

SQA Advanced Unit specification: general information

Unit title: Application of Electrical and Electronic Instruments

Unit code: HV2H 46

Superclass: XJ

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Unit purpose

This Unit is designed to provide candidates with the opportunity to develop practical skills in the testing and measurement of electrical circuit properties using a range of analogue and digital instruments.

On completion of the Unit the candidate should be able to:

- 1 Describe the function of measuring and test instruments, and their effect on the circuits in which they are connected.
- 2 Safely use analogue and digital multi-meters to measure parameters of electrical circuits.
- 3 Safely use an oscilloscope to measure waveform parameters in electrical circuits.
- 4 Safely use electrical installation test instruments to test electrical circuits.

Recommended prior knowledge and skills

Candidates should have some knowledge and understanding of electrical power circuits and the need to measure the characteristics of these. This may be evidenced by the possession of the following SQA Advanced Unit: HP47 47 *DC and AC Principles*. However, entry requirements are at the discretion of the centre.

Credit points and level

1 SQA Credit at SCQF level 6: (8 SCQF credit points at SCQF level 6*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates.*

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Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the Support Notes of this Unit specification.

There is no automatic certification of Core Skills or Core Skill components in this Unit.

Context for delivery

This Unit was developed for the SQA Advanced Certificate/SQA Advanced Diploma in Electrical Engineering. If this Unit is delivered as part of a group award, it is recommended that it should be taught and assessed within the subject area of the group award to which it contributes.

Unit specification: statement of standards

Unit title: Application of Electrical and Electronic Instruments

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The sections of the Unit stating the Outcomes, Knowledge and/or Skills, and Evidence Requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Describe the function of measuring and test instruments, and their effect on the circuits in which they are connected.

Knowledge and/or Skills

- ◆ Appreciation of the need for measuring and test instruments.
- ◆ Appreciation of the need to correctly interpret measured values.
- ◆ Appreciation that the instrument itself has a loading effect on the circuit.
- ◆ Comparison of analogue and digital instruments.
- ◆ Awareness of manufacturer's specifications in the selection of instruments for given applications.
- ◆ Connection of instruments for measurement of current, voltage and power values.

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this Outcome **four out of six** knowledge and/or skills items should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of four out of six knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all four items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ Describe the need for measuring and test instruments.
- ◆ Explain the importance of correctly interpreting measured values.
- ◆ Describe the loading effect of an instrument on the circuit into which it is connected.
- ◆ Describe the advantages and limitations of analogue and digital instruments.

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- ◆ Describe how manufacturer's specifications influence the selection of instruments for given applications.
- ◆ Draw circuit diagrams to show the connections of an ammeter, voltmeter and wattmeter for measurement of current, voltage and power values respectively.

Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under closed-book conditions and, as such, candidates must not be allowed to bring any textbooks, handouts or notes to the assessment.

Outcome 2

Safely use analogue and digital multi-meters to measure parameters of electrical circuit.

Knowledge and/or Skills

- ◆ Comparison of analogue and digital instruments.
- ◆ Appropriate instrument selection using manufacturer's specifications.
- ◆ Instrument sensitivity, loading effects and errors.
- ◆ Use of analogue and digital instruments to measure current, voltage and resistance values in electrical circuits.

Outcome 3

Safely use an oscilloscope to measure waveform parameters in electrical circuits.

Knowledge and/or Skills

- ◆ Comparison of analogue and digital oscilloscopes.
- ◆ Use of manufacturer's specifications in the calibration and adjustment of an oscilloscope.
- ◆ Use of manufacturer's specifications to select an oscilloscope for a given application
- ◆ Use of an oscilloscope to measure electrical waveform parameters.
- ◆ Interpretation of results obtained from oscilloscope measurements.

Outcome 4

Safely use electrical installation test instruments to test electrical circuits.

Knowledge and/or Skills

- ◆ Description of function of electrical installation test instruments
- ◆ Appreciation of the system/circuit parameters measured by the test instruments.
- ◆ Appreciation of standard/reference test values.
- ◆ Use of manufacturer's specifications to select appropriate instruments for given applications.
- ◆ Use of instruments to measure circuit/system parameters.
- ◆ Comparison of measured and expected values and the implications of variances.

Evidence Requirements for Outcomes 2 to 4

Evidence for the knowledge and /or skills in Outcomes 2 to 4 will be recorded on a test results schedule document. Each candidate will need to demonstrate that she/he can select and use appropriate instruments safely and effectively to measure the parameters given in the knowledge and skills items in all three Outcomes.

For Outcome 2, current, voltage and resistance values should be measured using both analogue and digital instruments.

For Outcome 3, the most appropriate oscilloscope should be used.

For Outcome 4, a sample of three out of the six parameters: insulation resistance, circuit continuity, earth fault loop impedance, prospective short-circuit current (PSCC), load current, residual current device (RCD) operation should be measured.

Candidates should produce a written report on the measurement tasks for each Outcome. These reports should include as appropriate:

- ◆ Reasons for the choice of instrument
- ◆ Test result schedule
- ◆ Comparisons of measured values with expected values
- ◆ Reasons for variations between measured and expected values

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of three out of six parameters from Outcome 4 are required each time the Unit is assessed.

Candidates must provide a satisfactory response to all items.

This testing exercise is intended to be undertaken on a simulated LV circuit operating at a safe level of working voltage. Load devices used in this exercise should relate to an industrial, domestic or commercial environment.

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A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

Outcome 2

- ◆ Select the most appropriate instrument in terms of the advantages and limitations of analogue and digital instruments.
- ◆ Select the most appropriate instrument in relation to the load parameter to be measured and the instrument specification.
- ◆ Use analogue and digital instruments to measure current, voltage and resistance values in electrical circuits.
- ◆ Interpret the measured results in terms of instrument sensitivity, the effects of instrument loading and instrument errors.

Outcome 3

- ◆ Select analogue and digital oscilloscopes in terms of the relative advantages and limitations.
- ◆ Use manufacturer's specifications to select an oscilloscope for a given application
- ◆ Carry out the appropriate calibration and adjustments of an oscilloscope.
- ◆ Use a digital or analogue oscilloscope to measure voltage amplitude and frequency of an electrical waveform.
- ◆ Interpret the results obtained from oscilloscope measurements.

Outcome 4

- ◆ Describe the functions of the appropriate electrical installation test instruments.
- ◆ Select appropriate instruments to measure the system/circuit parameters, ie insulation resistance, circuit continuity, earth fault loop impedance, prospective short-circuit current (PSCC), load current, residual current device (RCD) operation.
- ◆ State appropriate reference values for the listed system parameters.
- ◆ Select the most appropriate instruments for measuring the listed system parameters.
- ◆ Use appropriate instruments to measure the listed system parameters.
- ◆ Compare the measured parameters with their respective expected values and comment on the implications of any variances.

Unit specification: support notes

Unit title: Application of Electrical and Electronic Instruments

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

This Unit has been written in order to allow candidates to develop their practical skills in the use of measuring and testing instruments as follows:

- 1 Function of measuring and test instruments and their effect on the circuits in which they are connected.
- 2 Analogue and digital multi-meters to measure the parameters of electrical circuits.
- 3 Oscilloscopes to measure waveform parameters in electrical circuits.
- 4 Appropriate electrical installation instruments to test electrical circuits.

In designing this Unit, the Unit writer has identified the range of topics expected to be covered by lecturers. The writer has also given recommendations as to how much time should be spent on each Outcome. This has been done to help lecturers decide what depth of treatment should be given to the topics attached to each of the Outcomes. Whilst it is not mandatory for Centres to use this list of topics, it is recommended that they do so since the assessment exemplar pack for this Unit is based on the knowledge and/or skills and list of topics in each of the Outcomes.

A list of topics for each Outcome is given below. Lecturers are advised to study this list in conjunction with the assessment exemplar pack so that they can get a clear indication of the standard of achievement expected of candidates in this Unit.

Reference should be made to manufacturer's data and specifications prior to using specific test/measuring instruments. Characteristics and features including instrument sensitivity, loading effect, precautions during use modes of operation etc. should be included.

1 Describe the function of measuring and test instruments, and their affect on the circuits in which they are connected. (4 hours).

The purpose of this Outcome is to provide the candidate with the basic theory of instrument use and highlight the main characteristics of various instruments.

- ◆ The need for measuring instruments.
- ◆ The need to correctly interpret instrument readings by comparison with optimum/reference values.
- ◆ Appropriate instrument selection for given applications.
- ◆ Advantages/disadvantages of digital and analogue instruments.
- ◆ Connection of instruments in circuit for current, voltage and power measurement.
- ◆ Effect of instrument loading on measured values.

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2 Safely use analogue and digital multi-meters to measure parameters of electrical circuits. (10 hours).

This Outcome considers the safe and effective use of analogue and digital multi-meters, their applications and use in relation to measuring electrical quantities in circuits.

- ◆ Advantages and disadvantages of using moving coil and electronic multi-range instruments for measuring voltage, current and resistance.
- ◆ Zero settings and accuracy.
- ◆ Instrument sensitivity.
- ◆ Calculation of analogue instrument impedance using manufacturer's data.
- ◆ Calculation of loading effects of analogue instruments when used as ammeters and voltmeters.
- ◆ Selection of instrument range.
- ◆ Scale factors.
- ◆ Instrument errors.
- ◆ Applications of analogue and digital multi-meters to measure current, voltage and resistance in practical circuits.
- ◆ Comparison of accuracy from analogue and digital readings.

3 Safely use an oscilloscope to measure waveform parameters in electrical circuits. (12 hours).

The intention of this Outcome is to provide the candidate with practical experience in the safe and effective use of oscilloscopes and with an understanding of their operation.

- ◆ Principle of operation of analogue and digital oscilloscopes. (Block diagram approach).
- ◆ Comparison of analogue and digital oscilloscopes.
- ◆ Setting up of oscilloscope.
- ◆ Calibration of oscilloscope.
- ◆ Selection of 'y' input sensitivity and 'x' time division.
- ◆ Triggering setting.
- ◆ Use of oscilloscope to measure dc, sinusoidal and pulse waveform characteristics i.e. peak-to-peak values, periodic time, frequency, mark-to-space ratio.
- ◆ Problems associated with measuring very low frequency signals.
- ◆ Use of manufacturers' specification/data sheets to select suitable oscilloscope for given application on electrical circuit.
- ◆ Set up and use oscilloscope to measure characteristics of electrical circuit.

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4 Safely use electrical installation test instruments to test electrical circuits. (14 hours)

This Outcome should provide candidates with the opportunity to use instruments safely and effectively to measure the properties of electrical systems and to compare these with expected standard/reference values.

- ◆ The need for testing of electrical circuits/systems.
- ◆ Description of test instruments for: insulation resistance testing, continuity testing, earth fault loop impedance testing, prospective short-circuit current (PSCC) testing, load current testing, residual current device (RCD) testing.
- ◆ Appreciation of expected test results.
- ◆ Setting up the instruments.
- ◆ Precautions during testing.
- ◆ Use of manufacturer's data sheets and specifications in the selection and use of instruments for a given application.
- ◆ Use of instruments to measure system parameters. (electrical installation circuits, motor control circuits etc. may be used).
- ◆ Comparison of measured values with standard/reference values and the implications of result variances.

Guidance on the delivery of this Unit

This Unit was developed within the mandatory section of the SQA Advanced Certificate and SQA Advanced Diploma Awards in Electrical Engineering. It should be seen as being complimentary to the SQA Advanced Units HV3L 47 *Electricity Power Systems*, HV3A 47 *Electrical Safety* and HV3M 47 *Electrical Installation Skills*.

Guidance on the assessment of this Unit

The assessment for Outcomes 1 in this Unit should be in the form of one written assessment paper. This paper should be taken by candidates at one single assessment event that should last one hour. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions. This assessment should be conducted under controlled, supervised conditions. Candidates will not be allowed to consult notes, textbooks etc during the assessment exercises.

The assessment for Outcomes 2, 3 and 4 in this Unit may be combined to form one practical assignment exercise, lasting 6 hours, in which the candidates are asked to complete a series of tasks to demonstrate their ability to obtain the parameters of electrical circuits using test and measuring instruments and to write a short report on their findings.

This assessment may be divided into three discrete assessments lasting 2 hours each. Successful candidates should provide a satisfactory response to all items of this assessment exercise. Candidates should be provided with copies of the relevant sections of the current IEE Wiring Regulations BS 7671.

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The written assessment for Outcome 1 should be taken after the delivery of this Outcome. The practical assignment assessment for Outcomes 2, 3, and 4 should be carried out at the end of delivery of this Unit or may be spread over the delivery period. Both assessments will be carried out under supervised and controlled conditions.

Note:

Assessment of Outcomes 2, 3 and 4 may be undertaken during the delivery of other Units within SQA Advanced Certificate and SQA Advanced Diploma group awards. For example, there are opportunities to assess aspects of Outcomes 2 and 3 while carrying out laboratory tasks in the following Units: HP46 47 *DC and AC Principles*; HT7K 47 *Three Phase Systems*; HP3J 47 *Electrical Networks and Resonance*; and HT1R 47 *Fundamentals of Control Systems and Transducers*.

There are opportunities to assess aspects of Outcome 4 while carrying out practical work in the following Units: HV3M 47 *Electrical Installation Skills*; and HV2L 47 *Inspection and Testing of Low Voltage Installations*.

Assessment Guidelines

Outcome 1

The assessment of this Outcome should be in the form of a single assessment paper. The single assessment paper should be taken at a single assessment event lasting one hour and be carried out under supervised, controlled conditions. Such a paper should be composed of an appropriate balance of short answer, restricted response and structured response questions. This assessment should be carried out after the delivery of Outcome 1. This assessment will be carried out under supervised and controlled conditions. Candidates will not be allowed to consult notes, textbooks etc. during the assessment exercise.

Outcome 2–4

The assessment of Outcomes 2, 3 and 4 may be combined to form a single assessment exercise of 6 hours duration however, it may be more practical to divide it into three discrete assessments lasting 2 hours each, these assessments being spread over the delivery period of the Unit. The assessment exercise will specify that the work is intended to be undertaken on a simulated LV circuit operating at a safe level of working voltage and using loads related to an industrial, domestic or commercial environment. Such assessment exercise is intended to take place in a supervised laboratory or workshop environment. Candidates should have access to relevant information relating to the load characteristics and the specification of the instruments to be used.

It is important that centres develop a checklist to record the assessment requirements for each of the knowledge and/or skills items.

The assessment exercises should be carried out under controlled and supervised conditions and centres should ensure that the evidence generated is the candidate's own work

Candidates should be provided with copies of the relevant sections of the current IEE Wiring Regulations BS 7671.

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The assessment of Outcomes 2, 3 and 4 should be undertaken at the end of delivery of this Unit or may be spread over the delivery period. Assessment may be undertaken while carrying out laboratory tasks within the delivery of other appropriate Units.

Online and Distance Learning

This Unit may be delivered by distance learning however, due to its largely practical nature and significant resource requirements, a considerable degree of centre support will be required.

With regard to assessment, the centre concerned would be required to ensure that the test results and outcome of the testing procedures are indeed the work of the candidate and must be able to authenticate the assessment evidence. Arrangements would be required to ensure that the assessment was conducted under controlled and supervised conditions.

Opportunities for developing Core Skills

In this Unit candidates will develop practical skills in the testing and measurement of electrical circuit properties using a range of analogue and digital instruments.

Candidates will:

- ◆ describe:
 - the function of measuring and test instruments, and their effect on the circuits in which they are connected
 - the advantages and limitations of analogue and digital instruments
 - how manufacturer's specifications influence the selection of instruments for given applications.
- ◆ draw circuit diagrams to show the connections of an ammeter, voltmeter and wattmeter for measurement of current, voltage and power values respectively.
- ◆ select and use appropriate:
 - analogue and digital instruments to measure, current, voltage and resistance values in electrical circuits
 - an oscilloscope to measure electrical waveform parameters in electrical circuits
 - electrical installation instruments to measure circuit/system parameters.
- ◆ report on the measurement tasks which include: reasons for the choice of instrument, test result schedule, comparisons of measured values with expected values and reasons for variations between measured and expected values.

This means that as candidates are doing the Unit they will be developing aspects of the Core Skills in *Communication*, *Numeracy* and *Problem Solving*.

Equality and inclusion

This unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website www.sqa.org.uk/assessmentarrangements.

History of changes to Unit

Version	Description of change	Date

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General information for candidates

Unit title: Application of Electrical and Electronic Instruments

This Unit has been developed to provide you with an appreciation of both analogue and digital instruments and give you an opportunity to use these instruments safely and effectively to measure appropriate circuit parameters and to compare the results of these measurements.

The Unit will provide you with an appreciation of the need for test and measuring instrument and how to interpret the measured values. It considers how the instrument itself affects the loading of the circuit and the errors which might result from this. The Unit also develops your awareness of manufacturer's specification documentation for instruments and your use of these in selecting the most appropriate instrument for a particular application. Both digital and analogue instruments are considered in this Unit.

A wide range of instruments is considered by this Unit to give you an appreciation of many aspects of instrument use. This includes multipurpose instruments, oscilloscopes and instruments for the testing of electrical installations. It is hoped that this range will cover most of the general applications you will be expected to cover throughout your electrical engineering career.

By the end of this Unit you should have a good appreciation of a wide range of instruments and their applications and have developed an understanding the parameters which each instrument is designed to measure, the advantages and limitations of each instrument, the sensitivity and accuracy of instruments and the factors governing the choice of instrument for a given application. You will also have developed your skills in using instruments to measure the parameters of electrical circuits and will be able to apply these skills in a practical manner.

The formal assessment of this Unit is in two parts. Firstly, you will be expected to undertake a short written assessment on your appreciation of test instruments and how they are used to measure circuit parameters Secondly, you will be required to carry out a series of tasks to assess your ability to select the most appropriate instruments to measure specific parameters and the use of these instruments safely and effectively in measuring the values of these parameters. A test results schedule will be used to record the results of this measurement exercise and you will be expected to write reports on your findings.

The first of these two assessments will be taken after Outcome 1 has been delivered. You will not be allowed to consult notes, textbooks etc. The second assessment will be taken at the end of the Unit, or may be spread throughout the Unit delivery time. For this assessment you may be provided with copies of the relevant sections of the current IEE Wiring Regulations BS 7671. All assessments will be carried out under supervised and controlled conditions.