Unit 8: Electronic Circuit Design and Construction

Level: **1 and 2**

Unit type: **Optional specialist**

Guided learning hours: **60**

Assessment type: **Internal**

Unit introduction

In our world, we are surrounded by electronic devices that make life safer, more comfortable, more entertaining and more convenient.

Have you ever wondered how something as small as a mobile phone can do so much, or how computers can retrieve information from anywhere in the world in seconds? None of the things we take for granted, such as watching television, playing DVDs, listening to the radio, downloading music to personal devices or playing computer games, would be possible without the work of electronic engineers. Programmable domestic devices such as washing machines and microwave ovens use electronic control and on a larger scale the UK's military, financial, communication and commercial business systems rely on state-of-the-art electronics to operate successfully.

Almost all electronic circuits can be broken down into input, process and output blocks and you will learn to recognise and use some of the components that are classified in this way. You will learn about their function and application and how they can combine to make more complex electronic systems.

You will learn to design electronic circuits using input, process and output building blocks to solve problems and you will build circuits, working safely, and using permanent construction methods. You will also learn how to ensure that your construction methods are effective and are carried out using appropriate circuit boards.

In order to check the function of the circuits you have built, you will learn how to test them using appropriate test equipment.

Learning aims

In this unit you will:

A know about electronic systems design

B design and construct electronic circuits using electronic building blocks

C know how to populate circuit boards permanently and construct electronic circuits safely

D test and evaluate electronic circuits.

Learning aims and unit content

What needs to be learnt

Learning aim A: Know about electronic systems design

Topic A1: Input components

Identification, function and application of input components used in electronic circuits, including:

- sensors – light dependent resistor (LDR), thermistor (negative temperature coefficient – NTC), moisture sensor, piezo electric sensor
- switches – toggle, slide, rocker, push-to-make, push-to-break, key, micro, tilt.

Topic A2: Process components

Identification, function and application of process components used in electronic circuits, including:

- transistor (NPN and PNP)
- Darlington Pair
- thyristor
- field effect transistor (FET)
- 555 timer – in monostable and astable modes
- operational amplifier (Op-Amp)
- Peripheral Interface Controllers (PICs): how to program PICs using flowcharts to switch outputs on and off from input signals, create routines to control outputs with delays, and repeat loops and counts.

Topic A3: Output components

Identification, function and application of output components used in electronic circuits, including:

- lamp/bulb
- buzzer
- light emitting diode
- loudspeaker
- motor
- 7-segment display.

Topic A4: Passive components

Identification, function and application of passive components used in electronic circuits, including:

- fixed resistor (including resistor colour code and British Standard BS 1852/BS EN 60062), coding method to determine resistor values and tolerance
- variable resistor
- polarised capacitors
- non-polarised capacitors
- diode – used as a protective device against back voltage from electro-magnetic components
- relay – used as an interface between primary and secondary circuits.

continued

What needs to be learnt

Topic A5: Power

Power supplies, units of measurement and calculations for electronic circuits.

Identification, characteristics, application and advantages/disadvantages of power supplies used in some electronic circuits, including:

- batteries – zinc-carbon, alkaline, NiCad rechargeable, button cells
- low voltage power supply units – PSU
- solar power – when powering low current circuits.

Units of measurement:

- current (amp)
- resistance (ohm)
- voltage (volt)
- power (watt).

Application of the units and formulae when calculating values relating to electronic circuits, including:

- simple calculations:
  - Ohm's law – V = I x R in parallel circuits consisting of two resistors
  - resistors in series – Rtotal = R1 + R2 + R3 etc.
  - time period – t = R x C
  - power – W = I x V
- complex calculations:
  - Ohm's law – V = I x R in series circuits consisting of two resistors
  - resistors in parallel – Rtotal = (R1 x R2)/(R1 + R2).

What needs to be learnt

Learning aim B: Design and construct electronic circuits using electronic building blocks

Topic B1: Circuit design

Design an electronic circuit using input, process and output components, for example:

- a low temperature alarm that will give a warning when the temperature falls below a pre-set level, including –
  - input – thermistor and fixed/variable resistor
  - process – single transistor/Darlington Pair/Op-amp
  - output – buzzer/LED/lamp
- a timing circuit that gives a flashing LED or pulsing sound output after a set time period, including –
  - input – capacitor and variable resistor
  - process – 555 timer (monostable), 555 timer (astable)
  - output – LEDs/loudspeaker
- a circuit to count people passing through a sports stadium barrier, including –
  - input – push-to-make switch and fixed resistor
  - process – programmed PIC
  - output – 7 segment display.

Topic B2: Circuit board construction

Applications, advantages/disadvantages and construction of a circuit using an appropriate circuit board, including:

- prototyping board (breadboard)
- stripboard (veroboard)
- printed circuit board (PCB)
- mass production, miniaturisation and surface mount technology (SMT).

continued

What needs to be learnt

Learning aim C: Know how to populate circuit boards permanently and construct electronic circuits safely

Topic C1: Circuit soldering techniques

Use appropriate techniques for soldering components into an electronic circuit and dealing with exposed component legs, including:

- soldering using multi-core lead-free soldering technique to avoid dry joints
- tinning component legs and multi-strand wire using heat sinks and shunts
- using IC sockets and heat shrink sleeving or insulation tape.

Topic C2:Risk assessments

Specify risks and control measures appropriate to the engineering activity (handling soldering equipment), including:

- identifying hazards
- deciding who might be at harm and how
- evaluation of the risks and appropriate control measures
- recording of findings and implementation
- full Health and Safety Executive (HSE) risk assessment.

Learning aim D: Test and evaluate electronic circuits

Topic D1: Testing electronic circuits

Testing and evaluating electronic circuits to check voltage levels, continuity and current, and to identify and diagnose faults, including use of:

- a voltmeter or multimeter to measure voltage levels across components and power supplies in a circuit
- an ohmmeter or multimeter to check for continuity in circuit tracks and wires, and to detect breaks and bridges in connections
- an ammeter or multimeter to measure current levels in a circuit
- a logic probe to test digital signal levels when using PICs.

Assessment criteria

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim A: Know about electronic systems design			
1A.1 Describe the function and characteristics of electronic input, process, output and passive components.	2A.P1 Select and apply appropriate input, process and output, and passive components for a circuit.	2A.M1 Explain reasons for the selection of electronic input, process, output and passive components.	2A.D1 Justify the selection of appropriate input, process and output components in a circuit design to solve a given electronics problem.
1A.2 Carry out simple calculations using units of current, resistance, voltage and power.	2A.P2 Describe the characteristics of power supplies and carry out simple and complex calculations using units of current, resistance, voltage and power in electronic circuits. *		
Learning aim B: Design and construct electronic circuits using electronic building blocks			
1B.3 Identify components in a given circuit diagram.	2B.P3 Describe the design features of a simple circuit diagram that uses input, process and output components.	2B.M2 Explain the operation of the circuit in terms of its input, process and output components.	2B.D2 Explain the limits of operation of the circuit in terms of its input, process and output components.

Level 1	Level 2 Pass	Level 2 Merit	Level 2 Distinction
Learning aim C: Know how to populate circuit boards permanently and construct electronic circuits safely			
1C.4 Identify the main hazards and people at risk when using soldering equipment.	2C.P4 Describe the risks associated with identified hazards when using soldering equipment.	2C.M3 Explain, with reference to particular soldering activities, the risks involved and record appropriate control measures.	2C.D3 Using a full risk assessment, evaluate all activities in the production of electronic circuits.
1C.5 Identify the main features of a given electronic circuit.	2C.P5 Describe the main features of an electronic circuit and the construction techniques.	2C.M4 Compare the advantages and disadvantages of different circuit construction techniques.	
Learning aim D: Test and evaluate electronic circuits			
1D.6 Use a test meter to accurately measure the voltage of a power supply. *	2D.P6 Test voltage levels at specific points in an electronic circuit when in use. *	2D.M5 Use a range of measurements to test the performance of an electronic circuit. *	2D.D4 Use a range of measurements to evaluate the performance of an electronic circuit. *
1D.7 Identify basic faults in an electronic circuit.	2D.P7 Diagnose faults in an electronic circuit.		

*Opportunity to assess mathematics

Teacher guidance

Resources

The special resources required for this unit are:

- a range of electronic circuit input and passive components that can be used to form potential dividers when constructing circuits
- a range of electronic circuit processing components that can be used as amplifying devices in electronic circuits
- a range of output components
- general and specialist tools and equipment for constructing electronic circuits.

Assessment guidance

This unit is assessed internally by the centre and externally verified by Edexcel. Please read this guidance in conjunction with *Section 8 Internal assessment*.

Although learners are assessed individually, it is quite acceptable for them to share equipment and discuss issues relating to their practical work.

For learning aim A at level 2, learners must be able to select appropriate input, process, output and passive components, which could be used in a circuit represented by, for example, a block diagram. This diagram could include statements such as 'cold sensing potential divider', 'high gain amplifier', and 'loud audible output'. Learners should be able to: select an appropriate sensor and series resistor to respond to falling temperature; select a processing component or components that would produce a very high amplification; or select an output component that would give a loud audible output. Evidence could be in the form of annotation written on the block diagram presented to learners. At Merit, learners must give reasons for choices, or justify them. At Distinction, learners will solve a specific problem.

For 2A.P2, learners must describe the characteristics of power supplies and show evidence of carrying out at least one of each calculation. Evidence could be in the form of worksheets or a test.

For learning aim A at level 1, learners will state key functions and characteristics without applying these to specific circuit design. Evidence could be in the form of a completed worksheet.

For 1B.2, simple calculations as specified in the content should be carried out.

For learning aim B at level 2, learners will describe the design features of the circuit, with increasing levels of explanation of components at Merit and Distinction. Evidence will be in the form of an annotated design, a completed circuit and witness testimony authenticating the work and could be supported by annotated photographs.

Learners will construct the circuit, with increasing levels of explanation of components at Merit and Distinction. Evidence will be in the form of an annotated design, a completed circuit and witness testimony authenticating the work and could be supported by annotated photographs.

For learning aim B at level 1, learners will identify components in a given circuit with support. The circuit plan can be provided by the tutor. Learners must identify components on the circuit design, so the design, correctly annotated by the learner, could be evidence of assessment.

Evidence for learning aim C is likely to be in the form of authenticated discussion of hazards, photographs of outcomes along with witness statements, or learner observation records supported by annotated photographs. Evidence at level 2 will include a full assessment of risks, and increased precision in the creation of the circuit.

At level 1, learners must be able to use tools and equipment to build a simple circuit that functions as intended. They must be able to place polarised components into a circuit board in the correct orientation and use effective soldering techniques that avoid 'dry' joints.

For learning aim D, assessment could be in the form of circuits with planned faults. Evidence will include questioning and witness statements, annotated diagrams of the circuits to show measurements taken, annotated photographs of the process and use of test meters etc. The level of accuracy and scope of testing increases in Merit and Distinction. The Merit requirement includes testing the overall circuit performance and an evaluation of the performance.

Suggested assignment outlines

The table below shows a programme of suggested assignment outlines that cover the assessment criteria. This is guidance and it is recommended that centres either write their own assignments or adapt any assignments we provide to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment evidence
1A.1, 2A.P1, 2A.M1, 2A.D1, 1A.2, 2A.P2	Using Electronics to Give Warning of a Temperature Increase in a Greenhouse	You have been asked to make an electronic device for use in a greenhouse to give a warning when the temperature becomes too hot. You will be given a mixture of components (including passive components) to sort into categories. These are then to be used in conjunction to create potential dividers, time delays etc. The function and characteristics of each component are described. You need to select and apply electronic input, process and output components to match the needs of the device for the greenhouse, and explain and justify your choices. You need to find out about and report on different types of power supplies used to power low current electronic circuits. The list includes zinc carbon, alkaline, NiCad batteries, button cells transformed mains power packs and solar cells. Finally, you need to carry out calculations of resistance, voltage and current using Ohm's law and to carry out calculations of total resistance of resistors connected in series, parallel and in resistor networks.	Worksheet, investigation and written report, log. Investigation and written report.

Criteria covered	Assignment title	Scenario	Assessment evidence
1B.3, 2B.P3, 2B.M2, 2B.D2	Electronic Timer Design	A client requires an electronic timer that will accurately time up to five minutes in one-minute steps before giving an audible or visual warning that time is up. You should design and construct a circuit using discrete components or ICs and fully explain its operation.	Drawn and labelled circuit diagram with written description and explanation. Circuit drawn using circuit simulation software and tested virtually.
1C.4, 2C.P4, 2C.M3, 2C.D3, 1C.5, 2C.P5, 2C.M4	Designing a Permanent Circuit	You have been given a circuit diagram, which you need to use in conjunction with an appropriately selected type of circuit board to construct a fully functioning circuit, ensuring that safety hazards and risks are identified and control measures are in place. You should produce a report to describe, explain and evaluate safety issues.	Practical activity assessment through outcome. Photographic evidence. Written report on safety issues.
1D.6, 2D.P6, 2D.M5, 2D.D4	Checking Circuit Function	You have been asked to look at functioning and non-functioning circuits, and have been set the task of measuring voltage levels and identifying and diagnosing faults. More complex circuits are presented that contain ICs or PICs and a range of measurements are taken to test and evaluate the performance of the circuits.	Practical demonstration with commentary. Observation record.