SQA Advanced Unit Specification

General information for centres

Unit title: Electrical Engineering Principles 2

Unit code: HV32 47

Unit purpose: This Unit has been designed to enable candidates to develop the knowledge, understanding and skills to apply the Superposition, Thevenin and Norton's Theorems to the solution of DC circuit problems. The Unit will also allow candidates the opportunities to develop knowledge, understanding and skills to solve parallel AC circuit, ideal transformer and balanced three-phase load problems.

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

1 Use network theorems to solve DC circuit problems.
2 Solve parallel AC circuit problems.
3 Solve ideal transformer problems.
4 Solve balanced three phase load problems.

Credit points and level: 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*).

**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.*

Recommended prior knowledge and skills: Entry to the Unit is at the discretion of the centre however candidates should have knowledge and understanding of approaches to solving DC and AC series circuit problems. This knowledge and understanding may be evidenced by possession of the following SQA Advanced unit: Electrical Engineering Principles 1.

Core Skills: There are opportunities to develop the Core Skills of Using Number and Critical Thinking at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Context for delivery: 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.

Assessment: The assessment for this Unit should comprise of two separate assessment papers. One assessment paper should cover Outcomes 1 and the other should cover Outcomes 2, 3 and 4. The assessment paper for Outcome 1 should last one hour and 15 minutes and the paper for Outcomes 2, 3 and 4 should last one hour and 45 minutes. Both papers should be taken at single assessment events and should be carried out under supervised, controlled conditions. Assessment should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates should be permitted to use scientific calculators during the assessments.

SQA Advanced Unit Specification: statement of standards

Unit title: Electrical Engineering Principles 2

Unit code: HV32 47

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

Use network theorems to solve of DC circuit problems

Knowledge and/or skills

- Superposition Theorem
- Solve DC circuit problems using the Superposition Theorem
- Ideal and practical constant voltage sources
- Ideal and practical constant current sources
- Thevenin's Theorems
- Norton's theorem
- Application of Thevenin's Theorem to the solution of DC circuit problems
- Application of Norton's Theorem to the solution of DC circuit problems

Evidence Requirements

Evidence for the knowledge and/or skills items in Outcome 1 should be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that she/he can answer correctly questions based on a sample of the items shown under the knowledge and/or skills items in Outcome 1. In any assessment of the Outcome **bullet point 7 plus any other five out of seven** knowledge and/or skills items should be sampled.

In order to ensure that candidates will not be able to for see what items they will be questioned on, a different sample of five out of seven knowledge and/or skills items (plus bullet point 7) are required each time the Outcome is assessed. Candidates must provide a satisfactory response to all sampled 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 the candidate is able to:

- state the Superposition Theorem
- calculate current and voltage (or power) values in a two mesh DC resistance network containing two voltage sources using the Superposition Theorem
- identify the differences between an ideal and practical constant voltage source
- identify the differences between an ideal and practical constant current source
- state Thevenin's Theorem

- state Norton's Theorem
- apply Thevenin's Theorem to a DC network comprising of one voltage source and a minimum of four resistors plus a load resistor
- apply Norton's Theorem to a DC network comprising of one voltage/current source and a minimum of four resistors plus a load resistor

The assessment for Outcome 1 should be in the form of a single assessment paper. This assessment paper should be taken at a single assessment event lasting one hour and 15 minutes and carried out under supervised, controlled conditions. Assessment should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates should be permitted to use scientific calculators during the assessment.

Assessment guidelines

The assessment paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

Outcome 2

Solve parallel AC circuit problems

Knowledge and/or skills

- Graphical solutions
- Algebraic solutions
- Conductance, Susceptance and Admittance
- Active Power, Apparent Power, Reactive Power and power factor

Outcome 3

Solve ideal transformers problems

Knowledge and/or skills

- Transformer operation
- Transformer characteristics
- Ideal and practical transformers
- $E_1/E_2 = N_1/N_2$ and $I_1/I_2 = N_2/N_2$
- Calculations involving an ideal transformer on load
- Phasor diagram of an ideal transformer on load

Outcome 4

Solve balanced three-phase load problems

Knowledge and/or skills

- Generation of three phase supplies
- Star and delta windings and loads
- Line and phase voltage and current relationships associated with star and delta loads
- Power relationships
- Calculations involving star and delta loads
- Phasor diagram for star and delta load

Evidence requirements

Evidence for the knowledge and/or skills items in Outcomes 2, 3 and 4 will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that she/he can answer correctly questions based on a sample of the items shown under the knowledge and/or skills items in all three outcomes. In any assessment of the outcomes **bullet point 1** and **any two out of three** knowledge and/or skills items should be sampled from Outcome 2, **bullet point 5** and **any other three out of five** knowledge and/or skills items should be sampled from Outcome 3 and **bullet point 5** and **any other three out of five** knowledge and/or skills items should be sampled from Outcome 4.

In order to ensure that candidates will not be able to for see what items they will be questioned on, a different sample of two out of three knowledge and/or skills items (plus bullet point 1) from Outcome 2, three out of five knowledge and/or skills items (plus bullet point 5) from Outcomes 3 and a different sample of three out of five knowledge and/or skills items (plus bullet point 5) from Outcome 4 are required each time the Unit is assessed. Candidates must provide a satisfactory response to all sampled 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 the candidate is able to for:

Outcome 2

- determine impedance, current and voltage quantities in AC parallel circuits using graphical methods
- determine impedance, current and voltage quantities in AC parallel circuits using algebraic methods
- use Conductance, Susceptance and Admittance in solving parallel AC circuit problems
- calculate active power, apparent power, reactive power and power factor in a parallel AC circuit

Outcome 3

- explain the principle of operation of a transformer
- identify the characteristics of an ideal transformer
- compares the characteristics of ideal and practical transformers (descriptive only)
- undertakes calculations using $E_1/E_2 = N_1/N_2$ and $I_1/I_2 = N_2/N_2$
- undertake calculations involving an ideal transformer connected to an R-L load
- draws the phasor diagram of an ideal transformer connected to an R-L load

Outcome 4

- explain, with the aid of an appropriate diagram (s), the way in which a three-phase supply is produced
- identifies different forms of star and delta generator winding and load arrangements
- identifies line and phase voltage and current relationships associated with star and delta loads
- state the following relationships: Total Active Power = $\sqrt{3}\ V_L\ I_L \cos \Phi$; Total Apparent Power= $\sqrt{3}\ V_L\ I_L$ and Total Reactive Power = $\sqrt{3}\ V_L\ I_L \sin \Phi$
- calculates current, voltage and power quantities (including power factor) in one balanced star and one balanced delta load
- draws the complete phasor diagram for a balanced star or delta connected load

The assessment for Outcomes 2, 3 and 4 should be combined to form one assessment paper. This assessment paper should be taken at a single assessment event lasting one hour and 45 minutes and carried out under supervised, controlled conditions. Assessment should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates should be permitted to use scientific calculators during the assessment.

Assessment guidelines

The assessment paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

Administrative Information

Unit code: HV32 47

Unit title: Electrical Engineering Principles 2

Superclass category: XJ

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History of Changes:

Version	Description of change	Date

Source: SQA

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

SQA Advanced Unit specification: support notes

Unit title: Electrical Engineering Principles 2

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

The Unit has been written in order to allow candidates to develop knowledge, understanding and skills in the following areas:

1 Applying network theorems to the solution of DC circuit problems.
2 Solving parallel AC circuit problems.
3 Solving ideal transformer problems.
4 Solving balanced three phase load problems.

This Unit has been developed as one of two Electrical Principles Units within the SQA Advanced Certificate in Engineering Practice and SQA Advanced Certificate/Diploma in Mechatronics award frameworks. The other unit is Electrical Engineering Principles 1, which is a SCQF Level 6 unit. Both Electrical Engineering Principles 1 and 2 may be stand alone units in other SQA Advanced Certificate/Diploma awards.

In designing this Unit, the Unit writers have identified the range of topics they would expect to be covered by lecturers. The writers have 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 a centre to use this list of topics it is strongly recommended that it does so to ensure continuity of teaching and learning across the Electrical Engineering Principles units and because the assessment exemplar pack for this Unit is based on the knowledge and/or skills and list of topics in each of the Outcomes.

The list of topics 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.

Outcome 1

Use network theorems to solve d.c circuit problems (12 hours)

- explanation of Superposition Theorem
- the Superposition Theorem applied to two mesh resistive networks containing two voltage sources
- comparison of the application of Kirchhoff's Laws and the Superposition Theorem to the solution of electrical network problems
- state that an ideal voltage source is one whose voltage remains constant irrespective of the load applied and has no internal resistance
- state that a practical voltage source is one whose voltage varies with load and has internal resistance
- compare the characteristics of ideal and practical voltage sources graphically

- provide examples of voltage sources (e.g. battery, 230 V mains socket, power supply) and explore how closely these come to being ideal voltage sources
- state that an ideal current source is one whose current remains constant irrespective of the load applied and has no internal resistance
- state that a practical current source is one whose current varies with load and has internal resistance
- compare the characteristics of ideal and practical current sources graphically
- provide examples of current sources (e.g. electronic circuitry)
- explain Thevenin's Theorem
- demonstrate techniques for determining the Thevenin equivalent resistance of a circuit (containing resistors only)
- demonstrate techniques for determining the open circuit voltage across terminals where the load has been removed
- undertake calculations on DC circuits using Thevenin's theorem
- explain Norton's Theorem
- demonstrate techniques for determining the short circuit current between terminals where the load has been removed
- undertake calculations on DC circuits using Norton's theorem
- convert Thevenin equivalent circuits to Norton equivalent circuit and vice versa

Candidates should be allowed sufficient time to undertake formative assessments on the application of the Superposition and Thevenin and Norton's Theorems to DC circuit problems.

Areas for practical work may include, but not limited to, the following:

- explore the characteristics of a range of practical voltage sources and determine how closely they approximate to an ideal voltage source.

Assessment = 1 hour and 15 minutes

Outcome 2

Solve parallel AC circuit problems (9-hours)

- explain that voltage is the common phasor in parallel circuits
- demonstrate how graphical techniques using phasor diagrams can be used to solve AC parallel circuit problems
- demonstrate how algebraic techniques can be used to solve AC circuit problems
- undertake calculations on AC parallel circuits using graphical and algebraic methods
- explain what are meant by the terms Admittance, Conductance and Susceptance
- use Admittance to solve AC circuit problems
- calculate Active Power, Apparent Power, Reactive Power and power factor in parallel AC circuits

Candidates should be allowed sufficient time to undertake formative assessments on AC circuit problems.

Areas for practical work may include, but not limited to, the following

Measure current, voltage and power quantities in AC circuit and compare with calculated values

Outcome 3

Solve ideal transformers problems (6 hours)

- explain the principle of operation of a transformer
- examine the constructional features of typical transformers
- outlines the characteristics of an ideal transformer
- compares the characteristics of ideal and practical transformers (descriptive only)
- develop the equations $E_1/E_2 = N_1/N_2$ and $I_1/I_2 = N_2/N_2$
- undertake calculations involving an ideal transformer on load
- develop the phasor diagram for an ideal transformer on load

Candidates should be allowed sufficient time to undertake formative assessments on calculations involving ideal transformers.

Outcome 4

Solve balanced three phase load problems (10 hours)

- explain, with the aid of appropriate diagrams, the way in which three phase supplies is generated
- explain the advantages of three-phase supplies over single phase supplies
- clarify the notation used in three phase theory and practice
- outline star and delta winding and load configurations
- develop line and phase voltage and current relationships associated with star and delta loads
- develop the relationships: Total Active Power = $\sqrt{3}\ V_L\ I_L \cos \Phi$; Total Apparent Power= $\sqrt{3}\ V_L\ I_L$ and Total Reactive Power = $\sqrt{3}\ V_L\ I_L \sin \Phi$
- undertake calculations involving current, voltage and power quantities (including power factor) on balanced star and delta loads
- draws the complete phasor diagram for balanced star and delta connected loads

Candidates should be allowed sufficient time to undertake formative assessments on balanced three-phase load problems.

Areas for practical work may include, but not limited to, the following

Measurement of current, voltage and power quantities in balanced three-phase star and delta connected loads and comparison of measured values with calculated values.

Assessment = 1 hour and 45 minutes

Guidance on the delivery and assessment of this Unit

For candidates who have studied electrical principles previously, parts of this Unit may provide opportunities to revise the concepts, theories and practices.

This Unit has been designed to incorporate sufficient time to allow lecturers to teach each outcome contained in the Unit. The Unit has also been written to allow sufficient time for candidates to practice what they have learnt through appropriate formative assessment exercises. Additionally, the Unit has been designed to incorporate time for some experimental work and computer simulations (these will not be formally assessed in the Unit) so that candidates have an opportunity to confirm electrical theories in practice. Whilst it is recognised that computer simulation can be a valuable tool in confirming electrical theories, it is nevertheless felt important that candidates do some practical laboratory work so that they can gain experience in reading and wiring up circuit diagrams, using test equipment, analysing the results of experiments etc.

In regard to transformers, it is recommended that candidates are allowed to see different types of transformers disassembled so that they can study the various component parts at close hand. Good charts showing the disassembled parts of transformers will also assist candidate learning.

The total assessment time of three hours has been taken into account when the overall time allocation has been addressed.

Candidates will have opportunities to develop their knowledge and skills in Using Numbers and in Critical Thinking while undertaking formative assessment exercises involving a range of electrical problems and when analysing the results of electrical experiments.

This Unit and the Electrical Engineering Principles 1 Unit are designed to provide a complete course of studies in fundamental electrical principles for craft engineering candidates. It is recommended that this Unit is studied following the Electrical Engineering Principles 1 Unit.

Where this Unit is incorporated into other awards it is recommended that it be delivered in the context of the specific occupational area(s) that the award is designed to cover.

Information on Evidence requirements and Assessment guidelines is given after Outcomes 1 and 4 in the SQA Advanced Unit specification: statement of standards section. The first written assessment should take place after Outcomes 1 has been delivered and the second written assessment after Outcomes 2 to 4 have been completed.

Opportunities for developing Core Skills

There are opportunities to develop the Core Skills of Using Number and Critical Thinking at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line support. However, with regards to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that assessment, whether done at a single or multiple events, was conducted under controlled, supervised conditions.

To keep administrative arrangements to a minimum, it is recommended that for distance learning candidates the two assessment papers are taken at two separate assessment events following the guidance given in the Evidence requirement sections of Outcomes 1 and 4 in the SQA Advanced Unit specification: statement of standards section.

For further information and advice, please see *Assessment and Quality Assurance of Open and Distance Learning* (SQA, February 2001 — publication code A1030).

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.

General information for candidates

Unit title: Electrical Engineering Principles 2

In this Unit you will study three very important theorems, Superposition, Thevenin and Norton's theorem which are used in Electrical and Electronic Engineering to solve many different types of circuit problems. You will also learn about parallel AC circuits, transformers, which are used widely in both Electrical and Electronic Engineering and about three-phase supplies which are used to transmit electrical power to industry and the home.

This Unit will normally be delivered by a combination of lectures, tutorial exercises, practical work and/or computer work. The tutorial exercises will be designed to develop your knowledge, skills and confidence in solving electrical problems. Practical work is particularly important as it will allow you to confirm electrical theorem in practice as well as allowing you to learn important electrical skills such as interpreting circuit/wiring diagrams, wiring up circuits, using electrical test equipment and interpreting the results of experiments. Please ask your lecturer what practical work you will do in this Unit.

The formal assessment for this Unit will consist of two assessment papers: one for Outcome 1 and the other for Outcomes 2, 3 and 4.The assessment paper for Outcome 1 will last one hour and 15 minutes and the paper for Outcomes 2, 3 and 4 will last one hour and 45 minutes. Both papers will be taken at single assessment events and be carried out under supervised, controlled conditions. Assessment will be conducted under closed book conditions and as such you will not be allowed to bring any textbooks, handouts or notes into the assessment. However, you will be allowed to use a scientific calculator during the assessments.