

# 2023-2027 General Class Question Pool

Questions and correct answers only

FCC Element 3 Question Pool

Effective 7/01/2023 – 6/30/2027

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## SUBELEMENT G1 - COMMISSION'S RULES [5 Exam Questions - 5 Groups]

### *G1A - General Class control operator frequency privileges; primary and secondary allocations*

On which HF and/or MF amateur bands are there portions where General class licensees cannot transmit?

**80 meters, 20 meters, 15 meters, and 10 meters**

On which of the following bands is phone operation prohibited?

**30 meters**

On which of the following bands is image transmission prohibited?

**30 meters**

On which of the following frequencies are General class licensees prohibited from operating as control operator?

**7.125 MHz to 7.175 MHz**

Which of the following applies when the FCC rules designate the amateur service as a secondary user on a band?

**Amateur stations must not cause harmful interference to primary users and must accept interference from primary users**

On which amateur frequencies in the 10-meter band may stations with a General class control operator transmit CW emissions?

**The entire band**

Which HF bands have segments exclusively allocated to Amateur Extra licensees?

**80 meters, 40 meters, 20 meters, and 15 meters**

Which of the following frequencies is within the General class portion of the 15-meter band?

**21300 kHz**

What portion of the 10-meter band is available for repeater use?

**The portion above 29.5 MHz**

When General class licensees are not permitted to use the entire voice portion of a band, which portion of the voice segment is available to them?

**The upper frequency portion**

***G1B – Antenna structure limitations; good engineering and good amateur practice; beacon operation; prohibited transmissions; retransmitting radio signals***

What is the maximum height above ground for an antenna structure not near a public use airport without requiring notification to the FAA and registration with the FCC?

**200 feet**

With which of the following conditions must beacon stations comply?

**No more than one beacon station may transmit in the same band from the same station location**

Which of the following is a purpose of a beacon station as identified in the FCC rules?

**Observation of propagation and reception**

Which of the following transmissions is permitted for all amateur stations?

**Occasional retransmission of weather and propagation forecast information from US government stations**

Which of the following one-way transmissions are permitted?

**Transmissions to assist with learning the International Morse code**

Under what conditions are state and local governments permitted to regulate amateur radio antenna structures?

**Amateur Service communications must be reasonably accommodated, and regulations must constitute the minimum practical to accommodate a legitimate purpose of the state or local entity**

What are the restrictions on the use of abbreviations or procedural signals in the amateur service?

**They may be used if they do not obscure the meaning of a message**

When is it permissible to communicate with amateur stations in countries outside the areas administered by the Federal Communications Commission?

**When the contact is with amateurs in any country except those whose administrations have notified the ITU that they object to such communications**

On what HF frequencies are automatically controlled beacons permitted?

**28.20 MHz to 28.30 MHz**

What is the power limit for beacon stations?

**100 watts PEP output**

Who or what determines "good engineering and good amateur practice," as applied to the operation of an amateur station in all respects not covered by the Part 97 rules?

**The FCC**

***G1C – Transmitter power regulations; data emission standards; 60-meter operation requirements***

What is the maximum transmitter power an amateur station may use on 10.140 MHz?

**200 watts PEP output**

What is the maximum transmitter power an amateur station may use on the 12-meter band?

**1500 watts PEP output**

What is the maximum bandwidth permitted by FCC rules for amateur radio stations transmitting on USB frequencies in the 60-meter band?

**2.8 kHz**

Which of the following is required by the FCC rules when operating in the 60-meter band?

**If you are using an antenna other than a dipole, you must keep a record of the gain of your antenna**

What is the limit for transmitter power on the 28 MHz band for a General Class control operator?

**1500 watts PEP output**

What is the limit for transmitter power on the 1.8 MHz band?

**1500 watts PEP output**

What must be done before using a new digital protocol on the air?

**Publicly document the technical characteristics of the protocol**

What measurement is specified by FCC rules that regulate maximum power?

**PEP output from the transmitter**

*G1D – Volunteer Examiners and Volunteer Examiner Coordinators; temporary identification; element credit; remote operation*

Who may receive partial credit for the elements represented by an expired amateur radio license?

**Any person who can demonstrate that they once held an FCC-issued General, Advanced, or Amateur Extra class license that was not revoked by the FCC**

What license examinations may you administer as an accredited Volunteer Examiner holding a General class operator license?

**Technician only**

On which of the following band segments may you operate if you are a Technician class operator and have an unexpired Certificate of Successful Completion of Examination (CSCE) for General class privileges?

**On any General or Technician class band segment**

Who must observe the administration of a Technician class license examination?

**At least three Volunteer Examiners of General class or higher**

When operating a US station by remote control from outside the country, what license is required of the control operator?

**A US operator/primary station license**

Until an upgrade to General class is shown in the FCC database, when must a Technician licensee identify with "AG" after their call sign?

**Whenever they operate using General class frequency privileges**

Volunteer Examiners are accredited by what organization?

**A Volunteer Examiner Coordinator**

Which of the following criteria must be met for a non-US citizen to be an accredited Volunteer Examiner?

**The person must hold an FCC granted amateur radio license of General class or above**

How long is a Certificate of Successful Completion of Examination (CSCE) valid for exam element credit?

**365 days**

What is the minimum age that one must be to qualify as an accredited Volunteer Examiner?

**18 years**

What action is required to obtain a new General class license after a previously held license has expired and the two-year grace period has passed?

**The applicant must show proof of the appropriate expired license grant and pass the current Element 2 exam**

When operating a station in South America by remote control over the internet from the US, what regulations apply?

**Only those of the remote station's country**

**G1E – Control categories; repeater regulations; third-party rules; ITU regions; automatically controlled digital station**

Which of the following would disqualify a third party from participating in sending a message via an amateur station?

**The third party's amateur license has been revoked and not reinstated**

When may a 10-meter repeater retransmit the 2-meter signal from a station that has a Technician class control operator?

**Only if the 10-meter repeater control operator holds at least a General class license**

What is required to conduct communications with a digital station operating under automatic control outside the automatic control band segments?

**The station initiating the contact must be under local or remote control**

Which of the following conditions require a licensed amateur radio operator 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 these choices are correct**

What are the restrictions on messages sent to a third party in a country with which there is a Third-Party Agreement?

**They must relate to amateur radio, or remarks of a personal character, or messages relating to emergencies or disaster relief**

The frequency allocations of which ITU region apply to radio amateurs operating in North and South America?

**Region 2**

In what part of the 2.4 GHz band may an amateur station communicate with non-licensed Wi-Fi stations?

**No part**

What is the maximum PEP output allowed for spread spectrum transmissions?

**10 watts**

Why should an amateur operator normally avoid transmitting on 14.100, 18.110, 21.150, 24.930 and 28.200 MHz?

**A system of propagation beacon stations operates on those frequencies**

On what bands may automatically controlled stations transmitting RTTY or data emissions communicate with other automatically controlled digital stations?

**Anywhere in the 6-meter or shorter wavelength bands, and in limited segments of some of the HF bands**

When may third-party messages be transmitted via remote control?

**Under any circumstances in which third party messages are permitted by FCC rules**

## **SUBELEMENT G2 – OPERATING PROCEDURES [5 Exam Questions – 5 Groups]**

*G2A – Phone operating procedures: USB/LSB conventions, breaking into a contact, transmitter setup for voice operation; answering DX stations*

Which mode is most commonly used for voice communications on frequencies of 14 MHz or higher?

**Upper sideband**

Which mode is most commonly used for voice communications on the 160-, 75-, and 40-meter bands?

**Lower sideband**

Which mode is most commonly used for SSB voice communications in the VHF and UHF bands?

**Upper sideband**

Which mode is most commonly used for voice communications on the 17- and 12-meter bands?

**Upper sideband**

Which mode of voice communication is most commonly used on the HF amateur bands?

## Single sideband

Which of the following is an advantage of using single sideband, as compared to other analog voice modes on the HF amateur bands?

**Less bandwidth used and greater power efficiency**

Which of the following statements is true of single sideband (SSB)?

**Only one sideband is transmitted; the other sideband and carrier are suppressed**

What is the recommended way to break into a phone contact?

**Say your call sign once**

Why do most amateur stations use lower sideband on the 160-, 75-, and 40-meter bands?

**It is commonly accepted amateur practice**

Which of the following statements is true of VOX operation versus PTT operation?

**It allows "hands free" operation**

Generally, who should respond to a station in the contiguous 48 states calling "CQ DX"?

**Any stations outside the lower 48 states**

What control is typically adjusted for proper ALC setting on a single sideband transceiver?

**Transmit audio or microphone gain**

## *G2B – Operating effectively; band plans; drills and emergencies; RACES operation*

Which of the following is true concerning access to frequencies?

**Except during emergencies, no amateur station has priority access to any frequency**

What is the first thing you should do if you are communicating with another amateur station and hear a station in distress break in?

**Acknowledge the station in distress and determine what assistance may be needed**

What is good amateur practice if propagation changes during a contact creating interference from other stations using the frequency?

**Attempt to resolve the interference problem with the other stations in a mutually acceptable manner**

When selecting a CW transmitting frequency, what minimum separation from other stations should be used to minimize interference to stations on adjacent frequencies?

**150 Hz to 500 Hz**

When selecting an SSB transmitting frequency, what minimum separation should be used to minimize interference to stations on adjacent frequencies?

**2 kHz to 3 kHz**

How can you avoid harmful interference on an apparently clear frequency before calling CQ on CW or phone?

**Send "QRL?" on CW, followed by your call sign; or, if using phone, ask if the frequency is in use, followed by your call sign**

Which of the following complies with commonly accepted amateur practice when choosing a frequency on which to initiate a call?

**Follow the voluntary band plan**

What is the voluntary band plan restriction for US stations transmitting within the 48 contiguous states in the 50.1 MHz to 50.125 MHz band segment?

**Only contacts with stations not within the 48 contiguous states**

Who may be the control operator of an amateur station transmitting in RACES to assist relief operations during a disaster?

**Only a person holding an FCC-issued amateur operator license**

Which of the following is good amateur practice for net management?

**Have a backup frequency in case of interference or poor conditions**

How often may RACES training drills and tests be routinely conducted without special authorization?

**No more than 1 hour per week**

*G2C – CW operating procedures and procedural signals; Q signals; full break-in*

Which of the following describes full break-in CW operation (QSK)?

**Transmitting stations can receive between code characters and elements**

What should you do if a CW station sends "QRS?"

**Send slower**

What does it mean when a CW operator sends "KN" at the end of a transmission?

**Listening only for a specific station or stations**

What does the Q signal "QRL?" mean?

**"Are you busy?" or "Is this frequency in use?"**

What is the best speed to use when answering a CQ in Morse code?

**The fastest speed at which you are comfortable copying, but no faster than the CQ**

What does the term "zero beat" mean in CW operation?

**Matching the transmit frequency to the frequency of a received signal**

When sending CW, what does a "C" mean when added to the RST report?

**Chirpy or unstable signal**

What prosign is sent to indicate the end of a formal message when using CW?

**AR**

What does the Q signal "QSL" mean?

**I have received and understood**

What does the Q signal "QRN" mean?

**I am troubled by static**

What does the Q signal "QRV" mean?

**I am ready to receive**

## *G2D – Volunteer Monitor Program; HF operations*

What is the Volunteer Monitor Program?

**Amateur volunteers who are formally enlisted to monitor the airwaves for rules violations**

Which of the following are objectives of the Volunteer Monitor Program?

**To encourage amateur radio operators to self-regulate and comply with the rules**

What procedure may be used by Volunteer Monitors to localize a station whose continuous carrier is holding a repeater on in their area?

**Compare beam headings on the repeater input from their home locations with that of other Volunteer Monitors**

Which of the following describes an azimuthal projection map?

**A map that shows true bearings and distances from a specific location**

Which of the following indicates that you are looking for an HF contact with any station?

**Repeat "CQ" a few times, followed by "this is," then your call sign a few times, then pause to listen, repeat as necessary**

How is a directional antenna pointed when making a "long-path" contact with another station?

**180 degrees from the station's short-path heading**

Which of the following are examples of the NATO Phonetic Alphabet?

**Alpha, Bravo, Charlie, Delta**

Why do many amateurs keep a station log?

**To help with a reply if the FCC requests information about your station**

Which of the following is required when participating in a contest on HF frequencies?

**Identify your station according to normal FCC regulations**

What is QRP operation?

**Low-power transmit operation**

Why are signal reports typically exchanged at the beginning of an HF contact?

**To allow each station to operate according to conditions**

## *G2E – Digital mode operating procedures*

Which mode is normally used when sending RTTY signals via AFSK with an SSB transmitter?

**LSB**

What is VARA?

**A digital protocol used with Winlink**

What symptoms may result from other signals interfering with a PACTOR or VARA transmission?

- Frequent retries or timeouts
- Long pauses in message transmission
- Failure to establish a connection between stations

**All these choices are correct**

Which of the following is good practice when choosing a transmitting frequency to answer a station calling CQ using FT8?

**Find a clear frequency during the alternate time slot to the calling station**

What is the standard sideband for JT65, JT9, FT4, or FT8 digital signal when using AFSK?

**USB**

What is the most common frequency shift for RTTY emissions in the amateur HF bands?

**170 Hz**

Which of the following is required when using FT8?

**Computer time accurate to within approximately 1 second**

In what segment of the 20-meter band are most digital mode operations commonly found?

**Between 14.070 MHz and 14.100 MHz**

How do you join a contact between two stations using the PACTOR protocol?

**Joining an existing contact is not possible, PACTOR connections are limited to two stations**

Which of the following is a way to establish contact with a digital messaging system gateway station?

**Transmit a connect message on the station's published frequency**

What is the primary purpose of an Amateur Radio Emergency Data Network (AREDN) mesh network?

**To provide high-speed data services during an emergency or community event**

Which of the following describes Winlink?

An amateur radio wireless network to send and receive email on the internet

A form of Packet Radio

A wireless network capable of both VHF and HF band operation

**All of the above**

What is another name for a Winlink Remote Message Server?

**Gateway**

What could be wrong if you cannot decode an RTTY or other FSK signal even though it is apparently tuned in properly?

- The mark and space frequencies may be reversed
- You may have selected the wrong baud rate
- You may be listening on the wrong sideband

**All these choices are correct**

Which of the following is a common location for FT8?

**Approximately 14.074 MHz to 14.077 MHz**

## **SUBELEMENT G3 – RADIO WAVE PROPAGATION [3 Exam Questions – 3 Groups]**

### **G3A – Sunspots and solar radiation; geomagnetic field and stability indices**

How does a higher sunspot number affect HF propagation?

**Higher sunspot numbers generally indicate a greater probability of good propagation at higher frequencies**

What effect does a sudden ionospheric disturbance have on the daytime ionospheric propagation?

**It disrupts signals on lower frequencies more than those on higher frequencies**

Approximately how long does it take the increased ultraviolet and X-ray radiation from a solar flare to affect radio propagation on Earth?

**8 minutes**

Which of the following are the least reliable bands for long-distance communications during periods of low solar activity?

**15 meters, 12 meters, and 10 meters**

What is the solar flux index?

**A measure of solar radiation with a wavelength of 10.7 centimeters**

What is a geomagnetic storm?

**A temporary disturbance in Earth's geomagnetic field**

At what point in the solar cycle does the 20-meter band usually support worldwide propagation during daylight hours?

**At any point**

How can a geomagnetic storm affect HF propagation?

**Degrade high-latitude HF propagation**

How can high geomagnetic activity benefit radio communications?

**Creates auroras that can reflect VHF signals**

What causes HF propagation conditions to vary periodically in a 26- to 28-day cycle?

**Rotation of the Sun's surface layers around its axis**

How long does it take a coronal mass ejection to affect radio propagation on Earth?

**15 hours to several days**

What does the K-index measure?

**The short-term stability of Earth's geomagnetic field**

What does the A-index measure?

**The long-term stability of Earth's geomagnetic field**

How is long distance radio communication usually affected by the charged particles that reach Earth from solar coronal holes?

**HF communication is disturbed**

***G3B – Maximum Usable Frequency; Lowest Usable Frequency; short path and long path propagation; determining propagation conditions; ionospheric refraction***

What is a characteristic of skywave signals arriving at your location by both short-path and long-path propagation?

**A slightly delayed echo might be heard**

What factors affect the MUF?

- Path distance and location
- Time of day and season
- Solar radiation and ionospheric disturbances

**All these choices are correct**

Which frequency will have the least attenuation for long-distance skip propagation?

**Just below the MUF**

Which of the following is a way to determine current propagation on a desired band from your station?

**Use a network of automated receiving stations on the internet to see where your transmissions are being received**

How does the ionosphere affect radio waves with frequencies below the MUF and above the LUF?

**They are refracted back to Earth**

What usually happens to radio waves with frequencies below the LUF?

**They are attenuated before reaching the destination**

What does LUF stand for?

**The Lowest Usable Frequency for communications between two specific points**

What does MUF stand for?

**The Maximum Usable Frequency for communications between two points**

What is the approximate maximum distance along the Earth's surface normally covered in one hop using the F2 region?

**2,500 miles**

What is the approximate maximum distance along the Earth's surface normally covered in one hop using the E region?

**1,200 miles**

What happens to HF propagation when the LUF exceeds the MUF?

**Propagation via ordinary skywave communications is not possible over that path**

Which of the following is typical of the lower HF frequencies during the summer?

**High levels of atmospheric noise or static**

***G3C – Ionospheric regions; critical angle and frequency; HF scatter; near vertical incidence skywave (NVIS)***

Which ionospheric region is closest to the surface of Earth?

**The D region**

What is meant by the term "critical frequency" at a given incidence angle?

**The highest frequency which is refracted back to Earth**

Why is skip propagation via the F2 region longer than that via the other ionospheric regions?

**Because it is the highest**

What does the term "critical angle" mean, as applied to radio wave propagation?

**The highest takeoff angle that will return a radio wave to Earth under specific ionospheric conditions**

Why is long-distance communication on the 40-, 60-, 80-, and 160-meter bands more difficult during the day?

**The D region absorbs signals at these frequencies during daylight hours**

What is a characteristic of HF scatter?

**Signals have a fluttering sound**

What makes HF scatter signals often sound distorted?

**Energy is scattered into the skip zone through several different paths**

Why are HF scatter signals in the skip zone usually weak?

**Only a small part of the signal energy is scattered into the skip zone**

What type of propagation allows signals to be heard in the transmitting station's skip zone?

**Scatter**

What is near vertical incidence skywave (NVIS) propagation?

**Short distance MF or HF propagation at high elevation angles**

Which ionospheric region is the most absorbent of signals below 10 MHz during daylight hours?

**The D region**

## **SUBELEMENT G4 – AMATEUR RADIO PRACTICES [5 Exam Questions – 5 groups]**

### *G4A – Station configuration and operation*

What is the purpose of the notch filter found on many HF transceivers?

**To reduce interference from carriers in the receiver passband**

What is the benefit of using the opposite or "reverse" sideband when receiving CW?

**It may be possible to reduce or eliminate interference from other signals**

How does a noise blanker work?

**By reducing receiver gain during a noise pulse**

What is the effect on plate current of the correct setting of a vacuum-tube RF power amplifier's TUNE control?

**A pronounced dip**

Why is automatic level control (ALC) used with an RF power amplifier?

**To prevent excessive drive**

What is the purpose of an antenna tuner?

**Increase power transfer from the transmitter to the feed line**

What happens as a receiver's noise reduction control level is increased?

**Received signals may become distorted**

What is the correct adjustment for the LOAD or COUPLING control of a vacuum tube RF power amplifier?

**Desired power output without exceeding maximum allowable plate current**

What is the purpose of delaying RF output after activating a transmitter's keying line to an external amplifier?

**To allow time for the amplifier to switch the antenna between the transceiver and the amplifier output**

What is the function of an electronic keyer?

**Automatic generation of dots and dashes for CW operation**

Why should the ALC system be inactive when transmitting AFSK data signals?

**The ALC action distorts the signal**

Which of the following is a common use of the dual-VFO feature on a transceiver?

**To transmit on one frequency and listen on another**

What is the purpose of using a receive attenuator?

**To prevent receiver overload from strong incoming signals**

#### ***G4B – Tests and test equipment***

What item of test equipment contains horizontal and vertical channel amplifiers?

**An oscilloscope**

Which of the following is an advantage of an oscilloscope versus a digital voltmeter?

**Complex waveforms can be measured**

Which of the following is the best instrument to use for checking the keying waveform of a CW transmitter?

**An oscilloscope**

What signal source is connected to the vertical input of an oscilloscope when checking the RF envelope pattern of a transmitted signal?

**The attenuated RF output of the transmitter**

Why do voltmeters have high input impedance?

**It decreases the loading on circuits being measured**

What is an advantage of a digital multimeter as compared to an analog multimeter?

**Higher precision**

What signals are used to conduct a two-tone test?

**Two non-harmonically related audio signals**

What transmitter performance parameter does a two-tone test analyze?

**Linearity**

When is an analog multimeter preferred to a digital multimeter?

**When adjusting circuits for maximum or minimum values**

Which of the following can be determined with a directional wattmeter?

**Standing wave ratio**

Which of the following must be connected to an antenna analyzer when it is being used for SWR measurements?

**Antenna and feed line**

What effect can strong signals from nearby transmitters have on an antenna analyzer?

**Received power that interferes with SWR readings**

Which of the following can be measured with an antenna analyzer?

**Impedance of coaxial cable**

### ***G4C – Interference to consumer electronics; grounding and bonding***

Which of the following might be useful in reducing RF interference to audio frequency circuits?

**Bypass capacitor**

Which of the following could be a cause of interference covering a wide range of frequencies?

**Arcing at a poor electrical connection**

What sound is heard from an audio device experiencing RF interference from a single sideband phone transmitter?

**Distorted speech**

What sound is heard from an audio device experiencing RF interference from a CW transmitter?

**On-and-off humming or clicking**

What is a possible cause of high voltages that produce RF burns?

**The ground wire has high impedance on that frequency**

What is a possible effect of a resonant ground connection?

**High RF voltages on the enclosures of station equipment**

Why should soldered joints not be used in lightning protection ground connections?

**A soldered joint will likely be destroyed by the heat of a lightning strike**

Which of the following would reduce RF interference caused by common-mode current on an audio cable?

**Place a ferrite choke on the cable**

How can the effects of ground loops be minimized?

**Bond equipment enclosures together**

What could be a symptom caused by a ground loop in your station's audio connections?

**You receive reports of "hum" on your station's transmitted signal**

What technique helps to minimize RF "hot spots" in an amateur station?

**Bonding all equipment enclosures together**

Why must all metal enclosures of station equipment be grounded?  
**It ensures that hazardous voltages cannot appear on the chassis**

#### *G4D – Speech processors; S meters; sideband operation near band edges*

What is the purpose of a speech processor in a transceiver?  
**Increase the apparent loudness of transmitted voice signals**

How does a speech processor affect a single sideband phone signal?  
**It increases average power**

What is the effect of an incorrectly adjusted speech processor?  
-Distorted speech  
-Excess intermodulation products  
-Excessive background noise  
**All these choices are correct**

What does an S meter measure?  
**Received signal strength**

How does a signal that reads 20 dB over S9 compare to one that reads S9 on a receiver, assuming a properly calibrated S meter?  
**It is 100 times more powerful**

How much change in signal strength is typically represented by one S unit?  
**6 dB**

How much must the power output of a transmitter be raised to change the S meter reading on a distant receiver from S8 to S9?  
**Approximately 4 times**

What frequency range is occupied by a 3 kHz LSB signal when the displayed carrier frequency is set to 7.178 MHz?  
**7.175 MHz to 7.178 MHz**

What frequency range is occupied by a 3 kHz USB signal with the displayed carrier frequency set to 14.347 MHz?  
**14.347 MHz to 14.350 MHz**

How close to the lower edge of a band's phone segment should your displayed carrier frequency be when using 3 kHz wide LSB?  
**At least 3 kHz above the edge of the segment**

How close to the upper edge of a band's phone segment should your displayed carrier frequency be when using 3 kHz wide USB?  
**At least 3 kHz below the edge of the band**

#### *G4E – Mobile and portable HF stations; alternative energy source operation*

What is the purpose of a capacitance hat on a mobile antenna?  
**To electrically lengthen a physically short antenna**

What is the purpose of a corona ball on an HF mobile antenna?  
**To reduce RF voltage discharge from the tip of the antenna while transmitting**

Which of the following direct, fused power connections would be the best for a 100-watt HF mobile installation?

**To the battery using heavy-gauge wire**

Why should DC power for a 100-watt HF transceiver not be supplied by a vehicle's auxiliary power socket?

**The socket's wiring may be inadequate for the current drawn by the transceiver**

Which of the following most limits an HF mobile installation?

**Efficiency of the electrically short antenna**

What is one disadvantage of using a shortened mobile antenna as opposed to a full-size antenna?

**Operating bandwidth may be very limited**

Which of the following may cause receive interference to an HF transceiver installed in a vehicle?

-The battery charging system

-The fuel delivery system

-The control computers

**All these choices are correct**

In what configuration are the individual cells in a solar panel connected together?

**Series-parallel**

What is the approximate open-circuit voltage from a fully illuminated silicon photovoltaic cell?

**0.5 VDC**

Why should a series diode be connected between a solar panel and a storage battery that is being charged by the panel?

**To prevent discharge of the battery through the panel during times of low or no illumination**

What precaution should be taken when connecting a solar panel to a lithium iron phosphate battery?

**The solar panel must have a charge controller**

## **SUBELEMENT G5 – ELECTRICAL PRINCIPLES [3 Exam Questions – 3 Groups]**

*G5A – Reactance; inductance; capacitance; impedance; impedance transformation; resonance*

What happens when inductive and capacitive reactance are equal in a series LC circuit?

**Resonance causes impedance to be very low**

What is reactance?

**Opposition to the flow of alternating current caused by capacitance or inductance**

Which of the following is opposition to the flow of alternating current in an inductor?

**Reactance**

Which of the following is opposition to the flow of alternating current in a capacitor?

## **Reactance**

How does an inductor react to AC?

**As the frequency of the applied AC increases, the reactance increases**

How does a capacitor react to AC?

**As the frequency of the applied AC increases, the reactance decreases**

What is the term for the inverse of impedance?

**Admittance**

What is impedance?

**The ratio of voltage to current**

What unit is used to measure reactance?

**Ohm**

Which of the following devices can be used for impedance matching at radio frequencies?

-A transformer

-A Pi-network

-A length of transmission line

**All these choices are correct**

What letter is used to represent reactance?

**X**

What occurs in an LC circuit at resonance?

**Inductive reactance and capacitive reactance cancel**

*G5B – The decibel; current and voltage dividers; electrical power calculations; sine wave root-mean-square (RMS) values; PEP calculations*

What dB change represents a factor of two increase or decrease in power?

**Approximately 3 dB**

How does the total current relate to the individual currents in a circuit of parallel resistors?

**It equals the sum of the currents through each branch**

How many watts of electrical power are consumed if 400 VDC is supplied to an 800-ohm load?

**200 watts**

How many watts of electrical power are consumed by a 12 VDC light bulb that draws 0.2 amperes?

**2.4 watts**

How many watts are consumed when a current of 7.0 milliamperes flows through a 1,250-ohm resistance?

**Approximately 61 milliwatts**

What is the PEP produced by 200 volts peak-to-peak across a 50-ohm dummy load?

**100 watts**

What value of an AC signal produces the same power dissipation in a resistor as a DC voltage of the same value?

**The RMS value**

What is the peak-to-peak voltage of a sine wave with an RMS voltage of 120 volts?

**339.4 volts**

What is the RMS voltage of a sine wave with a value of 17 volts peak?

**12 volts**

What percentage of power loss is equivalent to a loss of 1 dB?

**20.6 percent**

What is the ratio of PEP to average power for an unmodulated carrier?

**1.00**

What is the RMS voltage across a 50-ohm dummy load dissipating 1200 watts?

**245 volts**

What is the output PEP of an unmodulated carrier if the average power is 1060 watts?

**1060 watts**

What is the output PEP of 500 volts peak-to-peak across a 50-ohm load?

**625 watts**

### ***G5C – Resistors, capacitors, and inductors in series and parallel; transformers***

What causes a voltage to appear across the secondary winding of a transformer when an AC voltage source is connected across its primary winding?

**Mutual inductance**

What is the output voltage if an input signal is applied to the secondary winding of a 4:1 voltage step-down transformer instead of the primary winding?

**The input voltage is multiplied by 4**

What is the total resistance of a 10-, a 20-, and a 50-ohm resistor connected in parallel?

**5.9 ohms**

What is the approximate total resistance of a 100- and a 200-ohm resistor in parallel?

**67 ohms**

Why is the primary winding wire of a voltage step-up transformer usually a larger size than that of the secondary winding?

**To accommodate the higher current of the primary**

What is the voltage output of a transformer with a 500-turn primary and a 1500-turn secondary when 120 VAC is applied to the primary?

**360 volts**

What transformer turns ratio matches an antenna's 600-ohm feed point impedance to a 50-ohm coaxial cable?

**3.5 to 1**

What is the equivalent capacitance of two 5.0-nanofarad capacitors and one 750-picofarad capacitor connected in parallel?

**10.750 nanofarads**

What is the capacitance of three 100-microfarad capacitors connected in series?

**33.3 microfarads**

What is the inductance of three 10-millihenry inductors connected in parallel?

**3.3 millihenries**

What is the inductance of a circuit with a 20-millihenry inductor connected in series with a 50-millihenry inductor?

**70 millihenries**

What is the capacitance of a 20-microfarad capacitor connected in series with a 50-microfarad capacitor?

**14.3 microfarads**

Which of the following components should be added to a capacitor to increase the capacitance?

**A capacitor in parallel**

Which of the following components should be added to an inductor to increase the inductance?

**An inductor in series**

## **SUBELEMENT G6 – CIRCUIT COMPONENTS [2 Exam Questions – 2 Groups]**

*G6A – Resistors; capacitors; inductors; rectifiers; solid-state diodes and transistors; vacuum tubes; batteries*

What is the minimum allowable discharge voltage for maximum life of a standard 12-volt lead-acid battery?

**10.5 volts**

What is an advantage of batteries with low internal resistance?

**High discharge current**

What is the approximate forward threshold voltage of a germanium diode?

**0.3 volts**

Which of the following is characteristic of an electrolytic capacitor?

**High capacitance for a given volume**

What is the approximate forward threshold voltage of a silicon junction diode?

**0.7 volts**

Why should wire-wound resistors not be used in RF circuits?

**The resistor's inductance could make circuit performance unpredictable**

What are the operating points for a bipolar transistor used as a switch?

**Saturation and cutoff**

Which of the following is characteristic of low voltage ceramic capacitors?

**Comparatively low cost**

Which of the following describes MOSFET construction?

**The gate is separated from the channel by a thin insulating layer**

Which element of a vacuum tube regulates the flow of electrons between cathode and plate?

**Control grid**

What happens when an inductor is operated above its self-resonant frequency?

**It becomes capacitive**

What is the primary purpose of a screen grid in a vacuum tube?

**To reduce grid-to-plate capacitance**

**G6B – Analog and digital integrated circuits (ICs); microwave ICs (MMICs); display devices; RF connectors; ferrite cores**

What determines the performance of a ferrite core at different frequencies?

**The composition, or "mix," of materials used**

What is meant by the term MMIC?

**Monolithic Microwave Integrated Circuit**

Which of the following is an advantage of CMOS integrated circuits compared to TTL integrated circuits?

**Low power consumption**

What is a typical upper frequency limit for low SWR operation of 50-ohm BNC connectors?

**4 GHz**

What is an advantage of using a ferrite core toroidal inductor?

-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 these choices are correct**

What kind of device is an integrated circuit operational amplifier?

**Analog**

Which of the following describes a type N connector?

**A moisture-resistant RF connector useful to 10 GHz**

How is an LED biased when emitting light?

**Forward biased**

How does a ferrite bead or core reduce common-mode RF current on the shield of a coaxial cable?

**By creating an impedance in the current's path**

What is an SMA connector?

**A small threaded connector suitable for signals up to several GHz**

Which of these connector types is commonly used for low frequency or dc signal connections to a transceiver?

**RCA Phono**

## **SUBELEMENT G7 – PRACTICAL CIRCUITS [3 Exam Questions – 3 Groups]**

### *G7A – Power supplies; schematic symbols*

What is the function of a power supply bleeder resistor?

**It discharges the filter capacitors when power is removed**

Which of the following components are used in a power supply filter network?

**Capacitors and inductors**

Which type of rectifier circuit uses two diodes and a center-tapped transformer?

**Full-wave**

What is characteristic of a half-wave rectifier in a power supply?

**Only one diode is required**

What portion of the AC cycle is converted to DC by a half-wave rectifier?

**180 degrees**

What portion of the AC cycle is converted to DC by a full-wave rectifier?

**360 degrees**

What is the output waveform of an unfiltered full-wave rectifier connected to a resistive load?

**A series of DC pulses at twice the frequency of the AC input**

Which of the following is characteristic of a switchmode power supply as compared to a linear power supply?

**High-frequency operation allows the use of smaller components**

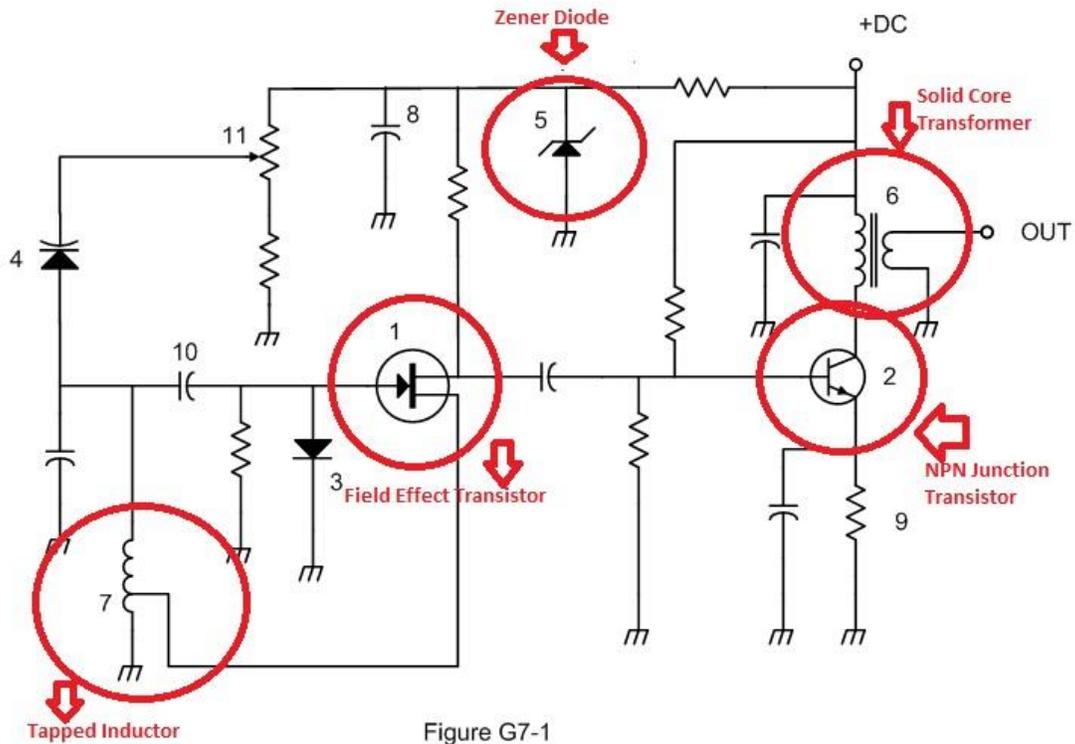


Figure G7-1

Which symbol in figure G7-1 represents a field effect transistor?

**Symbol 1**

Which symbol in figure G7-1 represents a Zener diode?

**Symbol 5**

Which symbol in figure G7-1 represents an NPN junction transistor?

**Symbol 2**

Which symbol in Figure G7-1 represents a solid core transformer?

**Symbol 6**

Which symbol in Figure G7-1 represents a tapped inductor?

**Symbol 7**

### *G7B – Digital circuits; amplifiers and oscillators*

What is the purpose of neutralizing an amplifier?

**To eliminate self-oscillations**

Which of these classes of amplifiers has the highest efficiency?

**Class C**

Which of the following describes the function of a two-input AND gate?

**Output is high only when both inputs are high**

In a Class A amplifier, what percentage of the time does the amplifying device conduct?

**100%**

How many states does a 3-bit binary counter have?

**8**

What is a shift register?

**A clocked array of circuits that passes data in steps along the array**

Which of the following are basic components of a sine wave oscillator?

**A filter and an amplifier operating in a feedback loop**

How is the efficiency of an RF power amplifier determined?

**Divide the RF output power by the DC input power**

What determines the frequency of an LC oscillator?

**The inductance and capacitance in the tank circuit**

Which of the following describes a linear amplifier?

**An amplifier in which the output preserves the input waveform**

For which of the following modes is a Class C power stage appropriate for amplifying a modulated signal?

**FM**

### *G7C – Transceiver design; filters; oscillators; digital signal processing (DSP)*

What circuit is used to select one of the sidebands from a balanced modulator?

**Filter**

What output is produced by a balanced modulator?

**Double-sideband modulated RF**

What is one reason to use an impedance matching transformer at a transmitter output?

**To present the desired impedance to the transmitter and feed line**

How is a product detector used?

**Used in a single sideband receiver to extract the modulated signal**

Which of the following is characteristic of a direct digital synthesizer (DDS)?

**Variable output frequency with the stability of a crystal oscillator**

Which of the following is an advantage of a digital signal processing (DSP) filter compared to an analog filter?

**A wide range of filter bandwidths and shapes can be created**

What term specifies a filter's attenuation inside its passband?

**Insertion loss**

Which parameter affects receiver sensitivity?

- Input amplifier gain
- Demodulator stage bandwidth
- Input amplifier noise figure

**All these choices are correct**

What is the phase difference between the I and Q RF signals that software-defined radio (SDR) equipment uses for modulation and demodulation?

**90 degrees**

What is an advantage of using I-Q modulation with software-defined radios (SDRs)?

**All types of modulation can be created with appropriate processing**

G7C11 (D)

Which of these functions is performed by software in a software-defined radio (SDR)?

- Filtering
- Detection
- Modulation

**All these choices are correct**

What is the frequency above which a low-pass filter's output power is less than half the input power?

**Cutoff frequency**

What term specifies a filter's maximum ability to reject signals outside its passband?

**Ultimate rejection**

The bandwidth of a band-pass filter is measured between what two frequencies?

**Upper and lower half-power**

## **SUBELEMENT G8 – SIGNALS AND EMISSIONS [3 Exam Questions – 3 Groups]**

*G8A – Carriers and modulation: AM, FM, and single sideband; modulation envelope; digital modulation; overmodulation; link budgets and link margins*

How is direct binary FSK modulation generated?

**By changing an oscillator's frequency directly with a digital control signal**

What is the name of the process that changes the phase angle of an RF signal to convey information?

**Phase modulation**

What is the name of the process that changes the instantaneous frequency of an RF wave to convey information?

**Frequency modulation**

What emission is produced by a reactance modulator connected to a transmitter RF amplifier stage?

**Phase modulation**

What type of modulation varies the instantaneous power level of the RF signal?

**Amplitude modulation**

Which of the following is characteristic of QPSK31?

-It is sideband sensitive

-Its encoding provides error correction

-Its bandwidth is approximately the same as BPSK31

**All these choices are correct**

Which of the following phone emissions uses the narrowest bandwidth?

**Single sideband**

Which of the following is an effect of overmodulation?

**Excessive bandwidth**

What type of modulation is used by FT8?

**8-tone frequency shift keying**

What is meant by the term "flat-topping," when referring to an amplitude-modulated phone signal?

**Signal distortion caused by excessive drive or speech levels**

What is the modulation envelope of an AM signal?

**The waveform created by connecting the peak values of the modulated signal**

What is QPSK modulation?

**Modulation in which digital data is transmitted using 0-, 90-, 180- and 270-degree phase shift to represent pairs of bits**

What is a link budget?

**The sum of transmit power and antenna gains minus system losses as seen at the receiver**

What is link margin?

**The difference between received power level and minimum required signal level at the input to the receiver**

### ***G8B – Frequency changing; bandwidths of various modes; deviation; intermodulation***

Which mixer input is varied or tuned to convert signals of different frequencies to an intermediate frequency (IF)?

**Local oscillator**

What is the term for interference from a signal at twice the IF frequency from the desired signal?

**Image response**

What is another term for the mixing of two RF signals?

**Heterodyning**

What is the stage in a VHF FM transmitter that generates a harmonic of a lower frequency signal to reach the desired operating frequency?

**Multiplier**

Which intermodulation products are closest to the original signal frequencies?

**Odd-order**

What is the total bandwidth of an FM phone transmission having 5 kHz deviation and 3 kHz modulating frequency?

**16 kHz**

What is the frequency deviation for a 12.21 MHz reactance modulated oscillator in a 5 kHz deviation, 146.52 MHz FM phone transmitter?

**416.7 Hz**

Why is it important to know the duty cycle of the mode you are using when transmitting?

**Some modes have high duty cycles that could exceed the transmitter's average power rating**

Why is it good to match receiver bandwidth to the bandwidth of the operating mode?

**It results in the best signal-to-noise ratio**

What is the relationship between transmitted symbol rate and bandwidth?

**Higher symbol rates require wider bandwidth**

What combination of a mixer's Local Oscillator (LO) and RF input frequencies is found in the output?

**The sum and difference**

What process combines two signals in a non-linear circuit to produce unwanted spurious outputs?

**Intermodulation**

Which of the following is an odd-order intermodulation product of frequencies F1 and F2?

**2F1-F2**

### **G8C – Digital emission modes**

Which digital mode is used as a low-power beacon for assessing HF propagation?

**WSPR**

What part of a packet radio frame contains the routing and handling information?

**Header**

Which of the following describes Baudot code?

**A 5-bit code with additional start and stop bits**

In an ARQ mode, what is meant by a NAK response to a transmitted packet?

**Request retransmission of the packet**

What action results from a failure to exchange information due to excessive transmission attempts when using an ARQ mode?

**The connection is dropped**

Which of the following narrow-band digital modes can receive signals with very low signal-to-noise ratios?

**FT8**

Which of the following statements is true about PSK31?

**Upper case letters use longer Varicode bit sequences and thus slow down transmission**

Which is true of mesh network microwave nodes?

**If one node fails, a packet may still reach its target station via an alternate node**

How does forward error correction (FEC) allow the receiver to correct data errors?

**By transmitting redundant information with the data**

How are the two separate frequencies of a Frequency Shift Keyed (FSK) signal identified?

**Mark and space**

Which type of code is used for sending characters in a PSK31 signal?

**Varicode**

What is indicated on a waterfall display by one or more vertical lines on either side of a data mode or RTTY signal?

**Overmodulation**

Which of the following describes a waterfall display?

**Frequency is horizontal, signal strength is intensity, time is vertical**

What does an FT8 signal report of +3 mean?

**The signal-to-noise ratio is equivalent to +3dB in a 2.5 kHz bandwidth**

Which of the following provide digital voice modes?

**DMR, D-STAR, and SystemFusion**

## **SUBELEMENT G9 – ANTENNAS AND FEED LINES [4 Exam Questions – 4 Groups]**

*G9A – Feed lines: characteristic impedance and attenuation; standing wave ratio (SWR) calculation, measurement, and effects; antenna feed point matching*

Which of the following factors determine the characteristic impedance of a parallel conductor feed line?

**The distance between the centers of the conductors and the radius of the conductors**

What is the relationship between high standing wave ratio (SWR) and transmission line loss?

**High SWR increases loss in a lossy transmission line**

What is the nominal characteristic impedance of "window line" transmission line?

**450 ohms**

What causes reflected power at an antenna's feed point?

**A difference between feed line impedance and antenna feed point impedance**

How does the attenuation of coaxial cable change with increasing frequency?

**Attenuation increases**

In what units is RF feed line loss usually expressed?

**Decibels per 100 feet**

What must be done to prevent standing waves on a feed line connected to an antenna?

**The antenna feed point impedance must be matched to the characteristic impedance of the feed line**

If the SWR on an antenna feed line is 5:1, and a matching network at the transmitter end of the feed line is adjusted to present a 1:1 SWR to the transmitter, what is the resulting SWR on the feed line?

**5:1**

What standing wave ratio results from connecting a 50-ohm feed line to a 200-ohm resistive load?

**4:1**

What standing wave ratio results from connecting a 50-ohm feed line to a 10-ohm resistive load?

**5:1**

What is the effect of transmission line loss on SWR measured at the input to the line?

**Higher loss reduces SWR measured at the input to the line**

### ***G9B – Basic dipole and monopole antennas***

What is a characteristic of a random-wire HF antenna connected directly to the transmitter?

**Station equipment may carry significant RF current**

Which of the following is a common way to adjust the feed point impedance of an elevated quarter-wave ground-plane vertical antenna to be approximately 50 ohms?

**Slope the radials downward**

Which of the following best describes the radiation pattern of a quarter-wave ground-plane vertical antenna?

**Omnidirectional in azimuth**

What is the radiation pattern of a dipole antenna in free space in a plane containing the conductor?

**It is a figure-eight at right angles to the antenna**

How does antenna height affect the azimuthal radiation pattern of a horizontal dipole HF antenna at elevation angles higher than about 45 degrees?

**If the antenna is less than 1/2 wavelength high, the azimuthal pattern is almost omnidirectional**

Where should the radial wires of a ground-mounted vertical antenna system be placed?

**On the surface or buried a few inches below the ground**

How does the feed point impedance of a horizontal 1/2 wave dipole antenna change as the antenna height is reduced to 1/10 wavelength above ground?

**It steadily decreases**

How does the feed point impedance of a 1/2 wave dipole change as the feed point is moved from the center toward the ends?

**It steadily increases**

Which of the following is an advantage of using a horizontally polarized as compared to a vertically polarized HF antenna?

**Lower ground losses**

What is the approximate length for a 1/2 wave dipole antenna cut for 14.250 MHz?

**33 feet**

What is the approximate length for a 1/2 wave dipole antenna cut for 3.550 MHz?

**132 feet**

What is the approximate length for a 1/4 wave monopole antenna cut for 28.5 MHz?

**8 feet**

### **G9C – Directional antennas**

Which of the following would increase the bandwidth of a Yagi antenna?

**Larger-diameter elements**

What is the approximate length of the driven element of a Yagi antenna?

**1/2 wavelength**

How do the lengths of a three-element Yagi reflector and director compare to that of the driven element?

**The reflector is longer, and the director is shorter**

How does antenna gain in dBi compare to gain stated in dBd for the same antenna?

**Gain in dBi is 2.15 dB higher**

What is the primary effect of increasing boom length and adding directors to a Yagi antenna?

**Gain increases**

What does "front-to-back ratio" mean in reference to a Yagi antenna?

**The power radiated in the major lobe compared to that in the opposite direction**

What is meant by the "main lobe" of a directive antenna?

**The direction of maximum radiated field strength from the antenna**

In free space, how does the gain of two three-element, horizontally polarized Yagi antennas spaced vertically 1/2 wavelength apart typically compare to the gain of a single three-element Yagi?

**Approximately 3 dB higher**

Which of the following can be adjusted to optimize forward gain, front-to-back ratio, or SWR bandwidth of a Yagi antenna?

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

**All these choices are correct**

What is a beta or hairpin match?

**A shorted transmission line stub placed at the feed point of a Yagi antenna to provide impedance matching**

Which of the following is a characteristic of using a gamma match with a Yagi antenna?

**It does not require the driven element to be insulated from the boom**

### *G9D – Specialized antenna types and applications*

Which of the following antenna types will be most effective as a near vertical incidence skywave (NVIS) antenna for short-skip communications on 40 meters during the day?

**A horizontal dipole placed between 1/10 and 1/4 wavelength above the ground**

What is the feed point impedance of an end-fed half-wave antenna?

**Very high**

In which direction is the maximum radiation from a VHF/UHF "halo" antenna?

**Omnidirectional in the plane of the halo**

What is the primary function of antenna traps?

**To enable multiband operation**

What is an advantage of vertically stacking horizontally polarized Yagi antennas?

**It narrows the main lobe in elevation**

Which of the following is an advantage of a log-periodic antenna?

**Wide bandwidth**

Which of the following describes a log-periodic antenna?

**Element length and spacing vary logarithmically along the boom**

How does a "screwdriver" mobile antenna adjust its feed point impedance?

**By varying the base loading inductance**

What is the primary use of a Beverage antenna?

**Directional receiving for MF and low HF bands**

In which direction or directions does an electrically small loop (less than 1/10 wavelength in circumference) have nulls in its radiation pattern?

**Broadside to the loop**

Which of the following is a disadvantage of multiband antennas?

**They have poor harmonic rejection**

What is the common name of a dipole with a single central support?

**Inverted V**

## **SUBELEMENT G0 – ELECTRICAL AND RF SAFETY [2 Exam Questions – 2 Groups]**

### *G0A – RF safety principles, rules, and guidelines; routine station evaluation*

G0A01 (A)

What is one way that RF energy can affect human body tissue?

**It heats body tissue**

Which of the following is used to determine RF exposure from a transmitted signal?

- Its duty cycle
- Its frequency
- Its power density

**All these choices are correct**

How can you 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 these choices are correct**

What does "time averaging" mean when evaluating RF radiation exposure?

**The total RF exposure averaged over a certain period**

What must you do if an evaluation of your station shows that the RF energy radiated by your station exceeds permissible limits for possible human absorption?

**Take action to prevent human exposure to the excessive RF fields**

What must you do if your station fails to meet the FCC RF exposure exemption criteria?

**Perform an RF Exposure Evaluation in accordance with FCC OET Bulletin 65**

What is the effect of modulation duty cycle on RF exposure?

**A lower duty cycle permits greater power levels to be transmitted**

Which of the following steps must an amateur operator take to ensure compliance with RF safety regulations?

**Perform a routine RF exposure evaluation and prevent access to any identified high exposure areas**

What type of instrument can be used to accurately measure an RF field strength?

**A calibrated field strength meter with a calibrated antenna**

What should be done if evaluation shows that a neighbor might experience 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 in their direction when they are present**

What precaution should be taken if you install an indoor transmitting antenna?

**Make sure that MPE limits are not exceeded in occupied areas**

What stations are subject to the FCC rules on RF exposure?

**All stations with a time-averaged transmission of more than one milliwatt**

### *G0B – Station safety: electrical shock, grounding, fusing, interlocks, and wiring; antenna and tower safety*

Which wire or wires in a four-conductor 240 VAC circuit should be attached to fuses or circuit breakers?

**Only the hot wires**

According to the National Electrical Code, what is the minimum wire size that may be used safely for wiring with a 20-ampere circuit breaker?

**AWG number 12**

Which size of fuse or circuit breaker would be appropriate to use with a circuit that uses AWG number 14 wiring?

**15 amperes**

Where should the station's lightning protection ground system be located?

**Outside the building**

Which of the following conditions will cause a ground fault circuit interrupter (GFCI) to disconnect AC power?

**Current flowing from one or more of the hot wires directly to ground**

Which of the following is covered by the National Electrical Code?

**Electrical safety of the station**

Which of these choices should be observed when climbing a tower using a safety harness?

**Confirm that the harness is rated for the weight of the climber and that it is within its allowable service life**

What should be done before climbing a tower that supports electrically powered devices?

**Make sure all circuits that supply power to the tower are locked out and tagged**

Which of the following is true of an emergency generator installation?

**The generator should be operated in a well-ventilated area**

Which of the following is a danger from lead-tin solder?

**Lead can contaminate food if hands are not washed carefully after handling the solder**

Which of the following is required for lightning protection ground rods?

**They must be bonded together with all other grounds**

What is the purpose of a power supply interlock?

**To ensure that dangerous voltages are removed if the cabinet is opened**

Where should lightning arrestors be located?

**Where the feed lines enter the building**

~~~end of question pool text~~~