Unit 19: Electronic Devices and Circuits

Delivery guidance

Approaching the unit

In this unit, learners will explore the processes that are used by engineering organisations to develop both analogue and digital electronic circuits. They will investigate the various stages of designing, simulating, constructing and testing circuits using practical tasks. They will develop their understanding of how electronic components are used in a range of applications, from domestic home entertainment systems through to the control systems for nuclear power stations and aircraft.

There is an opportunity to develop links with appropriate local engineering organisations where learners could see how electronic systems are integrated into a very wide range of engineering products. This could also allow learners to experience safe working practices for circuit construction on an industrial scale.

In this unit, learners will also develop the skills necessary to simulate and construct a range of electronic circuits, considering how these circuits function and analysing results from tests.

You can involve local employers in the delivery of this unit if there are local opportunities to do so.

Delivering the learning aims

For learning aim A you could introduce learners to the practices that will be required in order to work safely whilst carrying out both the construction and testing of electronic circuits. This could involve the use of simulations of emergency procedures that will need to be carried out in the event of an emergency situation. You should make sure that learners are aware of the location of isolators for both power and heat sources, along with the procedures for raising alarms or evacuation if necessary.

Once learners have a good understanding of safe working practices, they could be introduced to a range of analogue devices including diodes, transistors and operational amplifiers. You could approach this using a theoretical introduction to each type of component, followed by practical tasks where learners would gain experience of how each type of device operates within a circuit. At this stage, it would be appropriate to introduce learners to the conventions for representing electrical circuit drawing standards BS8888 and BS3939 (or international equivalents) so that they are able to correctly note the circuits that they construct.

Circuit construction could then be completed using a prototyping board or stripboard. In addition to constructing prototype circuits, you could give learners the opportunity to simulate their circuits virtually in order to gain data that they can use for comparative purposes. Finally, you could introduce learners to the skills that they will require to carry out tests on physical analogue circuits, including the safe use of multimeters and other items of test equipment. Data collected from tests could then be compared to those obtained theoretically from simulations.

For learning aim B, you should introduce learners to the theory of logic gates, including the symbols used for the different types of logic gates. You will also develop learners' ability to produce circuit schematics for digital circuits and introduce them to the methods of testing that are used for physical digital circuits.

You could initially consider truth tables for the standard logic gates, and how Boolean algebra can be used to describe the outcomes of different types of logic gate based upon their inputs.

Once learners have an understanding of the different types of logic gates and how the operation of these gates can be represented using Boolean algebra, you should introduce learners to how Boolean algebra is applied to combinational logic circuits and methods that can be used to minimise combinational logic circuits. Learners should also be given the opportunity to construct prototype logic circuits using a suitable prototyping method. This can be followed by introducing learners to sequential logic circuits and the prototyping of circuits that employ bi-stable devices.

For learning aim C, you will encourage learners to reflect on their explorations of circuit construction, including methods in which they have represented their circuits using schematics, methods of simulations and testing of completed circuits.

You should encourage learners to reflect on their skills and experiences in each of the areas they have studied whilst completing the unit. This should include health and safety, the practical skills related to manufacturing circuits and their engineering skills in general. Learners need to consider the lessons that they have learnt throughout the process, and their performance whilst carrying out the various practical activities.

Learning aim	Key content areas	Recommended assessment approach
A Explore the safe operation and applications of analogue devices and circuits that form the building blocks of commercial circuits	**A1** Safe electronic working practices **A2** Diode devices and diode-based circuits **A3** Transistor devices and transistor-based circuit **A4** Operational amplifier circuits **A5** Schematic capture and simulation of analogue circuits **A6** Testing physical analogue circuits	A report containing circuit diagrams, photographs, tables of results, sketches, screenshots, calculations and an evaluation of the physical and simulated circuits, supported by observation records and/or witness statements.
B Explore the safe operation and applications of digital logic devices and circuits that form the building blocks of commercial circuits	**B1** Logic gates and Boolean algebra **B2** Combinational logic circuits **B3** Sequential logic circuits **B4** Schematic capture and simulation of digital circuits **B5** Testing physical digital circuits	A report containing circuit diagrams, photographs, tables of results, sketches, screenshots, calculations and an evaluation of the physical and simulated circuits, supported by observation records and/or witness statements.
C Review the development of analogue and digital electronic circuits and reflect on own performance	**C1** Lessons learnt from exploring electronic devices and circuits **C2** Personal performance while exploring electronic devices and circuits	The evidence will focus on the skills and knowledge gained when exploring analogue and digital electronic devices and their common applications, reflecting on the ways in which theoretical, simulated and measured values compare. A portfolio of evidence generated while exploring electronic devices and circuits, reflecting on own performance.

Assessment guidance

The assessment of this unit is most likely to be in the form of three assignments. For learning aim A the evidence would normally be presented in the form of a written report containing schematic diagrams for circuits, calculations, results from simulations and tests along with comparisons of these results to those obtained from circuits that they have constructed. For learning aim B learners will present a further report that evaluates logic circuits, including reference to truth tables and schematic diagrams for sequential circuits. Evidence to support the award of criteria that address learning aim C will be drawn from the evidence contained within the first two assignments. Learners would be expected to demonstrate relevant behaviours and engineering skills to a professional standard whilst also providing a balanced review of practical activities.

Getting started

This gives you a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

Unit 19: Electronic Devices and Circuits

Introduction

This unit offers the opportunity for learners to gain the skills necessary to be able to simulate, construct, test and evaluate a range of transistor and diode based analogue circuits, along with digital circuits that feature sequential and combinational logic.

There is significant opportunity for learners to carry out a range of practical activities that could be based on either stripboard or breadboard construction techniques. You will prepare learners for this by appropriate teaching and learning activities covering safe working practices along with the functions and applications of a range of discrete electronic components.

This unit offers the opportunity for you to develop links with engineering organisations so that visits could take place, which could be used to emphasise safe working procedures along with how electronics is integrated into products produced by a range of engineering sectors.

You should encourage learners to develop the skills required to carry out practical activities safely, and to then to reflect on the activities they have completed to identify lessons they have learnt and the processes they carried out in order to complete tasks within an appropriate time scale and safely.

Learning aim A – Explore the safe operation and applications of analogue devices and circuits that form the building blocks of commercial circuits

- Learning aim A initially gives the foundation of knowledge that is required for learners to be able to carry out practical electronics work safely. This should include methods to isolate power or heat supplies, reporting procedures to follow during emergencies and the importance of following instructions in such situations.
- Once learners have a good understanding of emergency procedures, you should demonstrate to learners the methods of safe working during the construction and testing of electronic circuits.
- Having gained the knowledge and understanding required to work safely during construction and testing of circuits, you should start to introduce learners to a range of analogue components that feature in a wide range of electronic applications. You should take a similar approach when introducing learners to each of the components, including diodes, transistors and operational amplifiers. For each type of component, you should allow learners to investigate the specific components that are named in the unit specification, and how each of these components functions within a circuit. Subsequently, for each, learners should be given the opportunity to investigate a number of different circuits that make use of the specific components. This could be approached using either a prototyping board or strip boards. The relevant skills to construct circuits using these methods will also need to be demonstrated to learners.
- Whilst carrying out activities to construct circuits, learners will be developing their ability to work with others, as it is likely that there will be some paired work during the prototyping of circuits with resources being shared between learners. It would be beneficial to learners if they also had the opportunity to construct circuits using both prototyping board and strip board.

- Alongside the investigations into the functions and use of the analogue components, you should be equipping learners with the skills that they will need to be able to represent these circuits schematically. You should make sure that learners are able to produce circuit schematic diagrams that are to recognised standards such as BS3939 (or international equivalent).
- You could then introduce learners to methods for testing circuits, both physically and using simulations. This will include the use of equipment such as multimeters, oscilloscopes and other test equipment that learners will need to be instructed how to use safely. Learners should be taught a range of methods to take measurements, and then be introduced to the calculations that need to be carried out on these test results. This should include transistor current gain, circuit voltage gain and determining the cut off frequency for op-amp filters. These values could also be determined using simulations of circuits where measurements and data should be extracted from virtual test instrumentation.
- Once learners have developed the skills needed to be able to simulate, construct, test and analyse circuits safely, you should give them the opportunity to complete their first assessment. You should allow learners the opportunity to evaluate a range of circuits, including at least one diode, one transistor and one operational amplifier circuit. Learners should construct these circuits safely, testing the function of the circuit and comparing their results to those obtained through the use of simulation. Learners should be encouraged to produce a range of different types of evidence within their report, including circuit schematic diagrams, annotated photographs of circuits, tabulated results, calculations, screenshots and sketches. Further supporting evidence could be given in the form of witness statements or observation records.

Learning aim B – Explore the safe operation and applications of digital logic devices and circuits that form the building blocks of commercial circuits

- Learning aim B is designed to give learners an insight into how logic devices can be used within commercial electronic circuits, including how the use of Boolean algebra is used to indicate the outcomes that are produced by these devices.
- Initially, you should introduce learners to the six main types of logic gates that form the building blocks of logic circuits. For each of these, you should give learners the opportunity to develop their understanding of the relevant truth tables for each type of gate. They should also be able to apply the correct gate symbols when representing logic gates in schematic diagrams.
- Once learners have a good understanding of the six main types of logic gates, you should move on to considering the different types of logic family, including transistor-transistor logic (TTL) and complementary metal oxide semiconductor (CMOS) logic. For each, you should make sure that learners are aware of the characteristics of each logic family and have an understanding of their functions.
- With a good understanding of the types of logic gates that are used within digital circuits, learners then should have the opportunity to develop the skills required to apply Boolean algebra to combinational logic circuits. You should introduce learners to the rules of Boolean algebra. This should include the expressions for the sum of products along with the truth tables for Boolean expressions. You could then progress to explain to learners the methods that can be applied to minimise combinational logic gates, with reference to both Karnaugh maps and De Morgan's theorem.
- This knowledge should then be expanded upon by introducing learners to a range of sequential logic circuits, including flip-flops, counter circuits and shift registers. You should again ensure that learners have the opportunity to construct the aforementioned types of circuit using either prototyping board and/or strip board. The circuits themselves should make use of a range of bi-stable devices.

- As with analogue devices, learners will need to be equipped with the skills necessary to be able to represent digital circuits using circuit schematic diagrams. Again, you should make sure that learners are able to produce these schematic diagrams to a recognised standard.
- Learners should again be taught how to use test equipment safely, including the safe use of logic probes and analysers. As with analogue circuits, you should also ensure that learners have the necessary skills to carry out simulations on digital circuits so that the logic states for inputs and outputs can be extracted. You should also give learners the opportunities to carry out calculations using Boolean algebra and truth tables.
- Following revision of each of the topics and further practical tasks, learners should complete their second assignment for the unit, which is targeted at learning aim B. You should give learners the opportunity to evaluate the operation of at least one combinational logic circuit and two sequential logic circuits. Learners should construct these circuits safely, testing the function of the circuit and comparing their results to those obtained through the use of simulation. Learners should be encouraged to produce a range of different types of evidence within their report, including circuit schematic diagrams, annotated photographs of circuits, tabulated results, calculations, screenshots and sketches. Further supporting evidence could be given in the form of witness statements or observation records.

Learning aim C – Review the development of analogue and digital electronic circuits and reflect on own performance

- You could introduce learning aim C simultaneously with learning aims A and B as the nature of the learning aim is to develop the reflective skills of learners whilst they carry out a range of practical electronic activities. You should encourage learners to evaluate the skills that they have either gained or developed whilst carrying out the construction of electronic circuits, including those skills related to health and safety, development of circuits and any potential impact on the general engineering skills of the learners. It is important that learners are able to explain how they have been able to apply these skills whilst carrying out practical activities and can identify where they may need to develop these skills further.
- You should encourage learners to develop and improve appropriate behaviours when carrying out practical tasks. The time planning and management skills that they may have applied in other units could be applied to practical activities in this unit. You should encourage learners to consider the order in which activities will need to be carried out when solving problems that relate to either analogue or digital circuits. Furthermore, transferable skills such as those related to communication and literacy should be refined with reference to electronic devices. An awareness of the transferable nature of many of the skills used in this unit should be encouraged.
- It would be appropriate to allow learners the opportunity to carry out a number of practical activities as a part of the teaching and learning for the unit, which can then be evaluated by learners with reference to the previously identified skills, and also the engineering behaviours that they should be able to demonstrate whilst carrying out practical tasks.
- To address learning aim C, learners should reflect on the tasks that they carried out for learning aims A and B when explaining how skills were applied and how the development of the circuits could be improved. You should encourage learners to present their work with a balanced view, considering actions that they have taken in order to comply with the behaviours expected of an engineering professional during the development work.

Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

Pearson BTEC International Level 3 Qualifications in Engineering:

- *Unit 17: Power and Energy Electronics*
- *Unit 20: Analogue Electronic Circuits*
- *Unit 21: Electronic Measurement and Testing of Circuits*
- *Unit 22: Electronic Printed Circuit Board Design and Manufacture*
- *Unit 23: Digital and Analogue Electronic Systems*
- *Unit 57: Electrical and Electronic Principles*

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC Nationals in Engineering. Check the Pearson website (http://qualifications.pearson.com/en/support/published-resources.html) for more information as titles achieve endorsement.

Textbooks

- Gibson J – *Electronic Logic Circuits* (Routledge, 2013) ISBN 9781136076695.
  Includes combinational and sequential logic, along with truth tables.
- Bird J – *Electronic Circuit Theory and Technology* (Routledge, 2010)
  ISBN 978-1136072697.
  Sections about diodes, transistors and Op Amps.

Websites

- www.allaboutcircuits.com
  Web-based resource that covers many analogue and digital components, along with Boolean algebra.
- https://www.i-programmer.info/babbages-bag/235-logic-logic-everything-is-%20logic.html
  Boolean logic and De Morgan's theorem.

Pearson is not responsible for the content of any external internet sites. It is essential for tutors to preview each website before using it in class so as to ensure that the URL is still accurate, relevant and appropriate. We suggest that tutors bookmark useful websites and consider enabling learners to access them through the school/college intranet.