SQA Advanced Unit Specification

General information for centres

Unit title: Telecommunications Fundamentals

Unit code: HP40 48

Unit purpose: This Unit provides candidates with the knowledge and understanding associated with noise sources, and the various methods of reducing their effects on the performance of electronic circuits. It also identifies and describes the factors affecting electromagnetic compatibility (EMC) and how these can be minimised by good design practice. The Unit also provides the candidate with an understanding of the modulation and demodulation techniques used in the telecommunications industry and applies these methods to explain the function of various RF circuits used in transmitters and receivers.

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

1. Outline the various sources and factors which cause noise and EMC, and explain the reduction methods applied in practice.
2. Analyse modulation techniques.
3. Analyse demodulation techniques.
4. Outline the principles of digital data modulation and demodulation.

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 basic knowledge and understanding of electromagnetic waves and telecommunications. This may be evidenced by possession of a Higher in Electronics or Telecommunications or the following National Qualification Units: E7SG 12 Communication Radio Circuits and Systems 2, E7S6 11 Basic Telecommunications, E7S7 12 Principles of Telecommunications Systems, EG3B 12 Telecommunications Signal Processing, EG39 11 Introduction to Telecommunications

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

Context for delivery: This Unit was developed for the SQA Advanced Diploma in Electronics award. 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.

Assessment: All Outcomes in this Unit should be combined into one assessment paper. This paper should be taken by candidates at one single assessment event, which should last two hours. The assessment paper could be composed of a suitable balance of short answer, restricted response and structured questions. Candidates will be permitted to use scientific calculators.

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.

Unit specification: statement of standards

Unit title: Telecommunications Fundamentals

Unit code: HP40 48

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

Outline the various sources and factors which cause noise and EMC and explain the reduction methods applied in practice

Knowledge and/or skills

- Internal noise
- External noise
- Johnson noise formula
- Internal noise sources
- External noise sources
- Noise reduction methods for internal noise
- Noise reduction methods for external noise
- Factors affecting EMC
- EMC reduction methods

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 five out of nine 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 five out of nine knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide satisfactory responses to all five 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:

- classify six noise types as internal or external
- list three noise sources for each classification
- explain the reduction methods used in three internal noise sources

- explain the reduction methods used in three external noise sources
- perform one calculation using the Johnson noise equation
- describe two conductive factors affecting EMC
- describe two radiated factors affecting EMC
- describe two transient sources affecting EMC
- explain one method of reducing EMC effects for conductive, radiated and transient sources

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

Questions used to elicit candidate evidence may 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.

Outcome 2

Analyse modulation techniques

Knowledge and/or skills

- The principles of amplitude modulation, including power calculation
- Bandwidth and use of spectrum diagrams
- Modulating factor (m) and depth of modulation
- The principles of frequency modulation
- Modulating index
- Frequency deviation and deviation ratio
- Bandwidth Carson's rule and spectrum diagrams

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 four out of seven 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 the seven knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all four 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:

- explain the principles of amplitude modulation
- perform one power calculation
- perform one calculation on modulation factor
- explain the principles of frequency modulation
- perform one calculation on modulating index
- solve one problem involving frequency deviation
- use Carson's rule to determine the bandwidth of an FM system

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

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

The assessment of this Outcome can be combined with Outcome 1 and 3 and 4 to form a single assessment paper.

Outcome 3

Analyse demodulation techniques

Knowledge and/or skills

- The principles of the superhet. receiver
- Use of block diagrams to determine demodulation stages
- Choice of intermediate frequency
- Choice of local oscillator frequency
- Calculations involving choice of local oscillator and intermediate frequency

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 the 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 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:

- explain the principles of the superhet. receiver
- analyse annotated block diagrams to identify the demodulation stages

- explain the choice of intermediate frequency
- explain the choice of local oscillator frequency
- perform one calculation using the local oscillator frequency, RF frequency and intermediate frequency equation

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

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

The assessment of this Outcome should be combined with those for Outcomes 1 and 2 and 4 to form one assessment paper for the Unit.

Outcome 4

Outline the principles of digital data modulation and demodulation

Knowledge and/or skills

- Pulse code modulation (PCM)
- Time division multiplexing (TDM)
- Amplitude shift keying (ASK)
- Phase shift keying (PSK)
- Frequency shift keying (FSK)

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 the five knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

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:

- explain the principles involved in PCM
- explain the fundamentals of time division multiplexing (TDM)
- explain the modulation and demodulation techniques used in amplitude shift keying
- explain the modulation and demodulation techniques used in phase shift keying
- explain the modulation and demodulation techniques used in frequency shift keying

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

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

The assessment of this Outcome should be combined with those for Outcomes 1, 2 and 3 to form one single assessment paper for the Unit. The assessment paper should be taken at a single assessment event lasting two hours and carried out under supervised, controlled conditions. Such a paper could be composed of an appropriate balance of short answer, restricted response and structured questions.

Administrative information

Unit code: HP40 48

Unit title: Telecommunications Fundamentals

Superclass category: XM

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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.

Unit specification: support notes

Unit title: Telecommunications Fundamentals

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 to provide candidates with the knowledge and skills involved in the following areas:-

1. The sources of noise and electromagnetic compatibility (EMC) encountered in radio communications circuits.
2. The techniques applied to minimise noise and EMC.
3. The modulation methods used in radio transmitters.
4. The demodulation methods used in radio receivers.
5. Digital data modulation methods.
6. Digital demodulation methods

This Unit has been designed to develop a candidate's ability to describe the most frequently used methods by which a carrier signal is modulated. It has also been devised to contain underpinning knowledge to support SQA Advanced Units specialising in RF and telecommunications engineering. It may also be taken as a standalone Unit to introduce electronic students to RF circuits and telecommunications applications.

In designing this Unit, the writer has identified the range of topics which the lecturer would be expected to cover. Recommendations have also been given on how much time should be spent on each Outcome. This has been done to help lecturers to 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 strongly recommended that they do so to ensure continuity of teaching and learning across the Unit. 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.

Outcome 1
Outline the various sources and factors which cause noise and EMC and explain the reduction methods applied in practice. (8 hours)

- Internal noise sources (thermal, shot, partition, pink and white)
- Use of Johnson noise formula to determine rms noise voltage
- External noise sources (mains hum, switching or contact noise, natural and crosstalk
- Noise reduction methods to include shielding, capacitive coupling and decoupling, common grounding, PCB layout, twisted pair and co-axial cable
- Types of equipment that are likely to generate external noise
- Description of the EM wave (electric field, magnetic field and direction of propagation)

- Radiation from a monopole (dominant E-field, near field and far field)
- Conducted sources (mains and system interconnections
- Radiated sources (antennae and other RF radiators)
- Transient sources(lighting, electro-mechanical switches, inductive circuits, electrostatic discharge, power loading and dropouts
- Identification of potential sources of EMC
- Measures to counteract the sources of EMC

Outcome 2
Analyse modulation techniques (11 hours)

- Requirements for modulation
- Low and high level modulation methods and how they are applied in a transmitter using given block diagrams
- The development of the amplitude modulated wave using a single sine wave (AM)
- The modulating factor (m)
- Depth of modulation
- Effects of overmodulation and undermodulation
- Power distribution in an AM wave
- Application of the power distribution formula using one pair of sidebands
- Use of spectrum diagrams to determine bandwidth for one pair of sidebands
- Definition of double sideband modulation (dsb)
- Definition of single sideband modulation (ssb)
- Definition of double sideband suppressed carrier modulation (dsbsc)
- Definition of single sideband suppressed carrier modulation (ssbsc)
- The principles of frequency modulation (FM)
- Definition of frequency deviation (f_d)
- Rated system deviation
- Use of deviation ratio formula (δ)
- Use of Carson's rule to determine bandwidth
- Use of spectrum diagrams

Outcome 3
Analyse demodulation techniques (11 hours)

- Identification of the stages of a superheterodyne receiver using a given block diagram
- The principle of superheterodyning
- Use of mixer and local oscillator
- The principles of the Colpitts oscillator using a given schematic diagram
- The principles of the Hartley oscillator using a given schematic diagram
- Crystal oscillators (Colpitts application only with given diagram)
- Factors determining choice of intermediate frequency
- Factors determining choice of local oscillator frequency
- Image channel interference
- Adjacent channel interference

Outcome 4
Outline the principles of digital data modulation and demodulation. (8 hours)

- Principles of pulse code modulation applied to a sinusoidal wave
- Diagrams showing effect of PCM on a sinusoidal wave
- Sampling requirements
- Coding requirements
- Quantisation requirements
- Fundamentals of time slots and channel distribution using TDM
- Principles of amplitude shift keying applied to a sinusoidal signal
- Principles of phase shift keying applied to a sinusoidal signal
- Principle of frequency shift keying applied to a sinusoidal signal
- Phase locked loop used as demodulator for digital data modulation methods

Written Assessment (2 Hours)

Guidance on the delivery and assessment of this Unit

This Unit is a core Unit within the SQA Advanced Diploma in Electronics award but may also be delivered on a free standing basis or as part of an SQA Advanced course. It will also incorporate the knowledge and skills acquired from digital and analogue electronics which form part of the SQA Advanced Diploma infrastructure. The content of this Unit is such that it will give candidates an opportunity to explore telecommunications topics which are fundamental to all aspects of RF engineering and telecommunication engineering which will enable them to progress to other SQA Advanced Units involving radio technology, satellite technology and radio broadcasting systems.

Where this Unit is incorporated into other group awards it is recommended that it be delivered in the context of the specific occupational areas 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.

The content of the Unit is such that all four outcomes of the Unit should be assessed by one holistic assessment 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, whether done at a single or at multiple events, was conducted under controlled and supervised conditions.

To keep administrative arrangements to a minimum, it is recommended that a single assessment paper (taken by candidates at a single assessment event) be used for distance learning candidates.

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: Telecommunications Fundamentals

This Unit has been designed to introduce you to the techniques involved in modulation and demodulation. It also contains an element on noise and electromagnetic compatibility which have direct effects on circuit performance and channel information capacity.

This Unit will provide you with the opportunity to understand the frequently used techniques of modulation and demodulation used in telecommunications and broadcasting. This together with your knowledge and skills developed in digital and analogue electronics will enable you to progress to other specific Units in telecommunications and RF engineering.

This Unit will also give you an understanding of the transmission and receiving side of telecommunications and will give you the opportunity to study commonly used circuits in the industry.

This Unit looks at both internal and external noise, lists common sources of these two classifications and discusses methods of reducing their effects. Electromagnetic compatibility (EMC) is also discussed and you will learn the radiation, conductive and transient factors responsible. As with noise, you will learn current methods of reducing EMC effects.

The techniques of modulation and demodulation are discussed with reference to amplitude modulation, frequency modulation and frequency shift keying. You will also gain an understanding of how some of the more common AM, FM and FSK systems function. This will give you an understanding of analogue and digital methods of modulation, both of which are commonly used. You will also be asked to perform calculations on common parameters such as modulation index, depth of modulation, frequency deviation and maximum rated deviation. You will also use Carsons's rule to determine bandwidth.

The use of the superheterodyne receiver is of importance in all aspects of telecommunications and RF engineering hence you will learn the principle of operation of this receiver by using annotated block diagrams and also its specific
characteristics such as intermediate frequency, local oscillator frequency, image channel interference and adjacent channel interference.

You will also be introduced to the fundamentals of digital modulation and demodulation methods as well as the techniques of PCM and TDM.

When you have completed this Unit you will be expected to solve basic problems related to RF circuits and modulation methods. This will involve the use of simple formulae with which you should be familiar.

The Unit will be assessed by means of a single assessment covering all four outcomes and lasting two hours. The lecturer responsible for the assessment arrangements will provide you with information on the exact form the assessment will take. This should be made clear to you. The assessments will be conducted under closed book conditions in which you will not be allowed to take notes, textbooks etc. into the assessments. However you will be allowed to use a scientific calculator.