SQA Advanced Unit Specification

General information for centres

Unit title: Electrical Networks and Resonance

Unit code: HP3J 47

Unit purpose: This Unit is designed to enable candidates to develop knowledge and understanding and apply a range of network theorems to the solution of dc and ac electrical network problems. The Unit also allows candidates to undertake a detailed study of series and parallel electronic and electrical passive resonant circuits that includes the calculation of Q - factor and bandwidth and the plotting of impedance - frequency and current - frequency curves for both series and parallel cases.

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

1. Apply network theorems to solve electrical network problems.
2. Solve problems involving resonating passive circuits**.**

Credit value: 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: Candidates should have a knowledge and understanding of electrical theory including ac theory. Possession of the SQA Advanced Unit Single Phase AC Circuits may evidence this. Alternatively, the possession of some or all of the following may evidence suitable knowledge and understanding: a Higher in Electrical Engineering (C026 12) or the following National Qualification Units: D136 12 AC Circuit Theory and Applications; E9RR 12 Circuit Elements; E9RS 12 DC and AC Circuit Responses; E9RX 12 Network Analysis; E9S0 12 Single Phase AC and E9RY 12 Power Factor Improvement and Three Phase Theory.

Core skills: There may be opportunities to gather evidence towards Core Skills in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Context for delivery: This Unit was developed for the SQA Advanced Certificate and SQA Advanced Diploma in Electronics awards. If the Unit is used in another group award(s) it is recommended that it should be taught and assessed within the context of the particular group award(s) to which it contributes.

The Assessment Support Pack (ASP) for this unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website **(http://www.sqa.org.uk/sqa/46233.2769.html)**.

Assessment: The assessment for both Outcomes in this Unit should be combined together into one assessment paper. This paper should be taken by candidates at one single assessment event that should last one hour and thirty minutes. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions. Assessment should be conducted under controlled, supervised conditions. It should be noted that candidates must achieve all the minimum evidence specified for each Outcome in order to pass the Unit.

Furthermore, where a centre considers it appropriate, the assessment for this Unit could be combined with the assessment for the Unit Single Phase AC Circuits into one assessment paper. This paper should be taken by candidates at one single assessment event that should last two hours and thirty minutes. The assessment paper should be composed of a suitable balance of short answer, restricted response and structured questions. Assessment should be conducted under controlled, supervised conditions. It should be noted that candidates must achieve all the minimum evidence specified for each Outcome in this Unit and the Unit Single Phase AC Circuits in order to pass both Units.

Unit specification: statement of standards

Unit title: Electrical Networks and Resonance

Unit code: HP3J 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

Apply network theorems to solve electrical network problems

Knowledge and/or skills

- Kirchhoff's Laws (as applied to two mesh dc networks)
- Superposition Theorem (applied to dc or ac circuits)
- Concept of constant voltage and constant current sources
- Thevenin and Norton's Theorems (applied to dc or ac circuits)
- Maximum Power Transfer Theorem (dc or ac cases)

Evidence requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that she/he can answer correctly questions based on a sample of the items shown above. In any assessment of this Outcome three out of five 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 three out of five knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three 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:

- apply Kirchhoff's Laws to solve problems involving a two mesh dc electrical network containing two voltage sources
- apply the Superposition Theorem to solve problems involving a two mesh dc or ac electrical network containing two voltage sources
- identify the main characteristics of ideal constant voltage and constant current sources and practical voltage and current sources that approximate to the ideal
- apply Thevenin and Norton's Theorems to the solution of dc or ac electrical network problems containing a constant current and/or constant voltage source
- apply the Maximum Power Transfer Theorem to solve dc or ac electrical problems

Evidence should be generated through assessment undertaken in controlled, supervised 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 will be permitted to use scientific calculators during the assessment.

Assessment guidelines

The assessment of this Outcome should be combined with Outcome 2 to form a single assessment paper, details of which are given under Outcome 2.

Outcome 2

Solve problems involving resonating passive circuits

Knowledge and/or skills

- Resonant frequency and dynamic impedance in an R - L - C (a resistor (R) in series with an inductor (L) in series with a capacitor (C)) series circuit
- Q - factor and bandwidth in an R - L - C series circuit
- Impedance/frequency and current/frequency graphs associated with an R - L - C series circuit
- Resonant frequency and dynamic impedance in a R - L // C circuit (a resistor (R) in series with an inductor (L) and both in parallel with a capacitor (C)) when R << wL and when the circuit has appreciable R
- Q - factor and dynamic impedance in a R - L // C circuit when R << wL
- Impedance/frequency and current/frequency graphs associated with an R – L // C circuit

Evidence requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that she/he can answer correctly questions based on a sample of the items shown above. In any assessment of this Outcome three 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 three out of the six knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

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

- calculate correctly resonant frequency and dynamic impedance in a R - L - C series circuit
- calculate correctly Q - factor and bandwidth in a R - L - C series circuit
- sketch the impedance/frequency and current/frequency graphs for an R - L - C series circuit and show on the sketch resonant frequency and bandwidth
- calculate correctly resonant frequency and dynamic impedance in a R - L // C circuit when R << wL and when the circuit has an appreciable value of R

- calculate correctly Q - factor and bandwidth in a R - L // C circuit for the case when R<< wL
- sketch the impedance/ frequency and current/frequency graphs for an R - L // C series circuit and show on the sketch resonant frequency and bandwidth

Evidence should be generated through assessment undertaken in controlled, supervised 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 will be permitted to use scientific calculators during the assessment.

Assessment guidelines

The assessment for this Outcome should be combined with Outcome 1 to form a single assessment paper that should be taken at a single assessment event lasting one hour and thirty minutes and carried out under supervised, controlled conditions. Such a paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

In addition, where a centre considers it appropriate, the single assessment for Outcomes 1 and 2 can be combined with the assessment for the Unit Single Phase AC Circuits to form one single assessment paper for both Units. This assessment paper should be taken at a single assessment event lasting two hours and thirty minutes and carried out under supervised, controlled conditions. Such a paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

Administrative information

Unit code: HP3J 47

Unit title: Electrical Networks and Resonance

Superclass category: XJ

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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.

Unit specification: support notes

Unit title: Electrical Networks and Resonance

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 the knowledge, understanding and skills to perform the following:

1. Apply network theorems to the solution of electrical network problems.
2. Solve electronic and electrical resonating passive circuit problems.

This Unit has been developed as part of a group of Electronic and Electrical Principles Units. There are two other Units in the group entitled Single Phase AC Circuits and Transmission Lines and Complex Waves. This Unit and the Unit Single Phase AC Circuits are both at SCQF level 7 and are mandatory Units within the Principles/Technology section of the new SQA Advanced Certificate and SQA Advanced Diploma in Electronics awards. The SCQF level 8 Unit Transmission Lines and Complex Waves is included, as an optional Unit, within the options section of the SQA Advanced Diploma in Electronics award only.

The three Units mentioned in the previous paragraph have been developed as an integrated suite of Units to meet all the electrical and electronic principles requirements of the new SQA Advanced Certificate and SQA Advanced Diploma in Electronics and Electrical awards. However, this does not preclude the use of one or more of these Units in other awards where award designers feel this to be appropriate. As well as providing a substantial course in electrical and electronic principles these Units also provide important underpinning knowledge, understanding and skills for other parts of the SQA Advanced Certificate and SQA Advanced Diploma in Electronics awards (e.g. analogue electronics Units).

In designing this Unit the Unit writers have identified the 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 Electronic and Electrical 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.

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

1. **Apply network theorems to solve network problems (24 hours)**

- Kirchhoff's laws as applied to two mesh dc circuits.
- Superposition theorem applied to dc or ac circuit problems
- Concept of constant voltage and constant current sources (typical applications within an Electronics and Electrical context)
- Thevenin's and Norton's theorems applied to both dc and ac circuit problems
- Maximum Power Transfer Theorem (both dc and ac cases)
- Tutorial exercises involving network theorems

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

- Verification of Kirchhoff's laws
- Derivation of Thevevin and Norton equivalent circuits from measurements taken in an electronic or electrical network.
- Investigation of the characteristics of equipment that approximates to either a constant voltage or constant current source under varying load conditions.

2. **Solve problems involving resonating electronic circuits (14.5 hours)**

- Resonance in R – L - C series circuit, derivation of equations for resonant frequency and dynamic impedance, circuit behaviour above and below resonance, Q - factor, bandwidth. Impedance/frequency and current/frequency graphs. Solve problems involving this type of resonant circuit.
- Resonance in R – L // C. Consideration of the cases where R has a small value and R has an appreciable value. Derivation of equations for resonant frequency and dynamic impedance, Q - factor and bandwidth. Impedance/frequency and current/frequency graphs. Solve problems involving this type of resonant circuit.

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

Investigation of the changing behaviour of an R – L - C series circuit and/or R – L // C circuit to changes in frequency

Unit Assessment (1.5 hours)

Guidance on the delivery and assessment of this Unit

It should be noted that this Unit can be delivered on a free standing basis or combined with the Unit Single Phase AC Circuits for teaching and learning and assessment purposes to form an integrated Electronic and Electrical Principles programme. This provides course planners with the flexibility to keep the two Units separate or combine them for teaching and learning and assessment purposes. Such flexibility may be important to a centre where, for example, either Unit is included in a number of SQA Advanced Engineering courses, and these courses have to be combined to ensure viable candidate numbers in a class. For details of how the assessment for the two Units can be integrated see the Assessment guidelines in Outcome 2 of the Unit Single Phase AC Circuits and Outcome 2 of this Unit.

This Unit has been designed to incorporate sufficient time to allow lecturers to teach the core electrical and electronic principles contained in this Unit. This Unit has also been written such that there is sufficient time built in 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 gain experience in reading and wiring up circuit diagrams, using test equipment, analysing the results of experiments etc.

As this Unit provides core electrical and electronic principles which underpin much of the studies done in other areas of the SQA Advanced Certificate and SQA Advanced Diploma in Electronics awards it is recommended that the Unit be delivered towards the start of these awards.

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

Details on approaches to assessment are given under Evidence requirements and Assessment guidelines under each Outcome in the SQA Advanced Unit specification: statement of standards section. It is recommended that these sections be read carefully before proceeding with assessment of candidates.

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line support. However, with regard 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 the assessment, which is required to be at a single event, is conducted under controlled, supervised conditions.

For information on normal open learning arrangements, please refer to the SQA guide *Assessment and Quality Assurance of Open and Distance Learning* (SQA 2000).

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 Networks and Resonance

This Unit has been designed to meet many of the Electronic and Electrical Principles learning needs of candidates taking an SQA Advanced Certificate and/or SQA Advanced Diploma in Electronics award. As such studying this Unit will provide you with the opportunity to develop the knowledge, understanding and skills to apply network theorems to the solution of electronic and electrical circuits. Such theorems underpin much of the work in Electronics so it is important that you have a good grasp of them. You will also be provided with the opportunity to study in-depth the behaviour of series and parallel electronic and electrical passive circuits at resonance. Such studies are important in helping you to understand how tuned circuits (such as those used in communication equipment) and some electronic filters work.

It is good to gain sound theoretical knowledge and understanding but it is also important that you are able to set your theoretic knowledge within a practical Electronics and Electrical context. Thus, it is likely during this Unit that you will be provided with the opportunity to relate theory to practice by doing practical experiments and computer simulations on electronic and electrical circuits.

By the end of this Unit you will be expected to apply network theorems to the solution of electronic and electrical network problems. You will also be expected to undertake detailed calculations and draw graphs associated with series and parallel electronic and electrical resonating circuits.

The formal assessment for this Unit will consist of a single assessment paper lasting one hour and thirty minutes. The assessment will be conducted under closed book conditions in which you will not be allowed to take notes, textbooks etc. into the assessment. However, you will be allowed to use a scientific calculator. You will sit this assessment paper at the end of this Unit.

It is also possible that the centre where you take this Unit will combine it with the Unit Single Phase AC Circuits for teaching and learning and assessment purposes. Under these circumstances the assessment for both Units will take the form of a single assessment paper, taken at one assessment event conducted under controlled, supervised conditions. The length of the assessment paper will be two hours and thirty minutes and no notes, textbooks etc. will be allowed into the assessment. Ask your lecturer if the two Units will be combined for teaching and learning and assessment purposes.