SQA Advanced Unit Specification

General information for centres

Unit title: Transmission Lines and Complex Waves

Unit code: HT1H 48

Unit purpose: This Unit is designed to enable candidates to understand the basic principles and concepts of transmission lines and complex waves. It will provide candidates with the opportunity to develop knowledge and skills to determine electrical quantities associated with transmission lines and secondly, to solve simple electrical series and parallel circuits when a complex waveform is applied.

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

1. Evaluate the characteristics of transmission lines.
2. Evaluate the performance of a transmission line with a matched termination.
3. Evaluate the performance of a transmission line with various terminations.
4. Solve network response problems when complex waves are applied.

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

**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 good knowledge and understanding of electrical principles. This may be evidenced by possession of the SQA Advanced Units Single Phase A.C. Circuits and Electrical Network and Resonance. Preferably candidates will have achieved the SQA Advanced Unit Mathematics for Engineering 1: Electronics and Electrical.

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: 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.

Assessment: The assessments for Outcomes 1, 2, 3 and 4 should be combined into one assessment paper. This paper should be taken by candidates at one single assessment event that should last two hours. The assessment could be composed of a suitable balance of short answer, restricted response and structured questions.

It should be noted that candidates must achieve all the minimum evidence specified for each Outcome in order to pass this Unit.

Assessment should be conducted under controlled supervised conditions. Candidates will be permitted to use a supplied formulae sheet and a scientific calculator.

SQA Advanced Unit Specification: Statement of standards

Unit title: Transmission Lines and Complex Waves

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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

Evaluate the characteristics of transmission lines

Knowledge and/or skills

- Describe and classify different types of transmission line
- Calculation of primary parameters
- Calculation of secondary parameters

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 response to specific questions. Each candidate will need to demonstrate that they can correctly answer questions based on the items shown above. In any assessment of this Outcome two out of three knowledge and/or skills items should be sampled and the sample must include the third item.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of two out of three knowledge and/or skills items should be sampled.

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 and classify two types of transmission line
- calculate inductance and capacitance for two types of transmission line
- perform calculations to determine each of the following secondary parameters; Z_o , γ , α, β and ν

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 allowed to use a supplied formulae sheet and a scientific calculator during the assessment.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment of this Outcome should be combined with Outcomes 2, 3 and 4 to form a single assessment paper, details of which are given under Outcome 4.

Outcome 2

Evaluate the performance of a transmission line with a matched termination

Knowledge and/or skills

- Calculation of phasor voltages and currents at various points
- Calculation of dissipated power at the receiving end

Evidence requirements

Evidence for all the knowledge and/or skills in this Outcome must be provided. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that they can correctly answer questions based on the items shown above. In any assessment of this Outcome both knowledge and/or skills items are required.

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:

- calculate phasor voltages and currents at two points, one of which must be the receiving end
- calculate dissipated power at the receiving end

Evidence should be generated through assessment undertaken in controlled, supervised conditions. The 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 allowed to use a supplied formulae sheet and a scientific calculator during the assessment.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment of this Outcome should be combined with Outcomes 1, 3 and 4 to form a single assessment paper, details of which are given under Outcome 4.

Outcome 3

Evaluate the performance of a transmission line with various terminations

Knowledge and/or skills

- Calculation of incident, reflected and transmitted values of voltage, current and power for a transmission line with mismatched terminations
- Sketch incident, reflected and transmitted waves for a transmission line with various terminations
- Construct accurate scaled drawings for a repetitive, low duty cycle, voltage pulse on a transmission line with various terminations

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 response to specific questions. Each candidate will need to demonstrate that they can correctly answer questions based on a sample of the items shown above. In any assessment of this Outcome two out of three knowledge and/or skills items should be sampled and the sample must include the first item.

In order to ensure that candidates will not be able to foresee what items they will be questioned on a different sample of two out of three knowledge and/or skills items should be sampled.

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;

- calculate incident, reflected and transmitted values of voltage, current and power for one of the following mismatched terminations; $Z_L > Z_O$, $Z_L < Z_O$
- sketch incident, reflected and transmitted waves for one of the following terminations; $Z_L > Z_O$, $Z_L < Z_O$
- construct an accurate scaled drawing for a repetitive, low duty cycle, voltage pulse on a line with one of the following terminations; open circuit, short circuit, matched

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 allowed to use a supplied formulae sheet and a scientific calculator during the assessment.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment of this Outcome should be combined with Outcomes 1, 2 and 4 to form a single assessment paper details of which are given under Outcome 4.

Outcome 4

Solve network response problems when complex waves are applied

Knowledge and/or skills

- Explanation of the production of non-sinusoidal periodic waveforms in electronic or electrical circuits
- Calculate rms voltage and current values of complex waves
- Calculate power associated with complex waves
- Calculation of electrical quantities in an R – L - C series circuit or an R – L // C parallel circuit subject to a complex waveform with a fundamental and two harmonics
- Explanation of selective resonance
- Explanation of the effects of harmonics on measurement of voltage and current in single phase and electronic circuits

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 response to specific questions. Each candidate will need to demonstrate that they can correctly 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 and the sample must include items (2), (3) and (4).

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 should be sampled. In this case, for items (2), (3) and (4), different numerical values should be used and the fourth item should be different.

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:

- explain the production of non-sinusoidal periodic waveforms in electronic or electrical circuits
- calculate rms voltage and current values from given complex wave equations containing a fundamental and two harmonics
- calculate power associated with complex waves
- calculate electrical quantities in an R – L - C series circuit or an R – L // C parallel circuit subject to a complex waveform with a fundamental and two harmonics
- explain selective resonance
- explain the effects of harmonics on measurement of voltage and current in single phase and electronic circuits

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 allowed to use a supplied formulae sheet and a scientific calculator during the assessment.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment of this Outcome should be combined with Outcomes 1, 2 and 3 to form a single assessment paper, details of which are given below.

The single assessment paper should be taken at a single assessment event lasting two hours and carried out under supervised, controlled conditions. The paper could be composed of an appropriate balance of short answer, restricted response and structured questions.

Administrative information

Unit code: HT1H 48

Unit title: Transmission Lines and Complex Waves

Superclass category: XK

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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.

SQA Advanced Unit Specification: Support notes

Unit title: Transmission Lines and Complex Waves

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 knowledge, understanding and skills in the following areas:

1. Describe and classify types of transmission lines and use equations to determine primary and secondary parameters.
2. The use of relevant equations to determine various electrical quantities for a transmission line with a matched termination.
3. The use of relevant equations, sketches and scaled drawings to evaluate the performance of a transmission line with various terminations.
4. The use of relevant equations to solve problems when complex waves are applied to electronic or electrical circuits and to explain the production of non-sinusoidal periodic waveforms, selective resonance and the effects of harmonics in the measurement of electrical quantities.

This Unit has been developed as part of a group of Electronic and Electrical Principles Units. This Unit is included within the Options section of the SQA Advanced Diploma in Electronics award. This is a single credit Unit at SCQF level 8.

In designing this Unit, the 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. While it is not mandatory for centres to use this list of topics, it is strongly recommended that they do so to ensure continuity of teaching and learning 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 overleaf. 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. **Evaluate the characteristics of transmission lines (7 hours)**

- Line classification and description of open (isolated) twin wire, twisted pair and coaxial construction.
- Primary parameters: resistance, inductance, capacitance and conductance.
- Calculation of inductance and capacitance parameters for twin wire and coaxial lines.
- Secondary parameters: characteristic impedance (Z_o), propagation coefficient (γ), attenuation coefficient (α), phase coefficient (β) and velocity of propagation (ν).

2. **Evaluate the performance of a transmission line with matched terminations (7 hours)**

- Use of equations relating sending end voltage/current to voltage/current at specified points.
- Phasor voltages and currents at receiving end and various points, given sending end voltage and/or current. Attenuation and phase shift coefficients to be used.
- Calculation of power at receiving end only.

3. **Evaluate the performance of a transmission line with various terminations (9 hours)**

- Calculate incident, reflected and transmitted values of voltage, current and power for a transmission line with mismatched terminations: ZL > ZO, ZL < ZO
- Sketch incident, reflected and transmitted waves with various terminations: ZL > ZO, ZL < ZO
- Construct accurate scaled drawings for a repetitive, low duty cycle voltage pulse on a line with various terminations: ZL = ∞, ZL = ZO , ZL = 0.

4. **Solve network response problems when complex waves are applied (15 hours)**

- Production of non-sinusoidal periodic waveforms in electronic or electrical circuits using non-linear devices.
- Calculation of rms voltage and current values for a complex wave with a fundamental and two harmonics.
- Power associated with complex waves (fundamental and two harmonics).
- Calculate electrical quantities in an R – L - C series circuit and an R – L // C parallel circuit subject to a complex waveform (fundamental and two harmonics).
- Explain selective (harmonic) resonance.
- Explain the effects of harmonics on measurement of voltage and current in single phase and electronic circuits.

Unit Assessment — 2 hours

Guidance on the delivery and assessment of this Unit

This Unit has been designed as a freestanding Unit. The Unit should be delivered towards the end of the award, students having previously completed the SQA Advanced Units Single Phase A.C. Circuits, Electrical Networks and Resonance and Mathematics for Engineering 1: Electronics and Electrical.

The Unit has been designed to incorporate sufficient time to allow lecturers to teach all the electrical and electronic principles contained in the Unit. There is sufficient time to include the use of formative assessment exercises. Although there is no practical assessment, it would be very useful if candidates undertook laboratory work and computer simulation throughout the Unit to support theory and avoid the delivery of the Unit becoming too theoretical. For example, candidates could undertake experimental work on examples of open circuit, short circuit and matched lines, particularly set within an electronics context.

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.

The content of this Unit is such that it should be assessed by one holistic assessment instrument and this should be carried out at the end of the Unit delivery time.

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 assessment was 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: Transmission Lines and Complex Waves

This Unit has been designed to allow you to develop your knowledge, understanding and skills in the principles and concepts of transmission lines and complex waves. It can be delivered, as a stand alone Unit but it would be beneficial if you have completed the SQA Advanced Units Single Phase A.C. Circuits, Electrical Networks and Resonance and Mathematics for Engineering 1: Electronics and Electrical.

By the end of the Unit, you should be able to solve through calculation and graphical analysis; electrical quantities associated with transmission lines and secondly, solve simple electronic circuit problems involving complex waveforms.

In Outcome 1, you will be introduced to different types of transmission line. You will also learn how a transmission line can be represented by electrical quantities and how to determine the secondary parameters of a line.

In Outcome 2, you will use the parameters introduced in Outcome 1 to calculate by the use of equations, voltage, current and power in a transmission line with a matched termination.

In Outcome 3, you will use equations and graphical methods to determine values of voltage, current and power for a transmission line with various terminations.

In Outcome 4, you will learn about complex waveforms and how to solve various electrical quantities in an R – L - C and an R – L // C circuit when a complex wave is applied.

Although there is no practical assessment in this Unit, it is likely that laboratory work and computer simulation will be used to support the theory.

The Unit will be assessed by one written assessment at one assessment event. Your lecturer should inform you how the Unit will be assessed. The assessment will take place at the end of the Unit and shall last two hours under controlled, supervised conditions. You will not be allowed to use or refer to any notes or textbooks during the assessment but you will be allowed to use a supplied formulae sheet and a scientific calculator.