Higher National Unit specification: general information

Unit title: Radio Communications

Unit code: H1FD 35

Superclass: ZF

Publication date: April 2012

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

The purpose of this Unit is to develop an understanding of the systems and sub-systems involved in communication by radio. The candidate will investigate the way in which information is conveyed by mixing the wanted signal with a radio frequency carrier and the methods by which the signals are generated and received. The candidate will also be able to determine the choice of carrier frequency and the resulting effect this has on the propagation of the signal through free space, along with the causes and effects of noise in radio systems.

Outcomes

1 Analyse amplitude and angle modulation.
2 Explain the principles of radiation and propagation of transverse electromagnetic waves in the bands very low frequency (VLF) to extra high frequency (EHF).
3 Investigate and evaluate the principles and operation of radio transmitters.
4 Investigate and evaluate the principles and operation of radio receivers.
5 Outline Satellite communication principles.

Recommended prior knowledge and skills

It would be an advantage if candidates had a knowledge and understanding of electrical and electronic theory. This can be evidenced by possession of the following SQA Units: *DC and AC Principles* (FY9E 34), *Power Electronics* (FY9R 34), *Marine Engineering: Electrical and Electronic Devices* (F90W 34). Candidates should also have a minimum of a level 7 mathematics such as Mathematics for Engineering 2 (DG4L 34) or equivalent.

General information (cont)

Credit points and level

2 Higher National Unit credits at SCQF level 8: (16 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 Access 1 to Doctorates.*

Core Skills

There are opportunities to develop the Core Skill: *Working with Others* at SCQF level 6 and the Core Skills components: Critical Thinking at SCQF level 6; Reviewing and Evaluating 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.

Higher National Unit specification: statement of standards

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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

Analyse amplitude and angle modulation**.**

Knowledge and/or Skills

- Waveform and modulation index for an amplitude modulated (AM) waveform.
- Signal spectrum of an AM waveform.
- Power in each frequency component of a radiated AM waveform.
- Operation of an AM envelope detector.
- Signal spectrum of a single sideband (SSB) transmitter at key points.
- Modulation index and frequency deviation of a frequency modulated (FM) waveform.
- Signal spectrum of an FM waveform.
- Frequency deviation and the use of pre-emphasis and de-emphasis in a FM context.
- The applications of FM and AM.

Evidence Requirements

Evidence for the Knowledge and/or Skills items in Outcome 1 should be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that they can answer correctly questions based on a sample of the knowledge and skills items listed in the Outcome. 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 are required each time the Unit is assessed. Candidates must provide a satisfactory response to all items.

Higher National Unit specification: statement of standards (cont)

Unit title: Radio Communications

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:

- Sketch waveform and determine modulation index for an AM waveform.
- Sketch and determine frequency components for an AM waveform.
- Calculate the power in each frequency component of a radiated AM waveform.
- Describe how an AM envelope detector works.
- Determine and sketch the signal spectrum of a SSB transmitter at key points.
- Calculate the modulation index and frequency deviation of a FM modulated waveform.
- Estimate the bandwidth and sketches the spectrum of a FM modulate waveform using Bessel Functions and Carson's Rule.
- Describe Frequency deviation and the use of pre-emphasis and de-emphasis in a FM context.
- State the main advantages of FM when compared to AM.

Where calculations are performed the candidate must:

- Apply appropriate formulae.
- Apply the principles of the calculation.
- Show all working through a calculation.
- Provide reasonable answers to the questions asked. The answer should derive from the application of the formula and correct application of the principles of the calculation.

The Evidence Requirements state that candidates must ensure answers are derived 'from the application of the formulae and correct application of the principles of the calculation'. This allows for acknowledgement of the correct working and application of formulae, even where the candidates' final answer may be inaccurate.

The statement allows for the eventuality where a single error at one stage in an extended calculation sequence has a cumulative effect on the final answer, even though working/formulae are otherwise correctly applied. Acknowledgement of the correct working should be given in such cases.

Evidence should be generated through assessment in 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, although standard formulae may be given. Candidates will be permitted to use scientific calculators during the assessment.

Higher National Unit specification: statement of standards (cont)

Unit title: Radio Communications

Outcome 2

Explain the principles of radiation and propagation of transverse electromagnetic waves in the bands very low frequency (VLF) to extra high frequency (EHF).

Knowledge and/or Skills

- Fundamentals of electromagnetic waves.
- Radiation and reception of electromagnetic waves.
- Properties of aerials for electromagnetic waves.
- The electromagnetic spectrum.
- Bandwith, classification, application of radio bands.
- Modes of propagation of radio waves of different frequencies.
- Errors and losses within the propagation of radio waves.
- Radio horizon.
- Anomalous propagation.

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- Explain the principles of electromagnetic radiation.
- Describe the radiation and reception of electromagnetic waves.
- Determine the type of aerial required for reception of electromagnetic waves.
- Describe the electromagnetic spectrum in terms of frequency and wavelength
- Classify the radio bands in terms of bandwidth and application.
- Explain the modes of propagation of radio waves of different frequencies.
- Identify and explain the errors and losses that occur within the propagation of electromagnetic waves.
- Calculate the effective antenna height to achieve a given radio horizon.
- Explain the application of anomalous propagation.

Higher National Unit specification: statement of standards (cont)

Unit title: Radio Communications

Outcome 3

Investigate and evaluate the principles and operation of radio transmitters.

Knowledge and/or Skills

- The legal requirements for transmitter operation.
- The operating principles of an amplitude-modulated (AM) transmitter.
- The function of the stages of an AM transmitter.
- The operating principles of a frequency-modulated (FM) transmitter.
- The function of the stages of an FM transmitter.
- Carrier frequency generation.

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- State the legislative bodies and legislation concerning the transmission of radio communications.
- Describe the principles of operation of an AM transmitter.
- Explain with the use of a block diagram approach, the function of the individual stages of an AM transmitter.
- Describe the principles of operation of an FM transmitter.
- Explain with the use of a block diagram approach, the function of the individual stages of an FM transmitter.
- Explain the need for a high stability carrier frequency.

Higher National Unit specification: statement of standards (cont)

Unit title: Radio Communications

Outcome 4

Investigate and evaluate the principles and operation of radio receivers.

Knowledge and/or Skills

- The operation of an AM tuned-radio frequency (TRF) receiver.
- The disadvantages of TRF.
- The operating principles of the superheterodyne receiver.
- The operation of a superheterodyne receiver.
- Arrangements for transceiver operation.

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- Describe the operation of an AM tuned-radio frequency (TRF) receiver using a block diagram approach.
- Explain interference and the disadvantages of TRF.
- Explain the principle of operation of the superheterodyne receiver.
- Describe the operation of the superheterodyne receiver by explaining the function of its component parts.
- Describe the necessary arrangements for transceiver operation.

Outcome 5

Outline Satellite communication principles.

Knowledge and/or Skills

- Principles of operation of satellite communication systems.
- Maritime satellite communication systems.
- Satellite communication system aerials.
- Modulation techniques.

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- Explain the principles of operation of satellite communication systems.
- Describe the satellite communication systems used in the Maritime environment.
- Describe the aerials used for satellite communications.
- Explain modulating techniques used in satellite communications.

Higher National Unit specification: support notes

Unit title: Radio Communications

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 80 hours.

Guidance on the content and context for this Unit

This Unit has been written to form part of the Group Award HND Electro-Technical Engineering.

This Unit has been written in order to allow candidates to develop skills, knowledge and understanding of the principles of Radio Communications in the following areas:

1 Analyse amplitude and angle modulation.
2 Explain the principles of radiation and propagation of transverse electromagnetic waves in the bands very low frequency (VLF) to extra high frequency (EHF).
3 Investigate and evaluate the principles and operation of radio transmitters.
4 Investigate and evaluate the principles and operation of radio receivers.
5 Outline Satellite communication principles.

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 strongly recommended that they do so to ensure continuity of teaching and learning.

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

1 Analyse amplitude and angle modulation. (25 hours)

Amplitude modulation: for example the need for modulation; the components of a carrier wave which may be varied; range of carrier frequencies; how modulation may be achieved; derivation of the expression for an AM wave-form; modulation factor (m); the importance of modulation factor (m); frequency spectrum and power content of AM wave-forms; representation in the time and frequency domains when modulated by a single frequency and when modulated by a complex wave-form; bandwidth requirements; commercial speech modulation; low level and high level modulation; the advantages and disadvantages of double sideband full carrier AM.

Single sideband modulation: for example typical applications; how the carrier is suppressed by means of the balanced modulator; how one sideband is suppressed (filter and phasing methods); the importance of stability; comparison of DSB and SSB systems; power and bandwidth considerations; extensions of SSB (pilot carrier and vestigial sideband systems); typical applications.

Angle modulation: for example the distinction between frequency and phase modulation; definition of frequency deviation; modulation index and deviation ratio; the modulation process; the number and power content of side frequencies; the use of Bessel charts/graphs; the determination of bandwidth; Carson's rule; signal-to-noise ratio; emphasis techniques; threshold levels and capture effect; the need for squelch/muting; advantages and disadvantages of angle modulation; typical applications.

2 Explain the principles of radiation and propagation of transverse electromagnetic waves in the bands very low frequency (VLF) to extra high frequency (EHF). (25 hours)

Electromagnetic radiation: for example fundamentals of electromagnetic waves; the isotropic source; free space propagation; power density; the inverse square law; radiation and reception; polarisation; the reciprocity theorem; attenuation and absorption; reflection; refraction; diffraction; properties of periodic and aperiodic aerials.

Electromagnetic spectrum: the complete spectrum for electromagnetic radiation (DC to cosmic rays); classification of the bands within the complete spectrum in terms of frequency and wavelength; classification and bandwidth range of each of the bands used for radio (very low frequency to extra high frequency); typical applications for each band.

Modes for the propagation of radio waves: surface wave (eg characteristics, typical coverage and range, limitations); sky wave (eg characteristics, the ionosphere and its effects, layers, daily/seasonal/long-term variations); terms and definitions (critical frequency, maximum usable frequency, skip distance, dead zone, multiple hop); causes of fading; space wave characteristics; radio horizon (calculations involving transmitter and receiver antennae for various applications); anomalous propagation (sub-refraction, superrefraction, ducting); tropospheric scatter; extra-terrestrial communication.

3 Investigate and evaluate the principles and operation of radio transmitters. (20 hours)

Legal requirements: for example licensing, regulatory authorities, frequency of operation, antenna effective height, power restrictions, stability tolerance, spurious emissions.

Amplitude-modulated transmitters: audio stages (compression and amplitude limiters, low pass filtering for commercial speech frequencies); the modulator stage (high level and low level, balanced and unbalanced); frequency translation by mixing and harmonic multipliers; final stage power amplifier (the need for linear amplification, the need for high efficiency, maximum power requirement, suppression of harmonics).

Frequency-modulated transmitters: audio stages (amplitude limiters, low pass filtering for speech frequencies, pre-emphasis); the modulator stage (direct and indirect methods for achieving frequency modulation); frequency translation by mixing and harmonic multipliers; the final stage power amplifier (impedance matching and duplexing arrangements).

Carrier frequency generation: frequency synthesisers (phase locked loops); the requirement for high stability; tolerance issues.

Higher National Unit specification: support notes (cont)

Unit title: Radio Communications

4 Investigate and evaluate the principles and operation of radio transmitters. (20 hours)

AM tuned-radio frequency (TRF) receiver: sensitivity and selectivity; the action of the diode detector (demodulator); the TRF receiver (radio frequency amplification and the need for high Q ganged tuned circuits); adjacent channel interference; the disadvantages of the TRF (ganging difficulties and the reduction of Q at high frequencies leading to a lack of selectivity).

Superheterodyne receiver: principle of operation; mixing; frequency conversion; selection of the intermediate frequency; IF amplification; second channel (image) interference; choice of intermediate frequency; need for the RF stage; oscillator tracking problems; dual conversion; automatic gain control; demodulation of amplitude-modulated (DSB and SSB) and frequency-modulated signals; diplexing arrangements for transceiver operation.

5 Outline Satellite communication principles. (10 hours)

Systems in use at sea: INMARSAT overview; overview of Sat C, Sat B, Sat M and Fleet 77 principles of operation; aerials for use with satellite communication systems; modulation techniques.

Guidance on the delivery of this Unit

This Unit should be delivered by a combination of whole class teaching, tutorial work and practical laboratory work where appropriate. The latter is seen as particularly important as it provides candidates with an opportunity to relate theoretical knowledge to a practical context. In order that candidates achieve a firm understanding it is expected that centres delivering this Unit will have examples of actual modern radio communication equipment available for candidates to use and investigate. The Unit has been designed to incorporate sufficient time to allow lecturers to use the radio communications equipment within their teaching.

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.

The Unit has been written such that there is sufficient time built in to allow candidates to practise what they have learnt through appropriate formative assessments.

Guidance on the assessment of this Unit

Details on the approaches to assessment are given under the Assessment Guidelines. It is recommended that these sections are read carefully before proceeding with assessment of candidates.

Higher National Unit specification: support notes (cont)

Unit title: Radio Communications

Assessment Guidelines

Outcome 1

The assessment of this Outcome should be a single written assessment paper. This paper should be taken by candidates at one single assessment event that should last no more than 90 minutes. 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.

If a candidate requires to be re-assessed, a different selection of questions must be used from all sections. A significant proportion of the questions used in the re-assessment must be different from those used in the original test.

Outcome 2

The assessment of this Outcome should be a single assignment that allows the candidates to achieve all of the minimum evidence specified.

Outcome 3

The assessment of this Outcome should be combined together with that for Outcomes 4 and 5 to form a single assignment, details of which are given under Outcome 5 of this section.

Outcome 4

The assessment of this Outcome should be combined together with that for Outcome 3 and 5 to form a single assignment.

Outcome 5

The assessment for this Outcome could be combined with Outcomes 3 and 4 to form a single assignment. The assignment should holistically assess all three Outcomes and ensure that the candidate satisfies the minimum Evidence Requirements of each Outcome.

The minimum Evidence Requirements of each Outcome must be achieved in order to pass this Unit

Online and Distance Learning

This Unit could be delivered by distance learning, which may incorporate some degree of on- line support. Centres would need to have arrangements for candidates to undertake any laboratory work necessary for the completion of the Unit. 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 assessments are conducted under controlled, supervised conditions.

Higher National Unit specification: support notes (cont)

Unit title: Radio Communications

Opportunities for developing Core Skills

There are opportunities to develop the Core Skill *Working with Others* at SCQF level 6. Throughout this Unit it is expected that candidates will carry out several investigations into the navigation systems within the laboratory. This would be completed as small groups working together.

The formative laboratory work and the formal assessments will give the opportunity to develop the Core Skills components: Critical Thinking at SCQF level 6; Reviewing and Evaluating at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**

History of changes to Unit

Version	Description of change	Date

General information for candidates

Unit title: Radio Communications

This Unit has been designed to allow you to develop knowledge, skills and understanding in Radio Communications principles and concepts.

This Unit will also allow you the opportunity to develop the necessary practical and operating skills for working with and maintaining the radio communications equipment found on board modern merchant marine vessels.

It is good to gain sound theoretical knowledge and understanding but it is also important that you are able to set your theoretical knowledge within a practical context. Thus, it is likely during the Unit you will be provided with the opportunity to relate theory to practice by doing practical experiments using the type of equipment found in the marine industry.

Throughout this Unit it is expected that candidates will carry out several investigations into the navigation systems within the laboratory. This would be completed as small groups working together and give the opportunity to develop the Core Skill *Working with Others* at SCQF level 6.

The formative laboratory work and the formal assessments will give the opportunity to develop the Core Skills components: Critical Thinking at SCQF level 6; Reviewing and Evaluating at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

The formal assessment for this Unit will consist of one written examination lasting no more than 90 minutes and two assignments. The written assessment will include Outcome 1, assignment 1 will include Outcome 2 and assignment 2 will include Outcomes 3, 4, and 5.

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.

This Unit will consist of 5 Outcomes that you will study:

1 Analyse amplitude and angle modulation.
2 Explain the principles of radiation and propagation of transverse electromagnetic waves in the bands very low frequency (VLF) to extra high frequency (EHF).
3 Investigate and evaluate the principles and operation of radio transmitters.
4 Investigate and evaluate the principles and operation of radio receivers.
5 Outline Satellite communication principles.