Review of the Radio Amateur Examination Syllabus in South Africa

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Contents

Executive Summary

This review of the RAE Class A and B syllabi suggests the following changes:

1. The use of publicly accessible question banks should be phased out.

2. The Class A examination should follow the HAREC syllabus with an additional module covering microprocessors, digital modes and digital signal processing.

3. The Class B syllabus should be simplified by removing the technical electronics component. This, combined the removal of the Morse requirement for the ZU license and the introduction of the practical operating test, will result in an entry-level license similar to the British Foundation License which can be used to attract newcomers to the hobby.

4. Candidates who have passed the Class B RAE and who wish to write the Class A RAE should have the option of only writing the Class A "Technical" paper. Their marks from the "Regulations and Operating Procedures" paper would then be carried over from the Class B examination.

5. Council should investigate the use of online testing for the RAE examinations.

A syllabus is also outlined for the Practical Operating Test proposed by Council.

Introduction

The Radio Amateur Examination (RAE) is written by candidates wishing to obtain an Amateur Radio Operator Certificate, which is one if the prerequisites for the issuing of an amateur license in South Africa. There are two syllabi for the RAE: the Class A syllabus for candidates applying for a ZS or ZR license, and the Class B syllabus for candidates applying for a ZU license. The current syllabi for the Class A and B examinations can be found in Appendix A.

This document reviews the RAE syllabi in order to determine:

1. Whether they meet our international obligations under the CEPT[1] and HAREC[2] agreements.
2. Whether they reflect the technologies, modes and operating procedures used by amateurs today.
3. Whether they are best structured to attract new amateurs and to encourage them to acquire knowledge and skills relevant to amateur radio.

This review does not consider the issue of Morse code testing, as it is the subject of a separate process within Council.

The Radio Amateur Examination

Both the Class A and Class B examinations are written as two papers: "Regulations and Operating Practices" and "Technical". A minimum of 40% is required for each paper with an overall average of at least 50% for both papers. However ICASA has informed the SARL that when the new Radio Regulations take effect, a minimum of 50% will be required in each of the papers, with an overall average of at least 65% for both papers. Candidates sitting the Class A and Class B examinations write the same "Regulations and Operating Practices" paper, but they write different "Technical" papers.

The RAE is administered by the SARL on behalf of ICASA. The questions for both examinations are drawn from a question pool of 600 questions, which is available from the SARL web site. The question pool does not change from examination to examination, although different questions are selected from the pool for each sitting of the RAE.

[1] European Conference of Postal and Telecommunications Administrations (CEPT) Recommendation T/R 61-01: CEPT RADIO AMATEUR LICENCE
[2] CEPT Recommendation T/R 61-02: HARMONISED AMATEUR RADIO EXAMINATION CERTIFICATES

The use of a public question pool has the following effects:

1. The content of the question pool affects what is taught in RAE courses. For example, although Valve characteristics and circuits are included in both the RAE and HAREC syllabi, there are no questions about valves in the question pool, so as a result some RAE courses do not teach this aspect of the syllabus.

2. Since all possible questions are known before the examination, and the number of questions is quite limited, some candidates choose to learn the answers to the questions by rote rather than learning the underlying theory and how to apply it to problems other than the pool questions.

It is the author's opinion that both of these effects are negative. The curriculum taught in RAE classes should depend only on the examination syllabus, and not on what questions happen to be in a question pool. And we should encourage students to learn how to apply the theory to new problems; otherwise it will not be of any use to them.

Hence it is recommended that the public question pool be phased out. It is recognized that this cannot be done immediately and that it would be onerous to have to set completely new questions for each examination sitting, so the following guidelines are proposed:

1. In each sitting of the examination at least 20% of the questions set should be completely new, i.e. they must not have appeared in any question bank or previous examination.

2. The new questions created should not be added to the public question bank, but to a private question bank maintained by the SARL. These questions should not be made available to candidates or course instructors.

3. Once the private question bank acquires 600 questions, then examination questions should no longer be taken from the current public question bank. This question bank should remain available to students as an example of the sort of question that they might encounter and for revision purposes. However the questions themselves should not appear in examinations.

4. New questions for the RAE should be drawn from all areas of the syllabus, including those areas for which there are no (or very few) questions in the present question bank.

It is hoped that these measures will encourage RAE course instructors to teach the entire syllabus and will encourage the candidates to learn how to apply the theory to any problem that may arise.

HAREC Requirements

South Africa is a signatory to the CEPT Harmonized Amateur Radio Examination Certificates (HAREC) agreement[3]. This requires that CEPT member states and other signatories recognize amateur radio certificates issued by other CEPT states. This would allow, for example, an amateur with a license issued in South Africa who emigrates to the United Kingdom to apply for a British amateur license without having to rewrite the RAE.

The HAREC agreement specifies a minimum syllabus that must be covered in order for a HAREC to be issued. Note that there is a minimum requirement only and nothing in the agreement prevents member states from including additional material in their national examinations that lead to the issuing of a HAREC. In South Africa, only the Class A RAE is subject to HAREC requirements. The Class B RAE and its corresponding license class, the ZU license, do not conform to HAREC requirements and so could not be used to obtain a license in another CEPT country.

The HAREC and existing RAE Class A syllabi cover very similar subjects, although the HAREC syllabus is specified in more detail and covers some topics that are not mentioned in the RAE Class A syllabus. Since as a signatory to the HAREC agreement South Africa is required to implement at least

[3] CEPT Recommendation T/R 61-02: HARMONISED AMATEUR RADIO EXAMINATION CERTIFICATES

the HAREC syllabus for our Class A examination there is no point discussing the pros and cons of the two syllabi. Hence it is suggested that we use the HAREC syllabus as the basis for our Class A RAE examination and add additional topics to this if deemed necessary.

One area where the current RAE syllabus is more detailed than the HAREC is for national regulations, where the current RAE syllabus specifies which sections of the Radio Regulations and Telecommunications Act must be known by candidates. However even the RAE syllabus here is not very detailed so it is recommended that a more detailed syllabus for the Regulations component be outlined, listing topics rather than just chapter and section numbers.

Applicability to Current Amateur Practice

Because our international obligations require that we implement the HAREC syllabus in full, there is not much point in looking for components of the syllabus that are no longer relevant to current amateur practices. Fortunately however the HAREC syllabus is fairly up to date and there are in any case relatively few topics of dubious relevance.

However there are a few areas where the HAREC syllabus does not seem complete in the light of current amateur technologies and operating modes. These are as follows:

1. Digital Modes. The HAREC syllabus has very little on digital modes despite their increasing popularity.

2. Microprocessors. Despite the fact the microprocessors are a crucial component of almost all modern transceivers, the HAREC syllabus does not even mention them. The digital electronics is confined to a single topic, “simple digital circuits”, which I presume means “and” and “or” gates and so on. In an age where radio is becoming increasingly digital, this is clearly inadequate.

3. Digital Signal Processing. Just as microprocessors have become ubiquitous in control circuits, so digital signal processing is rapidly taking over many of the traditional analogue circuit functions. It is important that we provide tomorrow’s amateurs with at least a basic qualitative understanding of DSP if we hope to restore amateur radio’s status as a technology leader.

For these reasons, I suggest that in addition to the HAREC requirements the Class A RAE should include an additional technical element structured as follows:

11. MICROPROCESSORS AND DIGITAL MODES

11.1 Microprocessors

The binary encoding of numbers.
Microprocessor architecture (CPU, memory, I/O, clock, address and data busses) and applications
Microprocessor programming: machine code, high-level languages, and compilers.
Applications of the Personal Computer in amateur radio
The PC soundcard/radio interface.

11.2 Digital Modes

Packet Radio: The TNC, AX.25 protocol, addresses, bulletin boards and digipeaters.
PSK31: Baud rate, bandwidth, character encoding, PSK modulation, software and hardware required.
The WSJT modes: FSK441, JT6M, JT44 and JT65: purpose, baud rate and bandwidth of each mode.
Digital Telephony: Basic architecture – CODEC, Error correction and MODEM.

11.3 Digital Signal Processing

Using numbers to represent signals in the time domain.
Sampling theory, aliasing and the role of anti-aliasing and reconstruction filters.
Analog-to-digital and digital-to-analog converters.
Structure of the Finite Impulse Response (FIR) Filter (not including calculation of coefficients)
Digital Mixing by multiplication
Digital oscillators and direct digital synthesis (DDS)
Applications of DSP in modern amateur transceivers

The Class B RAE

Discussions so far have focused on the Class A RAE dues to its relationship with the HAREC syllabus. In contrast, the Class B syllabus is not required to conform to the HAREC requirements, which gives us a much freer hand to tailor it to our purposes.

Our first question should be, what is the purpose of the Class B RAE and the associated ZU license class? In my mind it should provide a simple means for new amateurs to get on the air as easily as possible. For this reason I suggest that the majority of the technical content should be removed from the Class B syllabus, which should concentrate on what new amateurs need to know in order to operate commercially manufactured transceivers safely, legally, correctly and without causing interference.

Although I believe that the Class B "Regulations and Operating Practices" syllabus should remain as it is I believe the "Technical" syllabus should include only the following subjects:

1. PROPAGATION

Calculation of wavelength and frequency.
Nature and propagation of radio waves.
Ionospheric and tropospheric conditions and their influence on propagation.

2. ANTENNAS

Basic receive and transmit antennas - MF, HF and VHF

3. MEASUREMENTS

The measurement of standing-wave ratios.
The measurement of frequency using a frequency counter.

4. INTERFERENCE

Frequency stability: causes and correction of instability.
The effect and avoidance of harmonic radiation.
Parasitic emission caused by short key clicks.
Long distance key clicks and chirp, and the use of various filters to prevent this interference.
The effect and problem of over-modulation and bandwidth.

5. GENERAL SAFETY IN THE AMATEUR RADIO STATION

Earthing of sets.
Loading of power plugs.
Protection against RF and electric shocks.
Treatment of electric shock and action.
Lightning and fire protection.

6. OPERATING PROCEDURES

Knowledge of the following:
- Allocated frequencies.
- Operator's procedure for all allocated modes.
- International phonetic alphabet.
- Keeping of Log Books.

The objective is that the Class B RAE should become a fairly easy entry point into the hobby for new amateurs who will then hopefully become interested in the more technical aspects of amateur radio and will write the Class A RAE. The frequency and power limitations of the ZU license should provide further encouragement to ZU licensees to upgrade to a ZR or ZS license by writing the Class A RAE.

Although this review does not cover the Morse requirements in general, it is recommended that the Morse requirement for the ZU license be removed to make it more accessible.

In addition, a practical test of the candidate's ability to correctly set up, adjust and operate a commercial HF transceiver should be included as an additional requirement for the ZU license. The objective of this is to ensure that new ZU licensees have practical experience of operating a transceiver before they obtain a license. The necessary on-air practice and the practical test itself could be conducted in terms of the current agreement with ICASA that allows unlicensed individuals to operate registered educational stations under the supervision of a control operator.

Practical Operating Test

The objective of the practical operating test is to ensure that new amateurs have some training in the operation of an HF transceiver before obtaining a license that allows them to transmit on the HF bands. This test would be required for all license classes with access to HF bands. According to the current Council proposal regarding license restructuring this will include the ZU, ZR and ZS licenses.

Examiner

It is proposed that the practical test be conducted by examiners nominated by clubs and appointed by the SARL for the purpose. In order to qualify as an examiner, an amateur should be a current member of the SARL who has passed the Class A RAE and has held a license with HF privileges for at least 2 years. The appointment of examiners should be subject to annual renewal by the SARL. It is recommended that the examination be conducted by two appointed examiners in each instance. The main motivation for this is to protect examiners from allegations of misconduct made by candidates.

Procedure

The test should be conducted using an amateur HF transceiver typical of the sort used by new amateurs. An entry-level solid-state transceiver is recommended. The candidate should be given the option of bringing his or her transceiver, or a club transceiver, for the test so they can be tested with the equipment, which they will use in practice. The operating manual for the transceiver should be available to the candidate, who should be allowed to consult it if necessary during the test.

The candidate should not be prejudiced for asking the examiner questions about the location of controls on the particular transceiver being used for the test. For example, it is quite permissible for the candidate to ask: "Now I should adjust the microphone gain. I don't see the microphone gain control, where is it located on this transceiver?". However the examiner should be alert for questions that show ignorance not of the control locations on a particular transceiver but of the procedure to be followed – for example "Should I adjust the microphone gain or the RF gain?". A candidate who demonstrates ignorance of the basic procedures being tested should be marked down accordingly.

1. Setting up the Transceiver

The transceiver should initially be presented with the antenna, earth, power supply (either DC or mains), microphone and headphones disconnected. The candidate should be asked to indicate how each of these is connected and, once the examiner has confirmed that this is correct, to make the connection.

2. Adjusting the Transceiver for Reception

The microphone gain, RF gain, Audio gain (volume) and transmit power controls should initially be set to zero. The candidate should be asked to select a frequency nominated by the instructor and adjust the transceiver for correct reception of an SSB signal. This should include selecting the correct sideband depending on the band chosen.

3. Adjusting the Transceiver for Transmission

The examiner should explain to the candidate how to connect a dummy load to the transceiver in place of the antenna. With the dummy load in place, the candidate should demonstrate how to correctly adjust the microphone gain, transmit power and any other controls (for example VOX/PTT switch) required to transmit.

4. Operating Procedures

This section may be tested either by through an on-air test in the case of a registered educational station, or by means of a simulated (off-air) QSO. The candidate should be required to demonstrate two

QSOs, one where the candidate calls CQ and one where the candidate answers another station calling CQ. The examiner should be alert for the following:

- The correct use of the *standard* phonetic alphabet
- Getting the callsign of the other station correct
- Correct use of the RS standard for reports
- Not using unnecessary jargon
- Observing all regulations, including giving his/her callsign in each transmission
- Correctly making out a log entry for each of the QSOs
- Courtesy and a professional manner

Marking

The practical operating test is intended partly as a learning experience for the candidate, so when he/she makes a mistake the mistake should be explained by the examiner who should then give the candidate an opportunity to try that activity again.

The candidate should be graded "satisfactory" or "unsatisfactory" for each of the activities required of him or her. These activities should be specified on a mark sheet to be used by the examiner. Where the candidate makes a mistake, his or her performance should be marked as "unsatisfactory" even if he or she gets it right after the mistake is explained.

The candidate should pass the test if she or he performs satisfactorily in 65% or more of the activities (this coincides with the 65% pass mark for the RAE papers) and if he or she does not make any mistakes which, in the opinion of the examiner, would be likely to result in death, injury or damage to equipment (such as attempting to connect the AC mains to the DC power supply socket on a transceiver, for example). In the event that a candidate makes a mistake that would be likely to result in death, injury or damage to equipment then he or she must be failed even if s/he obtains the required 65% aggregate.

If a candidate fails a test, then it is permitted for the candidate to be retested immediately by the same examiner. If the candidate fails a second time then s/he may not be tested again on the same day.

Certification

On successfully passing the practical operating test the candidate should be issued with a certificate signed by the examiner. The certificate should be a standard form printed in colour and distributed to examiners by the SARL.

Fees

Due to the complexity of having examiners collect and account for fees received from candidates it is suggested that no fee be levied for the practical operating test. The cost of printing and distributing the certificates should rather be included in the fees charged for issuing licenses that require a practical test.

Upgrading from Class B to Class A RAE

A key objective of the new license structure proposed by Council is to attract new amateurs to the hobby through the relatively simple ZU license (which requires a Class B RAE) and then encourage them to upgrade to the ZR and ZS licenses (which require the Class A RAE). Since the Class B and Class A RAE share the same Regulations and Operating Procedure syllabus and examination paper, we should allow a candidate who has passed the Class B RAE and wishes to write the Class A RAE the option of only writing the Technical paper, with the marks for the Regulations and Operating Procedures paper being carried over from their Class B examination. This should only be an option, as some candidates may choose to write both papers in order to improve their marks for the Regulations and Operating Procedures paper.

Online Examinations

At present the RAE is using paper-based examination papers, which must be couriered to exam venues around the country. This results in considerable expense, which must in turn be passed on to the candidates through examination fees, and also means that the examination can only be conducted twice a year due to the cost and amount of organization required.

The widespread availability of Internet access makes it feasible to offer the examination over the Internet through a Web page. There is commercially available web-based assessment software available[4] or we could write our own. An online examination would have the following benefits:

1. The examination system could select questions at random from a question pool, ensuring that it had the correct number of questions on each topic. This means that each candidate would receive a different examination paper, and the examination could be written at a time and place convenient to the candidate.

2. The costs of administering the examination would be reduced, especially if written examinations could be discontinued, as we would no longer incur the printing and courier fees. The resulting lower costs could be passed on to candidates as a lower examination fee, reducing one barrier to entry to our hobby.

3. The examination could be marked automatically and immediately. This would reduce the workload on the examiner, and would mean that candidates would not have to wait for their results[5].

4. It would make it easier to regularly offer the Class B RAE, which will be important if we are to use the ZU license to attract newcomers to the hobby.

These benefits make it worth investigating the use of online testing. However the following concerns must be addressed before it is introduced:

1. Assuring that the person writing the exam is who he or she claims to be, and that he or she is not receiving any unauthorized assistance from books, notes or third parties. The only feasible solution will probably be to require that online examination sessions are invigilated, and that the invigilator inspects the identity document of the candidate and vouches for his or her identity and that the examination was properly conducted.

2. Ensuring that the provision of online examinations does not allow candidates to make copies of examination questions. Since these questions will be drawn from a (non-public) question bank and may be used multiple times, it is important that the integrity of our non-public question bank not be compromised by online examinations.

3. Provision must be made for payment for examinations. This could be done either by taking credit card details or by requiring that the candidate pay first through normal channels and then provide a receipt number for the examination.

4. We need to ensure that any online services offered (including examinations) abide by the provisions of all applicable legislation, including the Electronic Communications and Transactions Act, 25 of 2002.

If these concerns can be addressed then the use of online examinations could be very beneficial, especially when combined with the simplification of the requirements for the ZU license, as candidates could attend a short course, complete the practical operating test and write the examination online to obtain their licenses almost immediately.

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[4] See for example the Virtual Assessor offered by the South African company Eduflex.com www.eduflex.com.

[5] It should be noted that candidates rarely wait more than 2 weeks for results due to the excellent service provided by the current examiner.

Appendix A: The Current RAE Syllabus

PART 1: Regulations and Operating Practices (Classes A and B)

1.(a) Candidates must have a knowledge of Chapters 3 and 8 of the Radio Regulations and the applicable Definitions in Chapter 1 and of Sections 5, 6, 7, 8, 9, 10, 11, 14, 16 and 19 of the Telecommunications Act of 1996.

(b) Knowledge of the International Q Code and Operating Practices.

PART 2: Class A Technical

1. ELEMENTARY ELECTRICITY AND MAGNETISM

(a) Basic Electricity:

Theory of electricity: units; conductors; and insulators.
Application of Ohm's Law.
Resistors in series and parallel.
Types and use of resistors as well as the use of the international Colour Code and schematic symbols.
The calculation of power in a circuit as well as the difference between EMF and terminal voltage.

(b) Magnetism

The permanent magnet and its magnetic field.
The electromagnet and the development of its magnetic field.
The use and operation of moving coil meters, loudspeakers, relays and microphones.

(c) Inductors

Types of inductors and schematic symbols.
The transformer, use and construction of power, high-frequency and low-frequency transformers.
Low and mutual induction with inductors.
Inductors in series and parallel.

(d) Capacitance

Types of capacitors and schematic symbols.
Use of the capacitor and construction for high and low frequencies.
Capacitors in series and parallel.

2. ELEMENTARY RADIO PRINCIPLES

Relationship between frequency and wavelength.
Phase relationship between current and voltage in circuits containing combinations of resistor, capacitors and inductors.
Calculation of maximum, average and effective rms values of current, voltage and power in alternating-current circuits.
Capacitive and inductive reactance.
Impedance calculations (RLC)
Series and parallel resonance
Resonance: relationship between Q and bandwidth.
Two-element band-pass, stop and low-pass filters.

3. BASIC VALVE AND SEMI-CONDUCTOR CIRCUITS

Construction of diode, triode and multi-electrode valves: characteristic curves.
Construction of semi-conductor diode and transistor: character curves
Biasing methods with valves and semi- conductors.
Use of valves and semi-conductors as crystal and variable-frequency oscillators, amplifiers, detectors, frequency-converters, power rectifiers, power supplies, and for stabilisation and smoothing.

4. RADIO RECEIVING APPARATUS

Principles and operation of tuned radio frequency (TRF) and superhetrodyne receivers, continuous-wave receivers, beat frequency oscillators: FM and SSB receivers.
Problems causing interference to reception of signals: Cross- modulation, second or adjacent channel interference, image interference and break-through on radio and TV apparatus.
RF insulation of antenna and power supply.

5. TRANSMITTERS

Oscillatory circuits: the use of quartz crystals to control oscillators.
Frequency multipliers, power amplifiers: methods of keying transmitters.
Principles and operation of double sideband, single sideband, continuous wave and FM transmitters.
Method of modulation.

6. PROPAGATION

Calculation of wavelength, frequency and velocity.
Nature and propagation of radio waves.
Ionospheric and tropospheric conditions and their effect on propagation.
Critical frequency, maximum usable frequency, radiation angles.

7. ANTENNAS

Basic receiving and transmitting antennas - MF, HF and VHF.
Directional and omnidirectional antennas - MF, HF and VHF
Transmission lines.
Coupling of feeder lines and matching between transmitting/receiving apparatus and antenna.

8. MEASUREMENTS

The measurement of standing-wave ratios.
The measurements of frequency and the use of absorption and crystal- controlled frequency measuring instruments.
The use of vernier scales and interpolation methods to set up transmitter frequency
The use and output of artificial antennas.
The measurement of anode current and input to the transmitter final stage.
Expansion of meter scales: voltmeter, ammeter and ohmmeter.
Use of oscilloscope.

9. INTERFERENCE

Frequency stability: causes and correction of instability.
The effect and avoidance of harmonic radiation.
Interference caused by shock-excitation.
Parasitic emission caused by short key clicks.
Long distance key clicks and chirp, and the use of various filters to prevent this interference.
The effect and problem of overmodulation, bandwidth and deviation.

10. GENERAL SAFETY IN THE AMATEUR RADIO STATION

Earthing of sets.
Loading of power plugs.
Protection against RF and electric shocks.
Treatment for electric shock and action.
Lightning and fire protection.

11. KNOWLEDGE OF THE FOLLOWING:

Allocated frequencies.
Operator's procedures for all allocated modes.
Frequency network.
International phonetic alphabet.
Keeping of Log Books.

PART 3: Class B Technical

1. ELEMENTARY ELECTRICITY

(a) BASIC ELECTRICITY

Theory of electricity: units; conductors and insulators
Application of Ohm's Law.
Resistors in series and parallel.
Types and use of resistors as well as the use of the International Colour Code and schematic symbols.

(b) MAGNETISM

The permanent magnet and its magnetic field.
The electromagnet and the development of its magnetic field.

(c) INDUCTORS

Types of inductors and schematic symbols.

(d) CAPACITANCE

Types of capacitors and schematic symbols.

2. ELEMENTARY RADIO PRINCIPLES

The relationship between frequency and wavelength.

3. RADIO RECEIVING APPARATUS

Principle and operation of continuous-wave receivers, hetrodyne oscillators, FM and SSB receivers.
Problems causing interference to the reception of signals: cross modulation, second or adjacent-channel interference, image interference and break-through on radio and TV receiving apparatus.
RF insulation of antenna and power supply.

4. TRANSMITTERS

Principles and operation of double sideband, single sideband and continuous-wave transmitters.

5. PROPAGATION

Calculation of wavelength and frequency.
Nature and propagation of radio waves.
Ionospheric and tropospheric conditions and their influence on propagation.

6. ANTENNAS

Basic receive and transmit antennas - MF, HF and VHF

7. MEASUREMENTS

The measurement of standing-wave ratios.
The measurement of frequency and the use of absorption and crystal controlled frequency measuring instruments.

8. INTERFERENCE

Frequency stability: causes and correction of instability.
The effect and avoidance of harmonic radiation.
Parasitic emission caused by short key clicks.
Long distance key clicks and chirp, and the use of various filters to prevent this interference.
The effect and problem of overmodulation and bandwidth.

9. GENERAL SAFETY IN THE AMATEUR RADIO STATION

Earthing of sets.
Loading of power plugs.
Protection against RF and electric shocks.
Treatment of electric shock and action.
Lightning and fire protection.

10. KNOWLEDGE OF THE FOLLOWING

Allocated frequencies.
Operators procedure for all allocated modes.
Frequency network.
International phonetic alphabet.
Keeping of Log Books.

Appendix B: The HAREC Syllabus[6]

a) Technical Content

1. ELECTRICAL, ELECTRO-MAGNETIC AND RADIO THEORY

1.1 Conductivity

− Conductor, semiconductor and insulator
− Current, voltage and resistance
− The units ampere, volt and ohm
− Ohm's Law [E=I.R]
− Kirchhoff's Laws
− Electric power [P=E.I]
− The unit watt
− Electric energy [W=P.t]
− The capacity of a battery [ampere-hour]

1.2 Sources of electricity

− Voltage source, source voltage [EMF], short circuit current, internal resistance and terminal voltage
− Series and parallel connection of voltage sources

1.3 Electric field

− Electric field strength
− The unit volt/metre
− Shielding of electric fields

1.4 Magnetic field

− Magnetic field surrounding live conductor
− Shielding of magnetic fields

1.5 Electromagnetic field

− Radio waves as electromagnetic waves
− Propagation velocity and its relation with frequency and wavelength
− Polarisation

1.6 Sinusoidal signals

− The graphic representation in time
− Instantaneous value, amplitude [Emax], effective [RMS] value and average value
− Period and duration of period
− Frequency
− The unit hertz
− Phase difference

1.7 Non-sinusoidal signals

− Audio signals
− Square wave
− The graphic representation in time
− D.C. voltage component, fundamental wave and higher harmonics

1.8 Modulated signals

− Amplitude modulation

[6] CEPT Recommendation T/R 61-02 (Chester 1990, revised in Nicosia 1994 and The Hague 2001), Annex 6. Some details have been omitted so please refer to the original for the complete syllabus. The Recommendation also includes a Morse code requirement but that is outside the scope of this review.

− Phase modulation, frequency modulation and single-sideband modulation
− Frequency deviation and modulation index
− Carrier, sidebands and bandwidth
− Waveform

1.9 Power and energy

− The power of sinusoidal signals
− Power ratios corresponding to the following dB values: 0 dB, 3 dB, 6 dB, 10 dB and 20 dB [both positive and negative]
− The input/output power ratio in dB of series-connected amplifiers and/or attenuators
− Matching [maximum power transfer]
− The relation between power input and output and efficiency
− Peak Envelope Power [p.e.p.]

2. COMPONENTS

2.1 Resistor

− The unit ohm
− Resistance
− Current/voltage characteristic
− Power dissipation
− Positive and negative temperature coefficients [PTC and NTC]

2.2 Capacitor

− Capacitance
− The unit farad
− The relation between capacitance, dimensions and dielectric. (Qualitative treatment only)
− The reactance
− Phase relation between voltage and current
− Characteristics of fixed and variable capacitors: air, mica, plastic, ceramic and electrolytic capacitors
− Temperature coefficient
− Leakage current

2.3 Coil

− Self-inductance
− The unit henry
− The effect of number of turns, diameter, length and core material on inductance. (Qualitative treatment only)
− The reactance
− Phase relation between current and voltage
− Q-factor
− Skin effect
− Losses in core materials

2.4 Transformers application and use

− Ideal transformer
− The relation between turn ratio and:
− voltage ratio
− current ratio
− impedance ratio. (Qualitative treatment only)
− Transformers

2.5 Diode

− Use and application of diodes:
− Rectifier diode, zener diode, LED [light-emitting diode], voltage-variable and capacitor [varicap]
− Reverse voltage and leakage current

2.6 Transistor

− PNP- and NPN-transistor
− Amplification factor
− Field-effect transistor [N channel and P channel, j-FET]
− The resistance between gate and source
− The transistor in the:
− common emitter [source] circuit
− common base [gate] circuit
− common collector [drain] circuit
− input and output impedances of the above circuits
− method of biasing

2.7 Miscellaneous

− Simple thermionic device [valve]
− Simple digital circuits

3. CIRCUITS

3.1 Combination of components

− Series and parallel circuits of resistors, coils, capacitors, transformers and diodes
− Current and voltage in these circuits
− Impedance of these circuits

3.2 Filter

− Series-tuned and parallel-tuned circuit:
− Impedance
− Frequency characteristic
− Resonant frequency
− Quality factor of a tuned circuit
− Bandwidth
− Band-pass filter
− Low-pass, high-pass, band-pass and band-stop filters composed of passive elements
− Frequency response
− Pi filter and T filter
− Quartz crystal

3.3 Power supply

− Circuits for half-wave and full-wave rectification and the Bridge rectifier
− Smoothing circuits
− Stabilisation circuits in low voltage supplies

3.4 Amplifier

− Lf and hf amplifiers
− Amplification factor
− Amplitude/frequency characteristic and bandwidth
− Class A, A/B, B and C biasing
− Harmonics [non-linear distortion]

3.5 Detector

− AM detectors
− Diode detector
− Product detector
− FM detectors
− Slope detector
− Foster-Seeley discriminator
− CW/SSB detectors

3.6 Oscillator

− Factors affecting frequency and frequency stability conditions necessary for oscillation
− LC oscillator
− Crystal oscillator, overtone oscillator

3.7 Phase Locked Loop [PLL]

− Control loop with phase comparator circuit

4. RECEIVERS

4.1 Types

− Single and double superheterodyne receiver

4.2 Block diagrams

− CW receiver [A1A]
− AM receiver [A3E]
− SSB receiver for suppressed carrier telephony [J3E]
− FM receiver [F3E]

4.3 Operation and function of the following stages (Block diagram treatment only)

− HF amplifier
− Oscillator [fixed and variable]
− Mixer
− Intermediate frequency amplifier
− Limiter
− Detector
− Beat frequency oscillator
− Crystal calibrator
− LF amplifier
− Automatic gain control
− S meter
− Squelch

4.4 Receiver characteristics (simple description treatment)

− Adjacent-channel
− Selectivity
− Sensitivity
− Stability
− Image frequency
− Intermodulation; cross modulation

5. TRANSMITTERS

5.1 Types

− Transmitter with or without frequency translation
− Frequency multiplication

5.2 Block diagrams

− CW transmitter [A1A]
− SSB transmitter with suppressed carrier telephony [J3E]
− FM transmitter [F3E]

5.3 Operation and functions of the following stages (Block diagram treatment only)

− Mixer
− Oscillator
− Buffer

− Driver
− Frequency multiplier
− Power amplifier
− Output filter [pi-filter]
− Frequency modulator
− SSB modulator
− Phase modulator
− Crystal filter

5.4 Transmitter characteristics (simple description)

− Frequency stability
− RF-bandwidth
− Sidebands
− Audio-frequency range
− Non-linearity
− Output impedance
− Output power
− Efficiency
− Frequency deviation
− Modulation index
− CW key clicks and chirps
− Spurious hf radiations
− Cabinet radiations

6. ANTENNAS AND TRANSMISSION LINES

6.1 Antenna types

− Centre fed half-wave antenna
− End fed half-wave antenna
− Folded dipole
− Quarter-wave vertical antenna [ground plane]
− Antenna with parasitic elements [Yagi]
− Parabolic antenna
− Trap dipole

6.2 Antenna characteristics

− Distribution of the current and voltage
− Impedance at the feed point
− Capacitive or inductive impedance of a non-resonant antenna
− Polarisation
− Antenna gain
− Effective radiated power [e.r.p.]
− Front-to-back ratio
− Horizontal and vertical radiation diagrams

6.3 Transmission lines

− Parallel conductor line
− Coaxial cable
− Waveguide
− Characteristic impedance [Z0]
− Velocity factor
− Standing-wave ratio
− Losses
− Balun
− Quarter-wave line as impedance transformer [$Z0^2$=Zin.Zout]
− Open and short-circuited lines as tuned circuits
− Antenna tuning units

7. PROPAGATION

− Ionospheric layers
− Critical frequency
− Influence of the sun on the ionosphere
− Maximum Usable Frequency
− Ground wave and sky wave, angle of radiation and skip distance
− Fading
− Troposphere
− The influence of the height of antennas on the distance that can be covered [radio horizon]
− Temperature inversion
− Sporadic E-reflection
− Auroral reflection

8. MEASUREMENTS

8.1 Making measurements

− Measurement of:
− DC and AC voltages and currents
− Measuring errors:
− Influence of frequency
− Influence of waveform
− Influence of internal resistance of meters
− Resistance
− DC and RF power [average power, Peak Envelope Power]
− Voltage standing-wave ratio
− Waveform of the envelope of an RF signal
− Frequency
− Resonant frequency

8.2 Measuring instruments

Making measurements using:
− Moving-coil meter
− Multi-range meter
− Reflectometer bridge
− Frequency counter
− Absorption frequency meter
− Dip meter
− Oscilloscope

9. INTERFERENCE AND IMMUNITY

9.1 Interference in electronic equipment

− Blocking
− Interference with the desired signal
− Intermodulation
− Detection in audio circuits

9.2 Cause of interference in electronic equipment

− Field strength of the transmitter
− Spurious radiation of the transmitter [parasitic radiation, harmonics]
− Undesired influence on the equipment:
− via the antenna input [aerial voltage, input selectivity]
− via other connected lines
− by direct radiation

9.3 Measures against interference

Measures to prevent and eliminate interference effects:

− Filtering
− Decoupling
− Shielding

10. SAFETY

− The human body
− Mains power supply
− High voltages
− Lightning

b) National and international operating rules and procedures

1. PHONETIC ALPHABET

Knowledge of the international phonetic alphabet.

2. Q-CODE

Knowledge of the following Q Codes and their meanings: QRK, QRM, QRN, QRO, QRP, QRS, QRT, QRZ, QRV, QSB, QSL, QSO, QSY, QRX, QTH.

3. OPERATIONAL ABBREVIATIONS AS USED IN THE AMATEUR SERVICE

AR *) End of transmission
BK Signal used to interrupt a transmission in progress
CQ General call to all stations
CW Continuous wave
DE From, used to separate the call sign of the station called from that of the calling station
K Invitation to transmit
MSG Message
PSE Please
RST Readability, signal-strength, tone-report
R Received
RX Receiver
TX Transmitter
UR Your
VA *) End of work
*) In Morse transmitted as one coherent character.

4. INTERNATIONAL DISTRESS SIGNS, EMERGENCY TRAFFIC AND NATURAL DISASTER COMMUNICATION

Distress signs:
− radiotelegraph ...---... [SOS]
− radiotelephone "MAYDAY"
− Resolution No. 640 of the Radio Regulations [ITU]
− International use of the amateur station in the event of national disasters
Frequency bands allocated to the amateur service

5. CALL SIGNS

− Identification of the amateur station
− Use of the call signs
− Composition of call signs
− National prefixes

6. IARU BAND PLANS

− IARU band plans

− Purposes

c) National and international regulations relevant to the amateur radio and radio amateur satellite service

1. ITU RADIO REGULATIONS

− Definition Amateur Service and Amateur Satellite Service
− Definition Amateur station
− Article 32 Radio Regulations
− Status Amateur Service and Amateur Satellite Service
− ITU Radio Regions

2. CEPT REGULATIONS

− Recommendation T/R 61-01
− Temporary use of amateur stations in CEPT countries
− Temporary use of amateur stations in NON-CEPT countries which participate in the T/R 61-01 system

3. NATIONAL LAWS, REGULATIONS AND LICENCE CONDITIONS

− National laws
− Regulations and licence conditions
− Demonstrate knowledge of maintaining a log
− log keeping
− purpose
− recorded data