Unit 63: Electronic Fault-finding

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

An understanding of the operation of electronics circuits is an important issue in the training of technicians and engineers. A complex electronic system is generally a number of individual circuits connected together to perform a specific function. However, to understand the overall circuit it is necessary to break it down into smaller, more easily understood circuits. This is particularly important when testing and fault-finding.

This unit will give learners an understanding of the principles of electronic fault-finding, including the procedures, knowledge and skills required when carrying out fault-finding activities.

Learners will gain an understanding of electronic components, circuits and systems and how to solve problems involving simple and complex faults to a professional standard.

Learners will develop their knowledge of the application of electronic components and how electrical signals are employed in a variety of analogue, digital and communications circuits. They will also develop the ability to select fault-finding instruments and apply the techniques used for the diagnosis of faults.

The unit will enable learners to read circuit, schematic and wiring diagrams and carry out fault-finding procedures by obtaining the necessary information, documentation, tools and equipment. They will also be able to prepare accurate reports of all the steps that have been taken during the fault-finding processes.

The unit will ensure that learners have a firm understanding of safe working practices when carrying out fault-finding activities and that they are able to take the necessary safeguards to protect their own safety and that of others in the workplace.

Learning outcomes

On completion of this unit a learner should:

1 Be able to interpret a circuit diagram for an electronic system and identify the type of circuit, the circuit components and the type of circuit signals

2 Be able to plan and implement a fault-finding strategy

3 Be able to diagnose fault conditions using test equipment and record the results.

Unit content

1 **Be able to interpret a circuit diagram for an electronic system and identify the type of circuit, the circuit components and the type of circuit signals**

Circuit diagrams: analogue and digital circuit diagrams drawn to national standards eg British Standards (BS) or American National Standards Institute (ANSI); types of circuit diagrams eg block schematic, circuit, wiring, printed circuit board (PCB) layout diagram that each include a minimum of five components and should show input, output and power supply connections plus any external control connections

Types of analogue circuits: eg audio/radio frequency amplifiers, oscillators, multiplexers, demultiplexers, function generators, power supplies

Types of digital circuits: eg combinational/sequential logic circuits, flip flops, encoders, decoders, asynchronous/synchronous counters, frequency dividers, ring counters, waveform generators, registers, shift registers, serial-to-parallel and parallel-to-serial code converters

Electronic components: passive components eg resistors, capacitors, inductors, diodes; active devices eg transistor and operational amplifiers – small (SSI), medium (MSI) and large scale integrated (LSI) devices for analogue circuits; logic devices for digital circuits eg logic gates, multivibrators, timers

Input/output signals: circuits working under normal/steady state operating conditions; signal values eg voltage, current, gain, logic levels, alternating sinusoidal and pulse periodic signals at low (LF), medium (MF) and high frequencies (HF), direct current (DC) levels

2 **Be able to plan and implement a fault-finding strategy**

Fault location strategy: planning eg obtain relevant diagrams (block schematic, circuit wiring diagrams), establish component/circuit tolerances, specifications, restrictions or limitations of operation; predict circuit operation from diagrams eg signal trace through schematic diagrams, produce a test schedule, identify key test nodes/input-output matrix/decision table, function tables; calculate expected signal conditions for analogue and digital circuits eg operational amplifier — determine the expected output voltage level given the input signal voltage and the values of the input and feedback resistors, logic gates — determine the expected logic level of the output given the input level conditions

Fault location and signal tracing techniques: input-to-output/output-to-input, half-split method, symptom to cause fault hierarchies, unit substitution, visual examination, top-down approach, module and component isolation; use of fault-finding aids eg functional charts, diagrams, trouble-shooting charts, component data sheets, operation and maintenance manuals, software based records and data; fault/repair reporting eg mean time between failure (MTBF) figures; path sensitisation; critical path and fault signal tracing node points

3 **Be able to diagnose fault conditions using test equipment and record the results**

Test instruments: eg ammeter, voltmeter, multimeter, logic probe, cathode ray oscilloscope, signal analyser, frequency counter, digital test set, power meter, software simulation tools

Fault conditions: normal (steady state) equipment operating conditions; component failures eg total, partial; circuit faults eg short circuit and open circuit connections, design and power supply faults; components out of specification; intermittent faults; fault and tolerance testing; digital faults eg input side, output side, logic stuck-at faults

Test data records: eg personal logbook, tabulated data, computer based records (tables, spreadsheet, database), referencing of data (indexed, cross-referenced, date), recorded details (description of systems/circuits, symptoms, operator details, equipment details, test conditions and methods, test results, statistics, comments)

Grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all of the learning outcomes for the unit. The criteria for a pass grade describes the level of achievement required to pass this unit.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 read a circuit diagram for an electronic system and identify two different types of analogue circuits, the components that make up each circuit and the circuit input and output signals P2 read a circuit diagram for an electronic system and identify two different types of digital circuit, the components that make up each circuit and the circuit input and output signals P3 prepare a written fault location strategy for a given analogue electronic system and identify the fault-finding and signal tracing techniques to be applied P4 prepare a written fault location strategy for a given digital electronic system and identify the fault-finding and signal tracing techniques to be applied	M1 compare the circuit diagrams of two different approaches to the same type of circuit M2 evaluate a fault location strategy and make recommendations for improvement M3 justify the choice of test instruments selected to identify fault conditions within an electronic system.	D1 evaluate a circuit diagram for an electronic system and identify incorrect circuits/input-output signals D2 identify the fault conditions within an electronic system that presents a fault in more than one circuit.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P5 select and use test instruments to identify fault conditions within an analogue electronic system that has at least one faulty circuit and one component fault P6 select and use test instruments to identify fault conditions within a digital electronic system that has at least one faulty circuit and one component fault P7 collect and record the test data from an analogue electronic system fault-finding test and prepare a test report P8 collect and record the test data from a digital electronic system fault-finding test and prepare a test report.		

Essential guidance for tutors

Delivery

While this unit may be delivered on a stand-alone basis, it is recommended that it is integrated with other units such as *Unit 54*: *Electronic Measurement and Testing*, *Unit 60*: *Principles and Applications of Analogue Electronics* and *Unit 61*: *Construction and Application of Digital Systems*.

Delivery will be most effective through a structured programme of practical activities involving the use of industry standard equipment and electronic circuit simulation software/hardware. The emphasis of the unit is on enabling learners to acquire the necessary skills for systematic and planned fault-finding, as opposed to an unsystematic and random approach. As a result, the strategy for delivery, practical work and assessment should all reflect and reinforce the need for sufficient levels of planning and documentation.

Learners should be given opportunities to investigate a range of electronic equipment by examining circuit diagrams and a wide variety of components. The unit is best delivered through a programme of lectures, demonstrations and practical work. Appropriate attention must be given to health, safety and welfare arrangements throughout the delivery of the unit.

The delivery approach used should be determined through an analysis of learners' needs and consideration of the range of industries that the centre is working with or preparing their learners for. Whatever approach is taken should be sufficiently varied to develop learners' ability to use the techniques required for good fault-finding practice. It should also develop the skills required to fault-find on electronic systems in a range of industrial settings.

During delivery, learners should be made aware of and have access to a range of UK health and safety legislation and know the importance of risk assessment appropriate to the techniques they are using.

It is always important in a workshop environment, even though this is not explicitly assessed by this unit, that the learner is able to work in a safe manner when using equipment or working on electronic systems. The application of safe working practices is implicitly expected of all the practical work undertaken by the learner in this unit.

Delivery of this unit could provide an opportunity for learners to work in teams or groups when diagnosing component or system faults. The unit should focus on learners' ability to develop diagnostic and practical skills and their understanding of electronic components and systems.

The learning outcomes are logically ordered and could be developed sequentially throughout the unit. In this way, learners will be able to apply the knowledge gained from reading circuit diagrams relating to electronic components and signals and the use of test instruments in a practical environment.

The content associated with learning outcomes 1 and 3 means that these two areas should be assigned a larger proportion of guided learning time than learning outcome 2.

Learners will need a broad overview of different electronic components and systems to enable correct selection and application of fault-finding and testing techniques.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Assessment

Throughout assessment activities, learners must be made aware of the health and safety hazards applicable to electronic fault-finding operations.

It is likely that a system that has a fault only needs one component to be replaced. However, on some occasions more component failures may be found. Care needs to be taken here not to disadvantage learners if this is the case during their assessment. The criteria can be split into two sets, one for analogue circuits/systems (P1, P3, P5 and P7) and the other digital (P2, P4, P6 and P8).

P1 and P2 relate to learning outcome 1. In order to meet P1, learners must be able to read a circuit diagram for an electronic system and identify two different types of analogue circuit within that system, the components that make up each circuit and the circuit input and output signals.

The circuit diagram should have been produced to a national standard, eg British Standards (BS) or American National Standards Institute (ANSI). The diagram can be a block schematic, circuit, wiring or printed circuit board (PCB) layout diagram. Each must include a minimum of five components and should show input, output and power supply connections plus any external control connections. The analogue circuits could be audio/radio frequency amplifiers, oscillators, multiplexers, demultiplexers, function generators or power supplies.

P2 requires a similar approach but for two different types of digital circuits, which could be any of those listed in the related section of unit content.

P3 and P4 cover learning outcome 2. Learners are expected to prepare a written fault location strategy for an analogue electronic system (P3) and a digital electronic system (P4) and identify the fault-finding and signal tracing techniques to be applied for each.

The fault location strategy for both P3 and P4 must provide details of the planning that is required for the task (eg obtaining relevant diagrams, establishing component/circuit tolerances, etc), predicting the circuit operation from diagrams and calculating expected signal conditions for analogue and digital circuits respectively.

The signal tracing techniques applied will depend upon the type of electronic circuit and the fault or faults present. However, learners should identify an appropriate strategy from the list provided in the unit content (eg input-to-output/output-to-input, half-split method, symptom to cause fault hierarchies, unit substitution, etc). They are not expected to demonstrate them all for assessment purposes, but should have experienced them all during delivery to enable them to make the most appropriate choice.

Learners should also identify the most appropriate fault-finding aids to be used (eg functional charts, diagrams, trouble-shooting charts, etc). The written strategy should also identify the required level of fault/repair reporting (eg MTBF figures and the use of path sensitisation, critical path and fault signal tracing node point techniques).

The remaining pass criteria relate to learning outcome 3 and all require proficiency in the practical techniques relating to fault-finding.

In order to satisfy P5 and P6, learners need to select and use the most appropriate test instruments for the circuits/systems under test.

For P7 and P8, learners must collect and record all the relevant test data and prepare relevant test reports. The data must be presented in a clear and legible form (eg use of a personal logbook, tabulated data that includes headings and relevant units (Voltage/mV, Resistance/Ohms, etc), computer based records, etc). It is expected that the report should reach a conclusion on the likely cause of the fault and include the learner's recommendation on how the circuit/system can be restored to full operational order.

When planning and designing assessment activities and assignments tutors should consider how best to incorporate opportunities for the achievement of the merit and distinction criteria. For example, M1 is a natural extension of the tasks carried out to satisfy P1 and P2, which assess learners' ability to read circuit diagrams for an analogue/digital electronic systems.

For M1, learners should be able to apply this skill in a deeper way by comparing the circuit diagrams of two different approaches to the same type of circuit. The circuit diagrams could be of an analogue or digital circuit and are likely to be provided by the tutor, although they could come from the learner's workplace if available. The important aspect here is the learners' ability to recognize that generally there is always more than one way to produce a given type of circuit.

M2 links with P3 and P4 — preparing written fault location strategies for given analogue/digital electronic systems. Learners should be able to evaluate either a given fault location strategy (analogue or digital) or their own and make recommendations for improvement. This should demonstrate their ability to reflect upon their own work or that of others and apply their understanding to arrive at realistic and relevant improvements.

M3 links with P5 and P6 — the selection and use of test instruments to identify fault conditions in analogue/digital electronic systems. Learners should be able to justify the choice of test instruments selected to identify fault conditions within an electronic system (analogue or digital). The justification should not only indicate why the test instruments were used but also why others were not. This will indicate the depth of understanding of a greater range of instruments (eg ammeter, voltmeter, multimeter, logic probe, cathode ray oscilloscope, signal analyser, frequency counter, digital test set, power meter, software simulation tools) than will be possible in the work for P5 and P6.

D1 is an extension of the work undertaken for P1, P2, and M1. Again, the circuit diagram could be either analogue or digital and could be provided by the tutor or be from the learner's workplace. It assumes that the circuit provided has errors with respect to either the circuit itself or the signals that have been indicated within the circuit. It is likely that such a circuit diagram will need to be produced by the tutor.

Alternatively, it may be possible for learners to produce work-based evidence of the detection of an error, for example through a quality assurance process in the design phase of an electronic product.

D2 is a natural extension of P5 and P6. It is intended to enable learners to demonstrate their ability to apply the skills gained at pass within a more complex context. This will mean that learners are not only able to appreciate that there is a fault in one of the circuits in a system, but that the symptoms indicate further external influence on the expected performance of the circuit as a whole.

For D2, the satisfactory response from learners will be to independently investigate beyond the original fault and identify the second problem. As this is unlikely to occur naturally, the circuit under investigation will need to be specially prepared for this particular task by the tutor.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit covers some of the knowledge and understanding associated with the SEMTA Level 3 National Occupational Standards in Engineering Maintenance, particularly:

- Unit 17: Testing Electronic Equipment and Circuits
- Unit 40: Maintaining Instrumentation and Control Systems.

The unit can be linked with *Unit 54*: *Electronic Measurement and Testing*, *Unit 60*: *Principles and Applications of Analogue Electronics* and *Unit 61*: *Construction and Application of Digital Systems*.

Essential resources

Centres must provide a range of analogue and digital electronic circuits and systems for practical investigation and suitable hardware and software for computer-based simulation.

Learners will require access to a range of manufacturers' literature for electronic components, devices and circuits/systems and a range of test equipment and their handbooks. The test equipment should be sufficient in number to allow learners to carry out fault-finding exercises on an individual basis.

A range of working and faulty electronic systems, circuits, devices and components should be made available for fault diagnosis purposes, together with the relevant manufacturer's service manuals, parts lists and circuit diagrams. The appropriate tools, safety equipment and a safe working environment must also be provided. In most cases, a typical electronics workshop or laboratory should prove adequate.

Indicative reading for learners

Gates E — *Introduction to Electronics* (Delmar, 2006) ISBN 140188900X

Loveday G C — *Electronic Testing and Fault Diagnosis* (Longman Scientific and Technical, 1996) ISBN 0582252423

Sinclair I and Lewis G — *Electronic and Electrical Servicing* (Newnes, 2002) ISBN 0750654236

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Tutors should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Application of number Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• preparing to carry out simulation and/or practical measurements • calculating expected signal characteristics and circuit performance characteristic • interpreting the results of tests and calculations to make predictions from circuit calculations and simulation.	N3.1 Plan an activity and get relevant information from relevant sources. N3.2 Use this information to carry out multi-stage calculations to do with: a amounts or sizes b scales or proportion c handling statistics d using formulae. N3.3 Interpret the results of your calculations, present your findings and justify your methods.
Communication Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• gathering information on electronic components, devices, circuits and systems • preparing written fault location strategies for given electronic systems • presenting the results of test data from electronic system fault-finding tests.	C3.2 Read and synthesise information from at least **two** documents about the same subject. Each document must be a minimum of 1000 words long. C3.3 Write **two** different types of documents each one giving different information about complex subjects. One document must be at least 1000 words long.

Information and communication technology Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• searching the internet and CD ROMs for product/ component/circuit information • preparing written fault location strategies for given electronic systems • recording the test data from electronic systems fault-finding tests and preparing fault-finding test reports • presenting results and reports of fault-finding exercises.	ICT3.1 Search for information, using different sources, and multiple search criteria in at least one case. ICT3.2 Enter and develop the information and derive new information. ICT3.3 Present combined information such as text with image, text with number, image with number.
Problem solving Level 3	
When learners are:	**They should be able to develop the following key skills evidence:**
• solving problems in electronics fault-finding and carrying out calculations and/or using software analysis/simulation packages to explore different approaches.	PS3.1 Explore a problem and identify different ways of tackling it. PS3.2 Plan and implement at least one way of solving the problem. PS3.3 Check if the problem has been solved and review your approach to problem solving.