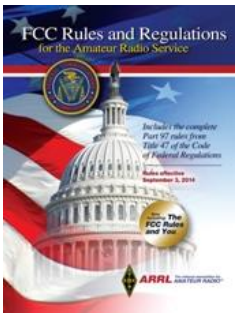
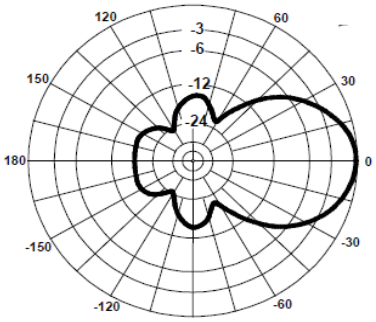
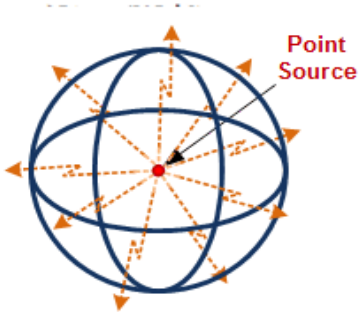
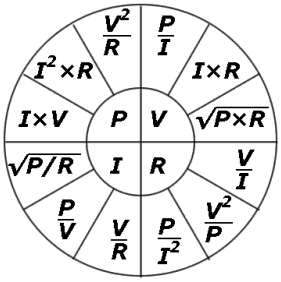
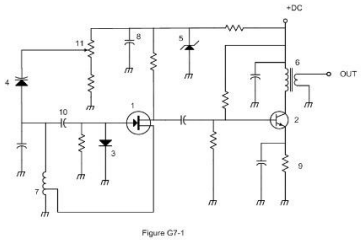
Amateur Radio
General Class License Class Syllabus
For July 1, 2023, to June 30, 2027, Question pool



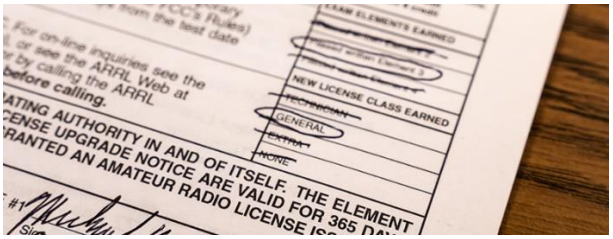








This syllabus contains everything you will need to know to pass your Amateur Radio General Class License exam



Revision 2.0 May 24, 2023
Jack Tiley – Retired Electrical Engineer
effective for exams on or after July 1, 2023
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General License Class Syllabus

For Exams from July 1, 2023, to June 30, 2027

All questions shown in this syllabus are exactly as they will appear in the exam with only the correct answer shown **(in green bold text)**. Question numbers have been included so you can go to the ARRL General Class License Manual, or the published question pool itself at http://ncvec.org/page.php?id=364 to see the additional choices in the exam for each question.

This material is based on the published 2023General Class License question pool, effective July 1, 2023, with additional information added by the author ***(in italicized blue text).***

An electronic file for this syllabus may downloaded from www.ad7fo.com. It is recommended that this syllabus is not posted to another web site. Instead post a reference to my web page www.ad7fo.com to ensure the latest revision is always downloaded.

Additional information and resources to help you study for the general and all License classes can be found on the AD7FO's web site and the ARRL web site (www.arrl.net). The ARRL web site has articles, resources, and reference materials on all aspects of the exam questions and Amateur Radio in general.

About the Author

Education: Electrical Engineering, Pennsylvania State University

Work Experience:

Hewlett Packard: (retired in 2004)

- Twenty-three years at the RF Products Division in Spokane WA – 1981 to 2004 – Responsible for Regional Sales Support, Application Engineering, Worldwide Sales Management, Systems Development and Product Management
- Eleven years at Hewlett Packard Valley Forge Pennsylvania sales office, from 1969 until 1981 – Responsible for Engineering Technical Support, Technical Customer Training and Field Sales.

American Electronics Laboratories:

- Nine years working in and managing a Metrology (Calibration) Laboratory in Colmar Pennsylvania- Responsible for a team of Technicians and Engineers who maintained a wide range DC thru Microwave test instruments and their calibration with traceability to the National Bureau of Standards (***NBS)*** [now the National Institute of Standards and Technology **(NIST**)].

Jerrold Electronics:

- Two years as a Technician at the Jerrold Electronics R&D Laboratory in Hatboro, PA working on RF test equipment and cable TV equipment.

Hobbies:

- Amateur Radio (Extra Class License Holder)
- Test Equipment
- Electronics in general.

Amateur Radio Activities:

- Teaching and mentoring
- Developing and teaching Technician, General and Extra License Classes
- Wrote and presented more than twenty short, one-hour or less, technical talks for local ham radio clubs (Many are available from the Authors web page www.ad7fo.com).
- Attending many of the Pacific Northwest Hamfest's

ARRL Appointments:

- ARRL VE (Volunteer Examiner)
- ARRL Eastern Washington Technical Specialist
- ARRL Registered Instructor

Syllabus Overview

The Syllabus is intended either for classroom study and/or for self-study in pursuit of the Amateur Radio General Class License and to assist instructors in teaching a General License class. It may be distributed freely as long as no charge for the material is made and **the note of copyright permission on page 2 is not removed.** Reproduction costs associated with delivering paper, electronic copies on CD-ROM's, etc. may be charged.

Any modified/customized copies must contain a note on the cover page that the original material by the author has been modified and contain the name and contact information of the person making the changes. An MS Word version of the syllabus is available from the Authors web page at ad7fo@com for those who want to customize this material for classes they teach.

Question numbers are shown in bold text like this, **T1A03,** so you can go to the ARRL General License Manual, or the question pool itself, to see the actual questions and other answer choices that will be in the exam. If there is an FCC (Federal Communications Commission) **Part 97 rule** relating to the answer it is shown following the question number. The FCC regulation reference number like this, **T1A07 [97.3(a)(45)]**

All questions are shown with only the correct answer **in bold green text**, which in the author's view makes it easier when you see the other choices on your exam to identify the correct answer because you have not seen the wrong answers.

Additional information when deemed helpful has been added by the author ***(in italicized blue text)*** and illustrations for some of the questions to explain the answer or show calculations.

A copy of the ARRL General Class License Manual is not required. Everything you need to study for your license exam is in this syllabus. The author recommends if you want additional technical background that you acquire a copy of the ARRL Handbook (available from ARRL web site or other retailers and bookstores). The Handbook will cover your technical needs for all three licenses and will be a great reference after you are licensed. The current edition of the handbook costs approximately $70 (from the ARRL web site). A recent copy (within the last 10 years) will suffice if you find a used one. Used ones are usually available for less than $25.

While every effort was made to ensure the accuracy of the material herein, this material was prepared by an ordinary human being, and it is likely that a few typographical and other errors remain. The author welcomes corrections and he can be contacted at ad7fo@arrl.net

You are encouraged to check the author's web site www.ad7fo.com to insure you have the latest revision of this syllabus.

Requirements for Students attending my classes

1. You will need a printed or downloaded copy of this syllabus for study prior to the class. The Class will be taught directly from a PowerPoint version of this syllabus. This syllabus can be downloaded from www.ad7fo.com. All the possible questions in the exam are covered in this syllabus.

2. A personal copy of Part 97 of the FCC rules is recommended. A PDF version can be downloaded for free from the ARRL website at http://www.arrl.org/part-97-amateur-radio or purchased in printed form from the ARRL Web site or other sources. The FCC rules require that you to have access to a copy of the part 97 rules (printed copy available from the ARRL at https://home.arrl.org/action/Store/Product-Details/productId/114291 for about $8 or free online from the web).

3. You will need a basic scientific calculator that you are familiar with operating that is capable of normal math functions, square roots, trigonometry, and Base 10 Log functions (all basic scientific calculators have these functions). Not all these functions are needed for the General Exam but will be needed when you go for the Extra exam. A reasonably priced scientific calculator like the Texas Instruments TI30 is available from office supply stores if you do not already have one. **It is recommended you do not purchase a programmable calculator as they will not be allowed in the test session. Cell phone calculators are never allowed in test sessions.** The dollar Stores sell a scientific calculator that will work for the class.

4. As a Student you should have a desire to learn and to ask questions. If you do not understand something that is being taught, be sure you ask the instructor(s) during the class.

5. You must take and pass the General Class written exam (element 3)

- There are 35 questions on the exam. All questions are multiple choice (4 choices).
- Questions only come from the published Question Pool (all possible questions are covered in this syllabus).
- The number of possible questions for each topic area is fixed and shown for each question group in the test.
- You must have 26 correct answers to pass the exam (no more than 9 incorrect answers).
- Here are a few of the online practice sites with the real test questions and where you can take practice exams:

  https://www.aa9pw.com/amateur-radio-exam-practice
  http://www.arrl.org/exam-practice
  http://www.eham.net/exams
  http://www.qrz.com/hamtest
  http://www.hamexam.org
  http://www.hamstudy.org

6. You should read through this syllabus before the class. You are not expected to learn and understand everything you read, but by being familiar with what will be covered, you can identify those areas where you need to focus on and bring up questions during the class. Do not be intimidated. The material will be made easy to understand by your instructor(s). You can check with ham radio clubs in your area for local Hams (known as Elmer's) that can help you prepare.

How the 2023 Exam Questions and this syllabus are organized

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

G1A – General class control operator frequency privileges; primary and secondary allocations
G1B – Antenna structure limitations; good engineering and good amateur practice; beacon operation; prohibited transmissions; retransmitting radio signals
G1C – Transmitter power regulations; data emission standards; 60-meter operation requirements
G1D – Volunteer Examiners and Volunteer Examiner Coordinators; temporary identification; element credit; remote operation
G1E – Control categories; repeater regulations; third-party rules; ITU regions; automatically controlled digital station

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
G2B – Operating effectively; band plans; drills and emergencies; RACES operation
G2C – CW operating procedures and procedural signals; Q signals; full break-in
G2D – Volunteer Monitor Program; HF operations
G2E – Digital mode operating procedures

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

G3A – Sunspots and solar radiation; geomagnetic field and stability indices
G3B – Maximum Usable Frequency; Lowest Usable Frequency; short path and long path propagation; determining propagation conditions; ionospheric refraction
G3C – Ionospheric regions; critical angle and frequency; HF scatter; near vertical incidence skywave (NVIS)

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

G4A – Station configuration and operation
G4B – Tests and test equipment
G4C – Interference to consumer electronics; grounding and bonding
G4D – Speech processors; S meters; sideband operation near band edges
G4E – Mobile and portable HF stations; alternative energy source operation

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

G5A – Reactance; inductance; capacitance; impedance; impedance transformation; resonance
G5B – The decibel; current and voltage dividers; electrical power calculations; sine wave root-mean-square (RMS) values; PEP calculations
G5C – Resistors, capacitors, and inductors in series and parallel; transformers

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

G6A – Resistors; capacitors; inductors; rectifiers; solid-state diodes and transistors; vacuum tubes; batteries
G6B – Analog and digital integrated circuits (ICs); microwave ICs (MMICs); display devices; RF connectors; ferrite cores

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

G7A – Power supplies; schematic symbols
G7B – Digital circuits; amplifiers and oscillators
G7C – Transceiver design; filters; oscillators; digital signal processing (DSP)

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
G8B – Frequency changing; bandwidths of various modes; deviation; intermodulation
G8C – Digital emission modes

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
G9B – Basic dipole and monopole antennas
G9C – Directional antennas
G9D – Specialized antenna types and applications

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

G0A – RF safety principles, rules, and guidelines; routine station evaluation
G0B – Station safety: electrical shock, grounding, fusing, interlocks, and wiring; antenna and tower safety

ELECTRICAL AND ELECTRONIC BASICS

(Technical background for some of the exam questions)

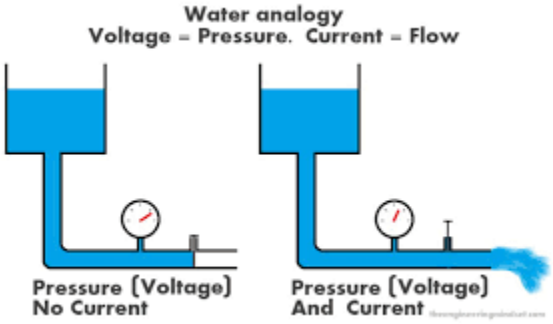
Metric system Basics for Ham Radio

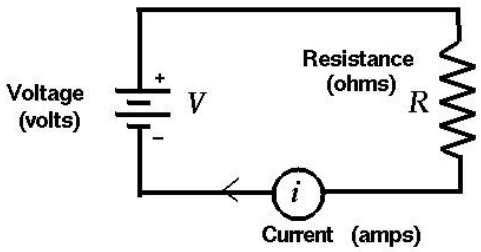
Giga XXXX = 1,000,000,000 (one thousand million) XXXX
Mega XXXX = 1,000,000 (one million) times XXXX
Kilo XXXX = 1,000 (one thousand) XXXX
Centi XXXX = 1/100 (one hundredth) XXXX
Milli XXXX = 1/1,000 (one thousandth) XXXX
Micro XXXX = 1/1,000,000 (one millionth) XXXX
Nano XXXX = 1/1,000,000,000 (one thousandth of a Micro) XXXX
Pico XXXX = 1/1,000,000,000,000 (one millionth of a millionth) XXXX

Example: XXXX is the value you are expressing such as Volts, Amperes, Ohms, Watts, etc. One Kilovolt would be 1,000 Volts, one megaohm would be 1,000,000 ohms

Voltage, Resistance and Current Flow:

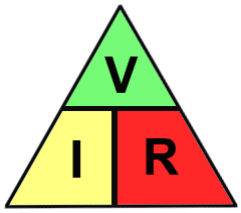
Everything we use in our amateur station requires a power source that delivers a specific **Voltage** and **Current**. *Voltage* is commonly referred to as ***Electro Motive Force*** *(EMF)* instead of volts. This is like the water pressure, the flow of electricity, is measured in ***amperes*** and is commonly represented by the letter **I.** Current is like the flow of water in the pipe. The amount of water flowing (**current**) would be limited by the diameter of the pipe **(resistance**) and the pressure (**Voltage/EMF**) exerted by the height of the water. In an electronic circuit the current flow would be limited by the EMF (***voltage)*** and the resistance to current flow **(resistor)** measured in ohms.





If we know the voltage and the resistance in a circuit, we can calculate the current that would be flowing using the following expression:

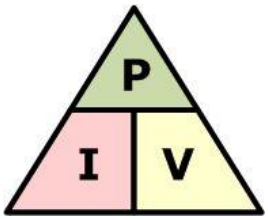
Current in amperes (I) is equal to the EMF in Volts (V) divided by the resistance in ohms (R).
I (amperes) = E (voltage) ÷ R (resistance)



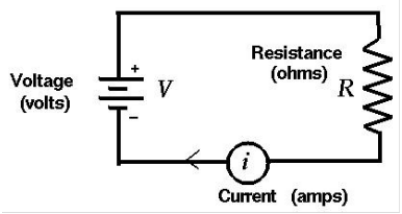
For example: if you have a 12-volt battery connected across a 6-ohm resistor the current flowing would be 2 amperes.

Current = V ÷ R or 12 volts ÷ 6 Ohms or Current = 2 amperes

Electrical Power:



Power is work done by electricity and is defined as the voltage across a circuit multiplied by the current flowing through the circuit.



Examples:
A circuit connected to a 120-volt power outlet that draws 10 amperes would be consuming 1200 watts of power.

Power = voltage times the current or Power = 120 x 10 or 1200 watts

A circuit powered by a 12-volt battery that draws 200 milliamperes (ma) would consume 2.4 watts.

Power = voltage times the current or Power = 12 x 0.20 or 2.4 watts

We have two kinds of commonly encountered sources of electric power:

The first source is Direct Current:

Direct Current (DC) is a voltage that has two terminals, one positive and one negative. Typically, DC power is available from batteries, accessory jacks in vehicles, and plug-in power supplies

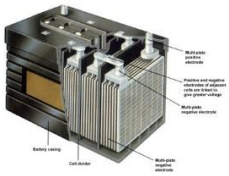
Commonly used batteries for amateur radio applications include the following:

Alkaline and Zinc Carbon cells that produce 1.5 V - available in AAA, AA, C, D cells. There is also a 9 Volt version with snap terminals. **These batteries are not rechargeable**.

Lithium batteries that produce 1.5 or 3 volts. A typical example would be AAA, AA and coin cells. **These batteries are not rechargeable**.

Nickel Cadmium (NICAD), Nickel Metal Hydride (NIMH) batteries that produce 1.2 volts, and are available in AAA, AA, C, D cells, and custom shapes. **These batteries are rechargeable.**

Flooded Lead Acid batteries that typically produce 12 volts. Examples are automotive batteries and deep cycle marine batteries. These contain a liquid electrolyte (sulfuric acid) and cannot be used only in an upright position and cannot be tipped over, laid on their side. **These batteries are rechargeable**. These batteries release Hydrogen gas while charging so ventilation is required to prevent explosive gas buildup. The automotive version is designed to produce a high current needed to drive a starting motor then be placed on a float charge



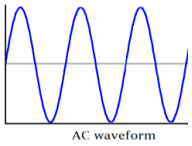
Marine lead Acid Batteries are flooded led acid batteries but are designed to produce a steady flow of current for a long time. A typical application would be a marine trolling motor.

Sealed Lead Acid batteries – Gel Cells and AGM (Absorbed Glass Mat) batteries that are available in 12-volt versions (other Voltages are available but for Amateur Radio the 12-volt version is the most commonly used). They are sealed and use a "gelled" electrolyte and they can be operated in any position. They have current ratings ranging from smaller ones with a 1 ampere hour rating up to 80 ampere hours and more. **These batteries are rechargeable.**

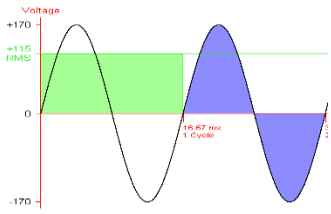
LiFePO4/LiFeMnPO4 Batteries: Lithium Iron Phosphate battery is a kind of lithium-ion rechargeable battery for high power applications, such as EV Car, power tools, and amateur radio. Thes batteries are capable of High discharge rate, rapid recharge, are lighter in weight, have no explosive gas release on recharge, and a long cycle life (>2,000 charge/discharge cycles). They maintain their output voltage throughout the discharge cycle better than most rechargeable batteries. They are excellent choice but are more expensive than other Batteries for Ham Radio applications.

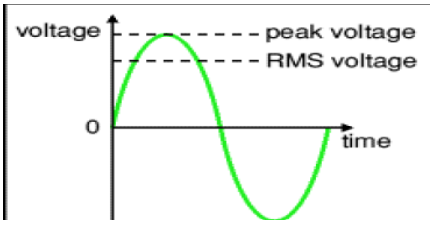
The Second source is Alternating Current

Alternating current is a voltage that alternates between equal positive and negative values. This is what is available from the common wall outlet in our homes.



The 120 Volts from the outlets in our home is the equivalent of a value that would provide the same heating effect (or work) as a DC voltage of the same value. voltage and is known as the RMS (Root Mean Square) value of the AC voltage. The heating effect of AC is less than the peak value because the voltage is continuously changing over the time for each cycle. The peak value of an AC RMS voltage is **1.414 times the RMS value**. Therefore, the peak voltage for a 120 Volts RMS coming from the outlet in our homes would be 1.414 times 120 volts or **169.68 volts Peak** or **339.36 volts peak to peak** (measured from the positive peak to the negative peak of the AC waveform).





For a pure AC sine wave the equivalent RMS value is 0.707 times the peak value.

Examples:

The peak voltage present in standard 120V RMS AC line power outlet is 1.414 x 120V or approx. 170 volts peak. The peak to peak (maximum negative to maximum positive peaks) would be two times the peak voltage or approx. 340 V Peak to Peak.

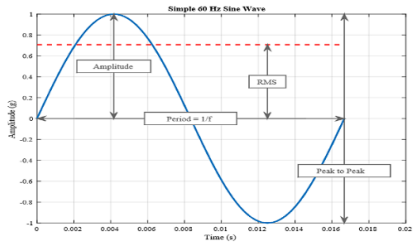
PP = 2x Peak or PP =2 x (120 x 1.414) or PP = 2 x 169.7 or PP = 339.4 Volts

An AC voltage that reads 65 volts on an RMS meter will have a peak to peak voltage of 184 Volts.

Peak to peak Voltage = 2 x RMS x 1.414 or PP = 2 x 65 x 1.414 or PP = 183.8 V PP

FREQUENCY: If we start at the first positive zero crossing to the next positive zero crossing is one cycle of our sine wave. The time it takes for one cycle of a sine wave is the "Period" of the sine wave. A 100 Hz sine wave has a period of 0.01 Seconds (or 10 milliseconds).

Frequency is the number of times that an event happens in one second of time. Shown below is a single cycle of a sine wave, as it would be displayed on an oscilloscope. To determine its frequency, you would divide the time in seconds for one cycle into 1.00.



Examples:

What is the frequency of a sine wave with a 10 ms (millisecond) period for one cycle?

F = 1 ÷ time or F = 1 ÷ 0.010 or F = 100Hz

What is the frequency of a sine wave with a 1 µs (microsecond) period for one cycle?

F = 1 ÷ time or F = 1 ÷ 0.000001 or F = 1,000,000 Hz or 1 MHz

What is the frequency of a sine wave with a 16.666 millisecond period for one cycle?

F = 1 ÷ time or F = 1 ÷ 0.0166 or F = 60.00 Hz

Wavelength:

Wavelength is the distance a wave will travel in free space during one cycle usually expressed in meters. Light travels at a velocity of ***approximately*** 300 million meters per second ***(the actual speed of light is 299,792,458 meters per second)*** in free space. Wavelength is important measure in amateur radio.

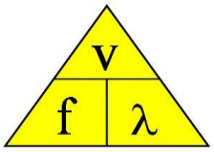
We frequently refer to the frequency bands in amateur radio by their approximate wavelength in meters. For instance, 146 Megahertz (MHz) would be the 2-meter band. Wavelength is easily calculated as using the following equation:

Wavelength equals the speed of light (in meters per second) divided by the frequency in Hertz Hz
Wavelength in meters = 300,000,000 ÷ frequency in Hertz) or to simplify
Wavelength in meters = 300 ÷ Frequency (in megahertz)

For the 146 MHz example above this would be:

300,000,000 divided by 146,000,000; or since both values are in millions simply,
300 ÷ 146 or 2.054 meters

This Triangle is an easy way to understand the relationship of wavelength, wave speed and frequency.



λ = wavelength
v = wave speed
f = frequency

This is an important relationship to remember since there are many questions in the exam relating to wavelength for a specific frequency or the frequency for a given wavelength.

In amateur radio we frequently refer to our frequencies in terms of approximate wavelength. Since we frequently operate in the megahertz band, we can simplify our conversion to wavelength by dividing the frequency in megahertz (MHz) into 300.
For example:

A 146 MHz signal would be in the 2-meter band --- 300 ÷ 146 = 2.054-meters
A 4.0 MHz signal would be in the 75-meter band --- 300 ÷ 4 = 75-meters

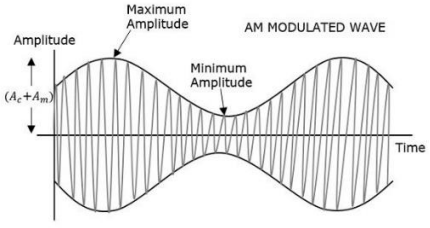
A frequency of 1 MHz (1,000,000 Hertz) which is in the middle of the AM broadcast band will travel 300 meters in one complete cycle.

300,000,000 ÷ 1,000,000 or 300 ÷ 1 or 300 meters

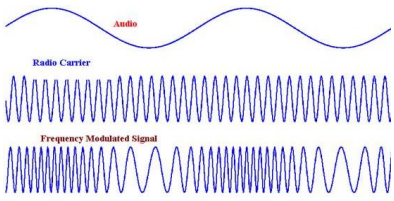
RF Signals and Modulation

Radio frequencies are simply sine waves like we see coming out of the outlet at home except at a much higher frequency (rate). Radio signals in the AM Broadcast band are operating from 500,000 hertz to 1,700,000 Hertz. This frequency range can be expressed in kilohertz (thousands of hertz as 500 KHz to 1,700 KHz), or in megahertz (millions of hertz) as 0.500 MHz to 1.700 MHz

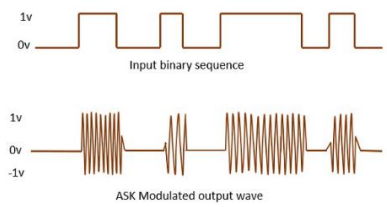
The frequency of a signal is just the carrier frequency, that is the frequency with no information applied. When we add voice or data to the carrier we are "modulating" or adding information. Simple modulation can be accomplished by varying the frequency of the carrier (Frequency Modulation or FM) or varying the amplitude of the carrier amplitude (Amplitude Modulation or AM).



Amplitude Modulation (AM)

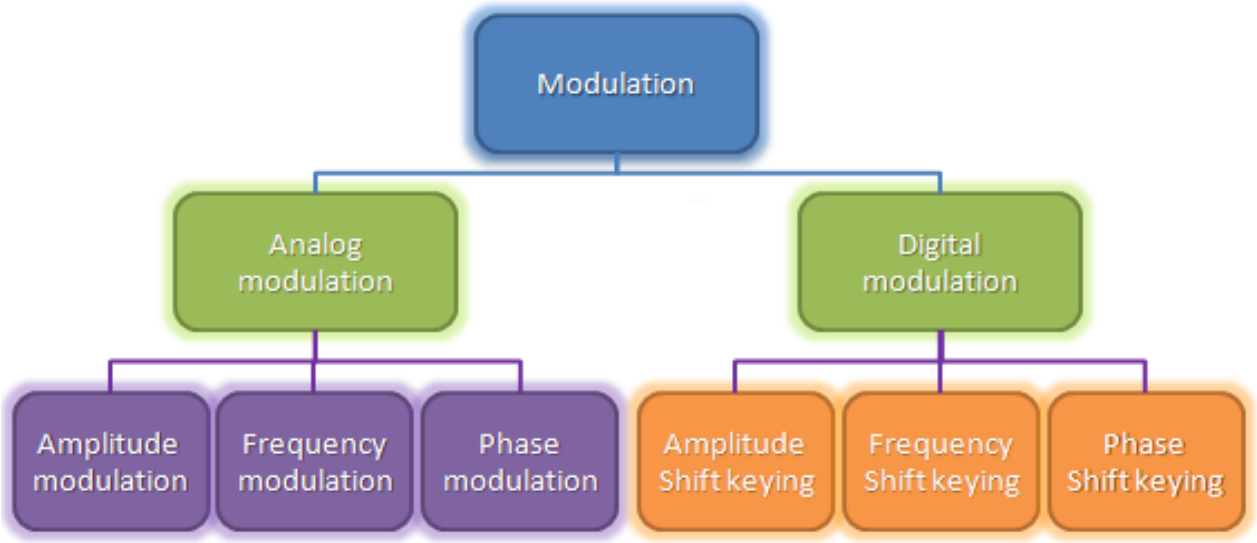


Frequency Modulation (FM)



Digital Modulation

There are many other forms of modulation other than simple amplitude and frequency modulation used in Amateur Radio here are a few:



US Amateur Radio Bands

US AMATEUR POWER LIMITS

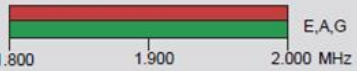
FCC 97.313 An amateur station must use the minimum transmitter power necessary to carry out the desired communications. (b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.

Effective Date March 5, 2012

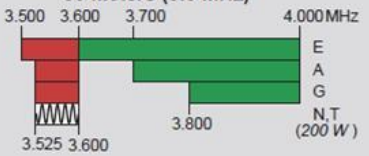
Published by:
ARRL The national association for AMATEUR RADIO®
www.arrl.org
225 Main Street, Newington, CT USA 06111-1494

160 Meters (1.8 MHz)

Avoid interference to radiolocation operations from 1.900 to 2.000 MHz



80 Meters (3.5 MHz)



60 Meters (5.3 MHz)

General, Advanced, and Amateur Extra licensees may operate on these five channels on a secondary basis with a maximum effective radiated output of 100 W PEP. Permitted operating modes include upper sideband voice (USB), CW, RTTY, PSK31 and other digital modes such as PACTOR III as defined by the FCC Report and Order of November 18, 2011. USB is limited to 2.8 kHz centered on 5332, 5348, 5358.5, 5373 and 5405 kHz. CW and digital emissions must be centered 1.5 kHz above the channel frequencies indicated above. Only one signal at a time is permitted on any channel.

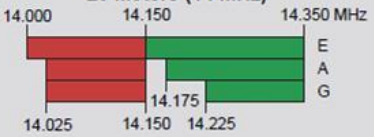
40 Meters (7 MHz)

Phone and Image modes are permitted between 7.075 and 7.100 MHz for FCC licensed stations in ITU Regions 1 and 3 and by FCC licensed stations in ITU Region 2 West of 130 degrees West longitude or South of 20 degrees North latitude. See Sections 97.305(c) and 97.307(f)(11).
Novice and Technician licensees outside ITU Region 2 may use CW only between 7.025 and 7.075 MHz and between 7.100 and 7.125 MHz. 7.200 to 7.300 MHz is not available outside ITU Region 2. See Section 97.301(e). These exemptions do not apply to stations in the continental US.

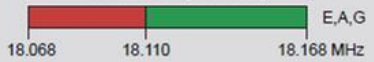
30 Meters (10.1 MHz)

Avoid interference to fixed services outside the US.

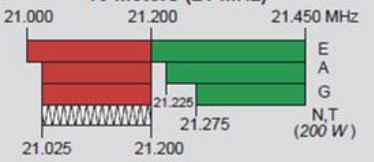
20 Meters (14 MHz)



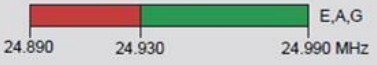
17 Meters (18 MHz)



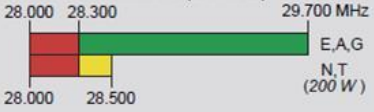
15 Meters (21 MHz)



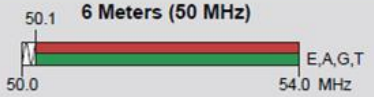
12 Meters (24 MHz)



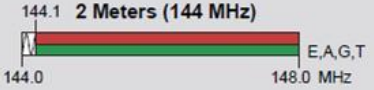
10 Meters (28 MHz)



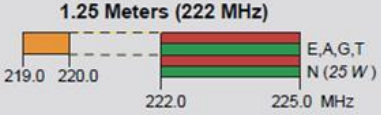
6 Meters (50 MHz)



2 Meters (144 MHz)

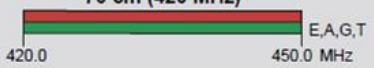


1.25 Meters (222 MHz)



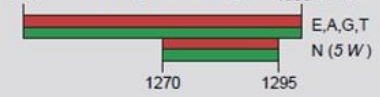
*Geographical and power restrictions may apply to all bands above 420 MHz. See *The ARRL Operating Manual* for information about your area.

70 cm (420 MHz)*



33 cm (902 MHz)*

23 cm (1240 MHz)*



All licensees except Novices are authorized all modes on the following frequencies:

2300-2310 MHz	10.0-10.5 GHz *	122.25-123.0 GHz
2390-2450 MHz	24.0-24.25 GHz	134-141 GHz
3300-3500 MHz	47.0-47.2 GHz	241-250 GHz
5650-5925 MHz	76.0-81.0 GHz	All above 275 GHz

* No pulse emissions

KEY

Note:
CW operation is permitted throughout all amateur bands.

MCW is authorized above 50.1 MHz, except for 144.0-144.1 and 219-220 MHz.

Test transmissions are authorized above 51 MHz, except for 219-220 MHz

- = RTTY and data
- = phone and image
- = CW *only*
- = SSB phone
- = USB phone, CW, RTTY, and data
- = Fixed digital message forwarding systems *only*

E = Amateur Extra
A = Advanced
G = General
T = Technician
N = Novice

See *ARRLWeb at www.arrl.org* for detailed band plans.

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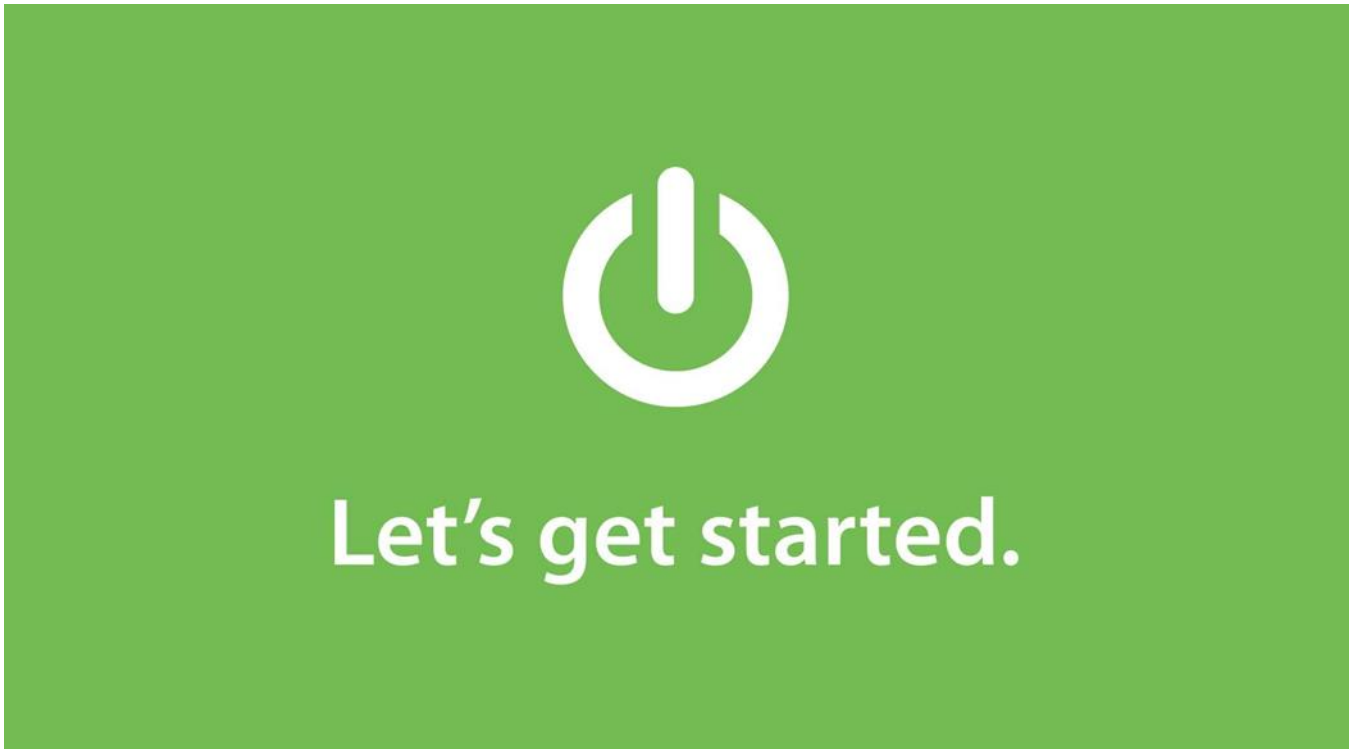
 rev. 4/12/2012

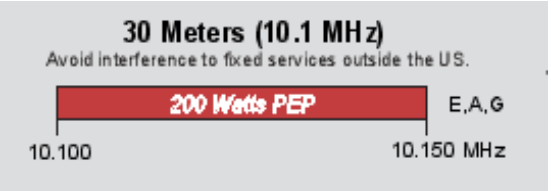

Let's get started.

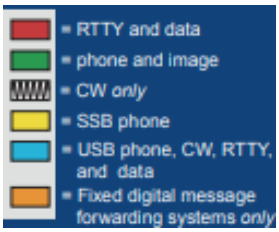
SUBELEMENT G1 – COMMISSION'S RULES [5 Exam Questions – 5 Groups]

G1A – General class control operator frequency privileges; primary and secondary allocations

G1A01 [97.301(d)]
On which HF and/or MF amateur bands are there portions where General class licensees cannot transmit
80 meters, 40 meters, 20 meters, and 15 meters
See ARRL Band Plan

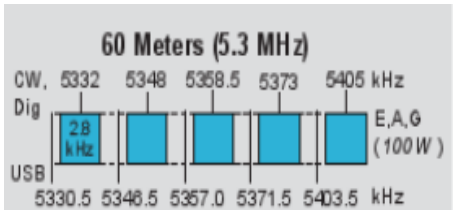
G1A02 [97.305]
On which of the following bands is phone operation prohibited? **30 meters**
See ARRL Band Plan



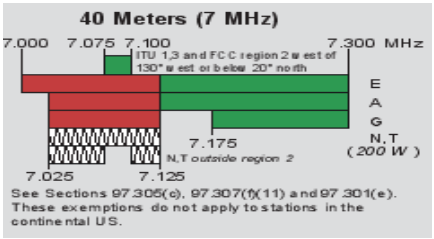


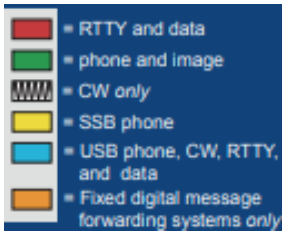
G1A03 [97.305]
On which of the following bands is image transmission prohibited? **30 meters**
See ARRL Band Plan

G1A04 [97.303(h)]
Which of the following amateur bands is restricted to communication only on specific channels, rather than frequency ranges? **60 meters**



G1A05 [97.301(d)]
On which of the following frequencies are General class licensees prohibited from operating as control operator? **7.125 MHz to 7.175 MHz**

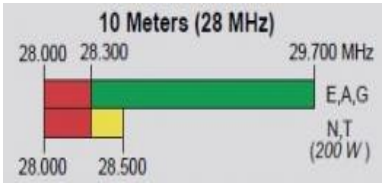


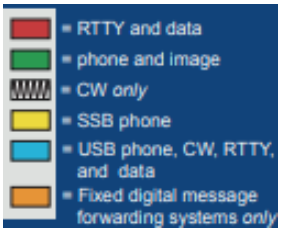


See ARRL Band Plan. This portion of the 40 meter band is for operators with an advanced or Extra class license

G1A06 [97.303]
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

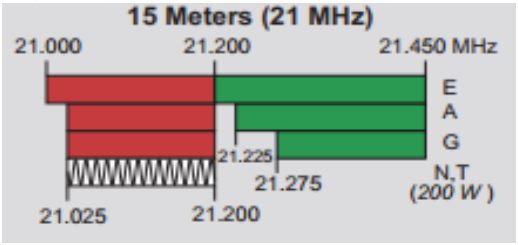
G1A07 [97.305(a)]
On which amateur frequencies in the 10-meter band may stations with a General class control operator transmit CW emissions? **The entire band**





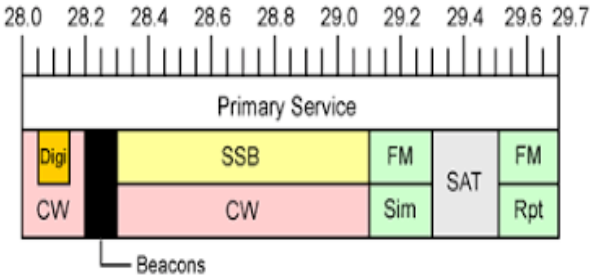
G1A08 [97.301(b)]
Which HF bands have segments exclusively allocated to Amateur Extra licensees?
80 meters, 40 meters, 20 meters, and 15 meters
See ARRL Band Plan

G1A09 [97.301(d)]
Which of the following frequencies is within the General class portion of the 15-meter band? **21,300 kHz *(or 21.3 MHz)***



See ARRL Band Plan

G1A10 [97.205(b)]
What portion of the 10-meter band is available for repeater use? **The portion above 29.5 MHz**



G1A11 [97.301]
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**
See Band Plan

G81B – Antenna structure limitations; good engineering and good amateur practice; beacon operation; prohibited transmissions; retransmitting radio signals.

G1B01 [97.15(a)]
What is the maximum height above ground for an antenna structure near a public use airport without requiring notification to the FAA and registration with the FCC? **200 feet**

G1B02 [97.203(b)]
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

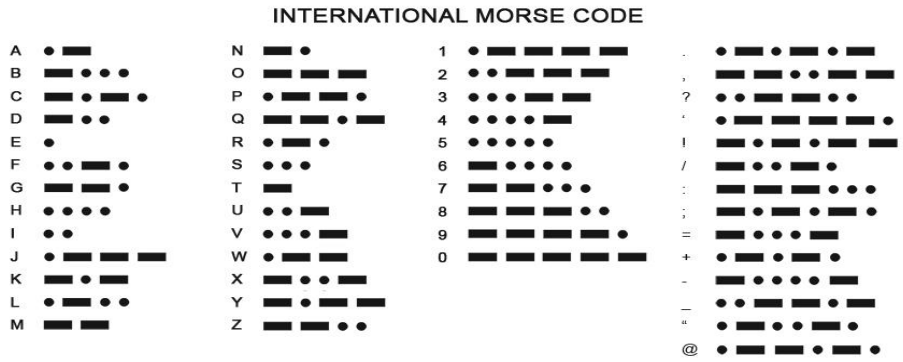
An amateur radio propagation beacon is a radio beacon, whose purpose is the investigation of the propagation of radio signals. Most radio propagation beacons use amateur radio frequencies. They can be found on LF, MF, HF, VHF, UHF, and microwave frequencies.

The International Amateur Radio Union (IARU) and its member societies coordinate beacons established by radio amateurs

G1B03 97.3(a)(9)]
Which of the following is a purpose of a beacon station as identified in the FCC rules?
Observation of propagation and reception

G1B04 [97.113(c)]
Which of the following transmissions is permitted for all amateur stations?
Occasional retransmission of weather and propagation forecast information from US government stations.

G1B05 [97.111((5)(b)]
Which of the following one-way transmissions are permitted?
Transmissions to assist with learning the International Morse code.



G1B06 [97.15(b), PRB-1, 101 FCC 2d 952 (1985)]
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
If you are living in a neighborhood with an agreed to HOA (Home Owners Association) rule it may supersede this and restrict what antennas, if any may be deployed.

G1B07 [97.113(a)(4)]
What are the restrictions on the use of abbreviations or procedural signals in amateur services?
They may be used if they do not obscure the meaning of a message.

G1B08 [97.111(a)(1)]
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

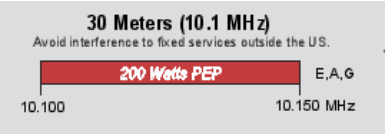
G1B09 [97.203(d)]
On what HF frequencies are automatically controlled beacons permitted? **28.20 MHz to 28.30 MHz**
See graphic for G1A10

G1B10 [97.203(c)]
What is the power limit for beacon stations? **100 watts PEP output**

G1B11 [97.101(a)]
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**

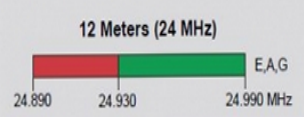
G1C – Transmitter power regulations; data emission standards; 60-meter operation requirements

G1C01 [97.313(c)(1)]
What is the maximum transmitting power an amateur station may use on 10.140 MHz? **200 watts PEP output**



See ARRL Band Plan

G1C02 [97.313]
What is the maximum transmitting power an amateur station may use on the 12-meter band? **1500 watts PEP output**



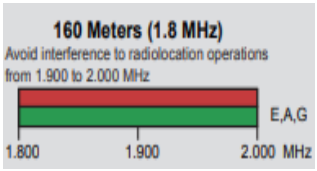
See ARRL Band Plan

G1C03 [97.303(h)(1)]
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**
See Band Plan and G1A04 answer

G1C04 [97.303(i)]
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.

G1C05 [97.313]
What is the limit for transmitter power on the 28 MHz band for a General Class control operator?
1500 watts PEP output
See Band Plan

G1C06 [97.313]
What is the limit for transmitter power on the 1.8 MHz band? **1500 watts PEP output**



See Band Plan

G1C07 [97.309(a)(4)]
What must be done before using a new digital protocol on the air?
Publicly document the technical characteristics of the protocol

G1C08 [97.307(f)(3)]
What is the maximum symbol rate permitted for RTTY or data emission transmitted at frequencies below 28 MHz? **300 baud**

Maximum Symbol rates (baud)

Band	***Max Symbol Rate***	***Signal Bandwidth***
Below 10 Meters	***300 baud***	***1 KHz***
10 Meters	***1200 baud***	***1 KHz***
6 & 2 meters	***19.6 K baud***	***20 KHz***
1.25m to 70 cm	***56 K baud***	***100 KHz***
23 cm and above	***no limit***	***no limit***

Bit rate vs Baud rate
Bit – a unit of information
Baud - a unit of signaling speed
Bit rate (data rate) – Number of bits transmitted in a second
Baud rate (symbol rate) – Number of symbols transmitted per second

G1C09 [97.313(i)]
What is the maximum power limit on the 60-meter band? **ERP of 100 watts PEP with respect to a dipole**
ERP is effective radiated power which is the sum of the transmitter output power, Transmission line loss and antenna gain.
For a 500 watt peak output SSB transmitter, with a 2 dB transmission line loss and a 5 dB antenna gain, the ERP would be 1,000 watts.

ERP = 500 watts -2dB + 5 dB or ERP= 500 watts + 3 dB or ERP = 500 x 2 or ERP = 1,000 watts

G1C10 [97.305(c) and 97.307(f)(4)]
What is the maximum symbol rate permitted for RTTY or data emission transmissions on the 10-meter band?
1200 baud
See explanation for G1C08

G1C11 [97.313]
What measurement is specified by FCC rules that regulate maximum power? **PEP output from the transmitter**
PEP is the Peak Envelope Power of your transmission,

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

G1D01 [97.501, 97.505(a)]
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
This assumes the renewal takes place within the two year grace period.

G1D02 [97.509(b)(3)(i)]
What license examinations may you administer as an accredited Volunteer Examiner holding a General class operator license? **Technician only**

G1D03 [97.9(b)]
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

G1D04 [97.509(3)(i)(c)]
Who must observe the administration of a Technician class license examination?
At least three Volunteer Examiners of General class or higher

G1D05 [97.7]
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**

G1D06 [97.119(f)(2)]
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**

G1D07 [97.509(b)(1)]
Volunteer Examiners are accredited by what organization? **A Volunteer Examiner Coordinator**

G1D08 [97.509(b)(3)]
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

G1D09 [97.9(b)]
How long is a Certificate of Successful Completion of Examination (CSCE) valid for exam element credit?
365 days

G1D10 [97.509(b)(2)]
What is the minimum age that one must be to qualify as an accredited Volunteer Examiner? **18 years**

G1D11 [97.505]
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.
Element 2 is the technician license exam.

G1D12 [97.507]
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.

G1E01 [97.115(b)(2)]
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**

G1E02 [97.205(b)]
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**

G1E03 [97.221]
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

G1E04 [97.13(b), 97.303, 97.311(b)]
Which of the following conditions require a licensed amateur radio operator to take specific steps to avoid harmful interference to other users or facilities?

8A. When operating within one mile of an FCC Monitoring Station
B. When using a band where the Amateur Service is secondary
C. When a station is transmitting spread spectrum emissions
D. All these choices are correct

G1E05 [97.115(a)(2), 97.117]
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

G1E06 [97.301, ITU Radio Regulations]
The frequency allocations of which ITU region apply to radio amateurs operating in North and South America?
Region 2

G1E07 [97.111]
In what part of the 2.4 GHz band may an amateur station communicate with non-licensed Wi-Fi stations?
No part

G1E08 [97.313(j)]
What is the maximum PEP output allowed for spread spectrum transmissions? **10 watts**
A spread spectrum communications system is one that is built upon the principle of transmitting information signals over a much wider bandwidth than is strictly necessary for transferring the information. By transmitting over a larger bandwidth, robustness against external narrowband interference is increased since the wider the bandwidth of any transmitted signal the lower will be the relative influence of interference over a small part of the bandwidth. A variety of spread spectrum techniques exist, such as Frequency Hopping Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS).

G1E09 [97.115]
Under what circumstances are messages that are sent via digital modes exempt from Part 97 third-party rules that apply to other modes of communication? **Under no circumstances**

G1E10 [97.101]
Why should an amateur operator normally avoid transmitting on 14.100, 18.110, 21.150, 24. 930 and 28.200
A system of propagation beacon stations operates on those frequencies

G1E11 [97.221, 97.305]
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

G1E12 [97.115]
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

G2A01
Which mode is most commonly used for voice communications on frequencies of 14 MHz or higher?
Upper sideband
Generally, Upper Sideband (USB) is used for frequencies above 10 MHz and Lower Sideband (LSB) is used for frequencies below 10 MHz.

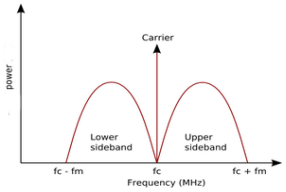
G2A02
Which mode is most commonly used for voice communications on the 160-, 75-, and 40-meter bands?
Lower sideband
These frequencies are below 10 MHz.

G2A03
Which mode is most commonly used for SSB voice communications in the VHF and UHF bands?
Upper sideband
These frequencies are above 10 MHz.

G2A04
Which mode is most commonly used for voice communications on the 17- and 12-meter bands?
Upper sideband
These frequencies are above 10 MHz.

G2A05
Which mode of voice communication is most commonly used on the HF amateur bands? **Single sideband**
Single-sideband modulation (SSB) or single-sideband suppressed-carrier modulation (SSB-SC) is a type of modulation used to transmit information, such as an audio signal by an RF carrier. As a form of amplitude modulation (AM), it uses transmitter power and bandwidth more efficiently. Amplitude modulation produces an output signal the bandwidth of which is twice the maximum frequency of the original baseband signal. Single-sideband modulation avoids this bandwidth increase, and the power wasted on a carrier, at the cost of increased device complexity and more difficult tuning at the receiver.

G2A06
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**
In single sideband transmission we remove one of the sidebands (both the upper and lower sidebands contain the same information) and the carrier (which is not required once the sidebands have been generated) from a normal double sideband AM signal.



G2A07
Which of the following statements is true of single sideband (SSB)?
Only one sideband is transmitted; the other sideband and carrier are suppressed

G2A08
What is the recommended way to break into a phone contact? **Say your call sign once**

G2A09
Why do most amateur stations use lower sideband on the 160-, 75-, and 40-meter bands?
It is commonly accepted amateur practice.
It is generally agreed to use the lower sideband for frequencies below 10 MHz. All three of these bands are below 10 MHz.

G2A10
Which of the following statements is true of VOX operation versus PTT operation?
It allows "hands free" operation
VOX stands for Voice Operated transmit. Once a voice signal is sensed at the microphone; the radio switches into the transmit mode.

G2A11
Generally, who should respond to a station in the contiguous United states calling "CQ DX"?
Any stations outside the lower 48 states

G2A12
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.

G2B01 [97.101(b), (c)]
Which of the following is true concerning access to frequencies?
Except during emergencies, no amateur station has priority access to any frequency

G2B02
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**

G2B03
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

G2B04
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**

G2B05
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**

G2B06
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
See list of common Q signals in the Appendix

G2B07
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**

G2B08
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**

G2B09 [97.407(a)]
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**

G2B10
Which of the following is good amateur practice for net management?
Have a backup frequency in case of interference or poor conditions

G2B11 [97.407(d)(4)]
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

G2C01
Which of the following describes full break-in CW operation (QSK)? **Transmitting stations can receive between code characters and elements**

G2C02
What should you do if a CW station sends "QRS?" **Send slower**
See list of common Q signals in the Appendix

G2C03
What does it mean when a CW operator sends "KN" at the end of a transmission?
Listening only for a specific station or stations

G2C04
What does the Q signal "QRL?" mean? **"Are you busy?" or "Is this frequency in use?"**
See list of common Q signals in the Appendix

G2C05
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

G2C06
What does the term “zero beat” mean in CW operation?
Matching the transmit frequency to the frequency of a received signal

G2C07
When sending CW, what does a “C” mean when added to the RST report? **Chirpy or unstable signal**
The R stands for "Readability". Readability is a qualitative assessment of how easy or difficult it is to correctly copy the information being sent during the transmission. In a morse code transmission, readability refers to how easy or difficult it is to distinguish each of the characters in the text of the message being sent; in a voice transmission, readability refers to how easy or difficult it is for each spoken word to be understood correctly. Readability is measured on a scale of 1 to 5.

1. ***Unreadable***
2. ***Barely readable, occasional words distinguishable***
3. ***Readable with considerable difficulty***
4. ***Readable with practically no difficulty***
5. ***Perfectly readable***

G2C08
What prosign is sent to indicate the end of a formal message when using CW? **AR**

G2C09
What does the Q signal “QSL” mean? **I have received and understood.**
See list of common Q signals in the Appendix

G2C10
What does the Q signal “QRN” mean? **I am troubled by static**
See list of common Q signals in the Appendix

G2C11
What does the Q signal “QRV” mean? **I am ready to receive**
See list of common Q signals in the Appendix

G2D – Volunteer Monitor Program; HF operations

G2D01
What is the Volunteer Monitor Program?
Amateur volunteers who are formally enlisted to monitor the airwaves for rules violations
Volunteer monitors are accredited by the ARRL Volunteer Monitoring Program administrator.

G2D02
Which of the following are objectives of the Volunteer Monitor Program?
To encourage amateur radio operators to self-regulate and comply with the rules

G2D03
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

G2D04
Which of the following describes an azimuthal projection map?
A map that shows true bearings and distances from a specific location

G2D05
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

G2D06
How is a directional antenna pointed when making a "long-path" contact with another station?
180 degrees from the station's short-path heading

G2D07
Which of the following are examples of the NATO Phonetic Alphabet? **Alpha, Bravo, Charlie, Delta**

NATO Phonetic Alphabet

A	Alpha	N	November
B	Bravo	O	Oscar
C	Charlie	P	Papa
D	Delta	Q	Quebec
E	Echo	R	Romeo
F	Foxtrot	S	Sierra
G	Golf	T	Tango
H	Hotel	U	Uniform
I	India	V	Victor
J	Juliett	W	Whiskey
K	Kilo	X	X-ray
L	Lima	Y	Yankee
M	Mike	Z	Zulu

G2D08
Why do many amateurs keep a station log?
To help with a reply if the FCC requests information about your station

G2D09
Which of the following is required when participating in a contest on HF frequencies?
Identify your station according to normal FCC regulations

G2D10
What is QRP operation? **Low-power transmit operation**

G2D11
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

G2E01
Which mode is normally used when sending RTTY signals via AFSK with an SSB transmitter? **LSB**
RTTY is Radio Teletype, AFSK is Audio Shift Keying, SSB is single sideband and LSB is lower sideband.

G2E02
What is VARA? **A digital protocol used with Winlink**

G2E03
What symptoms may result from other signals interfering with a PACTOR or VARA transmission?
A. Frequent retries or timeouts.
B. Long pauses in message transmission.
C. Failure to establish a connection between stations.
D. All these choices are correct

G2E04
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**

G2E05
What is the standard sideband for JT65, JT9, FT4, or FT8 digital signal when using AFSK? **USB**
This is a protocol that does not follow the normal above or below 10 MHz rule.

G2E06
What is the most common frequency shift for RTTY emissions in the amateur HF bands? **170 Hz**

G2E07
Which of the following is required when using FT8? **Computer time accurate to within approximately 1 second**

G2E08
In what segment of the 20-meter band are most digital mode operations commonly found?
Between 14.070 MHz and 14.100 MHz

G2E09
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

G2E10
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

G2E11
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

G2E12
Which of the following describes Winlink?
A. An amateur radio wireless network to send and receive email on the internet.
B. A form of Packet Radio
C. A wireless network capable of both VHF and HF band operation
D. All of the above
***Winlink, also known as Winlink 2000 Network is a worldwide radio message system that uses Winlink Global Radio Email®. It* is a network of amateur radio and authorized government stations that provide worldwide radio email using radio pathways where the internet is not present. The system is built, operated, and administered entirely by licensed "Ham" volunteers. It supports email with attachments, position reporting, weather, and information bulletins, and is well-known for its role in interoperable emergency and disaster relief communications. It is capable of operating completely without the internet--automatically--using smart-network radio relays.**

G2E13
What is another name for a Winlink Remote Message Server? **Gateway**

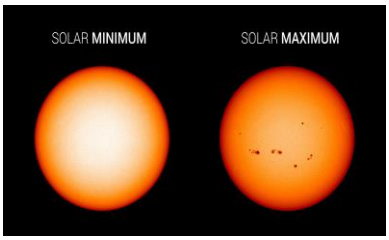
G2E14
What could be wrong if you cannot decode an RTTY or other FSK signal even though it is apparently tuned in properly?
A. The mark and space frequencies may be reversed.
B. You may have selected the wrong baud rate.
C. You may be listening on the wrong sideband.
D. All these choices are correct

G2E15
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

G3A01
How does a higher sunspot number affect HF propagation?
Higher sunspot numbers generally indicate a greater probability of good propagation at higher frequencies

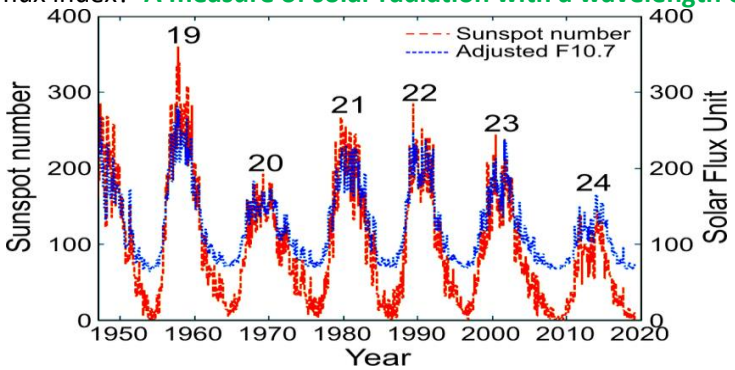


G3A02
What effect does a sudden ionospheric disturbance have on the daytime ionospheric propagation?
It disrupts signals on lower frequencies more than those on higher frequencies.

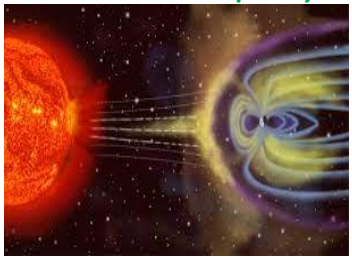
G3A03
Approximately how long does it take the increased ultraviolet and X-ray radiation from a solar flare to affect radio propagation on Earth? **8 minutes**

G3A04
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**

G3A05
What is the solar flux index? **A measure of solar radiation with a wavelength of 10.7 centimeters**



G3A06
What is a geomagnetic storm? **A temporary disturbance in Earth's geomagnetic field**



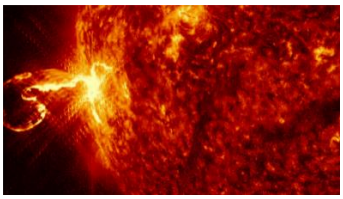
G3A07
At what point in the solar cycle does the 20-meter band usually support worldwide propagation during daylight hours? **At any point**

G3A08
How can a geomagnetic storm affect HF propagation? **Degrade high-latitude HF propagation**

G3A09
How can high geomagnetic activity benefit radio communications?
Creates auroras that can reflect VHF signals.

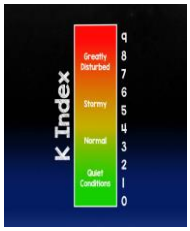
G3A10
What causes HF propagation conditions to vary periodically in a 26- to 28-day cycle?
Rotation of the Sun's surface layers around its axis

G3A11
How long does it take a coronal mass ejection to affect radio propagation on Earth? **15 hours to several days**
Coronal mass ejections (CMEs) are huge bubbles of coronal plasma threaded by intense magnetic field lines that are ejected from the sun over the course of several hours. CMEs often look like huge, twisted rope, which scientists call "flux rope."

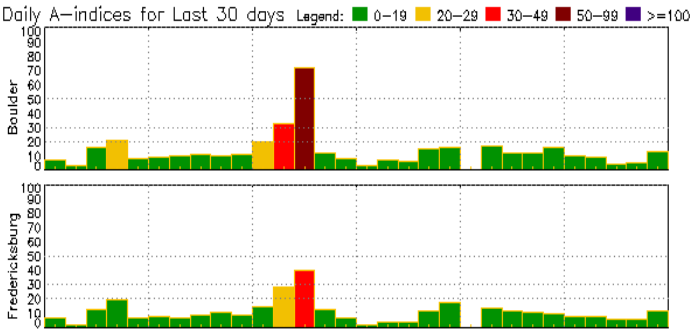


G3A12

What does the K-index measure? **The short-term stability of Earth's geomagnetic field**
Solar indices are a measure of activity on the sun. These indices can be used by amateur radio operators to get and sense of how radio signals will propagate globally and when to expect radio blackouts. Sites like Solar Harm give a good insight into the sun's current activity. The solar cycle is a roughly 11-year periodic change in the sun's sunspot activity, measured by the variation in the number of sunspots observed. The sun just ended its 24th solar cycle in 2020 and is currently in Solar Cycle 25.



G3A13
What does the A-index measure? **The long-term stability of Earth's geomagnetic field**



G3A14
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.

G3B01
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**

G3B02
What factors affect the MUF?
A. Path distance and location
B. Time of day and season
C. Solar radiation and ionospheric disturbances
D. All these choices are correct

G3B03
Which frequency will have the least attenuation for long-distance skip propagation? **Just below the MUF**
MUF is the Maximum Useable Frequency. Frequencies above the MUF will not be refracted back to earth.

G3B04
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

G3B05
How does the ionosphere affect radio waves with frequencies below the MUF and above the LUF?
They are refracted back to Earth

G3B06
What usually happens to radio waves with frequencies below the LUF? **They are attenuated before reaching the destination**

G3B07
What does LUF stand for? **The Lowest Usable Frequency for communications between two specific points**
Frequencies below the LUF will not be refracted back to earth.

G3B08
What does MUF stand for? **The Maximum Usable Frequency for communications between two points**

G3B09
What is the approximate maximum distance along the Earth's surface normally covered in one hop using the F2 region? **2,500 miles**

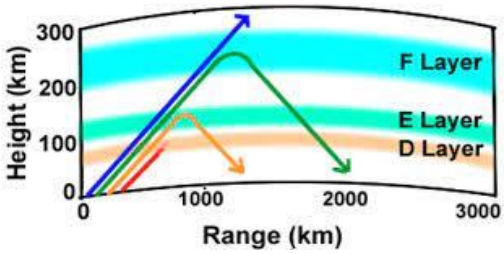
G3B10
What is the approximate maximum distance along the Earth's surface normally covered in one hop using the E region? **1,200 miles**
The E region is lower than the F regions.

G3B11
What happens to HF propagation when the LUF exceeds the MUF?
Propagation via ordinary skywave communications is not possible over that path

G3B12
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)

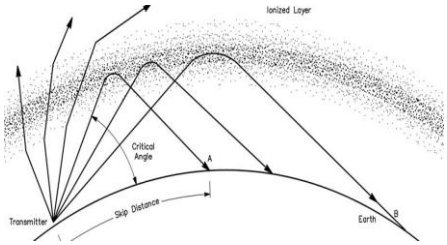
G3C01
Which ionospheric region is closest to the surface of Earth? **The D region**



G3C02
What is meant by the term "critical frequency" at a given incidence angle?
The highest frequency which is refracted back to Earth
Critical frequency is the highest magnitude of frequency above which the waves penetrate the ionosphere and below which the waves are reflected back from the ionosphere. It is denoted by "f_c". Its value is not fixed and it depends upon the electron density of the ionosphere.

G3C03
Why is skip propagation via the F2 region longer than that via the other ionospheric regions?
Because it is the highest

G3C04
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.



G3C05
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.

G3C06
What is a characteristic of HF scatter? **Signals have a fluttering sound.**

G3C07
What makes HF scatter signals often sound distorted?
Energy is scattered into the skip zone through several different paths

G3C08
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.

G3C09
What type of propagation allows signals to be heard in the transmitting station’s skip zone? **Scatter**

G3C10
What is near vertical incidence skywave (NVIS) propagation?
Short distance MF or HF propagation at high elevation angles
Near vertical incidence skywave, or NVIS, is a skywave radio-wave propagation path that provides usable signals in the medium distances range — usually 0–400 miles. It is used for military and paramilitary communications, broadcasting and by radio amateurs for nearby contacts circumventing line-of-sight barriers. The radio waves travel near-vertically upwards into the ionosphere, where they are refracted back down and can be received within a circular region up to 400 miles from the transmitter.

G3C11
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]

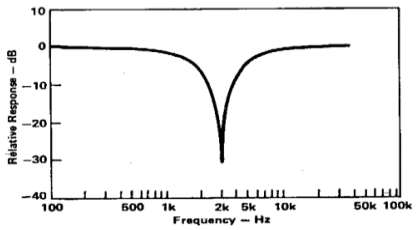
G4A – Station configuration and operation

G4A01

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

To reduce interference from carriers in the receiver passband

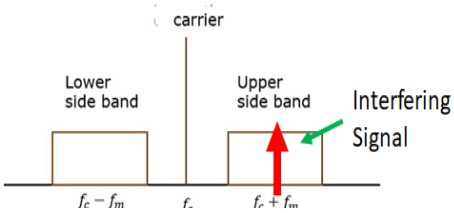
Notch filters are band-reject filters or stop band filters designed to provide maximum attenuation or rejection to a particular Frequency or range of frequencies. A band-reject filter with a narrow stop band is usually known as a notch filter.



G4A02

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

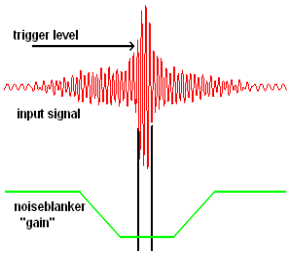
It may be possible to reduce or eliminate interference from other signals.



G4A03

How does a noise blanker work? **By reducing receiver gain during a noise pulse**

A Noise Blanker samples an off-the-air signal at a very wide bandwidth. If a noise pulse is found, it briefly turns off the audio to the receiver for the duration of the pulse and passes the remainder of the signal.



G4A04

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

A pronounced dip

When the output LC (Inductor Capacitor) circuit is in resonance power in the inductor and capacitor transfer energy back and forth reducing the input current.

G4A05

Why is automatic level control (ALC) used with an RF power amplifier? **To prevent excessive drive**

G4A06
What is the purpose of an antenna tuner? **Increase power transfer from the transmitter to the feed line.**
An antenna tuner allows the transmitter to Detect (see) a matched load and therefore deliver its full output power to a load/antenna system that is not matched.

G4A07
What happens as a receiver's noise reduction control level is increased?
Received signals may become distorted.

G4A08
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.

G4A09
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.

G4A10
What is the function of an electronic keyer? **Automatic generation of dots and dashes for CW operation**

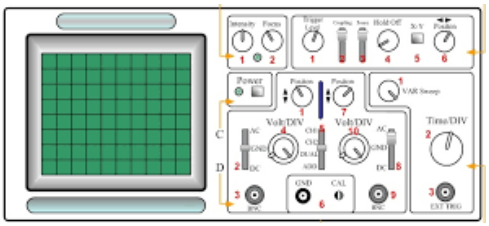
G4A11
Why should the ALC system be inactive when transmitting AFSK data signals? **The ALC action distorts the signal.**

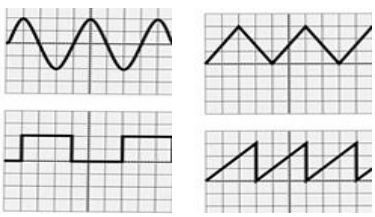
G4A12
Which of the following is a common use of the dual-VFO feature on a transceiver?
To transmit on one frequency and listen on another.

G4A13
What is the purpose of using a receive attenuator? **To prevent receiver overload from strong incoming signals**

G4B – Tests and test equipment

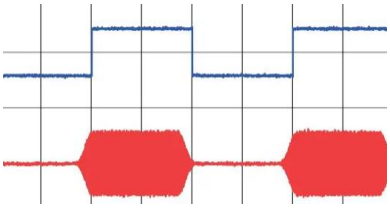
G4B01
What item of test equipment contains horizontal and vertical channel amplifiers? **An oscilloscope**





G4B02
Which of the following is an advantage of an oscilloscope versus a digital voltmeter?
Complex waveforms can be measured.
You can see the voltage versus time of the waveform.

G4B03
Which of the following is the best instrument to use for checking the keying waveform of a CW transmitter?
An oscilloscope



G4B04
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**
Be sure the attenuated signal is less than 100 mV, a direct connection will likely destroy the oscilloscope input circuitry.

G4B05
Why do voltmeters have high input impedance? **It decreases the loading on circuits being measured.**

G4B06
What is an advantage of a digital multimeter as compared to an analog multimeter? **Higher precision**

G4B07
What signals are used to conduct a two-tone test? **Two non-harmonically related audio signals**
The method involves 2 audio tones simultaneously applied to the microphone input of the Transmitter. The two frequencies must not be harmonically related, and with both falling within the audio passband of the transmitter. 850 Hz and 2200 Hz are a good choice. The transmitter output sampled is observed on an oscilloscope (not connected directly). With a spectrum analyzer having the appropriate resolution the Third Order Intermodulation Products (IM3) can also be observed.

G4B08
What transmitter performance parameter does a two-tone test analyze? **Linearity**

G4B09
When is an analog multimeter preferred to a digital multimeter?
When adjusting circuits for maximum or minimum values

G4B10

Which of the following can be determined with a directional wattmeter? **Standing Wave Ratio**

Standing Wave Ratio is referred to as SWR or VSWR (Voltage Standing Wave Ratio). This is the ratio between the forward power and the reflected power on the transmission line.

G4B11

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

G4B12

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

Received power that interferes with SWR readings

G4B13

Which of the following can be measured with an antenna analyzer? **Impedance of coaxial cable**

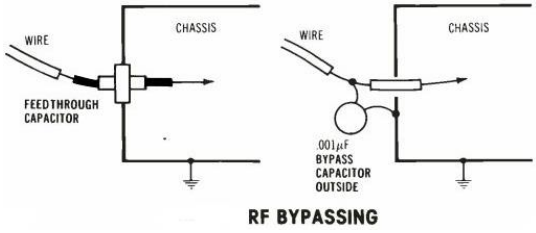
G4C – Interference to consumer electronics; grounding and bonding

G4C01

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

Bypass capacitor

A properly selected capacitor across an audio or DC signal line will have an Xc (capacative reactance) in the audio range that will not affect the signal but any RF traveling on the audio line will be shunted (bypassed) by the lower Capacitive Reactance (Xc) at RF Frequencies.



G4C02
Which of the following could be a cause of interference covering a wide range of frequencies?
Arcing at a poor electrical connection

G4C03
What sound is heard from an audio device experiencing RF interference from a single sideband phone transmitter? **Distorted speech**

G4C04
What sound is heard from an audio device experiencing RF interference from a CW transmitter?
On-and-off humming or clicking

G4C05
What is a possible cause of high voltages that produce RF burns?
The ground wire has high impedance on that frequency
The ground wire may look like an inductor and have a high inductive reactance (X_L) at the transmitter frequency.

G4C06
What is a possible effect of a resonant ground connection?
High RF voltages on the enclosures of station equipment

G4C07
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

G4C08
Which of the following would reduce RF interference caused by common-mode current on an audio cable?
Place a ferrite choke on the cable

G4C09
How can the effects of ground loops be minimized? **Bond equipment enclosures together**

G4C10
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

G4C11
What technique helps to minimize RF "hot spots" in an amateur station?
Bonding all equipment enclosures together

G4C12
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

G4D01
What is the purpose of a speech processor in a transceiver?
Increase the apparent loudness of transmitted voice signals.
This is done by compressing (reducing) the high and low peaks in the voice to a more uniform speech level.

G4D02
How does a speech processor affect a single sideband phone signal? **It increases average power**

G4D03
What is the effect of an incorrectly adjusted speech processor?
A. Distorted speech
B. Excess intermodulation products
C. Excessive background noise
D. All these choices are correct,

G4D04
What does an S meter measure? **Received signal strength.**

S Unit	dBm	Volts
9	-73	50uV
8	-79	25uV
7	-85	13uV
6	-91	6uV
5	-97	3uV
4	-103	2uV
3	-109	0.8uV
2	-115	0.4uV
1	-121	0.2uV
0	-127	0.1uV

G4D05
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.**

G4D06
How much change in signal strength is typically represented by one S unit? **6 dB**
An S meter is calibrated in signal strength in volts. Remember a two times change in power is 3dB but a two times change in voltage is 6dB:
dB for power = 10 ($\log_{10}$ ($P_1 \div P_2$)) and dB for voltage = 20 ($\log_{10}$ ($V_1 \div P_2$))

G4D07
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**

G4D08
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**
From 3 KHz below the displayed frequency to the displayed frequency.

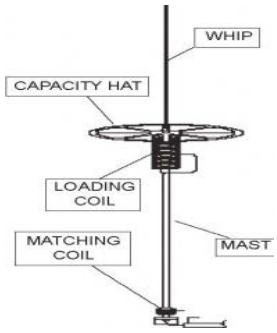
G4D09
What frequency range is occupied by a 3 kHz USB signal with the displayed carrier frequency set to 14.347 MHz?
14.347 MHz to 14.350 MHz
From the displayed frequency to the 3 KHz above the displayed frequency.

G4D10
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**

G4D11
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

G4E01
What is the purpose of a capacitance hat on a mobile antenna? **To electrically lengthen a physically short antenna**



G4E02
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
Corona Balls are used to eliminate the appearance of "fire" or "light" shooting off your antenna. This is caused by the discharge of corona off the ends of the elements; Adding these rounded balls help to prevent this when high power is being used. The Impedance of an antenna increases as the distance from the feed point increases, Therefore the voltage along the antenna increases. At the end of the antenna the voltage is high and if the antenna is simply narrow or pointed at the end there will be static discharge into the atmosphere. The corona ball on the end spreads the charge to reduce static discharge.

G4E03
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
Connect both the positive and negative leads close to, or if possible, directly to the battery. Place fuses in both leads.

G4E04
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.
Most auxiliary power sockets provide a maximum of 10 amperes and a 100-watt transceiver will draw 18 to 22 amperes.

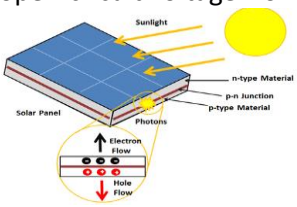
G4E05
Which of the following most limits an HF mobile installation? **Efficiency of the electrically short antenna**

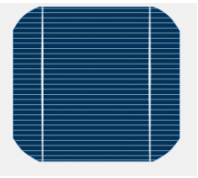
G4E06
What is one disadvantage of using a shortened mobile antenna as opposed to a full-size antenna?
Operating bandwidth may be very limited.

G4E07
Which of the following may cause receive interference to an HF transceiver installed in a vehicle?
A. The battery charging system.
B. The fuel delivery system.
C. The control computers.
D. All these choices are correct.

G4E08
In what configuration are the individual cells in a solar panel connected together? **Series-parallel**
Cells in parallel to increase the current and then the parallel groups connected in series for higher voltage.

G4E09
What is the approximate open-circuit voltage from a fully illuminated silicon photovoltaic cell? **0.5 VDC**





G4E10
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**

G4E11
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

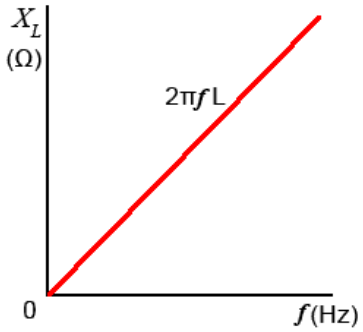
G5A01
What happens when inductive and capacitive reactance are equal in a series LC circuit?
Resonance causes impedance to be very low.

G5A02
What is reactance? **Opposition to the flow of alternating current caused by capacitance or inductance.**

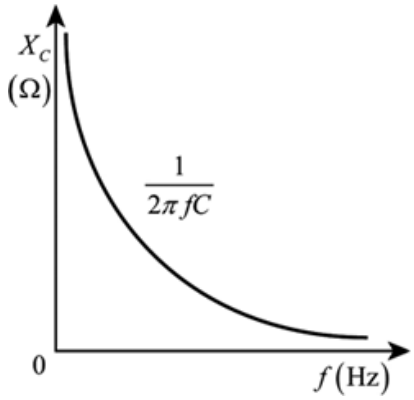
G5A03
Which of the following is opposition to the flow of alternating current in an inductor? **Reactance**
Reactance is the equivalent to resistance in a circuit with an alternating or RF current. Reactance in an inductor or inductive circuit increases as the frequency increases. $X_L = 2(\pi)(F_{Hz})$.

G5A04
Which of the following is opposition to the flow of alternating current in a capacitor? **Reactance**
Reactance is the equivalent to resistance in a circuit with alternating or RF current. Reactance in a capacitive circuit decreases as the frequency increases. $X_C = 1 \div ((2)(\pi)(F_{Hz}))$.

G5A05
How does an inductor react to AC? **As the frequency of the applied AC increases, the reactance increases.**
$X_L = 2\pi(F_{Hz})$



G5A06
How does a capacitor react to AC? **As the frequency of the applied AC increases, the reactance decreases.**
$X_C = 1 \div ((2\pi)(F_{Hz}))$

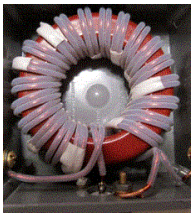


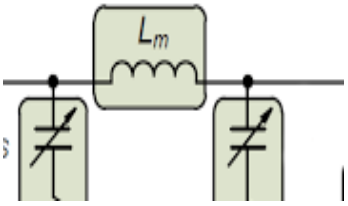
G5A07
What is the term for the inverse of impedance? **Admittance**
Admittance = 1/impedance For example an impedance of 1.5 ohms would be an admittance of 0.667 siemens. Admittance is expressed in siemens (not ohms).

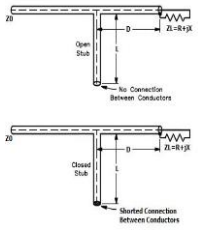
G5A08
What is impedance? **The ratio of voltage to current**
Z = voltage ÷ current

G5A09
What unit is used to measure reactance? **Ohm**

G5A10
Which of the following devices can be used for impedance matching at radio frequencies?
A. A transformer
B. A Pi-network
C. A length of transmission line
D. All these choices are correct.







G5A11
What letter is used to represent reactance? **X**

G5A12
What occurs in an LC circuit at resonance? **Inductive reactance and capacitive reactance cancel.**
They cancel each other and the current in the circuit is limited only by the circuit resistance.

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

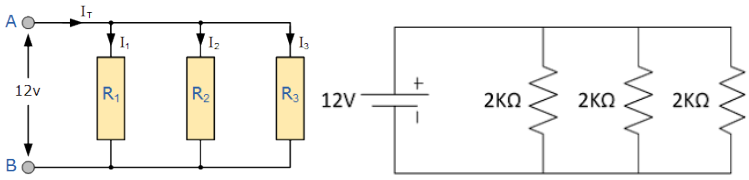
G5B01
What dB change represents a factor of two increase or decrease in power? **Approximately 3 dB**

dB(Decibel) = 10(log (power ratio)) or dB = 10(log (2)) or dB = 10(0.30 1) or dB = +3.01
dB(Decibel) = 10(log (power ratio)) or dB = 10(log (0.5)) or dB = 10(-0.30 1) or dB = -3.01

This Table will allow you to quickly solve many questions involving Decibels (dB):

minus (-)	*dB*	*Plus (+)*
one half	*3*	*2 times*
one quarter	*6*	*4 times*
one tenth	*10*	*10 times*

G5B02
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.



Total current (I_{total}) equals the sum of the current in each leg.
I_{total} = (12 ÷ 2,000) + (12 ÷ 2,000) + (12 ÷ 2,000) or 0.006 + 0.00.6 + 0.00.6 or .0.018 Amps or 18 ma

G5B03
How many watts of electrical power are consumed if 400 VDC is supplied to an 800-ohm load? **200 watts**
Power = $(E)^2 \div R$ or P = ((400 x 400) ÷ 800) or P = 160,000/800 or P = 200 watts

G5B04
How many watts of electrical power are consumed by a 12 VDC light bulb that draws 0.2 amperes? **2.4 watts**
Power =E x I or P = 12 x 0.2 or p = 2.4 Watts

G5B05
How many watts are consumed when a current of 7.0 milliamperes flows through a 1,250-ohm resistance?
Approximately 61 milliwatts
Power = $(I)^2$ x R or $(0.007)^2$x 1250 or P = 0.000049 x 1250 or P = 0 .0612 watts or P = 61.2 milliwatts

G5B06
What is the PEP produced by 200 volts peak-to-peak across a 50-ohm dummy load? **100 watts**
Divide PP volts by 2, to get the peak voltage. Then multiply it by 0.707 to get the RMS value and then square that answer and divide by 50 to get the power in watts:
P= ((200 ÷ 2) x (0.707))² ÷ (50) or $(100 \times 0.707)^2 \div 50$ or 4.998 ÷ 50 or 99.969 watts

G5B07
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.
The RMS or root mean square value of alternating current/voltage represents an AC voltage equivalent to DC current or voltage that produces the same amount of power to a circuit e alternating current/voltage.
For sinusoidal waveforms, the RMS value is equal to the peak value of the AC divided by the square root of 2.

$V_{rms} = V_{peak} \div (\sqrt{2})$ or for 100 volts peak the RMS value would be 100 ÷ (√2) or 100 ÷ 1.414 or 70.72 Volts

G5B08
What is the peak-to-peak voltage of a sine wave with an RMS voltage of 120 volts? **339.4 volts**
PP = (RMS x 1.4140) x 2 or PP = (120 x 1.414) x 2 or 169.68 x 2 or 339.4 Volts

G5B09
What is the RMS voltage of a sine wave with a value of 17 volts peak? **12 volts**
RMS = peak x .707 or RMS = 17 x .707 or 12.02 volts

G5B10

What percentage of power loss is equivalent to a loss of 1 dB? **20.6 percent**

dB percentage of input = [10^(dB ÷ 10)] x 100 or [10^(-1/10)] x 100 or 0.7943 x100 or 79.43%. The loss would be the difference between the 100% and output percentage or 100% - 79.43% or 20.57%

G5B11

What is the ratio of PEP to average power for an unmodulated carrier? **1.00**

Peak envelope power is the same as average power for an unmodulated carrier because the power is not changing with modulation.

G5B12

What is the RMS voltage across a 50-ohm dummy load dissipating 1200 watts? **245 volts**

$RMS = \sqrt{((P)(R))}$ *or* $\sqrt{((1200)\ (50)\ )}$ *or* $\sqrt{(60{,}000)}$ *or 244.94 Volts*

G5B13

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

Peak envelope power is the same as average power for an unmodulated carrier because the power is not changing with modulation.

G5B14

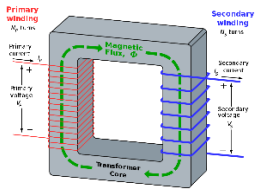
What is the output PEP of 500 volts peak-to-peak across a 50-ohm load? **625 watts**

PEP= E ÷/R or ((500÷2) (.707)) ² / 50 or ((250) (.707)) ² / 50 or (176.75) ² /50 or 312,240 / 50 or 624.8 watts

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

G5C01

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**



G5C02

What is the output voltage if an output 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**

A 25-turn primary with a 100-turn secondary (Step up configuration) is a 4:1 ratio. A 100-volt primary voltage would give a 400 volt secondary voltage.

G5C03

What is the total resistance of a 10-, a 20-, and a 50-ohm resistor connected in parallel? **5.9 ohms**

R=1 ÷ ((1 ÷ R1) +(1 ÷ R2) + (1 ÷ R3)) or R=1 ÷ ((1 ÷ 10) +(1 ÷ 20) + (V 50)) or R= 1 ÷ (0.1+ 0.05 + 0.02) or R= 1 ÷ 0.17 or R + 5.882 ohms

Remember the total resistance in a parallel resistor circuit will always be lower than the lowest value resistor in the circuit.

G5C04
What is the approximate total resistance of a 100- and a 200-ohm resistor in parallel? **67 ohms**

R=1 ÷ ((1 ÷ R1) + (1 ÷ R2)) or R=1 ÷ ((1 ÷ 100) + (1 ÷ 200) or R =1 ÷ (0.01 + 0.005) or R= 66.66 ohms

G5C05
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**

G5C06
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**
The secondary voltage is the ratio between the secondary and primary windings multiplied by the input voltage:
$V = (1{,}500 \div 500)\ (120)$ **or** $(3)\ (120)$ **or** 360 ***Volts***

G5C07
What transformer turns ratio matches an antenna's 600-ohm feed point impedance to a 50-ohm coaxial cable?
3.5 to 1
Turns ratio is the square root of the impedance ratio.
Turns ratio = $\sqrt{(600/50)}$ **or** $\sqrt{(12)}$ ***or 3.46 to 1.***

G5C08
What is the equivalent capacitance of two 5.0-nanofarad capacitors and one 750-picofarad capacitor connected in parallel? **10.750 nanofarads**
Total parallel capacitance adds. Therefore Ct= C1 + C2 +C3 +…… Cx
A Nanofarad is 1,000 pf. Therefore C_{total} ***= 5,000 pf + 5,000 pf + 750pF or Ct = 10,750 picofarads or 10.75 nanofarads.***

G5C09
What is the capacitance of three 100-microfarad capacitors connected in series? **33.3 microfarads**
Series capacitors are like parallel resistors.
C_{total} ***= 1 ÷ ((1 ÷ C1) +(1 ÷ C2) +(1 ÷ C3)) or Ct =1 ÷ (1 ÷ 100) + (1 ÷ 100) + (1 ÷ 100)) or Ct =1 ÷ (0.03) or Ct = 33.33 Microfarads***

For capacitors of the same value in series the total is the value of one of the capacitors divided by the number in parallel: 100 ÷ 3 or 33.333

G5C10
What is the inductance of three 10-millihenry inductors connected in parallel?
3.3 millihenries
Parallel inductors are like parallel resistors.
L_{total}***=1 ÷ ((1 ÷ L1) +(1 ÷ L2) +(1 ÷ l3)) or L =1 ÷ ((1 ÷ 10) +(1 ÷ 10) +(1 ÷ 10)) or L =1 ÷ (0.3) or L = 3.33 millihenries (mH)***

For Inductors of the same value in parallel the total is the value of one of the inductors divided by the number in parallel: 10 ÷ 3 or 3.333 millihenries (mH)

G5C11

What is the inductance of a circuit with a 20-millihenry inductor connected in series with a 50-millihenry inductor? **70 millihenries**

L= L1 + L2 or L = 20 +50 or L=70 millihenries

G5C12

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

With series capacitors the total capacitance will always be less than the smallest capacitor in the string. You can calculate the value:

$1/Ct = 1/C_1 + 1/C_2$ or $1/C_t = 1/50 + 1/20$ or $1/C_t = 0 .020 + .050$ or $1/C_t = 0.070$ or $C_t = 14.28$ microfarads

G5C13

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

G5C14

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

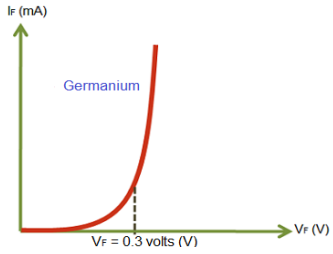
SUBELEMENT G6 – CIRCUIT COMPONENTS [2 Exam Questions – 2 Groups]

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

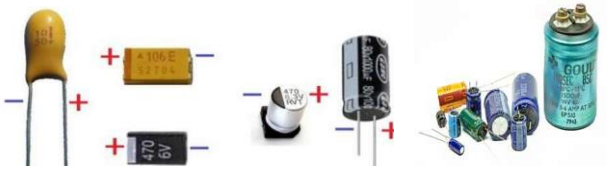
G6A01
What is the minimum allowable discharge voltage for maximum life of a standard 12-volt lead-acid battery?
10.5 volts

G6A02
What is an advantage of batteries with low internal resistance? **High discharge current**

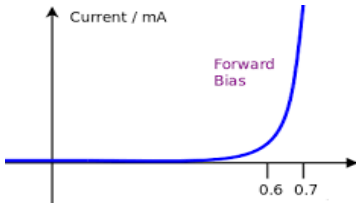
G6A03
What is the approximate forward threshold voltage of a germanium diode? **0.3 volts**
Threshold voltage is the voltage level across the diode when forward current will start to flow.



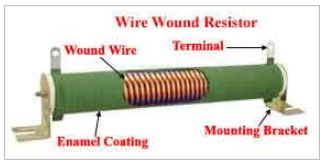
G6A04
Which of the following is characteristic of an electrolytic capacitor? **High capacitance for a given volume.**



G6A05
What is the approximate forward threshold voltage of a silicon junction diode? **0.7 volts**

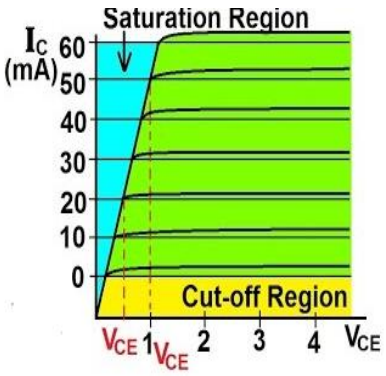


G6A06
Why should wire-wound resistors not be used in RF circuits?
The resistor's inductance could make circuit performance unpredictable.



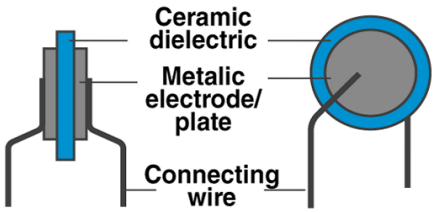
G6A07

What are the operating points for a bipolar transistor used as a switch? **Saturation and cutoff**



G6A08

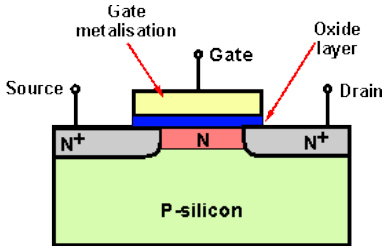
Which of the following is characteristic of low voltage ceramic capacitors? **Comparatively low cost**

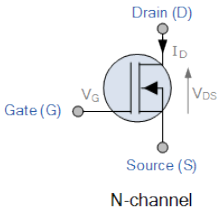


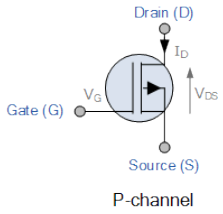
G6A09

Which of the following describes MOSFET construction?

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



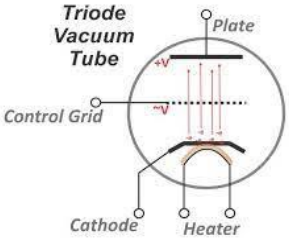


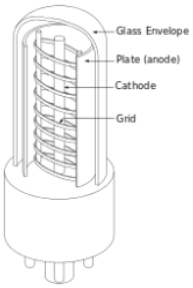


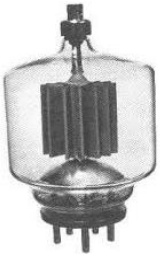
G6A10

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

Control grid

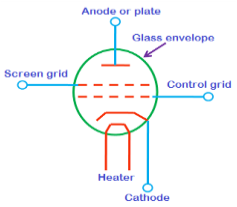






G6A11
What happens when an inductor is operated above its self-resonant frequency? **It becomes capacitive.**

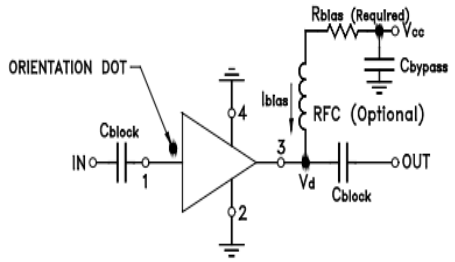
G6A12
What is the primary purpose of a screen grid in a vacuum tube? **To reduce grid-to-plate capacitance**

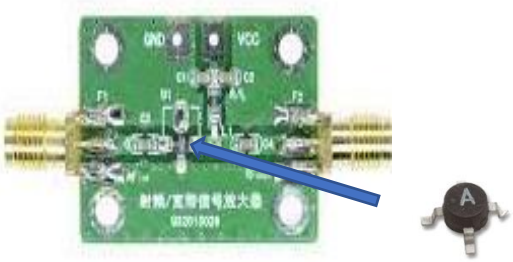


G6B – Analog and digital integrated circuits (ICs); microwave ICs (MMICs); display devices; RF connectors; ferrite cores.

G6B01
What determines the performance of a ferrite core at different frequencies?
The composition, or "mix," of materials used.
Go to the following web site https://cdn-reichelt.de/documents/datenblatt/D500/FT%23AMI.pdf
for information in different core types and applications.

G6B02
What is meant by the term MMIC? **Monolithic Microwave Integrated Circuit**
A typical MMIC amplifier has a 50 ohm input and output impedance, a gain of 20 or more dB, and a bandwidth of 5 to 2,000 MHz and costs $1 in small quantities. .





G6B03
Which of the following is an advantage of CMOS integrated circuits compared to TTL integrated circuits?
Low power consumption

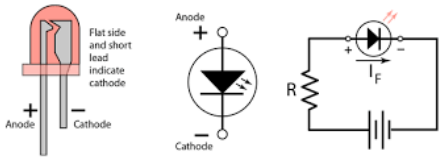
G6B04
What is a typical upper frequency limit for low SWR operation of 50-ohm BNC connectors? **500 MHz**

G6B05
What is an advantage of using a ferrite core toroidal inductor?
A. Large values of inductance may be obtained
B. The magnetic properties of the core may be optimized for a specific range of frequencies
C. Most of the magnetic field is contained in the core
D. All these choices are correct

G6B06
What kind of device is an integrated circuit operational amplifier? **Analog**

G6B07
Which of the following describes a type N connector? **A moisture-resistant RF connector useful to 10 GHz**
Currently available type N connectors are specified up to 18 GHz.

G6B08
How is an LED biased when emitting light? **Forward biased**



G6B09
How does a liquid crystal display compare to an LED display? **Higher contrast in high ambient lighting**

G6B10
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

G6B11
What is an SMA connector? **A small threaded connector suitable for signals up to several GHz**

G6B12

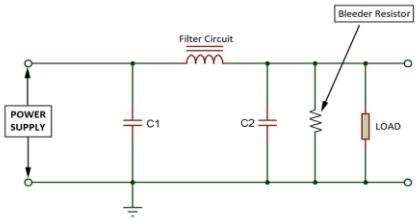
Which of these connector types is commonly used for low frequency or dc signal connections to a transceiver?

RCA Phono

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

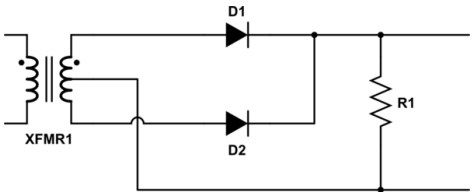
G7A – Power supplies; schematic symbols

G7A01
What is the function of a power supply bleeder resistor?
It discharges the filter capacitors when power is removed

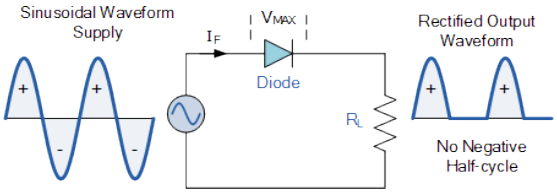


G7A02
Which of the following components are used in a power supply filter network? **Capacitors and inductors**
See Illustration in G7A01 above.

G7A03
Which type of rectifier circuit uses two diodes and a center-tapped transformer? **Full-wave**



G7A04
What is characteristic of a half-wave rectifier in a power supply?
Only one diode is required



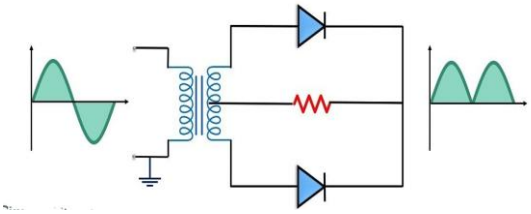
G7A05
What portion of the AC cycle is converted to DC by a half-wave rectifier?
180 degrees
See Illustration in G7A04 above.

G7A06
What portion of the AC cycle is converted to DC by a full-wave rectifier?
360 degrees
See Graphic for G7A07.

G7A07

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



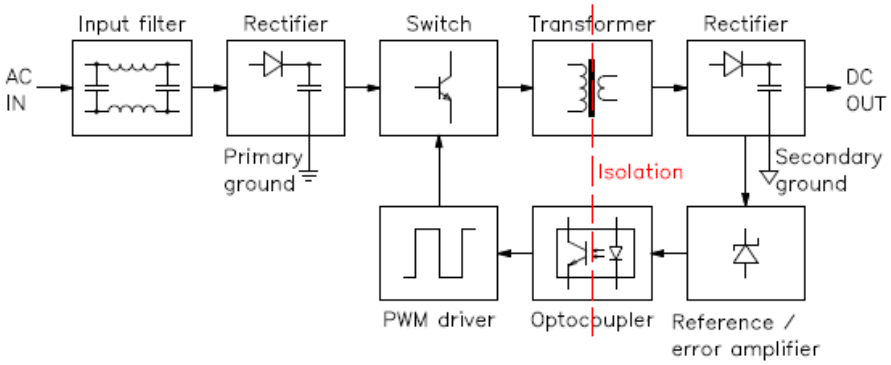
G7A08

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

In a switching power supply the raw 60 Hz line voltage is directly rectified and then the resulting DC is switched into a square wave at a higher rate. This higher frequency AC square wave is passed through transformers that are much smaller and lighter since they do not need to pass the lower 60 Hz and the final rectified voltage does not require the larger capacitors that would be needed for a linear power supply that is filtering 60 or 120 Hz.

Switch mode power supply block diagram



THIS FIGURE, G7-1, IS FOR QUESTIONS G709 THRU G7A13

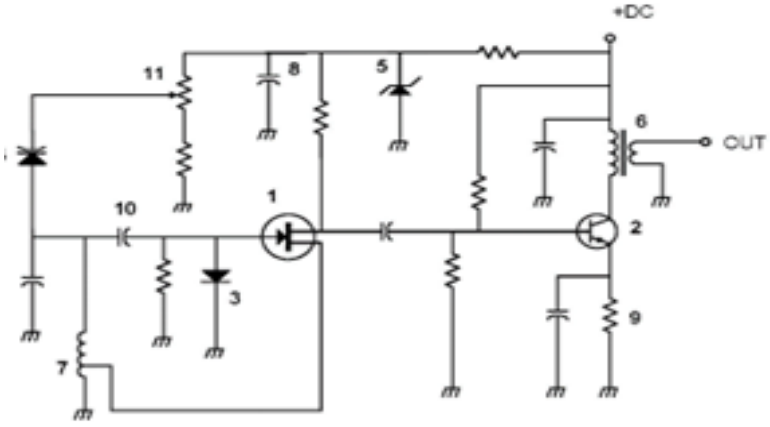


Figure G7-1

G7A09
Which symbol in figure G7-1 represents a field effect transistor? **Symbol 1**

G7A10
Which symbol in figure G7-1 represents a Zener diode? **Symbol 5**

G7A11
Which symbol in figure G7-1 represents an NPN junction transistor? **Symbol 2**

G7A12
Which symbol in Figure G7-1 represents a solid core transformer? **Symbol 6**

G7A13
Which symbol in Figure G7-1 represents a tapped inductor? **Symbol 7**

G7B – Digital circuits amplifiers and oscillators

G7B01
What is the purpose of neutralizing an amplifier? **To eliminate self-oscillations**
Neutralization is primarily concerned with correcting unwanted feedback that occurs from normal anode-cathode feedback in a grounded grid amplifier.

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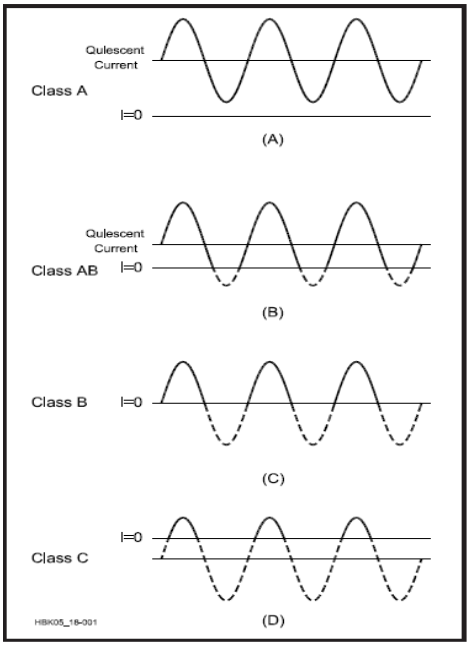
Tutorial for Amplifier Operation Class

Amplifiers are categorized by their type or class of operation, and circuit configuration.

CLASSES OF OPERATION (A, AB, B &C)



The class of operation of an amplifier stage is defined by its conduction angle, that is the portion of the sine wave drive cycle, in degrees, during which plate current (or collector or drain current in the case of transistors) flows. This, in turn, determines the amplifier's efficiency and linearity.

Class A: The conduction angle is 360º. DC bias and drive level are set so that the device is not driven to output current cutoff at any point in the driving- voltage cycle, so some device output current flows throughout the complete 360º of the input cycle. Output voltage is generated by the variation of output current flowing through the load resistance. Maximum linearity and gain are achieved in a Class A amplifier, but the efficiency of the stage is low. Maximum theoretical efficiency is 50%, but 25 to 30% is more common in practice.

Class AB: The conduction angle is greater than 180º but less than 360º. In other words, dc bias and drive level are adjusted so device output current flows during appreciably more than half the drive cycle, but less than the whole drive cycle. Efficiency is much better than Class A, typically reaching 50-60% at peak output power. Class AB linearity and gain are not as good as that achieved in Class A but are very acceptable for even the most rigorous high-power SSB applications in Amateur Radio.

Class B: Conduction angle = 180º. Bias and RF drive are set so that the device is just cut off with no signal applied (see Fig 18.1C), and device output current flows during one half of the drive cycle. Efficiency commonly reaches as high as 65%, with fully acceptable linearity.

Class C: The conduction angle is much less than 180º—typically 90º. DC bias is adjusted so that the device is cut off when no drive signal is applied. Output current flows only during positive crests in the drive cycle, so it consists of pulses at the drive frequency. Efficiency is relatively high— up to 80%—but linearity is extremely poor. Thus, Class C amplifiers are not suitable for amplification of amplitude modulated signals such as SSB or AM but are quite satisfactory for use in on off keyed stages or with frequency or phase modulation. Gain is lower than for the previous classes of operation, typically 10-13 dB.

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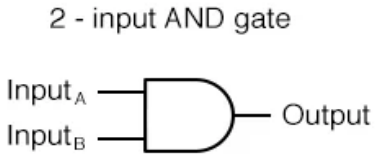
G7B02
Which of these classes of amplifiers has the highest efficiency? **Class C**

G7B03
Which of the following describes the function of a two-input AND gate?
Output is high only when both inputs are high



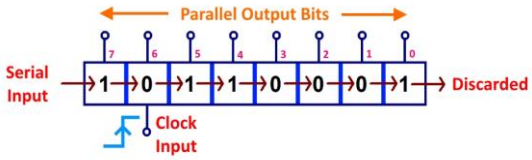
A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

G7B04
In a Class A amplifier, what percentage of the time does the amplifying device conduct? **100%**

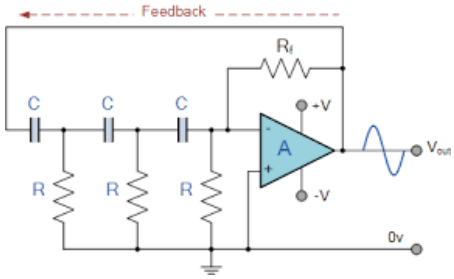
G7B05
How many states does a 3-bit binary counter have? **8**

Count	Bit 3	Bit 2	Bit 1
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

G7B06
What is a shift register?
A clocked array of circuits that passes data in steps along the array



G7B07
Which of the following are basic components of a sine wave oscillator?
A filter and an amplifier operating in a feedback loop



G7B08
How is the efficiency of an RF power amplifier determined?
Divide the RF output power by the DC input power

G7B09
What determines the frequency of an LC oscillator? **The inductance and capacitance in the tank circuit**
The LC oscillator is a type of tuned oscillator that uses a combination of L (Inductor) and C (Capacitor) to provide the required positive feedback, which is essential to produce sustained oscillations in the circuit.

The inductor uses the released energy from the capacitor to form a magnetic field around it. This magnetic field induces a voltage and starts charging the capacitor with opposite polarity. This cycle between the inductor and capacitor continues and results in oscillations.

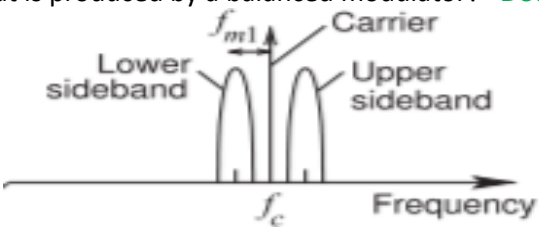
G7B10
Which of the following describes a linear amplifier?
An amplifier in which the output preserves the input waveform
This would be a class A amplifier.

G7B11
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)

G7C01
What circuit is used to select one of the sidebands from a balanced modulator? **Filter**
Double Side Band Suppressed Carrier (DSBSC) Filtering Method: Since SSB modulation is the transmission of only the upper or lower side bands, SSB modulation can be generated by filtering the undesired side band and carrier of a DSBSC signal and retaining the desired one using a bandpass filter with bandwidth equal that of the message signal (3kHz).

G7C02 4
What output is produced by a balanced modulator? **Double-sideband modulated RF**



G7C03
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
By seeing a matched load the transmitter can deliver its maximum power.

G7C04
How is a product detector used? **Used in a single sideband receiver to extract the modulated signal**

G7C05
Which of the following is characteristic of a direct digital synthesizer (DDS)?
Variable output frequency with the stability of a crystal oscillator
***Direct digital synthesis* (DDS) is a method of producing an analog waveform by generating a time-varying signal in digital form and then performing a digital-to-analog conversion. Because operations within a DDS device are primarily digital, it can offer fast switching between output frequencies, fine frequency resolution, and operation over a broad spectrum of frequencies.**

G7C06
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

G7C07
What term specifies a filter's attenuation inside its passband? **Insertion loss**

G7C08
Which parameter affects receiver sensitivity?
A. Input amplifier gain
B. Demodulator stage bandwidth
C. Input amplifier noise figure
D. All these choices are correct

G7C09
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**

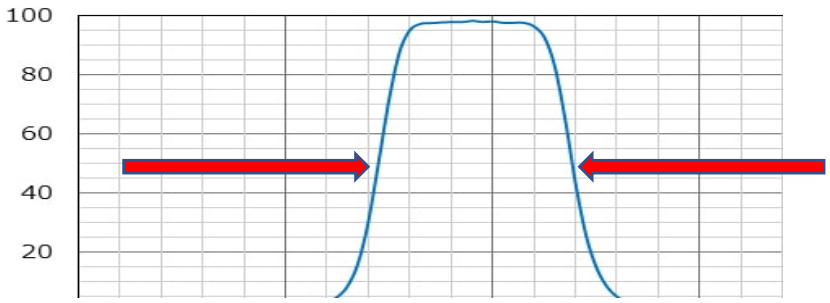
G7C10
What is an advantage of using I-Q modulation with software-defined radios (SDRs)?
All types of modulation can be created with appropriate processing

G7C11
Which of these functions is performed by software in a software-defined radio (SDR)?
A. Filtering
B. Detection
C. Modulation
D. All these choices are correct

G7C12
What is the frequency above which a low-pass filter's output power is less than half the input power?
Cutoff frequency

G7C13
What term specifies a filter's maximum ability to reject signals outside its passband? **Ultimate rejection**

G7C14
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

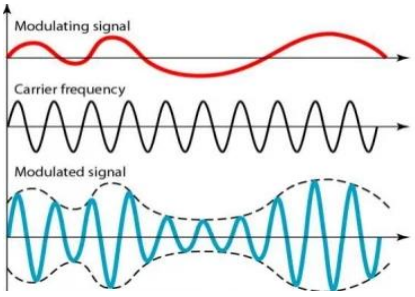
G8A01
How is direct binary FSK modulation generated?
By changing an oscillator's frequency directly with a digital control signal
FSK is the process of shifting (modulating) an analog carrier frequency at a digital rate. FSK closely resembles standard FM (Frequency Modulation). With FSK, the modulating signal is not a sinusoidal signal but a series of dc pulses that vary between two discrete voltage levels.

G8A02
What is the name of the process that changes the phase angle of an RF signal to convey information?
Phase modulation

G8A03
What is the name of the process that changes the instantaneous frequency of an RF wave to convey information? **Frequency modulation**

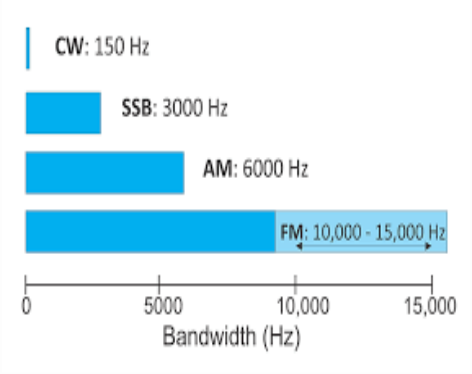
G8A04
What emission is produced by a reactance modulator connected to a transmitter RF amplifier stage?
Phase modulation

G8A05
What type of modulation varies the instantaneous power level of the RF signal?
Amplitude modulation



G8A06
Which of the following is characteristic of QPSK31?
A. It is sideband sensitive
B. Its encoding provides error correction
C. Its bandwidth is approximately the same as BPSK31
D. All these choices are correct

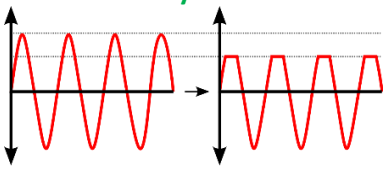
G8A07
Which of the following phone emissions uses the narrowest bandwidth? **Single sideband**



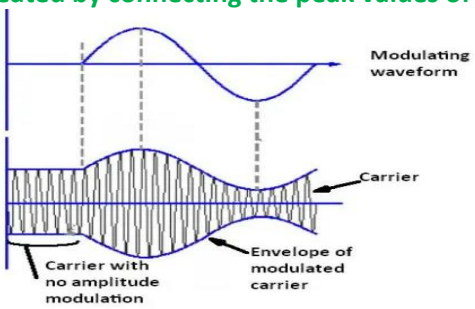
G8A08
Which of the following is an effect of overmodulation? **Excessive bandwidth**

G8A09
What type of modulation is used by FT8? **8-tone frequency shift keying**

G8A10
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



G8A11
What is the modulation envelope of an AM signal?
The waveform created by connecting the peak values of the modulated signal



G8A12
What is QPSK modulation?
Modulation in which digital data is transmitted using 0-, 90-, 180- and 270-degrees phase shift to represent pairs of bits
QPSK is Quadrature Phase Shift Keying

G8A13
What is a link budget?
The sum of transmit power and antenna gains minus system losses as seen at the receiver

G8A14
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

G8B01
Which mixer input is varied or tuned to convert signals of different frequencies to an intermediate frequency (IF)? **Local oscillator**

G8B02
What is the term for interference from a signal at twice the IF frequency from the desired signal?
Image response

G8B03
What is another term for the mixing of two RF signals? **Heterodyning**

G8B04
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**

G8B05
Which intermodulation products are closest to the original signal frequencies? **Odd-order**

G8B06
What is the total bandwidth of an FM phone transmission having 5 kHz deviation and 3 kHz modulating frequency? **16 kHz**
The bandwidth is the max deviation, which is plus or minus 5 KHz plus the maximum modulating frequency which is 3 KHz for a total deviation of plus and minus 8 KHz, for a total occupied bandwidth of 16 KHz.

Total bandwidth = 2 x ($f_{m\ (modulation)}$ + $f_{(deviation)}$) or 2 (3 KHz + 5 kHz) or 2 (8 KHz) or 16 KHz

G8B07
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**
12.21 MHz must be multiplied by 12 [146.52/12.21] to achieve a 146.52 MHz signal. The deviation on the 12.21 signal is also multiplied. The deviation at 12.21 MHz would be 1/12 of the desired modulation or 5 KHz ÷ 12 or 416.66 Hz.

G8B08
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
A 100-watt SSB transmitter will not be capable of 100 watts CW or digital signals. The average power for a 100-watt pep transmission is significantly lower than 100 Watts. Typically about 40 watts.

G8B09
Why is it good to match receiver bandwidth to the bandwidth of the operating mode?
It results in the best signal-to-noise ratio

G8B10
What is the relationship between transmitted symbol rate and bandwidth?
Higher symbol rates require wider bandwidth

G8B11
What combination of a mixer's Local Oscillator (LO) and RF input frequencies is found in the output?
The sum and difference

G8B12
What process combines two signals in a non-linear circuit to produce unwanted spurious outputs?
Intermodulation
Intermodulation (IM) or intermodulation distortion (IMD) is the amplitude modulation of signals containing two or more different frequencies, caused by nonlinearities in a system.

G8B13
Which of the following is an odd-order intermodulation product of frequencies F1 and F2? **2F1-F2**

G8C – Digital emission modes

G8C01
On what band do amateurs share channels with the unlicensed Wi-Fi service? **2.4 GHz**

G8C02
Which digital mode is used as a low-power beacon for assessing HF propagation? **WSPR**

G8C03
What part of a packet radio frame contains the routing and handling information? **Header**

G8C04
Which of the following describes Baudot code? **A 5-bit code with additional start and stop bits**

G8C05
In an ARQ mode, what is meant by a NAK response to a transmitted packet?
Request retransmission of the packet
Automatic repeat request (ARQ), also known as automatic repeat query, is an error control method for data transmission that uses acknowledgements (messages sent by the receiver indicating that it has correctly received a packet) and timeouts (specified periods of time allowed to elapse before an acknowledgment is to be received) to achieve reliable data transmissions over an unreliable service.

G8C06
What action results from a failure to exchange information due to excessive transmission attempts when using 8 an ARQ mode? **The connection is dropped**

G8C07
Which of the following narrow-band digital modes can receive signals with very low signal-to-noise ratios?
FT8

G8C08
Which of the following statements is true about PSK31?
Upper case letters use longer Varicode bit sequences and thus slow down transmission

G8C09
Which is true of mesh network microwave nodes?
If one node fails, a packet may still reach its target station via an alternate node

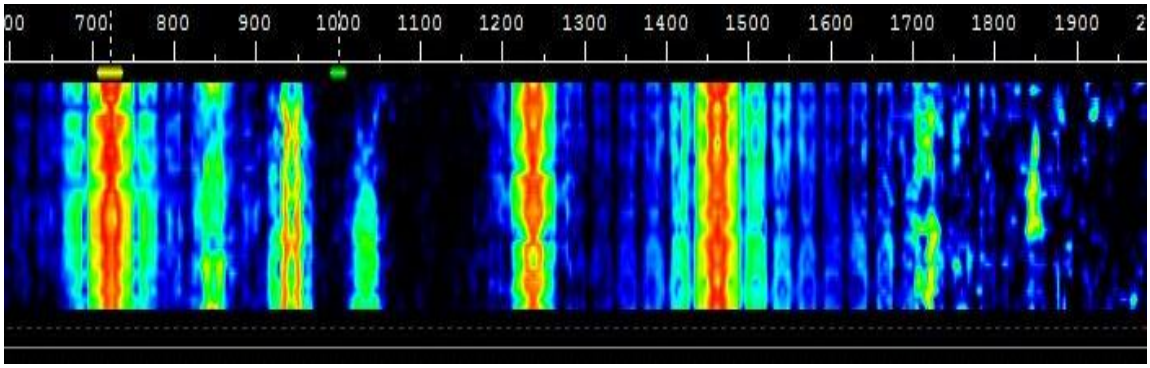
G8C10
How does forward error correction (FEC) allow the receiver to correct data errors?
By transmitting redundant information with the data

G8C11
How are the two separate frequencies of a Frequency Shift Keyed (FSK) signal identified?
Mark and space

G8C12
Which type of code is used for sending characters in a PSK31 signal? **Varicode**
Just like Morse Code, more frequently used characters are transmitted with a shorter code to speed up communication.

G8C13
What is indicated on a waterfall display by one or more vertical lines on either side of a data mode or RTTY signal? **Overmodulation**

G8C14
Which of the following describes a waterfall display?
Frequency is horizontal, signal strength is intensity, time is vertical



G8C15
What does an FT8 signal report of +3 mean?
The signal-to-noise ratio is equivalent to +3dB in a 2.5 kHz bandwidth

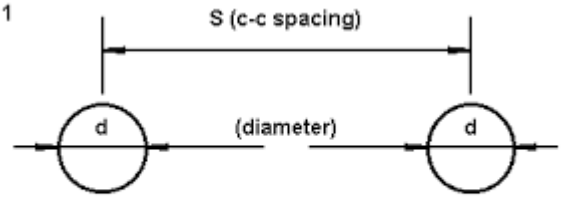
G8C16
Which of the following provide digital voice modes? **DMR, D-STAR, and SystemFusion**

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

G9A01
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

Fig. 1



The Basic Physical Properties of a Parallel Transmission Line

G9A02
What is the relationship between high standing wave ratio (SWR) and transmission line loss?
High SWR increases loss in a lossy transmission line

G9A03
What is the nominal characteristic impedance of "window line" transmission line?
450 ohms

Also called Ladder line

G9A04
What causes reflected power at an antenna's feed point?
A difference between feed line impedance and antenna feed point impedance

G9A05
How does the attenuation of coaxial cable change with increasing frequency?
Attenuation increases

G9A06
In what units is RF feed line loss usually expressed?
Decibels per 100 feet

G9A07
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

G9A08
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**

G9A09
What standing wave ratio results from connecting a 50-ohm feed line to a 200-ohm resistive load? **4:1**

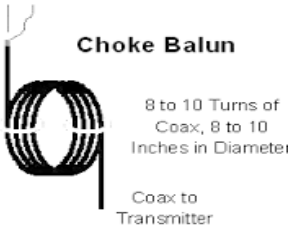
G9A10
What standing wave ratio results from connecting a 50-ohm feed line to a 10-ohm resistive load? **5:1**
Note that a 250 ohm resistive load would also be 5:1

G9A11
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
A 3db feed line loss would look like a 6dB return loss (or a 3:1 VSWR) with an open or short at the end of the transmission line. A 5dB loss would look like a 10 dB return loss or a VSWR of 2:1 with an open or short at the far end of the transmission line.

Return Loss (dB)	Reflected Pwr (%)	Forward Power (%)	Mismatch Loss (dB)	VSWR
0.00	100.00	0.00	∞	∞
1.00	79.43	20.57	6.87	17.39
2.00	63.10	36.90	4.33	8.72
3.00	50.12	49.88	3.02	5.85
4.00	39.81	60.19	2.20	4.42
5.00	31.62	68.38	1.65	3.57
6.00	25.12	74.88	1.26	3.01
7.00	19.95	80.05	0.97	2.61
8.00	15.85	84.15	0.75	2.32
9.00	12.59	87.41	0.58	2.10
10.00	10.00	90.00	0.46	1.92
12.00	6.31	93.69	0.28	1.67
15.00	3.16	96.84	0.14	1.43
20.00	1.00	99.00	0.04	1.22
30.00	0.10	99.90	0.00	1.07
∞	0.00	100.00	0.00	1.00

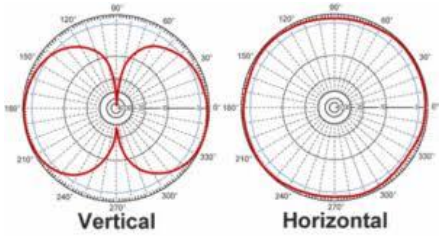
G9B – Basic dipole and monopole antennas

G9B01
What is a characteristic of a random-wire HF antenna connected directly to the transmitter?
Station equipment may carry significant RF current
You need to place sone isolation at the transmitter end of the antenna feedline by coiling coax or adding ferrite beads to reduce RF feedback.

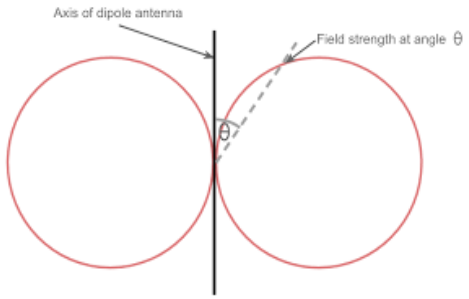


G9B02
Which of the following is a common way to adjust the feed point impedance of an elevated quarter-wave ground-plane vertical antenna to be approximately 50 ohms?
Slope the radials downward

G9B03
Which of the following best describes the radiation pattern of a quarter-wave ground-plane vertical antenna?
Omnidirectional in azimuth



G9B04
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



G9B05
How does antenna height affect the azimuthal radiation pattern of a horizontal dipole HF antenna?
If the antenna is less than 1/2 wavelength high, the azimuthal pattern is almost omnidirectional

G9B06
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

G9B07
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**
And the radiation pattern changes to omnidirectional.

G9B08
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**

G9B09
Which of the following is an advantage of using a horizontally polarized as compared to a vertically polarized HF antenna? **Lower ground losses**

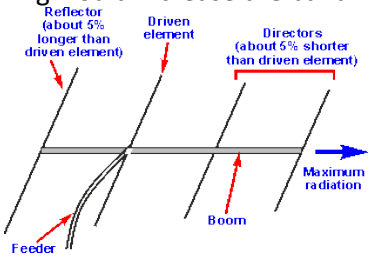
G9B10
What is the approximate length for a 1/2 wave dipole antenna cut for 14.250 MHz? **33 feet**
For a half wave dipole in feet divide the frequency in MHz into 468
Length = 468 /14.250 or 32.84 feet

G9B11
What is the approximate length for a 1/2 wave dipole antenna cut for 3.550 MHz? **132 feet**
For a half wave dipole in feet divide the frequency in MHz into 468
Length = 468 /3.550 or 131.8 feet

G9B12
What is the approximate length for a 1/4 wave monopole antenna cut for 28.5 MHz? **8 feet**
For a quarter wave mono pole in feet divide the frequency in MHz into 468 for one half wavelength then divide by two for ¼ wavelength:
Length = (468 /28.5)÷ 2 or 16.42 ÷2 or length = 8.21 feet

G9C – Directional antennas

G9C01
Which of the following would increase the bandwidth of a Yagi antenna? **Larger-diameter elements**



G9C02
What is the approximate length of the driven element of a Yagi antenna?
1/2 wavelength

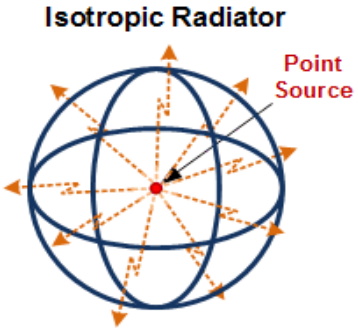
G9C03
How do the lengths of a three-element Yagi reflector and director compare to that of the driven element?
The reflector is longer, and the director is shorter
Each by about 5%

G9C04

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

Gain in dBi is 2.15 dB higher

dBi is dB intrinsic (a theoretical single point antenna) and dBd is dB compared to the gain of a Half wave dipole antenna.



G9C05

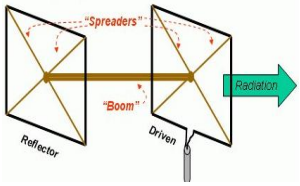
What is the primary effect of increasing boom length and adding directors to a Yagi antenna?

Gain increases

The antenna becomes more focused and directional.

G9C06

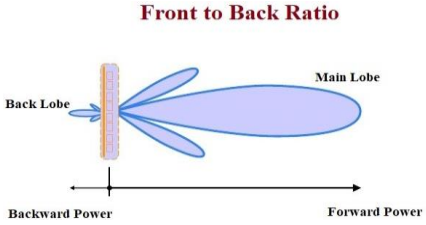
How does the forward gain of a two-element quad antenna compare to the forward gain of a three-element Yagi antenna? **About the same**



G9C07

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



G9C08

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

The direction of maximum radiated field strength from the antenna

See illustration in G9C07 above.

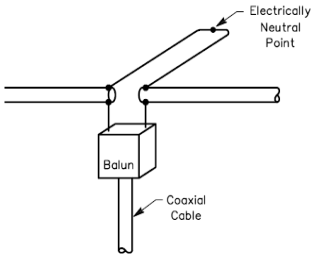
G9C09

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**

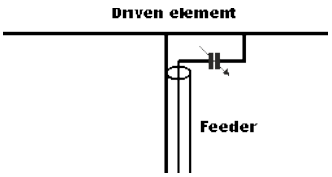
Since two antennas are used the signal would be twice as much as a single antenna, or 3 dB more.

G9C10
Which of the following can be adjusted to optimize forward gain, front-to-back ratio, or SWR bandwidth of a Yagi antenna?
A. The physical length of the boom
B. The number of elements on the boom
C. The spacing of each element along the boom
D. All these choices are correct

G9C11
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

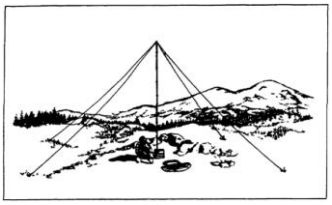


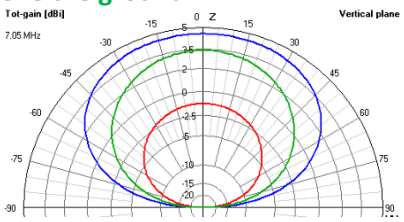
G9C12
Which of the following is a characteristic of using a gamma match with a Yagi antenna?
It does not require the driven element to be insulated from the boom



G9D – Specialized antenna types and applications

G9D01
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



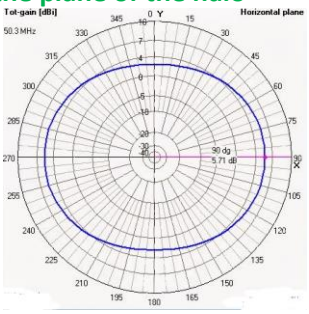


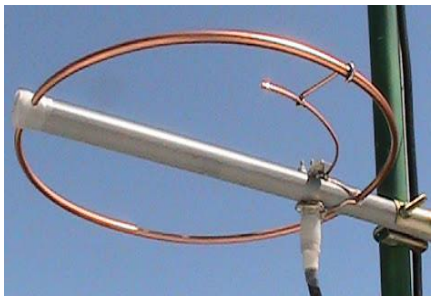
G9D02
What is the feed point impedance of an end-fed half-wave antenna? **Very high**

G9D03

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

Omnidirectional in the plane of the halo

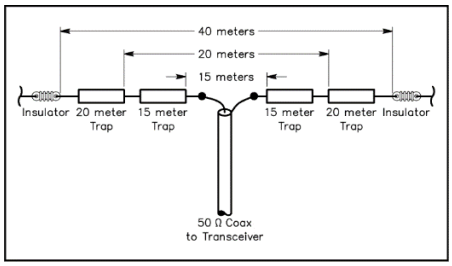


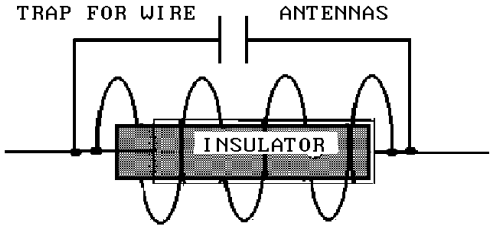


G9D04

What is the primary function of antenna traps?

To enable multiband operation





G9D05

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

It narrows the main lobe in elevation

G9D06

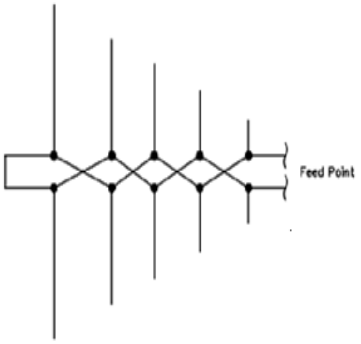
Which of the following is an advantage of a log-periodic antenna?

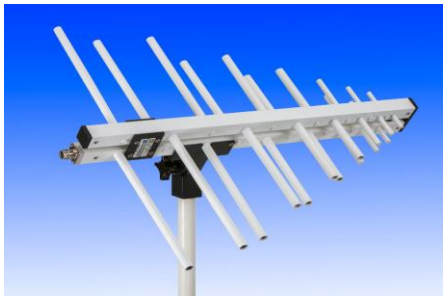
Wide bandwidth

G9D07

Which of the following describes a log-periodic antenna?

Element length and spacing vary logarithmically along the boom

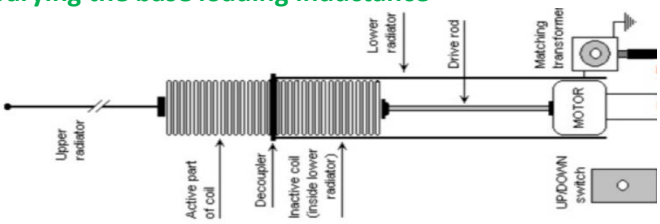




G9D08

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

By varying the base loading inductance



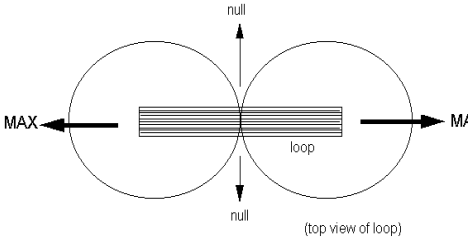
G9D09

What is the primary use of a Beverage antenna? **Directional receiving for low HF bands**

A Beverage antenna consists of a horizontal wire from one-half to several wavelengths long suspended a short distance above the ground, with the feedline to the receiver attached to one end, and the other end of the Beverage terminated through a resistor to ground. The antenna has a unidirectional radiation pattern with the main lobe of the pattern at a shallow angle into the sky off the resistor-terminated end, making it ideal for reception of long distance skip transmissions from stations over the horizon which reflect off the ionosphere.

G9D10

In which direction or directions does an electrically small loop (less than 1/3 wavelength in circumference) have nulls in its radiation pattern? **Broadside to the loop**

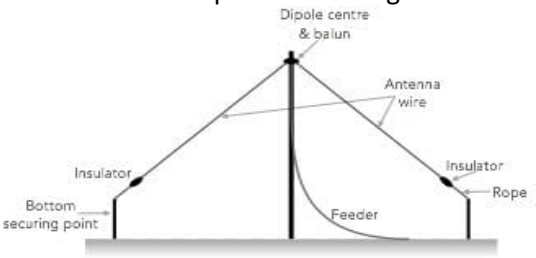


G9D11

Which of the following is a disadvantage of multiband antennas? **They have poor harmonic rejection**

G9D12

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



G9D13

What is the combined vertically and horizontally polarized radiation pattern of a multi-wavelength, horizontal loop antenna? **Virtually omnidirectional with a lower peak vertical radiation angle than a dipole**

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

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

G0A01
What is one way that RF energy can affect human body tissue? **It heats body tissue**

G0A02
Which of the following is used to determine RF exposure from a transmitted signal?
A. Its duty cycle
B. Its frequency
C. Its power density
D. All these choices are correct
You can use the ARRL Exposure Calculator at http://arrl.org/rf-exposure-calculator :

ARRL RF Exposure Example

Power at Antenna: (Need help with this?) 100 (watts)

- Mode duty cycle:

Conversational SSB, no speech processing (mode duty cycle=20%)

- Transmit duty cycle: (time transmitting)

You transmit for 5 minutes then receive for 10 minutes (and repeat).

- Antenna Gain (dBi): (Need help with this?) 3
- Operating Frequency (MHz): 15

☑ Include Effects of Ground Reflections

Calculate

Results for a controlled environment:

Maximum Allowed Power Density (mw/cm²): 4.0000
Minimum Safe Distance (feet): 1.3502
Minimum Safe Distance (meters): 0.4115

For an uncontrolled environment:

Maximum Allowed Power Density (mw/cm²): 0.8000
Minimum Safe Distance (feet): 1.9095
Minimum Safe Distance (meters): 0.5820

G0A03 [97.13(c)(1)]
How can you determine that your station complies with FCC RF exposure regulations?
A. By calculation based on FCC OET Bulletin 65
B. By calculation based on computer modeling
C. By measurement of field strength using calibrated equipment
D. All these choices are correct

G0A04
What does "time averaging" mean when evaluating RF radiation exposure?
The total RF exposure averaged over a certain period

G0A05 [97.13(c)(2), 1.1307(b)]
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

G0A06 [97.13(c)(2), 1.1307(1)(b)(3)(i)]
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

G0A07
What is the effect of modulation duty cycle on RF exposure?
A lower duty cycle permits greater power levels to be transmitted

G0A08 [97.13(c)(2)]
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

G0A09
What type of instrument can be used to accurately measure an RF field strength?
A calibrated field strength meter with a calibrated antenna

G0A10
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

G0A11
What precaution should be taken if you install an indoor transmitting antenna?
Make sure that MPE limits are not exceeded in occupied areas
MPE Limits can be found online and in the ARRL Publication RF Exposure and You. Tables can also be found online by searching for "Amateur Radio MPE Limits"

G0A12 [1.1307(1)(b)(3)(i)(A)]
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

G0B01
Which wire or wires in a four-conductor 240 VAC circuit should be attached to fuses or circuit breakers?
Only the hot wires

G0B02
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**
14-gauge wire - 15 amperes
12-gauge wire - 20 amperes
10-gauge wire - 30 amperes
8-gauge wire - 40 amperes

G0B03
Which size of fuse or circuit breaker would be appropriate to use with a circuit that uses AWG number 14 wiring? **15 amperes**

G0B04
Where should the station's lightning protection ground system be located?
Outside the building

G0B05
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

G0B06
Which of the following is covered by the National Electrical Code? **Electrical safety of the station**

G0B07
Which of these choices should be observed when climbing a tower using a safety harness?
2Confirm that the harness is rated for the weight of the climber and that it is within its allowable service life

G0B08
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

G0B09
Which of the following is true of an emergency generator installation?
The generator should be operated in a well-ventilated area

G0B10
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

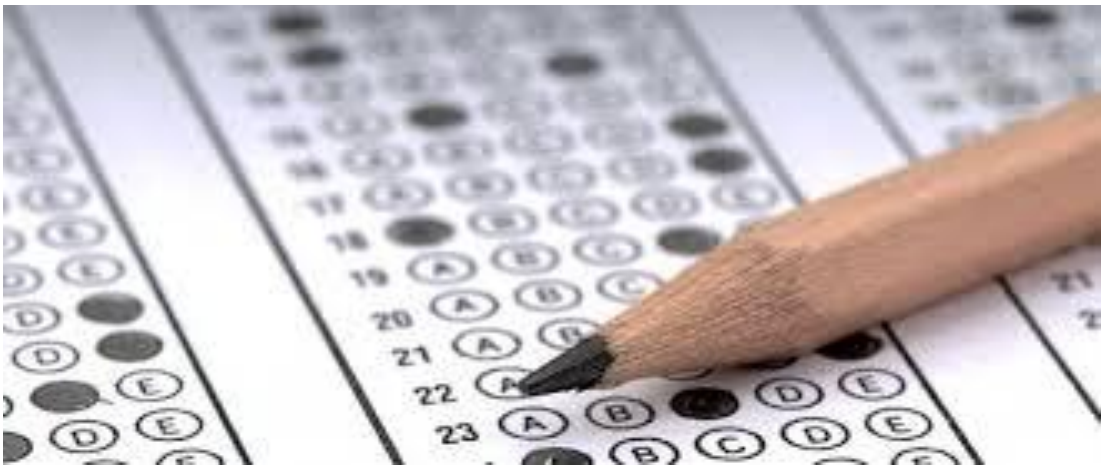
G0B11
Which of the following is required for lightning protection ground rods?
They must be bonded together with all other grounds

G0B12
What is the purpose of a power supply interlock?
To ensure that dangerous voltages are removed if the cabinet is opened

G0B13
Where should lightning, arrestors be located? **Where the feed lines enter the building**

WE HAVE REACHED THE END OF THE CLASS

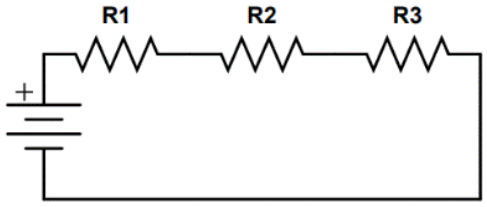
IT IS NOW TIME TO PREPARE FOR AND TAKE THE EXAM



Appendix of Useful information

Series and parallel resistors

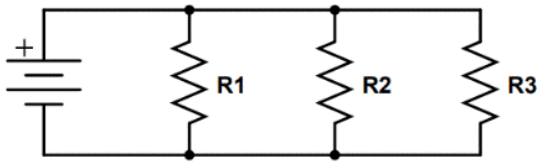
Resistors in Series



RESISTANCE TOTAL = R1+R2 + R3

NOTE: THE RESISTANCE WILL ALWAYS BE GREATER THAN THE LARGEST VALUE RESISTOR

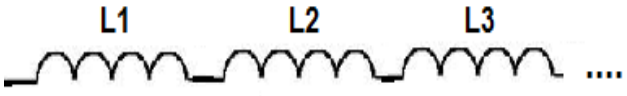
Resistors in Parallel



RESISTANCE TOTAL WILL ALWAYS BE LESS THAN THE LOWEST VALUE RESISTOR IN THE NETWORK

$$\frac{1}{Rt} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$

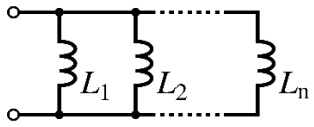
Series Inductances



$L_{total} = L1 + L2 + L3 \ldots\ldots$

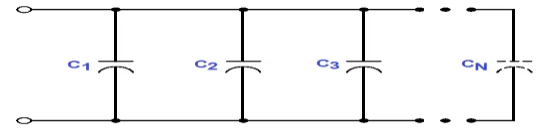
Parallel Inductance

$$L_{total} = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \ldots \frac{1}{L_n}}$$



Parallel Capacitors

$$C_{total} = C_1 + C_2 + \ldots C_n$$



Series Capacitors

$$\frac{1}{C_{Tot}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_{N-1}} + \frac{1}{C_N}$$

Calculating dB from power ratio:

dB = 10 (log (P1/P2))

Example: dB =10 (log (5/10)) or 10(log (.5)) or 10 (-.301) or -3 dB
dB =10 (log (10/5)) or 10(log (2)) or 10 (.301) or +3 dB

Calculating dB from voltage ratio: ***dB = 20 (log (V1/V2))***

Example: dB =20 (log (5/10)) or 20(log (.5)) or 20 (-.301) or -6 dB
dB =20 (log (10/5)) or 20(log (2)) or 20 (.301) or +6 dB

Calculating power ratio from dB: ***Ratio = 10^(dB/10)***

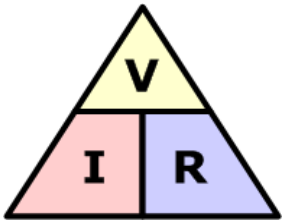
Example: Ratio = 10^(dB/10) or 10^ (3/10) or 10^ (.3) or 1.9999
Ratio = 10^(dB/10) or 10^ (-3/10) or 10^ (-.3) or 0.50

Calculating voltage ratio from dB: ***Ratio = 10^(dB/20)***

Example: Ratio = 10^(dB/20) or 10^ (6/20) or 10^ (.3) or 1.9999
Ratio = 10^(dB/20) or 10^ (-3/20) or 10^ (-.3) or .50

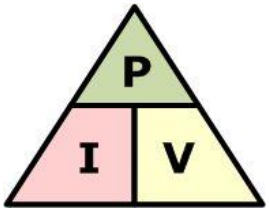
Note: to solve for a negative exponent press 10^x key to see *10^( )* the press the **+/- key** to see 10^ (-) then **enter -.3** to see 10^ (-.3) then press the **enter/=** key to see the answer **.501**

Triangles



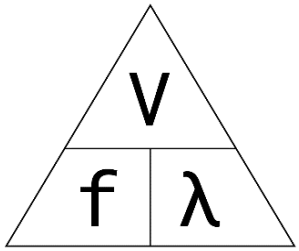
Ohms Law Triangle

V = Voltage in Volts
I = Current in Amperes
R= Resistance in Ohms



Power Law Triangle

V = Voltage in Volts
I = Current in Amperes
P = Power in Watts



Wavelength Triangle

V = Velocity of Light (300,000,000 meters per second)
f = Frequency in Hz
λ= Wavelength in Meters

Decibel Calculations:

By Calculation:

dB = 10 (log(P1÷P2)) or dB= 10(log (10÷5)) or dB= 10(log (2)) or dB= 10 (.3010) or dB= 3.01

By using the table

+	dB	-
2 x	3	.5 x
10 x	10	.1 x

One half wavelength in feet:

One Half wavelength= 468÷ Frequency in Mega Hertz

One Half Wave length in Inches:

One Half wavelength= (492 ÷ Frequency in Mega Hertz) x (12)

Commonly used Q signals

Q-Code	Used as a Question	Used as a Statement
QRA	What is the name of your station?	My name is ...
QRB	How far approximately are you from my station?	The distance between our stations is about ... your nautical miles (or kilometers).
QRG	What is my exact frequency?	Your exact frequency is ... kHz (Or MHz).
QRK	What is the intelligibility of my signals?	The intelligibility of your signals is ... (scale of 1 to 5).
QRL	Are you busy?	I'm busy Please do not interfere.
QRM	Are you bothered by noise?	I am disturbed by interference.
QRN	Are you bothered by noise of natural origin (storms, lightning)?	I am disturbed by natural origin noise
QRO	Shall I increase transmitter power?	Increase (or increase) the transmission power.
QRP	Shall I decrease transmitter power?	Decrease the transmission power.
QRQ	Shall I send faster?	Increase the transmission speed [... Words per minute].
QRS	Shall I send more slowly?	Send more slowly [... Words per minute].
QRT	Shall I stop transmissions?	Close (or I close) transmissions.
QRV	Are you ready?	I'm ready.
QRX	When you call me again?	I'll get back at ... on ... kHz (or MHz).
QRZ	Who is calling me?	You are called by ... on ... kHz (or MHz).
QSA	What is the strength of my signals?	The strength of your signals is ... (Scale from 1 to 5).
QSB	Does my signal strength fade?	The strength of your signals varies.
QSK	Can you hear me? If so, can I interrupt you?	I hear you, speak up.
QSL	Can you receive?	Confirmed, received.
QSO	Can you communicate with ... directly or through support?	I can communicate with ... directly NOTE: It is also synonymous of direct communication or direct connection.