturer data sheets could prove useful. Learners could focus on aspects of how rotary actuators operate effectively – including the servo motor types (e.g. http://electrical4u.com/servo-motor-servo-mechanism-theory-and-working-principle/) Learners may be able to practically investigate different types of rotary actuator.	2 hours	Unit 1, LO4 Unit 2, LO3 Unit 4, LO1 Unit 4, LO3

SUGGESTED ACTIVITIES

LO No:	3		
LO Title:	**Understand how to use signal conditioning techniques and signal conversion devices**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Sensors and their outputs	Sensors produce an output related somehow to the physical quantity they are measuring in order to control an electronic circuit. This output signal requires 'conditioning' to make it suitable. Typical sensors produce a varying voltage output, may change in resistance or could alter the value of current flowing in a circuit determined by the magnitude of what they are measuring. Learners might investigate the various types of outputs produced by different sensors, and how they are interfaced to electronic circuits (see http://www.electronics-tutorials.ws/io/io_1.html). Another common type of interface used in industrial control is the 4-20 mA current loop (see http://www.sensorland.com/HowPage028.html). Learners could investigate the operation of the current loop system, including the reasons for its use compared to other types of output.	2 hours	Unit 1, LO1 Unit 2, LO1 Unit 4, LO1
Sensor calibration and scaling	Sensors often require their output signal to be 'scaled' to the maximum input a circuit can withstand. They also require calibration in order that for a given output signal, the quantity being measured is known. Interfacing and scaling is sometimes done using the potential divider, and the bridge circuit. Learners could investigate sensor interfacing in detail (see http://www.sensorwiki.org/doku.php/tutorials/basic_sensor_interfacing_techniques). Teachers might set learners problems to solve, e.g. to determine values for a potential divider circuit. Learners might also perform an experiment to calibrate a sensor over a range of physical quantities being measured.	2 hours	Unit 1, LO2 Unit 2, LO1 Unit 4, LO1
High and low pass active filters	Filtering is a common technique for conditioning the signal from a sensor or transducer. Alternating signals can be modified by filtering. Low-pass filtering will remove higher frequencies, while high-pass filtering will remove lower frequencies. Teachers might begin by introducing learners to the theory of filtering using the operational amplifier (op amp). Web-based resources may prove useful such as - http://www.electronics-tutorials.ws/filter/filter_5.html Learners could explore practically the operation of op-amp filter circuits using a signal generator and oscilloscope, or could perform circuit simulations.	3 hours	Unit 1, LO1 Unit 4, LO1 Unit 4, LO5

Analogue to digital and digital to analogue conversion	Digital devices, such as a microcontroller or PIC, deal with digital information. In order to communicate with sensors and actuators, they require the conversion of analogue signals to digital form, and of digital information to an analogue signal. This is achieved using analogue to digital (A to D) and digital to analogue (D to A) conversion. Teachers could explain the basic principles of A to D and D to A conversion (see http://www.allaboutcircuits.com/vol_4/chpt_13/1.html). Learners may be able to construct simple converter circuits, or perform circuit simulation using software. The following shows a simulation of a D to A converter using the R-2R ladder principle and an op amp circuit - http://www.youtube.com/watch?v=wIKNRzjMZcs See Lesson Element Digital to Analogue conversion – the R-2R ladder.	4 hours	Unit 1, LO1 Unit 4, LO1 Unit 4, LO6
Parallel to serial and serial to parallel conversion (including bit and baud rate)	Data can be transmitted more efficiently in serial form using just two wires, but this requires some method of converting data from parallel to serial form and vice versa. Teachers might begin by explaining the reason for the transmission of data in serial form – including the terms bit and baud rate (see http://www.circuitstoday.com/bit-rate-vs-baud-rate-the-common-misconception). Learners could solve bit and baud rate problems set by the teacher. Learners could then investigate how data can be converted from parallel to serial and serial to parallel form. The following shows this using the flip flop and shift register – which learners may already be familiar with - http://www.allaboutcircuits.com/vol_4/chpt_12/1.html Learners could further investigate and simulate parallel to serial and serial to parallel conversion using computer simulation software.	4 hours	Unit 1, LO1 Unit 4, LO1 Unit 4, LO6

SUGGESTED ACTIVITIES

LO No:	**4**		
LO Title:	**Understand the application of smart and modern materials in electrical devices**		
Title of suggested activity	**Suggested activities**	**Suggested timings**	**Also related to**
Introduction to smart materials	Teachers might begin this section with an introduction to smart and modern materials – including materials that are controlled or stimulated using electricity. The following website includes a video introduction to the significance of smart materials in society, with many current examples - http://connect.innovateuk.org/web/smart-materials Learners could briefly investigate a range of modern materials and their applications.	1 hour	
QTC and SMA	Quantum Tunnelling Composites - QTC (see http://www.peratech.com/qtc-material.html) and Shape Memory Alloys - SMA (see http://www.technologystudent.com/equip1/sma1.htm) are both common forms of smart material. Both can be activated using electricity. Learners might begin by researching how both types of material operate, and common applications. As both are available relatively cheaply, then it may be possible for learners to conduct experiments with both types of material – documenting their findings.	3 hours	
Electroluminescent, electrochromic and electro-optic materials	Materials that emit light, or that can control the transmission of light include electroluminescent (EL) materials (i.e. wire, panels and tape), electro-optic and electrochromic materials. The following videos show examples of EL material being used in wearable electronics (http://www.youtube.com/watch?v=RJ2xGFfrND0) and electrochromic glass being used to control the transmission of light (http://www.youtube.com/watch?v=RIDN4iH8xr4). Learners could further investigate the operation and application of these materials (such as flat panel display backlighting, or controlling transmission of light through a window). Learners may be able to experiment practically with low-cost smart materials such as EL wire or tape, or electrochromic glass.	2 hours	

Conductive polymers and piezoelectric materials	Conductive polymers are typically used in switch panels, with piezoelectric materials being used to detect force and pressure. Learners could begin by researching conductive polymer and photoelectric material; both its operation and applications. The following web-based resources may prove a useful starting point - http://www.assemblymag.com/articles/88381-plastics-assembly-electrically-conductive-polymers (conductive polymers) and http://www.piezomaterials.com/ (piezoelectric materials) Again, learners may be able to explore the operation of these materials practically.	2 hours	
Electrostrictive materials and ER fluids	Electrostrictive materials are materials that cause movement when an electric current is applied (and can be used as a 'bionic muscle'). They have other applications, such as the harvesting of energy. Electrorheological (ER) fluids are materials that change their characteristics and fluidity when a current is applied. The following video shows an ER fluid experiment - http://www.youtube.com/watch?v=NOot5wxuxSg Learners could investigate the application of these materials in further detail – presenting their findings in poster form.	2 hours	
Thermoelectric materials	Thermoelectric materials are materials that are controlled by, or react to, heat. The following video provides an introduction to thermoelectric materials: http://www.youtube.com/watch?v=fmsQJYPpZ2o&index=4&list=PLEBnKbZjYJ_rHB5V3-uyD8_TYZ5wDGIkU Learners could investigate the application and operation of a number of practical applications of thermoelectric materials – summarising their findings as a presentation.	2 hours	

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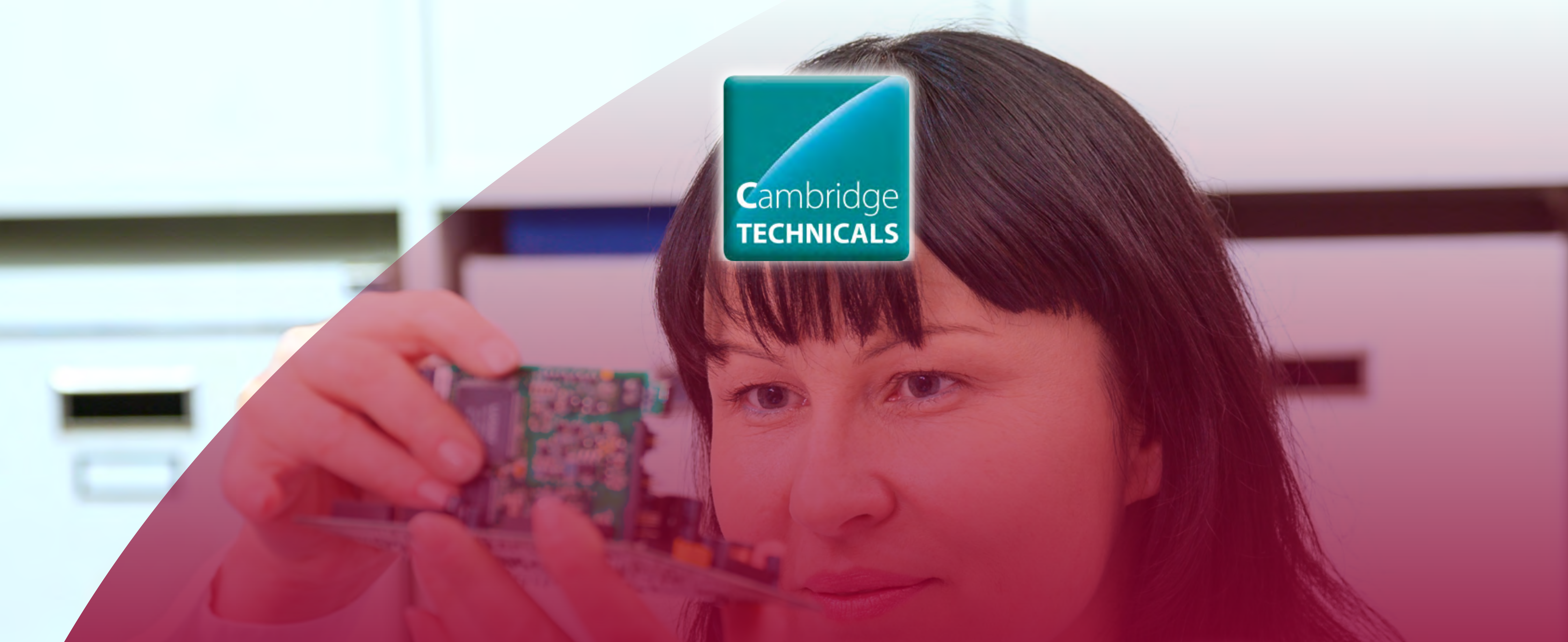

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