

Amateur Radio General Class License Study Guide

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Compliments of:

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Source Material is Publicly Available
(Source: Question Pool of 486 questions and CFR Title 47, Part 97, Amateur Radio Service.)

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Foreword

This document is simply a compilation of the publicly available question pool which has been converted into statements and formatted. The intent was to retain as much of the original words from the question pool as possible to leverage familiarization in the learning and memory process. Minimal additional information is provided to improve the document for use as a Study Guide. The 18 terms and acronyms most frequently used in the text are:

amateur	kHz	MHz
power	watts	output
station	transmitter	HF
antenna	RF	signal
frequency	band	impedance
meter	voltage	ohm

The author's hope is that this document might be useful as a resource in studying for the Element 3, General Class License Amateur Radio Exam.

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SUB-ELEMENT G1 - COMMISSION'S RULES

[5 Exam Questions - 5 Groups]

G1A - General class control operator frequency privileges

- A General Class license holder is granted all amateur frequency privileges on the following 160, 30, 17, 12, and 10 meters. [97.301(d)]
- Phone operation is prohibited on the 30 meter band. [97.305]
- Image transmission is prohibited on the 30-meter band. [97.305]
- The 60-meter amateur band restricts communication to specific channels, using only USB voice, and prohibits all other modes, including CW and data. [97.303(s)]
- The 7.250 MHz frequency is in the General Class portion of the 40-meter band. [97.301(d)]
- The 24.940 MHz frequency is in the 12 meter band. [97.301(d)]
- The 3900 kHz frequency is within the General class portion of the 75-meter phone band. [97.301(d)]
- The 14305 kHz frequency is within the General class portion of the 20-meter phone band. [97.301(d)]
- The 3560kHz frequency is within the General Class portion of the 80 meter band. [97.301(d)]
- The 21300 kHz frequency is within the General Class portion of the 15-meter band. [97.301(d)]
- The following frequencies are available to a control operator holding a General Class license [97.301(d)]: 28.020 MHz, 28.350 MHz, and 28.550 MHz.
[All of these answers are correct]
- When a General Class licensee is not permitted to use the entire voice portion of a particular band, the upper end or portion of the voice segment is generally available to them. [97.301]

G1A - Primary and secondary allocations

- NO amateur band is shared with the Citizens Radio Service. [97.303]
- When the FCC rules designate the amateur service as a secondary user and another service as a primary user on a band, amateur stations are allowed to use the frequency band only if they do not cause harmful interference to primary users. [97.303]
- When operating on either the 30 or 60 meter bands, if a station in the primary service interferes with your contact, stop transmitting at once and/or move to a clear frequency. [97.303]
- Amateur radio stations, as a secondary service in the 60-meter band, must not cause harmful interference to stations operating in other radio services. [97.303(s)]

G1B - Antenna structure limitations

- Two hundred (200) feet is the maximum height above ground to which an antenna structure may

be erected without requiring notification to the FAA and registration with the FCC, provided it is not at or near a public-use airport. [97.15(a)]

G1B - Good engineering and good amateur practice

- **The FCC requires an amateur station to be operated in conformance with good engineering and good amateur practice in all respects, whether covered or not covered by the Part 97 rules. [97.101(a)]**
- **The FCC determines “good engineering and good amateur practice” that applies to operation of an amateur station in all respects not covered by the Part 97 rules. [97.101(a)]**
- **If an amateur station is causing interference to a broadcast receiver of good engineering design, the FCC may restrict the amateur station operation to times other than 8 pm to 10:30 pm local time every day, as well as on Sundays from 10:30 am to 1 pm local time. [97.121(a)]**

G1B - Beacon operation

- **There must be no more than one beacon signal in the same band from a single location. [97.203(b)]**
- **A purpose of a beacon station as identified in the FCC Rules is observation of propagation and reception, or other related activities. [97.1(a)(9)]**
- **The power limit for beacon stations is 100 watts PEP output. [97.203(c)]**

G1B - Retransmitting radio signals

- **Music may be transmitted by an amateur station when it is an incidental part of a space shuttle or ISS retransmission. [97.113(a)(4),(e)]**

G1B - Restricted operation

- **The use of abbreviations or procedural signals in the amateur service is somewhat restricted but they may be used if they do not obscure the meaning of a message. [97.113(a)(4)]**
- **An amateur station is permitted to transmit secret codes to control a space station. [97.113(a)(4) and 97.207(f)]**
- **These are prohibited by the FCC Rules for amateur radio stations:**
 - **Transmission of music as the primary program material during a contact**
 - **The use of obscene or indecent words**
 - **Transmission of false or deceptive messages or signals**

[All of these answers are correct] [97.113(a)(4), 97.113(e)]
- **An amateur station may transmit communications in which the licensee or control operator has a pecuniary (monetary) interest only when other amateurs are being notified of the sale of**

apparatus normally used in an amateur station and such activity is not done on a regular basis.
[97.113(a)(3)]

- **In order for an amateur station to provide news information to the media during a disaster, the information must directly relate to the immediate safety of human life or protection of property and there is no other means of communication available.** [97.113(b)]

- **G1C - Transmitter power regulations**

- **The maximum transmitting power an amateur station may use on 10.140 MHz is 200 watts PEP output.** [97.313(c)(1)]
- **The maximum transmitting power an amateur station may use on the 12 meter band is 1500 watts PEP output.** [97.313(a),(b)]
- **The maximum transmitting power a General class licensee may use when operating between 7025 and 7125 kHz is 1500 watts PEP output.** [97.313]
- **Other than the 1500 watt PEP limit on transmitter power in the 14 MHz band only the minimum power necessary to carry out the desired communications is the restriction.** [97.313]

Authors Note: The rule to use the minimum power necessary to carry out the desired communications should be considered sacred. The smart person does not shout at a friend in order to communicate face-to-face and the same should always be true when you set your power level and microphone gain controls. If one watt will do, you do not need that 1500-watt amplifier. Switch it off!

- **The maximum transmitting power a station with a General Class control operator may use on the 28 MHz band is 1500 watts PEP output.** [97.313]
- **The maximum transmitting power an amateur station may use on 1825 kHz is 1500 watts PEP output.** [97.313(b)]
- **Transmissions must not exceed an effective radiated power of 50 Watts PEP referred to a dipole antenna when a station is transmitting on the 60 meter band.** [97.303(s)]

- **G1C - HF data emission standards**

- **The maximum symbol rate permitted for RTTY emissions transmitted on frequency bands below 28 MHz is 300 baud.** [97.305(c) and 97.307(f)(3)]
- **The maximum symbol rate permitted for RTTY or data emission transmissions on the 10-meter band is 1200 baud.** [97.305(c) and 97.307(f)(4)]
- **The maximum symbol rate permitted for RTTY or data emission transmissions on the 6 and 2 meter bands 19.6 kilobaud.** [97.305(c) and 97.307(f)(5)]
- **The maximum symbol rate permitted for packet emission transmissions on the 2-meter band 19.6 kilobaud.** [97.305(c) and 97.307(f)(5)]

- **The maximum authorized bandwidth for RTTY, data or multiplexed emissions using an unspecified digital code transmitted on the 6 and 2-meter bands is 20 kHz. [97.305(c) and 97.307(f)(5)]**
- **The maximum bandwidth permitted by FCC rules for amateur radio stations when operating on USB frequencies in the 60-meter band is 2.8 kHz. [97.303s]**

- **G1D - Volunteer Examiners and Volunteer Examiner Coordinators**
- **The license examination that you may administer when you are an accredited VE holding a General Class operator license is the Technician, Element 2. [97.509(b)(3)(i)]**
- **At Least three VEC-accredited General Class or higher VEs must be present when administering a Technician Class operator examination. [97.509(a)(b)]**
- **A FCC General Class or higher license and VEC accreditation is sufficient for you to be an administering VE for a Technician Class operator license examination. [97.509(b)(3)(i)]**
- **The administering VEs are responsible at a Volunteer Exam Session for determining the correctness of the answers on the exam. [97.509(h)]**
- **A CSCE document must be issued to a person that passes an exam element. [97.509(i)]**
- **A Certificate of Successful Completion of Examination (CSCE) is valid for exam element credit for 365 days. [97.3(a)(15)]**
- **The minimum age that one must be to qualify as an accredited Volunteer Examiner is 18 years old. [97.509(b)(2)]**
- **For a non-U.S. citizen to be an accredited Volunteer Examiner the person must hold a U.S. amateur radio license of General class or above. [97.509 (b)(3)]**
- **Volunteer Examiners are accredited by a Volunteer Examiner Coordinator. [97.509(b)(1)]**
- **You may participate as a VE in administering an amateur radio license examination after you have been granted a General class license and have received your VEC accreditation. [97.509]**

G1D - Temporary Identification

- **You may operate on any General Class band segment if you are a Technician Class operator and have a CSCE for General Class privileges. [97.9(b)]**
- **You must add the special identifier "AG" after your call sign if you are a Technician Class licensee and have a CSCE for General Class operator privileges whenever you operate using General class frequency privileges. [97.119(f)(2)]**
- **The proper way to identify when transmitting on General class frequencies if you have a CSCE for the required elements but your upgrade from Technician has not appeared in the ULS database is by giving your call sign followed by the words "temporary AG". [97.119(f)(2)]**

- **G1E - Control categories; ITU regions**

G1E - Repeater regulations

- **A 10-meter repeater may retransmit the 2-meter signal from a station having a Technician Class control operator only if the 10-meter control operator holds at least a General class license. [97.205(a)]**
- **A Repeater Station is an amateur station that simultaneously retransmits the signals of other stations on another channel. [97.3(a)(39)]**
- **The licensee of the non-coordinated repeater has primary responsibility to resolve the interference in the event of interference between a coordinated repeater and an uncoordinated repeater. [97.205(c)]**

G1E - Harmful interference

- **Each of the following conditions require an amateur radio station to take specific steps to avoid harmful interference to other users or facilities:**
- **When operating within one mile of an FCC Monitoring Station**
- **When using a band where the amateur service is secondary**
- **When a station is transmitting spread spectrum emissions**
[All of these answers are correct] [97.13(b),97.311(b), 97.303]

G1E - Third party rules

- **If the third party were a person previously licensed in the amateur service whose license had been revoked, it would disqualify the third party from participating in stating a message over an amateur station. [97.115(b)(2)]**
- **Only messages relating to amateur radio or remarks of a personal character, or messages relating to emergencies or disaster relief for a third party in another country may be transmitted by an amateur station. [97.115(a)(2), 97.117]**
- **Except for messages directly involving emergencies or disaster relief communications, third-party traffic is prohibited with any country other than the United States unless there is a third-party agreement in effect with that country. [97.115(a)(2)]**
- **For a non-licensed person to communicate with a foreign amateur radio station from a US amateur station at which a licensed control operator is present, the foreign amateur station must be in a country with which the United States has a third party agreement. [97.115(a)(b)]**
- **An example of permissible third party communication during routine amateur radio operations is sending a message to a third party through a foreign station, as long as that person is a licensed amateur radio operator.**

[97.115(a)(2)]

- **English is the language you must use when identifying your station if you are using a language other than English in making a contact. [97.119(b)(2)]**

SUB-ELEMENT G2 - OPERATING PROCEDURES

[6 Exam Questions - 6 Groups]

- **G2A - Phone operating procedures; Procedural signals; Breaking into a QSO in progress**
 - The expression "CQ DX" usually indicates the caller is looking for any station outside his or her own country.
 - The recommended way to break into a conversation when using phone is to say your call sign during a break between transmissions from the other stations.

G2A - USB/LSB utilization conventions

- Single-Sideband (SSB) mode of voice communication is most commonly used on the High Frequency Amateur bands.
- Single sideband (SSB) voice mode is a form of amplitude modulation in which one sideband and the carrier are suppressed.
- In single sideband (SSB) voice mode, only one sideband is transmitted. The other sideband and carrier are suppressed in single sideband (SSB) voice mode.
- Less bandwidth, used and high power efficiency is an advantage when using single sideband as compared to other voice modes on the HF amateur bands.
- Upper Sideband is most commonly used for phone communications on the bands above 20 meters.
- Lower Sideband is commonly used on the 160, 75, and 40-meter bands.
- Upper Sideband is commonly used in the VHF and UHF bands.
- Upper Sideband mode is most commonly used for voice communications on the 17 and 12-meter bands.
- Most amateur stations use lower sideband on the 160, 75 and 40-meter bands because it is the current amateur practice to use lower sideband on these frequency bands.

G2A - VOX operation

- VOX allows "hands free" operation
- The following user adjustable controls are usually associated with VOX circuitry:
 - Anti-VOX
 - VOX Delay
 - VOX Sensitivity

[All of these choices are correct]

- **G2B - Operating courtesy**

- **If the frequency on which a net normally meets is in use just before the net begins, the proper course of action that should be taken is to ask the stations if the net may use the frequency, or move the net to a nearby clear frequency if necessary.**
- **If a net is about to begin on a frequency you and another station are using, move to a different frequency as a courtesy to the net.**
- **Move your contact to another frequency if you notice increasing interference from other activity on a frequency you are using.**
- **The minimum frequency separation between CW signals to minimize interference is 150 to 500 Hz.**
- **The minimum frequency separation between SSB signals to minimize interference is approximately 3 kHz.**
- **The minimum frequency separation between 170 Hz shift RTTY signals to minimize interference is 250 to 500 Hz.**
- **A practical way to avoid harmful interference when selecting a frequency to call CQ using phone is to ask if the frequency is in use, say your callsign, and listen for a response.**
- **A practical way to avoid harmful interference when calling CQ using Morse code or CW is by sending "QRL? de" followed by your callsign and listen for a response.**

- **G2B - Band plans**

- **A band plan is a voluntary guideline for band use beyond the divisions established by the FCC.**
- **The "DX window" in a voluntary band plan is a portion of the band that should not be used for contacts between stations within the 48 contiguous United States.**
- **When choosing a frequency for Slow-Scan TV (SSTV) operation, you should follow generally accepted band plans for SSTV operation in order to comply with good amateur practice when choosing a frequency for Slow-Scan TV (SSTV) operation.**
- **When choosing a frequency for radio-teletype (RTTY) operation, you should follow generally accepted band plans for RTTY operation in order to comply with good amateur practice**
- **When choosing a frequency for HF PSK operation, you should follow generally accepted band plans for PSK operation in order to comply with good amateur practice.**

- **G2C – Emergencies, including drills and emergency communications**

- **When normal communications systems are not available, an amateur station may use any means of radio communication at its disposal to provide essential communications when there is an immediate threat to the safety of human life or the protection of property. [97.403]**
- **Only a person holding an FCC issued amateur operator license may be the control operator of an amateur station transmitting in RACES to assist relief operations during a disaster. [97.407(a)]**
- **When the President's War Emergency Powers have been invoked, the FCC may restrict normal frequency operations of amateur stations participating in RACES. [97.407(b)]**
- **An amateur station is NEVER prevented from using any means at its disposal to assist another station in distress. [97.405(b)]**
- **A control operator would be making an unidentified transmission when transmitting out of the amateur band without station identification during a life-threatening emergency. [97.403]**
- **Any frequency authorized to the control operator may be used by an amateur station to obtain assistance when in distress. [97.405(a)]**
- **The first thing you should do if you are communicating with another amateur station and hear a station in distress break in is to acknowledge the station in distress and determine what assistance may be needed.**
- **You are never prohibited from helping any station in distress. [97.405(b)]**
- **An amateur station may make transmissions necessary to meet essential communications needs and to facilitate relief actions during a disaster. [97.111(a)(2)]**
- **Any and/or all emission modes may be used to obtain assistance during a disaster.**
- **The location and nature of the emergency should be given to a station answering a distress transmission.**
- **Whatever frequency has the best chance of communicating the distress message should be used to send a distress call.**

- **G2D - Amateur auxiliary**

- **The Amateur Auxiliary to the FCC are amateur volunteers who are formally enlisted to monitor the airwaves for rules violations.**
- **The objectives of the Amateur Auxiliary are to encourage amateur self-regulation and compliance with the rules.**
- **Direction-finding skills used to locate stations violating FCC Rules, learned during "Fox Hunts", are of help to the Amateur Auxiliary.**

- **G2D - Minimizing Interference**

- **A unidirectional antenna HF antenna would be the best to use for minimizing interference.**

G2D - HF operations

- **An azimuthal projection map is a world map projection centered on a particular location.**
- **An Azimuthal projection type of map is the most useful when orienting a directional HF antenna toward a distant station.**

- **A directional antenna is pointed 180 degrees from its short-path heading when making a “long-path” contact with another station.**
- **Many amateurs keep a log even though the FCC does not require it to help with a reply if the FCC requests information on who was control operator of your station at a given date and time.**
- **The following information is traditionally contained in a station log:**
 - **Date and time of contact**
 - **Band and/or frequency of the contact**
 - **Call sign of station contacted and the signal report given**

[All of these choices are correct]

- **QRP operation is low power transmit operation, typically about 5 watts or less.**
- **A licensee must retain antenna gain calculations or manufacturer's data for antennas used on 60 meters as part of their station records. [97.103b]**
- **If you are using other than a dipole antenna, you must keep a record of the gain of your antenna when operating in the 60-meter band as required by the FCC rules. [97.303s]**

G2E - Digital operating: procedures;, procedural signals and common abbreviations

- **Lower-sideband (LSB) mode should be selected when using a SSB transmitter with an Audio Frequency Shift Keying (AFSK) RTTY signal.**
- **The number of data bits sent in a single PSK31 character varies.**
- **The Header part of a data packet contains the routing and handling information.**
- **The 14.070 - 14.100 MHz portion of the 20-meter band segments is most often used for most data transmissions.**
- **Baudot RTTY may be described as a 5-bit code, with additional start and stop bits.**
- **The most common frequency shift for RTTY emissions in the amateur HF bands is 170 Hz.**
- **The 3570 – 3600 kHz segment of the 80-meter band is most commonly used for data transmissions.**
- **PSK signals are generally found on the 20-meter band around 14.070 MHz.**
- **A major advantage of MFSK16 compared to other digital modes is that it offers good**

performance in weak signal environment without error correction.

- The abbreviation "RTTY" stands for Radio-Teletype.
- The abbreviation "MFSK" stands for Multi (or Multiple) Frequency Shift Keying.
- **G2F - CW operating procedures and procedural signals**
 - The speed at which the CQ was sent is the best speed to use answering a CQ in Morse Code.
 - The term "zero beat" means matching the frequency of the transmitting station in CW operation.

G2F - Q signals and common abbreviations

- If a CW station sends "QRS" when using Morse code, you should send slower.
- The Q signal "QSL" means, I acknowledge receipt, when operating CW.
- The Q signal "QRQ" means, Send faster, when operating CW.
- The Q signal "QRV" means, I am ready to receive messages, when operating CW.
- The prosign, AR, is sent using CW to indicate the end of a formal message.
- When a CW operator sends "KN" at the end of a transmission it means listening only for a specific station or stations.
- When a CW operator sends "CL" at the end of a transmission it means Closing station.
- When sending CW, a "C" means a chirpy or unstable signal when added to the RST report.

G2F - Full break in

- Full break-in telegraphy (QSK) occurs when incoming signals are received between transmitted code character elements.

SUB-ELEMENT G3 - RADIO WAVE PROPAGATION

[3 Exam Questions - 3 Groups]

G3A - Sunspots and solar radiation

- It takes approximately 8 minutes for increased ultraviolet and X-ray radiation from solar flares to affect radio-wave propagation on the Earth.
- The sunspot number is a measure of solar activity based on counting sunspots and sunspot groups.
- The typical sunspot cycle is approximately 11 years long.

G3A - Ionospheric disturbances

- An amateur station can try a higher frequency to continue communications during a sudden ionospheric disturbance.
- A Sudden Ionospheric Disturbance (SID) disrupts signals on lower frequencies more than those on higher frequencies affecting the daytime ionospheric propagation of HF radio waves.
- Geomagnetic disturbance is a significant change in the Earth's magnetic field over a short period.
- Latitudes, greater than 45 degrees North or South latitude, have propagation paths that are more sensitive to geomagnetic disturbances.
- An effect of a geomagnetic storm on radio-wave propagation can be degraded high-latitude HF propagation.
- HF radio communications are disturbed by the charged particles that reach the Earth from solar coronal holes.
- It takes charged particles from Coronal Mass Ejections about 20 to 40 hours to affect radio-wave propagation on the Earth.

G3A - Propagation forecasting and indices

- The solar flux index is a measure of the radio energy emitted by the sun.
- The solar-flux index is a measure of solar activity at 10.7 cm.
- Long-distance communication in the upper HF and lower VHF range is enhanced when radio communications when sunspot numbers are high.
- The K-index is a measure of the short-term stability of the Earth's magnetic field.
- The A-index is an indicator of the long-term stability of the Earth's geomagnetic field.
- At any point in the solar cycle, the 20-meter band usually supports worldwide propagation during daylight hours.
- If the HF radio-wave propagation (skip) is generally good on the 24-MHz and 28-MHz bands for

several days, you might expect a similar condition to occur 28 days later.

- Frequencies above 20 MHz are the least reliable for long distance communications during periods of low solar activity.
- A possible benefit to radio communications resulting from periods of high geomagnetic activity is Aurora that can reflect VHF signals.

• **G3B - Maximum Usable Frequency**

- MUF stands for the Maximum Usable Frequency for communications between two points.
- The 15-meter band should offer the best chance for a successful contact if the maximum usable frequency (MUF) between the two stations is 22 MHz.
- The 20-meter band should offer the best chance for a successful contact if the maximum usable frequency (MUF) between the two stations is 16 MHz.
- For lowest attenuation when transmitting on HF, select a frequency just below the MUF.
- A reliable way to determine if the maximum usable frequency (MUF) is high enough to support 28-MHz propagation between your station and Western Europe is to listen for signals on a 28 MHz international beacon.
- Radio waves with frequencies below the maximum usable frequency (MUF) are usually bent back to the Earth after they are sent into the ionosphere.
- The factors that affect the maximum usable frequency (MUF) are:
 - Path distance and location
 - Time of day and season
 - Solar radiation and ionospheric disturbance

[All of these choices are correct]

G3B - Lowest Usable Frequency

- LUF stands for the Lowest Usable Frequency for communications between two points.
- Radio waves with frequencies below the lowest usable frequency (LUF) are usually completely absorbed by the ionosphere

G3B - Propagation "hops"

- The maximum distance along the Earth's surface that is normally covered in one hop using the F2 region is 2,500 miles.
- The maximum distance along the Earth's surface that is normally covered in one hop using the E region is 1,200 miles.

- **When the lowest usable frequency (LUF) exceeds the maximum usable frequency (MUF), no HF radio frequency will support communications over the path.**
- **A sky-wave signal will sound like a well-defined echo when it arrives at your receiver by both short path and long path propagation.**
- **Short hop sky-wave propagation on the 10-meter band is a good indicator of the possibility of sky-wave propagation on the 6-meter band.**

• **G3C - Ionospheric layers**

- **The D layer of the ionosphere is closest to the surface of the Earth.**
- **The ionospheric D layer is the most absorbent of long skip signals during daylight hours on frequencies below 10 MHz.**
- **The F2 region be expected to reach its maximum height at your location at noon during the summer**
- **The F2 region is mainly responsible for the longest distance radio wave propagation because it is the highest ionospheric region.**
- **Ionospheric Absorption will be minimum near the maximum usable frequency (MUF).**

g3c - Critical angle and frequency

- **The term “critical angle” means the highest takeoff angle that will return a radio wave to the Earth under specific ionospheric conditions.**

g3c - HF scatter

- **Long distance communication on the 40, 60, 80 and 160-meter bands are more difficult during the day because the D layer absorbs these frequencies during daylight hours.**
- **A characteristic of HF scatter signals is that they have a wavering sound.**
- **HF scatter signals often sound distorted because energy is scattered into the skip zone through several radio wave paths.**
- **The HF scatter signals in the skip zone are usually weak because only a small part of the signal energy is scattered into the skip zone.**
- **Scatter radio wave propagation allows a signal to be detected at a distance too far for ground wave propagation but too near for normal sky wave propagation.**
- **An indication that signals heard on the HF bands are being received via scatter propagation can be when the signal is heard on a frequency above the maximum usable frequency.**

G3C - Near Vertical Incidence Sky waves

- **Near Vertical Incidence Sky-wave (NVIS), propagation is short distance HF propagation using high elevation angles.**
- **A horizontal dipole antenna placed between 1/8 and 1/4 wavelength above the ground will be most effective for skip communications on 40 meters during the day.**

SUB-ELEMENT G4 - AMATEUR RADIO PRACTICES

[5 Questions - 5 groups]

G4A - Two-tone Test

- An oscilloscope may be used to measure the output of a single-sideband transmitter when performing a two-tone test of amplitude linearity.
- Transmitter linearity performance is analyzed by a two-tone test.
- Two non-harmonically related audio signals are used to conduct a two-tone test.

G4A - Amplifier tuning and neutralization

- A pronounced dip on the plate current meter reading of a vacuum tube RF power amplifier indicates correct adjustment of the plate tuning control.
- The correct adjustment for the "Load" or "Coupling" control of a vacuum tube RF power amplifier is maximum power output without exceeding maximum allowable plate current.
- A technique called, Negative feedback, is used to neutralize an RF amplifier.
- A neutralizing circuit cancels the effects of positive feedback in an RF amplifier.
- The reason for neutralizing the final amplifier stage of a transmitter is to eliminate self-oscillations.

G4A - Digital Signal Processing (DSP)

- One use for a DSP in an amateur station is to remove noise from received signals.
- The following is needed for a DSP IF filter:
 - An Analog to Digital Converter
 - Digital to Analog Converter
 - A Digital Processor Chip

[All of the these answers are correct]
- An advantage of a receiver IF filter created with a DSP as compared to an analog filter is a wide range of filter bandwidths and shapes can be created.
- DSP filtering is accomplished by converting the signal from analog to digital and using digital processing.
- A DSP filter performs automatic notching of interfering carriers.

G4B - Test and monitoring equipment

- A signal tracer may normally be used to identify an inoperative stage in a receiver.
- One measurement that can be made with a dip meter is the resonant frequency of a circuit.
- An antenna and feedline must be connected to an antenna analyzer when it is being used for SWR measurements.

- **Standing Wave Ratio can be measured with a directional wattmeter.**
- **The power output of a transmitter must be raised approximately 4 times (~4X) to change the "S" meter reading on a distant receiver from S8 to S9.**

G4B Oscilloscope

- **An oscilloscope has horizontal and vertical channel amplifiers.**
- **A monitoring oscilloscope is the best instrument to use to check the keying waveform of a CW transmitter.**
- **The signal connected to the vertical input of a monitoring oscilloscope when checking the quality of a transmitted signal is the attenuated RF output of the transmitter.**
- **An advantage of an oscilloscope versus a digital voltmeter is that complex waveforms can be measured.**

G4B Voltmeter

- **An advantage of a digital voltmeter as compared to an analog voltmeter is significantly better precision for most uses.**
- **High input impedance is desirable for a voltmeter to decrease the loading on circuits being measured.**

G4B Noise Bridge

- **A noise bridge is normally connected between a receiver and an antenna of unknown impedance and is adjusted for minimum noise.**
- **One way a noise bridge might be used is for pre-tuning an antenna tuner.**

G4B Field Strength Meter

- **A field-strength meter may be used to monitor relative RF output when making antenna and transmitter adjustments.**
- **The radiation pattern of an antenna can be determined with a field strength meter.**
- **A use of a field strength meter might be close-in radio direction-finding.**

G4C - Interference with consumer electronics

- **A bypass capacitor might be useful in reducing RF interference to audio-frequency devices.**
- **An RFI filter at the affected telephone should be installed if a properly operating amateur station is interfering with a nearby telephone.**
- **Distorted speech is heard from a public-address system if there is interference from a nearby single-sideband phone transmitter.**
- **On-and-off humming or clicking is the effect on a public-address system if there is interference from nearby CW transmitter.**

- **A reason to place ferrite beads around audio cables to reduce common mode RF interference is they act as a series inductor.**
- **Induced currents in conductors that are in poor electrical contact can cause unintended rectification of RF signal energy and can result in interference to your station as well as nearby radio and TV receivers.**
- **Arcing at a poor electrical connection is one cause of broadband radio frequency interference at an amateur radio station.**

G4C - Grounding

- **If you receive an RF burn when touching your equipment while transmitting on a HF band, assuming the equipment is connected to a ground rod, the problem might be that the ground wire is resonant.**
- **Important reasons to have a good station ground are:**
 - **To reduce the likelihood of RF burns**
 - **To reduce the likelihood of electrical shock**
 - **To reduce interference**

[All of these answers are correct]
- **Keeping the station's ground wire as short as possible is one good way to avoid stray RF energy in an amateur station.**
- **RF hot spots can occur in a station located above the ground floor if the equipment is grounded by a long ground wire.**
- **Electrical safety inside the ham shack is covered in the National Electrical Code.**
- **A ground loop can be avoided by connecting all ground conductors to a single point.**

G4D - Speech processors

- **The reason for using a properly adjusted speech processor with a single sideband phone transmitter is it improves signal intelligibility at the receiver.**
- **A speech processor increases the average power of a transmitted single sideband signal.**
- **Each of the following can be the result of an incorrectly adjusted speech processor:**
 - **Distorted speech**
 - **Splatter**
 - **Excessive background pickup**

[All of these answers are correct]

G4D - S meters

- **An S-meter measures the received signal strength.**

- Assuming a properly calibrated S meter, an S-meter reading of 20 db over S-9 is 100 times stronger than an S-9 signal.
- An S-meter is generally found in a receiver.

G4D - Common connectors

- A Type-N connector is a moisture resistant RF connector useful to 10 GHz.
- A DB-9 type connector would be a good choice for a serial data port.
- An UHF type connector is commonly used for RF service at frequencies up to 150 MHz.
- An RCA Phono type connector is commonly used for audio signals in amateur radio stations.
- The main reason to use keyed connectors over non-keyed types is reduced chance of damage due to incorrect mating.

G4E - HF mobile radio installations

- All of the following emission types are permissible while operating HF mobile:
 - CW
 - SSB
 - FM

[All of these choices are correct]
- An alternator whine is a tone or buzz in transmitted or received audio that varies with engine speed.
- A direct, fused connection to the battery using heavy gauge wire, connection would be the best for a 100-watt HF mobile installation.
- It is NOT best to draw the DC power for a 100-watt HF transceiver from an automobile's cigarette lighter socket because the socket's wiring may be inadequate for the current being drawn by the transceiver.
- The HF mobile antenna system most limits the effectiveness of an HF mobile transceiver operating in the 75-meter band.

G4E - Emergency and battery powered operation

- For an emergency generator installation, the generator should be located in a well ventilated area.
- A lead-acid storage battery might give off explosive hydrogen gas when being charged.
- Photovoltaic conversion is the name of the process by which sunlight is changed directly into electricity.
- The approximate open-circuit voltage from a modern, well illuminated photovoltaic cell is 0.5

VDC.

- Doped Silicon material is used as the active element of a solar cell.
- A disadvantage to using wind power as the primary source of power for an emergency station is a large energy storage system is needed to supply power when the wind is not blowing.
- Danger of carbon monoxide poisoning is a primary reason for not placing a gasoline-fueled generator inside an occupied area.
- It may be unwise to power your station by back feeding the output of a gasoline generator into your house wiring by connecting the generator through an AC wall outlet because it might present a hazard for electric company workers.

Authors note: This assumes you didn't properly install an effective disconnect that separates your electrical system from the power company's electrical system.

SUB-ELEMENT G5 – ELECTRICAL PRINCIPLES

[3 exam questions – 3 groups]

G5A – Resistance; Reactance

- Reactance is opposition to the flow of alternating current caused by capacitance or inductance.
- Reactance causes opposition to the flow of alternating current in an inductor.
- Reactance causes opposition to the flow of alternating current in a capacitor.
- The Ohm is the unit used to measure reactance.

G5A – Inductance

- A coil reacts to AC such that as the frequency of the applied AC increases, the reactance increases. [Directly proportional]

$$X_L = 2 * \pi * F * L$$

$$\text{Inductive Reactance} = 2 * \pi * \text{Frequency} * \text{Inductance}$$

G5A – Capacitance

- A capacitor reacts to AC such that as the frequency of the applied AC increases, the reactance decreases. [Inversely proportional]

$$X_C = \frac{1}{2 * \pi * F * C}$$

$$\text{Capacitive Reactance} = 1 \text{ divided by } (2 * \pi * \text{Frequency} * \text{Capacitance})$$

G5A – Impedance

- Impedance is the opposition to the flow of current in an AC circuit.
- When the impedance of an electrical load is equal to the internal impedance of the power source the source can deliver maximum power to the load.

- The Ohm is the unit used to measure impedance.

G5A – Impedance matching

- Impedance matching is important so the source can deliver maximum power to the load. One reason to use an impedance matching transformer is to maximize the transfer of power.
- Core saturation of a conventional impedance matching transformer should be avoided because Harmonics and distortion could result.
- One reason to use an impedance matching transformer is to maximize the transfer of power.
- All of the following devices can be used for impedance matching at radio frequencies:
 - A transformer
 - A Pi-network
 - A length of transmission line

[All of these choices are correct]
- One method of impedance matching between two AC circuits is to insert an LC network between the two circuits.

G5B - The Decibel

- A two-times increase or decrease in power results in a change of 3 dB.
- A percentage of 20.5% power loss would result from a transmission line loss of 1 dB.

G5B - Current and voltage dividers

- The total current equals the sum of the currents through each branch of a parallel circuit.

G5B - Electrical power calculations

- There are 200 watts of electrical power used if 400 VDC is supplied to an 800-ohm load.

$$P = E^2/R \rightarrow P = 400^2/800 \rightarrow P = 160000/800 \rightarrow P = 200 \text{ watts}$$
- There are 2.4 watts of electrical power are used by a 12-VDC light bulb that draws 0.2 amperes.

$$P = I * E \rightarrow P = 0.2 * 12 \rightarrow P = 2.4 \text{ watts}$$
- Approximately 61 milliwatts are being dissipated when a current of 7.0 milliamperes flows through 1.25 kilohms.

$$P = I^2 * R \rightarrow P = .007^2 * 1250 \rightarrow P = 61 \text{ mW or } 0.061 \text{ watts}$$
- The voltage across a 50-ohm dummy load dissipating 1200 watts would be 245 volts.

$$P = I * E \text{ and } E = I * R \text{ therefore } E = \text{SQRT}(P * R)$$

$$E = \text{SQRT}(P * R) \rightarrow E = \sqrt{(1200 * 50)} \rightarrow E = \sqrt{60000} \rightarrow E = 245 \text{ volts}$$

G5B - Sine wave root-mean-square (RMS) values

- The RMS value measurement of an AC signal is equivalent to a DC voltage of the same value.

- If you combined two or more sine wave voltages, the RMS voltage would be the square root of the average of the sum of the squares of each voltage waveform.
- The RMS voltage of sine wave with a value of 17 volts peak is 12 volts RMS.

$$1.0 \text{ volt peak} == 0.707071 \text{ volts RMS}$$

Or

$$1.0 \text{ volt RMS} == 1.414 \text{ volts peak}$$

$$V_{\text{rms}} = V_p * 0.707071 \rightarrow V_{\text{rms}} = 17 * 0.707071 = 12 \text{ volts RMS}$$

G5B - PEP calculations

- The peak-to-peak (PEP) output power from a transmitter is 100 watts if an oscilloscope measures 200 volts peak-to-peak across a 50-ohm dummy load connected to the transmitter output.

- Root Mean Square (RMS)

$$2.0 \text{ volts peak-to-peak} == 1.0 \text{ volt peak} == 0.707071 \text{ volts RMS}$$

$$200 \text{ volts peak-to-peak} == 100 \text{ volts peak} == 70.7071 \text{ volts RMS}$$

$$P = E^2/R \rightarrow P = 70.7071^2/50 \rightarrow P = 4999.5/50 \rightarrow P = 100 \text{ watts}$$

- The peak-to-peak voltage of a sine wave that has an RMS voltage of 120 volts is 339.4 volts.

$$2.0 \text{ volts peak-to-peak} == 1.0 \text{ volt peak} == 0.707071 \text{ volts RMS}$$

Or

$$1.0 \text{ volt RMS} == 1.414 \text{ volts peak} == 2.828 \text{ volts peak-to-peak}$$

$$V_{\text{p-p}} = V_{\text{rms}} * 2.828 \rightarrow V_{\text{p-p}} = 120 * 2.828 = 339.4 \text{ volts p-p}$$

- The ratio of peak envelope power to average power for an unmodulated carrier is 1.00.
- The output PEP from a transmitter if an oscilloscope measures 500 volts peak-to-peak across a 50-ohm resistor connected to the transmitter output is 625 watts.

$$2.0 \text{ volts peak-to-peak} == 1.0 \text{ volt peak} == 0.707071 \text{ volts RMS}$$

$$500 \text{ volts peak to peak} = 176.77 \text{ volts RMS}$$

$$P = E^2/R \rightarrow P = 176.77^2/50 \rightarrow P = 31247/50 \rightarrow P = 625 \text{ watts}$$

- If an average reading wattmeter connected to the transmitter output indicates 1060 watts the output PEP of an unmodulated carrier is 1060 watts.

• **G5C – Resistors in series**

- To increase the circuit resistance a resistor should be added in series in a circuit. $R_{total} = R1 + R2 + R3 + \dots$

G5C – Resistors in parallel

- The total resistance of three 100-ohm resistors in parallel is 33.3 ohms.

$$R_t = 1 / ((1/100) + (1/100) + (1/100)) = 1 / 0.03 = 33.3 \text{ ohms}$$

$$R_{total} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots}$$

- The total resistance of a 10 ohm, a 20 ohm, and a 50 ohm resistor in parallel is 5.9 ohms.

$$R_t = 1 / ((1/10) + (1/20) + (1/50)) = 1 / 0.17 = 5.9 \text{ ohms}$$

- The value of each resistor is 150 ohms if three equal value resistors in parallel produce 50 ohms of resistance, and the same three resistors in series produce 450 ohms.

$$R_t = 150 + 150 + 150 = 450 \text{ ohms}$$

$$R_t = 1 / ((1/150) + (1/150) + (1/150)) = 1 / 0.02 = 50 \text{ ohms}$$

G5C – Capacitors in series

- The capacitance of three 100 microfarad capacitors connected in series is 33.3 microfarads.

$$C_t = 1 / ((1/100) + (1/100) + (1/100)) = 1 / 0.03 = 33.3 \text{ microfarads}$$

- The capacitance of a 20 microfarad capacitor in series with a 50 microfarad capacitor is 14.3 microfarads.

$$C_t = 1 / ((1/20) + (1/50)) = 1 / 0.07 = 14.3 \text{ microfarads}$$

- **G5C – Capacitors in parallel**

- To increase the circuit capacitance a capacitor should be added in parallel in a circuit. $C_{total} = C1 + C2 + C3 + \dots$

- The equivalent capacitance of two 5000 picofarad capacitors and one 750 picofarad capacitor connected in parallel is 10750 picofarads.

$$C_{total} = C1 + C2 + C3 = 5000 + 5000 + 750 = 10750 \text{ picofarads}$$

G5C – Inductors in series

- To increase the circuit inductance an inductor should be added in series in a circuit. $L_{total} = L1 + L2 + L3 + \dots$

- The inductance of a 20 millihenry inductor in series with a 50 millihenry inductor is 70 millihenrys.

$$L_{\text{total}} = L1 + L2 = 20 + 50 = 70 \text{ millihenrys}$$

G5C – Inductors in parallel

- The inductance of three 10 millihenry inductors connected in parallel is 3.3 millihenrys.

$$L_t = 1 / ((1/10) + (1/10) + (1/10)) = 1 / 0.3 = 3.3 \text{ millihenrys}$$

G5C – Transformers

- Mutual inductance causes a voltage to appear across the secondary winding of a transformer when an AC voltage source is connected across its primary winding.
- The source of energy is normally connected to the primary winding in a transformer.
- The current in the primary winding of a transformer if no load is attached to the secondary is called the Magnetizing current.
- The voltage across a 500-turn secondary winding in a transformer is 26.7 volts if the 2250-turn primary is connected to 120 VAC.

$$\frac{V_{\text{primary}}}{V_{\text{secondary}}} = \frac{\text{\# of turns of primary}}{\text{\# of turns in secondary}} \rightarrow V_s = V_p * N_s / N_p$$

$$V_s = 120 * 500 / 2250 = 26.7 \text{ volts}$$

- The turns ratio of a transformer used to match an audio amplifier having a 600-ohm output impedance to a speaker having a 4-ohm impedance is 12.2 to 1.

$$N_p / N_s = \text{SQRT}(Z_p / Z_s) = \text{SQRT}(600/4) = \text{SQRT}(150) = 12.2$$

Therefore $N_p / N_s = 12.2$ to 1

SUB-ELEMENT G6 – CIRCUIT COMPONENTS

[3 exam question – 3 groups]

G6A – Resistors

- **If the temperature of a carbon resistor is increased, the resistance will change depending on the resistor's temperature coefficient rating.**
- **The main disadvantage of using a conventional wire-wound resistor in a resonant circuit is the resistor's inductance could detune the circuit.**
- **A thermistor is a device having a controlled change in resistance with temperature variations.**

G6A – Capacitors

- **An Electrolytic type of capacitor is often used in power-supply circuits to filter the rectified AC.**
- **The primary advantage of ceramic capacitors is the comparatively low cost.**
- **An advantage of an electrolytic capacitor is the high capacitance for given volume.**
- **One effect of lead inductance in a capacitor used at VHF and above is effective capacitance may be reduced.**
- **The common name for a capacitor connected across a transformer secondary that is used to absorb transient voltage spikes is Suppressor capacitor.**

G6A – Inductors

- **The advantages of using a ferrite core with a toroidal inductor are:**
 - **Large values of inductance may be obtained**
 - **The magnetic properties of the core may be optimized for a specific range of frequencies**
 - **Most of the magnetic field is contained in the core**

[All of these choices are correct]
- **Two solenoid inductors should be placed with their winding axes at right angles to each another to minimize their mutual inductance.**
- **It might be important to minimize the mutual inductance between two inductors to reduce or eliminate unwanted coupling.**
- **An effect of inter-turn capacitance in an inductor is the inductor may become self resonant at some frequencies.**
- **The common name for an inductor used to help smooth the DC output from the rectifier in a conventional power supply is a Filter choke.**

G6B – Rectifiers and Solid state diodes

- **The peak-inverse-voltage rating of a rectifier is the maximum voltage the rectifier will handle in the non-conducting direction.**
- **The two major ratings that must not be exceeded for silicon-diode rectifiers are Peak Inverse Voltage and Average Forward Current.**
- **When two or more diodes are connected in parallel to increase current handling capacity, the purpose of the resistor connected in series with each diode is to ensure that one diode doesn't carry most of the current.**
- **The approximate junction threshold voltage of a germanium diode is 0.3 volts.**
- **The approximate junction threshold voltage of a silicon diode is 0.7 volts.**
- **An advantage of using a Schottky diode in an RF switching circuit as compared to a standard silicon diode is lower capacitance.**

G6B – Transistors

- **The stable operating points for a bipolar transistor that is used as a switch in a logic circuit are the transistor's saturation and cut-off regions.**
- **It is often necessary to insulate the case of a large power transistor to avoid shorting the collector or drain voltage to ground.**
- **In the construction of a MOSFET the gate is separated from the channel with a thin insulating layer.**
- **A Field Effect Transistor (FET) is a solid state device and is most like a vacuum tube in its general characteristics.**

G6B – Vacuum tubes

- **The Control Grid element of a triode vacuum tube is used to regulate the flow of electrons between cathode and plate.**
- **The primary purpose of a screen grid in a vacuum tube is to reduce grid-to-plate capacitance .**

G6B – Batteries; Solar Cells

- **An advantage of the low internal resistance of Nickel Cadmium batteries is high discharge current.**
- **The minimum allowable discharge voltage for maximum life of a standard 12 volt lead acid battery is 10.5 volts.**
- **It is never acceptable to recharge a carbon-zinc primary cell.**
- **A Nickel Metal Hydride is a rechargeable battery.**

G6C - Analog and digital integrated circuits (IC's)

- **Linear voltage regulator is an analog integrated circuit.**
- **An operational amplifier is an Analog type of integrated circuit.**
- **CMOS is the most commonly used digital logic family of integrated circuits.**
- **An advantage of CMOS Logic integrated circuits compared to TTL logic circuits is the low power consumption.**

G6C – Microprocessors

- **A microprocessor is a miniature computer on a single integrated circuit chip.**

G6C – Memory

- **Read Only Memory (ROM)**
- **When memory is characterized as “non-volatile” the stored information is maintained even if power is removed.**

G6C - I/O devices

- **A Computer and transceiver are two devices in an amateur radio station that might be connected using a USB interface.**

G6C - Microwave IC's (MMIC's)

- **Monolithic Microwave Integrated Circuit (MMIC)**

G6C - Display devices

- **One disadvantage of an incandescent indicator compared to a LED is the high power consumption.**
- **An LED is Forward Biased when emitting light.**
- **A liquid crystal display requires ambient or back lighting.**

SUB-ELEMENT G7 – PRACTICAL CIRCUITS

[2 exam question – 2 groups]

G7A - Power supplies

- **A power-supply bleeder resistor discharges the filter capacitors providing a safety feature.**
- **Capacitors and inductors are used in a power-supply filter network.**
- **The minimum peak-inverse-voltage rating of the rectifier in a full-wave power supply should be double the normal peak output voltage of the power supply.**
- **The approximate minimum peak-inverse-voltage rating of the rectifier in a half-wave power supply should be two times the normal peak output voltage of the power supply.**
- **A desirable characteristic for capacitors used to filter the DC output of a switching power supply is low equivalent series resistance.**
- **An advantage of a switched-mode power supply as compared to a linear power supply is high frequency operation allows the use of smaller components.**
- **A 180 degree portion of the AC cycle is converted to DC by a half-wave rectifier.**
- **A 360 degree portion of the AC cycle is converted to DC by a full-wave rectifier.**
- **The output waveform of an unfiltered full-wave rectifier connected to a resistive load is a series of DC pulses at twice the frequency of the AC input.**

G7A – Transmitters

- **A Balanced modulator circuit is used to combine signals from the carrier oscillator and speech amplifier and send the result to the filter in a typical single-sideband phone transmitter.**
- **An advantage of a crystal controlled transmitter is a Stable output frequency.**





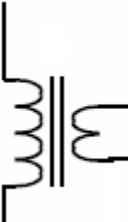

G7A - Receivers

- **A Mixer circuit is used to process signals from the RF amplifier and local oscillator and send the result to the IF filter in a super heterodyne receiver.**
- **A Product detector circuit is used to process signals from the IF amplifier and BFO and send the result to the AF amplifier in a single-sideband phone superheterodyne receiver.**
- **The simplest combination of stages that can be combined to implement a superheterodyne receiver is an HF oscillator, mixer, and detector.**
- **A direct conversion receiver is suitable for CW and SSB reception but does not require a mixer stage or an IF amplifier.**
- **A Discriminator circuit is used in many FM receivers to convert signals coming from the IF amplifier to audio.**

G7A – Filters

- The impedance of a low-pass filter as compared to the impedance of the transmission line into which it is inserted should be about the same.
- A Filter might be used to process signals from the balanced modulator and send them to the mixer in a single-sideband phone transmitter.

G7A - Schematic drawing symbols (Refer to Figure G7-1 in Question Pool)

	Fixed Resistor (Symbol 3)
	Single Cell Battery (Symbol 13)
	NPN Transistor (Symbol 4)
	Variable Capacitor (Symbol 5)
	Transformer (Symbol 6)
	Single Pole Switch (Symbol 11)

• G7B - Digital circuits (gates, flip-flops, shift registers)

- A “flip-flop” circuit is a digital circuit with two stable states.
- Digital circuits use the binary number system because binary "ones" and "zeros" are easy to represent with an "on" or "off" state.
- The output of a two-input NAND gate, given both inputs are “one” is Zero.
- The output of a NOR gate given that both inputs are “zero” is One.
- There are 8 states in a 3-bit binary counter.

- **A shift register is a clocked array of circuits that passes data in steps along the array.**

G7B - Amplifiers

- **Low distortion is a characteristic of a Class A amplifier.**
- **A Class “C” power stage is appropriate for amplifying a modulated signal for the CW mode.**
- **High efficiency is an advantage of a Class C amplifier.**
- **The efficiency of an RF power amplifier is determined by dividing the RF output power by the DC input power.**
- **A linear amplifier is an amplifier whose output preserves the input waveform.**

G7B - Oscillators

- **The basic components of virtually all oscillators are a filter and an amplifier operating in a feedback loop.**
- **The phase shift of the RC feedback circuit determines the frequency of an RC oscillator.**
- **The inductance and capacitance in the tank circuit determines the frequency of an LC oscillator.**

SUB-ELEMENT G8 – SIGNALS AND EMISSIONS

[2 exam questions – 2 groups]

- **G8A - Carriers and modulation: AM**

- Amplitude modulation is the name of the process that changes the envelope of an RF wave to convey information.
- Amplitude modulation type of transmission varies the instantaneous power level of the RF signal to convey information.

G8A - Carriers and modulation: FM

- Frequency modulation is the name of the process, which changes the frequency of an RF wave to convey information.
- When a modulating audio signal is applied to an FM transmitter the carrier frequency changes proportionally to the instantaneous amplitude of the modulating signal.
- Phase modulation is the name of the process that changes the phase angle of an RF wave to convey information.
- Phase modulation emission is produced by a reactance modulator connected to an RF power amplifier.

G8A - Carriers and modulation: Single and double sideband

- One advantage of carrier suppression in a single-sideband phone transmission is more transmitter power can be put into the remaining sidebands.
- Single sideband phone emissions use the narrowest frequency bandwidth.
- Both upper and lower sideband signal(s) would be found at the output of a properly adjusted balanced modulator.

G8A - Modulation envelope; Deviation; Overmodulation

- The Audio or microphone gain control is typically adjusted for proper ALC setting on an amateur single sideband transceiver.
- The signal of an over-modulated single-sideband phone transmitter becomes distorted and occupies more bandwidth.
- Flat-topping of a single-sideband phone transmission is signal distortion caused by excessive drive.

- **G8B - Frequency mixing**

- Heterodyning is another term for the mixing of two RF signals.
- A mixer stage in a transmitter would change a 5.3 MHz input signal to 14.3 MHz.
- The Mixer stage in a receiver combines a 14.250 MHz input signal with a 13.795 MHz oscillator signal to produce a 455 kHz intermediate frequency (IF) signal.

$$\text{Sum} \rightarrow 14.250 \text{ MHz} + 13.795 \text{ MHz} = 28.045 \text{ MHz}$$

$$\text{Difference} \rightarrow 14.250 \text{ MHz} - 13.795 \text{ MHz} = 0.455 \text{ MHz or } 455 \text{ kHz}$$

- If a receiver mixes a 13.800 MHz VFO with a 14.255 MHz received signal to produce a 455 kHz intermediate frequency (IF) signal, a 13.345 MHz signal will produce Local Oscillator interference in the receiver .

G8B - Multiplication

- The Multiplier stage in a VHF FM transmitter selects a harmonic of an HF signal to reach the desired operating frequency.

G8B - HF data communications

- The frequency shift is related to keying speed in an FSK signal in that greater keying speeds require greater frequency shifts.
- RTTY, Morse code, PSK31 and packet communications are all digital modes.
- When transmitting a data mode signal, it is important to know the duty cycle of the mode you are using to prevent damage to your transmitter's final output stage.
- The part of the 20 meter band most commonly used for PSK31 operation is below the RTTY segment, near 14.070 MHz.

G8B - Bandwidths of various modes

- Frequency modulated (FM) phone isn't used below 29.5 MHz because the bandwidth would exceed FCC limits.
- The total bandwidth of an FM-phone transmission having a 5 kHz deviation and a 3 kHz modulating frequency is 16 kHz.

$$\text{Total Bandwidth} = 2 * (\text{Deviation} + \text{Modulating Frequency})$$

$$\text{Total Bandwidth} = 2 * (5 \text{ kHz} + 3 \text{ kHz}) = 16 \text{ kHz}$$

- For a 12.21-MHz reactance-modulated oscillator in a 5-kHz deviation, 146.52-MHz FM-phone transmitter, the frequency deviation is 416.7 Hz.

$$146.52 \text{ MHz} / 12.21 \text{ MHz} = 12$$

$$\text{Therefore} \rightarrow 5 \text{ kHz} / 12 = 0.41666 \text{ kHz or } 416.7 \text{ Hz}$$

SUB-ELEMENT G9 – ANTENNAS AND FEEDLINES

[4 exam questions – 4 groups]

- **G9A - Antenna feedlines: characteristic impedance, and attenuation**
 - The distance between the centers of the conductors and the radius of the conductors help determine the characteristic impedance of a parallel conductor antenna feedline.
 - The typical characteristic impedance of coaxial cables used for antenna feedlines at amateur stations is 50 and 75 ohms.
 - The characteristic impedance of flat ribbon TV type twin lead is 300 ohms.
 - The attenuation of coaxial cable increases as the frequency of the signal it is carrying increases.
 - RF feed line losses are usually expressed in dB per 100 ft.

G9A - Antenna feedlines: SWR calculation, measurement and effects

- If the SWR on an antenna feedline is 5 to 1, and a matching network at the transmitter end of the feedline is adjusted to 1 to 1 SWR, the resulting SWR on the feedline will be 5 to 1.
- A standing-wave-ratio of 4:1 will result from the connection of a 50-ohm feed line to a non-reactive load having a 200-ohm impedance.

$$\text{SWR} = 200:50 \rightarrow 4:1$$

- A standing-wave-ratio of 5:1 will result from the connection of a 50-ohm feed line to a non-reactive load having a 10-ohm impedance.

$$\text{SWR} = 50:10 \rightarrow 5:1$$

- A standing-wave-ratio of 1:1 will result from the connection of a 50-ohm feed line to a non-reactive load having a 50-ohm impedance.

$$\text{SWR} = 50:50 \rightarrow 1:1$$

- If you feed a vertical antenna that has a 25-ohm feed-point impedance with 50-ohm coaxial cable the SWR would be 2:1.

$$\text{SWR} = 50:25 \rightarrow 2:1$$

- If you feed a folded dipole antenna that has a 300-ohm feedpoint impedance with 50-ohm coaxial cable the SWR would be 6:1.

$$\text{SWR} = 300:50 \rightarrow 6:1$$

Authors note: In the preceding statements you are faced with the same mismatch of impedance whether you are looking at it from the "load" perspective or the "feedpoint" perspective. The ratio can appear to be flopped. The convention is to state the ratio as if you are referencing from 1:1 and increasing the number on the left side of the ratio.

G9A - Antenna feedlines: matching networks

- A common reason for the occurrence of reflected power at the point where a feedline connects to an antenna is a difference between feedline impedance and antenna feed point impedance.
- The antenna feed point impedance must be matched to the characteristic impedance of the feedline to prevent standing waves on an antenna feedline.
- A reason for using an inductively coupled matching network between the transmitter and parallel conductor feed line feeding an antenna is to match the unbalanced transmitter output to the balanced parallel conductor feedline.

G9B - Basic antennas: Random-wire antenna

- One disadvantage of a directly fed random-wire antenna is you may experience RF burns when touching metal objects in your station.

G9B - Basic antennas: Groundplane antenna

- An advantage of downward sloping radials on a ground-plane antenna is they can be adjusted to bring the feed-point impedance closer to 50 ohms.
- The feed-point impedance of a ground-plane antenna increases when its radials are changed from horizontal to downward-sloping.

G9B - Basic antennas: Vertical antenna

- The radial wires of a ground-mounted vertical antenna system should be placed on the surface or buried a few inches below the ground.
- The approximate length for a 1/4-wave vertical antenna cut for 28.5 MHz is 8.2 feet.
- Length (1/4-wave Vertical) = $\frac{234}{\text{Frequency (MHz)}}$ = $\frac{234}{28.5} = 8.2$ feet
- (in feet)

G9B - Basic antennas: Dipole

- The low angle azimuthal radiation pattern of an ideal half-wavelength dipole antenna installed 1/2 wavelength high and parallel to the earth is a figure-eight at right angles to the antenna.
- The antenna height affects the horizontal (azimuthal) radiation pattern of a horizontal dipole HF antenna if the antenna is less than 1/2 wavelength high and resulting the azimuthal pattern is almost omnidirectional.
- The feed-point impedance of a 1/2 wave dipole antenna steadily decreases as the antenna is lowered from 1/4 wave above ground.
- The feed-point impedance of a 1/2 wave dipole steadily increases as the feed-point location is moved from the center toward the ends.
- An advantage of a horizontally polarized as compared to vertically polarized HF antenna is lower ground reflection losses.
- The approximate length for a 1/2-wave dipole antenna cut for 14.250 MHz is 32.8 feet.
- Length (1/2-wave Dipole) = $\frac{468}{\text{Frequency (MHz)}} = 468/14.250 = 32.8$ feet
(in feet)
- The approximate length for a 1/2-wave dipole antenna cut for 3.550 MHz is 131.8 feet.
- Length (1/2-wave Dipole) = $\frac{468}{\text{Frequency (MHz)}} = 468/3.550 = 131.8$ feet
(in feet)

- **G9C - Directional antennas: Yagi**

- A Yagi antenna consists of a driven element and some combination of parasitically excited reflector and/or director elements.
- The director is normally the shortest parasitic element in a three-element single-band Yagi antenna.
- The reflector is normally the longest parasitic element in a Yagi antenna.
- The SWR bandwidth of a Yagi antenna can be increased by using larger diameter elements.
- The approximate length of the driven element of a Yagi antenna is 1/2 wavelength.
- Increasing the boom length and adding directors to a Yagi antenna will increase Gain.
- A reason why a Yagi antenna is often used for radio communications on the 20 meter band is it helps reduce interference from other stations to the side or behind the antenna.
- In reference to a Yagi antenna, "front-to-back ratio" means the power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction.
- The "main lobe" of a directive antenna is the direction of maximum radiated field strength from the antenna.
- The approximate maximum theoretical forward gain of a 3 Element Yagi antenna is 9.7 dBi.
- All of these Yagi antenna design variables could be adjusted to optimize forward gain, front-to-back ratio, or SWR bandwidth:

- **The physical length of the boom**
- **The number of elements on the boom**
- **The spacing of each element along the boom**

[All of these choices are correct]

- **The purpose of a "gamma match" used with Yagi antennas is to match the relatively low feed-point impedance to 50 ohms.**
- **No insulation is needed for insulating the driven element of a Yagi antenna from the metal boom when using a gamma match.**

[None of the above. No insulation is needed]

G9C - Directional antennas: Quad; Loop

- **Each side of a cubical-quad antenna driven element is approximately 1/4 wavelength long.**
- **The forward gain of a 2-element cubical-quad antenna is about the same as the forward gain of a 3 element Yagi antenna.**
- **Each side of a cubical-quad antenna reflector element is slightly more than 1/4 wavelength.**
- **A cubical quad antenna is a directional antenna and is typically constructed from 2 square loops of wire each having a circumference of approximately one wavelength at the operating frequency and separated by approximately 0.2 wavelength.**
- **When the feed-point of a cubical quad antenna is changed from the center of the lowest horizontal wire to the center of one of the vertical wires, the polarization of the radiated signal changes from horizontal to vertical.**
- **In order for a cubical-quad antenna to operate as a beam antenna, one of the elements is used as a reflector and the reflector element must be approximately 5% longer than the driven element.**
- **The gain of a two element delta-loop beam is about the same as the gain of a two element cubical quad antenna.**
- **Each leg of a symmetrical delta-loop antenna Driven element is approximately 1/3 wavelengths long.**

G9D - Specialized antennas: NVIS

- **The term "NVIS" means Near Vertical Incidence Skywave as it relates to antennas.**
- **An advantage of an NVIS antenna is the high vertical angle radiation for short skip during the day.**
- **An NVIS antenna is typically installed at a height between 1/10 and 1/4 wavelength above**

ground.

G9D - Specialized antennas: Horizontally Polarized Yagi

- **The gain of two 3-element horizontally polarized Yagi antennas spaced vertically 1/2 wave apart from each another typically is approximately 3 dB higher than the gain of a single 3-element Yagi.**
- **The advantage of vertical stacking of horizontally polarized Yagi antennas is it narrows the main lobe in elevation.**

G9D - Specialized antennas: Log Periodic Antenna

- **An advantage of a log periodic antenna is wide bandwidth.**
- **A log periodic antenna is described by the length and spacing of element increasing logarithmically from one end of the boom to the other.**

G9D - Specialized antennas: Beverage Antenna

- **A Beverage antenna generally is not used for transmitting because it has high losses compared to other types of antennas.**
- **An application for a Beverage antenna is directional receiving for low HF bands.**
- **A Beverage antenna is a very long and low receiving antenna that is highly directional.**

G9D - Specialized antennas: Multi-band Antenna

- **A disadvantage of multiband antennas is poor harmonic rejection.**
- **The primary purpose of traps installed in antennas is to permit multiband operation.**

SUB-ELEMENT G0 – ELECTRICAL AND RF SAFETY

[2 Exam Questions – 2 groups]

G0A - RF safety principles, rules and guidelines

- **RF energy can heat human body tissue.**
- **The RF safety rules require no further action when the maximum power output capability of an otherwise compliant station is reduced.**
- **Whenever you make adjustments or repairs to an antenna turn off the transmitter and disconnect the feedline.**
- **If an evaluation of your station shows RF energy radiated from your station exceeds permissible limits you must take action to prevent human exposure to the excessive RF fields.**
- **You should make sure that MPE limits are not exceeded in occupied areas if you install an indoor transmitting antenna.**
- **When installing a ground-mounted antenna it should be installed so no one can be exposed to RF radiation in excess of maximum permissible limits.**
- **If evaluation shows that a neighbor might receive more than the allowable limit of RF exposure from the main lobe of a directional antenna take precautions to ensure that the antenna cannot be pointed at their house.**

G0A - Routine station evaluation

- **An amateur operator must perform a routine RF exposure evaluation to ensure compliance with RF safety regulations.**
- **Any transmitter that contributes 5% or more of the MPE at a multiple user site is/are responsible for RF safety compliance.**
- **You can determine that your station complies with FCC RF exposure regulations:**
 - **By calculation based on FCC OET Bulletin 65**
 - **By calculation based on computer modeling**
 - **By measurement of field strength using calibrated equipment**

[All of these choices are correct]
- **A calibrated field-strength meter with a calibrated antenna can be used to accurately measure an RF field.**
- **The critical angle is NOT important in estimating if an RF signal exceeds the maximum permissible exposure (MPE).**
- **The power level and frequency of the energy have the most direct effect on the permitted exposure level of RF radiation.**
- **The term, "time averaging", means the total RF exposure averaged over a certain time in**

reference to RF radiation exposure.

- A lower transmitter duty cycle permits greater short-term exposure levels when evaluating RF exposure.
- **G0B - Safety in the ham shack: electrical shock and treatment**
- The most hazardous type of electrical energy is 60 cycle Alternating Current.
- The maximum amount of electrical current flow through the human body that can be tolerated safely is 50 microamperes.
- Current through the heart can cause the heart to stop pumping. Electrical shock can be lethal.

G0B - Safety in the ham shack: grounding

- Current flowing from the hot wire to ground will cause a Ground Fault Circuit Interrupter (GFCI) to disconnect the 120 or 240 Volt AC line power to a device.
- The metal chassis of every item of station equipment must be grounded (assuming the item has such a chassis) because it ensures that hazardous voltages cannot appear on the chassis.
- A good engineering practice for lightning protection grounds is ensuring they are bonded together with all other grounds.
- It is not safe to use soldered joints with the wires that connect the base of a tower to a system of ground rods because a soldered joint will likely be destroyed by the heat of a lightning strike.
- A danger from lead-tin solder is Lead can contaminate food if hands are not washed carefully after handling.

G0B - Safety in the ham shack: fusing

- A 15 ampere fuse or circuit breaker would be appropriate to use with a circuit that uses AWG number 14 wiring.

G0B - Safety in the ham shack: wiring

- Only the "hot" (black and red) wires in a four-conductor line cord should be attached to fuses or circuit breakers in a device operated from a 240-VAC single-phase source.
- AWG number 12 is the minimum wire size that may be safely used for a circuit that draws up to 20 amperes of continuous current.

G0B - Safety in the ham shack: interlocks

- The purpose of a transmitter power supply interlock is to ensure that dangerous voltages are removed if the cabinet is opened.

G0B - Safety in the ham shack: antenna and tower safety

- For safety when climbing on a tower using a safety belt or harness always attach the belt safety

hook to the belt "D" ring with the hook opening away from the tower.

- **Any person preparing to climb a tower that supports electrically powered devices should make sure all circuits that supply power to the tower are locked out and tagged.**