Unit 30: Electronic Measurement and Testing

Level:	**3**
Unit type:	**Optional**
Assessment type:	**Internal**
Guided learning:	**60**

Unit introduction

Practical electronic engineering demands the extensive use of electronic test equipment and measurement techniques. These range from basic measurements of parameters such as voltage, current and resistance to highly sophisticated software-controlled measurements based on advanced mathematical techniques such as Fast Fourier Transformation (FFT).

This unit will give learners an understanding of a variety of electronic measurement equipment such as voltmeters, ammeters, analogue/digital multimeters and oscilloscopes or specialist diagnostic equipment. The unit also examines a range of electronic test equipment such as signal generators, digital counter/frequency meter, alternating current (AC) bridge, logic probe, logic pulsar and current tracer.

Learners will develop an understanding of the function, features and characteristics of electronic measurement and test equipment. They will also gain practical experience of their use when carrying out electronic testing and measurements in a wide range of electronic engineering applications. This will include selecting, connecting and operating different types of test equipment and applying measurement techniques.

Learners will demonstrate that they can apply common testing methods and be able to assess errors inherent in the instruments used. Particular attention is paid to ensure that the test procedure, as well as the test and measurement equipment used is fit-for-purpose and properly calibrated. Learners will be expected to explain the effects of instrument characteristics such as accuracy, display resolution and loading and how these affect the measured quantity.

Finally, learners will be introduced to the use of virtual test instruments and software to make measurements and analyse measurement data. They will examine equipment such as a digital storage oscilloscope, spectrum analyser, digital voltmeter, digital frequency meter, arbitrary waveform generator or logic analyser. Learners will be expected to make measurements using virtual instruments and analyse the captured data using appropriate software.

Note that the use of 'e.g.' 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 'e.g.' needs to be taught or assessed.

Learning outcomes

On completion of this unit a learner should:

1 Understand the function, features and characteristics of electronic measurement and test equipment

2 Be able to select and use electronic measurement and test equipment to make meaningful measurements on an electronic circuit

3 Know the principles of calibration and configuration of electronic test equipment

4 Be able to select and use virtual test instruments and software to make measurements and analyse measurement data.

Unit content

- 1 **Understand the function, features and characteristics of electronic measurement and test equipment**

  Function of equipment: as appropriate to the measurement and test equipment e.g. accurate measurement of alternating current (AC) and direct current (DC) voltage and current, resistance, waveform and distortion measurement, accurate measurement of waveform parameters (period, duty cycle, on-time, off-time, rise time, fall time, frequency, pulse repetition frequency (PRF), impedance, logic level)

  Features of equipment: as appropriate to the measurement and test equipment e.g. displays ands display technology, input and output connectors, attenuators, manual and automatic range selection (auto ranging), in-built calibration facilities, portability, power sources, external bus interfaces

  Characteristics of equipment: measurement and test equipment specifications e.g. input impedance, output impedance, resolution, accuracy, distortion, bandwidth, input signal range, output level, sample rate, trigger sources

  Measurement instruments: meters (voltmeter, ammeter); analogue/digital multimeter; oscilloscope to include specialist or manufacturer diagnostic/ measuring equipment

  Electronic test equipment: signal generator e.g. audio frequency (AF), radio frequency (RF) and pulse generators, waveform/function generators; digital counter/frequency meter; AC bridge; logic probe; logic pulsar; current tracer

- 2 **Be able to select and use electronic measurement and test equipment to make meaningful measurements on an electronic circuit**

  Selection of equipment: selection based on instrument specifications, characteristics and limitations e.g. output, level, input sensitivity, frequency range, accuracy, resolution and distortion

  Measurement techniques: test-point voltage and waveform measurement; supply voltage and current measurement; power, impedance and phase angle measurement using variable loads; frequency and PRF measurement; rise and fall time measurement; distortion and noise measurement (qualitative only); use of test specifications e.g. in the case of a variable DC power supply, measurement of the actual output voltage delivered at a specified load current when the power supply has been set to a specified voltage under no-load conditions; in the case of an audio amplifier, measurement of the output power delivered to an externally connected load of specified resistance, using a specified test frequency and waveform and at a specified level of distortion

  Measurements: use of test points, test leads and probes; minimisation of loading effects; use of appropriate instrument ranges; precautions to be taken when measuring high voltages and currents; precautions to be taken when working on low voltage and computerised systems; effect of DC levels on AC signals and waveforms; effect of signals present at DC test points; effect of drift and temperature; need for calibration; relevant test specification and measurement techniques e.g. sampling, averaging

Electronic equipment: industrial/consumer electrical and electronic equipment including low-voltage DC power supplies e.g. linear, switched-mode types; amplifiers e.g. AF, RF, small-signal, power; oscillators e.g. sinusoidal, square wave, crystal controlled; radio equipment e.g. radio receivers, low-power transmitters and transceivers; digital electronic equipment e.g. microcontrollers, microcomputers, programmable logic controllers; manufacturer specific equipment; video equipment e.g. television and video players/recorders

3 **Know the principles of calibration and configuration of electronic test equipment**

Calibration principles: procedures e.g. check, adjust, systematically standardise measuring instrument, set-up arrangement; reference standards e.g. standard resistors, standard inductor; theory e.g. accuracy, uncertainty; impact of calibration on quality, productivity and safety; applications e.g. during manufacture, following installation, periodic scheduled maintenance, in response to identified deviation, after repair or change in environment; terminology e.g. zero shift, range (or span) error, combined zero shift and range error, non-linearity

Health and safety issues: e.g. precautions to be observed when setting and adjusting mains supply voltages, replacing/charging/disposing of batteries, dismantling and reassembling equipment, removal/replacement of external and internal covers, making adjustments on 'live' equipment, continuity of earth (grounding or bonding) of electrical equipment, safety cut-outs and residual current device (RCD), earth leakage circuit breaker (ELCB)

Configuration issues: pre-conditions and checks to ensure that system/equipment is safe to test and instruments safe to use; test equipment set-up e.g. use of the equipment manufacturer's procedures, using commissioning guides

4 **Be able to select and use virtual test instruments and software to make measurements and analyse measurement data**

Virtual measurement and test system: e.g. digital storage oscilloscope, spectrum analyser, digital voltmeter, digital frequency meter, arbitrary waveform generator, logic analyser

Measurement techniques, connection, hardware and software: tests carried out on electronic equipment using virtual test and measuring instruments; instrument connection e.g. external/internal PC interface, instrument connection standards (parallel port, serial port, USB, PCI/PXI bus, IEEE-488, PCMCIA); use of hardware and software to carry out measurements e.g. voltage, frequency, frequency spectra measurements (for sinusoidal and non-sinusoidal waveforms); measurement software, data storage and data transfer e.g. to a spreadsheet, automated measurement/data collection techniques

Assessment and grading criteria

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

Assessment and 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 explain the function, features and characteristics of a measurement instrument		
P2 explain the function, features and characteristics of three different pieces of electronic test equipment		
P3 select and use test equipment and measuring techniques to take measurements from three different pieces of electronic equipment	M1 use a manufacturer's recommended procedure together with laboratory instruments and standards to calibrate and configure an item of electronic test equipment	D1 evaluate the accuracy of own test measurements and relate them to limitations of the test equipment, test procedures, or possible emerging fault conditions
P4 explain the importance of test specifications as an aid to ensuring the validity and consistency of measurements		

P5 describe the principles and need for the calibration of an item of electronic test equipment	M2 explain the importance of resolution, accuracy, sensitivity bandwidth and input impedance on the performance of a piece of test equipment	D2 devise and demonstrate a calibration procedure for an item of electronic test equipment.
P6 explain the health, safety and configuration issues that need to be considered when connecting test equipment to an item of electronic equipment that requires testing		
P7 use a virtual measurement and test system to carry out a test on a piece of electronic equipment		
P8 describe the measurement techniques, instrument connection, hardware and software used.	M3 use appropriate software to display and analyse voltage/ time data captured from a virtual oscilloscope.	

Essential guidance for tutors

Assessment

To achieve P1 and P2, learners will need to describe the function, features and characteristics of one measurement instrument and three different pieces of electronic test equipment. The evidence for this could be block diagrams/sketches (with appropriate annotation) and short notes. The actual function, features and characteristics explained will be dependent on the electronic test equipment selected but examples of the types of things to consider are provided in the unit content.

P3 requires learners to select and use test equipment and measuring techniques to take measurements from three different pieces of electronic equipment. These can be low-voltage dc power supplies, amplifiers, oscillators, radio equipment, digital electronic test, measurement or diagnostic equipment or display equipment. Further examples of each of these are provided in the unit content.

Learners will need to perform practical measurements in an electronic laboratory or electronic workshop. Given a particular measurement requirement (for example, to investigate the frequency range of an oscillator) learners should then be able to select the appropriate items of test and measurement equipment to carry out the task. Both the selected item(s) of test equipment and the measuring technique(s) should be appropriate to each measured quantity. For example, an oscilloscope and x10 probe would not be appropriate for the accurate measurement of the output frequency produced by an oscillator. The three different pieces of electronic equipment should enable as wide a range of test equipment and measuring techniques to be applied as possible. All three pieces could come from one category (e.g. consumer electrical and electronic equipment) as long as the chosen equipment provided for the use of a sufficient range of test equipment and measuring techniques. It is expected that all the content listed under measurement techniques and measurements will have been covered by the time learners has carried the measurements on all three pieces of equipment.

Evidence for P3 is likely to take the form of tutor observations and learner records of the selection and use of equipment and techniques employed. Suitably annotated photographic records could also be used (e.g. a photograph of the equipment being tested, the test equipment and the test set-up, all suitably labelled to highlight the key features of the test/measurements).

For P4, learners should provide a written or verbal presentation to explain the importance of test specifications as an aid to ensuring the validity and consistency of measurement. Centres should ensure that learners have access to a variety of test specifications for common measurements (e.g. determining the output impedance of a power supply by voltage/current measurement when a suitably rated variable load is applied). The achievement of this criterion could be effectively linked with the practical work in any one of the tests carried out for P3.

P5 requires learners to describe the principles and need for calibration of an item of electronic test equipment. Again, one of the tests undertaken for P3 could provide the focus for this criterion. The description, which is likely to be a written report, must include the electronic test equipment calibration procedures that need to be carried out, the reference standards required and any relevant theory. Examples of each of these and typical applications are given in the unit content. As an aid to understanding the calibration process, centres should demonstrate the calibration procedures for equipment used in the laboratory (e.g. oscilloscopes, digital multimeters, signal generators, etc.).

For P6, learners must be able to describe the health, safety and configuration issues that need to be considered when connecting test equipment to an item of

electronic equipment that requires testing. The health and safety issues considered will depend upon the equipment being tested. The configuration issues considered must, as a minimum, enable the learner to take into account the required pre-conditions and checks to ensure that it is safe to test the system/equipment. For example the selection of an adequately rated load in terms of both impedance and power rating when testing an audio amplifier or the need to check that an oscilloscope probe is correctly matched to the oscilloscope that it is to be used with. Learners will also need to ensure instruments are safe to use (e.g. use of a high-voltage probe when measuring DC voltages in excess of 500 V) and test equipment set-up correctly e.g. use of equipment manufacturer's procedures, using commissioning guides. Again it would make sense to link this criterion to one of the tests undertaken for P3.

To satisfy P7 and P8 learners should use a virtual measurement and test system to carry out a test on a piece of electronic equipment. They should provide a written or verbal description of the procedure used, explaining the connections made, the software settings, and the measuring techniques used. A typical example would be the use of a virtual digital storage oscilloscope used in conjunction with a personal computer (PC). Learners should connect and configure the instrument in conjunction with the software running on the PC and select, for example, appropriate sampling rates, input ranges and display and data capture settings. Evidence of individual learner's work can most conveniently be presented in the form of a selection of screen dumps that have been suitably annotated by the learner.

For M1, learners are required to calibrate and configure a test instrument (such as a waveform generator), using the manufacturer's recommended procedures and appropriate laboratory instruments and standards. Learners should be supplied with relevant documentation (e.g. manufacturer's handbook) and laboratory standards (such as a standard frequency or time generator). Evidence is likely to be a logbook record of the calibration exercise or a technical report of the calibration activity. Tutor observation records should be used to support either of these forms of evidence. There is a clear link between this merit criterion and P5.

To achieve M2 learners need to explain the importance of resolution, accuracy, sensitivity bandwidth and input impedance on the performance of a piece of test equipment. This could be achieved as a natural extension to one of the tasks carried out for P3.

To satisfy M3, learners should use a virtual storage oscilloscope (using a PC with appropriate interface hardware and software) to display and analyse a waveform. Note that the emphasis should be on the analysis of the waveform rather than its display. A typical example might involve the production of a frequency spectrum for the sampled waveform using FFT techniques. Once again, learners should keep a record of their work in a logbook, supported by tutor observation records. Relevant screen dumps and print outs that have been suitably annotated by the learner could also be incorporated.

The learner's work towards D1 should require them to evaluate the accuracy of their own test measurements and relate them to limitations of the test equipment, test procedures, or possible emerging fault conditions. For example, learners should be aware of the inability of an oscilloscope to accurately display a transient pulse due to the oscilloscope's own finite rise-time and bandwidth. Another example would be the need to be aware of the effects of aliasing on the captured and displayed waveform when sampling a fast waveform.

For D2, learners need to be able to devise and demonstrate a calibration procedure for an item of electronic test equipment. A typical example might be a procedure to calibrate a 'x10' oscilloscope probe using a fast-rise time square wave generator, a

high-speed oscilloscope, and a matching 'x10' probe. Evidence is likely to be in the form of a technical report although it would be beneficial if the devised calibration could be linked into the work done for P5 and M2.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Pearson assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2	Measurement Instruments and Test Equipment	Learners are requested to generate an information booklet and an accompanying report for new staff.	Written assignment
P3, P4, P5, P6, M1, M2, D1, D2	Selecting, Using and Calibrating Electronic Test Equipment	Learners have been asked to show a new learner how to take measurements from electronic equipment and talk them through the calibration of test equipment and relevant health, safety and configuration issues.	A practical assignment with additional written tasks
P7, P8, M3	Virtual Testing	Learners have been asked by their employer to carry out tests on a piece of electronic equipment.	A practical assignment

Essential resources

Centres will need to provide access to an electronics laboratory fitted with a range of electronic test and measurement equipment (such as multimeters, signal generators, oscilloscopes, or specialist manufacturer equipment within industry etc.). A limited number of specialist items of electronic test equipment and calibration sources (e.g. standard cells and off-air signal sources) should also be available. Specialist items of electronic equipment (such as AC bridges, earth continuity testers, logic analysers, component testers, etc.) may be required as appropriate to the needs of local industry.

A small number of computer-based virtual instruments should also be available together with the appropriate hardware and software (e.g. LabVIEW, DASYLab, DADiSP, MATLAB etc.). Test and measurement applications should be installed on these systems.

Indicative reading for learners

Textbooks

Hughes E – *Electrical and Electronic Technology* (Pearson Education, 2012) ISBN 9780273755104

Tooley M – *Electronic Circuits: Fundamentals and Applications* (Routledge, 2006) ISBN 9780750669238

Tooley M – *PC Based Instrumentation and Control* (Routledge, 2005) ISBN 9780750647168