



**IRISH RADIO
TRANSMITTERS SOCIETY**

**PATRON Michael D. Higgins
PRESIDENT OF IRELAND**

**Amateur Radio
in Ireland**

Since 1932

www.irts.ie



Harmonised Amateur Radio Examination Certificate (HAREC)

Examination Syllabus

This syllabus complies with the conditions of
CEPT Recommendation T/R 61-02

5 July 2022 Revision 2.0.2

Copyright 2022 © Irish Radio Transmitters Society



1 The Irish HAREC Amateur Station Licence Exam

The Irish HAREC exam consists of 60 questions belonging to two sections, A and B, each containing 30 questions. The pass mark is 60% and a pass is required in each of the two sections of the paper. In other words, you need to have at least 18 correctly answered questions in each section to pass the exam. The exam lasts two hours. If you fail one of the sections but pass the other, you will need to take the entire exam again—no partial credits are allowed.

If you have physical or other impairments, such as those outlined in the Irish Disability Act 2005, you should contact the IRTS Examination Board to discuss making special arrangements to facilitate you during the exam. Please see <https://irts.ie/contactus> for contact details.

To help you study for the exam and to better understand the scope of the material that is included or excluded from the exam, please use the **IRTS HAREC Study Guide**, available from the IRTS web site downloads section¹. You will also find there a **Sample HAREC Exam Paper**:

<http://irts.ie/downloads>

The tables below show the structure of the exam: the topic and the number of questions. The IRTS HAREC Study Guide includes a similar table, also showing page and chapter numbers where these topics are explained in detail.

¹ The IRTS HAREC Study Guide is currently being updated. It will be available from the irts.ie web site in August 2022. A draft version of the guide is available, upon request. Please contact info@swl.ie to request a pre-publication draft. The Sample HAREC Exam Paper is already available in the downloads section of irts.ie.



Table 1-A: HAREC Exam Section A—Technical—30 Questions

Exam Section A		
Subsection	Topics	Questions
A.1	Safety	5
A.2	Interference and Immunity	4
A.3	Electrical, Electromagnetic, and Radio Theory	4
A.4	Components and Circuits	3
A.5	Transmitters and Receivers	4
A.6	Antennas and Transmission Lines	4
A.7	Propagation	4
A.8	Measurements	2

Table 1-B: HAREC Exam Section B—Operating Rules, Procedures, Regulations—30 Questions

Exam Section B		
Subsection	Topics	Questions
B.1	Phonetic Alphabet	1
B.2	Q-Codes	3
B.3	International Distress Signs, Emergency Traffic and Natural Disaster Communications	3
B.4	Call Signs	3
B.5	Radio Spectrum Allocation in Ireland and IARU Band Plans	4
B.6	Social Responsibility of Radio Amateur Operation and the Code of Conduct	3
B.7	Operating Procedures and Non-Interference	5
B.8	ITU Radio Regulations	2
B.9	CEPT Regulations	3
B.10	Irish Laws, Regulations, and Licence Conditions	3



2 Section A: Technical

A.1 Safety (5 Questions)

Radio safety and the Irish law: Wireless Telegraphy (Amateur Station Licence) Regulations 2009.

Equipment labelling and access control requirements: ComReg Amateur Station Licence Guidelines 09/45.

Electricity and the human body. Dealing with electric shock.

Mains power supply. Earthing. Bonding to protective earth and installation certification: Irish electrical safety regulations (Safe Electric). Wiring and plugs. Fuse ratings. Precautions when adjusting live equipment.

Mobile and battery safety.

Antenna (aerial) mechanical safety. Lightning protection.

Electrical safety. CE type approval mark.

Chemical safety. Reduction of Hazardous Substances (RoHS) directive.

Non-Ionising Radiation and Electromagnetic Field Safety. ICNIRP (International Commission on Non-Ionising Radio Protection) guidelines 1998 and 2020. How to comply? Nature of the risks. Station characteristics influencing radiation: Effective Radiated Power (ERP), location and the distance of people from the reactive near field vs far field. Role of estimating and modelling radiation exposure. Importance of accurate, calibrated measurements. Practical approaches towards limiting non-ionising radiation exposure.

A.2 Interference and Immunity (4 Questions)

Interference in electronic equipment. Intermodulation. Detection in audio circuits. Cross-modulation. Overmodulation. Splatter. Key clicks. Overdriving linear amplifiers.

Causes of interference in electronic equipment. Transmitter and field strength. Spurious radiation of the transmitter. Undesired influence on the equipment via the antenna input, via other connected lines, and by direct radiation.

CE type approval mark. Radio Emission Directive. Electromagnetic Compatibility Directive.

Measures to prevent and eliminate interference effects. Filtering. Decoupling. Shielding. Location of antennas. Drive levels in linear amplifiers.

A.3 Electrical, Electromagnetic, and Radio Theory (4 Questions)

Units and Dimensions

SI units of the following physical phenomena: current (ampere), emf (volt), voltage (volt), power (watt), energy (kilowatt-hour), electric charge and battery capacity (ampere-hour), resistance (ohm), inductive reactance (ohm), capacitive reactance (ohm), reactance (ohm), impedance (ohm), inductance (henry), capacitance (farad), frequency (hertz), wavelength (metre), length (metre), time (second).

Commonly used dimension symbols of the above phenomena.



Metric prefixes: giga, mega, kilo, deci, centi, milli, micro, nano, pico. Prefix as a decimal and a power of 10. Unit conversion using different prefixes and no prefixes.

Electricity and Current

Conductivity. Insulators. Conductors. Semiconductors and solid-state electronics.

DC and AC current.

Sources of electricity and electromotive force (emf). Series vs parallel connection of sources of electricity.

Voltage. Difference between voltage (potential difference) and electromotive force (emf).

Practical understanding of the distribution of voltage and current in series and parallel circuits as a consequence of Kirchhoff's current and voltage laws. Branches in a circuit.

Resistance.

Ohm's law. Different ways to express Ohm's law in equations so as to find out the current, voltage, or resistance, given the others.

Electric power and energy. Work. Power and Ohm's law.

Electrical energy and battery capacity. Calculating time to discharge to empty of a battery given its capacity in ampere-hours and kilowatt-hours.

Alternating Current and Sinusoidal Signals

Time domain representation. Amplitude. Frequency. Period vs frequency. Wavelength vs frequency. Instantaneous and average values.

Effective voltage, peak voltage, max and min voltage, rms, peak-to-peak voltage. Power.

Alternating current as mains power supply current. Voltage and frequency of mains power supply in Ireland.

Radio frequency alternating current.

Phase in degrees. Phase difference of sinusoidal signals.

Harmonics.

Modulated sinusoidal signals.

Digital Signal Processing and Non-Sinusoidal Signals

Non-sinusoidal signals. Non-periodic signals. Square wave. Digital signals. Audio as a non-sinusoidal signal comprised of a combination of sinusoidal signals.

Digital Signal Processing (DSP). Use of DSP for audio frequency (AF) vs radio frequency (RF) signals.

Frequency domain representation. Fast Fourier Transform (FFT). Conversion between time and frequency domain representations using FFT. FFT use in DSP.

Analogue-Digital Converter (ADC). Sampling. Sampling rate. Sampling rate and bandwidth. Minimum sampling rate. Quantisation. Resolution. Resolution and signal-to-noise ratio (SNR) and dynamic range. Oversampling.

Direct Digital Synthesis (DDS) using a Numerically Controlled Oscillator (NCO) and a Digital-Analogue Converter (DAC). Reconstruction filter.



Software Defined Radio (SDR). SDR as a broadband receiver. SDR as a transceiver.

Radio Waves and Spectrum

Nature of radio waves and electromagnetic radiation. Speed of propagation in vacuum (speed of light).

Electromagnetic wave. Electric (E) field. Electric field strength in V/m and its relationship to the distance from the antenna. Magnetic (H) field. Magnetic (H) field strength in A/m and its relationship to the distance from the antenna. Static vs changing (time-varying) fields. Fields vs. waves. Polarisation.

Radio spectrum frequencies. ITU radio band names and frequency ranges for LF, MF, HF, VHF, and UHF.

Power Ratios and Decibels

Decibel. Approximate power ratio of the following decibel values: 30 dB, 20 dB, 10 dB, 9 dB, 6 dB, 3 dB, 0 dB, -3 dB, -6 dB, -10 dB, -20 dB.

Power ratios. Power ratios in watts as decibels. Power ratios using voltage or current as decibels.

Absolute power in dBW. Watt value of the following dBW values: 10 dBW, 12 dBW, 14 dBW, 17 dBW, 20 dBW, 26 dBW, 32 dBW.

Effective power. Calculation using dBW and decibel values of connected components. Relationship to Effective Radiated Power (ERP).

Modulation, Signals, and Modes

Bandwidth and modulation.

Traditional vs computer modes.

Modes of transmission and modulation. CW (A1A). AM (A3E). SSB (J3E). FM (F3E). RTTY (F1B). FT8, FSK (F1B). PSK. Digital Voice.

A.4 Components and Circuits (3 Questions)

Resistors

Resistors. Resistance. Power rating. Power dissipation in a resistor. Resistors in circuits. Ohm's law for multiple resistors connected in parallel, in series, and in mixed ways.

Resonant circuits and components

Inductors. Inductance. What influences inductance. Back-electromotive force. Inductors connected in series, in parallel, and in mixed ways. Inductive reactance. Inductive reactance calculated from inductance and frequency. Behaviour of inductors in DC vs AC. Phase difference between current and voltage.

Capacitors. Capacitance. What influences capacitance. Dielectrics (air, paper, plastics, mica, silvered mica, ceramic, hi-k ceramic, electrolyte). Capacitors connected in series, in parallel, and in mixed ways. Capacitive reactance. Capacitive reactance calculated from capacitance and frequency. Behaviour of capacitors in DC vs AC. Phase difference between current and voltage.

Reactance.

Resonance. Resonant frequency (qualitative understanding only, no formula).

Impedance (qualitative understanding only, no complex impedance nor magnitude of impedance formulae).



Tuned circuits. Series and parallel LC circuits. Acceptor vs rejector. Effects of connecting series and parallel LC circuits in series and in parallel with a load.

Filters. Filter and tuned circuit bandwidth. Frequency response of the following filter types: low-pass, high-pass, band-pass, band-stop. Half-power bandwidth. Passband. Stopband. Transition band.

Filter implementation using basic LC circuits. Band-pass using: series LC in series, parallel LC in parallel, cascaded, T-filter. Band-stop using: series LC in parallel, parallel LC in series. Low-pass using a resistor and a capacitor in parallel, Pi filter. High-pass using a capacitor in series and a resistor, Pi filter.

Filter implementation using digital technology. Infinite impulse response filters (IIR). Finite impulse response filters (FIR). Advantages and disadvantages of analogue vs digital filter implementations.

Q factor. Q factor and bandwidth. Q factor and losses. Q factor and resonant frequency.

Quartz crystals.

Oscillators. Applications as: Carrier Wave Oscillator, Local Oscillator (LO), Beat Frequency Oscillator (BFO), Carrier Insertion Oscillator (CIO), Variable Frequency Oscillator (VFO). Resonant Circuit Oscillator.

Other Components and Circuits

Diode (only power/rectifying diode). LEDs (qualitative understanding only). Forward voltage (bias voltage). Peak inverse voltage. Leakage current. Power rating.

Transistor. Bipolar Junction Transistor (BJT). NPN vs PNP BJT. Amplification factor. Transistor gain. Currents in a BJT. Qualitative understanding of the difference between BJT vs Field Effect Transistor (FET).

Valves (thermionic devices) basic understanding only. Triode. Construction of a triode (heater/filament, cathode, anode/plate, control grid). Valve safety.

Integrated circuits (basic understanding).

Transformers. Step-up and step-down. Turns ratio. Current and voltage ratio.

Power supplies. Half-wave vs full-wave rectification. Bridge rectifier.

Amplifiers. AF vs RF amplification. Class A, AB, B, and C amplification. Gain.

A.5 Transmitters and Receivers (4 Questions)

Transmitters

Transmitter subjects in this syllabus concern only the following modes: CW, SSB, AM, FM.

Generic HF station block diagram. Dummy load. Antenna switch.

Block diagrams and principal function of each transmitter stage. Oscillator. Mixer. Buffer. Driver. Frequency multiplier. Amplifiers. Filters.

Block diagram of SDR transmitter using Digital Signal Processing (DSP), Direct Digital Synthesis (DDS), a Numerically Controlled Oscillator (NCO) and a Digital-Analogue Converter (DAC).



Content of transmitted signals for each mode and implications for power amplifier duty cycle and rating. Effect of audio modulation.

Sidebands. Typical RF bandwidth of signals in each mode.

Methods of achieving frequency stability.

FM: modulation index, deviation, calculating total bandwidth. Carson's rule.

Amplifiers including linear amplifiers and their uses. Output power.

Calculation of ERP (dBW) from output power (watts), antenna gain (dB), feeder loss (dB).

Purpose of Automatic Level Control (ALC).

Non-linearity. Harmonic distortion.

Receivers

Receiver subjects in this syllabus concern only the following modes: CW, SSB, AM, FM.

Superheterodyne receiver: block diagram and principal function of each stage. Oscillators. Mixer. Amplifiers. Detector. S meter. Squelch.

SDR receiver using an Analogue-Digital Converter (ADC) and Digital Signal Processing (DSP).

Achieving selectivity and sensitivity. Intermodulation.

Uses of the Intermediate Frequency (IF), Beat Frequency Oscillator (BFO), Automatic Gain Control (AGC), Carrier Insertion Oscillator (CIO).

Image frequency. Image response. High vs low intermediate frequencies.

Minimum dynamic range (qualitative understanding of concepts).

Signal to noise ratio, SNR (qualitative understanding of concepts).

Transverters.

A.6 Antennas and Transmission Lines (4 Questions)

Transmission Lines

Feeder types: open-wire (narrow-spaced, wide-spaced), coaxial cable, waveguide.

Factors determining characteristic impedance.

Velocity factor.

Standing waves: causes and consequences. Standing Wave Ratio (SWR). VSWR.

Antenna tuning (matching) units (ATUs).

Use of baluns.

Antennas

Reactive Near Field. Radiating Near Field. Radiating Far Field. Approximate distance from a half-wave dipole antenna to the boundary between its reactive and radiating near field, and to its radiating far field.

Antenna types: half-wave (centre fed and end-fed), quarter-wave vertical (ground plane), folded dipole, trap dipole, Yagi.

Physical construction (dimensions, components).



Balanced and unbalanced antennas.

Distribution of current and voltage.

Impedance at the feed point.

Capacitive or inductive reactance of a non-resonant antenna.

Polarisation, directivity, efficiency, and gain. Effective radiated power (ERP).

Front to back ratio.

Horizontal and vertical radiation pattern.

A.7 Propagation (4 Questions)

Atmospheric regions: troposphere, ionosphere. D layer. E layer. F1 and F2 layers. Influence of the Sun. Daily cycle. Effect on propagation at different frequencies. Solar cycle.

Critical frequency. Maximum usable frequency (MUF). Lowest usable frequency (LUF). Approaches for predicting propagation (basic understanding only).

Modes of propagation: ground wave, sky wave, space wave (tropospheric wave), ducting, refraction, diffraction. Fading.

Angle of radiation and skip distance. Dead zone.

The influence of the height of antennas on the distance that can be covered.

Meteor scatter. Auroral scattering. Earth-moon-earth propagation.

Sporadic E propagation.

Impact of distance on field strength for line-of-sight propagation.

A.8 Measurements (2 Questions)

Measurement of DC and AC (including RF). Voltage and voltmeter. Current and ammeter. Resistance and ohmmeter. Multimeter. Power.

Ammeter and voltmeter. Usage in a circuit. Internal resistance.

Transmitter measurements. Voltage. Current and power. Usage and placement of an SWR meter.

Oscilloscope. Vertical vs horizontal axis. Use of oscilloscope to monitor RF envelope. Overmodulation. Key clicks.



3 Section B: Operating Rules, Procedures, Regulations

B.1 Phonetic Alphabet (1 Question)

Spelling of letters and numbers according to the ITU International Radiotelephony Spelling Alphabet. Pronunciation of letters according to the ITU International Radiotelephony Spelling Alphabet. Pronunciation of numbers according to the International Civil Aviation Organization (ICAO) recommendation.

B.2 Q-Codes (3 Questions)

The meaning of the following Q-Codes as a question and as an answer: QRG, QRK, QRL, QRM, QRN, QRO, QRP, QRS, QRT, QRU, QRV, QRX, QRZ, QSB, QSL, QSO, QSY, QTH, QUF.

Operational abbreviations, including those Q-Codes which are commonly used as abbreviations, for the following abbreviations: BK, CQ, CW, DE, DX, K, MSG, PSE, RST, R, QRG, QSL, QSO, QTH, QSY, SKED, TX, UR.

B.3 International Distress Signs, Emergency Traffic and Natural Disaster Communications (3 Questions)

Radiotelegraphy (Morse) distress signal SOS (dit-dit-dit-dah-dah-dah-dit-dit-dit). Radiotelephony (voice) distress signal MAYDAY.

Use of amateur radio for emergency and natural disaster communications according to ITU and Irish regulations. Public Service Voluntary Radio Emergency Networks (such as AREN).

Irish emergency frequency centres of activity for the 80 m, 40 m, and the 20 m bands: 3.660 MHz, 7.115 MHz, 14.300 MHz. Use of emergency frequency centres of activity for non-emergency purposes.

Role of licensed radio amateurs in emergency communications including what not to do. What is a communication emergency? Served agencies in Ireland. Principal Emergency Services (PES). Principal Response Agencies (PRA). Voluntary Emergency Services (VES). Emergency nets. Means of emergency communications.

B.4 Call Signs (3 Questions)

Allocation of call signs.

Composition of call signs according to the ITU format.

Irish call signs.

Call sign usage. Mobile. Maritime mobile. Frequency of identification. Call sign suffixes permitted for use in Ireland.

B.5 Radio Spectrum Allocation in Ireland and IARU Band Plans (4 Questions)

Spectrum allocation in Ireland. Priority of ComReg Radio Frequency Plan for Ireland over IARU R1 band plans.

Meaning of all columns in IARU R1 band plans.

IARU R1 80 m band plan.



Operational bands according to ComReg and IARU R1 plans. For the 160, 80, 60, 40, 30, 20, 17, 15, 12, 10, 4, 2 m and 70 cm bands, including detailed knowledge of: band edges, PEP power limits, status of allocation, permission to contest, maritime mobile use, existence of emergency centres of activity within a band.

Differences between Irish regulations and IARU R1 band plan for the 160 and 60 m bands.

Bands on which SSB is allowed. LSB vs USB.

Propagation beacon frequencies in MHz: 14.099–14.101, 18.109–18.111, 21.149–21.151, 24.929–24.931, 28.190–28.225, 144.400–144.490.

Irish emergency frequency centres of activity for the 80 m, 40 m, and the 20 m bands: 3.660 MHz, 7.115 MHz, 14.300 MHz. Use of emergency frequency centres of activity for non-emergency purposes.

B.6 Social Responsibility of Radio Amateur Operation and the Code of Conduct (3 Questions)

Sections of the *IARU Ethics and Operating Procedures for the Radio Amateur* guide, 3rd edition, that cover: basic principles of social responsibility, danger of conflict, how to avoid conflict, the authority vs. self-discipline in amateur radio, code of conduct, ethics, practical rules, ham language, use of Q-Codes in common ham language, importance of politeness, importance of listening, correct use of call signs.

B.7 Operating Procedures and Non-Interference (5 Questions)

Sections of the *IARU Ethics and Operating Procedures for the Radio Amateur* guide, 3rd edition, that cover: structure of a QSO, how to make a QSO on phone and in Morse, contents of transmissions, subjects to avoid, making initial calls, selecting a frequency, format of a CQ call, CQ calls to specific geographic areas, CQ DX, format of an initial call to a specific station, replying to initial calls.

RS and RST codes. R values. Meaning of S when using an S meter including values in dB in excess of S9. Meaning of T9 vs all other values (please note, T values of 1–8 are not part of the syllabus).

Importance of non-interference. Other radio spectrum users in Ireland. Legal prohibition of interference according to Wireless Telegraphy (Amateur Station Licence) Regulations 2009 Act.

Regulatory and non-interference considerations when building transmitting equipment or purchasing it. Usefulness of European Union CE type approvals. Non-interference and Electromagnetic Compatibility.

How to deal with deliberate spectrum interference? Reporting interference to IARU IARUMS R1 via the IRTS. Role of the regulators in Ireland (ComReg) and other countries.

B.8 ITU Radio Regulations (2 Questions)

Role of ITU.

ITU Radio Regions and the IARU.



Purpose of Amateur Service. Permitted Communications. Emergency communications.

Primary and secondary allocation of radio spectrum.

Emission designations. Meaning and typical use of the following emission designations: A1A, J3E, A3E, F3E, F1B, F2B, J2B, F1D, F2D, J2D.

Frequency of identification using call signs according to ITU and Irish regulations.

B.9 CEPT Regulations (3 Questions)

Role of CEPT.

HAREC. Benefits of HAREC in participating countries during short visits. Duration of a short visit.

Knowledge of the purpose of ECC documents T/R 61-01 and T/R 61-02.

CEPT Radio Amateur Licence. Differences between Irish CEPT Class 1 and CEPT Class 2 licences.

Country prefix to use when visiting a CEPT T/R 61-01 region for the following countries and their regions: Austria, Belgium, Bulgaria, Canada, Croatia, Cyprus, Czechia, Denmark, England, Estonia, Finland, France, Germany, Guernsey, Greece, Hungary, Iceland, Ireland (both mainland and offshore islands), Isle of Man, Italy, Jersey, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Northern Ireland,

Norway, Poland, Portugal, Romania, Russia, Scotland, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, USA, Wales.

B.10 Irish Laws, Regulations, and Licence Conditions (3 Questions)

Legal requirements placed on amateurs by the Wireless Telegraphy (Amateur Station Licence) Regulations 2009 Act.

ComReg Amateur Station Licence Guidelines 09/45—detailed knowledge of this document is required.

Obtaining an Irish Amateur Station Licence and a call sign. Differences between Irish CEPT Class 1 and Class 2 licences. Examinations. Licence application, duration, amendments, cancellation, revocation. 5-year requirement to confirm station particulars.

Club licences.

Special events.

Land mobile. Maritime mobile. Power and band limitations. Frequency and the format of identification.

Logbook keeping requirements.

Additional authorisations.

Technical station requirements.

Operational bands and their limits as specified in exam section B.5.



4 Document Revision History

Table 4-A: Document Revision History

Date	Version	Changes Made
9 June 2010	1.0	Initial version
17 Dec 2011	1.1	No significant change to the content of the Syllabus and Notes for Candidates. The layout of the document has been adjusted to conform to the revised arrangement of examination sections
6 Feb 2013	1.2	Changes to the “Licensing Conditions” section of the syllabus consequent on the publication of revised Amateur Station Licence Guidelines by ComReg
17 Sept 2016	1.21	Minor drafting changes
28 Dec 2016	1.22	Minor drafting changes
30 Apr 2018	1.23	Minor drafting changes
5 July 2022	2.0.2	Substantially rewritten, reorganised, and reformatted, to match the new 2022 HAREC exam in line with ComReg tender 21/123.

