

Download the Ham Radio Prep

MOBILE APP

Unlimited Practice Tests & Quizzes
Video Lessons • Progress Tracking



How to download:

1. Visit our website here

<https://hamradioprep.com/mobile-apps/>

2. Scan the QR code or search for "Ham Radio Prep" on the app store



Online Course Coupon Code

Coupon code valid for **20% off** all online programs:

To Redeem:

1. Visit www.HamRadioPrep.com/pricing
2. At checkout, click on the “Have a coupon?” button and enter the following code
3. Click “Apply”

Your Coupon Code:

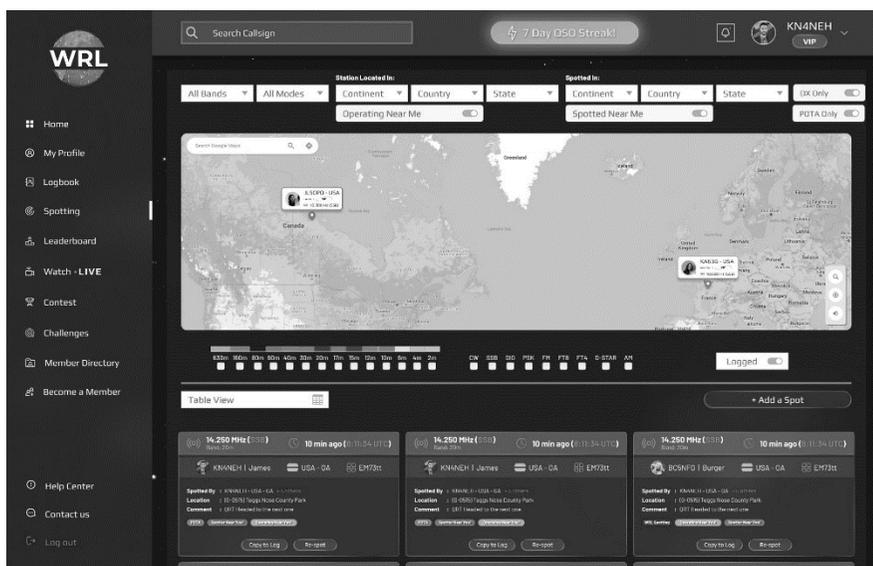


Log your contacts and join the fun!

Ham radio is more than just getting licensed - it's about getting active on the air and learning something new every day.

That's why you should check out the World Radio League:

- General logbook (perfect for POTA)!
- Instructional videos
- Network with other hams in your area
- And much more!



The screenshot displays the WRL website interface. At the top, there is a search bar for callsigns and a notification for a "7 Day DSO Streak!". Below this, there are filters for "Station Located In" (Continent, Country, State) and "Spotted In" (Continent, Country, State). A map of the United States is shown with several call signs marked, including K5SPD and K4R5S. Below the map, there are various radio modes and bands listed, such as 630, 800, 830, 880, 930, 990, 1200, 1300, 1430, 1710, 1810, 2400, 2810, 29.7, CW, USB, CQ, PSK, FT8, FT4, FT1, S-Star, and A1. A "Logged" button is visible. Below the map, there is a "Table View" section with a grid of logbook entries. Each entry shows the frequency (14.250 MHz), time (10 min ago), and call sign (K4R5S, K4R5S, B0SNF0). The entries include details like "Spotted by", "Location", and "Comment".

Start for FREE at www.WorldRadioLeague.com

THE HAM RADIO PREP

**Technician
Class License
Manual**

2022 - 2026

Copyright © 2025 by Ham Radio Prep

All rights reserved. No part of this publication may be reproduced, distributed, or transmitted in any form or by any means, including photocopying, recording, or other electronic or mechanical methods, without the prior written permission of the publisher, except in the case of brief quotations embodied in critical reviews and certain other noncommercial uses permitted by copyright law. For permission requests, write to the publisher, addressed "Attention: Permissions Coordinator," at the address below.

1309 Coffeen Ave Ste 1956
Sheridan, WY 82801

Or visit: www.HamRadioPrep.com

Ordering Information:

Special discounts are available on quantity purchases by corporations, associations and others. For details, contact the publisher at the address below.

Email: contact@HamRadioPrep.com

Printed in the United States of America

ISBN: 9798840563335

Imprint: Independently published

“This book is dedicated to Valentina. Thank you for being there every step of the way, without your support, this book would not have been possible.”

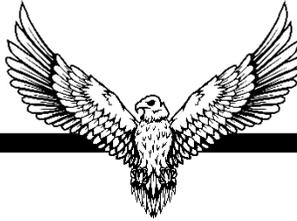
- James

“To my dad, my original BFR, and all the family members who support and inspire us.”

- Jim

DISCLAIMER

You must have an amateur radio license from the Federal Communications Commission to transmit on any amateur radio frequencies. Transmitting without a license can result in heavy fines and/or imprisonment. This book is intended to help you pass your license exam and is not meant to serve as an operator's manual. Ham Radio Prep or World Radio League Inc. are not liable for your on-air operations. For correct operation please refer to Part 97 of the FCC rules.



 HAM RADIO PREP

Operators Creed

Licensed amateur radio operators play an important role in our nation and world. They :

Operate on the air legally and follow Federal Communications Commission rules and side agreements that allow others to use the airwaves or furtherance of the hobby.

Use their radio equipment and stations in a way that benefits themselves as a hobby but also their community and nation, and even worlds. Amateur radio is valuable resource that always must be put to good use for the benefit of all.

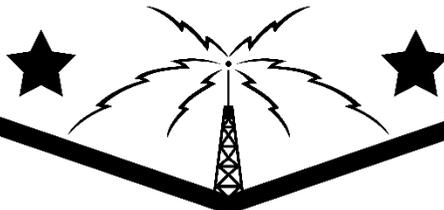
Utilize spectrum efficiently and properly so that amateur radio has a presence throughout the spectrum to ensure frequencies are available for generations of new amateurs to come.

Embrace emerging technologies and digital standards and platforms so that they are advancing the art of amateur radio by being on the air.

Respect fellow amateurs on the air and ensure that amateur radio frequencies are a welcoming place for all to gather, no matter their background.

Prepare others to learn the science and art of amateur radio so that we always are increasing our ranks to ensure that our spectrum is utilized as much as possible.

Use the hobby to learn not only more about science and technology, but also our family and neighbors.



©

Contents

Lesson 1: Introduction to Amateur Radio	1
Lesson 2: Talking on Ham Radio.....	11
Lesson 3: Restrictions and Band Basics	24
Lesson 4: Operating, Repeaters, and Emergencies.....	37
Lesson 5: Calling Another Station	56
Lesson 6: Squelch, Net Operations, and RACES	70
Lesson 7: Basic Concepts of Radio Waves.....	83
Lesson 8: Introduction to the Atmosphere.....	94
Lesson 9: Station Setup, SWR, and Using Computers	107
Lesson 10: Basic Electrical Concepts	123
Lesson 11: Ohm's Law & Calculating Power	136
Lesson 12: Units of Measurement.....	147
Lesson 13: Intro to Electrical Components.....	157
Lesson 14: Amplifiers and Devices	170
Lesson 15: SWR and Common Problems.....	186
Lesson 16: Modes of Operation.....	200
Lesson 17: Digital Modes.....	213

Lesson 18: Satellite, Space, and Contesting.....	226
Lesson 19: Antennas.....	238
Lesson 20: Cables and Tuning.....	251
Lesson 21: Electrical and Radiation Safety	260
Lesson 22: Antenna and Tower Safety	274
Practice Exam.....	281
Answer Keys	295
Official Technician License Question Pool w/ Explanations	297
Scheduling and Taking Your Exam	377
Resources.....	389

Helpful links and Resources

Full Online Course: <https://hamradioprep.com>

Band Plan: <https://hamradioprep.com/band-plans/>

Online Testing Information:

<https://hamradioprep.com/ham-radio-license-test-online/>

Scheduling an Exam:

<https://hamradioprep.com/schedule-an-exam/>

Why do you need a ham license?:

<https://hamradioprep.com/why-do-you-need-a-ham-radio-license/>

How to Register for your FRN:

<https://hamradioprep.com/how-to-register-for-your-frn/>

Thank you and welcome!



HAM RADIO PREP

Thank you for purchasing the Ham Radio Prep Technician License manual. This book has been carefully constructed using years of development to help you pass your ham radio license exam easily.

We founded Ham Radio Prep in 2017, when a group of aspiring ham radio operators went to get our ham radio licenses. We found that all of the materials were too confusing, too long, too boring, and we were NEVER going to be able to get our licenses.



As it turns out, a lot of other people felt the same way. And this was preventing many Americans from taking the first step of getting into ham radio - which we believe is critical for independent communications, public service, STEM education, and more.

So, with almost no money in our pockets, we decided to create a new program to make getting your ham radio license FAST, EASY, and FUN!



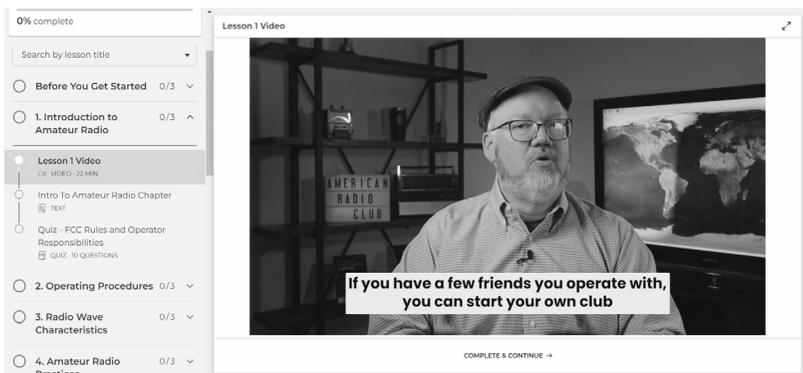
It's been a lot of blood, sweat and tears since 2017 when we started the program, but we can now happily say, Ham Radio Prep is the most popular program in the world for studying for your ham radio license. We've had over 60,000 students use our program to pass their ham radio license tests. We've used all of the proceeds of every purchase to continue to improve our program and support our students.

As a token of our appreciation, we would like to share a coupon code with you for any of our online programs.

If you have already used our online program, feel free to share this with a friend, or many friends! Share the love and let's get more folks licensed and on the air.

Of course, this book works great on its own - it has been carefully designed to cover the full question pool and you will pass the exam successfully.

However, the online course adds in video with animations, games, and a full interactive media experience.



This helps reinforce the concepts for different learning styles, and you also have extra benefits like unlimited practice tests. If you enjoy learning through video as well as a multimedia program, we encourage you to check it out!

You can even try a free lesson at
www.HamradioPrep.com to see what our online
program is all about.

Need additional support?

See an error that needs to be corrected?

Please reach out to our student success team at support@hamradioprep.com for any assistance you may need at all!

Accuracy of material is crucial to the success of any learning program, and Ham Radio Prep is no exception. We take errors very seriously, one of our agents will reach out to you within one business day of when you submitted the ticket for any follow up necessary.

We greatly appreciate your help in making Ham Radio Prep the best it can be!

Follow us on social media:

www.facebook.com/HamRadioPrep

www.linkedin.com/hamradioprep

www.tiktok.com/@hamradioprep

www.twitter.com/HamPrep

www.instagram.com/HamRadioPrep

www.reddit.com/user/HamRadioPrep

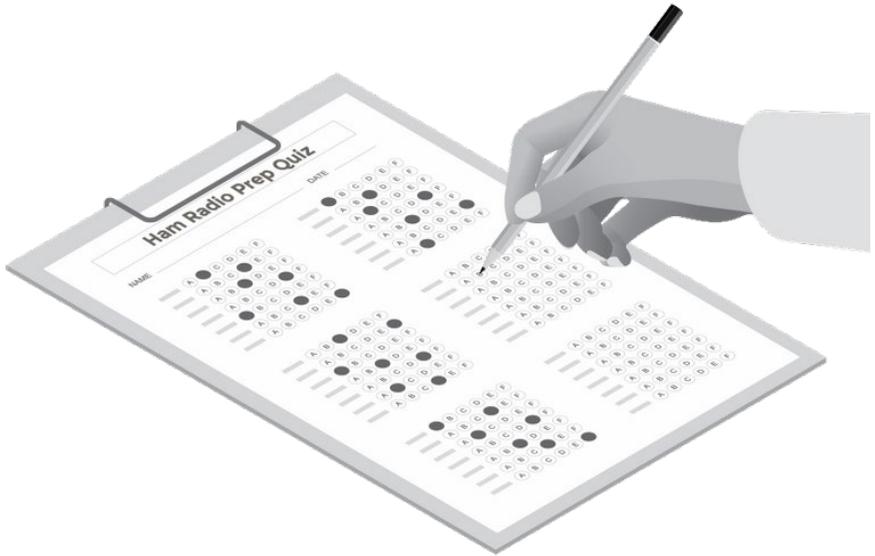
www.youtube.com/c/HamRadioPrep



How to use this book

Each chapter in this book was written to give context and understanding to the questions in the FCC Technician license exam pool.

At the end of each chapter, you will find a quiz to review the information you just learned. Use a pencil to mark the answer you think is correct.



Check your work using the answer keys located in the back of the book.

At the end of Chapter 22, you will find a full-length practice exam. Our quizzes and practice

exam use the exact same questions as on the official FCC exam. Although the actual questions may vary, the number of questions derived from each section follows the same requirements as the FCC exam.

Again, using a pencil to mark the answer you think is correct, you will be able to check your work with the answer key. You need to answer at least 26 questions, or 74 percent correct, on your actual FCC exam. Thus, you will want to score 80 percent or greater on your practice exam with Ham Radio Prep so that you feel comfortable going into your test day to attain at least a 74 percent passing grade!

Before you get started



These are the correct answers directly from the FCC question pools.



My brain is only a receiver,
in the universe there is a
core from which we obtain
knowledge, strength and
inspiration.



- Nikola Tesla

Lesson 1: Introduction to Amateur Radio

The FCC and Part 97

The Federal Communications Commission regulates the airwaves in the United States; we call them the FCC. The FCC **enforces the rules** for all types of radio and TV, including your local stations.



For ham radio, officially called the Amateur Radio Service, the rules are outlined in Part 97 of

the Code of Federal Regulations. FCC Part 97 can be found for free online. Since you are expected to know the rules, we added a link at the end of this course so you can download it to use as a reference.

According to the FCC, the basis and purpose of the Amateur Radio Service is **advancing skills in the technical and communication phases of the radio art.**

The key word here is **art** — amateur radio is both a practical skill and an art!

Getting Licensed and Receiving a Call Sign

The three levels of new licenses currently available from the FCC are **Technician, General and Amateur Extra**. You must pass each exam in order, starting with Technician.

Once you pass your Technician exam, the FCC will grant your call sign as part of your... get ready for this term... “operator/primary station license.” You can prove you have your license

because the control operator's operator/primary station license must appear in the FCC ULS consolidated licensee database. Each person can have only one amateur radio license, and they are good for 10 years.

	<p>UNITED STATES OF AMERICA FEDERAL COMMUNICATIONS COMMISSION AMATEUR RADIO LICENSE AAIRC</p>		
AMERICAN RADIO CLUB EMPLOYEES SOCIETY			
FCC Registration Number (FRN): 0031900608			
Special Conditions / Endorsements			
NONE			
Grant Date	Effective Date	Print Date	Expiration Date
02-18-2022	02-18-2022	02-18-2022	02-18-2032
File Number	Operator Privileges		Station Privileges
0009891791	Amateur Extra		CLUB
THIS LICENSE IS NOT TRANSFERABLE			
<p>_____</p> <p>(Licensee's Signature)</p>			
FCC 660 - August 2021			

You will be told immediately after your exam whether you passed, and you can start operating

as soon as **your operator/station license grant appears in the FCC's license database**, but not until then!

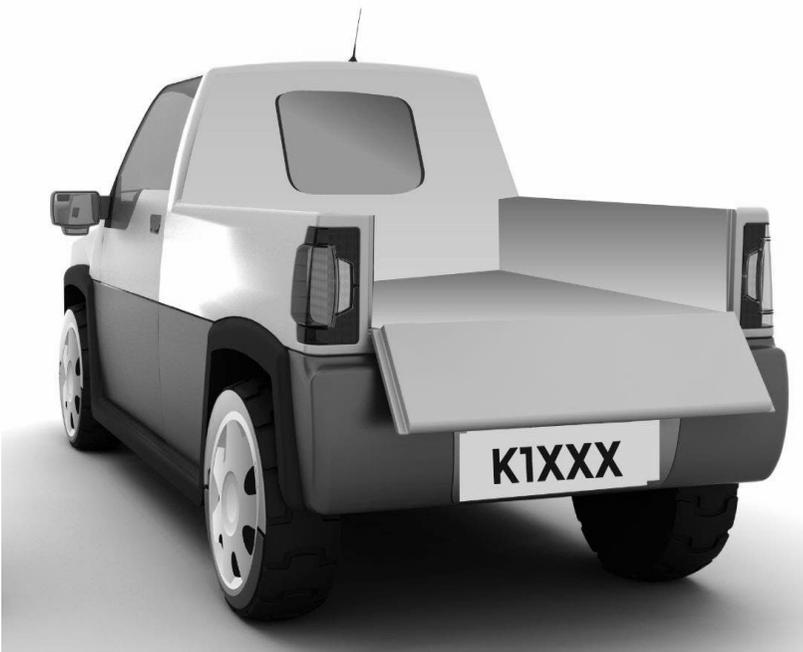
On your new license, you will see an assigned call sign. The FCC will give you a unique group of letters with a number that you use to identify yourself on the air.

Your first call sign probably will be a 2-by-3 call sign. This means 2 letters, then a number, then 3 more letters. For example, **KF1XXX** – is a valid Technician License because it meets the 2 x 3 format.

Amateur Radio Call Signs

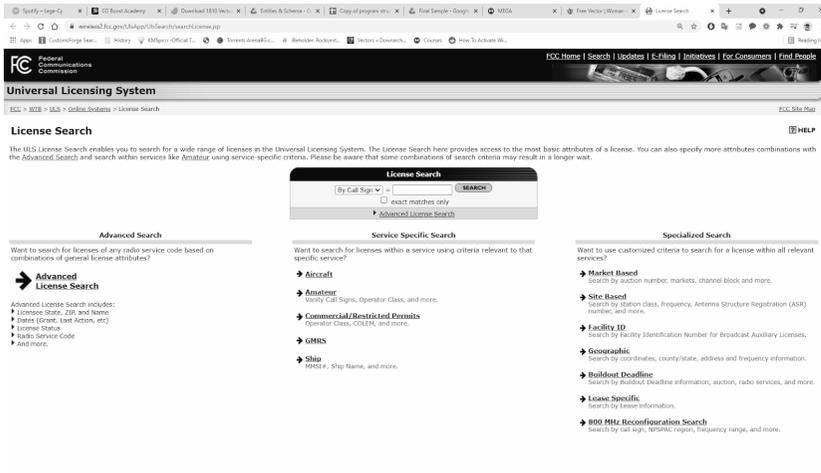
KE **8** **XXX**
⏟ ⏟ ⏟
2 X 3

Once you receive the call sign you are issued, **any licensed amateur** is eligible for a personalized, or vanity call sign, if that call is available. Technicians can request a vanity callsign in the 1-by-3 format, too, like K1XXX.



Within the rules for vanity call signs, you can use your initials, nickname or any other letters with a number that has meaning to you. Numbers are generally assigned by geographic region, but with a vanity call sign you can choose to have a call sign from a different number region. There are additional fees for vanity call signs.

Let's focus on the **FCC database**, which you can check online at any time.



The database is an authoritative source for your license. Which means if it's valid there, you can operate, and if it's not, you can't.

You don't have to worry about renewals and updates right away, but let's make sure you know. If after your 10 year term your license shows as expired in the database you have a grace period of **two years** to renew it. If your license shows as expired, **transmitting is not allowed until the FCC license database shows that the license has been renewed.**

If you are a Technician and you miss the grace period, you must retake the exam.

The FCC requires that while you are licensed, you must keep your email address updated in the FCC database. **Failure to provide and maintain a correct email address with the FCC** means you can have your license suspended or revoked.

If you have a few friends you operate with, you can start your own club. A club station license requires that **the club must have at least four members.**

Chapter 1 Quiz:

- 1) Which of the following is part of the Basis and Purpose of the Amateur Radio Service?
 - a. Providing personal radio communications for as many citizens as possible
 - b. Providing communications for international non-profit organizations
 - c. Advancing skills in the technical and communication phases of the radio art
 - d. All these choices are correct

- 2) How soon after passing the examination for your first amateur radio license may you transmit on the amateur radio bands?

- a. Immediately on receiving your Certificate of Successful Completion of Examination (CSCE)
 - b. As soon as your operator/station license grant appears on the ARRL website
 - c. As soon as your operator/station license grant appears in the FCC's license database
 - d. As soon as you receive your license in the mail from the FCC
- 3) What is the grace period for renewal if an amateur license expires?
- a. Two years
 - b. Three years
 - c. Five years
 - d. Ten years
- 4) Which of the following is a requirement for the issuance of a club station license grant?
- a. The trustee must have an Amateur Extra Class operator license grant
 - b. The club must have at least four members
 - c. The club must be registered with the American Radio Relay League
 - d. All these choices are correct
- 5) Which of the following is a valid Technician class call sign format?
- a. KF1XXX
 - b. KA1X
 - c. W1XX
 - d. All these choices are correct
- 6) What is the normal term for an FCC-issued amateur radio license?

- a. Five years
 - b. Life
 - c. Ten years
 - d. Eight years
- 7) Which agency regulates and enforces the rules for the Amateur Radio Service in the United States?
- a. FEMA
 - b. Homeland Security
 - c. The FCC
 - d. All these choices are correct
- 8) For which license classes are new licenses currently available from the FCC?
- a. Novice, Technician, General, Amateur Extra
 - b. Technician, Technician Plus, General, Amateur Extra
 - c. Novice, Technician Plus, General, Advanced
 - d. Technician, General, Amateur Extra
- 9) Who may select a desired call sign under the vanity call sign rules?
- a. Only a licensed amateur with a General or Amateur Extra Class license
 - b. Only a licensed amateur with an Amateur Extra Class license
 - c. Only a licensed amateur who has been licensed continuously for more than 10 years
 - d. Any licensed amateur
- 10) Which of the following can result in revocation of the station license or suspension of the operator license?

- a. Failure to inform the FCC of any changes in the amateur station following performance of an RF safety environmental evaluation
- b. Failure to provide and maintain a correct email address with the FCC
- c. Failure to obtain FCC type acceptance prior to using a home-built transmitter
- d. Failure to have a copy of your license available at your station

Answers to this quiz are located in the answer key at the end of the book.

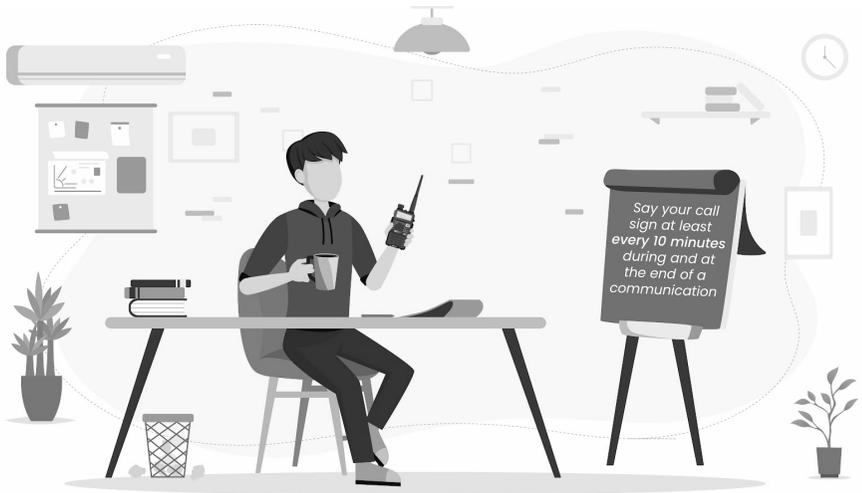
Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Lesson 2: Talking on Ham Radio

Talking on Ham Radio

You just received your call sign, let's make sure you use it properly on the air. An amateur station is required to transmit its call sign **at least every 10 minutes during and at the end of a communication.**



You may decide to help out with a community event like a bike race. For a community service

communications net, ham radio operators may use a special call sign called a “tactical identifier” like “Race Headquarters.” The call sign identification rule does not change in this situation – you must transmit your FCC call sign **at the end of each communication and every 10 minutes during a communication.**

Have you heard of the ITU Phonetic Alphabet? It’s a way of converting letters to words, so “K” becomes “Kilo.” The FCC says its use **is encouraged** when identifying your call sign on the air. Our callsign of AA1RC would be “Alpha Alpha One Romeo Charlie.” It makes it easier for other stations to understand and helps distinguish letters that may sound the same like “J” and “A.”

Phonetic Alphabet

A lpha	J uliet	S ierra
B ravo	K ilo	T ango
C harlie	L ima	U niform
D elta	M ike	V ictor
E cho	N ovember	W hiskey
F oxtrot	O scar	X ray
G olf	P apa	Y ankee
H otel	Q uebec	Z ulu
I ndia	R omeo	



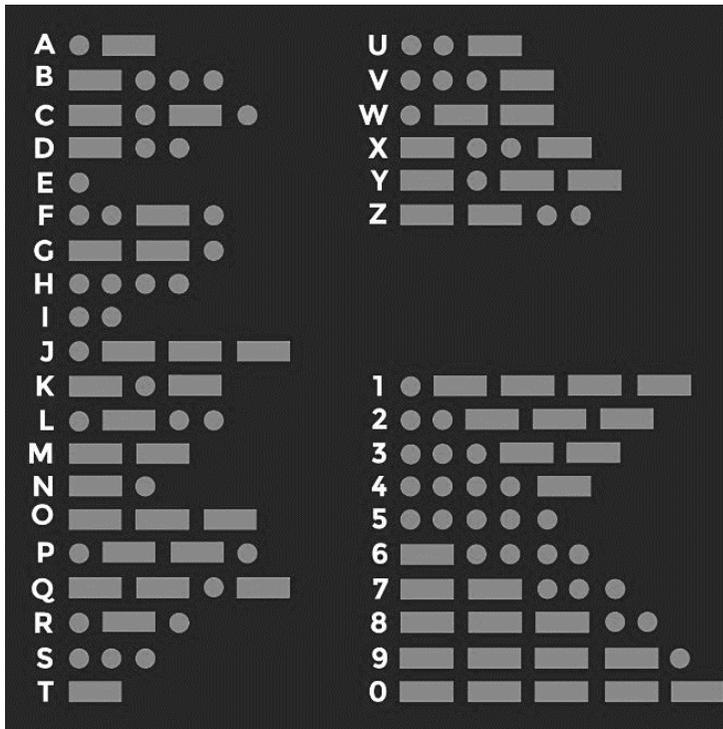
HAM RADIO PREP

In the United States and its territories, **the English language** is the only acceptable language to use for station identification when operating in a phone sub-band.

Two quick things to cover here. While you must give your call sign to identify your station in English, you can talk in whatever language you

like for the rest of the conversation. Also, let's take the confusion out of the term "phone." Think of it as "telephone," or voice communications. We leave it as "phone" in the course because that's the way it appears in the questions on the exam.

You've probably heard the term Morse code, but not the term CW. CW stands for Continuous Wave and is a way to transmit Morse code. It sounds like a single tone, either long or short, that can be used to transmit letters or numbers.



It is also acceptable to send your call sign via Morse code even if you are in a phone area of the band. This gives you options to identify, send **the call sign using a CW or phone emission.**

Here's another term for you, think of "emission" as a signal transmission.

So, you have a call sign from one part of the country, let's use KL7CC in Alaska, but you want to identify that you're operating from another part of the country, like Pennsylvania, which is

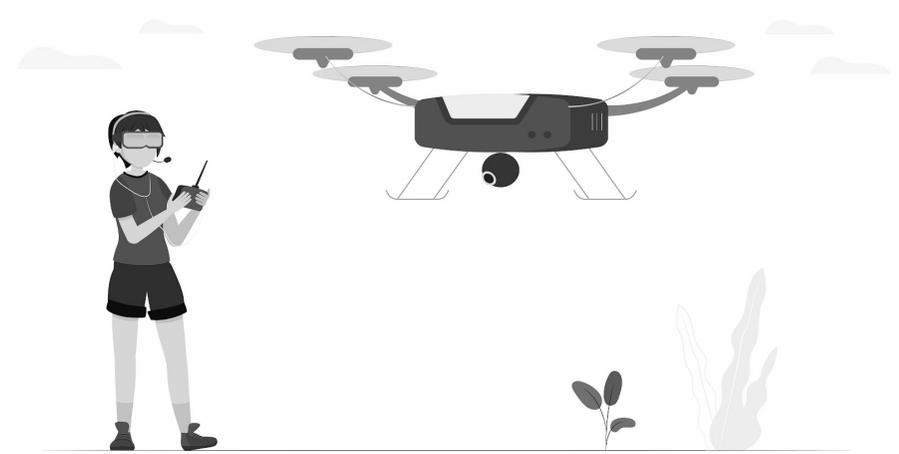
in call sign area 3. You can add a self-assigned indicator to help avoid confusion. It's usually a slash after your call sign with a number and letter. In the case of KL7CC, adding a "slash W3," or /3, to would tell hams they are out of their Alaska call area right now.

Which of the following self-assigned indicators are acceptable when using a phone transmission?

- KL7CC stroke W3
- KL7CC slant W3
- KL7CC slash W3
- **All these choices are correct**

In ham radio, "stroke," "slant" and "slash" all have the same meaning here.

One really cool way to use your ham radio license is to control drones, planes, and other model craft. Because you do this without a voice signal, you get an exception on station identification. **When transmitting signals to control model craft** such as boats, cars and drones, amateurs do not need to identify.



What can you say on ham radio?

Let's start with the FCC definition which is, locally or internationally, licensed amateur radio operators can make **communications incidental to the purposes of the Amateur Radio Service and remarks of a personal character.**

You'll hear hams saying hi, talking about the weather, giving an opinion on a new radio or dozens of other kinds of small talk, all of which are considered "remarks of a personal character."

This next group of rules are about third-party communications. Let's start with the definition of this. Third-party communications means **a message from a control operator to another amateur station control operator on behalf of another person (a third party).**



Think of third-party communication as exchanging family messages out of a flood zone. The messages that hams would pass are for other people, third parties.

Here's another level of complexity on international third-party communications. If the stations we're talking about are in Texas and Morocco for example, and they are talking, when

the non-licensed person is operating a station under the control of an amateur control operator, **the foreign station must be in a country with which the U.S. has a third-party agreement.**

Third party communications can be really rewarding, but read up more closely on the rules if you plan to do this type of ham radio operation.

Lesson 2 Quiz:

- 1) When are you required to transmit your assigned call sign?
 - a. At the beginning of each contact, and every 10 minutes thereafter
 - b. At least once during each transmission
 - c. At least every 15 minutes during and at the end of a communication
 - d. At least every 10 minutes during and at the end of a communication
- 2) What do the FCC rules state regarding the use of a phonetic alphabet for station identification in the Amateur Radio Service?
 - a. It is required when transmitting emergency messages
 - b. It is encouraged
 - c. It is required when in contact with foreign stations
 - d. All these choices are correct

- 3) What method of call sign identification is required for a station transmitting phone signals?
 - a. Send the call sign followed by the indicator RPT
 - b. Send the call sign using a CW or phone emission
 - c. Send the call sign followed by the indicator R
 - d. Send the call sign using only a phone emission
- 4) When may an amateur station transmit without identifying on the air?
 - a. When the transmissions are of a brief nature to make station adjustments
 - b. When the transmissions are unmodulated
 - c. When the transmitted power level is below 1 watt
 - d. When transmitting signals to control model craft
- 5) What is the definition of third party communications?
 - a. A message from a control operator to another amateur station control operator on behalf of another person
 - b. Amateur radio communications where three stations are in communications with one another
 - c. Operation when the transmitting equipment is licensed to a person other than the control operator
 - d. Temporary authorization for an unlicensed person to transmit on the amateur bands for technical experiments
- 6) Which of the following restrictions apply when a non-licensed person is allowed to speak to a foreign

- station using a station under the control of a licensed amateur operator?
- a. The person must be a U.S. citizen
 - b. The foreign station must be in a country with which the U.S. has a third party agreement
 - c. The licensed control operator must do the station identification
 - d. All these choices are correct
- 7) What types of international communications are an FCC-licensed amateur radio station permitted to make?
- a. Communications incidental to the purposes of the Amateur Radio Service and remarks of a personal character
 - b. Communications incidental to conducting business or remarks of a personal nature
 - c. Only communications incidental to contest exchanges; all other communications are prohibited
 - d. Any communications that would be permitted by an international broadcast station
- 8) Which of the following self-assigned indicators are acceptable when using a phone transmission?
- a. KL7CC stroke W3
 - b. KL7CC slant W3
 - c. KL7CC slash W3
 - d. All these choices are correct
- 9) What language may you use for identification when operating in a phone sub-band?
- a. Any language recognized by the United Nations
 - b. Any language recognized by the ITU
 - c. English

- d. English, French, or Spanish
- 10) How often must you identify with your FCC-assigned call sign when using tactical call signs such as “Race Headquarters”?
- a. Never, the tactical call is sufficient
 - b. Once during every hour
 - c. At the end of each communication and every ten minutes during a communication
 - d. At the end of every transmission

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Lesson 3: Restrictions and Band Basics

Ham Radio Restricted Communications

It's important to consider what you cannot say when operating your ham radio. Any **indecent or obscene language is prohibited** on the air. As ham radio operators, we all have a responsibility to keep our airwaves clean and respect the hobby.



There are two terms that mean similar things but have very different implications in the FCC rules, so let's review the difference between “broadcasting” and “one-way communications”

Broadcasting means **transmissions intended for reception by the general public**. Your local TV and FM stations are broadcasters. Amateur Radio operators are not broadcasters.



A one-way transmission is something ham radio operators do for things like training and identifying band conditions via a beacon. Allowed items include **transmitting code practice, information bulletins, or transmissions necessary to provide emergency communications. Broadcasting** is a restricted one-way transmission.

The exception comes in the case of an immediate risk to public safety. Only in that condition may an amateur station transmit signals in support of broadcasting, program production or newsgathering when no other means are available. But remember this term,

“Only where such communications directly relate to the immediate safety of human life or protection of property.”



If you want to stay off the FCC’s enforcement radar, remember these two things.

Don’t ever try and block or mess with another station's transmissions! **At no time** is willful interference to other amateur radio stations is permitted.

The station records must be available for FCC inspection **at any time upon request by an FCC representative**. Don’t overthink this! If the FCC

asks for paperwork or to inspect your station, don't argue with them if they present proper credentials.

These last two items cover many of the FCC-related inquiries that happen to hams and can result in hefty fines and jail time. Following these two rules closely can save you money and hassle in the long term, and they are the right thing to do.

Commercial Restrictions

Your amateur radio license doesn't allow you to advertise when you transmit, but you can sell off your spare equipment. You can talk about selling gear **when the equipment is normally used in an amateur station and such activity is not conducted on a regular basis.**

In addition to no commercial selling, you cannot be paid to operate an amateur radio station, unless you are a teacher in class. FCC rules say that the only time an amateur operator may receive compensation for operating a station is

when the communication is incidental to classroom instruction at an educational institution.

Frequency and Band Basics

Enough with restrictions, let's talk about frequencies.

You may not know this, but your state or region has something called a “band plan.” It's a recommendation on transmit and receive channels and other parameters for auxiliary and repeater stations. Every region has a **Volunteer Frequency Coordinator recognized by local amateurs** that does this work like keeping repeaters from interfering with each other.

The amateur operators in a local or regional area can select their own frequency coordinator to be in charge of frequency assignments. A web search using your state name and “Band Plan” should help you find this quickly.

TECHNICIAN CLASS | license frequency privileges

HF

200 watts PEP maximum

80 meters	3.525 - 3.600 MHz	CW
40 meters	7.025 - 7.125 MHz	CW
15 meters	21.025 - 21.200 MHz	CW
10 meters	28.000 - 28.300 MHz	CW, RTTY/data
	28.300 - 28.500 MHz	CW, SSB

VHF

1,500 watts PEP maximum

6 meters	50.000 - 50.100 MHz	CW
	50.100 - 54.000 MHz	CW, digital, SSB, AM, FM, TV
2 meters	144.000 - 144.100 MHz	CW
	144.100 - 148.000 MHz	CW, digital, SSB, AM, FM, TV
1.25 meters	219.000 - 220.000 MHz	Point-to-point digital links - 50 watts PEP maximum, 100 kHz bandwidth
	222.000 - 225.000 MHz	CW, digital, SSB, AM, FM, TV

UHF

1,500 watts PEP maximum

70 cm	420.000 - 450.000 MHz	CW, digital, SSB, AM, FM, TV
	420.000 - 430.000 MHz	Not available for use north of Line A near Canada border
33 cm	902.000 - 928.000 MHz	CW, digital, SSB, AM, FM, TV
23 cm	1.240 - 1.300 GHz	CW, digital, SSB, AM, FM, TV
13 cm	2.300 - 2.310 GHz	CW, digital, SSB, AM, FM, TV
	2.390 - 2.460 GHz	CW, digital, SSB, AM, FM, TV

SHF

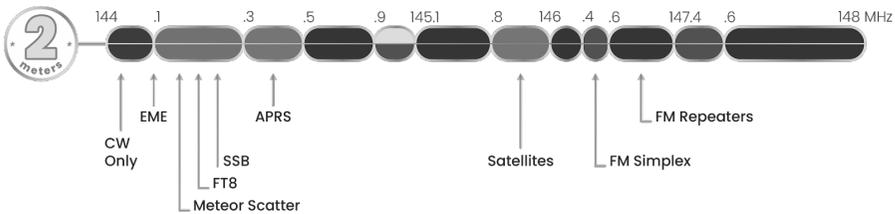
1,500 watts PEP maximum

9 cm	3.300 - 3.500 GHz	CW, digital, SSB, AM, FM, TV
5 cm	5.650 - 5.925 GHz	CW, digital, SSB, AM, FM, TV
3 cm	10.000 - 10.500 GHz	CW, digital, SSB, AM, FM, TV
1.2 cm	24.000 - 24.250 GHz	CW, digital, SSB, AM, FM, TV

EHF

1,500 watts PEP maximum

6 mm	47.000 - 47.200 GHz	CW, digital, SSB, AM, FM, TV
4 mm	76.000 - 81.000 GHz	CW, digital, SSB, AM, FM, TV
2.5 mm	122.250 - 123.000 GHz	CW, digital, SSB, AM, FM, TV
2 mm	134.000 - 141.000 GHz	CW, digital, SSB, AM, FM, TV
1 mm	241.000 - 250.000 GHz	CW, digital, SSB, AM, FM, TV
All Above	275 GHz and above	CW, digital, SSB, AM, FM, TV



When you talk about frequencies in ham radio, you can use either exact frequencies or you can refer to the band. For example:

- **52.525 MHz** is a frequency in the 6-meter band.
- **146.52 MHz** is included on the amateur **2-meter** band.

We will discuss frequencies in depth later; this is a quick item to memorize.

Morse code uses dots and slashes to communicate. Because it is so simple, it needs just a very small bandwidth to operate, so a specific frequency range is given. **50.0 MHz to 50.1 MHz and 144.0 MHz to 144.1 MHz** are limited to CW only.

Another limitation you should know: The frequencies between 219 and 220 MHz are limited for **fixed digital message forwarding systems only**.

The Technician license is great for VHF and UHF frequencies, which are higher frequency and generally used for local and regional communications. However, Technician licensees have some limited privileges on the HF (or High Frequency) bands.

With your Technician license, you will have HF phone privileges on the **10-meter band only**. Those frequencies are **28.300 MHz to 28.500 MHz**, where you are permitted to use SSB or

Single Side Band for HF voice communications as a Technician.

As a Technician, you can also use SSB on parts of the **higher frequency** VHF and above bands. Above 50 MHz, SSB can be used **in at least some segment of all of these bands.**

The maximum peak envelope power output in HF bands for Technician class operators is **200 watts**. For frequencies above 30 MHz, up to **1500 watts** may be used by Technician licensees.

There are several bands, including parts of the 70-centimeter band, that ham radio shares with other services such as the military or services in other countries. **U.S. amateurs may find non-amateur stations in those portions and must avoid interfering with them.**

You should be careful not to accidentally cross over into another band. There are many reasons not to set your transmit frequency exactly at the edge of an amateur band or sub-band:

- You could end up interfering due to calibration error

- Modulation sidebands
- Transmitter frequency drift.
- **All of these choices are correct!**

Lesson 3 Quiz:

- 1) What, if any, are the restrictions concerning transmission of language that may be considered indecent or obscene?
 - a. The FCC maintains a list of words that are not permitted to be used on amateur frequencies
 - b. Any such language is prohibited
 - c. The ITU maintains a list of words that are not permitted to be used on amateur frequencies
 - d. There is no such prohibition
- 2) How does the FCC define broadcasting for the Amateur Radio Service?
 - a. Two-way transmissions by amateur stations
 - b. Any transmission made by the licensed station
 - c. Transmission of messages directed only to amateur operators
 - d. Transmissions intended for reception by the general public
- 3) Under which of the following circumstances are one-way transmissions by an amateur station prohibited?
 - a. In all circumstances
 - b. Broadcasting
 - c. International Morse Code Practice
 - d. Telecommand or transmissions of telemetry

- 4) When may amateur stations transmit information in support of broadcasting, program production, or news gathering, assuming no other means is available?
 - a. When such communications are directly related to the immediate safety of human life or protection of property
 - b. When broadcasting communications to or from the space shuttle
 - c. Where noncommercial programming is gathered and supplied exclusively to the National Public Radio network
 - d. Never
- 5) When is willful interference to other amateur radio stations permitted?
 - a. To stop another amateur station that is breaking the FCC rules
 - b. At no time
 - c. When making short test transmissions
 - d. At any time, stations in the Amateur Radio Service are not protected from willful interference
- 6) When must the station and its records be available for FCC inspection?
 - a. At any time ten days after notification by the FCC of such an inspection
 - b. At any time upon request by an FCC representative
 - c. At any time after written notification by the FCC of such inspection
 - d. Only when presented with a valid warrant by an FCC official or government agent

- 7) When may amateur radio operators use their stations to notify other amateurs of the availability of equipment for sale or trade?
 - a. Never
 - b. When the equipment is not the personal property of either the station licensee, or the control operator, or their close relatives
 - c. When no profit is made on the sale
 - d. When selling amateur radio equipment and not on a regular basis
- 8) Who selects a Frequency Coordinator?
 - a. The FCC Office of Spectrum Management and Coordination Policy
 - b. The local chapter of the Office of National Council of Independent Frequency Coordinators
 - c. Amateur operators in a local or regional area whose stations are eligible to be repeater or auxiliary stations
 - d. FCC Regional Field Office
- 9) Except for some specific restrictions, what is the maximum peak envelope power output for Technician class operators using frequencies above 30 MHz?
 - a. 50 watts
 - b. 100 watts
 - c. 500 watts
 - d. 1500 watts
- 10) Why should you not set your transmit frequency to be exactly at the edge of an amateur band or sub-band?
 - a. To allow for calibration error in the transmitter frequency display

- b. So that modulation sidebands do not extend beyond the band edge
- c. To allow for transmitter frequency drift
- d. All these choices are correct

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Lesson 4: Operating, Repeaters, and Emergencies

Operating in Other Countries, At Sea and in Space

The FCC is in charge of radio law and enforcement in the United States and its territories while the ITU, or International Telecommunication Union, guides international communication. You cannot communicate with **any country whose administration has notified the International Telecommunications Union (ITU) that it objects to such communications.**

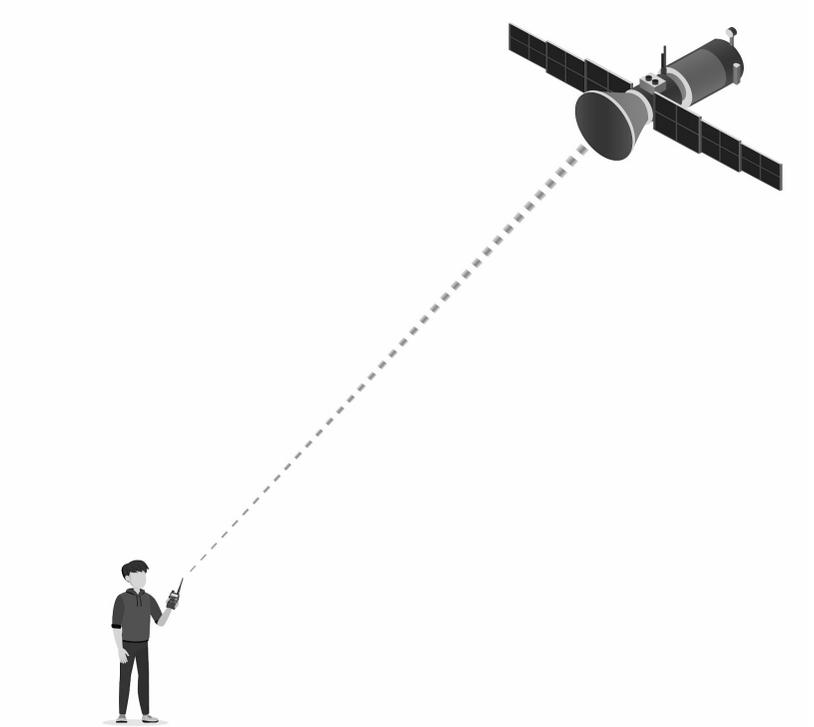


You may transmit from **any vessel or craft located in international waters and documented or registered in the United States.**

A space station is just what it sounds like, **an amateur station located more than 50 km above the Earth's surface.**

Any amateur allowed to transmit on a satellite uplink frequency can communicate through an

amateur satellite or space station, and many of these fall in the Technician class frequencies.



The Technician license lets you talk to astronauts in space, too. **Any amateur holding a Technician or higher class license** can make contact with the International Space Station (ISS) on VHF bands.



Here's another rule about what you can and can't do on ham radio. Transmitting encoded or encrypted messages that hides their meaning is only allowed in a special case: **transmitting control commands to space stations or radio**

control craft. Transmitting music is normally not allowed, but there is one exception. You also can transmit music only when **incidental to an authorized retransmission of manned spacecraft communications.**

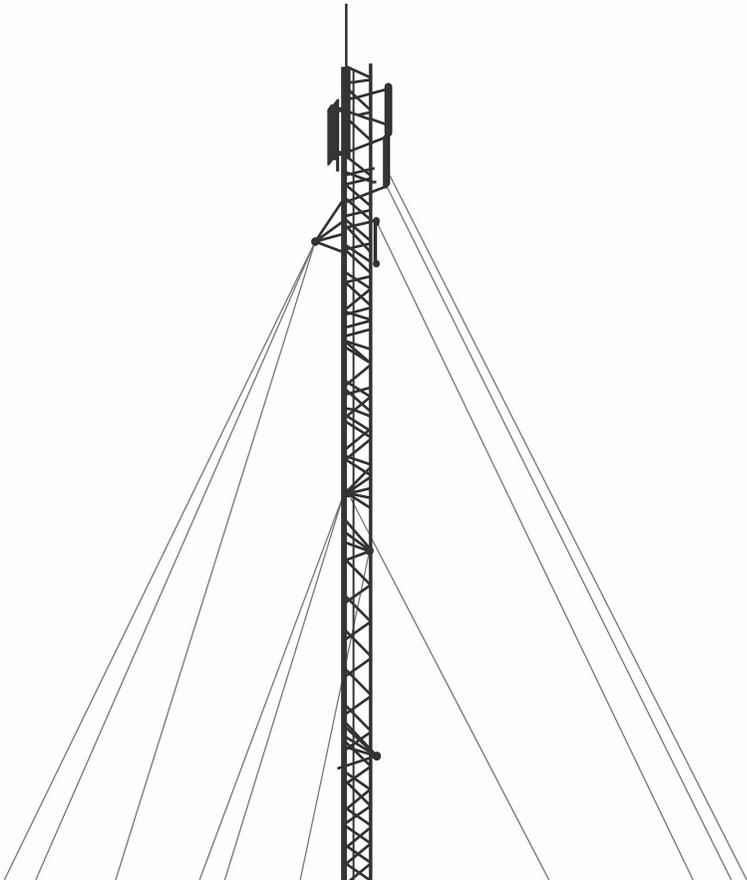
Many amateur radio satellites often have a beacon. A beacon is **an amateur station transmitting communications for the purposes of observing propagation or related experimental activities.** In layman's terms, a beacon is a station that transmits health or status information. It's one way, so you cannot transmit to a beacon.



Repeaters

For many new hams, connecting to a repeater is one of their first activities after getting licensed. It is a great way to chat with other hams in your area.

A repeater station simultaneously retransmits the signals of an amateur station on a different channel or channels. It is used to repeat your signal from a high location and can help you communicate farther.



Repeaters typically are located on tall buildings, towers and mountaintops to relay handheld and mobile radio stations. You'll typically find repeaters in the VHF and UHF bands. This allows for wide area communications around a city or county. **Repeater operation** is an example of automatic control – it is automatic and doesn't

need anyone operating. But it's not the only type of station that can retransmit.

Repeater, auxiliary or space stations can automatically retransmit the signals of other amateur stations.

If a repeater retransmits communications that violate FCC rules, **the control operator of the originating station** is responsible.



The originating station is responsible, so follow the rules when using a repeater.

Emergency Communications

Public service communications are an important part of amateur radio. One group you will hear of is RACES, the Radio Amateur Civil Emergency Service.

What is the Radio Amateur Civil Emergency Service (RACES)?

- A radio service using amateur frequencies for emergency management or civil defense communications
- A radio service using amateur stations for emergency management or civil defense communications
- An emergency service using amateur operators certified by a civil defense organization as being enrolled in that organization
- **All these choices are correct**



Other amateur radio groups like ARES, the Amateur Radio Emergency Service, or AuxComm are more prominent in some regions, so check around if you are interested in Emergency Communications.

Station Control

This next section covers a term called “control operators” and discusses who is responsible for radio control, because someone has to be in control. For the next few minutes, think of the term “station” as a handheld radio because it’s a combination of radio and antenna - it’s a mini station.

The person who controls the radio is called the control operator. An amateur station is **never** permitted to transmit without a control operator.

An amateur station control point **is the location at which the control operator function is performed**. I'm pushing the buttons to control the radio, I'm at the control point.

The station licensee designates the station control operator. If it's my radio station and I'm holding it, I have the license, so I make myself the control operator. Unless otherwise stated, **the station licensee** is assumed to be the control operator.



Let's talk about how privileges follow the control operator.

The **class of operator license held by the control operator** determines the frequency privileges. **At no time** may a Technician class licensee be the control operator of a station operating in an exclusive Amateur Extra class operator frequency segment.

Here are a couple of quick scenarios to help you understand.

- If I let you use my handheld with your call sign, you become the control operator and you are restricted to your license privileges
- If I let you operate my home radio, but I remain with you as control operator, and we use my call sign, we can use my license privileges.
- When there are two of us together, **the control operator and the station licensee** are both responsible for following the rules.

Privileges follow the control operator, no matter whose equipment it is. The control operator does not need to be the person using the key or push-to-talk button at that time. For example, if a group is operating multiple stations in a contest, there are many operators using AA1RC at the same time, but there is one control operator supervising them. They can all use the privileges of that control operator.

Remote Control

When the FCC talks about remote control in Part 97 rules, they are talking about operating your

station from afar. It's **NOT** about remote-control craft, so don't get tricked by the remote control aircraft/boat answer!

Operating the station over the internet is an example of remote control as defined by Part 97. For example, if you have a ham radio shack at your home, you may want to operate your station remotely over the internet while away from home.

The following are required for remote control operation:

- The control operator must be at the control point.
- A control operator is required at all times.
- The control operator must indirectly manipulate the control.
- **All these choices are correct.**

Lesson 4 Quiz:

- 1) From which of the following locations may an FCC-licensed amateur station transmit?
 - a. From within any country that belongs to the International Telecommunication Union

- b. From within any country that is a member of the United Nations
 - c. From anywhere within International Telecommunication Union (ITU) Regions 2 and 3
 - d. From any vessel or craft located in international waters and documented or registered in the United States
- 2) What is the FCC Part 97 definition of a space station?
- a. Any satellite orbiting Earth
 - b. A manned satellite orbiting Earth
 - c. An amateur station located more than 50 km above Earth's surface
 - d. An amateur station using amateur radio satellites for relay of signals
- 3) Under what conditions is an amateur station authorized to transmit music using a phone emission?
- a. When incidental to an authorized retransmission of manned spacecraft communications
 - b. When the music produces no spurious emissions
 - c. When transmissions are limited to less than three minutes per hour
 - d. When the music is transmitted above 1280 MHz
- 4) What type of amateur station simultaneously retransmits the signal of another amateur station on a different channel or channels?
- a. Beacon station

- b. Earth station
 - c. Repeater station
 - d. Message forwarding station
- 5) What types of amateur stations can automatically retransmit the signals of other amateur stations?
- a. Auxiliary, beacon, or Earth stations
 - b. Earth, repeater, or space stations
 - c. Beacon, repeater, or space stations
 - d. Repeater, auxiliary, or space stations
- 6) When may an amateur station transmit without a control operator?
- a. When using automatic control, such as in the case of a repeater
 - b. When the station licensee is away and another licensed amateur is using the station
 - c. When the transmitting station is an auxiliary station
 - d. Never
- 7) When, under normal circumstances, may a Technician class licensee be the control operator of a station operating in an Amateur Extra Class band segment?
- a. At no time
 - b. When designated as the control operator by an Amateur Extra Class licensee
 - c. As part of a multi-operator contest team
 - d. When using a club station whose trustee holds an Amateur Extra Class license
- 8) Which of the following is an example of remote control as defined in Part 97?

- a. Repeater operation
 - b. Operating the station over the internet
 - c. Controlling a model aircraft, boat, or car by amateur radio
 - d. All these choices are correct
- 9) Which of the following are required for remote control operation?
- a. The control operator must be at the control point
 - b. A control operator is required at all times
 - c. The control operator must indirectly manipulate the controls
 - d. All these choices are correct
- 10) What determines the transmitting frequency privileges of an amateur station?
- a. The frequency authorized by the frequency coordinator
 - b. The frequencies printed on the license grant
 - c. The highest class of operator license held by anyone on the premises
 - d. The class of operator license held by the control operator

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!



The achievement of one goal should be the starting point of another.



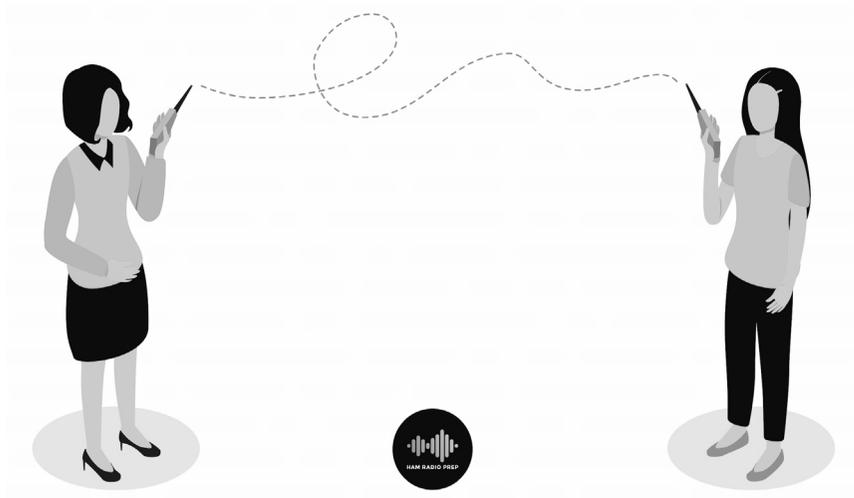
- Alexander Graham Bell

Lesson 5: Calling Another Station

Calling another Station

Ham radio is about communication, so once you have your license you are going to want to call another station. If you are calling a station and you know that station's call sign, **say the station's call sign, then identify with your call sign.**

So, you would say "K1XXX this is AA1RC."



Remember, you are always required to **identify the transmitting station**, even when making on-the-air test transmissions.

The phonetic alphabet is recommended when saying your call sign, but it is also useful to make sure other operators can understand your message. For example, if you are transmitting some unusual words and want to make sure they are received correctly, you can **spell the words using the standard phonetic alphabet**.



Another tip is to not **talk too loudly** – it could cause your transmissions to break up on voice peaks.

Calling CQ

You may not know another station to call, or you just might want to talk to someone new. In that

case you would be calling “CQ,” which simply means **calling any station**. To put it even simpler, it means: “Is there anyone out there who wants to start a conversation?” Think of it as “I Seek You”

So, let’s talk about how to call CQ correctly.

First of all, set your operating frequency on your radio. When choosing an operating frequency for calling CQ, you should do the following:

- Listen first to be sure that no one else is using the frequency.
- Ask if the frequency is in use.
- Make sure you are in your assigned band.
- **All of these answers are correct**

Then you can call “CQ, CQ, this is K1XXX,” and hopefully, someone will start a conversation!

To respond to a station calling CQ, it’s exactly the same as before: **transmit the other station’s call sign, followed by your call sign.**

Q Signals

Q signals are used as a standard communications code. They are always three letters beginning with a Q. There are many Q codes, and you'll find a whole video about them on our website.

Q-Code	Used as a Question	Used as a Statement
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.

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].

The exam covers a few examples. There are two Q-codes dealing with interference.

QRM means you are receiving interference from other stations. You can think of the **M** as standing for **m**anmade interference.

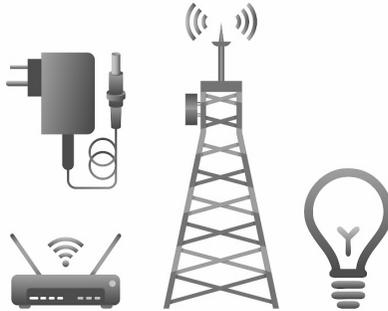
QRN means you are experiencing static. You can think of **N** standing for **n**atural interference or **n**oise like lightning,

TYPES OF INTERFERENCE



QRN

Interference from a Natural source



QRM

Interference from a Man Made source

QSY means that you are changing frequency. You can remember this because frequency ends in **Y**.

Simplex

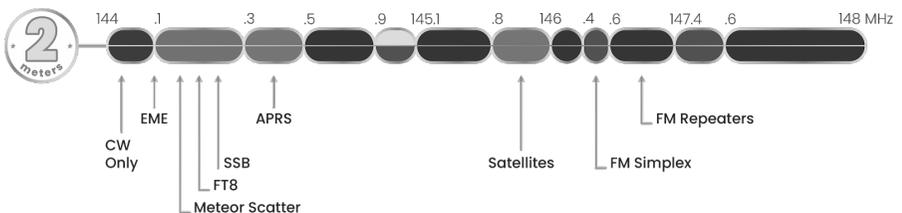
Let's move on from what to say into two key ways to communicate, via simplex and via repeaters.

Simplex is when an amateur station is transmitting and receiving on the same

frequency. Simplex = simple! Simplex is a great simple way to communicate.

When operating in simplex, a repeater is not needed because the two stations can talk directly.

Simplex channels are designated in the VHF and UHF band plans **so that stations within mutual communications range can communicate without tying up a repeater.**



So, what's a band plan? It's a **voluntary guide for using different modes or activities within an amateur band.** Band plans lay out how different parts of each group of frequencies are used to avoid interference. The band plan tells

us things like the national calling frequency for FM simplex operations in the **2-meter band is 146.520 MHz.**

When two stations transmitting on the same frequency interfere with each other, **common courtesy should prevail, but no one has an absolute right to an amateur frequency.** As ham radio operators, we are all responsible for being respectful on our airwaves.

Repeaters

A repeater hears a radio signal on one frequency and repeats it simultaneously on another frequency. If you transmit to a repeater, it will take your signal and broadcast it out over a much farther distance, typically from an antenna on a tall tower or building, or mountaintop.

Repeaters are one of the most fun parts of the ham radio hobby, and after you get your license, you will be able to use repeaters to start

conversations with other ham radio operators all over your area.

As an operating guide, to let folks know you are listening on a repeater, the ham would say their **stations call sign followed by the word “monitoring.”** What does that sound like? Hit the push-to-talk button and say something like “AA1RC - Monitoring” and someone can answer you.

There is a little equipment setup required before talking on a repeater. Let’s go through some terms.

“Repeater offset” is **the difference between a repeater’s transmit frequency and its receive frequency.** Repeaters transmit on one frequency and listen on another. You generally know the frequency the repeater transmits on, and to get to the receive frequency you need to set your radio to match the repeater’s offset frequency.

If you are listening to a repeater on **70 cm**, a common repeater frequency offset is **plus or minus 5 MHz.** For example, a repeater transmitting on 442.200, with a positive 5

megahertz offset, has a receive frequency of 447.200.

Over on the 2-meter band, very important for amateur radio operators because it's local and reliable, the repeater's offset frequency is commonly plus or minus 600 kHz. A repeater with an output on 147.790 and a negative offset would have an input frequency of 147.190.

A reminder on terms here. 600 kilohertz is the same as 0.6 megahertz

If you're trying to find the offset of a repeater you can hear, try the transceiver "reverse split" function on some radios to allow you to **listen on a repeater's input frequency.**

Lesson 5 Quiz:

- 1) What is an appropriate way to call another station on a repeater if you know the other station's call sign?
 - a. Say "break, break," then say the station's call sign
 - b. Say the station's call sign, then identify with your call sign
 - c. Say "CQ" three times, then the other station's call sign
 - d. Wait for the station to call CQ, then answer

- 2) What technique is used to ensure that voice messages containing unusual words are received correctly?
 - a. Send the words by voice and Morse code
 - b. Speak very loudly into the microphone
 - c. Spell the words using a standard phonetic alphabet
 - d. All these choices are correct
- 3) What should you do before calling CQ?
 - a. Listen first to be sure that no one else is using the frequency
 - b. Ask if the frequency is in use
 - c. Make sure you are authorized to use that frequency
 - d. All these choices are correct
- 4) How should you respond to a station calling CQ?
 - a. Transmit "CQ" followed by the other station's call sign
 - b. Transmit your call sign followed by the other station's call sign
 - c. Transmit the other station's call sign followed by your call sign
 - d. Transmit a signal report followed by your call sign
- 5) Which Q signal indicates that you are receiving interference from other stations?
 - a. QRM
 - b. QRN
 - c. QTH
 - d. QSB

- 6) Which Q signal indicates that you are changing frequency?
- QRU
 - QSY
 - QSL
 - QRZ
- 7) Why are simplex channels designated in the VHF/UHF band plans?
- So stations within range of each other can communicate without tying up a repeater
 - For contest operation
 - For working DX only
 - So stations with simple transmitters can access the repeater without automated offset
- 8) Which of the following indicates that a station is listening on a repeater and looking for a contact?
- “CQ CQ” followed by the repeater’s call sign
 - The station’s call sign followed by the word “monitoring”
 - The repeater call sign followed by the station’s call sign
 - “QSY” followed by your call sign
- 9) What is a common repeater frequency offset in the 70 cm band?
- Plus or minus 5 MHz
 - Plus or minus 600 kHz
 - Plus or minus 500 kHz
 - Plus or minus 1 MHz
- 10) How is a VHF/UHF transceiver’s “reverse” function used?
- To reduce power output

- b. To increase power output
- c. To listen on a repeater's input frequency
- d. To listen on a repeater's output frequency

Answers to this quiz are located in the answer key at the end of the book.

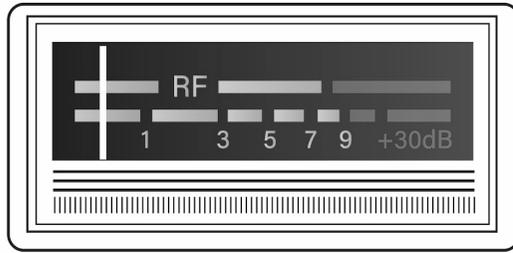
Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Lesson 6: Squelch, Net Operations, and RACES

Squelch, Tones and Signaling

Let's talk about squelch. Your radio's squelch function is to **mute the receiver audio when a signal is not present**. Without setting your squelch, you would hear static all the time when there are no communications in progress.



VOLUME

SQUELCH



OFF

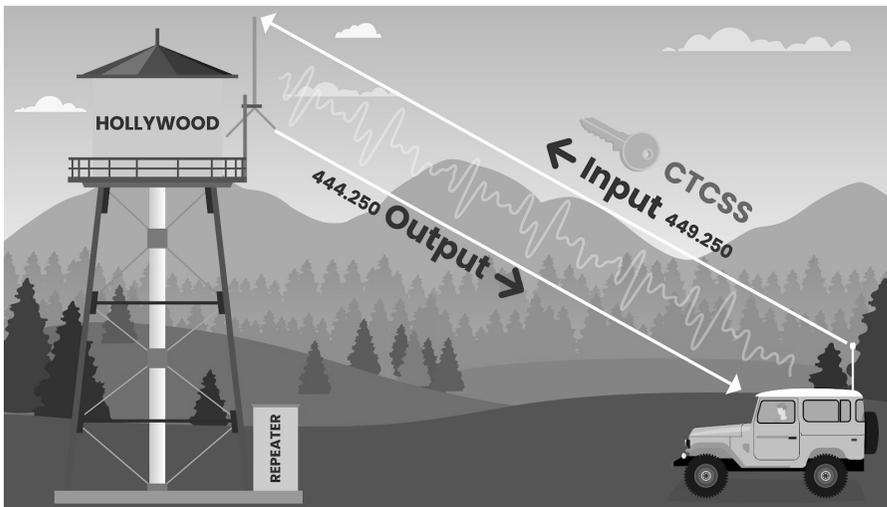


Being high up, repeaters hear a lot of signals and frequently use squelch signaling settings to help keep stray signals from being retransmitted. They do this with different types of tones sent from your radio, CTCSS or DCS.

The **CTCSS** is a subaudible tone transmitted along with normal voice audio to open the squelch of a receiver. It stands for Continuous Tone-Coded Squelch System. Think of this as a “key” that allows you to use a repeater. When the repeater hears the subaudible tone you transmit

on your signal, the repeater opens up and retransmits your signal for all to hear.

Similarly, **DCS**, or Digital Coded Squelch, uses digital codes instead of subaudible CTCSS tones to open repeaters. DCS tones seem to be used more frequently in metropolitan areas.



CTCSS is a subaudible tone you transmit on your radio signal to open the squelch of a receiver, especially for repeaters.

So, if you can't transmit on a repeater, even though you can hear the output, it could be because of:

- Improper transceiver offset.
- The repeater may require a proper CTCSS tone from your transceiver.
- The repeater may require a proper DCS tone from your transceiver.

All of the above would be correct because you need the offset and tone to access a repeater.

Similar to CTCSS and DCS, you might need special codes to access some features. On DMR repeater systems, you'll find a "color code" which **must match the repeater color code for access**. You can join a digital repeater's "talk group" by **programming your radio with the group's ID or code**.

Sometimes you'll hear Touch-Tones over a radio, those are **DTMF** audio tones, for signaling repeaters or other equipment.

A linked repeater network is **a network of repeaters where signals received by one repeater are repeated by all the repeaters**.

There's a really popular one in California called the PAPA network that allows you to talk up and down the coast from home.

Net Operations

Now let's go through times you will interact with others more formally using amateur radio. Net operations are a way to manage the communications flow on a frequency. They are set up for things like weekly club interactions, special event support or communicating storm conditions.

The station you'll hear most on a net is the net control station. Their typical duties are to **call the net to order and direct communications between stations checking in.**



While you are on a net, it's standard practice to just listen. **Unless you are reporting an emergency, transmit only when directed by the net control station.**

Some nets are for sending messages from one group to another. The term "traffic" in net operation means **formal messages exchanged by net stations.**

Good traffic handling means **passing messages exactly as received.** This is important in an emergency so there is no confusion.

In formal traffic messaging, **the information needed to track the message** is stored in the preamble.

Another tip to help make sure a message is heard correctly is asking for a “check”. A “check” is **the number of words or word equivalents in the text portion of the message**. If you ask for a “check,” and the other operator confirms the number of words correctly, you know that your message was received entirely.

RACES, ARES and Emergencies

Let’s wrap up with a discussion of emergency and public service communications on ham radio, centered around RACES and ARES.



RACES is an abbreviation for the Radio Amateur Civil Emergency Service. It is an **FCC Part 97 amateur radio service for civil defense communications during national emergencies.**

The Amateur Radio Emergency Service – known as ARES – is a group of **licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public service.**

FCC rules say: “**In situations involving the immediate safety of human life or protection of property,**” you may transmit outside

frequency privileges authorized under your class of amateur license.

It's a trick question, but one exam question asks when you can break FCC rules. The answer is: **Never, FCC rules always apply.** There are no special rules for emergency communications teams.

Lesson 6 Quiz:

- 1) What is the purpose of a squelch function?
 - a. Reduce a CW transmitter's key clicks
 - b. Mute the receiver audio when a signal is not present
 - c. Eliminate parasitic oscillations in an RF amplifier
 - d. Reduce interference from impulse noise
- 2) What term describes the use of a sub-audible tone transmitted along with normal voice audio to open the squelch of a receiver?
 - a. Carrier squelch
 - b. Tone burst
 - c. DTMF
 - d. CTCSS
- 3) What is the purpose of the color code used on DMR repeater systems?
 - a. Must match the repeater color code for access
 - b. Defines the frequency pair to use
 - c. Identifies the codec used

- d. Defines the minimum signal level required for access
- 4) What type of signaling uses pairs of audio tones?
- a. DTMF
 - b. CTCSS
 - c. GPRS
 - d. D-STAR
- 5) Which of the following are typical duties of a Net Control Station?
- a. Choose the regular net meeting time and frequency
 - b. Ensure that all stations checking into the net are properly licensed for operation on the net frequency
 - c. Call the net to order and direct communications between stations checking in
 - d. All these choices are correct
- 6) What does the term “traffic” refer to in net operation?
- a. Messages exchanged by net stations
 - b. The number of stations checking in and out of a net
 - c. Operation by mobile or portable stations
 - d. Requests to activate the net by a served agency
- 7) What is meant by “check” in a radiogram header?
- a. The number of words or word equivalents in the text portion of the message
 - b. The call sign of the originating station
 - c. A list of stations that have relayed the message
 - d. A box on the message form that indicates that the message was received and/or relayed
- 8) What is RACES?

- a. An emergency organization combining amateur radio and citizens band operators and frequencies
 - b. An international radio experimentation society
 - c. A radio contest held in a short period, sometimes called a “sprint”
 - d. An FCC part 97 amateur radio service for civil defense communications during national emergencies
- 9) Are amateur station control operators ever permitted to operate outside the frequency privileges of their license class?
- a. No
 - b. Yes, but only when part of a FEMA emergency plan
 - c. Yes, but only when part of a RACES emergency plan
 - d. Yes, but only in situations involving the immediate safety of human life or protection of property
- 10) When do FCC rules NOT apply to the operation of an amateur station?
- a. When operating a RACES station
 - b. When operating under special FEMA rules
 - c. When operating under special ARES rules
 - d. FCC rules always apply

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!



I do not think that the radio waves I have discovered will have any practical application.



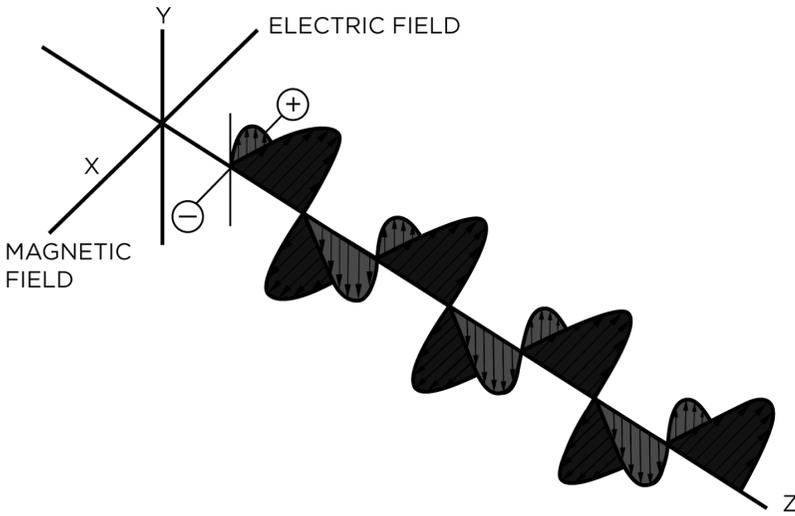
- Heinrich Hertz

Lesson 7: Basic Concepts of Radio Waves

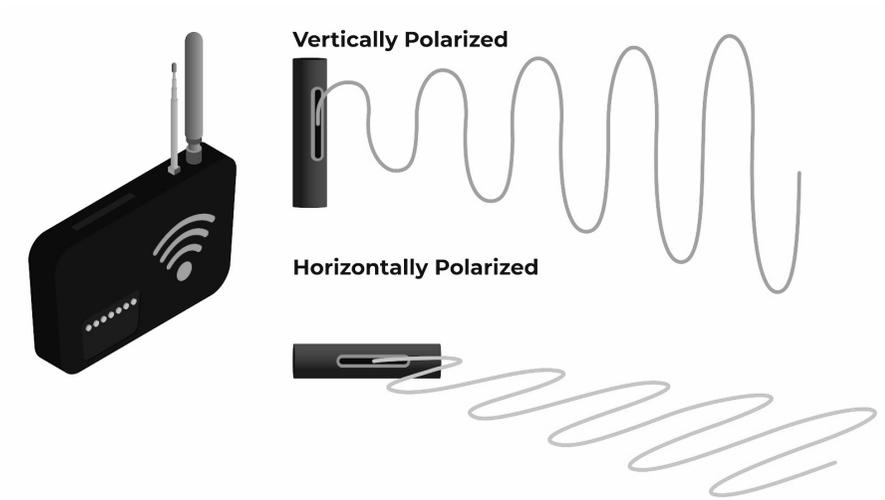
Basic Concepts of Radio Waves

Let's start with the components of radio waves, which are generated into the air at different frequencies by a transmitter and antenna. Radio waves travel **at the speed of light** in free space, which is **300 million meters per second!**

The two components of a radio wave are the **electric and magnetic fields**. These two fields have a specific relationship - electric and magnetic fields of an electromagnetic wave **are at right angles** to each other.



The term polarization is used to explain **the orientation of the electric field** of a radio wave. Every radio wave has a certain polarization, depending on the type and setup of the antenna. Here are some examples:

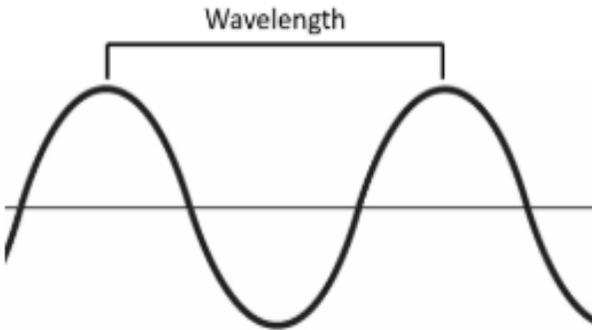


- A horizontally polarized antenna will be one that is in parallel with the ground. An antenna with **horizontal polarization** normally is used for long-distance weak-signal CW – also known as Morse code – and SSB – or single sideband voice – contacts using the VHF and UHF bands.
- An antenna with vertical polarization typically is used for things such as FM repeaters and simplex.

Wavelength and Frequency

Now that you understand the components of a radio wave, let's discuss the terms wavelength and frequency, which are directly related to each other.

A wavelength is the distance a radio wave travels during one complete cycle. Its frequency is how often the wave oscillates. They are inversely proportional to each other so the **wavelength gets shorter as the frequency increases.**



In the Amateur Radio Service, you'll hear people talk about both wavelengths, like "10 meters," or frequencies, like "28.5 megahertz." You can calculate wavelength with this formula:
Wavelength in meters equals 300 divided by

frequency in megahertz. If you do the math for 28.5 MHz, you will see it comes out to 10.5 something, indicating this frequency is inside the 10-meter band.

Ham radio operators will often use **the approximate wavelength** to identify the different frequency bands. Here's another example, the popular 2-meter simplex frequency is 146.52 MHz. Divide 300 by 146.52 to see that it is in the 2-meter band.

300 ÷ Frequency in Megahertz

The frequency or wavelength of radio waves plays a large role in determining how far your signal will travel and also ensuring you are operating within the rules.

There are three major frequency ranges used by ham radio operators. High frequency, abbreviated HF, is the range from **3 to 30 MHz**. Very high frequency or VHF is between **30 and 300 MHz**. Ultra-high frequency, known as UHF, is **300 to 3000 MHz**. Two things to remember is that High Frequency is actually lower than the other two, and they are all listed in megahertz. These three ranges contain multiple bands where you'll have different approved uses.

Line-of-Sight Communication

As a Technician level ham radio operator, line-of-sight communications is one of the most basic tools you will use, because it's a direct straight-line signal from your radio to the other station. You'll hear it referred to frequently as "simplex."

The distance over which two stations can communicate by a direct path is known as the radio horizon. Because **the Earth seems less curved to radio waves than to light**, VHF and

UHF radio signals usually travel farther than the visual line of sight.



So, now that you know the hypothetical distance is about 15% further if there were no obstructions, let's talk about things that will impact the distance your signal will really travel.

If you're operating in the rain, **precipitation** might decrease your range at microwave frequencies as those are in the upper UHF band. The good news is that **fog and light rain have little effect** on radio range on the 10- and 6-meter bands.

Vegetation, like leaves, causes absorption of UHF and microwave signals.

For line-of-sight communication, you want to make sure the transmitting and receiving antennas are polarized the same. If the antennas at opposite ends of a VHF or UHF line-of-sight radio link are not using the same polarization, **signals could be significantly weaker.**

Lesson 7 Quiz:

- 1) What is the velocity of a radio wave traveling through free space?
 - a. Speed of light
 - b. Speed of sound
 - c. Speed inversely proportional to its wavelength
 - d. Speed that increases as the frequency increases
- 2) What is the approximate velocity of a radio wave in free space?
 - a. 150,000 meters per second
 - b. 300,000,000 meters per second
 - c. 300,000,000 miles per hour
 - d. 150,000 miles per hour
- 3) What is the relationship between wavelength and frequency?
 - a. Wavelength gets longer as frequency increases

- b. Wavelength gets shorter as frequency increases
 - c. Wavelength and frequency are unrelated
 - d. Wavelength and frequency increase as path length increases
- 4) What weather condition might decrease range at microwave frequencies?
- a. High winds
 - b. Low barometric pressure
 - c. Precipitation
 - d. Colder temperatures
- 5) What is the effect of vegetation on UHF and microwave signals?
- a. Knife-edge diffraction
 - b. Absorption
 - c. Amplification
 - d. Polarization rotation
- 6) What frequency range is referred to as VHF?
- a. 30 kHz to 300 kHz
 - b. 30 MHz to 300 MHz
 - c. 300 kHz to 3000 kHz
 - d. 300 MHz to 3000 MHz
- 7) What frequency range is referred to as UHF?
- a. 30 to 300 kHz
 - b. 30 to 300 MHz
 - c. 300 to 3000 kHz
 - d. 300 to 3000 MHz
- 8) What property of a radio wave defines its polarization?
- a. The orientation of the electric field
 - b. The orientation of the magnetic field

- c. The ratio of the energy in the magnetic field to the energy in the electric field
 - d. The ratio of the velocity to the wavelength
- 9) What is the relationship between the electric and magnetic fields of an electromagnetic wave?
- a. They travel at different speeds
 - b. They are in parallel
 - c. They revolve in opposite directions
 - d. They are at right angles
- 10) What is the formula for converting frequency to approximate wavelength in meters?
- a. Wavelength in meters equals frequency in hertz multiplied by 300
 - b. Wavelength in meters equals frequency in hertz divided by 300
 - c. Wavelength in meters equals frequency in megahertz divided by 300
 - d. Wavelength in meters equals 300 divided by frequency in megahertz

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Lesson 8: Introduction to the Atmosphere

Using Reflection to Communicate even Farther

While nature and terrain sometimes can work against you in ham radio, it also can be a benefit. Many signals can travel much farther than a simple line of sight by using reflection.

Let's say you are trying to hit a repeater across town, but find yourself behind a building that blocks your signal directly. Using a directional antenna, you may be able to reflect your signal off something in the distance.

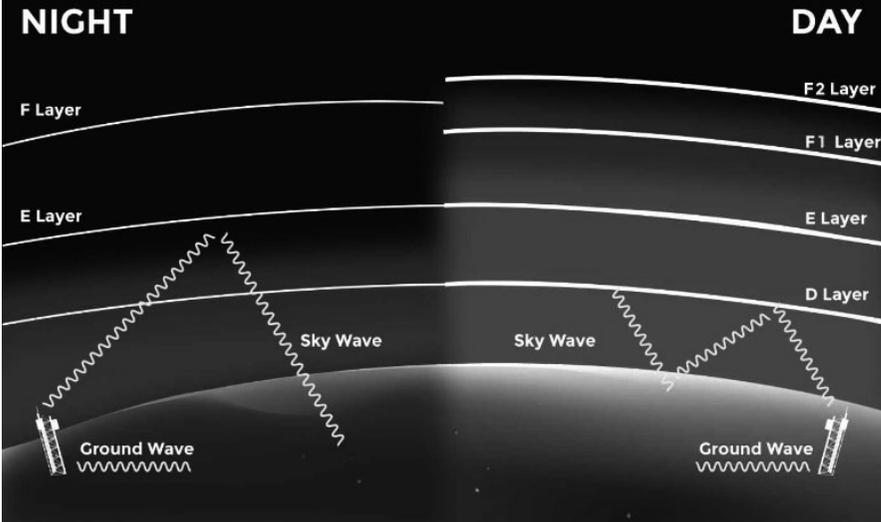
Knife-edge diffraction allows radio signals to be heard despite obstructions between two stations by bouncing radio waves off a mountain or another obstacle. So, to overcome an obstruction, **try to find a path that reflects signals to the repeater.**

A tip here, particularly when using digital signals, is it is important to avoid reflecting off multiple objects because when data signals arrive via multiple paths, **error rates are likely to increase.**

So, we know we can bounce signals off buildings or obstacles. Let's think bigger and reflect or "skip" signals off the atmosphere. We'll need to explain more about two parts of the atmosphere - the ionosphere and the troposphere.

The **ionosphere** is the part of the atmosphere that enables the propagation of radio signals around the world. Different layers of the ionosphere reflect different frequencies at different times of the day and in different seasons.

Layers of the Ionosphere



Long distance ionospheric propagation is far more common on HF, which is an advantage HF has over VHF and higher frequencies.

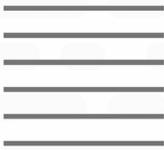
Under special atmospheric conditions, something called a “sporadic E layer” may form in the atmosphere, which has special uses for ham radio. **Sporadic E** propagation - or “band openings” - commonly is associated with occasional strong over-the-horizon signals on the 10-meter HF band along with the 6- and 2-

meter VHF bands. Many hams make a habit of trying to optimize these openings by chasing the VUCC award by tracking and confirming contacts in unique grid squares.

Direct UHF signals rarely are heard from stations outside their local coverage area because **UHF signals usually are not reflected by the ionosphere.**

From an antenna perspective, the ionosphere makes it easy to skip signals. Because the ionosphere elliptically polarizes skip signals, **either vertically or horizontally polarized antennas may be used for transmission or reception.**

Ionosphere



**Horizontally
Polarized**



**Vertically
Polarized**

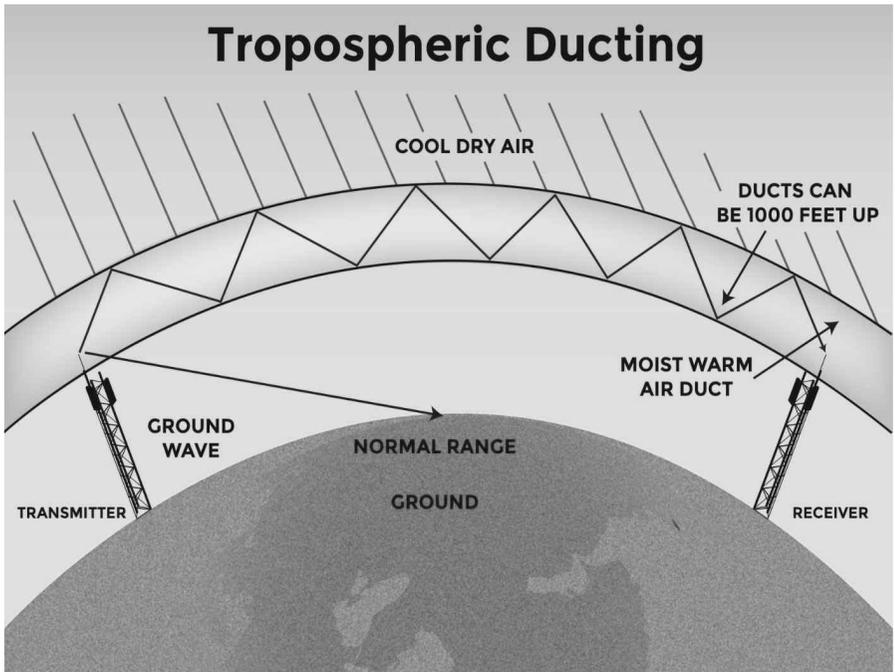


**Elliptically
Polarized**

The Troposphere

Below the ionosphere, the troposphere is the lowest level of the atmosphere.

Long-distance communication can be facilitated by a really interesting effect called **tropospheric ducting**, which can be used on both VHF and UHF to communicate up to 300 miles on a regular basis



Tropospheric ducting is caused by **temperature inversions in the atmosphere** and can help carry your signal much farther than normal. During tropospheric ducting, the signals get trapped in the duct of warm, moist air over the

earth and are carried through the duct for greater distances.

Sunspots and Meteor Scatter

Two other atmospheric phenomena that hams work with are sunspots and meteors.

Sunspots have an 11-year cycle, and a peak is expected in 2025. During peak sunspot activity, the **6- or 10-meter bands** provide great long-distance communications. The best time for long-distance 10-meter band propagation via the F layer is **from dawn to shortly after sunset during periods of high sunspot activity.**

If you're interested in bouncing your signal off meteors, the **6-meter band** is your best option for meteor scatter!

Distortion

Let's wrap it up with a couple of negatives to the items we discussed on reflection that create signal distortion.

If you are receiving a signal that is reflecting off multiple buildings or objects at the same time, you're hearing "picket fencing" or **rapid flutter on mobile signals due to multipath propagation**. Similarly, **multipath propagation cancels or reinforces signals** in VHF bands, causing signal strengths sometimes to vary greatly when the antenna is moved only a few feet.

Auroras are pretty to see in the sky, but VHF signals also can reflect off the aurora – in this case, **the signals exhibit rapid fluctuations of strength and often sound distorted**.



Lastly, **the random combining of signals arriving via different paths** can cause irregular fading of signals received by ionospheric reflection.

Lesson 8 Quiz:

- 1) Which of the following effects may allow radio signals to travel beyond obstructions between the transmitting and receiving stations?
 - a. Knife-edge diffraction
 - b. Faraday rotation
 - c. Quantum tunneling
 - d. Doppler shift
- 2) What effect does multi-path propagation have on data transmissions?

- a. Transmission rates must be increased by a factor equal to the number of separate paths observed
 - b. Transmission rates must be decreased by a factor equal to the number of separate paths observed
 - c. No significant changes will occur if the signals are transmitted using FM
 - d. Error rates are likely to increase
- 3) What is a characteristic of HF communication compared with communications on VHF and higher frequencies?
- a. HF antennas are generally smaller
 - b. HF accommodates wider bandwidth signals
 - c. Long-distance ionospheric propagation is far more common on HF
 - d. There is less atmospheric interference (static) on HF
- 4) Which of the following types of propagation is most commonly associated with occasional strong signals on the 10, 6, and 2 meter bands from beyond the radio horizon?
- a. Backscatter
 - b. Sporadic E
 - c. D region absorption
 - d. Gray-line propagation
- 5) Which of the following results from the fact that signals propagated by the ionosphere are elliptically polarized?
- a. Digital modes are unusable

- b. Either vertically or horizontally polarized antennas may be used for transmission or reception
 - c. FM voice is unusable
 - d. Both the transmitting and receiving antennas must be of the same polarization
- 6) What type of propagation is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis?
- a. Tropospheric ducting
 - b. D region refraction
 - c. F2 region refraction
 - d. Faraday rotation
- 7) What is generally the best time for long-distance 10 meter band propagation via the F region?
- a. From dawn to shortly after sunset during periods of high sunspot activity
 - b. From shortly after sunset to dawn during periods of high sunspot activity
 - c. From dawn to shortly after sunset during periods of low sunspot activity
 - d. From shortly after sunset to dawn during periods of low sunspot activity
- 8) What is a likely cause of irregular fading of signals propagated by the ionosphere?
- a. Frequency shift due to Faraday rotation
 - b. Interference from thunderstorms
 - c. Intermodulation distortion
 - d. Random combining of signals arriving via different paths

- 9) Which of the following bands may provide long-distance communications via the ionosphere's F region during the peak of the sunspot cycle?
- a. 6 and 10 meters
 - b. 23 centimeters
 - c. 70 centimeters and 1.25 meters
 - d. All these choices are correct
- 10) What causes tropospheric ducting?
- a. Discharges of lightning during electrical storms
 - b. Sunspots and solar flares
 - c. Updrafts from hurricanes and tornadoes
 - d. Temperature inversions in the atmosphere

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!



The three great essentials
to achieve anything
worthwhile are: hard work,
stick-to-itiveness, and
common sense.



- Thomas Edison

Lesson 9: Station Setup, SWR, and Using Computers

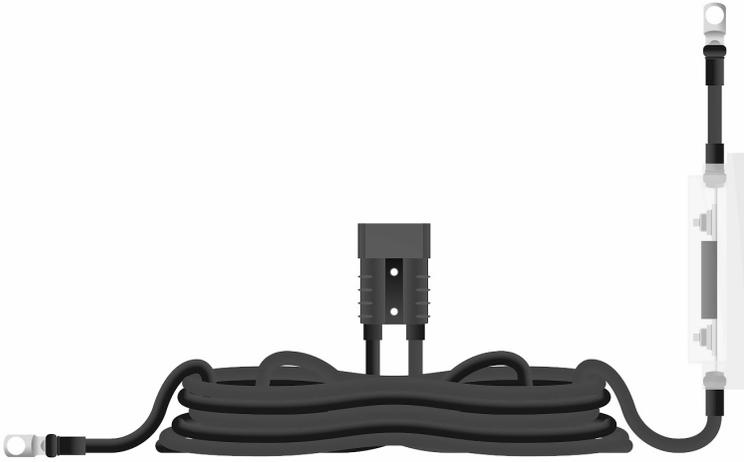
Station Setup

There are many types of radio stations in ham radio, from mobile stations to base stations you operate out of your home.

Let's start by talking about power and wiring. To operate any station, you need to power and connect it safely.

If you are using a typical 50-watt output mobile FM transceiver, an appropriate power supply rating would be **13.8 volts at 12 amperes**.

The wiring and cables used impact both electrical safety and interference. Short, heavy-gauge wires are used for a transceiver's DC power connection **to minimize voltage drop when transmitting**. Longer wires can act like an antenna and pick up stray signals.



To determine the length of time that equipment can be powered from a battery, **divide the battery ampere-hour rating by the average current draw of the equipment.**

Sources of noise and distortion are all around us. Even your car can cause interference.

The negative return connection of a mobile transceiver's power cable should be connected **at the 12 volt battery chassis ground.** A flat strap provides the lowest impedance to RF signals.

Operating your Station

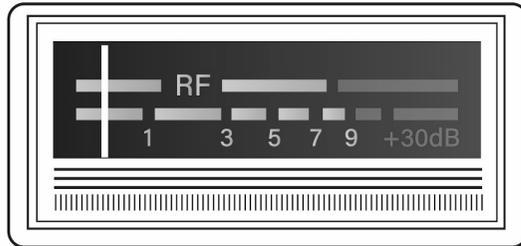
Let's move on to controls you'll find on your radio. To operate your station, you need to set the transmit and receive frequency. To enter the operating frequency on a modern transceiver, you can use **the keypad or VFO knob**. This will depend on what model of radio you are using.



To enable quick access to a favorite frequency, you can **store the frequency in a memory channel**.

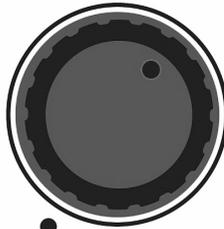
Squelch control is used to eliminate static on a radio's receiver, its function is **to mute receiver output noise when no signal is being received.**

When you open the squelch all the way, and hear full static or "hiss," it allows reception of weak-signal stations. When you rotate the squelch control the other direction, you will hear only very strong stations.



VOLUME

SQUELCH



OFF

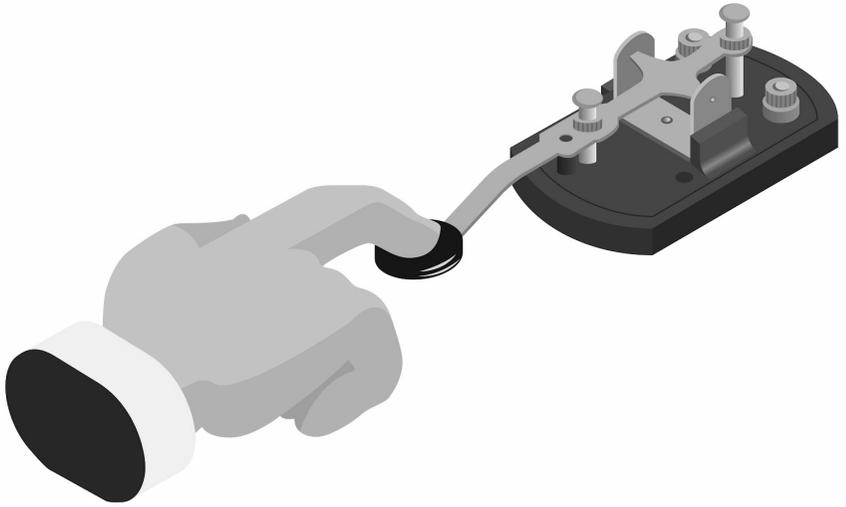
Some radios have receive bandwidth choices to allow you to change the filter depending on the

mode you are using: Morse code, SSB voice or others.

Having multiple receive bandwidth choices on a multimode transceiver **permits noise or interference reduction by selecting a bandwidth matching the mode.** You can improve noisy signals even more by using a bandwidth filter.

Each filter limits the signal bandwidth coming through for you to hear, and the right filter depends on the mode you're using. To eliminate noise and interference during **SSB reception**, choose a **2400 Hz** bandwidth filter.

When operating CW, many chose a **500 Hz** bandwidth filter. CW, or Morse code, uses very low bandwidth by only sending a single tone, unlike your voice, which has a wide range of tones. Because CW uses this narrower bandwidth, you select a narrow filter to match.



Making sure you are tuned in to the proper frequency the other station is transmitting on is very important. There are a couple of tools to know here.

If you tune an FM receiver above or below a signal's frequency, you'll hear **distortion of the signal's audio**.

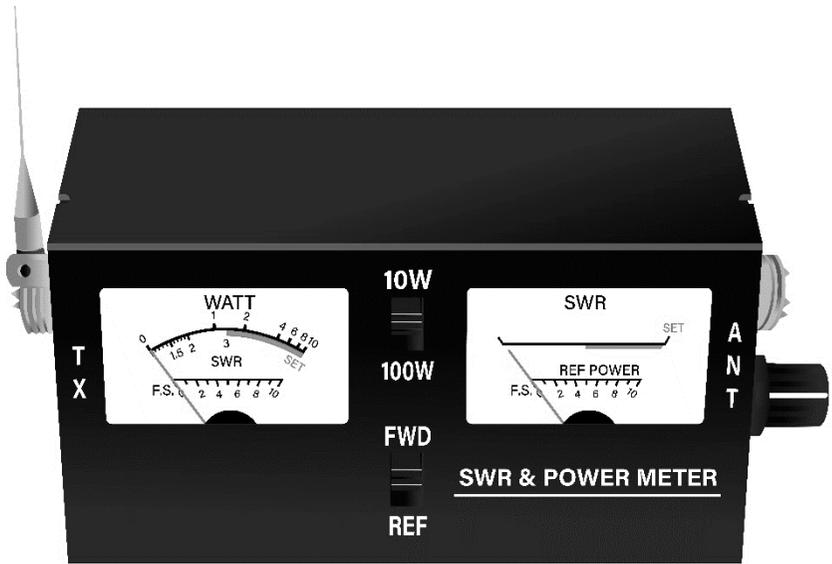
When using modes like single sideband or CW, you'll want to know about RIT, which stands for Receiver Incremental Tuning. This lets you

change your receive frequency without changing your transmit frequency. If the voice pitch of a single-sideband signal seems too high or low, you could use the **receiver RIT or clarifier** to change the receiver's frequency.

Finally, sending good audio helps other stations hear you better. If you are operating on SSB and you are told you have **distorted transmitted audio**, it's often the effect of excessive microphone gain.

SWR — Standing-Wave Ratio

When setting up your antenna and transmission line, you need a way to make sure they are calibrated for your transmitter. That is done using SWR or standing-wave ratio. An SWR meter measures the impedance matching of transmitter loads to the characteristic impedance of a transmission line.



These devices are calibrated for different frequency bands, so when selecting an accessory SWR Meter, consider **the frequency and power level at which the measurements will be made**. For instance, if you are operating with a 50-watt transceiver on 2 meters FM, make sure the meter covers that power level and frequency.

Place the external SWR meter in your station **in series with the feed line, between the transmitter and antenna**.

Computers and Digital Modes

There are a lot of different accessories you can use to enhance your amateur radio experience. Let's start with connecting it up to a computer.

You'll need to make three connections between the computer and the radio for digital mode operation. Connect **receive audio, transmit audio and transmitter keying** between the transceiver and a computer to make it work.

The computer "line in" to transceiver speaker connector allows the PC to hear what's being sent on the radio. Connect the computer's speaker or "line out" to the radio's mic circuit to give the computer the ability to send digital mode signals through the radio. Finally, the push-to-talk connection will allow the radio to switch between receiving and transmitting.

If you are going to operate CW, you might use an electronic keyer. It's **a device that assists in manual sending of Morse code.**

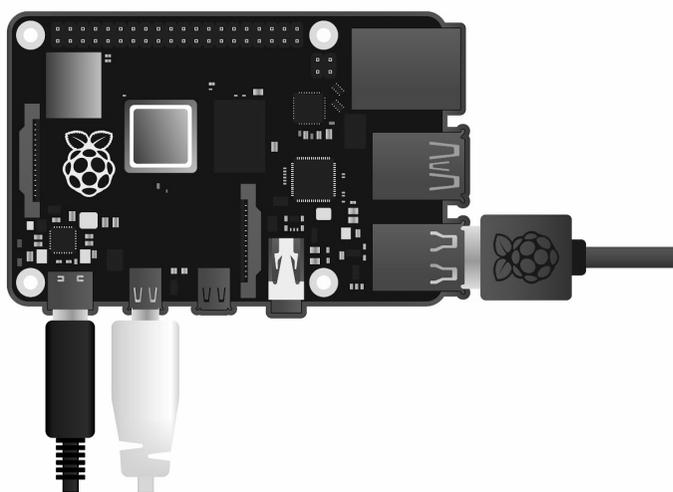


Does your transceiver support digital mobile radio, or DMR? A DMR “code plug” contains **access information for repeaters and talkgroups.**

If your transceiver supports D-STAR digital, **your call sign** must be programmed in before transmitting.

A quick tip: Both DMR and D-STAR require a one-time registration of your call sign on their systems before use.

You might hear that DMR or D-STAR users are operating their transceivers into a digital mode hot spot. That allows for **communication using digital voice or data systems via the internet** at home, like using a little Raspberry Pi as a repeater for those modes.



Lesson 9 Quiz:

- 1) Which of the following is an appropriate power supply rating for a typical 50 watt output mobile FM transceiver?
 - a. 24.0 volts at 4 amperes

- b. 13.8 volts at 4 amperes
 - c. 24.0 volts at 12 amperes
 - d. 13.8 volts at 12 amperes
- 2) How can you determine the length of time that equipment can be powered from a battery?
- a. Divide the watt-hour rating of the battery by the peak power consumption of the equipment
 - b. Divide the battery ampere-hour rating by the average current draw of the equipment
 - c. Multiply the watts per hour consumed by the equipment by the battery power rating
 - d. Multiply the square of the current rating of the battery by the input resistance of the equipment
- 3) Which of the following can be used to enter a transceiver's operating frequency?
- a. The keypad or VFO knob
 - b. The CTCSS or DTMF encoder
 - c. The Automatic Frequency Control
 - d. All these choices are correct
- 4) What is a way to enable quick access to a favorite frequency or channel on your transceiver?
- a. Enable the frequency offset
 - b. Store it in a memory channel
 - c. Enable the VOX
 - d. Use the scan mode to select the desired frequency
- 5) Which of the following should be considered when selecting an accessory SWR meter?
- a. The frequency and power level at which the measurements will be made

- b. The distance that the meter will be located from the antenna
 - c. The types of modulation being used at the station
 - d. All these choices are correct
- 6) What signals are used in a computer-radio interface for digital mode operation?
- a. Receive and transmit mode, status, and location
 - b. Antenna and RF power
 - c. Receive audio, transmit audio, and transmitter keying
 - d. NMEA GPS location and DC power
- 7) What function is performed with a transceiver and a digital mode hot spot?
- a. Communication using digital voice or data systems via the internet
 - b. FT8 digital communications via AFSK
 - c. RTTY encoding and decoding without a computer
 - d. High-speed digital communications for meteor scatter
- 8) What does a DMR “code plug” contain?
- a. Your call sign in CW for automatic identification
 - b. Access information for repeaters and talkgroups
 - c. The codec for digitizing audio
 - d. The DMR software version
- 9) What is the effect of excessive microphone gain on SSB transmissions?

- a. Frequency instability
 - b. Distorted transmitted audio
 - c. Increased SWR
 - d. All these choices are correct
- 10) Which of the following controls could be used if the voice pitch of a single-sideband signal returning to your CQ call seems too high or low?
- a. The AGC or limiter
 - b. The bandwidth selection
 - c. The tone squelch
 - d. The RIT or Clarifier

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!



Everyone should have their
mind blown once a day.



- Neil deGrasse Tyson

Lesson 10: Basic Electrical Concepts

Basic Electrical Concepts and Terms

The first part of this lesson focuses on terms related to primary electrical concepts that form the basis for all circuits in ham radio and other electronics.

Voltage is the electromotive force, or EMF, that causes electrons to flow. This first unit is an easy one, voltage is measured in **volts**.

Current is the flow of electrical charge; it's the movement of electrons. Electrical current is measured in **amperes**.

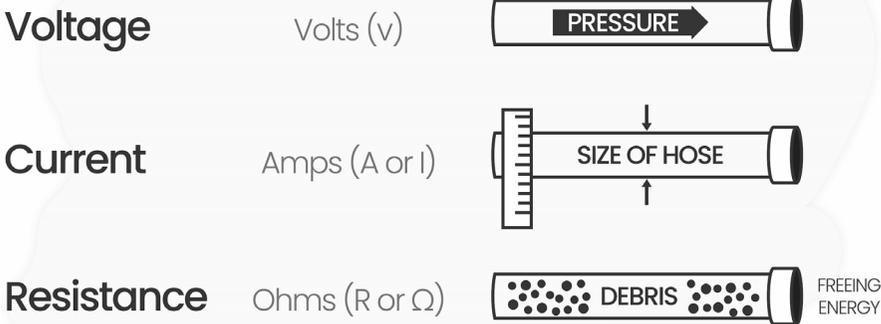
Resistance is the property that resists current flow. Resistance is measured in **ohms**.

Resistance opposes the flow of

- Direct Current
- Alternating Current
- RF Current
- **All of these choices are correct.**

These three concepts are very dependent on each other. Imagine the flow of water in a pipe. The voltage is the pressure that pushes the current, and the current is the water that flows through the pipe. Rocks or other obstructions that block the flow of water in a pipe are resistance!

Electricity is similar to a pipe



Power is the rate at which electrical energy is used and is measured in **watts**. You also can remember the relationship between power and energy because if you use a lot of power, you will run out of energy.

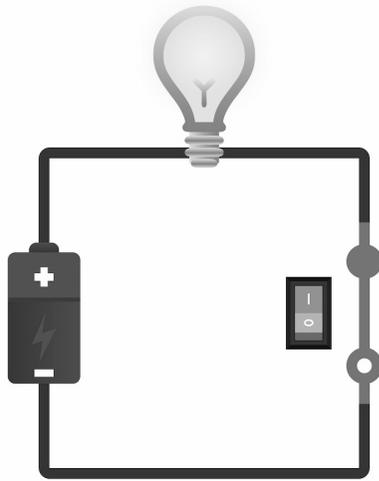
Capacitance is the ability to store energy in an electric field and is measured in **farads**. The component in a circuit for this is a capacitor.

Inductance is the ability to store energy in a magnetic field and the basic unit of inductance is **the henry**. The component for this in an electric circuit is called an inductor.

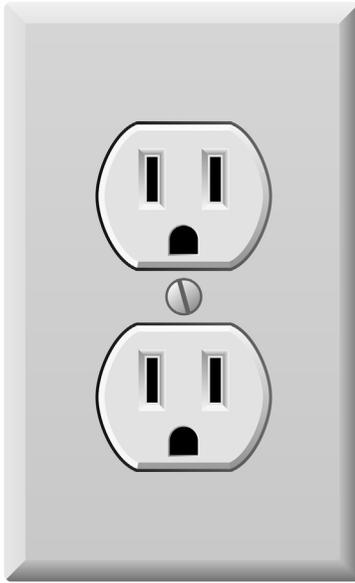
If that sounds familiar, Lesson 3 covered how electric fields and magnetic fields work together to generate radio waves. Capacitors and inductors are some of the tools to do that, and we'll get to those in more detail in the next lesson.

AC and DC

When current moves electrons, it does so in a circuit, which is a complete loop of components that current can flow around. Current usually flows in one of two ways: AC, or alternating current, and DC, or direct current.



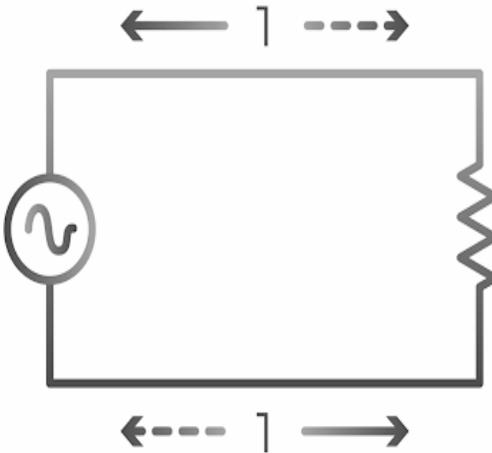
The current used in the outlets in your home is AC, or alternating current, which is **current that alternates between positive and negative directions.**



Frequency is the number of times per second that alternating current makes a complete cycle, and its basic unit is **Hertz**.

The abbreviation RF refers to **radio frequency signals of all types**.

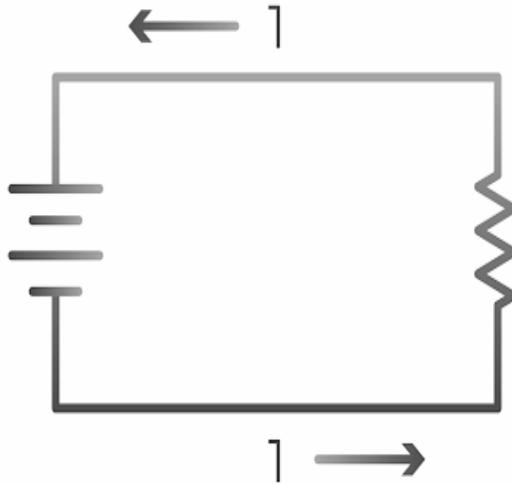
ALTERNATING CURRENT (AC)



Impedance is **a measure of the opposition to AC current flow in a circuit**, and its unit also is **ohms**. Impedance is another thing that resists or “impedes” the flow, which is why it uses the same unit as resistance.

The other way current moves in a circuit is using DC or direct current. You’ll see DC batteries powering a great deal of ham radio equipment.

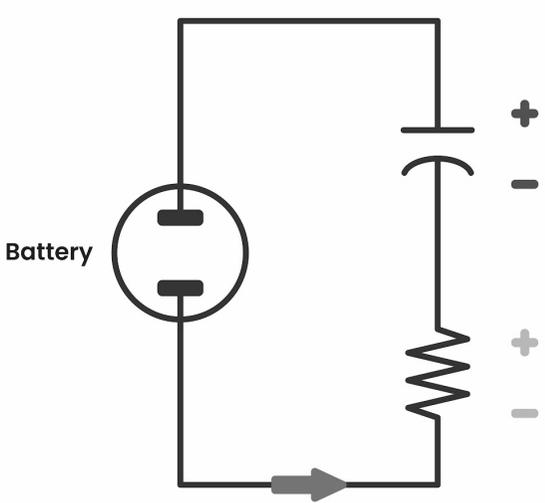
DIRECT CURRENT (DC)



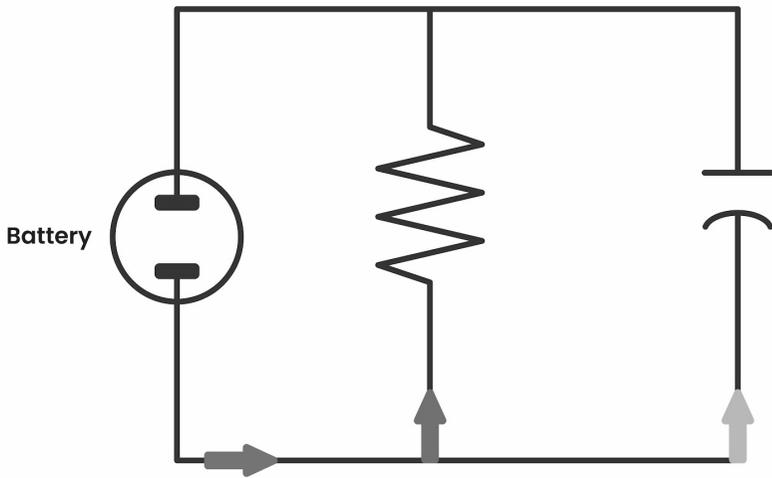
Series and Parallel

Current flowing through a circuit can perform work when components like capacitors and inductors are connected. There are two ways to connect components in a circuit – series or parallel.

A **series** circuit has all components connected in line. There is only one path, so the DC current is the same through all components in that circuit. A series circuit is like a track that you just keep going around and around.

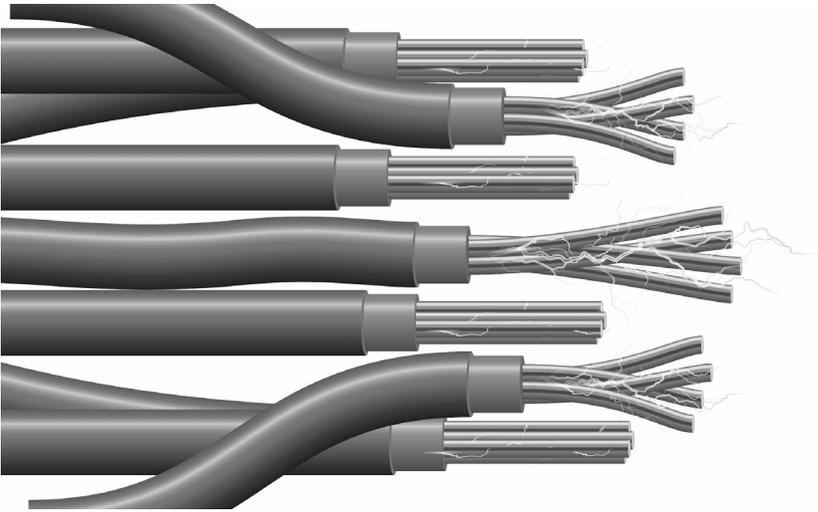


In a **parallel** circuit, components are connected allowing two more paths for current to flow through the elements. This means the voltage is the same across all the components in a parallel circuit. To imagine a parallel circuit, think of a road that forks in two, but both routes come back together at the other end.



Conductors and Insulators

When handling electricity, you want things that will help the flow and things that will impede the flow. Conductors help the flow by allowing electricity to pass through them easily. Metals generally are good conductors of electricity because **they have many free electrons.**



Just like how a coat can insulate you from the cold, an insulator in electrical circuits protects from the electrical charge. **Glass** is an example of a good insulator, but you may be more familiar with the plastic covering on a copper wire, like an electrical cord.

Lesson 10 Quiz:

- 1) Electrical current is measured in which of the following units?
 - a. Volts
 - b. Watts
 - c. Ohms
 - d. Amperes
- 2) Electrical power is measured in which of the following units?

- a. Volts
 - b. Watts
 - c. Watt-hours
 - d. Amperes
- 3) What type of current flow is opposed by resistance?
- a. Direct current
 - b. Alternating current
 - c. RF current
 - d. All these choices are correct
- 4) What is the unit of inductance?
- a. The coulomb
 - b. The farad
 - c. The henry
 - d. The ohm
- 5) Which of the following describes alternating current
- a. Current that alternates between a positive direction and zero
 - b. Current that alternates between a negative direction and zero
 - c. Current that alternates between positive and negative directions
 - d. All these answers are correct
- 6) What does the abbreviation "RF" mean?
- a. Radio frequency signals of all types
 - b. The resonant frequency of a tuned circuit
 - c. The real frequency transmitted as opposed to the apparent frequency
 - d. Reflective force in antenna transmission lines
- 7) What is impedance?
- a. The opposition to AC current flow
 - b. The inverse of resistance

- c. The Q or Quality Factor of a component
 - d. The power handling capability of a component
- 8) Why are metals generally good conductors of electricity?
- a. They have relatively high density
 - b. They have many free electrons
 - c. They have many free protons
 - d. All these choices are correct
- 9) Which of the following is a good electrical insulator?
- a. Copper
 - b. Glass
 - c. Aluminum
 - d. Mercury
- 10) In which type of circuit is DC current the same through all components?
- a. Series
 - b. Parallel
 - c. Resonant
 - d. Branch

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

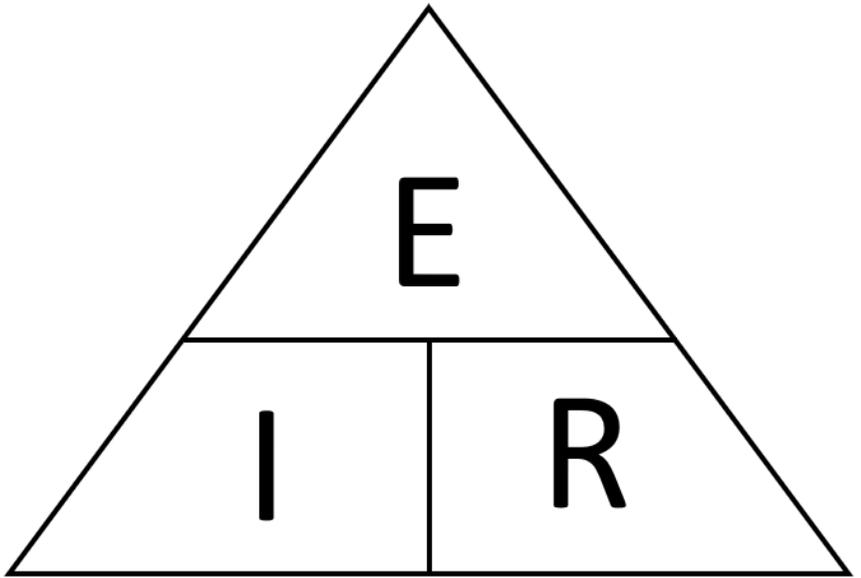
Lesson 11: Ohm's Law & Calculating Power

Ohm's Law

When working with circuits, you will need to calculate what the voltage, current or resistance is for the circuit, and the three are interdependent. Typically, you find one of the values by calculating from the other two. To do this, you use the most fundamental formula in electronics, Ohm's Law.

Ohm's Law states that voltage (E) equals current (I) multiplied by resistance (R). In modern times, voltage often is represented as a V, but on the test, voltage is represented with an E.

Using Ohm's Law, we can calculate either voltage, current or resistance, as long as we have two of the three values. This triangle representation is useful to help calculate items using Ohm's Law. Voltage is on top, and current and resistance are on the bottom of the triangle.

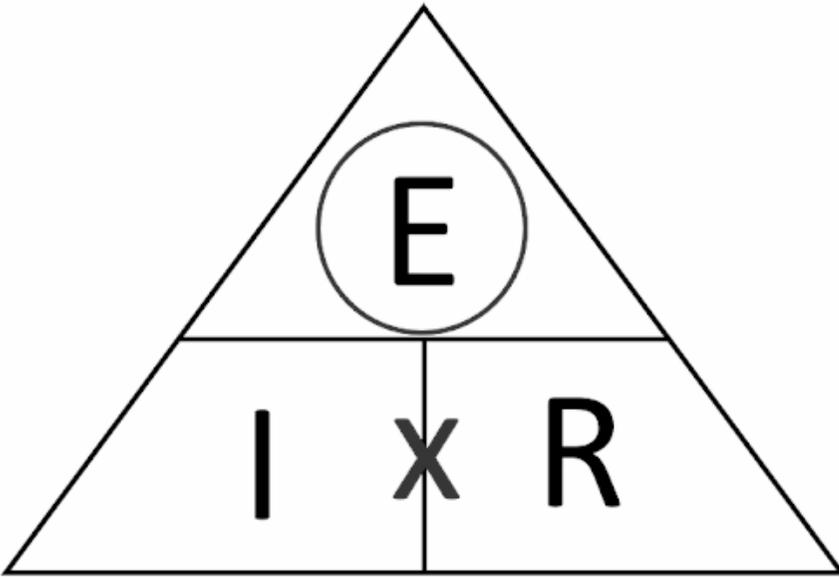


To calculate for the missing value, circle the value you want to calculate. Then, using the triangle, either multiply or divide the other two values.

For the first example, we want to calculate the voltage (E).

1. First, circle the voltage (E)
2. Notice that the current (I) is side by side with resistance (R), so add a multiplication sign.

3. Now, you have your answer: **voltage (E) equals current (I) multiplied by resistance (R)**



Let's solve Ohm's Law for voltage with some real values. Our circuit has a 2-ohm resistor with a current of 0.5 amperes flowing through it.

1. First, plug in our values: voltage = 0.5 amperes x 2 ohms.
2. Voltage equals **1 volt**.

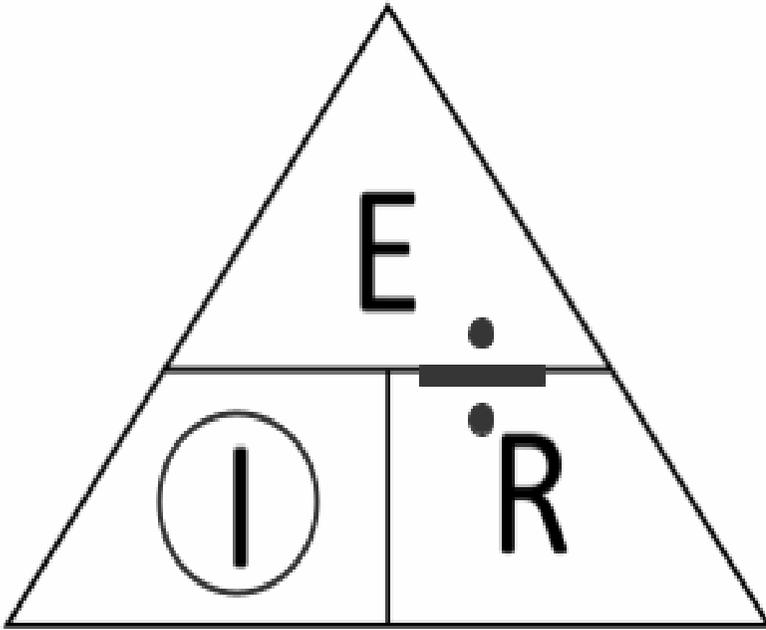
For a circuit with a 10-ohm resistor with a current of 1 ampere flowing through it:

1. Voltage = 1 ampere x 10 ohms
2. Voltage = **10 volts.**

The voltage across a 10-ohm resistor with a current of 2 amperes flowing through it is **20 volts.**

Now, we can move on to calculating current (I).

1. First, circle the current (I)
2. Notice that the voltage (E) is on top of resistance (R), so add a division sign
3. Now, you have your answer: **current (I) equals voltage (E) divided by resistance (R).**



Here are a few examples of calculating to find current. For a circuit with an applied voltage of 120 volts across a resistance of 80 ohms:

1. Current (I) = 120 volts divided by 80 ohms
2. Current = **1.5 amperes.**

For a circuit with a 100-ohm resistor connected across 200 volts:

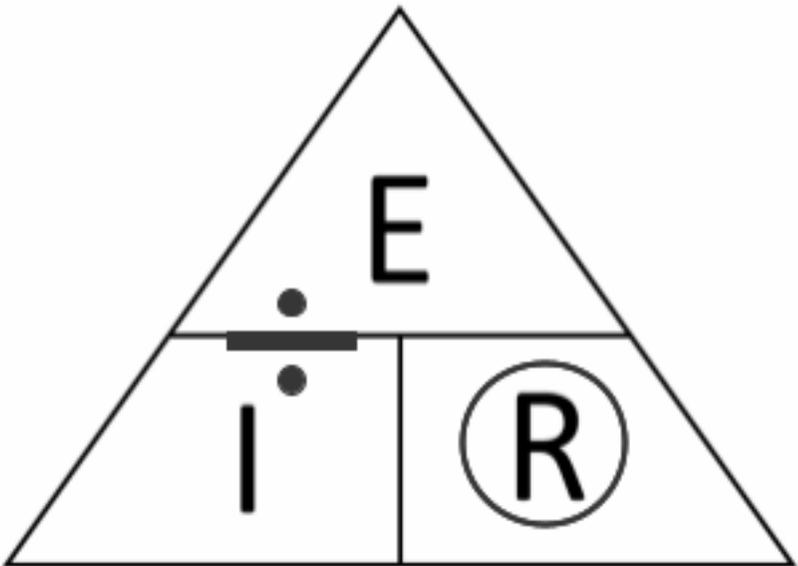
1. Current (I) = 200 volts divided by 100 ohms
2. Current (I) = **2 amperes.**

For a circuit with a 24-ohm resistor connected across 240 volts:

1. Current (I) = 240 volts divided by 24 ohms
2. Current (I) = **10 amperes.**

Now, let's use the triangle to calculate resistance.

1. First, circle the resistance (R).
2. Notice that the voltage (E) is on top of current (I), so add a division sign.
3. Now, you have your answer: **resistance (R) equals voltage (E) divided by current (I).**



Let's say we have a current of 3 amperes that flows when connected to 90 volts and we want to calculate the resistance.

1. We know from our triangle that resistance (R) = voltage (E) divided by current (I).
2. We plug in our values of resistance = 90 divided by 3.
3. Our final answer is resistance = **30 ohms**.

Let's find the resistance of another circuit. This time the applied voltage is 12 volts and the current flow is 1.5 amperes.

1. Enter our values so resistance = 12 volts divided by 1.5 amperes.
2. Our final answer is resistance = **8 ohms**.

We have another circuit that draws 4 amperes from a 12-volt source.

1. Here's our values resistance = 12 volts divided by 4 amperes
2. Resistance = **3 ohms**.

Calculating Power

Continuing on with the math of amateur radio, there will be times that instead of calculating resistance you'll need to calculate power.

The formula for power in a DC circuit is: **power (P) equals voltage (E) multiplied by current (I).**

Power is measured in watts. Using the prior formula, you can say volts times amps equals watts.

On to the simple math. If we have 13.8 volts and 10 amps, then 13.8 volts times 10 amps = **138 watts.**

In a circuit when the applied voltage is 12 volts DC and the current is 2.5 amperes:

1. Power (P) = 12 volts x 2.5 amperes
2. Power (P) = **30 watts**

This time, we need to find current when we know volts and watts. We'll modify the formula so that the applied voltage is 12 volts DC and the load is 120 watts in a circuit:

1. Current (I) = 120 watts divided by 12 volts
2. Current (I) = **10 amperes**

Let's recap the two formulas in this section.

Ohm's Law is voltage (E) equals current (I) multiplied by resistance (R).

$$E = I * R$$

Watts of power is calculated by the formula power (P) equals voltage (E) multiplied by current (I).

$$P = E * I$$

Knowing those two and focusing on the formulas will let you calculate the answers to any question in this section.

Lesson 11 Quiz:

- 1) What formula is used to calculate voltage in a circuit?
 - a. $E = I \times R$
 - b. $E = I / R$
 - c. $E = I + R$
 - d. $E = I - R$
- 2) What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it?
 - a. 1 volt
 - b. 10 volts
 - c. 11 volts
 - d. 9 volts
- 3) What is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it?
 - a. 8 volts

- b. 0.2 volts
 - c. 12 volts
 - d. 20 volts
- 4) What formula is used to calculate current in a circuit?
- a. $I = E \times R$
 - b. $I = E / R$
 - c. $I = E + R$
 - d. $I = E - R$
- 5) What is the current through a 100-ohm resistor connected across 200 volts?
- a. 20,000 amperes
 - b. 0.5 amperes
 - c. 2 amperes
 - d. 100 amperes
- 6) How much current is required to deliver 120 watts at a voltage of 12 volts DC?
- a. 0.1 amperes
 - b. 10 amperes
 - c. 12 amperes
 - d. 132 amperes
- 7) What formula is used to calculate resistance in a circuit?
- a. $R = E \times I$
 - b. $R = E / I$
 - c. $R = E + I$
 - d. $R = E - I$
- 8) What is the resistance of a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes?
- a. 18 ohms
 - b. 0.125 ohms

- c. 8 ohms
 - d. 13.5 ohms
- 9) How much power is delivered by a voltage of 13.8 volts DC and a current of 10 amperes?
- a. 138 watts
 - b. 0.7 watts
 - c. 23.8 watts
 - d. 3.8 watts
- 10) What is the current through a 24-ohm resistor connected across 240 volts?
- a. 24,000 amperes
 - b. 0.1 amperes
 - c. 10 amperes
 - d. 216 amperes

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Lesson 12: Units of Measurement

Units of Measurement

When describing a value like voltage, current or resistance, it is important to understand units. Every measurement has a base unit, like volts, amps or ohms. However, when the value becomes too large or too small, we use prefixes such as milli- or kilo-. These prefixes are the same ones you'll find in the metric system. We get a lot of questions from students on this section, so give yourself some extra time on this, if needed.

This chart describes the basic prefixes:

	Prefix	Symbol	Multiplying Factor
	giga-	G	1,000,000,000 = 10^9
	mega-	M	1,000,000 = 10^6
	kilo-	k	1,000 = 10^3
		Basic Unit (Volts, amp, etc.)	1
	milli-	m	0.001 = 10^{-3}
	micro-	μ	.000001 = 10^{-6}
	nano-	n	.000000001 = 10^{-9}
	pico-	p	.000000000001 = 10^{-12}

We can convert the units of a value up and down the chart by moving the decimal place 3 spaces for every level.

To move UP one row in the chart, move the decimal point three places to the left. As you can see, **1,000 volts equals 1 kilovolt**. Moving the decimal point to the left takes away zeroes and uses a larger descriptor for the value.

To move DOWN one row in the chart, move the decimal point three places to the right. In this case, 0.001 volts becomes 1 millivolt. Moving the decimal point to the right adds zeroes, and uses a smaller descriptor for the value.

Here's a question that asks to convert 1.5 amperes to milliamperes. 1.5 amperes is in base units, and we want to move down the chart to milli.

First, write out your number, 1.5 amps, and add some zeros:

1.5000 amps

To change 1.5 amperes to milliamperes, we are moving from the base unit (amps) to milliamps, which means move the decimal three places to the right.

1.5 amperes = 1,500 milliamperes

Here's a quick way to check - does it make sense that there are more milliamperes than amperes? Yes, of course, because milliamperes are smaller! We need 1,000 smaller milliamperes to make one full ampere.

We can use the same method to convert 1,500,000 hertz to kHz, but in the opposite direction. The base unit is Hertz, and we are converting to kilohertz, which means we move the decimal three places to the left.

1,500,000 Hz = 1,500 kHz

To change a volt to microvolt, we change the decimal in the opposite direction, but now it is six places over because we are moving two rows down in the chart.

One microvolt = One one-millionth of a volt

Let's use an example with a base unit of watts. Remember, unit conversions always follow the same rules, even when the base unit changes. Focus on the prefix.

How many watts are equivalent to 500 milliwatts?

To convert 500 mW to watts, move the decimal point by 3 places to the left.

500 mW = 0.5 watts – (or a half-watt).

Let's move on to calculations that don't make it to the base unit. How do you convert picofarads to microfarads?

Focus on the units **pico** and **micro**. To go from pico to micro, we have to move up two columns on the graphic above. This means we have to move the decimal point **six places** to the left.

1,000,000 picofarads is equal to **1 microfarad**. (Remember, farads are the measurement of capacitance.)

Let's run a few more conversions:

An ammeter calibrated in amperes used to measure a 3,000-milliampere current would show a reading of **3 amperes**.

If a frequency display calibrated in megahertz shows a reading of 3.525 MHz, it would show **3525 kHz** if it were calibrated in kilohertz.

From megahertz to kilohertz, we need to move the decimal point 3 places to the right. **28.400 MHz = 28400 kHz**

Let's back check those abbreviations. Kilohertz is abbreviated kHz. Megahertz is abbreviated **MHz**, with a capital M to differentiate from millihertz. Don't miss the fact that both have a capital H for Hertz in the abbreviation.

One more frequency conversion to know: 2425 MHz = **2.425 GHz**, moving the decimal point three places to the left.

Decibels

Let's wrap up this lesson with one more term. Decibels are used to measure the gain or loss of a signal, especially sound waves. Someone may use a hearing aid to increase the decibels, or intensity, of the sound to their ear.



The decibel scale is logarithmic when comparing two values, so you cannot directly multiply the decibel value. The formula is a bit complex, but for the test, there are three decibel examples you need to know.

3 dB creates a power multiplier of 2 times. 5 watts to 10 watts is **3 dB**.

10 dB is a power multiplier of 10 times. An increase of 20 watts to 200 watts would be **10 dB**.

Number in decibels	Multiplier
3 dB	<i>Times 2</i>
6 dB	<i>Times 4</i>
10 dB	<i>Times 10</i>

Decibels also can be used to describe a power loss. That would be negative decibels. A decrease of 12 watts to 3 watts is **-6 dB**.

Lesson 12 Quiz:

- 1) Which is equal to 1,000,000 picofarads?
 - a. 0.001 microfarads
 - b. 1 microfarad
 - c. 1000 microfarads
 - d. 1,000,000,000 microfarads
- 2) Which is equal to 1,500,000 hertz?
 - a. 1500 kHz
 - b. 1500 MHz
 - c. 15 GHz
 - d. 150 kHz
- 3) Which is equal to one microvolt?
 - a. One one-millionth of a volt
 - b. One million volts
 - c. One thousand kilovolts
 - d. One one-thousandth of a volt
- 4) Which is equal to 3.525 MHz?
 - a. 0.003525 kHz
 - b. 35.25 kHz
 - c. 3525 kHz
 - d. 3,525,000 kHz
- 5) Which is equal to 28400 kHz?
 - a. 28.400 kHz
 - b. 2.800 MHz
 - c. 284.00 MHz
 - d. 28.400 MHz
- 6) What is the abbreviation for kilohertz?
 - a. KHZ
 - b. khz
 - c. khZ
 - d. kHz
- 7) What is the abbreviation for megahertz?
 - a. MH
 - b. mh

- c. Mhz
 - d. MHz
- 8) Which is equal to 2425 MHz?
- a. 0.002425 GHz
 - b. 24.25 GHz
 - c. 2.425 GHz
 - d. 2425 GHz
- 9) Which decibel value most closely represents a power increase from 5 watts to 10 watts?
- a. 2 dB
 - b. 3 dB
 - c. 5 dB
 - d. 10 dB
- 10) Which decibel value represents a power increase from 20 watts to 200 watts?
- a. 10 dB
 - b. 12 dB
 - c. 18 dB
 - d. 28 dB

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!



Smart people learn from everything and everyone, average people from their experiences, stupid people already have all the answers.



- Socrates

Lesson 13: Intro to Electrical Components

Intro to Electrical Components

Electrical components are the building blocks of circuits that make ham radio transmitting possible. When you connect electrical components, you create a circuit that controls electrical signals.

All circuits are made up of these same basic components:

- **Resistors**, which oppose the flow of current in a DC circuit. Think that it “resists” flow.
- **Potentiometers**, which are a special kind of resistor, where the resistance can be adjusted. These often are used as an adjustable volume control.
- **Capacitors** consist of two conductive surfaces separated by an insulator. They’re like a sandwich where the bread is the metal, and the meat and cheese are the

insulator. Capacitors store energy in an electric field.

- **Inductors** are made of a coil of wire, like wrapping wire around a nail. Inductors store energy in a magnetic field.
- Switches are used to connect or disconnect electrical circuits. **A single circuit is switched between one of two other circuits** by using a SPDT, or Single Pole-Double Throw, switch.
- Relays are **electrically-controlled switches**.
- **Fuses** are used to protect other circuit components from current overload. These are the same components you have in your home or car!
- **Meters** are used to display an electrical quantity like signal strength or voltage on a numeric scale.
- Shielded wire is used **to prevent coupling of unwanted signals to or from the wire**.
- **Diodes** are components that limit the electrical current to flow in only one direction.

- A diode has two parts called electrodes: **the anode and cathode**.
- **A stripe** indicates the cathode lead of a semiconductor diode.
- An **LED** is a special kind of diode. The letters LED stand for Light-Emitting Diode. **Forward current** causes an LED to emit light. An LED commonly is used as a visual indicator. You've seen this all over, like that blinking light that tells you your TV remote is working.

Take many of these components and combine them, include some semiconductors, and the result is called an integrated circuit.

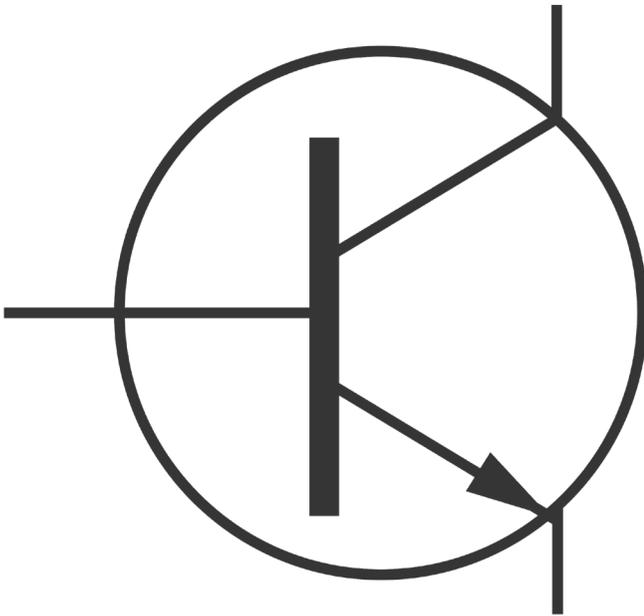
You can combine a **capacitor** with an inductor to make a tuned circuit. A resonant or tuned circuit is when **an inductor and a capacitor are connected in series or parallel to form a filter**.

Transistors

Transistors are an extremely important component in electronics and ham radio.

A transistor can be made of three layers of semiconductor material.

What makes a transistor so powerful?



- A transistor can **control the flow of current** or voltages in a circuit, which gives them a lot of uses right there.

- **A transistor** can be used as an electronic switch or amplifier. When it is used as an amplifier, it creates **gain**. The **transistor** frequently is the primary gain-producing component in an RF power amplifier

There are two types of transistors to be aware of for the exam.

- The most common is the FET, which stands for **field effect transistor**. A **field-effect** transistor typically has three connections: a gate, drain and source.
- A bipolar junction transistor has three electrodes as well: **emitter, base, collector**.

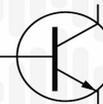
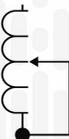
Schematics

A **schematic** diagram is an electrical wiring drawing that uses standard component symbols. It's a roadmap of a circuit that represents the **component connections**.

The most common symbols you will see include a resistor and a variable resistor. Anytime you

see the arrow pointing to the middle of the symbol, it is the variable version of that component.

Symbols also include capacitor, transistor, switch (this one is a single pole-single throw), battery, LED, transformer, variable inductor (there's that arrow again), antenna and lamp or bulb.

Resistor	
Variable resistor	
Capacitor	
Transistor	
Switch (Hint: Single-pole single throw)	
Battery	
Light-emitting diode	
Transformer	
Variable inductor	
Antenna	
Bulb	

On the exam, expect to have a question that asks you to identify an element in a schematic from a diagram. There are three possible schematics you will see. Here's an example.

What type of switch is represented by component 3 in figure T-2?

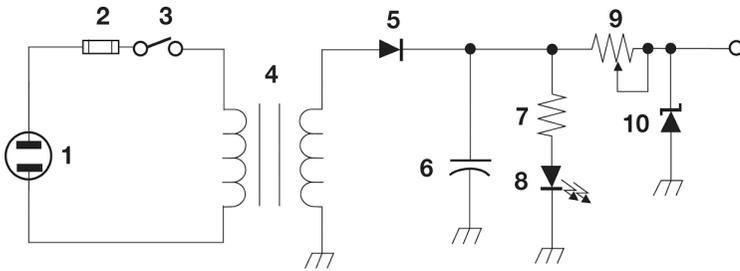


Figure T-2

Component 3 is a **single-pole single-throw switch**.

Using multiple components from the list, and adding a few additional components, you can make more complex circuits.

A transformer is a frequently used component. You may have one on the telephone pole outside

your house. Transformers are used to go from one AC voltage to another. In ham radio, a **transformer** is commonly used to change 120-volt AC house current to a lower AC voltage.

However, suppose you need to go from AC current to DC current? A transformer only can change one AC signal to another, so that won't work. However, if you use a **rectifier**, it changes alternating current into a varying direct current signal.

When you see transformers and rectifiers together, you usually also see a **regulator** circuit that controls voltage from a power supply.

Batteries

Let's wrap up this lesson with a section on batteries. A battery obviously is an essential component to any hand radio, or "walkie talkie." They also are frequently used for mobile operation in an emergency when power is out.

While **carbon-zinc** batteries you buy from the store are not rechargeable, there are several types used in ham radio that are rechargeable. Rechargeable battery types include nickel-metal hydride, lithium-ion and lead-acid gel-cell. **All of the above** is the right answer when asked about rechargeable batteries on the exam.

Lesson 13 Quiz:

- 1) What electrical component opposes the flow of current in a DC circuit?
 - a. Inductor
 - b. Resistor
 - c. Inverter
 - d. Transformer
- 2) What is the function of an SPDT switch?
 - a. A single circuit is opened or closed
 - b. Two circuits are opened or closed
 - c. A single circuit is switched between one of two other circuits
 - d. Two circuits are each switched between one of two other circuits
- 3) What are the names for the electrodes of a diode?
 - a. Plus and minus
 - b. Source and drain
 - c. Anode and cathode
 - d. Gate and base
- 4) Which of the following is a resonant or tuned circuit?

- a. An inductor and a capacitor in series or parallel
 - b. A linear voltage regulator
 - c. A resistor circuit used for reducing standing wave ratio
 - d. A circuit designed to provide high-fidelity audio
- 5) What does the abbreviation FET stand for?
- a. Frequency Emission Transmitter
 - b. Fast Electron Transistor
 - c. Free Electron Transmitter
 - d. Field Effect Transistor
- 6) What are the names of the electrodes of a bipolar junction transistor?
- a. Signal, bias, power
 - b. Emitter, base, collector
 - c. Input, output, supply
 - d. Pole one, pole two, output
- 7) Which of the following is accurately represented in electrical schematics?
- a. Wire lengths
 - b. Physical appearance of components
 - c. Component connections
 - d. All these choices are correct
- 8) Which of the following devices or circuits changes an alternating current into a varying direct current signal?
- a. Transformer
 - b. Rectifier
 - c. Amplifier
 - d. Reflector

- 9) What type of circuit controls the amount of voltage from a power supply?
- a. Regulator
 - b. Oscillator
 - c. Filter
 - d. Phase inverter
- 10) Which of the following battery chemistries is not rechargeable?
- a. Nickel-cadmium
 - b. Carbon-zinc
 - c. Lead-acid
 - d. Lithium-ion

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!



Man's mind, once stretched
by a new idea, never regains
its original dimensions.



- Oliver Wendell Holmes

Lesson 14: Amplifiers and Devices

Transmitting and Receiving

An amateur radio has two basic functions – to transmit your signal to other people’s radios, and to receive signals from other radios to you. When you put both the sending and receiving functions into one radio, it’s called a transceiver

– A unit combining the functions of a transmitter and a receiver.



When you are ready to talk on any kind of radio, you'll use the PTT or "push-to-talk" button. Electrically, a transceiver's PTT button **switches the transceiver from receive to transmit when grounded**. The PTT button is on the left side of this handheld radio.



To get your radio on the frequency you want to transmit on or listen to, the transceiver uses an oscillator. An **oscillator** is a circuit that generates a signal at a specific frequency. The oscillator does both generation of the transmit frequency and helps process the received signal.

Other terms you'll use when talking about a transceiver:

- **Sensitivity** is the ability of a receiver to detect the presence of a signal
 - **Selectivity** is the ability of a receiver to discriminate between multiple signals
 - **Modulation** is combining speech with an RF carrier signal
-

Amplifiers

Most radios generate a low level of power for transmitting and then boost it with an amplifier. An **RF power amplifier** increases the low-power output from a handheld transceiver.



If you need to boost your power, you'll have a broad choice of amplifiers. With a Technician license, you might use an amp to boost your signal from 4 watts to 70 on VHF. As a General or Extra class HF operator, linear or tube amps can boost your transmit power from 100 watts to the legal limit of 1,500 watts.

When using an amp like a VHF power amplifier, the SSB/CW-FM switch **sets the amplifier for the proper operation in the selected mode.** Remember though, this ONLY sets the

AMPLIFIER for the correct mode, you still need to change the mode of the transmitter to match.

Amplifiers work the other way, too. If you want to get a stronger received signal, an RF preamplifier can help boost weak signal reception and is installed **between the antenna and the receiver**.

Devices for Converting Signals

If you want to operate on higher frequency bands, instead of a dedicated radio, you can add a transverter to your equipment. A **transverter** converts the RF input and output of a transceiver to another band.



One transverter example converts the 1296-MHz amateur band to frequencies on the 2-meter band, allowing a ham to communicate on that higher frequency band just by using their 2-meter radio.

A transverter functions via a **mixer**, which is used to convert a radio signal from one frequency to another.

Measurement Devices

Lesson 6 covered things such as volts, amps and ohms, but how do you measure them? Let's look at the electronics tools that will help you measure voltage, current, resistance, power and more.

The most common tool is a multimeter, which measures **voltage and resistance**. You can change the setting on the multimeter, depending on what you would like to measure. Before attempting to measure any circuit, first make sure that the multimeter is on the correct setting.



Ohms are a measurement of resistance, so that function is called an ohmmeter. When measuring circuit resistance with an ohmmeter, **ensure that the circuit is not powered**. Here's a helpful troubleshooting tip: If you see **increasing resistance with time**, it indicates

that an ohmmeter is connected across a large, discharged capacitor. You're actually "charging up" the capacitor as part of the measurement process.

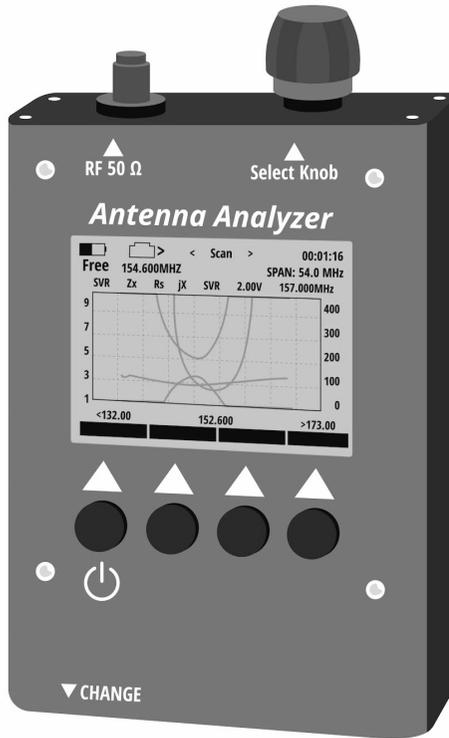
Also in your multimeter is a **voltmeter**, which is used to measure electric potential or electromotive force. Just like with ohms, the basic unit of voltage is called the volt, which gives its name to the voltmeter.

A voltmeter should be connected **in parallel with the circuit**. When connected in parallel, the voltmeter is positioned across the voltage. **Attempting to measure voltage when using the resistance setting** on your meter could damage a multimeter.

Some multimeters include an **ammeter** that is used to measure electric current, but you also can find all these meters as standalone devices. Remember that an amp is a measurement of current, therefore an ammeter is a meter that measures amps. A meter measuring current should be connected **in series** with the

component so the current flows through the ammeter.

Another meter in your tool kit will likely be an **antenna analyzer**, which can be used to determine whether an antenna is resonant at the desired operating frequency.



When you are testing your radio or other equipment, it's good practice not to transmit over the air. A tool called a dummy load is used **to prevent transmitting signals over the air when making tests.** When you replace your antenna with a dummy load, you are using a

non-inductive resistor mounted on a heat sink. This simulates an antenna and helps avoid potential interference so you can test for as long as necessary, based on the dummy load's rating.

Solder

Solder is used to “glue” or permanently attach wires and components in circuits. Solder is a conductive material that is liquid while hot, and then cools down and turns solid over the connection.

Acid-core solder should never be used for radio and electronic use. Good solder joints are shiny. If you have a bad solder joint, often called a cold tin-lead solder joint, its characteristic appearance will be **a rough or lumpy surface.**

Lesson 14 Quiz:

- 1) What is the function of a transceiver's PTT input?
 - a. Input for a key used to send CW

- b. Switches transceiver from receive to transmit when grounded
 - c. Provides a transmit tuning tone when grounded
 - d. Input for a preamplifier tuning tone
- 2) Which term describes the ability of a receiver to detect the presence of a signal?
- a. Linearity
 - b. Sensitivity
 - c. Selectivity
 - d. Total Harmonic Distortion
- 3) Which of the following describes combining speech with an RF carrier signal?
- a. Impedance matching
 - b. Oscillation
 - c. Modulation
 - d. Low-pass filtering
- 4) What device increases the transmitted output power from a transceiver?
- a. A voltage divider
 - b. An RF power amplifier
 - c. An impedance network
 - d. All these choices are correct
- 5) Where is an RF preamplifier installed?
- a. Between the antenna and receiver
 - b. At the output of the transmitter power amplifier
 - c. Between the transmitter and the antenna tuner
 - d. At the output of the receiver audio amplifier
- 6) What device converts the RF input and output of a transceiver to another band?

- a. High-pass filter
 - b. Low-pass filter
 - c. Transverter
 - d. Phase converter
- 7) Which of the following measurements are made using a multimeter?
- a. Signal strength and noise
 - b. Impedance and reactance
 - c. Voltage and resistance
 - d. All these choices are correct
- 8) Which of the following types of solder should not be used for radio and electronic applications?
- a. Acid-core solder
 - b. Lead-tin solder
 - c. Rosin-core solder
 - d. Tin-copper solder
- 9) What is the primary purpose of a dummy load?
- a. To prevent transmitting signals over the air when making tests
 - b. To prevent over-modulation of a transmitter
 - c. To improve the efficiency of an antenna
 - d. To improve the signal-to-noise ratio of a receiver
- 10) Which instrument is used to measure electric current?
- a. An ohmmeter
 - b. An electrometer
 - c. A voltmeter
 - d. An ammeter

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

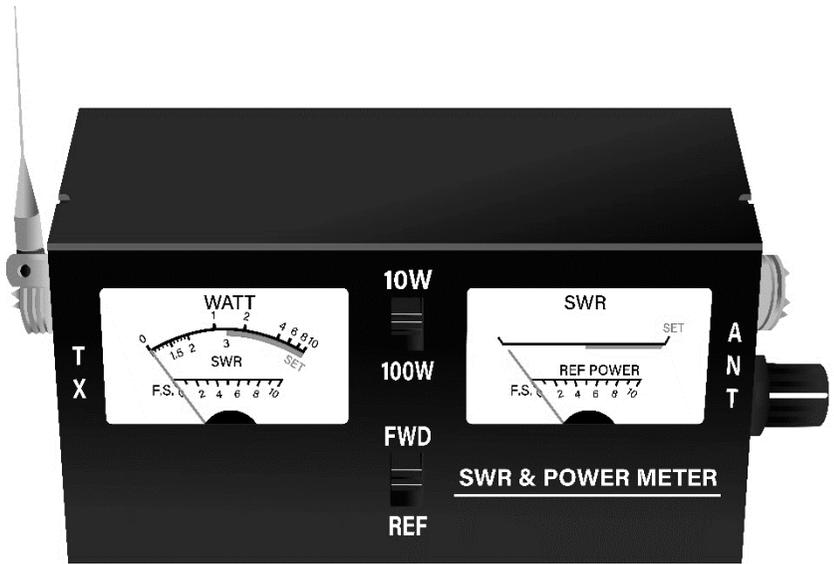
Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Lesson 15: SWR and Common Problems

SWR

We covered that impedance is the resistance to alternating current in a circuit. A radio wave is alternating current and once it leaves your transmitter, you want to give it the path of least resistance through your feedline and antenna.

Ham radio uses the term standing wave ratio, or SWR, to measure impedance matching. SWR is a measure of how well a load, in this case an antenna and transmission line, is matched to a transceiver. An SWR meter reading of **1 to 1** (written as 1:1) indicates a perfect impedance match between the antenna and the feed line. It is best to strive for as close to a 1:1 match as possible, because at 1:1 the transceiver delivers maximum power to the antenna. This also is the point of maximum efficiency.



SWR can be measured using an SWR meter in line with your antenna, or a **directional wattmeter** could be used to determine whether a feed line and antenna are properly matched.

When there is an impedance mismatch, you will see a high SWR reading. For example, an SWR reading of 4:1 would indicate an **impedance mismatch**, in this case more than 40 percent of your transmit power is being lost before it gets out your antenna. Where does this power go?

The mismatch of current means power lost in a feed line **is converted into heat**.

If you have a solid-state amateur radio transmitter, it's designed to reduce output power as SWR increases **to protect the output amplifier transistors**. The radio is protecting itself from damage because of a mismatch in SWR.

Common Problems

Don't worry if you run into trouble as even more experienced hams have issues from time to time. Let's cover some common problems you'll find as the last part of this lesson.

Microphones are sensitive instruments, and talking too close to them can cause an overload. Speaking one to two inches away is a good measurement. If another ham tells you that your FM handheld or mobile transceiver is "overdeviating," **talk farther away from the microphone** so you don't sound distorted.



Sometimes your transmitted signal, or RF, can feed back into your equipment. This can cause **reports of garbled, distorted or unintelligible voice transmissions.** A **ferrite choke** could be used to cure distorted audio caused by RF current on the shield of a microphone cable.

There could be several problems if you receive a report that your audio signal through the repeater is distorted or unintelligible:

- Your transmitter is slightly off frequency

- Your batteries are running low
- You are in a bad location

All of these choices are correct!

Let's get into the topic of interference. You don't want to interfere with other signals and you don't want them interfering with you.

Three of the ways interference can be caused in your radio include fundamental overload, harmonics and spurious emissions. **All of the above** will be the answer to the exam question for interference causes, but let's break those down quickly so you know them when you see them.

Fundamental overload is when your receiver gets too much of a strong signal. One example would be if you are operating your handheld radio right next to someone else's radio and you hear distortion.

Harmonics means additional signals are generated in addition to the primary one. A signal on 144 megahertz also would have a lower

power harmonic at 288 megahertz, or double the operating frequency. A spurious emission can be a strong harmonic or odd frequency generation, like the sound your speakers make when your cell phone gets too close.

If your signal is suffering from harmful interference by something else, like a noisy transformer in a neighbor's home, there are several things you can do:

- Work with your neighbor to identify the offending device.
- Politely inform your neighbor about the rules that prohibit the use of devices that cause interference.
- Check your station and make sure it meets the standards of good amateur practice.

All of these choices are correct!

It's also possible that a nearby FM broadcast station could interfere with a ham radio station. A tool called a **band-reject filter** can reduce overload to a VHF transceiver from a nearby FM broadcast station.



You may spend more time understanding why your signal is interfering with someone else's equipment, because we want to be good operators. Radio transmissions can affect telephones, television and radio reception in many cases. Some broadcast radio receivers in cars pick up ham radio signals as interference if the **receiver is unable to reject strong signals outside the AM or FM band.**

If your neighbor says that your station's transmissions are interfering with their radio or TV reception, **make sure that your station is**

functioning properly and that it does not cause interference to your own radio or television when it is tuned to the same channel. An overload of a non-amateur radio or TV receiver by an amateur signal can be eliminated by **blocking the amateur signal with a filter at the antenna input of the affected receiver.**

If the issue is cable television interference, the first step is to **be sure all TV feed line connectors are installed properly.**

Let's wrap up with issues that can be caused by the cables we use. Choosing good cables and keeping them in good condition is critical for high quality communications. You will want to protect your cables from the elements as much as possible.



Moisture contamination is the most common cause of failure of coaxial cables. Use of air core coaxial cable has a disadvantage when compared to foam or solid dielectric types because **it requires special techniques to prevent water absorption.**

In any cable, **ultraviolet light can damage the jacket and allow water to enter the cable.**

Here's a tip from our elmers to wrap up the troubleshooting section: When trying to track down an issue, the scientific method is your

friend. Change ONE thing, test the change, then go on.

Lesson 15 Quiz:

- 1) What reading on an SWR meter indicates a perfect impedance match between the antenna and the feed line?
 - a. 50:50
 - b. Zero
 - c. 1:1
 - d. Full Scale
- 2) What happens to power lost in a feed line?
 - a. It increases the SWR
 - b. It is radiated as harmonics
 - c. It is converted into heat
 - d. It distorts the signal
- 3) What can you do if you are told your FM handheld or mobile transceiver is over-deviating?
 - a. Talk louder into the microphone
 - b. Let the transceiver cool off
 - c. Change to a higher power level
 - d. Talk farther away from the microphone
- 4) What might be a problem if you receive a report that your audio signal through an FM repeater is distorted or unintelligible?
 - a. Your transmitter is slightly off frequency
 - b. Your batteries are running low
 - c. You are in a bad location
 - d. All these choices are correct

- 5) Which of the following can reduce overload of a VHF transceiver by a nearby commercial FM station?
- Installing an RF preamplifier
 - Using double-shielded coaxial cable
 - Installing bypass capacitors on the microphone cable
 - Installing a band-reject filter
- 6) What should be the first step to resolve non-fiber optic cable TV interference caused by your amateur radio transmission?
- Add a low-pass filter to the TV antenna input
 - Add a high-pass filter to the TV antenna input
 - Add a preamplifier to the TV antenna input
 - Be sure all TV feed line coaxial connectors are installed properly
- 7) Which of the following causes failure of coaxial cables?
- Moisture contamination
 - Solder flux contamination
 - Rapid fluctuation in transmitter output power
 - Operation at 100% duty cycle for an extended period
- 8) Why should the outer jacket of coaxial cable be resistant to ultraviolet light?
- Ultraviolet resistant jackets prevent harmonic radiation
 - Ultraviolet light can increase losses in the cable's jacket
 - Ultraviolet and RF signals can mix, causing interference

- d. Ultraviolet light can damage the jacket and allow water to enter the cable
- 9) Which of the following could you use to cure distorted audio caused by RF current on the shield of a microphone cable?
- a. Band-pass filter
 - b. Low-pass filter
 - c. Preamplifier
 - d. Ferrite choke
- 10) What is a symptom of RF feedback in a transmitter or transceiver?
- a. Excessive SWR at the antenna connection
 - b. The transmitter will not stay on the desired frequency
 - c. Reports of garbled, distorted, or unintelligible voice transmissions
 - d. Frequent blowing of power supply fuses

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

“

The difference between a
stumbling block and a
stepping stone is how high
you raise your foot.

”

- Benny Lewis

Lesson 16: Modes of Operation

Common Modes of Operation

In ham radio, a mode of operation refers to the way information is encoded when sending information from one station to another. Using the same mode is like speaking the same language; it's critical that the sending and receiving stations are using the same mode to communicate. The three most common modes used in ham radio are FM, single sideband and CW.

FM — Frequency Modulation

FM is an abbreviation for the mode called Frequency Modulation. You are probably familiar with the FM broadcast radio band that uses this mode to send news and music to our cars and homes. FM works by causing small

changes to the frequency of a signal to send information like our voice.



Many ham radio handhelds are designed around FM transmitting and receiving. You'll encounter **FM** most commonly on VHF and UHF voice repeaters and simplex. It's a good bet that most hams today make their first contact via FM.



Each mode of modulation has advantages and disadvantages that we'll touch on. A VHF FM repeater phone signal uses **10 to 15 kHz** of bandwidth per signal, which is pretty large compared to other signals we'll talk about. So bandwidth is a disadvantage when compared to

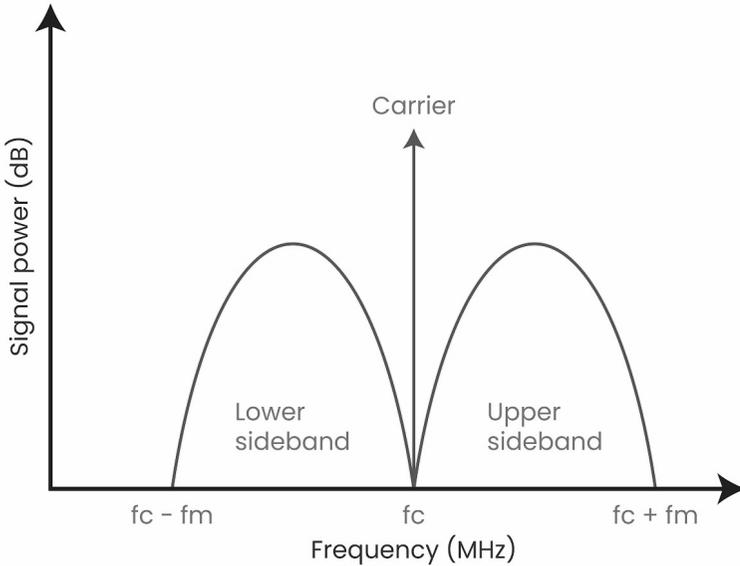
the advantage that FM usually is a clearer signal.

Sometimes FM carries digital information instead of voice. **FM** is most commonly used for VHF packet radio transmissions. We have a whole lot more about packet radio and digital communications coming up in this lesson.

SSB — Single Sideband

Let's move on to AM and its component single sideband, or SSB. While FM modulates the frequency to convey information, AM modulates the signal strength, called amplitude. That gives it its name - AM means amplitude modulation.

Single sideband is a form of amplitude modulation.



The graphic above shows an AM signal and its two sidebands, both of which carry all the information in the signal, as well as the carrier, which is in the center of the signal. SSB means we use only a single sideband from the two sidebands without a carrier for our transmission. The two sidebands are called upper and lower. Sometimes hams use the lower sideband on lower HF bands, but as a Technician licensee you'll mostly encounter **upper sideband**, which is normally used for 10-meter HF, VHF and UHF single-sideband

communications. Single sideband (**SSB**) is most often used for long-distance (weak signal) contacts on the VHF and UHF bands.

Because SSB splits the 6-kHz AM signal into 2 parts, the approximate bandwidth of an SSB signal is **3 kHz**. Compare that to the 10-15 kHz for FM and you can see an advantage of single sideband transmissions - **SSB signals have a narrower bandwidth**. FM has another disadvantage versus SSB because **only one signal can be received at a time** on FM.

Here's a chart that compares FM and SSB advantages:

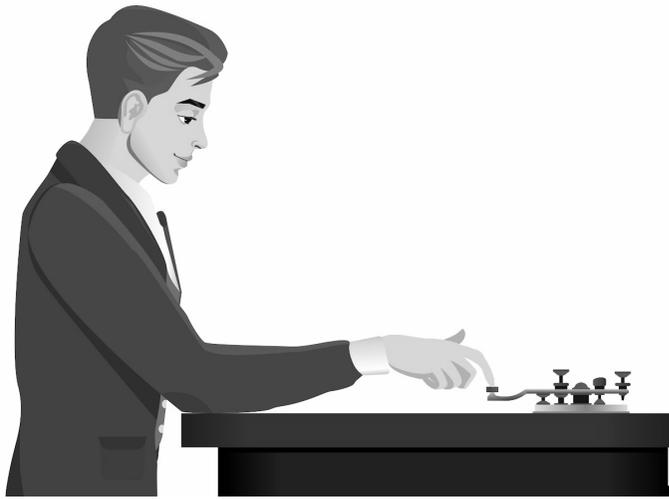
FM	SSB
Easier to tune	Trickier to tune
Larger bandwidth	Smaller bandwidth
Most commonly used for VHF and UHF voice	Used for long-distance contacts on VHF and UHF bands
Used for VHF packet radio transmissions	Upper sideband is used for 10-meter HF, VHF and UHF SSB communications

CW — Morse Code

Morse code proficiency is not required for a ham radio license any longer, but it's good to know because it's still a popular mode of communication. **Another name for a Morse code transmission is CW, or continuous wave.** This means a carrier wave is switched on and

off, giving CW its characteristic “beeping” sound.

Morse code is extremely simple – it just uses one on/off tone that is either long or short.



Because it is so simple, **CW** has the narrowest bandwidth of the common modes with an approximate maximum bandwidth of just **150 Hz**.

Amateur Television

In some cases, hams don't just transmit words, they can send video. Amateur television sends voice and video using the NTSC mode to transmit **an analog fast scan color TV signal**. When operating, you usually find amateur TV signals in the UHF band.



Bandwidth Comparison of Common Modes

Let's recap the amount of bandwidth each mode uses to operate. The bandwidth is the range of frequency that the signal occupies. This chart shows that the most efficient is CW, or Morse code. It occupies the least amount of bandwidth, at only 150 Hz. Next is SSB, which requires only 3 kHz bandwidth in order to be used. The FM phone signal comes in at 10 to 15 kHz, which is modest compared to amateur television. The NTSC fast scan TV mode tops the chart at 6 MHz used per transmission. Think about it: It takes a great deal more data to send pictures than it does to send words.

Lowest bandwidth	1	Morse code (CW)	150 Hz
	2	SSB	3 kHz
	3	VHF FM repeater phone signal	10 to 15 kHz
Highest bandwidth	4	Analog fast-scan TV transmissions (NTSC) on the 70-cm band	6 MHz

Lesson 16 Quiz:

- 1) Which type of modulation is commonly used for VHF and UHF voice repeaters?
 - a. AM
 - b. SSB
 - c. PSK
 - d. FM or PM
- 2) What is a characteristic of single sideband (SSB) compared to FM?
 - a. SSB signals are easier to tune in correctly
 - b. SSB signals are less susceptible to interference
 - c. SSB signals have narrower bandwidth
 - d. All these choices are correct
- 3) What is the approximate bandwidth required to transmit a CW signal?
 - a. 2.4 kHz
 - b. 150 Hz
 - c. 1000 Hz
 - d. 15 kHz
- 4) What type of transmission is indicated by the term "NTSC?"
 - a. A Normal Transmission mode in Static Circuit
 - b. A special mode for satellite uplink
 - c. An analog fast-scan color TV signal
 - d. A frame compression scheme for TV signals
- 5) Which of the following is a disadvantage of FM compared with single sideband?
 - a. Voice quality is poorer
 - b. Only one signal can be received at a time
 - c. FM signals are harder to tune
 - d. All these choices are correct

- 6) What is the approximate bandwidth of a typical single sideband (SSB) voice signal?
 - a. 1 kHz
 - b. 3 kHz
 - c. 6 kHz
 - d. 15 kHz
- 7) Which sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications?
 - a. Upper sideband
 - b. Lower sideband
 - c. Suppressed sideband
 - d. Inverted sideband
- 8) What is the approximate bandwidth of a VHF repeater FM voice signal
 - a. Less than 500 Hz
 - b. About 150 kHz
 - c. Between 10 and 15 kHz
 - d. Between 50 and 125 kHz
- 9) What is CW?
 - a. A type of electromagnetic propagation
 - b. A digital mode used primarily on 2 meter FM
 - c. A technique for coil winding
 - d. Another name for a Morse code transmission
- 10) Which of the following types of signal has the narrowest bandwidth?
 - a. FM voice
 - b. SSB voice
 - c. CW
 - d. Slow-scan TV

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Lesson 17: Digital Modes

Digital and Non-Voice Communication

All those modes we just covered are analog transmissions. Technology also allows us to send digital signals with ham radio. Digital modes use protocols to enable sending emails, text messages, images and more.

Which of the following is a digital communications mode?

- Packet radio,
- IEEE 802.11, and
- FT8

These are all examples of digital modes, so **All of these choices are correct** on the exam.

Packet Radio

Packet radio sends data, or “packets” that consist of several parts.

Which of the following is included in packet radio transmissions?

- A checksum that permits error detection
- A header that contains the call sign of the station to which the information is being sent
- Automatic repeat request in case of error.

All of the above is correct here.

One of the most popular uses of packet radio is the Automatic Packet Reporting System, or APRS. APRS is used **to provide real-time tactical digital communications in conjunction with a map showing the locations of stations.**

Because it’s digital information, APRS can transmit many different types of data.

What kind of data can be transmitted by APRS?

- GPS position data

- Text messages
- Weather data

This is another point on the exam when **all these choices are correct.**

Using that data, hams running APRS on handheld radios or on their mobile stations can be tracked on online maps so you can see where they are in real time. Practical uses include tracking hikers or coordinating a marathon or bike race.

Packet radio uses automatic repeat request (ARQ) technology that helps make sure there are no errors in the transmission. The ARQ transmission system is **an error correction method in which the receiving station detects errors and sends a request for retransmission.**

Voice over Internet Protocol (VoIP)

Voice over Internet Protocol (VoIP) is **a method of delivering voice communications over the internet using digital techniques.** VoIP

connections are offered via a **gateway**, which is an amateur radio station that is used to connect other amateur stations to the internet.



You'll experience VoIP on ham radio with services like IRLP and EchoLink.

IRLP is the Internet Radio Linking Project, a **technique to connect amateur radio systems, such as repeaters, via the internet using Voice over Internet Protocol (VoIP). Access to some**

IRLP nodes is accomplished by using DTMF signals, which essentially are just Touch-Tone signals.

EchoLink systems also allow amateurs to communicate via the internet. The **EchoLink** protocol enables an amateur station to transmit through a repeater without using a radio to initiate the transmission. It uses a mobile phone and computer app. To keep EchoLink from being used by non-hams, **you must register your call sign and provide proof of license** before you use it the first time.

One more IP-based ham radio use is Broadband-Hamnet™, **an amateur-radio-based data network using commercial Wi-Fi gear with modified firmware.**

DMR — Digital Mobile Radio

When you combine digital communications and repeater linking via the internet, one of the results is DMR. DMR is one of the fastest

growing modes in amateur radio, basically allowing the use of low-power handheld equipment or mobiles to talk all over the world with the aid of an internet connection.



DMR stands for Digital Mobile Radio and it's a **technique for time-multiplexing two digital voice signals on a single 12.5-kHz repeater channel**. This time multiplex technology provides a doubling of capacity, essentially allowing two stations to talk on the same frequency at the very same time. On the repeater side of DMR, a “talkgroup” is **a way for groups of users to share a channel at different times without hearing other users on the channel**. Repeaters link via the internet to different talkgroups, allowing around-the-world discussion.

If you are interested in DMR, also look into D-STAR, another digital protocol for amateur radio found frequently on VHF and UHF repeaters. As DMR and D-STAR continue to grow, your area may have one or the other already deployed. Other digital types you might encounter on repeaters in various locales include Fusion, P25 and NXDN.



By the way, like EchoLink, DMR, D-STAR and NXDN require call-sign registration before first use of the systems. P25 just uses your DMR ID.

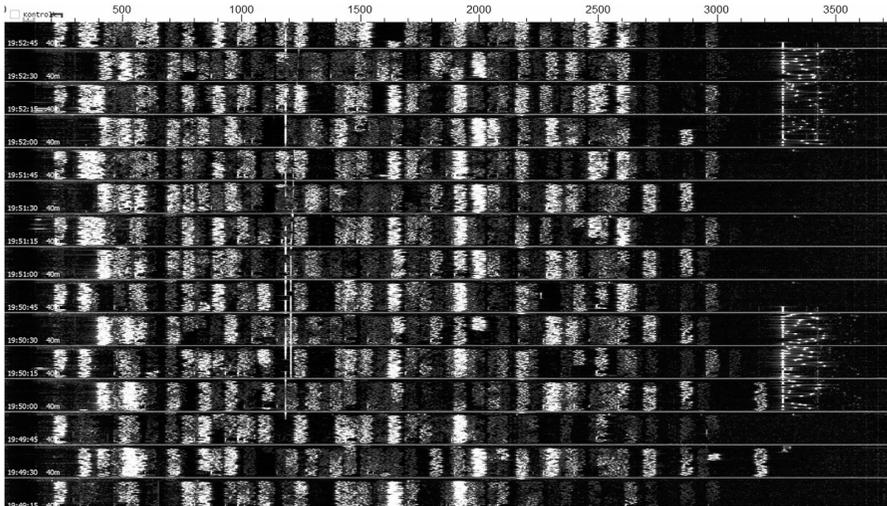
Digital HF Modes

Two of the many digital modes that operate primarily on HF bands are PSK31 and FT8.

PSK31 is a very common HF digital mode used by ham radio operators to communicate in a keyboard-to-keyboard chat. The underlying modulation technology is called PSK, which stands for **Phase Shift Keying**. In phase shift keying, information is transmitted by changing (modulating) the phase of the carrier signal. Phase shift keying technology also is widely used in wireless LANs, RFID and Bluetooth communication.

Probably the hottest digital mode right now is FT8, which is **a digital mode capable of operating in low signal-to-noise conditions that transmits on 15-second intervals**. FT8 is a narrow-band digital mode that can receive signals with very low signal-to-noise ratios. It's part of a suite of weak-signal modes that have been released since 2001. For more information on that, check out the WSJT program. The image below shows multiple FT8 signals

displayed on a waterfall display which shows frequencies over time.



Lesson 17 Quiz:

- 1) Which of the following is a digital communications mode?
 - a. Packet radio
 - b. IEEE 802.11
 - c. FT8
 - d. All these choices are correct
- 2) Which of the following is an application of APRS?
 - a. Providing real-time tactical digital communications in conjunction with a map showing the locations of stations

- b. Showing automatically the number of packets transmitted via PACTOR during a specific time interval
 - c. Providing voice over internet connection between repeaters
 - d. Providing information on the number of stations signed into a repeater
- 3) What is an ARQ transmission system?
- a. A special transmission format limited to video signals
 - b. A system used to encrypt command signals to an amateur radio satellite
 - c. An error correction method in which the receiving station detects errors and sends a request for retransmission
 - d. A method of compressing data using autonomous reiterative Q codes prior to final encoding
- 4) Which of the following protocols enables an amateur station to transmit through a repeater without using a radio to initiate the transmission?
- a. IRLP
 - b. D-STAR
 - c. DMR
 - d. EchoLink
- 5) Which of the following describes DMR?
- a. A technique for time-multiplexing two digital voice signals on a single 12.5 kHz repeater channel
 - b. An automatic position tracking mode for FM mobiles communicating through repeaters

- c. An automatic computer logging technique for hands-off logging when communicating while operating a vehicle
 - d. A digital technique for transmitting on two repeater inputs simultaneously for automatic error correction
- 6) What does the abbreviation "PSK" mean?
- a. Pulse Shift Keying
 - b. Phase Shift Keying
 - c. Packet Short Keying
 - d. Phased Slide Keying
- 7) What is FT8?
- a. A wideband FM voice mode
 - b. A digital mode capable of low signal-to-noise operation
 - c. An eight channel multiplex mode for FM repeaters
 - d. A digital slow-scan TV mode with forward error correction and automatic color compensation
- 8) What is a "talkgroup" on a DMR repeater?
- a. A group of operators sharing common interests
 - b. A way for groups of users to share a channel at different times without hearing other users on the channel
 - c. A protocol that increases the signal-to-noise ratio when multiple repeaters are linked together
 - d. A net that meets at a specified time
- 9) What is required before using the EchoLink system?
- a. Complete the required EchoLink training

- b. Purchase a license to use the EchoLink software
 - c. Register your call sign and provide proof of license
 - d. All these choices are correct
- 10) What is an amateur radio station that connects other amateur stations to the internet?
- a. A gateway
 - b. A repeater
 - c. A digipeater
 - d. A beacon

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Lesson 18: Satellite, Space, and Contesting

Satellite and Space Communication

Let's move on and talk about satellite and space communications, because the WSJT-X software suite also facilitates a lot of radio activities, including moonbounce, or Earth-Moon-Earth radio, meteor scatter and weak-signal propagation beacons.

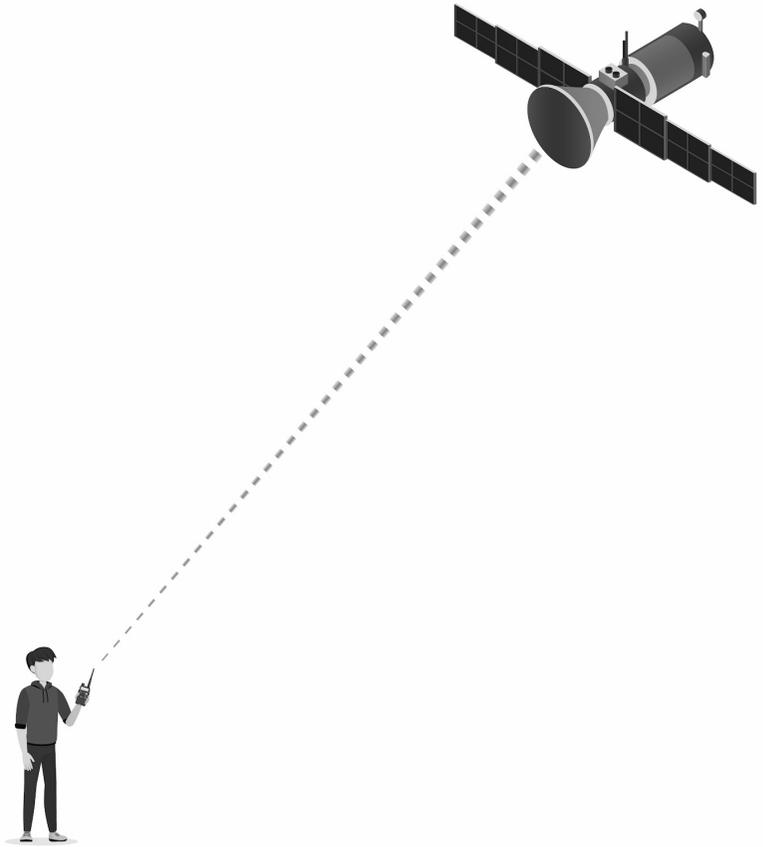
Which of the following operating activities is supported by digital mode software in the WSJT-X software suite?

- Earth-Moon-Earth
- Weak-signal propagation beacons
- Meteor scatter

You know, **All of the above!**

An amateur satellite is just what it sounds like, an LEO device orbiting the earth that has a

small radio repeater in it. The most commonly used modes by amateur satellites are SSB, FM and CW/data – you know, **All of the above!** The acronym LEO tells you **the satellite is in a Low Earth Orbit.**



Most satellites have a beacon that is a **transmission from a satellite that contains status information**. Inside this status information is something called telemetry that generally includes information about the **health and status of the satellite**.

What telemetry information is typically transmitted by satellite beacons?

- The signal strength of received signals
- Time of day accurate to plus or minus 1/10 second
- **Health and status of the satellite**

There are no restrictions on receiving this data and **anyone who can receive the telemetry signal** can receive telemetry from a space station.

If you're ready to work a satellite station, you'll need to know what frequency and modes it uses. If a satellite is operating in mode U/V, **the satellite uplink is in the 70-centimeter band and the downlink is in the 2-meter band**.

Operating via satellites is definitely a case where you only want to use the minimum power you need to make the contact. Using too much effective radiated power on a satellite uplink could lead to **blocking access by other users**. A good way to judge whether your uplink power is neither too low nor too high is that **your signal strength on the downlink should be about the same as the beacon**.

Two phenomena to deal with when making a satellite contact are Doppler shift and satellite rotation. Doppler shift is **an observed change in signal frequency caused by relative motion between the satellite and the earth station**. **Rotation of the satellite and its antennas** causes spin fading of satellite signals.

Before you can hear or transmit to a satellite, you need to know where it is in the sky. Most amateur satellites are in a variable orbit and may pass by only every 90 minutes or so. Satellite tracking programs are used to help hams make connections with amateur satellites and the International Space Station.

Which of the following are provided by satellite tracking programs?

- Maps showing the real-time position of the satellite track over Earth
- The time, azimuth, and elevation of the start, maximum altitude, and end of a pass
- The apparent frequency of the satellite transmission, including effects of Doppler shift

All these choices are correct.

The Keplerian elements are inputs to a satellite tracking program – they are seven numbers that are used to define a satellite orbit.

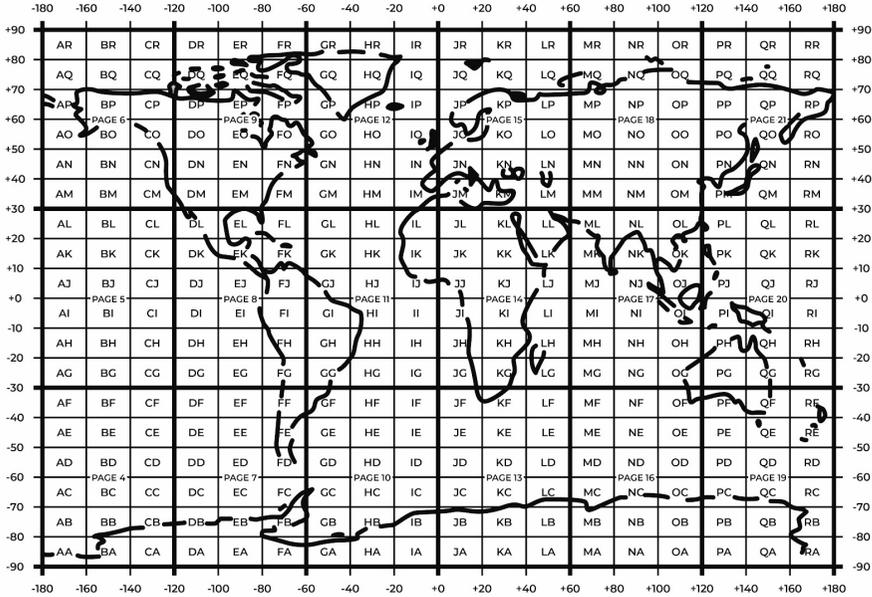
Ham Radio Contests and Activities

We can wrap up this chapter with some other fun challenges you'll find in amateur radio.

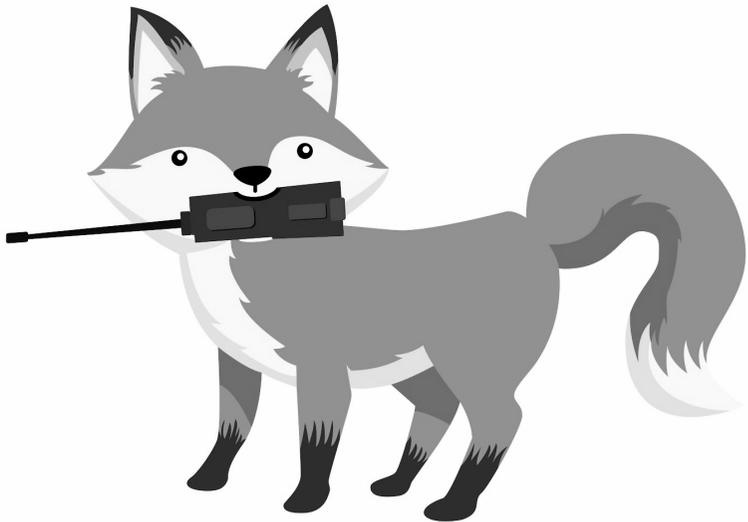
The first is radio sport, also known as contesting. **Contesting** is trying to contact as many other stations as possible during a

specified period of time. It could be trying to reach all the other counties in your state or another state, or talking to as many countries as possible in a weekend. When contacting another station in a radio contest, a good procedure is to **send only the minimum information needed for proper identification and the contest exchange**. Most contesters don't want to stop and chat during the contest.

A grid locator is a **letter-number designator assigned to a geographic location**, which could be important in contacting stations from different geographic areas as part of a contest. Many VHF and UHF contests focus on grid locators. Here's a map of all the grids worldwide.



A fox hunt makes a game of radio direction finding. Typically **radio direction finding** is used to locate sources of noise interference or jamming. In a fox hunt, teams of hams search for a hidden transmitter. It's great practice if you ever get called on to search for malicious interference. A **directional antenna** is useful for a hidden transmitter hunt, we'll cover those in more detail in the next lesson.



Lesson 18 Quiz:

- 1) Which of the following operating activities is supported by digital mode software in the WSJT-X software suite?
 - a. Earth-Moon-Earth
 - b. Weak signal propagation beacons
 - c. Meteor scatter
 - d. All these choices are correct
- 2) What is a LEO satellite?
 - a. A sun synchronous satellite
 - b. A highly elliptical orbit satellite
 - c. A satellite in low energy operation mode
 - d. A satellite in low earth orbit

- 3) What telemetry information is typically transmitted by satellite beacons?
 - a. The signal strength of received signals
 - b. Time of day accurate to plus or minus 1/10 second
 - c. Health and status of the satellite
 - d. All these choices are correct
- 4) Which of the following is a way to determine whether your satellite uplink power is neither too low nor too high?
 - a. Check your signal strength report in the telemetry data
 - b. Listen for distortion on your downlink signal
 - c. Your signal strength on the downlink should be about the same as the beacon
 - d. All these choices are correct
- 5) Which of the following are inputs to a satellite tracking program?
 - a. The satellite transmitted power
 - b. The Keplerian elements
 - c. The last observed time of zero Doppler shift
 - d. All these choices are correct
- 6) Which of the following is good procedure when contacting another station in a contest?
 - a. Sign only the last two letters of your call if there are many other stations calling
 - b. Contact the station twice to be sure that you are in his log
 - c. Send only the minimum information needed for proper identification and the contest exchange

- d. All these choices are correct
- 7) Which of the following methods is used to locate sources of noise interference or jamming?
- a. Echolocation
 - b. Doppler radar
 - c. Radio direction finding
 - d. Phase locking
- 8) Which of these items would be useful for a hidden transmitter hunt?
- a. Calibrated SWR meter
 - b. A directional antenna
 - c. A calibrated noise bridge
 - d. All these choices are correct
- 9) What is a grid locator?
- a. A letter-number designator assigned to a geographic location
 - b. A letter-number designator assigned to an azimuth and elevation
 - c. An instrument for neutralizing a final amplifier
 - d. An instrument for radio direction finding
- 10) What is the impact of using excessive effective radiated power on a satellite uplink?
- a. Possibility of commanding the satellite to an improper mode
 - b. Blocking access by other users
 - c. Overloading the satellite batteries
 - d. Possibility of rebooting the satellite control computer

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

“

All the world is a laboratory
to the inquiring mind.

”

- Martin Fisher

Lesson 19: Antennas

Antennas

Your antenna is a key tool into getting your signal on the air; it is definitely one of the most important aspects of any amateur radio station. Every station has an antenna, from a handheld radio with a small antenna called a “rubber duck” to a bigger long-range antenna used with a base station.



Let's focus for a minute on that handheld radio with the standard “rubber duck” antenna. That antenna probably was chosen for cost and size, not effectiveness. The major disadvantage of the “rubber duck” is **it does not transmit or receive as effectively** as a full antenna. You can

find upgraded antennas for your handheld at most ham stores and online.

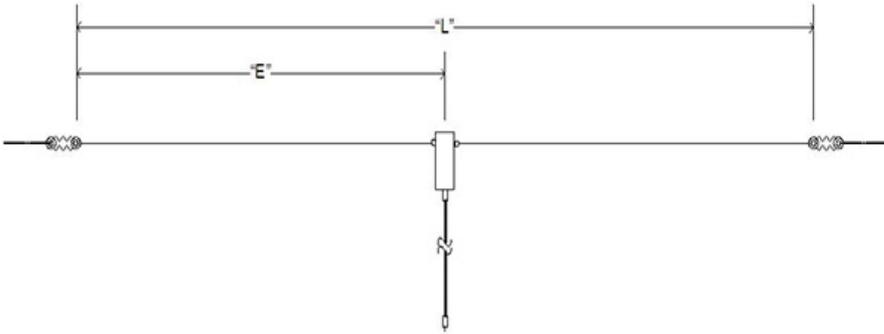
If you want to use your handheld radio in a car or truck, an external antenna will help you get better transmission and reception. With an antenna inside the car on VHF, the metal body of the vehicle is going to impact your transmission, so the **signals might not propagate well due to the shielding effect of the vehicle.**



Dipole Antennas

Before we get into details of the antenna, remember in Lesson 3 we covered the radio wave characteristics related to polarization, frequency and wavelength. We'll touch on those principles now so refresh yourself if needed.

One of the simplest antennas is a dipole antenna. A classic dipole, known as a half-wave dipole, appears like a single wire, or a straight line, with the feed line attached to the center creating a “T” shape.



How you position a dipole determines its polarization. If you have that classic T-shaped antenna between two trees in your backyard, the dipole is oriented parallel to the Earth’s surface, making it **a horizontally polarized antenna**. A half-wave dipole antenna radiates the strongest signal **broadside to the antenna**. If the wires run north to south, the strongest signals will be east and west of the antenna.

If you positioned that antenna on its side with the elements up and down, it would now be a vertically polarized antenna.



To make the antenna resonant on the frequency or band you want to use, you will adjust the length of the dipole. Remember, frequency and wavelength are inversely related. Higher frequency means shorter wavelength. Therefore, to change a dipole antenna to make it resonant on a higher frequency, you can **shorten it**.

300 ÷ Frequency in Megahertz

Here are two examples that will show you the difference in antenna lengths for different bands. First, let's say you want to create a quarter-wavelength vertical antenna to operate at 146 MHz. We'll do some math to get the approximate length:

- Let's bring back the formula: Wavelength = $300 / \text{Frequency in MHz}$
- Wavelength = $300 / 146 \approx 2$ meters

- Going from metric to imperial, 2 meters is about 80 inches.
- We want our antenna to be a quarter-wavelength, so we'll divide that by 4 = $80 \text{ in} / 4 = 20 \text{ in}$.
- The closest answer from the choices on the exam is **19**.

Let's calculate our second antenna length. This time we want the approximate length in inches of a half-wavelength 6-meter dipole. This process is even simpler.

- Because we know the frequency band, we skip the wavelength calculation and move right to converting meters to inches: 6 meters ≈ 236 inches
- We want a half-wavelength antenna, so we divide that in half: $236 \text{ inches} / 2 = 118 \text{ in}$.
- The closest answer is **112 inches**.

In both of these examples we used an approximate length because there are a bunch of different factors you don't need to know for the exam. They include types of metal used,

height above ground of the antenna, and other factors.

There may be reasons why you can't make your physical antenna longer or shorter – such as space considerations. If you can't change the antenna length, you can change the resonant frequency of your antenna with an antenna loading coil, which is a kind of inductor by **inserting an inductor in the radiating portion of the antenna to make it electrically longer.** Here's a popular portable antenna that is built to take advantage of this principle.

In our 2-meter calculation, we figured the length of a quarter-wavelength dipole. On VHF and UHF, hams find an advantage of using a properly mounted 5/8-wavelength antenna because **it has a lower radiation angle and more gain than a 1/4-wavelength antenna.**

Other Antennas

A beam antenna **concentrates signals in one direction**. The gain of the antenna is **the increase in signal strength in a specified direction compared to a reference antenna**.

Think of it as “beaming” its signal in a chosen direction to increase gain.

If you can't increase your radio power, antenna gain gives you the advantage of more power through antenna performance and design. You'll recognize directional antennas like a satellite dish or quad antenna. A **Yagi** type antenna offers the greatest gain.

Lesson 19 Quiz:

- 1) What is a disadvantage of using a handheld VHF transceiver with a flexible antenna inside a vehicle?
 - a. Signal strength is reduced due to the shielding effect of the vehicle
 - b. The bandwidth of the antenna will decrease, increasing SWR
 - c. The SWR might decrease, decreasing the signal strength
 - d. All these choices are correct
- 2) Which of the following describes a simple dipole oriented parallel to Earth's surface?

- a. A ground-wave antenna
 - b. A horizontally polarized antenna
 - c. A travelling-wave antenna
 - d. A vertically polarized antenna
- 3) What is the approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz?
- a. 112
 - b. 50
 - c. 19
 - d. 12
- 4) What is the approximate length, in inches, of a half-wavelength 6 meter dipole antenna?
- a. 6
 - b. 50
 - c. 112
 - d. 236
- 5) What is a beam antenna?
- a. An antenna built from aluminum I-beams
 - b. An omnidirectional antenna invented by Clarence Beam
 - c. An antenna that concentrates signals in one direction
 - d. An antenna that reverses the phase of received signals
- 6) Which of the following types of antenna offers the greatest gain?
- a. 5/8 wave vertical
 - b. Isotropic
 - c. J pole
 - d. Yagi
- 7) What is antenna gain?

- a. The additional power that is added to the transmitter power
 - b. The additional power that is required in the antenna when transmitting on a higher frequency
 - c. The increase in signal strength in a specified direction compared to a reference antenna
 - d. The increase in impedance on receive or transmit compared to a reference antenna
- 8) In which direction does a half-wave dipole antenna radiate the strongest signal?
- a. Equally in all directions
 - b. Off the ends of the antenna
 - c. In the direction of the feed line
 - d. Broadside to the antenna
- 9) Which of the following increases the resonant frequency of a dipole antenna?
- a. Lengthening it
 - b. Inserting coils in series with radiating wires
 - c. Shortening it
 - d. Adding capacitive loading to the ends of the radiating wires
- 10) What is an advantage of a $5/8$ wavelength whip antenna for VHF or UHF mobile service?
- a. It has more gain than a $1/4$ -wavelength antenna
 - b. It radiates at a very high angle
 - c. It eliminates distortion caused by reflected signals
 - d. It has 10 times the power gain of a $1/4$ wavelength whip

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Lesson 20: Cables and Tuning

Cables

It may seem simple, but choosing the correct antenna cables is extremely important for your station to operate efficiently. Just like you wouldn't choose a skinny lamp cord to power your clothes dryer, the coaxial cables you use have different performance properties.



Coaxial cable is the most common feed line selected for amateur radio antenna systems because **it is easy to use and requires few special installation considerations.** The impedance of most coaxial cables used in amateur radio is **50 ohms.**

When choosing coaxial cable for your station, you may wonder about the difference between RG-58 and RG-213 cable. The electrical difference between the two is that **RG213 cable has less loss at a given frequency.**

When choosing a transmission line, understand the frequency of the signal you will use because as the frequency is increased, **the loss increases.** **Air-insulated hard line** has the lowest loss on VHF and UHF frequencies.

To connect cables, you need to choose coax connectors. Radios and antennas come with a variety of connectors, including PL-259, Type N and even SMA. PL-259-type connectors **are commonly used at HF and VHF frequencies.** **A Type N connector** is most suitable for frequencies above 400 MHz.

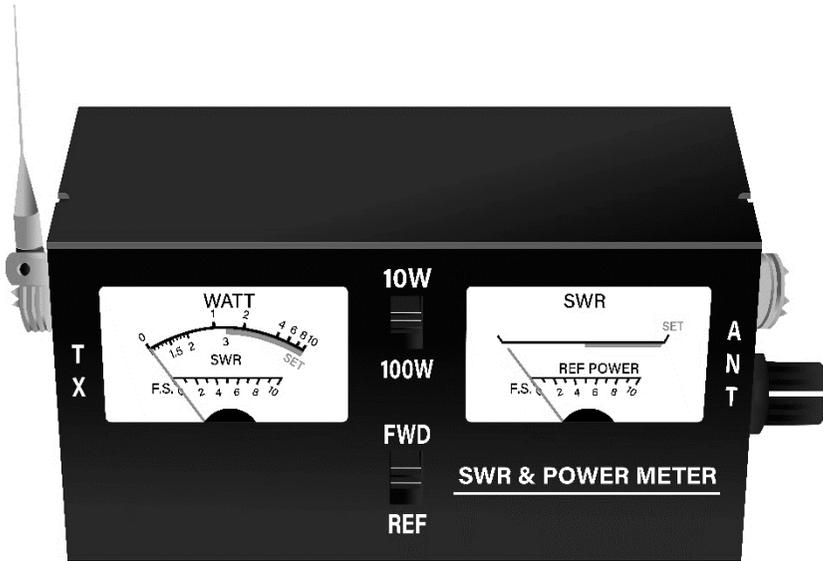


In the image above, this cable has a SO-239 connector on the left and a PL-259 on the right. Check your equipment before buying the cable and connectors you need to save time and money.

Tuning

Once you've got all your gear gathered, it's time to make sure it's tuned up. An antenna tuner – also known as an antenna coupler – can help here.

The major function of an antenna tuner is to **match the antenna system impedance to the transceiver's output impedance.**



Another important tool is an SWR meter. It is important to have low SWR when using coaxial cable feed lines **to reduce signal loss.** At an SWR of 1:1, the transmitter delivers maximum power to the antenna and loss is minimized.

Let's finish this lesson with a recap of SWR - standing wave ratio - from Lesson 7 and touch on some troubleshooting tips.

Remember, SWR is **a measure of how well a load is matched to a transmission line**. If the antenna and transmission line are not well matched to a transceiver, signal loss is created through heat.

Which of the following is a source of loss in coaxial feedline?

- water intrusion into the coaxial connector
- high SWR
- multiple connectors in the line.

All of these choices are correct on the exam.

If you see erratic changes in SWR readings, it could mean you have a **loose connection in an antenna or a feed line**.

Lesson 20 Quiz:

- 1) Why is coaxial cable the most common feed line for amateur radio antenna systems?
 - a. It is easy to use and requires few special installation considerations
 - b. It has less loss than any other type of feed line
 - c. It can handle more power than any other type of feed line

- d. It is less expensive than any other type of feed line
- 2) What is the electrical difference between RG-58 and RG-213 coaxial cable?
- a. There is no significant difference between the two types
 - b. RG-58 cable has two shields
 - c. RG-213 cable has less loss at a given frequency
 - d. RG-58 cable can handle higher power levels
- 3) Which of the following is true of PL-259 type coax connectors?
- a. They are preferred for microwave operation
 - b. They are watertight
 - c. They are commonly used at HF and VHF frequencies
 - d. They are a bayonet-type connector
- 4) What is the major function of an antenna tuner (antenna coupler)?
- a. It matches the antenna system impedance to the transceiver's output impedance
 - b. It helps a receiver automatically tune in weak stations
 - c. It allows an antenna to be used on both transmit and receive
 - d. It automatically selects the proper antenna for the frequency band being used
- 5) What is standing wave ratio (SWR)?
- a. A measure of how well a load is matched to a transmission line
 - b. The ratio of amplifier power output to input
 - c. The transmitter efficiency ratio

- d. An indication of the quality of your station's ground connection
- 6) What can cause erratic changes in SWR?
- a. Local thunderstorm
 - b. Loose connection in the antenna or feed line
 - c. Over-modulation
 - d. Overload from a strong local station
- 7) Which of the following is a source of loss in coaxial feed line?
- a. Water intrusion into coaxial connectors
 - b. High SWR
 - c. Multiple connectors in the line
 - d. All these choices are correct
- 8) What is a benefit of low SWR?
- a. Reduced television interference
 - b. Reduced signal loss
 - c. Less antenna wear
 - d. All these choices are correct
- 9) Which of the following types of feed line has the lowest loss at VHF and UHF?
- a. 50-ohm flexible coax
 - b. Multi-conductor unbalanced cable
 - c. Air-insulated hardline
 - d. 75-ohm flexible coax
- 10) Which of the following RF connector types is most suitable for frequencies above 400 MHz?
- a. UHF (PL-259/SO-239)
 - b. Type N
 - c. RS-213
 - d. DB-25

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

“

In the new era, thought
itself will be transmitted by
radio.

”

- Guglielmo Marconi

Lesson 21: Electrical and Radiation Safety

Electrical Safety

Why is electrical safety important? Because receiving an electrical current through your body presents a series of health hazards.

What health hazard is presented by electrical current flowing through the body?

- It may cause injury by heating tissue
- It may disrupt the electrical functions of cells
- It may cause involuntary muscle contractions.

Knowing **all of these choices are correct** on the exam and in practice helps keep you safe.

Protecting yourself and your station from harmful electrical currents includes a broad list of things you can do.

What is a good way to guard against electrical shock at your station?

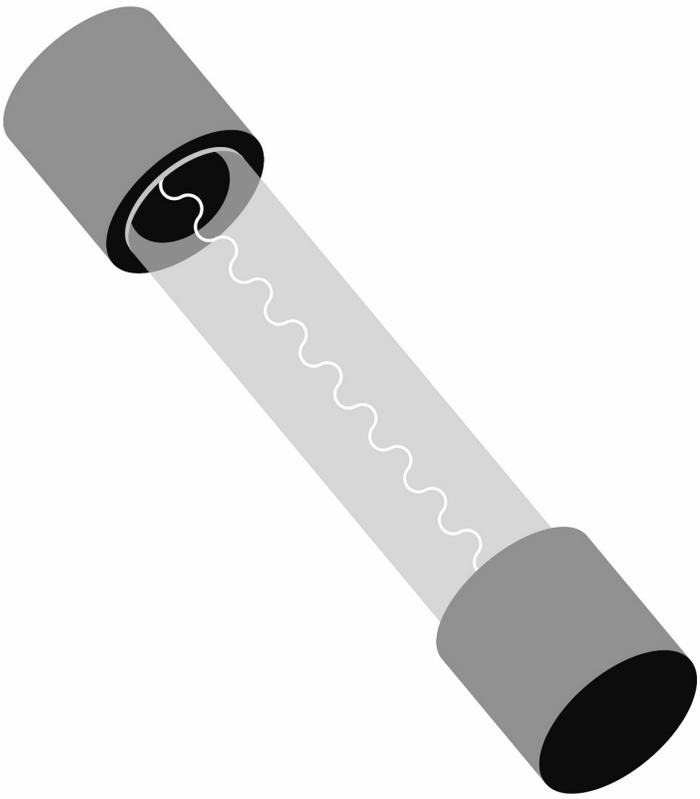
- Use three-wire cords and plugs for all AC-powered equipment
- Connect all AC-powered station equipment to a common safety ground
- Installing mechanical interlocks in high-voltage circuits.

All of these choices are correct, they list several best practices.

Grounding prevents you from having a live electrical surface that could severely shock you, as it creates a path to discharge an accidental short circuit. That's part of the three-wire cord and plug you'll use. The U.S. has a standard for color coding the wire in that cord. The black wire insulation indicates the **hot** wire, white is the neutral wire and green is ground.

Continuing on with equipment in your house, circuit breakers and fuses can be a lifesaver from excessive current. A circuit breaker or fuse is used **to interrupt power in case of overload**. **A fuse interrupts current by breaking the**

connection if the current capacity is exceeded.
When the fuse or breaker are installed in a 120-volt AC power circuit, it should be in **series with the hot conductor only.**



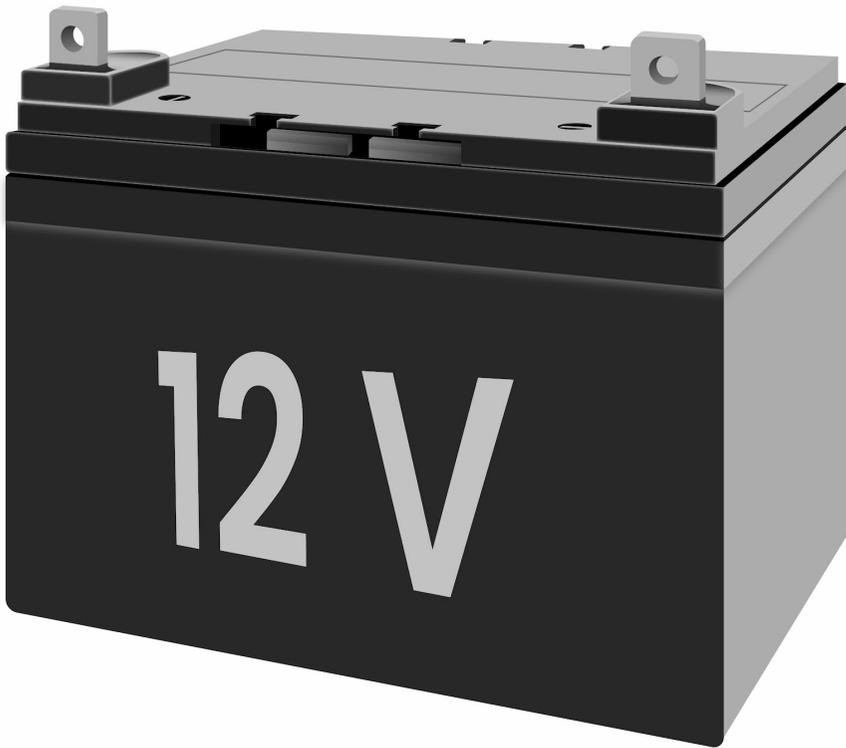
In an AC or DC circuit, each fuse has a specific current threshold with which it will support. You

should pay careful attention to this. Never replace a 5-ampere fuse with a 20-ampere fuse because the **excessive current could cause a fire.**

In a DC circuit, you'll likely have a power supply or a battery and both have some risks.

Your power supply contains capacitors, because that's what is used to store energy in an electric field. That charge can remain even when a power supply is turned off and disconnected, so use caution to avoid getting hurt from the **charge stored in filter capacitors.**

There are two things to remember when using a 12-volt storage battery. First, **shorting the terminals can cause burns, fire or an explosion.** Also, don't charge or discharge a battery too quickly because that can create dangerous **overheating or out-gassing.**



Electrical safety applies to tools and meters as well. Before connecting a multimeter or voltmeter to a circuit, **ensure that the voltmeter and leads are rated for use at the voltages to be measured** when measuring high voltages.



Radiation

Let's start the radiation section with a definition of terms. We will be discussing radio frequency or RF radiation. RF radio signals are **non-**

ionizing radiation, which means it's different from radiation you might find in a nuclear power plant or X-ray radiation because **RF radiation does not have sufficient energy to cause chemical changes in cells and damage DNA.**

RADIATION EXPOSURE



There is a cancer risk from x - rays.

The radiation an antenna creates via RF still is dangerous in a number of ways. For example, if a person accidentally touches your antenna while you are transmitting, they could receive an **RF burn to skin**. I've had a couple of mild ones and they are no fun.

What factors affect the RF exposure of people near an amateur station antenna?

- frequency and power level of the RF field,
- distance from the antenna to a person
- radiation pattern of the antenna.

All of these choices are correct! is the exam answer here, but let's break down why frequency is an important factor.

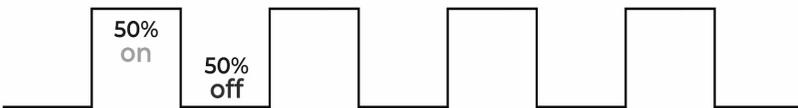
Frequency is a factor because **the human body absorbs more RF energy at some frequencies than at others**, so certain frequencies may be more dangerous than others.

The concept of maximum permissible exposure is based on research that shows that 50 MHz is in the 30 to 300 MHz range of frequencies that are absorbed well by the human body. The

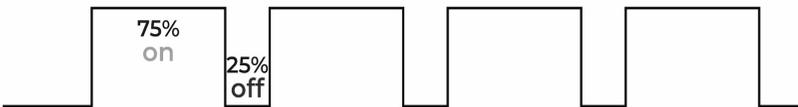
maximum permissible exposure has the lowest value in the **50-MHz** frequency range for ham radio.

In addition to the frequency you transmit on, how frequently you transmit can play a role in station safety. This is called the duty cycle, and it's used as a factor used to determine safe RF radiation exposure levels because **it affects the average exposure to radiation.**

50% duty cycle



75% duty cycle



25% duty cycle



The duty cycle is defined as **the percentage of time that a transmitter is transmitting**. For example, If you were transmitting a message for two minutes straight, that would be a 100-percent duty cycle. In that same two minutes though, if you are using the FT8 digital mode, it transmits for 15 seconds, listens for 15 seconds, and repeats the cycle. That is a 50-percent duty cycle.

When you decrease the duty cycle from 100 percent to 50 percent, you increase the amount of time for RF safety of a signal. When you cut the transmit time in half, the safe time around the RF signal **increases by a factor of 2**.

To prevent exposure to RF radiation in excess of FCC-supplied limits, you could **relocate antennas**. But how do you know if there is an issue?

There are methods you should use to ensure your antenna is in compliance with FCC RF exposure regulations.

Which of the following is an acceptable method to determine whether your station complies with FCC RF exposure regulations?

- calculation based on FCC OET Bulletin 65, or
- calculation based on computer modeling, or by
- measurement of field strength using calibrated equipment.

All of these choices are correct ways to evaluate your compliance.

You always can make sure you are in FCC compliance by **re-evaluating the station whenever an item in the transmitter or antenna system is changed**. This is because **the station licensee** – that’s you! – is responsible for ensuring that no person is exposed to RF energy above the FCC exposure limits.

Lesson 21 Quiz:

- 1) What health hazard is presented by electrical current flowing through the body?

- a. It may cause injury by heating tissue
 - b. It may disrupt the electrical functions of cells
 - c. It may cause involuntary muscle contractions
 - d. All these choices are correct
- 2) What is a good way to guard against electrical shock at your station?
- a. Use three-wire cords and plugs for all AC powered equipment
 - b. Connect all AC powered station equipment to a common safety ground
 - c. Install mechanical interlocks in high-voltage circuits
 - d. All these choices are correct
- 3) In the United States, what circuit does black wire insulation indicate in a three-wire 120 V cable?
- a. Neutral
 - b. Hot
 - c. Equipment ground
 - d. Black insulation is never used
- 4) What is the purpose of a fuse in an electrical circuit?
- a. To prevent power supply ripple from damaging a component
 - b. To remove power in case of overload
 - c. To limit current to prevent shocks
 - d. All these choices are correct
- 5) Where should a fuse or circuit breaker be installed in a 120V AC power circuit?
- a. In series with the hot conductor only
 - b. In series with the hot and neutral conductors
 - c. In parallel with the hot conductor only
 - d. In parallel with the hot and neutral conductors

- 6) What type of radiation are radio signals?
- Gamma radiation
 - Ionizing radiation
 - Alpha radiation
 - Non-ionizing radiation
- 7) How does RF radiation differ from ionizing radiation (radioactivity)?
- RF radiation does not have sufficient energy to cause chemical changes in cells and damage DNA
 - RF radiation can only be detected with an RF dosimeter
 - RF radiation is limited in range to a few feet
 - RF radiation is perfectly safe
- 8) At which of the following frequencies does maximum permissible exposure have the lowest value?
- 3.5 MHz
 - 50 MHz
 - 440 MHz
 - 1296 MHz
- 9) How does the allowable power density for RF safety change if duty cycle changes from 100 percent to 50 percent?
- It increases by a factor of 3
 - It decreases by 50 percent
 - It increases by a factor of 2
 - There is no adjustment allowed for lower duty cycle
- 10) How can you make sure your station stays in compliance with RF safety regulations?

- a. By informing the FCC of any changes made in your station
- b. By re-evaluating the station whenever an item in the transmitter or antenna system is changed
- c. By making sure your antennas have low SWR
- d. All these choices are correct

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Lesson 22: Antenna and Tower Safety

Antenna and Tower Safety

You might decide to put your new amateur radio antenna on your roof, in a tree or mount it on a tower. When setting up an antenna, make sure you are far away enough from any power line. You can judge the minimum safe distance by planning **so that if the antenna falls, no part of it can come closer than 10 feet to the power wires**. That includes not just the final placement, but activities while raising and lowering the antenna, too.

An antenna should not be attached to a utility pole because **the antenna could contact high-voltage power lines**.

Grounding for static and lightning protection is important as well. **Local electrical codes** establish the proper grounding techniques for amateur radio towers and antennas. A lightning

arrester should be installed in a coaxial feed line mounted **on a grounded panel near where feed lines enter the building.**

For all external ground rods or earth connections, you must consider a high current situation from a lightning strike. Therefore, you should **bond them together with heavy wire or conductive strap** that can handle high current.

When installing grounding conductors used for lightning protection, **sharp bends must be avoided.** For the exam, remember that lightning takes a straight path to ground, so you want your ground to be straight and direct.

If you are ready to set up a tower, be ready for some additional challenges.

Just like when raising or lowering an antenna, make sure to **look for and stay clear of any overhead electrical wires** when putting up an antenna tower.

You'll need extra grounding considerations for your tower. One example of proper grounding is **separate eight-foot-long ground rods for each**

tower leg, bonded to the tower and each other.

This configuration will allow one path for each of the four tower legs to disperse the energy in the event of a lightning strike. When installing ground wires on a tower for electrical protection, **ensure that connections are short and direct.**

Guy lines are wires that are connected to the tower to keep the tower upright and secured to the ground. In order to **prevent loosening of the turnbuckle from vibration**, a safety wire through a turnbuckle is used to tension these guy lines.

Once your tower is up, you may need to climb it from time to time. It is **NEVER** safe to climb a tower without a helper or observer.

What is required when climbing an antenna tower?

- have sufficient training on safe tower climbing techniques
- use appropriate tie-off to the tower at all times
- always wear an approved climbing harness.

When it comes to tower safety, **all these choices are correct** to maintain your safe environment.

A crank-up tower is one that has mechanical gears that allow you to raise and lower them with a crank or motor. Choosing a crank-up tower is a fast and convenient solution, but you have to make sure to lock them, or the tower could rapidly slide down. They must **not be climbed unless retracted or mechanical safety locking devices have been installed.**

Lesson 22 Quiz:

- 1) What is the minimum safe distance from a power line to allow when installing an antenna?
 - a. Add the height of the antenna to the height of the power line and multiply by a factor of 1.5
 - b. The height of the power line above ground
 - c. $1/2$ wavelength at the operating frequency
 - d. Enough so that if the antenna falls, no part of it can come closer than 10 feet to the power wires
- 2) Why should you avoid attaching an antenna to a utility pole?
 - a. The antenna will not work properly because of induced voltages
 - b. The 60 Hz radiations from the feed line may increase the SWR

- c. The antenna could contact high-voltage power lines
 - d. All these choices are correct
- 3) Which of the following establishes grounding requirements for an amateur radio tower or antenna?
- a. FCC Part 97 rules
 - b. Local electrical codes
 - c. FAA tower lighting regulations
 - d. UL recommended practices
- 4) What should be done to all external ground rods or earth connections?
- a. Waterproof them with silicone caulk or electrical tape
 - b. Keep them as far apart as possible
 - c. Bond them together with heavy wire or conductive strap
 - d. Tune them for resonance on the lowest frequency of operation
- 5) What is the purpose of a safety wire through a turnbuckle used to tension guy lines?
- a. Secure the guy line if the turnbuckle breaks
 - b. Prevent loosening of the turnbuckle from vibration
 - c. Provide a ground path for lightning strikes
 - d. Provide an ability to measure for proper tensioning
- 6) Under what circumstances is it safe to climb a tower without a helper or observer?
- a. When no electrical work is being performed
 - b. When no mechanical work is being performed

- c. When the work being done is not more than 20 feet above the ground
 - d. Never
- 7) What is required when climbing an antenna tower?
- a. Have sufficient training on safe tower climbing techniques
 - b. Use appropriate tie-off to the tower at all times
 - c. Always wear an approved climbing harness
 - d. All these choices are correct
- 8) Which of the following is an important safety rule to remember when using a crank-up tower?
- a. This type of tower must never be painted
 - b. This type of tower must never be grounded
 - c. This type of tower must not be climbed unless it is retracted, or mechanical safety locking devices have been installed
 - d. All these choices are correct
- 9) Which of the following is good practice when installing ground wires on a tower for lightning protection?
- a. Put a drip loop in the ground connection to prevent water damage to the ground system
 - b. Make sure all ground wire bends are right angles
 - c. Ensure that connections are short and direct
 - d. All these choices are correct
- 10) Which of the following is an important safety precaution to observe when putting up an antenna tower?
- a. Wear a ground strap connected to your wrist at all times

- b. Insulate the base of the tower to avoid lightning strikes
- c. Look for and stay clear of any overhead electrical wires
- d. All these choices are correct

Answers to this quiz are located in the answer key at the end of the book.

Want more practice?

Go to the Android or iOS App Store and search for 'Ham Radio Prep' to download the companion app to take Free Lesson Quizzes for every lesson as well as Unlimited Practice Tests!

Practice Exam

Go here for free online practice exams:

<https://hamradioprep.com/free-ham-radio-practice-tests/>

1) Which of the following is part of the Basis and Purpose of the Amateur Radio Service?

- A. Providing personal radio communications for as many citizens as possible
- B. Providing communications for international non-profit organizations
- C. Advancing skills in the technical and communication phases of the radio art
- D. All these choices are correct

2) Which agency regulates and enforces the rules for the Amateur Radio Service in the United States?

- A. FEMA
- B. Homeland Security
- C. The FCC
- D. All of these choices are correct

3) Which of the following frequency ranges are available for phone operation by Technician licensees?

- A. 28.050 MHz to 28.150 MHz
- B. 28.100 MHz to 28.300 MHz
- C. 28.300 MHz to 28.500 MHz

D. 28.500 MHz to 28.600 MHz

4) Which amateurs may contact the International Space Station (ISS) on VHF bands?

A. Any amateur holding a General class or higher license

B. Any amateur holding a Technician class or higher license

C. Any amateur holding a General class or higher license who has applied for and received approval from NASA

D. Any amateur holding a Technician class or higher license who has applied for and received approval from NASA

5) For which license classes are new licenses currently available from the FCC?

- A. Novice, Technician, General, Amateur Extra
- B. Technician, Technician Plus, General, Amateur Extra
- C. Novice, Technician Plus, General, Advanced
- D. Technician, General, Amateur Extra

6) Who may select a desired call sign under the vanity call sign rules?

- A. Only a licensed amateur with a General or Amateur Extra class license
- B. Only a licensed amateur with an Amateur Extra class license
- C. Only a licensed amateur who has been licensed continuously for more than 10 years
- D. Any licensed amateur

7) What is a common repeater frequency offset in the 2 meter band?

- A. Plus or minus 5 MHz
- B. Plus or minus 600 kHz
- C. Plus or minus 500 kHz
- D. Plus or minus 1 MHz

8) What is the national calling frequency for FM simplex operations in the 2 meter band?

- A. 146.520 MHz

- B. 145.000 MHz
- C. 432.100 MHz
- D. 446.000 MHz

9) How is a VHF/UHF transceiver's "reverse" function used?

- A. To reduce power output
- B. To increase power output
- C. To listen on a repeater's input frequency
- D. To listen on a repeater's output frequency

10) Why do VHF signal strengths sometimes vary greatly when the antenna is moved only a few feet?

- A. The signal path encounters different concentrations of water vapor
- B. VHF ionospheric propagation is very sensitive to path length
- C. Multipath propagation cancels or reinforces signals
- D. All these choices are correct

11) What is the effect of vegetation on UHF and microwave signals?

- A. Knife-edge diffraction
- B. Absorption
- C. Amplification
- D. Polarization rotation

12) What is the relationship between the electric and magnetic fields of an electromagnetic wave?

- A. They travel at different speeds
- B. They are in parallel
- C. They revolve in opposite directions
- D. They are at right angles

13) Which of the following is an appropriate power supply rating for a typical 50 watt output mobile FM transceiver?

- A. 24.0 volts at 4 amperes
- B. 13.8 volts at 4 amperes
- C. 24.0 volts at 12 amperes
- D. 13.8 volts at 12 amperes

14) Which of the following should be considered when selecting an accessory SWR meter?

- A. The frequency and power level at which the measurements will be made
- B. The distance that the meter will be located from the antenna
- C. The types of modulation being used at the station
- D. All of these choices are correct

15) Electrical current is measured in which of the following units?

- A. Volts

- B. Watts
- C. Ohms
- D. Amperes

16) Electrical power is measured in which of the following units?

- A. Volts
- B. Watts
- C. Watt-hours
- D. Amperes

17) What is the unit of frequency?

- A. Hertz
- B. Henry
- C. Farad
- D. Tesla

18) Which of the following is a good electrical insulator?

- A. Mercury
- B. Copper
- C. Glass
- D. Aluminum

19) What electrical component opposes the flow of current in a DC circuit?

- A. Inductor
- B. Resistor
- C. Inverter
- D. Transformer

20) What type of component is often used as an adjustable volume control?

- A. Fixed resistor
- B. Power resistor
- C. Potentiometer
- D. Transformer

21) Which is true about forward voltage drop in a diode?

- A. It is lower in some diode types than in others
- B. It is proportional to peak inverse voltage
- C. It indicates that the diode is defective
- D. It has no impact on the voltage delivered to the load

22) What electronic component allows current to flow in only one direction?

- A. Resistor
- B. Fuse
- C. Diode
- D. Driven element

23) Which term describes the ability of a receiver to detect the presence of a signal?

- A. Linearity
- B. Sensitivity
- C. Selectivity
- D. Total Harmonic Distortion

24) What is a transceiver?

- A. A device for matching feed line impedance to 50 ohms
- B. A device that combines a receiver and transmitter
- C. A device for automatically sending and decoding Morse code
- D. A device for converting receiver and transmitter frequencies to another band

25) How can fundamental overload of a non-amateur radio or TV receiver by an amateur signal be reduced or eliminated?

- A. Block the amateur signal with a filter at the antenna input of the affected receiver
- B. Block the interfering signal with a filter on the amateur transmitter
- C. Switch the transmitter from FM to SSB
- D. Switch the transmitter to a narrow-band mode

26) Which of the following actions should you take if a neighbor tells you that your station's transmissions are interfering with their radio or TV reception?

- A. Make sure that your station is functioning properly and that it does not cause interference to your own radio or television when it is tuned to the same channel
- B. Immediately turn off your transmitter and contact the nearest FCC office for assistance
- C. Install a harmonic doubler on the output of your transmitter and tune it until the interference is eliminated
- D. All of these choices are correct

27) Which of the following is a form of amplitude modulation?

- A. Spread spectrum
- B. Packet radio
- C. Single sideband
- D. Phase shift keying (PSK)

28) What type of modulation is commonly used for VHF packet radio transmissions?

- A. FM or PM
- B. SSB
- C. AM
- D. PSK

29) What mode of transmission is commonly used by amateur radio satellites?

- A. SSB
- B. FM
- C. CW/data
- D. All of these choices are correct

30) What is a satellite beacon?

- A. The primary transmit antenna on the satellite
- B. An indicator light that shows where to point your antenna
- C. A reflective surface on the satellite
- D. A transmission from a satellite that contains status information

31) Which of the following describes a type of antenna loading?

- A. Electrically lengthening by inserting inductors in radiating elements
- B. Inserting a resistor in the radiating portion of the antenna is make it resonant
- C. Installing a spring in the base of a mobile vertical antenna to make it more flexible
- D. Strengthening the radiating elements of a beam antenna to better resist wind damage

32) Which of the following describes a simple dipole oriented parallel to the Earth's surface?

- A. A ground-wave antenna
- B. A horizontally polarized antenna
- C. A traveling-wave antenna
- D. A vertically polarized antenna

33) Which of the following is a safety hazard of a 12-volt storage battery?

- A. Touching both terminals with the hands can cause electrical shock
- B. Shorting the terminals can cause burns, fire, or an explosion
- C. RF emissions from a nearby transmitter can cause the electrolyte to emit poison gas
- D. All of these choices are correct

34) What health hazard is presented by electrical current flowing through the body?

- A. It may cause injury by heating tissue
- B. It may disrupt the electrical functions of cells
- C. It may cause involuntary muscle contractions
- D. All of these choices are correct

35) In the United States, what circuit does black wire in a three-wire 120 V cable?

- A. Neutral
- B. Hot
- C. Equipment ground
- D. Black insulation is never used

Answer Keys

Lesson 1 Quiz: 1)C 2)C 3)A 4)B 5)A 6)C 7)C 8)D 9)D 10) B

Lesson 2 Quiz: 1)D 2)B 3)B 4)D 5)A 6)B 7)A 8)D 9)C 10) C

Lesson 3 Quiz: 1)B 2)D 3)B 4)A 5)B 6)B 7)D 8)C 9)D 10) D

Lesson 4 Quiz: 1)D 2)C 3)A 4)C 5)D 6)D 7)A 8)B 9)D 10) D

Lesson 5 Quiz: 1)B 2)C 3)D 4)C 5)A 6)B 7)A 8)B 9)A 10) C

Lesson 6 Quiz: 1)B 2)D 3)A 4)A 5)C 6)A 7)A 8)D 9)D 10) D

Lesson 7 Quiz: 1)A 2)B 3)B 4)C 5)B 6)B 7)D 8)A 9)D 10) D

Lesson 8 Quiz: 1)A 2)D 3)C 4)B 5)B 6)A 7)A 8)D 9)A 10) D

Lesson 9 Quiz: 1)D 2)B 3)A 4)B 5)A 6)C 7)A 8)B 9)B 10) D

Lesson 10 Quiz: 1)D 2)B 3)D 4)C 5)C 6)A 7)A 8)B 9)B 10) A

Lesson 11 Quiz: 1)A 2)B 3)D 4)B 5)C 6)B 7)B 8)C 9)A 10) C

Lesson 12 Quiz: 1)B 2)A 3)A 4)C 5)D 6)D 7)D 8)C 9)B 10) A

Lesson 13 Quiz: 1)B 2)C 3)C 4)A 5)D 6)B 7)C 8)B 9)A 10) B

Lesson 14 Quiz: 1)B 2)B 3)C 4)B 5)A 6)C 7)C 8)A 9)A 10) D

Lesson 15 Quiz: 1)C 2)C 3)D 4)D 5)D 6)D 7)A 8)D 9)D 10)
C

Lesson 16 Quiz: 1)D 2)C 3)B 4)C 5)B 6)B 7)A 8)C 9)D 10)
C

Lesson 17 Quiz: 1)D 2)A 3)C 4)D 5)A 6)B 7)B 8)B 9)C 10) A

Lesson 18 Quiz: 1)D 2)D 3)C 4)C 5)B 6)C 7)C 8)B 9)A 10)
B

Lesson 19 Quiz: 1)A 2)B 3)C 4)C 5)C 6)D 7)C 8)D 9)C 10) A

Lesson 20 Quiz: 1)A 2)C 3)C 4)A 5)A 6)B 7)D 8)B 9)C 10)
B

Lesson 21 Quiz: 1)D 2)D 3)B 4)B 5)A 6)D 7)A 8)B 9)C 10)
B

Lesson 22 Quiz: 1)D 2)C 3)B 4)C 5)B 6)D 7)D 8)C 9)C 10)
C

Practice Exam 1

- | | | | | |
|-------|-------|-------|-------|-------|
| 1) C | 2) C | 3) C | 4) B | 5) D |
| 6) D | 7) B | 8) A | 9) C | 10) C |
| 11) B | 12) D | 13) D | 14) A | 15) D |
| 16) B | 17) A | 18) C | 19) B | 20) C |
| 21) A | 22) C | 23) B | 24) B | 25) A |
| 26) A | 27) C | 28) A | 29) D | 30) D |
| 31) A | 32) B | 33) B | 34) D | 35) B |

Official Technician License Question Pool w/ Explanations

T1 – Commission’s Rules

T1A01 - Which of the following is part of the Basis and Purpose of the Amateur Radio Service? **Advancing skills in the technical and communication phases of the radio art**

Explanation: The FCC broadly defines the amateur radio services as an opportunity for self-training, intercommunication and technical investigations. This broad explanation is clearly defined in Part 97 of the rules and regulations in a brief legal description as "advancing skills in the technical and communication phases of the radio art." In plain English, this means getting on the air and having fun while improving your contesting skills, your traffic handling skills, your electronic and radio skills all while incorporating the latest technological advances into the amateur radio hobby. In other words, having fun!

T1A02 - Which agency regulates and enforces the rules for the Amateur Radio Service in the United States? **The FCC**

Explanation: In the United States, the Federal Communications Commission regulates amateur radio services. All amateur radio operators must have a license issued by the FCC before they are allowed to transmit. The FCC establishes the rules and regulations governing amateur radio operations. These regulations are in Part 97 of the commission's rules (47 C.F.R. Part 97).

T1A03 - What do the FCC rules state regarding the use of a phonetic alphabet for station identification in the Amateur Radio Service? **It is encouraged**

Explanation: Using a phonetic alphabet ensures the other amateur radio stations properly record your call sign and other important information in your transmissions. Using the phonetic alphabet during poor or difficult radio conditions on voice communications confirms the other amateur radio operator has recorded the correct information.

T1A04 - How many operator/primary station license grants may be held by any one person? **One**

Explanation: The primary station license and the amateur radio license are issued together. The FCC only grants one operator/primary station license to any one individual.

T1A05 - What proves that the FCC has issued an operator/primary license grant? **The license appears in the FCC ULS database**

Explanation: The operator/station license can be verified only in the FCC's database. The paper license issued by the FCC is a good document, but does not reflect the current status of an amateur radio operator's license. For an amateur radio license to be valid, the status in the FCC's database must show as active, not revoked or canceled.

T1A06 - What is the FCC Part 97 definition of a beacon? **An amateur station transmitting communications for the purposes of observing propagation or related experimental activities**

Explanation: The signal strength of a beacon station is a good indicator of current band conditions without relying on charts or graphs that are only projections. Some hams use beacon stations in designing, building and testing their antenna systems. You can make quick adjustments on your system to see whether the signal from the beacon station has improved or diminished.

T1A07 - What is the FCC Part 97 definition of a space station? **An amateur station located more than 50 km above the Earth's surface**

Explanation: All transmitters on board an amateur radio space station must have the ability to be shut off by telecommands when ordered to do so by the FCC.

T1A08 - Which of the following entities recommends transmit/receive channels and other parameters for auxiliary and repeater stations? **Volunteer Frequency Coordinator recognized by local amateurs**

Explanation: Nearly every area in the United States that has amateur radio repeater coverage also has volunteer organizations to help with the coordination of frequencies and locations. The local repeater coordinator organization is recognized by the amateur radio operators in the area and works with other repeater coordinator organizations. These organizations provide guidelines for repeater physical locations and operating parameters. The organizations work hard to maximize the efficient use of our precious amateur radio frequencies. In cases where there are disputes, or the FCC is required to intervene, the FCC nearly always sides with the amateur radio repeater that has been coordinated through a recognized organization.

T1A09 - Who selects a Frequency Coordinator? **Amateur operators in a local or regional area whose stations are eligible to be repeater or auxiliary stations**

Explanation: Frequency coordinators for an area are chosen by the amateur radio operators in that area served by their repeater. Frequency coordinators work with other coordination groups to verify that your repeater will not cause interference to other repeaters and that your repeater has a good chance of being in the clear without interference as well.

Frequency and/or repeater coordinators work with other groups across state lines to make sure interference is kept to an absolute minimum.

T1A10 - What is the Radio Amateur Civil Emergency Service (RACES)? **All of these choices are correct**

Explanation: RACES, or Radio Amateur Civil Emergency Service, is an emergency amateur radio service authorized by the FCC. The rules and regulations governing amateur radio operations for RACES are described in Part 97.407 of the FCC's rules and regulations. RACES usually provides communications between government organizations while ARES, or the Amateur Radio Emergency Service, focuses on providing communications support to private organizations such as the American National Red Cross, Salvation Army, faith-based organizations, etc.

T1A11 - When is willful interference to other amateur radio stations permitted? **At no time**

Explanation: The FCC is very strict on the subject of "willful interference." FCC Rules Part 97 Section 101 (d) state: "No amateur operator shall willfully or maliciously interfere with or cause interference to any radio communication or signal." The FCC has the authority to impose fines, license suspension or revocation and prison time for these violations. To augment the FCC, the ARRL has implemented a Volunteer Monitor Program where amateurs are given training on how to identify "willful interference" and submit the proper observations and documentation to the FCC for legal action against the offenders. Willful interference can cause life-and-death situations when public service agencies such as police, fire and ambulance are prevented from performing their duties because of disrupted communications.

T1B01 - Which of the following frequency ranges are available for phone operation by Technician licensees? **28.300 MHz to 28.500 MHz**

Explanation: Amateur radio uses band plans to help share the different parts of bands where hams have privileges. Bands are broken up by mode (CW, Digital, Phone) and by license level. On 10 Meters, phone is allocated from 28.300 to 29.700 MHz, but Technicians are only allowed to use 28.300 to 28.500.

T1B02 - Which amateurs may contact the International Space Station (ISS) on VHF bands? **Any amateur holding a Technician or higher-class license**

Explanation: In the United States, the Technician class license is currently the entry-level license. The Technician license class and above allows operator privileges on the 2-meter and 70-centimeter bands. Both of these bands allow communications with the International Space Station.

T1B03 - Which frequency is in the 6 meter amateur band? **52.525 MHz**

Explanation: In the United States, the amateur radio band for 6 meters covers from 50 to 54 MHz. Learning the frequencies and bands will come with time after operating on the bands for a little while. A good rule of thumb is to take 300,000,000 meters per second and divide by the frequency in MHz, yielding the wavelength. For example 300,000,000 divided by 50,000,000 Hz (50 MHz) = 6 meters, therefore 50 MHz is equal to the wavelength of 6 meters.

T1B04 - Which amateur band includes 146.52 MHz? **2 meter band**

Explanation: The national simplex calling frequency for 2 meters is 146.520 MHz. Here's a short way to find a band if you know the frequency. Use the formula: Band = 300 / (Frequency in MHz). In this case 300/146.52 = 2.04 which rounds to 2 meters. One of the rules for taking the FCC exam is to choose the "most correct answer." You will see that given your choices, the 2 meter wavelength is the most correct or closest to the correct answer. Where does the 300 come from? The speed of light is roughly 300 Million meters per second. correct answer.

T1B05 - How may amateurs use the 219 to 220 MHz segment of 1.25 meter band? **Fixed digital message forwarding systems only**

Explanation: Some of the restrictions are amateur radio operators can use this band only for fixed digital message forwarding. Amateurs who still hold a Novice class license are not allowed to use these frequencies. Amateur operators must not cause interference to the existing users. Amateur radio equipment must be able to accept interference from the primary users of this frequency range and other adjacent bands. Amateur transmitters are limited to 50 watts PEP output and 100 kHz bandwidth. There are other restrictions in place that require permission from the primary users of these frequencies; please refer to the FCC Part 97.303(e) or ARRL publications before operating on these frequencies.

T1B06 - On which HF bands does a Technician class operator have phone privileges? **10 meter band only**

Explanation: There are excellent frequency allocation charts and graphs available from the ARRL for downloading. The General and Extra class licenses allow phone, or voice, privileges on nearly all amateur radio bands.

T1B07 - Which of the following VHF/UHF frequency ranges are limited to CW only? **50.0 MHz to 50.1 MHz and 144.0 MHz to 144.1 MHz**

Explanation: Nearly all amateur radio band plans have areas reserved for only CW and digital emissions. After referring to one of the many band plan charts, you will slowly learn the subband allocations by heart. Many radio manufacturers provide complimentary band plan charts at hamfests (ham radio flea markets) or by mail. The ARRL has several different designs available for downloading and printing, too.

T1B08 - How are US amateurs restricted in segments of bands where the Amateur Radio Service is secondary? **U.S. amateurs may find non-amateur stations in those portions, and must avoid interfering with them**

Explanation: The key word here is "secondary user." There are some bands in which amateur radio is not the sole user or primary user. As a secondary user on these shared bands, you need to be mindful of the fact other services are sharing their frequencies with us. You must not cause interference with these other users. You also may not cause willful or harmful interference with other non-amateur radio services.

T1B09 - Why should you not set your transmit frequency to be exactly at the edge of an amateur band or sub-band? **All of these choices are correct**

Explanation: The majority of hams choose an older radio as their first rig. Calibration on these radios is very good, but not exact. There are many volunteer monitors watching for out-of-band activity. A best practice is to not operate at the very band edge.

T1B10 - Where may SSB phone be used in amateur bands above 50 MHz? **In at least some segment of all these bands**

Explanation: Following the amateur radio band plan, all bands above 50 MHz allow for phone operation. Check the individual bands plan for the best location to use SSB phone.

T1B11 - What is the maximum peak envelope power output for Technician class operators in their HF band segments? **200 watts**

Explanation: Some amateur radio rules and regulations just have to be memorized; this is one of those rules. On HF, the Technician class license is limited to 200 watts PEP (peak envelope power). To help you memorize, HF is only two letters, therefore, the limit is 200 watts.

T1B12 - Except for some specific restrictions, what is the maximum peak envelope power output for Technician class operators using frequencies above 30 MHz? **1500 watts**

Explanation: There are a few specific restrictions, but for the most part, a Technician class licensee may operate on frequencies above 30 MHz using the full power authorized for amateur transmissions. This limit is 1,500 watts PEP.

T1C01 - For which license classes are new licenses currently available from the FCC?
Technician, General, Amateur Extra

Explanation: The FCC currently is only issuing Technician, General and Extra class amateur licenses. When operating on the air, you will run into other operators who may hold a Novice or Advanced class license. These individuals are allowed to renew these license classes, but there are no new ones currently being issued.

T1C02 - Who may select a desired call sign under the vanity call sign rules? **Any licensed amateur**

Explanation: Any licensed amateur radio operator may select a vanity call sign. Your class of license determines which format of a vanity call sign you are eligible to receive. Currently, Technician and General class license holders may select the 1-by-3 call sign format (or the 2-by-3 format that new licensees generally are issued). Advanced class license holders can choose from available 2-by-2 formats (or 1-by-3 or 2-by-3 formats) while Extra class licensees can qualify for available 1-by-2, 2-by-1 or 2-by-2 formats, including all other formats.

T1C03 - What types of international communications is an FCC-licensed amateur radio station permitted to make? **Communications incidental to the purposes of the Amateur Radio Service and remarks of a personal character**

Explanation: You can eliminate three of these answers to find the correct one. No business communication is allowed with amateur radio, you can do more than contest on ham radio, and radio amateurs are not allowed to broadcast to the general public.

T1C04 - What may happen if the FCC is unable to reach you by email? **Revocation of the station license or suspension of the operator license**

Explanation: The FCC moved to email communications on June 29, 2021. The requirement states all amateurs “must have a current email address on file as part of their ULS record.”

T1C05 - Which of the following is a valid call sign for a Technician class amateur radio station? **KF1XXX**

Explanation: Both Technician and General class license holders are eligible to select 1-by-3 call sign formats.

T1C06 - From which of the following locations may an FCC-licensed amateur station transmit? **From any vessel or craft located in international waters and documented or registered in the United States**

Explanation: The FCC regulates all amateur radio communications when operation occurs within the United States. However, amateurs holding a valid FCC-issued license may transmit from any vessel or craft located in international waters as long as the vessel or craft is documented or registered in the United States.

T1C07 - Which of the following can result in revocation of the station license or suspension of the operator license? **Failure to provide and maintain a correct email address with the FCC**

Explanation: The FCC moved to email communications on June 29, 2021. The requirement states all amateurs "must have a current email address on file as part of their ULS record."

T1C08 - What is the normal term for an FCC-issued primary station/operator amateur radio license grant? **Ten years**

Explanation: FCC Part 97.25(a) states: An amateur service license normally is granted for a 10-year term.

T1C09 - What is the grace period following the expiration of an amateur license within which the license may be renewed? **Two years**

Explanation: While you can not operate once your license is expired, you have 2 years from the time of expiration to renew your amateur license without having to take an additional exam.

T1C10 - How soon after passing the examination for your first amateur radio license may you transmit on the amateur radio bands? **As soon as your operator/station license grant appears in the FCC's license database**

Explanation: Upon successfully passing your first amateur radio license exam, you may operate as soon as the license information has been updated in the FCC database. If you have upgraded from a previous amateur radio license, you start using your new privileges immediately. You must use the suffix "/AG" if you upgrade to a General class license or "/AE" if you upgrade to Extra class.

T1C11 - If your license has expired and is still within the allowable grace period, may you continue to transmit on the amateur radio bands? **No, you must wait until the license has been renewed**

Explanation: The FCC's definition of a "grace period" is referring to the fact you can simply renew your license without having to retake all the exams once again. The "grace period" does not mean that you can continue to operate your amateur radio transmitting equipment. Once your license expires, you are no longer allowed to transmit on ham frequencies. Renewal online using the FCC's website is fast and efficient.

T1D01 - With which countries are FCC-licensed amateur radio stations prohibited from exchanging communications? **Any country whose administration has notified the International Telecommunications Union (ITU) that it objects to such communications**

Explanation: FCC Part 97.111 allows amateur radio communications with other amateur stations in other countries, except when those countries have given notice to the International Telecommunications Union (ITU) that they object to such radio communications. There currently are no countries on the banned list as defined in 47 C.F.R. "97.111.

T1D02 - Under which of the following circumstances are one-way transmissions by an amateur station prohibited? **Broadcasting**

Explanation: Normally broadcasting one-way communications are prohibited; the exceptions are for using your amateur radio station to transmit code practice sessions, sending out information bulletins or any transmissions necessary to provide emergency communications. One-way communications are defined as one station transmitting to many receiving stations, such as done by a commercial radio or television station.

T1D03 - When is it permissible to transmit messages encoded to obscure their meaning? **Only when transmitting control commands to space stations or radio control craft**

Explanation: The FCC prohibits encoding or hiding the meaning of any message. The exception to this rule is when using control codes and commands that need to be ciphered or coded to prevent unauthorized users from controlling a radio control craft or space station.

T1D04 - Under what conditions is an amateur station authorized to transmit music using a phone emission? **When incidental to an authorized retransmission of manned spacecraft communications**

Explanation: The FCC strictly prohibits transmitting music from your amateur radio station. The only exception to this rule is when retransmitting audio from a manned spacecraft such as the space shuttle or the International Space Station. Occasionally Mission Control for the manned spacecraft will broadcast music to the crew such as wakeup calls and other special occasions.

T1D05 - When may amateur radio operators use their stations to notify other amateurs of the availability of equipment for sale or trade? **When selling amateur radio equipment and not on a regular basis**

Explanation: FCC rules and regulations prohibit using amateur radio for business or profit, but there is an exception with some restrictions. Amateur radio operators may offer their equipment for sale or trade providing this only occurs on an occasional basis.

T1D06 - What, if any, are the restrictions concerning transmission of language that may be considered indecent or obscene? **Any such language is prohibited**

Explanation: The FCC and ITU do not maintain a list of words that are considered "indecent or obscene." However, FCC Part 97 still prohibits any such language on amateur radio. Please keep in mind that the whole world listens to amateur radio transmissions. You are strongly urged to always keep your transmissions family safe. Be mindful of what you are saying; there are many ears listening.

T1D07 - What types of amateur stations can automatically retransmit the signals of other amateur stations? **Repeater, auxiliary, or space stations**

Explanation: FCC Part 97.3 (a)(7) allow transmitting communications point to point within a system of cooperating amateur radio stations. This does not include store-and-forward messaging systems. Rules provide for repeater, auxiliary, space station or satellite operation for communications purposes.

T1D08 - In which of the following circumstances may the control operator of an amateur station receive compensation for operating that station? **When the communication is incidental to classroom instruction at an educational institution**

Explanation: FCC Part 97.113 (2) gives a list of prohibited transmissions, including communications for hire or for material compensation, direct or indirect, paid or promised, except as otherwise provided in these rules. However, FCC Part 97.113 (iii) states that teachers, as a control operator, may accept compensation when an amateur station is used by that teacher as a part of classroom instruction at an educational institution.

T1D09 - When may amateur stations transmit information in support of broadcasting, program production, or news gathering, assuming no other means is available? **When such communications are directly related to the immediate safety of human life or protection of property**

Explanation: FCC Part 97.113 (b) clearly states an amateur radio station shall not engage in any form of broadcasting. However, there is an exception to this rule that says that

communications directly related to the immediate safety of human life or the protection of property may be provided by an amateur radio station to broadcasters for dissemination to the public where no means of communications is reasonably available before or at the time of the event. In other words, if amateur radio operators have spotted a tornado on the ground headed toward a populated area, it is perfectly legal for the local TV station to rebroadcast ham communications to the general public in order to save human lives and property.

T1D10 - How does the FCC define broadcasting for the Amateur Radio Service?

Transmissions intended for reception by the general public

Explanation: The FCC defines broadcasting as a one-way transmission to many receivers at the same time. This is no different than a local commercial radio or television station. Broadcasting is a one-way transmission to many receivers at the same time (such as a local AM or FM station or television station). Part 97.113 (b) strictly prohibits amateur radio stations to broadcast with a few exceptions. Two-way communications is where both stations take turns transmitting and receiving.

T1D11 - When may an amateur station transmit without identifying on the air? **When transmitting signals to control model craft**

Explanation: FCC Part 97.119 states that each amateur radio station, except a space station or telecommand station, must transmit its assigned call sign on its transmitting channel at the end of each communication and at least every 10 minutes during a communication. The exception for a telecommand station includes sending commands to model craft such as radio control planes.

T1E01 - When may an amateur station transmit without a control operator? **Never**

Explanation: FCC Part 97.3 (13) defines a control operator as an amateur radio operator designated by the licensee of a station to be responsible for the transmissions from that station to assure compliance with FCC rules. There is no exception to this rule; you must always have a control operator responsible for operating your amateur radio station within the FCC's rules and regulations.

T1E02 - Who may be the control operator of a station communicating through an amateur satellite or space station? **Any amateur whose license privileges allow them to transmit on the satellite uplink frequency**

Explanation: FCC Part 97.207 (a) states that any amateur radio station may be a space station. Also, a holder of any class of amateur license may be the control operator of a space station, subject to the privileges of the class of operator held by the control operator.

So providing you have the privileges to transmit on the satellite's uplink frequency, you are eligible to be a control operator.

T1E03 - Who must designate the station control operator? **The station licensee**

Explanation: The amateur radio station license holder is who owns a station. Because it is their station, they can designate the control operator.

T1E04 - What determines the transmitting privileges of an amateur station? **The class of operator license held by the control operator**

Explanation: When operating your amateur radio station, the control operator determines the transmitting privileges. This is not a trick question, remember the control operator is the one who makes sure the station is operated within the FCC's rules.

T1E05 - What is an amateur station control point? **The location at which the control operator function is performed**

Explanation: The control point is where the control operator performs their functions.

T1E06 - When, under normal circumstances, may a Technician class licensee be the control operator of a station operating in an exclusive Amateur Extra class operator segment of the amateur bands? **At no time**

Explanation: The purpose of the control operator is to ensure the amateur radio station is operated within the FCC's rules. The control operator is responsible for proper operation of the amateur station within their operating privileges. At no time may a Technician class license holder allow operations outside of their operating privileges.

T1E07 - When the control operator is not the station licensee, who is responsible for the proper operation of the station? **The control operator and the station licensee**

Explanation: The control operator and the station licensee are equally responsible when the control operator is not the station licensee.

T1E08 - Which of the following is an example of automatic control? **Repeater operation**

Explanation: A repeater is an example of automatic control because there is a device managed by the trustee which monitors the repeater's performance and can shut it down or perform other management actions as needed. The other two options are just using the computer as a tool.

T1E09 - Which of the following are required for remote control operation? **All of these choices are correct**

Explanation: Remote control model cars, boats and aircraft operated by remote control and a control operator is directly operating these types of craft.

T1E10 - Which of the following is an example of remote control as defined in Part 97?
Operating the station over the internet

Explanation: The FCC defines the control point where the control operator performs his functions. Remote operation does not mean that the control operator is away from their control point. The control operator must be at the control point at all times and the control operator indirectly controls the remote station.

T1E11 - Who does the FCC presume to be the control operator of an amateur station, unless documentation to the contrary is in the station records? **The station licensee**

Explanation: Providing there is no documentation or information in the station's records clearly stating who the control operator is of a given amateur radio station, the FCC will assume that the license holder is the control operator.

T1F01 - When must the station licensee make the station and its records available for FCC inspection? **At any time upon request by an FCC representative**

Explanation: FCC Part 97.103 (c) states that the amateur radio station licensee must make the station and the station records available for inspection upon request by an FCC representative.

T1F02 - How often must you identify with your FCC-assigned call sign when using tactical call signs such as "Race Headquarters"? **At the end of each communication and every ten minutes during a communication**

Explanation: FCC Part 97.119 (a) clearly specifies that an amateur radio station must transmit their assigned call sign on its transmitting channel at the end of each communication, and at least every 10 minutes during your transmissions or conversation. So even though you are using tactical identifiers, you still have to give your FCC call sign every 10 minutes and at the end of your communication.

T1F03 - When are you required to transmit your assigned call sign? **At least every 10 minutes during and at the end of a communication**

Explanation: FCC Part 97.119 (a) clearly states than an amateur radio station must transmit its assigned call sign on its transmitting channel at the end of each communication and at least every 10 minutes.

TIF04 - What language may you use for identification when operating in a phone sub-band? **English**

Explanation: When talking with other stations, you are allowed to use any language you wish. FCC Part 97.119 (b) (2) requires that when using phone that the English language be used for identification. The FCC strongly encourages using a phonetic alphabet as an aid for correct station identification.

TIF05 - What method of call sign identification is required for a station transmitting phone signals? **Send the call sign using a CW or phone emission**

Explanation: FCC Part 97.119 (b) (1) and (2) state that you may identify your station using either CW or phone. If using CW, the speed must be 20 words per minute or slower.

TIF06 - Which of the following self-assigned indicators are acceptable when using a phone transmission? **All of these choices are correct**

Explanation: FCC Part 97.119 (c) states that each self-assigned indicator must be separated from the call sign by the slant mark (/) or by any suitable word that denotes the slant mark. Using words such as "slant," "forward slant," "stroke" or "slash" are all acceptable words.

TIF07 - Which of the following restrictions apply when a non-licensed person is allowed to speak to a foreign station using a station under the control of a licensed amateur operator? **The foreign station must be in a country with which the U.S. has a third party agreement**

Explanation: Before you engage in third-party communications, verify the foreign country you are communicating with has a third-party agreement with the United States. The ARRL maintains a copy of the current list of approved countries.

TIF08 - What is the definition of third party communications? **A message from a control operator to another amateur station control operator on behalf of another person**

Explanation: FCC Part 97.3 (a) (47) defines third-party communications as a message from an amateur radio control operator (first party) of an amateur radio station to another amateur station control operator (second party) on behalf of another person (third party). This occurs every day, a good example is you have a non-licensed friend come over to your

house. He sees your QSL cards from Spain and mentions that he is from Spain. You turn on your radio and contact a station from Spain. You give the microphone to your friend so he can talk to someone from his home country. Before you do this, you need to verify the United States has a third-party agreement with Spain. In this example, the United States DOES NOT have third-party agreements with Spain and you would be breaking U.S. federal law as well as laws in Spain.

T1F09 - What type of amateur station simultaneously retransmits the signal of another amateur station on a different channel or channels? **Repeater station**

Explanation: FCC Part 97.3 (a) (40) defines a repeater as an amateur station that simultaneously retransmits the transmission of another amateur station on a different channel or channels. As a newly licensed Technician class ham, you will enjoy extended-range repeaters generally on 2 meters, 1.25 meters and 70 centimeters.

T1F10 - Who is accountable if a repeater inadvertently retransmits communications that violate the FCC rules? **The control operator of the originating station**

Explanation: FCC Part 97.205 (g) clearly states that the control operator of a repeater that inadvertently retransmits communications that violate the rules is NOT accountable for the violative communications. The control operator of the amateur station that originates the violative communications will be held accountable.

T1F11 - Which of the following is a requirement for the issuance of a club station license grant? **The club must have at least four members**

Explanation: FCC Part 97.5 (b) (2) outlines the requirements for a club station license. The FCC will grant a club station license to a person who is the trustee designated by an officer of the club. The club also must be composed of at least four persons and must have a name, document of organization, management and a primary purpose devoted to amateur radio service activities consistent with FCC Part 97.

T2 – Operating Procedures

T2A01 - What is a common repeater frequency offset in the 2 meter band? **Plus or minus 600 kHz**

Explanation: This is not a trick question, but the two key words are "common" and "2 meter band." The most common offset used in the 2-meter band is minus 600 kHz or plus 600

kHz. In larger metropolitan areas, where frequency pairs are in high demand, you may find some non-standard offsets used to accommodate more repeaters. Other bands use a different offset frequency.

T2A02 - What is the national calling frequency for FM simplex operations in the 2 meter band? **146.520 MHz**

Explanation: This is another item that you will just have to memorize at first, but after a while this will become second nature. 146.520 MHz is the national calling frequency on the 2-meter band. You will see cars on the interstate with stickers on the back that say ".52 Call Me" and will have a call sign on the decal. The question asks for the 2-meter frequency, so you can rule out the two answers that have frequencies in the 440-MHz band.

T2A03 - What is a common repeater frequency offset in the 70 cm band? **Plus or minus 5 MHz**

Explanation: If you are listening to a repeater on 70cm, a common repeater frequency offset is plus or minus 5 MHz. For example, a repeater transmitting on 442.200, with a positive 5 megahertz offset, has a receive frequency of 447.200. Just like with other bands, you may see different offsets in larger metropolitan areas in order to accommodate more repeaters on the air.

T2A04 - What is an appropriate way to call another station on a repeater if you know the other station's call sign? **Say the station's call sign, then identify with your call sign**

Explanation: When you know the other amateur radio station's call sign, you just give their call sign and then identify your station with your call sign. For example, given your call sign is WB1XXX and the other ham's call is WB2XXX, you would say, "WB2XXX, this is WB1XXX."

T2A05 - How should you respond to a station calling CQ? **Transmit the other station's call sign followed by your call sign**

Explanation: Answering another station calling CQ is easy. Once you copy down the other operator's call sign, then you are ready to respond to their CQ. For example, given the station calling CQ is WB2XXX and your call sign is WB1XXX, to answer their CQ you would say, "WB2XXX, this is WB1XXX."

T2A06 - Which of the following is required when making on-the-air test transmissions? **Identify the transmitting station**

Explanation: As with all transmissions, the FCC requires that you must identify your station when transmitting. When performing on-the-air test transmissions, you must identify your amateur station with your call sign.

T2A07 - What is meant by "repeater offset"? The difference between a repeater's transmit frequency and its receive frequency

Explanation: The "repeater offset" is the difference between the repeater's transmit frequency and its receive frequency. The transmit frequency can either be above or below the repeater's receive frequency.

T2A08 - What is the meaning of the procedural signal "CQ"? Calling any station

Explanation: This is the process where you make a general call to any other amateur station. A good rule of thumb is to call CQ three times and then give your call sign three times. If you are using phone, it is always a good idea to use a widely recognized phonetic alphabet when giving your call sign. An example would be: "CQ CQ CQ. This is WB1XXX, Whiskey Bravo One X-ray X-ray X-ray, Whiskey Bravo One X-ray X-ray X-ray."

T2A09 - Which of the following indicates that a station is listening on a repeater and looking for a contact? The station's call sign followed by the word "monitoring"

Explanation: For the most part, calling CQ on a repeater is considered a poor practice. The preferred method is to key up the repeater and give your call sign. Giving your call sign phonetically is a good idea if you are not well known in the area or just received your Technician license. In larger cities, you sometimes will hear a station give their call sign followed by the repeater's frequency and the word "monitoring." This is because larger cities have many repeaters and many hams scan multiple repeaters with their radios. So if they hear your call sign and want to return your call, they will not know which repeater you made the call from. In addition to using the frequency when calling out on a repeater, you also might hear the repeater referred to by a geographic location, such as a mountaintop name or a community name, such as: "N1USA listening Cherryville" or "N1USA listening Mount Washington." "Listening" is the same as "monitoring."

T2A10 - What is a band plan, beyond the privileges established by the FCC? A voluntary guideline for using different modes or activities within an amateur band

Explanation: The band plans specify what modes of operations -- such as voice, digital and/or CW -- are used on what frequencies. A band plan indicates, according to local needs, what modes of operations (voice, packet, etc.) are used on what frequencies. Many amateur radio equipment manufacturers and ham organizations have really nice band plan charts you can either obtain directly or download from the web. The ARRL is an excellent source of amateur radio operating aids.

T2A11 - What term describes an amateur station that is transmitting and receiving on the same frequency? **Simplex**

Explanation: Simplex operation defines an amateur station that is transmitting and receiving on the same frequency. Sometimes you will hear hams asking you to go to the repeater's transmit frequency on simplex. An example would be: "WB1XXX, this is WB2XXX. Joe, please go to 146.94 simplex." The national calling frequency, 146.52 MHz, is used on a simplex basis.

T2A12 - What should you do before calling CQ? **All of these choices are correct**

Explanation: Before calling CQ, you first must listen on the frequency you have selected to use. By listening, you can verify whether anyone is currently using the frequency. Next you must identify your station and ask whether the frequency is in use. There may be an emergency operations activity in progress that you can not hear, particularly both sides of the conversation. Asking whether the frequency is in use with your call sign will make sure you are not going to cause interference. Then as the last step, double check that the frequency you have chosen is within your assigned privileges for the band as well as designated uses within the band plan.

T2B01 - How is a VHF/UHF transceiver's "reverse" function used? **To listen on a repeater's input frequency**

Explanation: This is very handy in case of an emergency. You can drive to a small hill or mountain and put your radio into the "reverse split" mode if your repeater is off the air due to the emergency. This way everyone can still talk to the net control station during the emergency, and not have to reprogram their radio or try and figure out what other backup frequency to use when the repeater is off the air. It also might help in a situation where another operator is outside the range of the repeater, but possibly could be close enough to you and you hear that station on the input. You then can communicate with that station using "reverse."

T2B02 - What term describes the use of a sub-audible tone transmitted along with normal voice audio to open the squelch of a receiver? **CTCSS**

Explanation: This means that the repeater's squelch will be opened only by a transmitter that transmits the proper sub-audible tone. This technique was developed and implemented by Motorola under the name "Private Line" or PL. Many modern radios and programming software refer to this sub-audible tone as CTCSS, or Continuous Tone-Coded Squelch System. The FCC is looking for the term CTCSS when referring to PL tones and codes. There also are digital codes that aren't sub-audible but work in the same way and are known as Digital Code Squelch, or DCS. The Motorola term for DCS is "Digital Private Line," or DPL.

T2B03 - Which of the following describes a linked repeater network? **A network of repeaters in which signals received by one repeater are transmitted by all the repeaters in the network**

Explanation: A linked repeater network is a network of repeaters where signals received by one repeater are repeated by all the repeaters. There's a popular repeater network in California called the PAPA network that allows users to talk up and down the coast from home or with handheld and mobile radios.

T2B04 - Which of the following could be the reason you are unable to access a repeater whose output you can hear? **All of these choices are correct**

Explanation: Sometimes you can hear a repeater perfectly fine, but you are unable to transmit through the repeater. Common problems are that you are using the wrong transmit/receive offset, you have the incorrect CTCSS tone or you may have the incorrect DCS code. A quick check with the repeater owners, maybe the repeater owner's website or repeater directories or other stations using the repeater will get you the correct information in short order.

T2B05 - What would cause your FM transmission audio to be distorted on voice peaks? **You are talking too loudly**

Explanation: Many times you will hear an amateur station having difficulty getting into the repeater, especially on their voice peaks. This usually is caused by the other station overdeviating their transmitter. By the nature of FM operating characteristics, the louder you talk the more your frequency changes. By speaking softer into the microphone, your transmitted signal's deviation will be reduced as well as the condition of chopping in and out of the repeater.

T2B06 - What type of signaling uses pairs of audio tones? **DTMF**

Explanation: Sometimes you'll hear Touch-Tones over a radio. Those are DTMF (dual-tone, multi-frequency) audio tones, for signaling repeaters or other equipment.

T2B07 - How can you join a digital repeater's "talk group"? **Program your radio with the group's ID or code**

Explanation: DMR (Digital Mobile Radio) communications use "talkgroups" in order to talk with other amateurs. To access a given talkgroup, you first must program that talkgroup ID into your radio's parameters, sometimes referred to as a code plug. Yes, everyone still needs to be in the same talkgroup, even when operating simplex. There are thousands of

different talkgroups; some are for specific topics while others cover a specific geographical area or location.

T2B08 - Which of the following applies when two stations transmitting on the same frequency interfere with each other? **The stations should negotiate continued use of the frequency**

Explanation: When using HF, it is very common for propagation conditions to change over the course of a few minutes. When this occurs, you may find other amateurs using the same frequency you have been using. In these cases, it's best to let common courtesy prevail and work out a solution. Remember, no amateur "owns" a given frequency. Please share and strive to get along with one another. The whole world can listen to your behavior on the air.

T2B09 - Why are simplex channels designated in the VHF/UHF band plans? **So stations within range of each other can communicate without tying up a repeater**

Explanation: Simplex frequencies are designated in VHF and UHF band plans so stations within close communications range can communicate without tying up repeaters. This works when both or all stations are within range of each other. This allows the repeaters to be used for those who are not within range of each other.

T2B10 - Which Q signal indicates that you are receiving interference from other stations? **QRM**

Explanation: When first getting started in amateur radio, you quickly will find out many operators use a lot of different abbreviations in their conversations. Nearly all of these originated from CW operations, where it was important to keep your transmissions as short as possible by using common abbreviations. The Q signals are one example of these abbreviations; you will learn them after operating on the air for a short while, especially using CW. QRM refers to man-made interference from other amateur stations. QRN refers to interference due to static.

T2B11 - Which Q signal indicates that you are changing frequency? **QSY**

Explanation: QSY means you are changing frequency. You can remember this because frequency ends in Y, much like this Q code.

T2B12 - What is the purpose of the color code used on DMR repeater systems? **Must match the repeater color code for access**

Explanation: On Digital Mobile Radio (DMR) repeaters, color codes are similar to CTCSS and DCS on analog repeaters. The color code you transmit on your radio must match the repeater's color code in order to access the repeater and have it retransmit your signal.

T2B13 - What is the purpose of a squelch function? **Mute the receiver audio when a signal is not present**

Explanation: The squelch function on your radio mutes the receiver audio when there is no signal present. If you don't set the squelch on your radio, you would hear static even in the absence of communications in progress.

T2C01 - When do FCC rules NOT apply to the operation of an amateur station? **FCC rules always apply**

Explanation: Over the years, there has been false information given out about the FCC's jurisdiction. Sometimes you will hear comments such as: "FCC rules do not apply to me now. I am operating under RACES rules." The FCC governs all radio frequencies in the United States. The FCC's rules and regulations apply at all times.

T2C02 - Which of the following are typical duties of a Net Control Station? **Call the net to order and direct communications between stations checking in**

Explanation: The typical duties of a net control station (NCS) are to call the net to order on the air and direct communications between stations that check in for the net.

T2C03 - What technique is used to ensure that voice messages containing unusual words are received correctly? **Spell the words using a standard phonetic alphabet**

Explanation: The propagation between two amateur stations is not always perfect and sometimes atmospheric conditions make communications difficult. When using voice modes, you are encouraged to use a phonetic alphabet to spell strange or unusual words, names, locations, etc., to ensure the voice message is received correctly.

T2C04 - What is RACES? **An FCC part 97 amateur radio service for civil defense communications during national emergencies**

Explanation: Many individuals join the ranks of the amateur community to help and assist with emergency communications. Two of the largest such communications organizations are RACES and ARES. RACES (Radio Amateur Civil Emergency Service) provides emergency communications solely to government agencies and elected officials. ARES (Amateur Radio Emergency Service) deals primarily with private organizations such as the American

National Red Cross, the Salvation Army, etc. Both RACES and ARES provide valuable communications during emergencies.

T2C05 - What does the term "traffic" refer to in net operation? Messages exchanged by net stations

Explanation: Amateur radio nets allow for a number of amateurs to use a single frequency. The use of nets allows for efficient use of our frequency privileges. There are many different types of nets. Some are for weather, antique cars, model railroads and more. One type of net is traffic nets. These are nets that are designed to exchange formal messages between different stations. The word "traffic" refers to formal messages. These types of nets were very popular up until the early 1980s.

T2C06 - What is the Amateur Radio Emergency Service (ARES)? A group of licensed amateurs who have voluntarily registered their qualifications and equipment for communications duty in the public service

Explanation: The Amateur Radio Emergency Service, or ARES, is a group of licensed amateurs who have voluntarily registered their qualifications and radio equipment for communications duty in the public service.

T2C07 - Which of the following is standard practice when you participate in a net? Unless you are reporting an emergency, transmit only when directed by the net control station

Explanation: After checking into a net, you are to remain on frequency without transmitting until you are asked to do so by the net control station. After a group of amateur operators check into the net, the NCS will acknowledge who has checked in to the net. If your call sign was not mentioned, then you can check in again and avoid conflicting with other stations when you transmit. If for some reason you need to leave the net before it terminates, wait until there is a pause in the net, give your call sign and request to secure your station. This is important in traffic nets because the net control may direct formal messages to your station and you would have left long before.

T2C08 - Which of the following is a characteristic of good traffic handling? Passing messages exactly as received

Explanation: The National Traffic System takes great pride in the fact the messages that travel through their system are received exactly as they were sent. Many of the prosigns used today came from the formal traffic and message handling procedures. Each message has a "check" that is used to validate the number of words or groups in a formal message. The characteristic of good traffic handling is passing the messages exactly as they were received.

T2C09 - Are amateur station control operators ever permitted to operate outside the frequency privileges of their license class? **Yes, but only in situations involving the immediate safety of human life or protection of property**

Explanation: Only under extreme situations are amateur radio control operators permitted to operate outside the frequency privileges of their license class. Operating outside the privileges of your license class is permitted, but only if necessary in situations involving the immediate safety of human life or protection of property.

T2C10 - What information is contained in the preamble of a formal traffic message? **Information needed to track the message**

Explanation: Every formal message passed over amateur radio has a predetermined format. The preamble of the formal message contains the information needed to track the message. The preamble includes information such as the amateur station that sent the message, the station that received the message, the message number, etc.

T2C11 - What is meant by "check" in a radiogram header? **The number of words or word equivalents in the text portion of the message**

Explanation: One of the pieces of information in a formal message is the "check." The check in a formal message is the number of words or word equivalents in the text portion of the message. This "check" ensures the integrity of the messages being sent through the National Traffic System. When the receiving station performs the check -- and it is different from what is in the message -- they immediately know they have copied something incorrectly in the message.

T3 - Radio Waves

T3A01 - Why do VHF signal strengths sometimes vary greatly when the antenna is moved only a few feet? **Multipath propagation cancels or reinforces signals**

Explanation: When using a handheld or mobile 2-meter radios, sometimes moving the radio or the vehicle a few feet will make the difference from being received perfectly by the other station to a very distorted signal. If the receiving station reports that your 2-meter signal was strong just a moment ago but now it is weak or distorted, usually moving the radio or the mobile station a few feet will improve your signal. Many times the signals are reflected and may cause multipath distortion of your signals.

T3A02 - What is the effect of vegetation on UHF and microwave signals? **Absorption**

Explanation: Vegetation, like leaves, causes absorption of UHF and microwave signals. Yes, those leaves on trees between two UHF or microwave stations can absorb and degrade your signal.

T3A03 - What antenna polarization is normally used for long-distance weak-signal CW and SSB contacts on the VHF and UHF bands? **Horizontal**

Explanation: On the VHF and UHF bands, horizontally polarized antennas are normally better for long-distance weak-signal CW and SSB contacts.

T3A04 - What happens when antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization? **Received signal strength is reduced**

Explanation: Given two stations using the VHF or UHF bands for line-of-sight radio links, if one station is vertically polarized and the other station is horizontally polarized, the signals could be significantly weaker.

T3A05 - When using a directional antenna, how might your station be able to communicate with a distant repeater if buildings or obstructions are blocking the direct line of sight path? **Try to find a path that reflects signals to the repeater**

Explanation: There are many obstructions that can affect VHF and UHF electromagnetic radio waves, such as buildings with foil-backed insulation, metal roofs and steel structures. Unlike an omnidirectional antenna that radiates equally in all directions, a directional antenna can focus most of its signal in one direction. By changing the direction in which your directional antenna is pointing, you can find a path that reflects your signals to the repeater.

T3A06 - What is the meaning of the term "picket fencing"? **Rapid flutter on mobile signals due to multipath propagation**

Explanation: When studying for your Technician license, you have seen references to conditions when moving your antenna just a few feet one direction or the other makes the difference from being heard or not. Now apply these conditions while you are mobile transmitting from your vehicle while moving. The station receiving your signal sometimes hears a rapid fluttering signal from you. Think about shining a light through a picket fence while walking down the sidewalk. The rapid on/off of the light is the way the radio signal sounds. This is where the term "picket fencing" originated.

T3A07 - What weather condition might decrease range at microwave frequencies?
Precipitation

Explanation: If you are using microwave frequencies, such as those in the upper UHF band, you may see decreased range if you are transmitting while it is raining.

T3A08 - What is a likely cause of irregular fading of signals propagated by the ionosphere?
Random combining of signals arriving via different paths

Explanation: Radio waves are not a single beam of energy that goes from your station to another station. The radio waves can take multiple paths to go from one point to another. One example is that part of your signal is going directly to the other station, while another part of your signal is bouncing off a building before it arrives at the other station. The random combining of these signals arriving via different paths causes irregular fading.

T3A09 - Which of the following results from the fact that signals propagated by the ionosphere are elliptically polarized? **Either vertically or horizontally polarized antennas may be used for transmission or reception**

Explanation: The elliptically polarized signals contain properties of both vertical and horizontal polarization. Because of this distortion from the original polarization, either a vertically or horizontally polarized antenna may be used for transmitting or receiving.

T3A10 - What effect does multi-path propagation have on data transmissions? **Error rates are likely to increase**

Explanation: Many times, the analog voice or CW signals will sound like they are underwater or have a slight echo. When listening to analog audio signals that have arrived via multiple paths, our brain has the ability to fill in the gaps of missing words or distorted words. With digital data signals being distorted by this condition, the computer can't fill in the gaps. In this case, your error rate will start to increase as the signal quality decreases.

T3A11 - Which region of the atmosphere can refract or bend HF and VHF radio waves? **The ionosphere**

Explanation: The upper layer of the atmosphere that becomes ionized when exposed to radiation from the sun is called the Ionosphere. When radio waves transmitted by an amateur transmitter reach the ionosphere, they bounce back to earth to be received by another station many miles away, or in some cases many thousands of miles away -- or around the world.

T3A12 - What is the effect of fog and rain on signals in the 10 meter and 6 meter bands?
There is little effect

Explanation: Radio waves, or RF energy, are absorbed by water and solids. The energy absorbed by the moisture is converted to heat. As you go higher in frequency, this absorption property becomes more and more of a problem. This is well documented in microwave frequencies from years of commercial applications. For 10-meter and 6-meter wavelengths, the frequency isn't high enough to be affected by fog and light rain. Thus, fog and light rain will have little effect on those amateur bands.

T3B01 - What is the relationship between the electric and magnetic fields of an electromagnetic wave? **They are at right angles**

Explanation: A radio wave has two components: the electric and magnetic fields. The two fields of an electromagnetic wave are at right angles to each other.

T3B02 - What property of a radio wave defines its polarization? **The orientation of the electric field**

Explanation: A radio wave contains two properties, electric waves and magnetic waves, therefore the name "electromagnetic waves." The property of the electric field is used to describe the polarization. So just remember radio waves travel at the speed of light and the polarization does not affect the speed of the radio waves. Other distractors such as the ratio of velocity to wavelength has no effect on the polarization.

T3B03 - What are the two components of a radio wave? **Electric and magnetic fields**

Explanation: But these two different properties work together to create a resonate circuit.

T3B04 - What is the velocity of a radio wave traveling through free space? **At the speed of light**

Explanation: For most all amateur radio calculations, we will use the constant of 300,000 kilometers per second for formulas requiring the speed of light.

T3B05 - What is the relationship between wavelength and frequency? **The wavelength gets shorter as the frequency increases**

Explanation: There is a direct relationship between the wavelength of radio waves and frequency. As the wavelength gets shorter, the frequency increases -- just like the strings on a musical instrument where the shorter the string the higher the frequency of the note.

T3B06 - What is the formula for converting frequency to approximate wavelength in meters? **Wavelength in meters equals 300 divided by frequency in megahertz**

Explanation: Amateur radio operators refer to frequency bands in meters. For instance, the 144-148 MHz band is the 2-meter band, while the 28-29.7 MHz band is 10 meters. Here's how to convert megahertz to wavelength in meters: Take 300 and divide it by the frequency in megahertz, so for 146 MHz, its 300 divided by 146 = 2.05, or 2 meters!

T3B07 - In addition to frequency, which of the following is used to identify amateur radio bands? **The approximate wavelength in meters**

Explanation: The approximate wavelength of the various frequency bands used by ham radio operators often is used to identify the bands. For instance, frequencies in the 144-148 MHz band used by hams often is called the 2-meter band, which is a reference to the 2-meter wavelength of radio signals on that band.

T3B08 - What frequency range is referred to as VHF? **30 MHz to 300 MHz**

Explanation: The VHF (very high frequency) radio spectrum refers to radio waves with a frequency of 30 MHz to 300 MHz. The wavelength of this radio spectrum is 10 meters to 1 meter.

T3B09 - What frequency range is referred to as UHF? **300 to 3000 MHz**

Explanation: The UHF (ultra high frequency) radio spectrum refers to radio waves with a frequency of 300 MHz (megahertz) to 3 GHz (gigahertz). Sometimes you will see 3 GHz referred to as the "decimeter band." Wavelengths in the UHF radio spectrum range from one meter to one tenth of a meter (one decimeter).

T3B10 - What frequency range is referred to as HF? **3 to 30 MHz**

Explanation: The HF (high frequency) radio spectrum refers to radio waves with a frequency of 3 MHz to 30 MHz. The wavelength of this spectrum is 100 meters to 10 meters.

T3B11 - What is the approximate velocity of a radio wave in free space? **300,000,000 meters per second**

Explanation: On amateur exams, the constant of 300 million meters per second will be used for the speed of light.

T3C01 - Why are simplex UHF signals rarely heard beyond their radio horizon? **UHF signals are usually not propagated by the ionosphere**

Explanation: Signals on UHF frequencies rarely are heard from stations outside their local area because these frequencies usually are not reflected by the ionosphere.

T3C02 - What is a characteristic of HF communication compared with communications on VHF and higher frequencies? **Long distance ionospheric propagation is far more common on HF**

Explanation: The amateur radio VHF and UHF and above bands are mostly for communications with other stations that are within line of sight. These bands depend on repeaters to increase their effective range. The HF bands are well suited for long-range communications because their radio waves are reflected back toward earth instead of punching through the ionosphere. The ability of HF frequencies to bounce off the ionosphere and provide long-distance propagation is far more common.

T3C03 - What is a characteristic of VHF signals received via auroral backscatter? **They are distorted and signal strength varies considerably**

Explanation: VHF signals reflected off an aurora tend to sound distorted with a rapid fluctuation of signal strength.

T3C04 - Which of the following types of propagation is most commonly associated with occasional strong signals on the 10, 6, and 2 meter bands from beyond the radio horizon? **Sporadic E**

Explanation: Sometimes you will hear amateur stations located past the horizon on 10 meters, 6 meters and 2 meters with strong signals. These over-the-horizon signals are being reflected by the E layer of the atmosphere. This propagation type is called sporadic E.

T3C05 - Which of the following effects may allow radio signals to travel beyond obstructions between the transmitting and receiving stations? **Knife-edge diffraction**

Explanation: Radio waves are not a single beam of energy going from one amateur station to another. Radio waves can take many different directions between any given two stations. Sometimes reliable two-way communications can be accomplished between two stations despite obstructions between them. This propagation type is called knife-edge diffraction.

T3C06 - What type of propagation is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis? **Tropospheric ducting**

Explanation: Sometimes you can have reliable communications on VHF and UHF with other amateur stations that are over-the-horizon approximately 300 miles away on a regular basis. This propagation mode is called tropospheric ducting. These conditions can occur at any given time, but are more common during the summer and autumn.

T3C07 - What band is best suited for communicating via meteor scatter? **6 meter band**

Explanation: Communications via meteor scatter occurs when radio waves are reflected back to Earth from the ionized atmosphere because meteorites are entering Earth's atmosphere and burning up on entry. The 6-meter, or 50 MHz, band is excellent for meteor scatter communications because of its wavelength.

T3C08 - What causes tropospheric ducting? **Temperature inversions in the atmosphere**

Explanation: Sometimes warmer air becomes trapped above cooler air. This is called temperature inversion or thermal inversion. This atmospheric condition allows for a condition called tropospheric ducting.

T3C09 - What is generally the best time for long-distance 10 meter band propagation via the F layer? **From dawn to shortly after sunset during periods of high sunspot activity**

Explanation: Each amateur band has its own characteristics and personalities. As you spend time operating and communicating with other amateurs on each of these bands, you will learn the capabilities and limitations of each one. The 10-meter band follows the sun and thus is best in daylight hours when the sun has created the maximum amount of ionization in the ionosphere. So during periods of high sunspot activity, 10 meters will be useful from dawn to shortly after sunset. 6 meters often is referred to as the "magic band."

T3C10 - Which of the following bands may provide long-distance communications via the ionosphere's F region during the peak of the sunspot cycle? **6 or 10 meter bands**

Explanation: Once again, this is a question that you must read a couple of times to actually understand what the FCC is asking on your test. The key words here are "sunspot cycle." So out of the given list of bands to choose from, which amateur bands are affected by the sunspot cycle. Most VHF and UHF frequencies pass right through the ionosphere and into space. The lower frequencies or longer wavelength amateur bands tend to be reflected back to Earth, where they are received long distances from your location. From the list of given

distractors, the 6- and 10-meter bands are the correct choice. The other frequencies offered as choices are ones that penetrate the ionosphere and continue into space.

T3C11 - Why is the radio horizon for VHF and UHF signals more distant than the visual horizon? **The atmosphere refracts radio waves slightly**

Explanation: The radio horizon for VHF and UHF signals is more distant than the visual horizon because VHF and UHF frequencies can follow the Earth's curvature and travel farther than we can see. The Earth seems less curved to radio waves than to light waves. Basically, if you can "see" the other amateur station, then you probably can communicate with them on VHF or UHF.

T4 – Radio Practices

T4A01 - Which of the following is an appropriate power supply rating for a typical 50 watt output mobile FM transceiver? **13.8 volts at 12 amperes**

Explanation: For a typical 50-watt output mobile FM transceiver, an appropriate power supply rating would be 13.8 volts at 12 amperes. When shopping for a power supply to run your transceiver, first look at the specification of the radio. What does the manufacturer state as the maximum current? If their radio is a 50-watt radio at 12 volts, then a 10-ampere power supply is sufficient. (12 volts X 10 amperes = 120 watts, which is greater than the 50 watts of the radio). There are other factors to consider, but this information helps address this question on the exam.

T4A02 - Which of the following should be considered when selecting an accessory SWR meter? **The frequency and power level at which the measurements will be made**

Explanation: SWR meters are calibrated for use on different frequency bands, so be sure the meter you acquire can handle the frequencies and power level you want to measure. If you are transmitting with a 50-watt radio on the 2-meter band, be sure your SWR meter covers the 144-148 MHz 2-meter band and can accommodate 50 watts transmitting through the meter.

T4A03 - Why are short, heavy-gauge wires used for a transceiver's DC power connection? **To minimize voltage drop when transmitting**

Explanation: In all cases, you want to avoid the operating voltage falling below that needed for proper operation of the radio.

T4A04 - How are the transceiver audio input and output connected in a station configured to operate using FT8? **To the audio input and output of a computer running WSJT-X software**

Explanation: A station operating using the FT8 digital mode should have the transceiver's audio output and input connected to the audio input and output of a computer running WSJT-X software.

T4A05 - Where should an RF power meter be installed? **In the feed line, between the transmitter and antenna**

Explanation: An RF power meter used in your station should be connected in series with the feed line, between the transmitter and the antenna.

T4A06 - What signals are used in a computer-radio interface for digital mode operation? **Receive audio, transmit audio, and transmitter keying**

Explanation: The signals used in a computer-radio interface for digital mode operation require that three connections be made between the computer and the radio. Connect the receive audio, transmit audio and transmitter keying between the transceiver and a computer to make it function.

T4A07 - Which of the following connections is made between a computer and a transceiver to use computer software when operating digital modes? **Computer "line in" to transceiver speaker connector**

Explanation: To use computer software when operating digital modes, you connect the computer "line in" to the transceiver's speaker connector so the computer can hear what is being sent on the radio.

T4A08 - Which of the following conductors is preferred for bonding at RF? **Flat copper strap**

Explanation: A flat copper strap is preferred for bonding at RF. The flat copper strap provides the lowest impedance to RF signals, effectively providing a direct route to ground potential.

T4A09 - How can you determine the length of time that equipment can be powered from a battery? **Divide the battery ampere-hour rating by the average current draw of the equipment**

Explanation: Divide the battery ampere-hour rating by the average current draw of the equipment to determine the length of time that equipment can be powered from a battery.

T4A10 - What function is performed with a transceiver and a digital mode hot spot?
Communication using digital voice or data systems via the internet

Explanation: A digital mode hot spot allows hams using digital radios such as DMR or D-STAR to communicate on digital voice or data systems via the internet while at home (or mobile). A hot spot like a Raspberry Pi acts as a repeater for those nodes, retransmitting the signal from the radio onto the internet and back from other users to the radio.

T4A11 - Where should the negative power return of a mobile transceiver be connected in a vehicle? **At the 12 volt battery chassis ground**

Explanation: The negative power cable to your radio should be connected to the battery or the engine block ground strap. The battery or the engine block ground strap is the answer the FCC is expecting for this question. In real life, please consult with the vehicle's manufacturer if unsure. Some newer vehicles use the negative battery connection to determine current drain, thus your radio connection might cause inaccurate readings or problems. Many electric vehicles have voltages in excess of 12 volts flowing through some wiring harnesses. If unsure, please consult with an expert or professional.

T4A12 - What is an electronic keyer? **A device that assists in manual sending of Morse code**

Explanation: An electronic keyer can be used while operating CW to assist in the manual sending of Morse code.

T4B01 - What is the effect of excessive microphone gain on SSB transmissions? **Distorted transmitted audio**

Explanation: If you are told that your transmitted audio is distorted when operating on SSB, it most likely is the result of excessive microphone gain. Good audio helps other stations hear you better on the air.

T4B02 - Which of the following can be used to enter a transceiver's operating frequency? **The keypad or VFO knob**

Explanation: Use the keypad or VFO knob on most modern transceivers to enter the operating frequency desired. This can vary depending on the model of radio you are using.

T4B03 - How is squelch adjusted so that a weak FM signal can be heard? **Set the squelch threshold so that receiver output audio is on all the time**

Explanation: In order to hear weak-signal FM stations, adjust the squelch so that the receiver's output audio is on all the time, in essence, you hear static even when the other station isn't transmitting.

T4B04 - What is a way to enable quick access to a favorite frequency or channel on your transceiver? **Store it in a memory channel**

Explanation: After you operate on the air for a while, you will develop a small list of your favorite frequencies. These favorite frequencies may be local repeaters in your area, important amateur radio nets or frequencies used for emergency communications. By storing these frequencies into your transceiver's memory channels, you will have quick access. Some transceivers give you the ability to scan your memory channels, too.

T4B05 - What does the scanning function of an FM transceiver do? **Tunes through a range of frequencies to check for activity**

Explanation: The scanning function on an FM transceiver will tune through a range of predetermined frequencies to search for activity. This automatic function helps you find frequencies that are in use to reach out to other stations.

T4B06 - Which of the following controls could be used if the voice pitch of a single-sideband signal returning to your CQ call seems too high or low? **The receiver RIT or clarifier**

Explanation: Many times when you are on a single-sideband (SSB) net, some of the other stations' voice pitch will be a little too high or low. Without changing your transmitter's frequency, you can adjust your RIT (receiver incremental tuning) control to adjust your receiver to the proper voice pitch.

T4B07 - What does a DMR "code plug" contain? **Access information for repeaters and talkgroups**

Explanation: A DMR "code plug" contains access information for repeaters and talkgroups. This information is programmed into the radio via software.

T4B08 - What is the advantage of having multiple receive bandwidth choices on a multimode transceiver? **Permits noise or interference reduction by selecting a bandwidth matching the mode**

Explanation: Today's multimode transceivers have multiple bandwidth choices or filters available to the amateur operator. These filters allow you to eliminate, or reduce, noise and interference. You will select the bandwidth option that matches the mode you are using. Narrow modes such as CW allow you to use a narrow bandwidth such as 250 Hz or 500 Hz. Single-sideband bandwidth is limited to 3 kHz, but most stations do not use that much bandwidth so a 2.4-kHz filter is best for SSB. Digital modes such as FT8 pack as many different signals as possible into a 3-kHz bandwidth. In this case, your 3-kHz or 3.5-kHz bandwidth option would be the best selection.

T4B09 - How is a specific group of stations selected on a digital voice transceiver? **By entering the group's identification code**

Explanation: To select a group on a digital voice transceiver, simply enter the group's identification code.

T4B10 - Which of the following receiver filter bandwidths provides the best signal-to-noise ratio for SSB reception? **2400 Hz**

Explanation: When using SSB, choosing the 2400-Hz bandwidth option would be the appropriate option for the best signal-to-noise ratio for SSB reception.

T4B11 - Which of the following must be programmed into a D-STAR digital transceiver before transmitting? **Your call sign**

Explanation: Your call sign must be programmed into a D-STAR-capable radio before it can be used for transmitting in the digital mode. D-STAR requires a one-time online registration of your call sign before use.

T4B12 - What is the result of tuning an FM receiver above or below a signal's frequency? **Distortion of the signal's audio**

Explanation: You will hear distortion of the signal's audio if you tune an FM receiver above or below a signal's actual frequency.

T5 – Electrical Principles

T5A01 - Electrical current is measured in which of the following units? **Amperes**

Explanation: Electric current is measured in amperes, or amps. An ampere is the rate of flow of electrons. The flow rate of one coulomb per second is equal to one amp of current. You measure current flow with an amp meter connected in series with the electrical circuit. Many times you will see electrical current referenced as "A."

T5A02 - Electrical power is measured in which of the following units? **Watts**

Explanation: Electrical power is measured in watts, or sometimes kilowatts. (1 kilowatt is equal to 1,000 watts). A single watt is defined as the electrical power equal to one ampere at one volt. In Ohm's Law, Power = Amps times Volts.

T5A03 - What is the name for the flow of electrons in an electric circuit? **Current**

Explanation: The flow of electrons in an electrical circuit defines current. Current or amps is the rate of flow of electrons in an electrical circuit.

T5A04 - What are the units of electrical resistance? **Ohms**

Explanation: Ohms are the units of electrical resistance in the International System of Units. They can be measured using a multimeter or calculated using the Ohm's Law formula: Ohms = Voltage / Amps. The symbol for the ohm is Ω .

T5A05 - What is the electrical term for the force that causes electron flow? **Voltage**

Explanation: Volts is the definition for EMF (electromotive force) that causes electrons to flow. Volts sometimes is expressed as E (electromotive force).

T5A06 - What is the unit of frequency? **Hertz**

Explanation: Hertz are the units of frequency in the International System of Units, and in amateur radio are used to describe electromagnetic radiation. They can be measured using tools that count frequency, including an oscilloscope. The symbol for Hertz is Hz.

T5A07 - Why are metals generally good conductors of electricity? **They have many free electrons**

Explanation: Electrons are the primary part of an atom that conducts electricity. The chemical makeup of metal atoms allows electrons to move more freely than other types of material, this makes metal good conductors.

T5A08 - Which of the following is a good electrical insulator? **Glass**

Explanation: Glass is a good example of an electrical insulator. Glass is used on many high-voltage power distribution systems. Copper is an example of a good conductor.

T5A09 - Which of the following describes alternating current? **Current that alternates between positive and negative directions**

Explanation: Alternating current reverses the direction of the current flow regularly, so it "alternates" between positive and negative directions. The period that it takes to alternate in a complete cycle is called the frequency. A radio signal is a type of electromagnetic alternating current and has a frequency.

T5A10 - Which term describes the rate at which electrical energy is used? **Power**

Explanation: Power is calculated as electromotive force times electrical current: Amps times Volts equals Watts.

T5A11 - What type of current flow is opposed by resistance? **All these choices are correct**

Explanation: Resistance is the opposition to current flow. In Direct Current fields this opposition is just called resistance. In Alternating Current fields, including Radio Frequency current, the resistance is called impedance. Both resistance and impedance are measured in Ohms.

T5A12 - What describes the number of times per second that an alternating current makes a complete cycle? **Frequency**

Explanation: Frequency is defined as the number of times per second an alternating current completes a full cycle. Frequency is measured in cycles per second or Hz (Hertz). One CPS (cycle per second) = 1 Hz.

T5B01 - How many milliamperes is 1.5 amperes? **1500 milliamperes**

Explanation: 1,000 milliamps = 1 ampere. 1.5 amperes = 1500 milliamperes.

T5B02 - Which is equal to 1,500,000 hertz? - **1500 kHz**

Explanation: 1,000,000 Hz = 1 MHz or 1,000 kHz. 1,500,000 Hz = 1.5 MHz or 1500 kHz

T5B03 - Which is equal to one kilovolt? **One thousand volts**

Explanation: 1,000 volts = 1 kilovolt.

T5B04 - Which is equal to one microvolt? **One one-millionth of a volt**

Explanation: 1 millionth of a volt = 1 microvolt

T5B05 - Which is equal to 500 milliwatts? **0.5 watts**

Explanation: 1 watt = 1000 milliwatts. Thus, 1/2 (0.5) watt = 500 milliwatts.

T5B06 - Which is equal to 3000 milliamperes? **3 amperes**

Explanation: 1 ampere = 1000 milliamperes. 3 amperes = 3000 milliamperes.

T5B07 - Which is equal to 3.525 MHz? **3525 kHz**

Explanation: 1 MHz = 1000 kHz. Thus 3.525 MHz = 3525 kHz.

T5B08 - Which is equal to 1,000,000 picofarads? **1 microfarad**

Explanation: 1 farad = 1,000,000,000 picofarads. 1 microfarad = 1,000,000 picofarads.

T5B09 - Which decibel value most closely represents a power increase from 5 watts to 10 watts? **3 dB**

Explanation: When working with decibels, every 3 dB of gain multiplies your signal by 2. Every 3 dB of loss divides your signal by 2. Thus, going from 5 watts to 10 watts is 3 dB of gain. And going from 10 watts to 5 watts is 3 dB of loss.

T5B10 - Which decibel value most closely represents a power decrease from 12 watts to 3 watts? **-6 dB**

Explanation: When working with decibels, every 6 dB of gain multiplies your signal by 4. Every 6 dB of loss divides your signal by 4. Thus, going from 12 watts to 3 watts is 6 dB of loss. Also, going from 10 watts to 40 watts is 6 dB of gain. Going from 40 watts to 10 watts is 6 dB of loss.

T5B11 - Which decibel value represents a power increase from 20 watts to 200 watts? **10 dB**

Explanation: When working with decibels, every 10 dB of gain multiplies your signal by 10. Every 10 dB of loss divides your signal by 10. Thus, going from 20 watts to 200 watts is 10 dB of gain. And going from 200 watts to 20 watts is 10 dB of loss.

T5B12 - Which is equal to 28400 kHz? **28.400 MHz**

Explanation: 1000 kHz = 1 MHz. 28400 kHz = 28.400 MHz.

T5B13 - Which is equal to 2425 MHz? **2.425 GHz**

Explanation: 1000 MHz = 1 GHz. 2425 MHz = 2.425 GHz.

T5C01 - What is the ability to store energy in an electric field called? **Capacitance**

Explanation: When the capacitor is discharged, the potential energy stored in the electric field is converted to the charge.

T5C02 - What is the unit of capacitance? **The farad**

Explanation: The unit of capacitance is the farad, and describes the ability of an item to store electrical charge. Named after famous English physicist, Michael Faraday.

T5C03 - What is the ability to store energy in a magnetic field called? **Inductance**

Explanation: The ability to store energy in a magnetic field is inductance. A magnetic field is created by inductance.

T5C04 - What is the unit of inductance? **The henry**

Explanation: The basic unit of inductance is the henry. Inductors come in many different forms. The very basic inductor consists of a core with wire wrapped around it to produce a magnetic field.

T5C05 - What is the unit of impedance? **The ohm**

Explanation: Inductance is the resistance in an AC circuit. Ohms are the units of electrical resistance in the International System of Units. The symbol for the ohm is Ω .

T5C06 - What does the abbreviation "RF" mean? **Radio frequency signals of all types**

Explanation: The abbreviation for radio frequency is RF. This is the electromagnetic energy.

T5C07 - What is the abbreviation for megahertz? **MHz**

Explanation: In the International System of Units, MHz is the abbreviation for megahertz. The base unit Hertz is Hz. When units are at or above the megahertz range, the first letter is capitalized to indicate a high multiple and differentiate from lower units. For instance, kHz is kilohertz.

T5C08 - What is the formula used to calculate electrical power (P) in a DC circuit? **$P = I \times E$**

Explanation: Ohm's Law provides the amateur operator with many useful formulas. You will use many of these formulas frequently during your time as an amateur radio operator. Calculating power is one of those basic formulas. P (power) = E (voltage) multiplied by I (current). This sometimes is referred to as amps x volts = watts.

T5C09 - How much power is delivered by a voltage of 13.8 volts DC and a current of 10 amperes? **138 watts**

Explanation: Here are the key pieces of information we need to solve this problem. How much power is being used in a circuit when the applied voltage is 13.8 volts DC and the current is 10 amperes? They are looking for power, you are given 13.8 Volts DC, and you are given 10 amperes. Looking at Ohm's Law, we quickly see that amps times volts equals power. Thus, 13.8 volts multiplied by 10 amperes equals 138 watts, or $13.8 \times 10 = 138$.

T5C10 - How much power is delivered by a voltage of 12 volts DC and a current of 2.5 amperes? **30 watts**

Explanation: These are the key pieces of information needed to solve this problem. How much power is being used in a circuit when the applied voltage is 12 volts DC and the current is 2.5 amperes? They are looking for power, you are given 12 volts DC and you are given 2.5 amperes. Looking at Ohm's Law, we quickly see that amps times volts equals power. Thus, 12 volts multiplied by 2.5 amperes equals 30 watts, or $12 \times 2.5 = 30$.

T5C11 - How much current is required to deliver 120 watts at a voltage of 12 volts DC? **10 amperes**

Explanation: Let's use the key pieces of information to solve this. How many amperes are flowing in a circuit when the applied voltage is 12 volts DC and the load is 120 watts? They are asking for amperes, you are given 12 volts DC and you are given 120 watts. Looking at the power formula, we quickly see that watts/volts equals amperes. Thus, 120 watts divided by 12 volts equals 10 amperes, or $120/12 = 10$

T5C12 - What is impedance? **The opposition to AC current flow**

Explanation: Impedance is a unit of measure of the opposition to AC current flow in a circuit. In a DC circuit, the opposition of flow would be called resistance.

T5C13 - What is the abbreviation for kilohertz? **kHz**

Explanation: In the International System of Units, kHz is the abbreviation for kilohertz. The base unit Hertz is Hz. When units are at or below above the kilohertz range, the first letter is lowercase to indicate a lower multiple and differentiate from higher units. For instance MHz would be megahertz.

T5D01 - What formula is used to calculate current in a circuit? **$I = E / R$**

Explanation: Using Ohm's Law, I (current) equals E (voltage) divided by R (resistance), or $I = E / R$.

T5D02 - What formula is used to calculate voltage in a circuit? **$E = I \times R$**

Explanation: Using Ohm's Law, E (voltage) equals I (current) multiplied by R (resistance), or $E = I \times R$.

T5D03 - What formula is used to calculate resistance in a circuit? **$R = E / I$**

Explanation: Using Ohm's Law, R (resistance) equals E (voltage) divided by I (current), or $R = E / I$.

T5D04 - What is the resistance of a circuit in which a current of 3 amperes flows when connected to 90 volts? **30 ohms**

Explanation: Using the key pieces of information we need to solve this problem, what is the resistance of a circuit in which a current of 3 amperes flows through a resistor connected to 90 volts? They are looking for R (resistance), you are given I (current) of 3 amperes and you are given E, which is 90 volts. Looking at Ohm's Law, we quickly see that volts divided by amperes equals resistance, or $R = E / I$. Thus, 90 volts divided by 3 amperes equals 30 ohms, or $90 / 3 = 30$.

T5D05 - What is the resistance in a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes? **8 ohms**

Explanation: Using the key pieces of information we need to solve this problem, what is the resistance in a circuit in which the applied voltage is 12 volts and the current flow is 1.5 amperes? They are looking for R (resistance), you are given E, which is 12 volts, and you are given I (current) which is 1.5 amperes. Using Ohm's Law, we quickly see that volts divided by amperes equals resistance, or $R = E / I$. Thus, 12 volts divided by 1.5 amperes equals 8 ohms, or $12 / 1.5 = 8$.

T5D06 - What is the resistance of a circuit that draws 4 amperes from a 12-volt source? **3 ohms**

Explanation: Using the key pieces of information we need to solve this problem, what is the resistance of a circuit that draws 4 amperes from a 12-volt source? They are looking for R (resistance), you are given I (current) of 4 amperes and you are given E, which is 12 volts. Looking at Ohm's Law, we quickly see that volts divided by amperes gives resistance, or $R = E / I$. 12 volts divided by amperes equals resistance, or $R = E / I$. Thus, 12 volts divided by 4 amperes equals 3 ohms, or $12 / 4 = 3$.

T5D07 - What is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms? **1.5 amperes**

Explanation: Using the key pieces of information we need to solve this problem, what is the current in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms? They are looking for I (current), you are given E, which is 120 volts, and you are given R, which is 80 ohms. Looking at Ohm's Law we quickly see that volts divided by resistance equals current, or $I = E / R$. Thus, 120 volts divided by 80 ohms equals 1.5 amperes, or $120 / 80 = 1.5$.

T5D08 - What is the current through a 100-ohm resistor connected across 200 volts? **2 amperes**

Explanation: Using the key pieces of information we need to solve this problem, what is the current through a 100-ohm resistor connected across 200 volts? They are looking for I (current), you are given R (resistance) of 100 ohms and you are given E, which is 200 volts. Looking at Ohm's Law we quickly see that volts divided by resistance equals current, or $I = E / R$. Thus, 200 volts divided by 100 ohms equals 2 amperes, or $200 / 100 = 2$.

T5D09 - What is the current through a 24-ohm resistor connected across 240 volts? **10 amperes**

Explanation: Using the key pieces of information we need to solve this problem, what is the current through a 24-ohm resistor connected across 240 volts? They are looking for I (current), you are given R (resistance) of 24 ohms and you are given E, which is 240 volts. Looking at Ohm's Law, we quickly see that volts divided by resistance equals current, or $I = E / R$. Thus, 240 volts divided by 24 ohms equals 10 amperes, or $240 / 24 = 10$.

T5D10 - What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it? **1 volt**

Explanation: Using the key pieces of information we need to solve this problem, what is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it? They are looking for E (volts), you are given R (resistance) of 2 ohms and you are given I (current) which is 0.5 amperes. Looking at Ohm's Law, we quickly see that amperes multiplied by resistance equals voltage, or $E = I \times R$. Thus, 2 ohms multiplied by 0.5 amperes equals 1 volt, or $2 \times 0.5 = 1$.

T5D11 - What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it? **10 volts**

Explanation: Using the key pieces of information we need to solve the problem, what is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it? They are looking for E (volts), you are given R (resistance) of 10 ohms and you are given I (current) of 1 amperes. Looking at Ohm's Law, we quickly see that amperes multiplied by ohms equals volts, or $E = I \times R$. Thus, 10 ohms multiplied by 1 ampere equals 10 volts, or $10 \times 1 = 10$.

T5D12 - What is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it? **20 volts**

Explanation: Using the key pieces of information we need to solve the problem, what is the voltage across a 10-ohm resistor if a current of 2 amperes flows through it? They are looking for E (volts), you are given R (resistance) of 10 ohms and you are given I (current) of 2 amperes. Looking at Ohm's Law, we quickly see that amperes multiplied by ohms equals volts, or $E = I \times R$. Thus, 10 ohms multiplied by 2 amperes equals 20 volts, or $10 \times 2 = 20$.

T5D13 - In which type of circuit is DC current the same through all components? **Series**

Explanation: A series circuit only has one path for the current to flow, so DC current is the same through all the components, however voltage may drop. A parallel circuit has sections so the current divides when flowing through the different areas.

T5D14 - In which type of circuit is voltage the same across all components? **Parallel**

Explanation: A parallel circuit has voltage equal across all components, but current may be different in different sections. A series circuit only has one path for the current to follow through so the current is the same through all the components, however voltage may drop.

T6 – Electrical Components

T6A01 - What electrical component opposes the flow of current in a DC circuit? **Resistor**

Explanation: A resistor opposes the flow of current in a DC circuit. The unit of measure for a resistor is an ohm.

T6A02 - What type of component is often used as an adjustable volume control?
Potentiometer

Explanation: The electronic component used as an adjustable volume control is a variable resistor commonly known as a potentiometer. A potentiometer sometimes is referred to as a "pot." Pots come in several different flavors: linear function, log function and audio function, as far as their relationship to resistance to the amount the knob is turned.

T6A03 - What electrical parameter is controlled by a potentiometer? **Resistance**

Explanation: A potentiometer is a variable resistor. A potentiometer has three electrical connections. If all three connections are used in the circuit, the device still is called a potentiometer, but if only two connections are used, the device is called a rheostat. A potentiometer's unit of measure is in ohms.

T6A04 - What electrical component stores energy in an electric field? **Capacitor**

Explanation: When working on electronic equipment that has been unplugged and disconnected, a shock hazard still exists. Capacitors have the ability to store electricity for periods of time.

T6A05 - What type of electrical component consists of conductive surfaces separated by an insulator? **Capacitor**

Explanation: A capacitor stores electrical energy in an electrical circuit. The conductive surfaces of a capacitor may be foil, film or metal separated by glass, ceramic, air or other elements that provide insulation.

T6A06 - What type of electrical component stores energy in a magnetic field? **Inductor**

Explanation: An inductor stores energy in a magnetic field when current flows through it. Inductors are also called chokes or coils. Generally, the more turns of a coil, the higher the inductance.

T6A07 - What electrical component is typically constructed as a coil of wire? **Inductor**

Explanation: An inductor is composed of a coil of wire. Sometimes you will see the coil constructed from small copper tubing. Remember the "skin effect." In AC circuits, the current flows on the outside of the conductor.

T6A08 - What is the function of an SPDT switch? **A single circuit is switched between one of two other circuits**

Explanation: SPDT stands for single pole, double throw. It is a switch that has a single input and two outputs. You might see this as a "low / high" switch in a circuit.

T6A09 - What electrical component is used to protect other circuit components from current overloads? **Fuse**

Explanation: A fuse is the most common electrical component used to protect other circuit components from current overloads or fault conditions. A fuse is engineered to carry only the current that is marked on the rating. If you exceed the designated current, the link will melt and the fuse will create the open circuit condition.

T6A10 - Which of the following battery chemistries is rechargeable? **All of these choices are correct**

Explanation: The most common types of rechargeable batteries are lead-acid, nickel-metal hydride (NiMH) and lithium-ion (Li-ion). Older handheld amateur radios still use the original nickel-cadmium (NiCd).

T6A11 - Which of the following battery chemistries is not rechargeable? **Carbon-zinc**

Explanation: Carbon-zinc batteries are not rechargeable. The chemical reactions that produce the electricity are not reversible. Do not try to recharge carbon-zinc batteries as they may leak or could explode.

T6A12 - What type of switch is represented by component 3 in figure T-2? **Single-pole single-throw**

Explanation: The schematic shows a single pole, single throw switch. This performs one function, to connect or disconnect this part of the circuit.

T6B01 - Which is true about forward voltage drop in a diode? **It is lower in some diode types than in others**

Explanation: A diode is a part of a circuit that allows a current to flow in only one direction. In the forward direction, a minimum amount of voltage, called the voltage drop, is required to have the diode conduct current. Because different materials are used in diodes, voltage drop is lower in some diode types.

T6B02 - What electronic component allows current to flow in only one direction? **Diode**

Explanation: The diode is classified as a semiconductor. The diode allows current to flow in only one direction. A diode is most commonly found in power supply circuits performing as a rectifier.

T6B03 - Which of these components can be used as an electronic switch? **Transistor**

Explanation: A transistor is classified as a semiconductor device. The transistor is commonly used as an amplifier or as a switch to control electric signals and power.

T6B04 - Which of the following components can consist of three layers of semiconductor material? **Transistor**

Explanation: The transistor is composed of three layers of semiconductor material and is doped with N and P dopants. The N-type dopants donate electrons, while the P-type dopants accept electrons. These configurations allow for two types of transistor configurations, the NPN and the PNP types.

T6B05 - What type of transistor has a gate, drain, and source? **Field-effect**

Explanation: A field effect transistor controls the current in a semiconductor via an electric field. The gate is used to control the current passing between the source and the drain. It is a unipolar transistor.

T6B06 - How is the cathode lead of a semiconductor diode often marked on the package? **With a stripe**

Explanation: The cathode lead of a semiconductor diode often is marked on the package with a stripe closest to the lead.

T6B07 - What causes a light-emitting diode (LED) to emit light? **Forward current**

Explanation: LED stands for light-emitting diode. Using LEDs for light sources is much more efficient than using incandescent light bulbs. LEDs are known for their low current consumption and low heat generation.

T6B08 - What does the abbreviation FET stand for? **Field Effect Transistor**

Explanation: FET stands for field-effect transistor. This type of transistor uses an electric field to control the flow of current. FETs are commonly found in amateur radio receivers because of their efficiency in the RF ranges.

T6B09 - What are the names for the electrodes of a diode? **Anode and cathode**

Explanation: Current flows into the anode and out of the cathode.

T6B10 - Which of the following can provide power gain? **Transistor**

Explanation: The transistor is the primary gain-producing component in an RF power amplifier. Understanding the function of each component in the list, you will see that the transistor is the only component that produces gain.

T6B11 - What is the term that describes a device's ability to amplify a signal? **Gain**

Explanation: Gain is the term that commonly describes a device's ability to amplify a signal. The gain or loss are expressed in units of dB.

T6B12 - What are the names of the electrodes of a bipolar junction transistor? **Emitter, base, collector**

Explanation: A bipolar junction transistor allows a small current at one terminal to control larger current at its other terminals allowing for amplification or switching. The energy passing from the collector to emitter is controlled by the base.

T6C01 - What is the name of an electrical wiring diagram that uses standard component symbols? **Schematic**

Explanation: The schematic or schematic diagram is the name of an electrical wiring diagram that uses standard component symbols.

T6C02 - What is component 1 in figure T1? **Resistor**

Explanation: Electronic component 1 in figure T1 is a resistor. This resistor is in series with the connector and the base of transistor 2.

T6C03 - What is component 2 in figure T1? **Transistor**

Explanation: This is an NPN transistor.

T6C04 - What is component 3 in figure T1? Lamp

Explanation: Electronic component 3 in figure T1 is a lamp. One lead of the lamp goes to the collector of the transistor (component 2) and the other lead goes to the "+" (plus) terminal on the battery.

T6C05 - What is component 4 in figure T1? Battery

Explanation: Electronic component 4 in figure T1 is a battery. The "+" (positive) lead of the battery goes to one lead of the lamp (component 3) and the "-" (negative) lead of the battery goes to ground.

T6C06 - What is component 6 in figure T2? Capacitor

Explanation: Electronic component 6 in figure T2 is a capacitor. One lead of the capacitor goes to ground; the other lead goes to power bus.

T6C07 - What is component 8 in figure T2? Light emitting diode

Explanation: Note the straight line on the LED symbol; this is the cathode side of the component.

T6C08 - What is component 9 in figure T2? Variable resistor

Explanation: Electronic component 9 in figure T2 is a variable resistor, or potentiometer.

T6C09 - What is component 4 in figure T2? Transformer

Explanation: Electronic component 4 in figure T2 is a transformer. Note the left-hand side of the transformer is the primary and the right hand side is the secondary winding.

T6C10 - What is component 3 in figure T3? Variable inductor

Explanation: Electronic component 3 in figure T3 is a variable inductor.

T6C11 - What is component 4 in figure T3? Antenna

Explanation: Electronic component 4 in figure T3 is an antenna.

T6C12 - Which of the following is accurately represented in electrical schematics?
Component connections

Explanation: A schematic is a representation of component connections. Schematics use symbols instead of pictures of components, so physical appearance is ruled out, so is wire lengths, because they can vary in a circuit from the schematic.

T6D01 - Which of the following devices or circuits changes an alternating current into a varying direct current signal? **Rectifier**

Explanation: A rectifier changes an alternating current into a varying direct current signal. A rectifier is composed of diodes to direct the flow of current into specific directions in the electronic circuit. This arrangement is commonly used in power supplies to send the positive side of the alternating current's sine wave to one part of the circuit and the negative side to another part of the circuit.

T6D02 - What is a relay? **An electrically-controlled switch**

Explanation: A relay is an electrically-controlled switch. A relay uses an electromagnet to switch the current flow. A relay is commonly used where a small amount of current can use mechanical contacts to control the flow of a much larger current.

T6D03 - Which of the following is a reason to use shielded wire? **To prevent coupling of unwanted signals to or from the wire**

Explanation: Shielded wire is a cable with an outer conductive layer of wire that provides electromagnetic reflection away from the inner wires. That electromagnetic reflection prevents unwanted signals from coupling with the inner wires.

T6D04 - Which of the following displays an electrical quantity as a numeric value?
Meter

Explanation: A meter is the electronic device that displays an electrical quantity as a numeric value. The other items in the list are electronic components. Meters come in a variety of flavors; analog and digital are the most common.

T6D05 - What type of circuit controls the amount of voltage from a power supply?
Regulator

Explanation: A regulator is a type of circuit that controls the amount of voltage from a power supply. Sometimes you will see this circuit referred to as a voltage regulator. Some power supply designs use a single chip to perform this task while other designs perform voltage regulation with many separate and independent components.

T6D06 - What component changes 120 V AC power to a lower AC voltage for other uses?
Transformer

Explanation: A transformer is a component that is commonly used to change 120 volts AC house current to a lower AC voltage for other uses. In this case, the transformer is a step-down transformer. But there also are step-up transformers for cases when the circuit needs a higher voltage than the 120-volt AC house current. Use caution when working with 120-volt and above AC house current. Remember: safety first.

T6D07 - Which of the following is commonly used as a visual indicator? **LED**

Explanation: A LED (light-emitting diode) is commonly used as a visual indicator. Because LEDs are inexpensive and very efficient, they are used in nearly all electronic circuits to display a status or operational mode. To aid in troubleshooting, many circuit boards have LEDs installed at various stages of the circuit to indicate status or a fault condition.

T6D08 - Which of the following is combined with an inductor to make a resonant circuit?
Capacitor

Explanation: A capacitor is combined with an inductor to make a tuned circuit. Many times you also will hear the phrase resonant circuit in place of a tuned circuit. This is a very common circuit found in RF applications. To construct a resonant or tuned circuit, you need an L (inductor) and a C (capacitor). This circuit is commonly referred to as an LC circuit.

T6D09 - What is the name of a device that combines several semiconductors and other components into one package? **Integrated circuit**

Explanation: An integrated circuit is a device that combines several semiconductors and other components into one package. This component is most commonly referred to as an IC.

T6D10 - What is the function of component 2 in figure T-1? **Control the flow of current**

Explanation: This is an NPN transistor.

T6D11 - Which of the following is a resonant or tuned circuit? **An inductor and a capacitor in series or parallel**

Explanation: An inductor and a capacitor connected in series or parallel to form a filter is a resonant or tuned circuit. Remember, a resonant or tuned circuit is composed of an L (inductor) and a C (capacitor). Sometimes you will see this referred to as an LC circuit.

T7 – Station Equipment

T7A01 - Which term describes the ability of a receiver to detect the presence of a signal?
Sensitivity

Explanation: Sensitivity is the ability of a receiver to detect the presence of a signal. Sensitivity is a measure of a receiver's performance, the values usually are expressed in microvolts. Understanding these performance indicators is important when making comparisons between different pieces of radio equipment. Calibrated signal generators can easily help you make or confirm a receiver's sensitivity with little or no effort.

T7A02 - What is a transceiver? **A device that combines a receiver and transmitter**

Explanation: A transceiver is a single unit that combines a transmitter and a receiver. Many older pieces of amateur radio equipment consisted of separate transmitter and receiver units.

T7A03 - Which of the following is used to convert a signal from one frequency to another?
Mixer

Explanation: The mixer circuit is used to convert a radio signal from one frequency to another. When two RF signals are mixed together you will get two additional frequencies. One will be the sum of the two frequencies and the other will be the difference of the two signals. So if you mix together a 5-MHz frequency and a 3-MHz frequency, you will get an 8-

MHz frequency and a 2-MHz frequency. $5 \text{ MHz} + 3 \text{ MHz} = 8 \text{ MHz}$ (sum) and $5 \text{ MHz} - 3 \text{ MHz} = 2 \text{ MHz}$ (difference).

T7A04 - Which term describes the ability of a receiver to discriminate between multiple signals? **Selectivity**

Explanation: Selectivity is the ability of a receiver to discriminate between multiple signals. Selectivity is another important property of a receiver. The selectivity of a receiver measures its ability to allow you to receive your desired signals when other stronger stations are on adjacent frequencies. This is another important performance indicator to consider when purchasing amateur radio equipment.

T7A05 - What is the name of a circuit that generates a signal at a specific frequency?
Oscillator

Explanation: An oscillator circuit generates a signal at a specific frequency. There are many different types of oscillators that are used in radio circuits; the Pierce and crystal oscillator circuits are just two examples. Some modern amateur transmitters still offer high-stability crystal oscillators as an added accessory option.

T7A06 - What device converts the RF input and output of a transceiver to another band?
Transverter

Explanation: A common use of a transverter is to allow amateur stations to easily get on the VHF and UHF bands without the investment of new radios specifically for VHF and UHF. Most amateur radio stations have a multimode transceiver with nice filters and many operating features. An inexpensive transverter will typically take your transceiver's 10-meter output and convert to 2 meters or 70 centimeters, then receive the same frequencies and convert them back to 10 meters. This allows you to utilize expensive radio equipment you already own.

T7A07 - What is the function of a transceiver's PTT input? **Switches transceiver from receive to transmit when grounded**

Explanation: PTT is an abbreviation for Push To Talk. So activating the transceiver's PTT input turns on the transmitter part of the radio.

T7A08 - Which of the following describes combining speech with an RF carrier signal?
Modulation

Explanation: Modulation is the combining of speech with an RF carrier signal. There are two basic types of modulation: amplitude modulation (AM) and frequency modulation

(FM). Amplitude modulation varies the signal's power with respect to the modulation characteristics of your voice pattern. Frequency modulation varies the frequency of the carrier based on the modulation characteristics of your voice pattern.

T7A09 - What is the function of the SSB/CW-FM switch on a VHF power amplifier? **Set the amplifier for proper operation in the selected mode**

Explanation: Most VHF power amplifiers are multimode. This means they can operate SSB, CW and FM. The VHF power amplifier will have an SSB and CW-FM selector switch to set the amplifier for the proper operation of the mode you wish to use. Running an SSB-modulated signal into a VHF amplifier set to FM will result in a distorted signal and could damage the VHF amplifier.

T7A10 - What device increases the transmitted output power from a transceiver? **An RF power amplifier**

Explanation: An RF (radio frequency) amplifier increases the low-power output from a handheld transceiver to a higher power level. This type of RF amplifier usually takes the 1-watt to 5-watt signal and amplifies it to 25 watts to 50 or more watts. Perform a cost analysis because sometimes it is just cheaper to purchase a mobile radio to use in place of the handheld transceiver.

T7A11 - Where is an RF preamplifier installed? **Between the antenna and receiver**

Explanation: An RF preamplifier amplifies the received signal when working with weak-signal reception. The RF preamplifier goes between the receiver and the antenna; the closer it is placed to the antenna will provide the best performance. If you install the RF preamplifier close to the receiver, you will never recover the signals you lost because of feed line losses.

T7B01 - What can you do if you are told your FM handheld or mobile transceiver is overdeviating? **Talk farther away from the microphone**

Explanation: Talking farther away from the microphone is an easy way to improve your signal when you are told your FM handheld or mobile transceiver is overdeviating. This same technique also is effective when you are told you are chopping in and out of the repeater on voice peaks.

T7B02 - What would cause a broadcast AM or FM radio to receive an amateur radio transmission unintentionally? **The receiver is unable to reject strong signals outside the AM or FM band**

Explanation: A receiver that is unable to reject strong signals outside the AM or FM band would receive amateur radio transmissions unintentionally. If this is happening to you, you should verify all your equipment is working properly. Verify the SWR on your antenna is in the acceptable range and that you do not have any connections in the feed line or the antenna that have been compromised because of the elements.

T7B03 - Which of the following can cause radio frequency interference? **All of these choices are correct**

Explanation: Harmonics interference is when a multiple of your operating frequency falls within the frequency the other receiver is capable of tuning. Spurious emissions sometimes are caused by a misadjusted or misaligned transmitter.

T7B04 - Which of the following could you use to cure distorted audio caused by RF current on the shield of a microphone cable? **Ferrite choke**

Explanation: A ferrite choke, also known as a ferrite bead, dissipates high frequency current to help eliminate electromagnetic interference.

T7B05 - How can fundamental overload of a non-amateur radio or TV receiver by an amateur signal be reduced or eliminated? **Block the amateur signal with a filter at the antenna input of the affected receiver**

Explanation: In other words, the amateur can install a filter at the antenna of the non-amateur radio or TV receiver to eliminate or reduce fundamental overload.

T7B06 - Which of the following actions should you take if a neighbor tells you that your station's transmissions are interfering with their radio or TV reception? **Make sure that your station is functioning properly and that it does not cause interference to your own radio or television when it is tuned to the same channel**

Explanation: Making sure that your station is functioning properly and that it does not cause interference to your radio or television when it is tuned to the same channel is the first action you should take if a neighbor tells you that your station's transmissions are interfering with their radio or TV reception. If you do in fact have a problem, it will be much easier to solve in your own home than your neighbors. Once the problem is solved for your own radio and television, the problem will have been solved for your neighbor as well.

T7B07 - Which of the following can reduce overload of a VHF transceiver by a nearby commercial FM station? **Installing a band-reject filter**

Explanation: Also, you do not need an RF preamplifier in this case because the signal already is so strong it is overloading your transceiver's input.

T7B08 - What should you do if something in a neighbor's home is causing harmful interference to your amateur station? **All of these choices are correct**

Explanation: Sometime during your time as a licensed amateur radio operator, you will have a situation where something in a neighbor's home is causing harmful interference to your station. When this occurs, you should check your own station and make sure it meets the standards of good amateur radio practice. After you have verified the interference is originating from your neighbor's equipment, you should work with your neighbor to identify the offending device. Finally, politely inform your neighbor about the rules that prohibit the use of devices that cause interference. In all cases, be professional and courteous with all your neighbors.

T7B09 - What should be the first step to resolve non-fiber optic cable TV interference caused by your amateur radio transmission? **Be sure all TV feed line coaxial connectors are installed properly**

Explanation: A loose coaxial cable connection can expose the inner conductor (copper core) where most of the signals are carried. Tightening the cable allows the outer core to do its job as a shield.

T7B10 - What might be a problem if you receive a report that your audio signal through an FM repeater is distorted or unintelligible? **All of these choices are correct**

Explanation: There are several conditions that might cause you to receive reception reports that your audio signal through the repeater is distorted or unintelligible. The circumstances may be that you are in a bad location and your signal is not being received into the repeater. If this is the case, try moving your HT or vehicle a few feet and see whether the condition clears up. Be sure to check that your batteries are fully charged; low batteries can cause you to have a weak signal and/or distorted audio. Finally, verify that you are transmitting on the proper frequency. Some VHF transceivers make it really easy to bump the frequency button up or down 5 kHz.

T7B11 - What is a symptom of RF feedback in a transmitter or transceiver? **Reports of garbled, distorted, or unintelligible voice transmissions**

Explanation: A transmission that is distorted, garbled or unintelligible is a symptom of RF feedback in a transmitter or transceiver. This condition is not all that uncommon. Sometimes reducing your power or trying a different microphone is a quick and easy way to determine when your transmitter's signal is being picked up by your microphone or

audio input circuits. If reducing your power cures your RF feedback, then you know RF is getting into your microphone or audio circuits.

T7C01 - What is the primary purpose of a dummy load? **To prevent transmitting signals over the air when making tests**

Explanation: The dummy load is very useful for troubleshooting.

T7C02 - Which of the following is used to determine if an antenna is resonant at the desired operating frequency? **An antenna analyzer**

Explanation: An antenna analyzer is an instrument that can be used to determine whether an antenna is resonant at the desired operating frequency. The antenna analyzer puts out a tiny signal just like your own transmitter, except the antenna analyzer can determine the reactance, impedance, standing wave ratio and resonant frequency of the antenna being evaluated, and in some cases it can detect a cable fault in your feed line.

T7C03 - What does a dummy load consist of? **A non-inductive resistor mounted on a heat sink**

Explanation: A dummy load takes the place of an antenna to allow a transmitter to be tested without sending signals over the air. The heat sink is used to dissipate the power of the transmitter during the test.

T7C04 - What reading on an SWR meter indicates a perfect impedance match between the antenna and the feed line? **1 to 1**

Explanation: A 1 to 1 reading on an SWR meter indicates a perfect impedance match between the antenna and the feed line. The 1 to 1 reading would be expressed as 1:1. Some amateur radio transmitters will fail to transmit and give an antenna fault if the SWR is over 2:1. Other transmitters will automatically reduce the power output until the SWR moves into an acceptable range.

T7C05 - Why do most solid-state transmitters reduce output power as SWR increases beyond a certain level? **To protect the output amplifier transistors**

Explanation: The most important part of an amateur radio transmitter circuit is the output amplifier transistors. In some cases, the most expensive part of the transmitter are the amplifier transistors. Most solid-state transmitters reduce output power as SWR increases in order to protect the output amplifier transistors. A common name for the circuit that reduces power in the presence of high SWR is a "foldback circuit."

T7C06 - What does an SWR reading of 4:1 indicate? Impedance mismatch

Explanation: An SWR (standing wave ratio) reading of 4:1 indicates an impedance mismatch. Given a transmitter putting out 100 watts, 36 of those watts would be reflected back into the transmitter with an SWR of 4:1. A best practice is to keep your SWR below 1.5:1.

T7C07 - What happens to power lost in a feed line? It is converted into heat

Explanation: The power lost in a feed line is converted to heat. Energy is never lost, it always is converted from one type to another. So if your transmitter puts out 100 watts but only 50 watts is measured at the antenna, your feed line is absorbing the 50 watts and that power is lost forever. This energy is dissipated in your feed line as heat.

T7C08 - Which instrument can be used to determine SWR? Directional wattmeter

Explanation: The directional watt meter can measure the forward and reflected power in watts. The directional watt meter gives you reflected power in actual watts instead of a ratio. Most all directional wattmeters come with a chart with three columns. The left-hand column has the forward power, the middle scale has the SWR values and the right-hand column has the reflected power. You just put a straight edge from the forward power to the reflected power and the values in the middle column that cross the straight edge are the actual SWR readings.

T7C09 - Which of the following causes failure of coaxial cables? Moisture contamination

Explanation: Moisture in a coaxial cable can cause corrosion in the shield or degradation of the dielectric element. Either will cause additional resistance and lower power through the cable.

T7C10 - Why should the outer jacket of coaxial cable be resistant to ultraviolet light? Ultraviolet light can damage the jacket and allow water to enter the cable

Explanation: The outer jacket of coaxial cable should be resistant to ultraviolet light, otherwise UV can damage the jacket and allow water to enter the cable.

T7C11 - What is a disadvantage of air core coaxial cable when compared to foam or solid dielectric types? It requires special techniques to prevent moisture in the cable

Explanation: One disadvantage of air core coaxial cable when compared to foam or solid dielectric types is that it requires special techniques to prevent water absorption. Some air core coaxial cables are charged with an inert gas to keep out moisture. Some air core coaxial cable has limitations on how tight of a radius they can be bent or folded.

T7D01 - Which instrument would you use to measure electric potential? **A voltmeter**

Explanation: You would use a voltmeter to measure electric potential or electromotive force. Remember E (electromotive force) is measured in volts. Remember: think safety. Always use caution when taking readings in a live circuit.

T7D02 - How is a voltmeter connected to a component to measure applied voltage? **In parallel**

Explanation: The correct way to connect a voltmeter to a circuit is in parallel. This configuration will measure the voltage across the circuit. Always start on a higher scan and slowly work down. Remember: safety first when measuring values in energized circuits.

T7D03 - When configured to measure current, how is a multimeter connected to a component? **In series**

Explanation: Current is measured in series in a circuit. This allows the current to flow through the ammeter or multimeter to be measured. Ensure the probes used can support the amount of amperage in the circuit.

T7D04 - Which instrument is used to measure electric current? **An ammeter**

Explanation: An ammeter is an instrument used to measure electric current. Remember: I (electric current) is measured in amperes.

T7D06 - Which of the following can damage a multimeter? **Attempting to measure voltage when using the resistance setting**

Explanation: Inattention to detail or being in a hurry can easily and quickly damage sensitive test equipment. Please pay attention and be safe when making any measurements on an energized circuit.

T7D07 - Which of the following measurements are made using a multimeter? **Voltage and resistance**

Explanation: Multimeters have a minimum of two modes, one that measures voltage and one that measures resistance. More advanced meters may measure other items, but this question is focused on the basics.

T7D08 - Which of the following types of solder should not be used for radio and electronic applications? **Acid-core solder**

Explanation: Solder is used to join electrical connections and contains elements like tin and lead. Rosin core solder is typically used in electronics because it contains an element, rosin flux, that cleans the contact as the solder is heated. Acid core solder is more aggressive and made for steel and other metals.

T7D09 - What is the characteristic appearance of a cold tin-lead solder joint? **A rough or lumpy surface**

Explanation: There are many YouTube videos on proper soldering techniques. Each type of solder material has its own unique look and when using cold tin-lead, it has a rough finish when the soldering is complete.

T7D10 - What reading indicates that an ohmmeter is connected across a large, discharged capacitor? **Increasing resistance with time**

Explanation: In order to measure resistance of a circuit, an ohmmeter uses a small electrical charge. If a large discharged capacitor is in the circuit being measured, the capacitor will want to store the charge and this will look like increasing resistance to the ohmmeter.

T7D11 - Which of the following precautions should be taken when measuring in-circuit resistance with an ohmmeter? **Ensure that the circuit is not powered**

Explanation: This is for both personal safety and the safety of your test equipment. When taking measurements using test equipment, always devote your full attention to what you are doing.

T8 - Modulation Modes

T8A01 - Which of the following is a form of amplitude modulation? **Single sideband**

Explanation: SSB (single sideband) is one form of amplitude modulation. Simply put, the louder your voice the more the amplitude of the carrier. Of all the different variations of amplitude modulation, SSB is the most common voice mode on amateur radio HF bands.

T8A02 - What type of modulation is commonly used for VHF packet radio transmissions?
FM or PM

Explanation: FM (frequency modulation) is most commonly used for VHF packet radio transmissions. Many older FM transceivers without subaudible tone capabilities have found their way into ham radio packet communications. A packet repeater is called a digipeater.

T8A03 - Which type of voice mode is most often used for long-distance (weak signal) contacts on the VHF and UHF bands? **SSB**

Explanation: SSB (single sideband) voice mode is most often used for long-distance (weak signal) contacts on the VHF and UHF bands. There are several VHF and UHF contests where nearly all voice contacts are made via SSB, while other contacts are made using CW. Horizontally polarized antennas are most commonly used for SSB communications on VHF and UHF amateur frequencies.

T8A04 - Which type of modulation is commonly used for VHF and UHF voice repeaters? **FM or PM**

Explanation: FM (frequency modulation) is most commonly used for VHF and UHF voice repeaters. Almost all VHF and UHF FM repeaters use vertical polarization.

T8A05 - Which of the following types of signal has the narrowest bandwidth? **CW**

Explanation: CW (continuous wave) or Morse code emissions have the narrowest bandwidth. CW transmissions normally use only about 25 Hz of bandwidth, depending on the speed of the transmission. On VHF and UHF amateur bands, FM typically uses about 10 kHz of bandwidth for voice transmission. SSB and SSTV normally use about 3 kHz of bandwidth for a typical signal. From the list of given modes, CW has the narrowest bandwidth.

T8A06 - Which sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications? **Upper sideband**

Explanation: USB (upper sideband) normally is used for 10-meter, HF, VHF and UHF single-sideband communications. In amateur radio, it is a common practice that frequencies below 10 MHz use LSB (lower sideband). For frequencies 10 MHz and above, use USB (upper sideband).

T8A07 - What is a characteristic of single sideband (SSB) compared to FM? **SSB signals have narrower bandwidth**

Explanation: SSB (single sideband) emissions only use 3 kHz of bandwidth while FM voice transmissions use 10 kHz to 15 kHz of bandwidth. This narrow bandwidth is an advantage of SSB over FM for voice transmissions.

T8A08 - What is the approximate bandwidth of a typical single sideband (SSB) voice signal? **3 kHz**

Explanation: 3 kHz is the approximate bandwidth of an SSB (single sideband) voice signal. Most modern amateur transceivers today limit the audio bandwidth frequencies on SSB. The transmitter's audio circuits limit audio frequencies below 300 Hz. So 3 kHz - 300 Hz = 2.7 kHz bandwidth. Most SSB receive filters are for a bandwidth of 2.4 kHz.

T8A09 - What is the approximate bandwidth of a VHF repeater FM phone signal? **Between 10 and 15 kHz**

Explanation: Between 10 kHz and 15 kHz is the approximate bandwidth of a VHF repeater FM phone signal. VHF and UHF FM repeater communications still remains one of the most popular activities in amateur radio. The repeater extends the range of low-power handheld devices as well as low-powered mobile stations. Digital modes such as DMR (Digital Mobile Radio) utilize time slots so that two different stations may use the same frequency at the same time, just as long as they are on different time slots. DMR is an efficient use of our bandwidth. Repeaters that have battery backup power or solar power are very valuable for emergency communications.

T8A10 - What is the approximate bandwidth of AM fast-scan TV transmissions? **About 6 MHz**

Explanation: Because of the 6-MHz bandwidth required, the FCC only allows analog fast scan television on amateur bands 70 cm (432 MHz) and above.

T8A11 - What is the approximate bandwidth required to transmit a CW signal? **150 Hz**

Explanation: In case you have not noticed, many of the FCC's exam questions concern bandwidth.

T8A12 - Which of the following is a disadvantage of FM compared with single sideband? **Only one signal can be received at a time**

Explanation: FM or frequency modulated signals are typically "captured" by a receiver meaning only the strongest is shared through the circuitry. AM or amplitude modulation signals are demodulated differently allowing multiple signals to be heard at the same

time. This is part of the reason why air traffic controller radios still use AM modulation, so multiple planes could be heard if pilots talked at the same time.

T8B01 - What telemetry information is typically transmitted by satellite beacons? **Health and status of the satellite**

Explanation: The health and status of the satellite is the telemetry information that is typically transmitted by satellite beacons. The owners and operators of amateur radio satellites use this telemetry data to make operational decisions that are in the best interest of the satellite. This information also can be traced and compared to previous health and status messages to determine whether any components are degrading or deteriorating in their ability to function at full capacity.

T8B02 - What is the impact of using excessive effective radiated power on a satellite uplink? **Blocking access by other users**

Explanation: It will be no secret as to who is running too much power and spoiling the fun for everyone else.

T8B03 - Which of the following are provided by satellite tracking programs? **All of these choices are correct**

Explanation: There are many key pieces of information that are provided by amateur satellite tracking programs and smartphone apps. Most all amateur satellite tracking programs give the user the apparent frequency of the satellite transmission, including effects of Doppler shift. The programs also provide an easy-to-read display of the time, azimuth and elevation of the start, maximum altitude and end of the pass, all plotted on maps showing the real-time position of the satellite track over Earth.

T8B04 - What mode of transmission is commonly used by amateur radio satellites? **All of these choices are correct**

Explanation: CW/data, FM and SSB are transmission modes that are commonly used by amateur satellites. Some of the amateur satellites that support data transmissions have a store-and-forward feature. You upload your digital message via packet radio to the intended station. When the satellite is over the other station's location, they can download the message. Other modes, such as SSB, are real time where as you transmit your signal is being rebroadcast back to Earth from the satellite.

T8B05 - What is a satellite beacon? **A transmission from a satellite that contains status information**

Explanation: A transmission for an amateur radio satellite that contains status information is called a satellite beacon. The beacon signals from amateur satellites are used by operators all over the world for different applications. Some stations use the beacons to verify their antennas and equipment are working properly. Other stations listen for the beacons to ensure their satellite tracking software is configured properly. Satellite owners and operators use the health and telemetry contained in the beacon message to determine the satellite's operational schedule. Not to confuse the issue, but there also are fixed land-based beacon transmitters in use as well.

T8B06 - Which of the following are inputs to a satellite tracking program? **The Keplerian elements**

Explanation: Keplerian elements are used as inputs to a satellite tracking program. Keplerian elements are named after Johannes Kepler and his laws of planetary motion. The elements are a set of parameters about each orbiting object or satellite. The satellite tracking program uses this data to accurately plot and display the exact location of a given satellite based on your location on Earth and your local time.

T8B07 - What is Doppler shift in reference to satellite communications? **An observed change in signal frequency caused by relative motion between the satellite and the Earth station**

Explanation: Watch any old movie from the 1930s and 1940s that involves a train. As the train approaches the crossing, you will hear the ding, ding, ding crossing signal go up in frequency. As they pass the railroad crossing, the ding, ding, ding sound goes down in frequency. This is a perfect example of Doppler shift.

T8B08 - What is meant by the statement that a satellite is operating in U/V mode? **The satellite uplink is in the 70 centimeter band and the downlink is in the 2 meter band**

Explanation: Uplink refers to you transmitting to the satellite. Downlink refers to you receiving from the satellite.

T8B09 - What causes spin fading of satellite signals? **Rotation of the satellite and its antennas**

Explanation: All amateur radio satellites in space are orbiting Earth. The satellites are not stationary in space. Usually the satellites rotate in one direction or another as they are moving in space. Even if the satellite has both omnidirectional or directional antennas, their polarization is changing as the satellite rotates. But the spin fading is nearly always caused because the antenna's radiation pattern is obstructed or blocked by the satellite. This is when the satellite is between its antennas and the Earth station.

T8B10 - What is a LEO satellite? **A satellite in low earth orbit**

Explanation: LEO (low Earth orbit) means that the satellite is in an orbit that is close to Earth. LEO typically refers to satellites that are 1,000 km to as low as 160 km above Earth. Most other satellites are in orbits much higher above Earth. So the next time you see the initials LEO, you will know they refer to a low Earth orbiting amateur satellite.

T8B11 - Who may receive telemetry from a space station? **Anyone**

Explanation: Anyone who can receive the telemetry signal is allowed to receive telemetry from a space station. For some reason, the general public believes this is illegal or requires a special license or authorization. This is not the case! Anyone is allowed to receive telemetry data from a space station. However, you must have a license before you are allowed to transmit to a space station.

T8B12 - Which of the following is a way to determine whether your satellite uplink power is neither too low nor too high? **Your signal strength on the downlink should be about the same as the beacon**

Explanation: Verifying that your signal strength on the downlink is about the same as the beacon is a good way to judge whether your uplink power is either too low or too high. If your signal is too weak, it will be difficult for other stations to understand, and if your signal is too strong, you will shut down satellite access for everyone else. Comparing your signal to the satellite's beacon signal is a good indication that your amount of power and/or ERP (effective radiated power) is just about right.

T8C01 - Which of the following methods is used to locate sources of noise interference or jamming? **Radio direction finding**

Explanation: Radio direction finding is used to locate sources of noise interference or jamming. Direction finding consists of one or more stations equipped with a directional antenna, an attenuator and a receiver that is able to receive the offending signal. You first swing your directional antenna in a full 360-degree pattern and note any peaks in the offending signal. Next, move a little ways in the direction of the signal and take another reading. Each time you stop to take a reading the signal should get stronger. When the signal is so strong you can't determine the actual direction, then you use your attenuator to reduce the signal to a manageable level and continue. Depending on the location and the power level, you should get a really good idea of the origin of the offending signal.

T8C02 - Which of these items would be useful for a hidden transmitter hunt? **A directional antenna**

Explanation: A directional antenna is an item that would be useful for a hidden transmitter hunt. Some amateur radio clubs sponsor hidden transmitter hunts throughout the year. An individual goes out in a predetermined area, usually within a several square mile area, and hides. He will periodically transmit a signal from his hidden radio location. This individual or radio is considered the fox. The "hound" stations are the ones hunting the fox. The hounds use directional antennas and radio receivers to determine the location of the fox. Usually afterward, the club has a picnic or cookout. Some countries even have the hidden transmitter activities as a sport with large turnouts.

T8C03 - What operating activity involves contacting as many stations as possible during a specified period? **Contesting**

Explanation: Some contests are designed to see how many countries -- or even counties within a state -- you can communicate with in a given time period, while other contests are designed to get you out of the house and operating under emergency conditions. Extra points are awarded for operating using emergency power and/or batteries. Other contests offer additional points for operating outside in February -- you get more points based on the local air temperatures. Contesting is a great way to learn more about this fascinating hobby.

T8C04 - Which of the following is good procedure when contacting another station in a contest? **Send only the minimum information needed for proper identification and the contest exchange**

Explanation: Sending only the minimum information needed for a proper identification and the contest exchange is a good procedure when contacting another station in a radio contest. Serious contesting stations do not wish to ragchew or discuss the weather, they only want to work the next station. The exchange information varies from contest to contest; you need to read the contest rules for the contest before entering.

T8C05 - What is a grid locator? **A letter-number designator assigned to a geographic location**

Explanation: Grid squares are very popular for VHF and UHF contacts. The ARRL has some great grid locator maps available for downloading directly from their website.

T8C06 - How is over the air access to IRLP nodes accomplished? **By using DTMF signals**

Explanation: IRLP (Internet Radio Linking Project) nodes are accessed by using DTMF (dual-tone multi-frequency) tones. Nearly all VHF/UHF mobile transceivers and handheld radios have these Touch-Tone keypads on either their front panel or integrated into their microphone. Some repeaters also require a password to be used in addition to the DTMF tones.

T8C07 - What is Voice Over Internet Protocol (VoIP)? **A method of delivering voice communications over the internet using digital techniques**

Explanation: Voice communications over the internet using digital techniques is VoIP (Voice Over Internet Protocol), which is used in ham radio. Several different areas of amateur radio use VoIP such as DMR and D-STAR.

T8C08 - What is the Internet Radio Linking Project (IRLP)? **A technique to connect amateur radio systems, such as repeaters, via the internet using Voice Over Internet Protocol (VoIP)**

Explanation: The Internet Radio Linking Project, also called IRLP, links amateur stations around the world by using voice over IP (VoIP). Each gateway consists of a dedicated computer running custom software that is connected to both a radio and the internet. This arrangement forms what is known as an IRLP node.

T8C09 - Which of the following protocols enables an amateur station to transmit through a repeater without using a radio to initiate the transmission? **EchoLink**

Explanation: Echolink is an option that repeater managers can add to their equipment that allows for a signal to be received from over the internet and transmitted over the air, as well as for that internet station to monitor the rest of the conversation. Echolink requires a smart phone or computer application and a login.

T8C10 - What is required before using the EchoLink system? **Register your call sign and provide proof of license**

Explanation: Before you may use the EchoLink system to communicate using a repeater, you first must register your call sign and provide proof of license. These measures are taken to ensure that unlicensed individuals are not given access to amateur airwaves. Anyone can access an EchoLink node over the internet, but by having the amateur register their call sign and provide proof of their license, the system administrators are able to verify only licensed operators are able to come out over the air in a remote location. Some hams don't own a radio, but use their computer to carry on FM voice QSOs with other stations which are using a radio.

T8C11 - What is an amateur radio station that connects other amateur stations to the internet? **A gateway**

Explanation: A gateway station is the name given to an amateur station that is used to connect other stations to the internet. Many individuals miss this question because they answer digipeater. The digipeater is used to connect one station to another via RF. The

gateway station is the interface between the amateur station and the internet. The key word here is Internet.

T8D01 - Which of the following is a digital communications mode? All of these choices are correct

Explanation: JT65, IEEE 802.11 and packet all are digital communications modes. The Technician class license give you access to a few of the digital communications modes. General and Extra class licenses give you access to all the different digital modes. JT65 is used primarily for EME (Earth-moon-Earth, moonbounce), IEEE 802.11 is primarily used for MESH or wireless networking and packet radio uses the AX.25 protocol.

T8D02 - What is a "talkgroup" on a DMR repeater? A way for groups of users to share a channel at different times without hearing other users on the channel

Explanation: A DMR talkgroup allows for sharing a conversation among a smaller group of users than can hear the whole repeater. One example would be different working groups on the same project, searchers could talk to other searchers, while leaders could talk to each other in separate discussions. DMR repeaters with internet connections can use regional, statewide and national talk groups.

T8D03 - What kind of data can be transmitted by APRS? All these choices are correct

Explanation: The Automatic Packet Reporting System, APRS, encodes data into digital packets and transmits it over the air. These small data packets can contain simple text data including weather conditions, GPS location and short messages.

T8D04 - What type of transmission is indicated by the term "NTSC?" An analog fast scan color TV signal

Explanation: NTSC (National Television System Committee) is the name of the standard used to encode colors in an analog fast-scan color TV signal. ATV (amateur television) is another mode of communications you are allowed to use with your license. Some larger cities have ATV repeaters.

T8D05 - Which of the following is an application of APRS? Providing real-time tactical digital communications in conjunction with a map showing the locations of stations

Explanation: APRS (Automatic Packet Reporting System) provides real-time tactical digital communications in conjunction with a map showing the locations of the stations. At many high-profile amateur repeater sites, there usually is an APRS gateway radio to send the reporting information to the internet so your location can be tracked from anywhere in the

world with internet access. The annual Rose Bowl Parade uses APRS in some of their floats so the event coordinators will have real-time location information of their key floats along the parade route.

T8D06 - What does the abbreviation "PSK" mean? **Phase Shift Keying**

Explanation: PSK-31 digital modes are very popular because of its keyboard-to-keyboard capabilities.

T8D07 - Which of the following describes DMR? **A technique for time-multiplexing two digital voice signals on a single 12.5 kHz repeater channel**

Explanation: DMR (Digital Mobile Radio) is a technique for time-multiplexing two digital voice signals on a single 12.5 kHz-repeater channel. In other words, each DMR repeater has two different time slots for communications. This technique allows two simultaneous conversations to take place on the same repeater using the same 12.5-kHz channel at the same time. This is a very efficient use of our precious amateur spectrum.

T8D08 - Which of the following is included in packet radio transmissions? **All of these choices are correct**

Explanation: The packet in packet transmissions contains several pieces of information, which includes automatic repeat request in case of an error, a header that contains the call sign of the station to which the information is being sent and a check sum that permits error detection. Amateur radio uses the AX.25 protocol standard for packet radio and is based on the X.25 protocol. Note that the "A" in AX.25 stands for amateur radio.

T8D09 - What is CW? **Another name for a Morse code transmission**

Explanation: International Morse code is used when sending CW in the amateur bands and is recognized all across the globe. American Morse code, or sometimes referred to as railroad Morse, was used by the early railroad telegraphers. The rest of the world adopted the international format.

T8D10 - Which of the following operating activities is supported by digital mode software in the WSJT-X software suite? **All of these choices are correct**

Explanation: The WSJT-X suite is a powerful software, allowing the use of a variety of digital modes designed for use in extremely weak signal situations, as well as other uses like meteor scatter and EME contacting. Some of the included modes are FT8, JT65, MSK144, and many more.

T8D11 - What is an ARQ transmission system? **An error correction method in which the receiving station detects errors and sends a request for retransmission**

Explanation: A digital scheme whereby the receiving station detects errors and sends a request to the sending station to retransmit the information is called an ARQ transmission system. ARQ (automatic repeat request) is sometimes referred to as automatic repeat query, an error-control method for amateur digital data transmissions.

T8D12 - Which of the following best describes an amateur radio mesh network? **An amateur-radio based data network using commercial Wi-Fi equipment with modified firmware**

Explanation: An amateur radio-based data network using commercial Wi-Fi gear with modified firmware best describes Broadband-Hamnet (TM), also referred to as an HSMM (high-speed multimedia) network. Many clubs use this configuration for their on-the-air events with multiple stations on the air at the same time. All the stations are networked together using the mesh network protocol and off-the-shelf commercial wireless routers running modified firmware. This multimedia aspect also allows VoIP or individual telephones for voice communications between the different stations on the network.

T8D13 - What is FT8? **A digital mode capable of low signal-to-noise operation**

Explanation: FT8 is a digital mode capable of operating in low signal-to-noise conditions that transmits on 15-second intervals. FT8 was developed by Joe Taylor, K1JT, and Steve Franke, K9AN, thus "FT," and the signal is 8-FSK, thus the 8. FT8 allows your station to auto sequence from one message to the next for quick and efficient communications. FT8 typically allows communications with stations that have a signal-to-noise ratio of -10 dB to -15 dB with no problem.

T9 – Antennas

T9A01 - What is a beam antenna? **An antenna that concentrates signals in one direction**

Explanation: The typical beam antenna consists of one or more elements along a common boom. Beam antennas can be either vertically polarized for VHF/UHF FM activities or horizontally polarized for HF SSB/CW operation.

T9A02 - Which of the following describes a type of antenna loading? **Electrically lengthening by inserting inductors in radiating elements**

Explanation: Inserting an inductor in the radiating portion of the antenna to make it electrically longer describes a type of antenna loading. Inductors inserted in series with the radiating portion of the antenna will make the antenna appear electrically longer to your amateur transmitter. This technique is useful when you have limited space for your low-frequency antennas. They can be physically shorter, but electrically, they will be proper length.

T9A03 - Which of the following describes a simple dipole oriented parallel to the Earth's surface? **A horizontally polarized antenna**

Explanation: Vertically polarized antennas usually have a lower angle of radiation, while horizontal polarized antennas have a higher angle of take off. This means when signals from a vertical bounce back to Earth they will land much farther away from the antenna than the signals from a horizontal antenna.

T9A04 - What is a disadvantage of the short, flexible antenna supplied with most handheld radio transceivers, compared to a full-sized quarter-wave antenna? **It has low efficiency**

Explanation: The disadvantage of the "rubber duck" antenna supplied with most handheld radio transceivers when compared to a full-sized quarter-wave antenna is that they do not transmit or receive as effectively. Rubber duck antennas offer more convenience than performance. There is nothing wrong with owning two separate antennas for your handheld radio. The rubber duck can be used for close-quarter or tactical communications where most everyone or the repeater is line of sight. A quarter-wave antenna can be substituted for conditions where performance is a priority such as hiking or locations farther away from other individuals or the repeater.

T9A05 - Which of the following increases the resonant frequency of a dipole antenna? **Shorten it**

Explanation: Shortening a dipole antenna will make it resonant on a higher frequency. Just think of the musical instrument with strings: the shorter the string, the higher the frequency; the longer the strings, the lower in frequency. If your antenna presents a high SWR on the frequency you wish to operate, then look at the SWR above your frequency and below your frequency. If the SWR is better below your current frequency you know you will have to shorten your antenna to raise its resonant frequency.

T9A06 - Which of the following types of antenna offers the greatest gain? **Yagi**

Explanation: The Yagi antenna is a directional antenna and offers the greatest gain. If you are unable to increase your radio's power output, antenna gain can offer you an advantage of more power through antenna performance and design!

T9A07 - What is a disadvantage of using a handheld VHF transceiver with a flexible antenna inside a vehicle? **Signal strength is reduced due to the shielding effect of the vehicle**

Explanation: A disadvantage of using a handheld VHF transceiver with its integral antenna inside a vehicle while mobile is that signals might not propagate well because of the vehicle's shielding effect. If practical, an external magnetic mount antenna will deliver superior performance. Also be aware that some cities and states have laws about operating handheld electronic devices while driving. Some vehicles have material in the window tinting that also has a shielding effect on VHF and UHF frequencies. Think safety.

T9A08 - What is the approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz? **19**

Explanation: The approximate length, in inches, of a quarter-wavelength vertical antenna for 146 MHz will be 19 inches. Let's break down the math: they want the length on an antenna in inches based on a given frequency. The tried-and-true formula for quarter-wavelength antennas is divide 234 by the frequency in MHz. $234 / \text{frequency in MHz} = \text{Antenna length in feet}$. Therefore, $234 / 146 \text{ MHz} = 1.602 \text{ feet}$. To convert feet to inches, multiply by 12. Therefore, $1.602 \text{ feet} \times 12 = 19.2 \text{ inches}$.

T9A09 - What is the approximate length, in inches, of a half-wavelength 6 meter dipole antenna? **112**

Explanation: The approximate length, in inches, of a half-wavelength 6-meter dipole antenna is 112.32 inches. Let's break down the math: they want the length of a half-wavelength antenna in inches based on a given wavelength. First let's get our wavelength to a frequency using 300 divided by wavelength in meters, which is equal to the frequency in megahertz. $300 / 6 \text{ meters} = 50 \text{ MHz}$. Now that we have our frequency (50 MHz), let's use the tried-and-true formula for a half-wavelength antenna: $468 / \text{frequency in MHz} = \text{antenna length in feet}$. $468 / 50 \text{ MHz} = 9.36 \text{ feet}$. To convert to inches, take $9.36 \text{ feet} \times 12 = 112.32 \text{ inches}$.

T9A10 - In which direction does a half-wave dipole antenna radiate the strongest signal? **Broadside to the antenna**

Explanation: This means if your half-wave dipole antenna runs north and south, the strongest gain will be east and west.

T9A11 - What is antenna gain? **The increase in signal strength in a specified direction compared to a reference antenna**

Explanation: In this case, you can calculate gain by comparing the measured signal either transmitted or received in a specified direction to the signal transmitted or received by a hypothetical ideal antenna in the same situation. The value of gain is expressed in dB.

T9A12 - What is an advantage of a 5/8 wavelength whip antenna for VHF or UHF mobile service? **It has more gain than a 1/4-wavelength antenna**

Explanation: Therefore, the 5/8-wavelength antenna has longer range and more gain when compared to the 1/4 wavelength antenna.

T9B01 - What is a benefit of low SWR? **Reduced signal loss**

Explanation: While 1 SWR is considered ideal, anything less than 2 SWR will ensure that your radio is working well. High SWR (2.5+) is a signifier that your antenna is being used inefficiently.

T9B02 - What is the most common impedance of coaxial cables used in amateur radio? **50 ohms**

Explanation: 50 ohms is the impedance of most coaxial cables used in amateur installations. Nearly all amateur radio transmitters are designed to use coaxial feed lines with a 50-ohm impedance. The coaxial cable used for television, CATV, cable and satellite installations is all 75 ohm. At first glance, the cable looks the same, but a close examination of the cable type printed on the jacket will allow you to reference the specifications on a data sheet.

T9B03 - Why is coaxial cable the most common feed line for amateur radio antenna systems? **It is easy to use and requires few special installation considerations**

Explanation: Coaxial cable is the most common feed line selected for amateur radio antenna systems because it is easy to use and requires few special installation considerations. Coaxial cable can be easily stuffed through a window or through a wall and can easily be strapped or taped to the leg of a tower going to the antenna on top. Open wire feed lines, on the other hand, are not that robust. Open wire feed lines must not be strapped directly to metal such as a tower leg; they need to be held at least 8 inches or more away from the metal leg. Open wire feed lines need to be insulated when penetrating walls or metal window frames. Open wire feed lines can not be bundled with other coaxial cables because of the interaction with the braid (ground) on each of the cables.

T9B04 - What is the major function of an antenna tuner (antenna coupler)? **It matches the antenna system impedance to the transceiver's output impedance**

Explanation: If the mismatch is too great, the antenna tuner will absorb the energy mismatch and convert the energy that was not transferred to the antenna into heat.

T9B05 - What happens as the frequency of a signal in coaxial cable is increased? **The loss increases**

Explanation: This is why coaxial cable used in VHF and UHF installations cost more than coaxial cable used on HF frequencies. Longer runs of coaxial cable for VHF and UHF installations should be avoided, if possible. Your antenna system is one of the most important pieces of your station.

T9B06 - Which of the following RF connector types is most suitable for frequencies above 400 MHz? **Type N**

Explanation: Type N connectors are most suitable for frequencies above 400 MHz. They have less loss than other types of coaxial cable connectors. Also, N connectors have much better shielding than other connectors rated for HF use. The extra shielding keeps stray RF from leaking out of the connector and also helps prevent strong RF fields from leaking into the system. Type N connectors are available in both solder and crimp styles.

T9B07 - Which of the following is true of PL-259 type coax connectors? **They are commonly used at HF and VHF frequencies**

Explanation: PL-259 type coax connectors are commonly used at HF frequencies. They are fairly inexpensive and are easy to install on coaxial cable. You can find PL-259 connectors in both solder and crimp-on styles.

T9B08 - Which of the following is a source of loss in coaxial feed line? **All of these choices are correct**

Explanation: If you have water intrusion into a coaxial connector, high SWR or multiple connectors in line, you could be experiencing a loss in your coaxial feedline. Thus, "all of these choices" is the correct answer on the exam.

T9B09 - What can cause erratic changes in SWR? **Loose connection in the antenna or feed line**

Explanation: A loose connection in an antenna or feed line can cause erratic changes in SWR (standing wave ratio) readings. Moisture in the coax from improper weatherproofing is another cause of erratic SWR readings. These problems can be easily reduced by good mechanical and electrical bonding of all connections and weather proofing.

T9B10 - What is the electrical difference between RG-58 and RG-213 coaxial cable? **RG-213 cable has less loss at a given frequency**

Explanation: The electrical difference between RG-58 and RG-213 coaxial cable is that RG-213 cable has less loss at a given frequency. With coaxial cable, the higher the frequency, the greater the loss. Also the longer the run of coaxial cable the more losses that are introduced into the antenna system. In your initial planning, take into consideration the frequencies you will be operating and the distance of the antennas from your transmitter(s). Having your 250-foot tower 100 feet from your station is great, but if more than half your signal is being lost in the coaxial cable, locating the tower closer to the station and locating your UHF antennas partly up the tower would be a good start in reducing your cable losses unless you move to 2-inch hardline cable.

T9B11 - Which of the following types of feed line has the lowest loss at VHF and UHF? **Air-insulated hard line**

Explanation: Air-insulated hard line is a type of feed line that has the lowest loss at VHF and UHF frequencies. The larger the coaxial cable, the more difficult it becomes to work with. Hard line cable is not very flexible. Coaxial connectors for the larger coax sometimes can cost more than \$50 each. Most high-powered commercial installations use air-insulated hard line coaxial feed lines because of the low loss. Many times this cable finds its way into the hands of lucky hams.

T10 – Safety

TOA01 - Which of the following is a safety hazard of a 12-volt storage battery? **Shorting the terminals can cause burns, fire, or an explosion**

Explanation: One of the safety hazards of a 12-volt storage battery occurs when you short the terminals, which can cause burns, fire or an explosion. Use extreme caution when working with 12-volt storage or lead acid batteries. Rapid charging and discharging a lead acid battery can generate hydrogen gas, which is very explosive. One spark from a relay or switch in your repeater shack full of hydrogen gas can cause a serious fire or explosion. The same goes for your ham shack, which always should have an area where batteries are kept well ventilated and free of combustible materials.

TOA02 - What health hazard is presented by electrical current flowing through the body? **All of these choices are correct**

Explanation: Involuntary muscle contractions, disruption of the electrical functions of cells and injury to tissue because of heating are some of the health hazards presented by electrical current flowing through the body. Please use extreme caution when working in and around energized electrical circuits. One good rule of thumb is to always keep one hand in your pocket when working around high-voltage amplifiers. Please think safety!

TOA03 - In the United States, what circuit does black wire insulation indicate in a three-wire 120 V cable? **Hot**

Explanation: In the United States 120 volt AC cables typically have three wires. Black is called the "hot" wire, a white wire for "neutral", and green for "ground."

TOA04 - What is the purpose of a fuse in an electrical circuit? **To remove power in case of overload**

Explanation: The fuse not only protects the equipment, but it can also prevent a dangerous situation such as equipment overheating or an electrical fire.

TOA05 - Why should a 5-ampere fuse never be replaced with a 20-ampere fuse? **Excessive current could cause a fire**

Explanation: A fuse protects a circuit from overload. Replacing a smaller fuse with a larger one increases the risk of overload on the components and could cause fires or other damage to the circuits.

TOA06 - What is a good way to guard against electrical shock at your station? **All of these choices are correct**

Explanation: Using three-wire cords and plugs for AC-powered equipment, connecting all AC-powered station equipment to a common safety ground and using a circuit protected by a ground-fault interrupter are all good ways to guard against electrical shock at your station. If you have any questions or concerns, please consult with a licensed electrician or professional concerning your amateur station AC house wiring.

TOA07 - Where should a lightning arrester be installed in a coaxial feed line? **On a grounded panel near where feed lines enter the building**

Explanation: Arresting lightning outside your home is the best protection for your equipment. Other options listed do not keep the energy outside the home.

TOA08 - Where should a fuse or circuit breaker be installed in a 120V AC power circuit? **In series with the hot conductor only**

Explanation: A fuse or circuit breaker in series with the AC hot conductor is one piece of safety equipment that always should be included in home-built equipment that is powered from 120-volt AC power circuits. Interlocks to remove AC power from home-built equipment when the cover is removed is another example of safety equipment that can be installed.

TOA09 - What should be done to all external ground rods or earth connections? **Bond them together with heavy wire or conductive strap**

Explanation: A good practice is for all external ground rods or Earth connections to be bonded together with heavy wire or conductive strap. The ARRL has an excellent book on this subject written by H. Ward Silver.

TOA10 - What hazard is caused by charging or discharging a battery too quickly? **Overheating or out-gassing**

Explanation: The battery could overheat, give off flammable gas or explode if a lead-acid storage battery is charged or discharged too quickly. Keep the area where the battery is located well ventilated at all times. Anytime you are working with or charging lead-acid batteries, wear acid-resistant goggles and face shield, acid-resistant gloves and, if possible an acid-resistant apron. Lead-acid batteries can deliver a very high amount of current. Always use fuses as close to the battery as possible to minimize any damage in case of a short circuit. If these batteries are improperly fused, they can easily start an electrical fire if a circuit fault occurs. Remember: safety first.

TOA11 - What hazard exists in a power supply immediately after turning it off? **Charge stored in filter capacitors**

Explanation: Capacitors store energy in a circuit, including power supplies. When a power supply is first turned off, it takes some time for the current stored in the capacitors to discharge. So a charged capacitor is a risk in this case.

TOA12 - Which of the following precautions should be taken when measuring high voltages with a voltmeter? **Ensure that the voltmeter and leads are rated for use at the voltages to be measured**

Explanation: Not all voltmeters are designed to measure all voltages. The circuits being measured could overheat, or the leads could be undersized for the job. Check your voltmeter's rating before measuring high voltage circuits.

TOB01 - Which of the following is good practice when installing ground wires on a tower for lightning protection? **Ensure that connections are short and direct**

Explanation: The quicker you can get lightning to ground the better. Short and direct connections allow for that.

TOB02 - What is required when climbing an antenna tower? **All of these choices are correct**

Explanation: Putting on a carefully inspected climbing harness (fall arrester) and safety glasses is a good precaution to observe before climbing an antenna or tower. Also never work alone when performing antenna or tower maintenance. If you are unsure or inexperienced with tower and antenna work, please hire an expert or professional. Many two-way radio shops have hams who work in various positions in that company. Getting advice from a professional who performs commercial work every day and is a ham is invaluable. Remember: Think safety first.

TOB03 - Under what circumstances is it safe to climb a tower without a helper or observer?
Never

Explanation: Under any circumstances, it never is safe to climb a tower without a helper or observer. Having a helper even if they are an inexperienced family member can prove invaluable when it comes to you needing a tool or fastener while working on top of the tower. They can at least put the needed material in a bucket so you can pull it up with a rope. This is much better than making many trips up and down the tower for parts and pieces that were not anticipated during the planning stages.

TOB04 - Which of the following is an important safety precaution to observe when putting up an antenna tower? **Look for and stay clear of any overhead electrical wires**

Explanation: An important safety precaution to observe when putting up an antenna or tower is to always look for and stay clear of any overhead electrical wires. Some tower installations also utilize guy wires as part of the design. Also take into account the guy wire placement in relation to any existing power lines. Remember: Think about safety first.

TOB05 - What is the purpose of a safety wire through a turnbuckle used to tension guy lines? **Prevent loosening of the turnbuckle from vibration**

Explanation: A turnbuckle tightens two pieces of guy lines to strengthen their connections using screw threads. To keep that from unscrewing, safety wire is used.

TOB06 - What is the minimum safe distance from a power line to allow when installing an antenna? **Enough so that if the antenna falls unexpectedly, no part of it can come closer than 10 feet to the power wires**

Explanation: When choosing the location for your tower and/or antenna, you need to ensure that if your antenna or tower falls unexpectedly that no part of it can come closer than 10 feet to power lines. This is the minimum safe distance. Also be aware, depending on the type of power line and the voltage on the power line, that you may encounter "line noise" emitted from the power line. A best practice is to remain as far away from any power line as possible. Remember: Think safety. Sometimes running your wire antennas perpendicular to the power lines, instead of parallel, will help minimize the amount of line noise you receive.

TOB07 - Which of the following is an important safety rule to remember when using a crank-up tower? **This type of tower must not be climbed unless it is retracted, or mechanical safety locking devices have been installed**

Explanation: A crank up tower is designed to go up and down with ease, which is a risk when climbing. Using the proper locking devices or retracting the tower is the safest way to access it.

TOB08 - What is considered to be a proper grounding method for a tower? **Separate eight-foot long ground rods for each tower leg, bonded to the tower and each other**

Explanation: The proper grounding method for a tower is separate eight-foot-long ground rods for each tower leg, bonded to the tower and each other. The ARRL has an excellent book written by Ward Silver. Remember: Think safety. If you have questions or you are unsure of your tower and antenna installation, please consult with licensed professionals.

TOB09 - Why should you avoid attaching an antenna to a utility pole? **The antenna could contact high-voltage power lines**

Explanation: You should avoid attaching an antenna to a utility pole because your antenna could contact high-voltage power lines. Think safety when working around power lines. It is considered a best practice to locate all antennas as far as possible away from existing power lines. This not only safe, but also reduces the chance of unwanted line noise being received by your station.

TOB10 - Which of the following is true when installing grounding conductors used for lightning protection? **Sharp bends must be avoided**

Explanation: Lightning likes to travel in a straight line. Lightning can't flow through conductors that make sharp turns and possibly could jump from the grounding conductor to surrounding equipment at the point of the sharp bend or turn. The potential for additional damage and possible fire hazard is possible with grounding conductors that do not follow a straight line.

TOB11 - Which of the following establishes grounding requirements for an amateur radio tower or antenna? **Local electrical codes**

Explanation: If there are questions or you are unsure about anything related to your tower or antenna installation, ask a professional. Many city codes are not the same from city to city or from state to state. Ask an expert when in doubt. Remember: Think safety.

TOC01 - What type of radiation are radio signals? **Non-ionizing radiation**

Explanation: Non-ionizing is the type of radiation in VHF and UHF radio signals. Non-ionizing radiation travels at the speed of light. The non-ionizing radiation energy is composed of electric and magnetic fields. The frequency spectrum for non-ionization radiation includes UV (ultraviolet), visible light, IR (infrared light), MW (microwave), RF (radio frequency) and ELF (extremely low frequency). Ionizing radiation consists of gamma rays, X-rays and above into the electromagnetic spectrum.

TOC02 - At which of the following frequencies does maximum permissible exposure have the lowest value? **50 MHz**

Explanation: 50 MHz has the lowest value for maximum permissible exposure limit. The FCC has determined that the human body can easily absorb frequencies between 30 MHz and 300 MHz. This range requires the lowest exposure. The closest amateur band within this range is the 6-meter band, or 50 MHz.

TOC03 - How does the allowable power density for RF safety change if duty cycle changes from 100 percent to 50 percent? **It increases by a factor of 2**

Explanation: The concept here is if you are transmitting half as much, you can be around it twice as long and have the same impact. If you are transmitting every 30 seconds and are allowed 2 minutes of exposure, by switching to transmitting every 60 seconds (half as often) you are allowed 4 minutes of exposure (twice as long).

TOC04 - What factors affect the RF exposure of people near an amateur station antenna? **All of these choices are correct**

Explanation: The FCC has set RF exposure limits based on these factors. As a licensed amateur radio operator, you are expected to perform an RF exposure survey of your station. In nearly all cases, most amateur stations will be exempt because they do not exceed the frequency and power level limits. But documenting the fact you are exempt is a best practice and be sure to keep this information in your station records.

TOC05 - Why do exposure limits vary with frequency? **The human body absorbs more RF energy at some frequencies than at others**

Explanation: The human body absorbs more RF energy at some frequencies than other frequencies, thus exposure limits vary with the frequency. Studies have shown that lower RF frequencies can penetrate the human body. Scientific evidence suggests that RF waves in the range 300 MHz to 3 GHz can be harmful for human health.

TOC06 - Which of the following is an acceptable method to determine whether your station complies with FCC RF exposure regulations? **All of these choices are correct**

Explanation: Calculations based on FCC OET Bulletin 65, based on computer modeling, and measurement of field strength using calibrated equipment are all acceptable methods to determine that your station complies with FCC RF exposure regulations. Any time you make changes to your station, a good practice is to re-evaluate your RF Exposure limits after all changes have been completed.

TOC07 - What hazard is created by touching an antenna during a transmission? **RF burn to skin**

Explanation: Because part of the burn is below the skin's surface, seek immediate medical attention. Remember: think safety. Most ham antennas are positioned out of the reach of the general public.

TOC08 - Which of the following actions can reduce exposure to RF radiation? **Relocate antennas**

Explanation: Relocating antennas is an action an amateur radio operator can take to prevent exposure to RF radiation in excess of the FCC-supplied limits. Limiting the amount of time you are in the field of radiation from the antenna is another action an amateur radio operator can take to prevent exposure to RF radiation, except it is not always practical. Increasing the distance between you and the antenna is the easiest way to limit your radiation exposure. The distance from your antenna is inversely proportional to the square of the distance. For example, if you double the distance from your antenna, you reduce the radiation exposure by a fourth. If you are 5 feet from your antenna and the exposure at your body is 100 watts, then if you move another 5 feet from the antenna (double the distance) your RF exposure to your body is now 25 watts.

TOC09 - How can you make sure your station stays in compliance with RF safety regulations? **By re-evaluating the station whenever an item in the transmitter or antenna system is changed**

Explanation: Re-evaluating your amateur station whenever an item of equipment is changed or reconfigured is one way you can make sure your station stays in compliance with RF safety regulations. The best practice is to keep all your RF evaluation information and station configuration information with your station records. In the unlikely event the FCC asks for your station documentation, everything will be together in one place. Many operators keep the configuration changes in their log book on the blank pages. They then always have the permanent log and configuration of their station. This is very handy to document when you buy each piece of equipment. Finally, if a little one disconnects some of your pretty cables, you have the latest connection diagrams with your station configuration.

TOC10 - Why is duty cycle one of the factors used to determine safe RF radiation exposure levels? **It affects the average exposure to radiation**

Explanation: The transmitter's duty cycle is one of the factors used to determine safe RF radiation exposure levels as it affects the average exposure of people to radiation. The FCC and OSHA uses the time, distance and shielding for limiting factors concerning RF exposure. You limit the time you are close to the radiating source, you increase the distance between you and the radiating source and you employ any shielding that can be maneuvered between you and the antenna or radiating source, such as a metal building or foil-backed insulation.

TOC11 - What is the definition of duty cycle during the averaging time for RF exposure? **The percentage of time that a transmitter is transmitting**

Explanation: The definition of duty cycle during the averaging time for RF exposure is the percentage of time that a transmitter is transmitting. The amateur radio station's duty cycle is used in many different calculations to answer questions found in FCC exams. How long the transmitter is transmitting versus the amount of time the transmitter is off and the receiver is active is basically your duty cycle. This calculation is also very important when calculating power supply capacity and power capabilities of antennas and baluns.

TOC12 - How does RF radiation differ from ionizing radiation (radioactivity)? **RF radiation does not have sufficient energy to cause chemical changes in cells and damage DNA**

Explanation: The difference from RF radiation to ionizing radiation (radioactivity) is that RF radiation does not have sufficient energy to cause genetic damage. Ionizing radiation includes radiation sources such as X-rays and gamma rays.

TOC13 - Who is responsible for ensuring that no person is exposed to RF energy above the FCC exposure limits? **The station licensee**

Explanation: When in doubt, you are responsible for everything your amateur radio station does. This includes when you transmit, what you transmit, and who is exposed to the RF energy from your signal.

Scheduling and Taking Your Exam

Here's what to expect as you get ready to take your official FCC exam.

Register for your FRN

Before scheduling your exam, the first thing you need to do is get your FRN (FCC Registration Number).

Go here to register for your FRN:

<https://hamradioprep.com/how-to-register-for-your-frn/>

How to find an exam

You're ready to schedule your exam, and you have options -- in person or online!

For most people, the easiest way to take the exam is in person with a friendly, local ham radio club. Volunteer Examiners, who are FCC accredited, will proctor your exam.

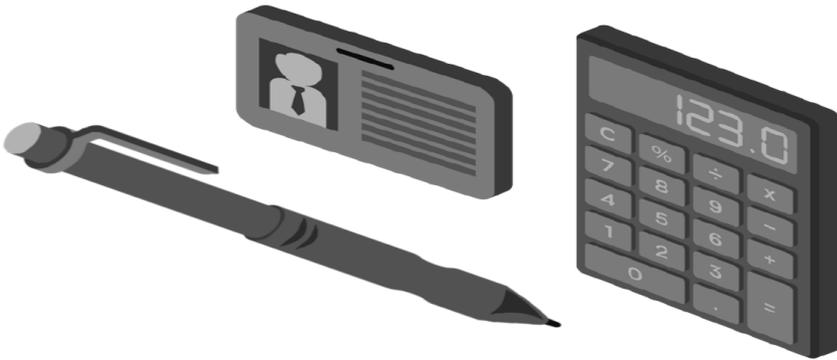
If an in-person exam is not available, you can also take the exam online!

Go here to schedule your exam:

<https://hamradioprep.com/schedule-an-exam/>

What to bring on exam day

Whether you test online, or in person, you will need to have the following items with you.



- 1) A legal photo ID or two forms of identification.
- 2) Your FCC FRN (Federal Registration Number) or Social Security number.
- 3) A calculator is allowed if you have cleared all memory and formulas.

If testing in person, you will also need:

- 1) Two No. 2 pencils.
- 2) A check or money order for payment
(Usually \$15).

You cannot bring notes or other documents or study materials with you for either form of the exam. If you are taking the exam online, you will not need a check or money order and will be prompted ahead of the exam to pay any associated fees online.

What is the exam like?

Whether you take the exam in person or online there will be testers watching you the whole time. They are charged with upholding the test standards, but they are passionate about ham radio and should not make you nervous. They want you to pass your test, too!

If you're testing online, exam proctors will ask that you keep both hands on your keyboard the entire time you test. They will show you which keys you will use to answer questions and move through the test.

Your cell phone will be used to help the proctors monitor your remote testing environment. They will let you know if you need to change something you're doing to stay within the guidelines during your test.

The Technician exam has 35 questions (just like the practice exam in this book). You do not earn any additional points for completing the exam

quickly; you just need to stay within the time allowed by the test examiners.

**Be confident! You've done
all the prep work, you're
passing your practice exams
– YOU'VE GOT THIS!**

Unauthorized conduct and test rules

The Federal Communications Commission, which grants amateur radio licenses, takes the testing process seriously and instills a variety of guidelines to ensure the integrity of all exams that are administered.

In order to obtain an FCC-issued amateur radio license, you must do one of two things:

- Appear at a local test session conducted by a local amateur radio club. Local amateur radio clubs are authorized by national Volunteer Examiner Coordinators to conduct testing on a local basis with accredited test session administrators, who are known as Volunteer Examiners.
- Take your test online from a national Volunteer Examiner Coordinator that will monitor your test session remotely with cameras in a room clear of any possible test aids. VECs can be located anywhere within the FCC's jurisdiction in the 50 states or territories, and those taking the exam can be located anywhere in the 50 states or territories, too. It doesn't matter where you or the examiners are located when taking your exam online!

FCC rules state the following for those administering tests:

Each VE must observe those taking their tests throughout the entire exam. VEs are charged with ensuring proper conduct and supervision of each exam. If a VE determines that a person taking an exam is not complying with their instructions, they are required to terminate the exam immediately.

VEs may not administer exams to family members, including his or her spouse, children, grandchildren, stepchildren, parents, grandparents, stepparents, brothers, sisters, stepbrothers, stepsisters, aunts, uncles, nieces, nephews and in-laws.

It goes without saying, but VEs may not administer or certify any exam by fraudulent means, or for any types or bribes or reimbursement in excess of that permitted by FCC rules. Any licensed amateur radio operator found guilty of this may find the FCC revoking their amateur station license and suspending the grant of the VE's amateur operator license.

Also, the FCC states that any compromised exam may not be administered to any examinee and that the same question set may not be readministered to the same examinee.

If the FCC determines that there was an issue with the administration of a test in which a license was issued, the FCC may choose to readminister any exam previously given by VEs. If the person fails to appear for re-administration of an exam, the FCC may cancel the operator/primary station

license of the licensee in question. If a person in question already holds a Technician or higher license, the FCC can revoke the higher class license in question for failure to appear for reexamination. Thus, if you are a General license holder and the FCC is challenging your Extra class exam, you can be reverted back to your previous General class license by the commission.

Check our website for more information about the testing process at www.HamRadioPrep.com.

Phonetic Alphabet:

Phonetic Alphabet

A lpha	J uliet	S ierra
B ravo	K ilo	T ango
C harlie	L ima	U niform
D elta	M ike	V ictor
E cho	N ovember	W hiskey
F oxtrot	O scar	X ray
G olf	P apa	Y ankee
H otel	Q uebec	Z ulu
I ndia	R omeo	

 HAM RADIO PREP

International Morse Code:

A	● —	U	● ● —
B	— ● ● ●	V	● ● ● —
C	— ● — ●	W	● — —
D	— ● ●	X	— ● ● —
E	●	Y	— ● — —
F	● ● — ●	Z	— — ● ●
G	— — ●		
H	● ● ● ●		
I	● ●		
J	● — — —		
K	— ● —	1	● — — —
L	● — ● ●	2	● ● — —
M	— —	3	● ● ● — —
N	— ●	4	● ● ● ● —
O	— — —	5	● ● ● ● ●
P	● — — ●	6	— ● ● ● ●
Q	— — ● —	7	— — ● ● ●
R	● — ●	8	— — — ● ●
S	● ● ●	9	— — — — ●
T	—	0	— — — — —

Free Band Plan PDF!

Leave us a five-star review on Amazon, and as a small token of appreciation, we'll send you a beautiful band plan PDF to your email that you can print!

★★★★★ **Easy to follow, quizzes after every chapter!**

Reviewed in the United States on March 24, 2019

Verified Purchase

Super easy to follow! There are quizzes after every chapter with answers at the end of the book. Also there's a free coupon for the online course at

Hamradioprep.com. Highly recommend for anyone trying to study for their license and very happy with my purchase!



Gregory K.

★★★★★ **Without a doubt the best study manual on the market!**

Reviewed in the United States on July 14, 2020

Verified Purchase

Without a doubt the best study manual on the market! Not only is this manual extremely helpful in itself but the free access to their online course absolutely guarantees that you can pass your test on the first try,



Jim

★★★★★ **Great tool to earn your license!**

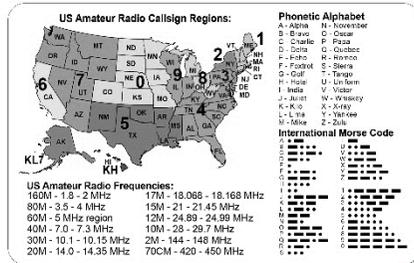
Reviewed in the United States on March 25, 2019

Simple to read and easy way to prep yourself for the ham radio technician's exam. I passed the exam easily after reading the book for preparation. Highly Recommend!

Take a screenshot of your review and go to **www.HamRadioPrep.com/book** to upload the screenshot of your five-star review!

FCC Amateur Radio License ID Card!

Carry your ham radio license with you everywhere with a pocket ID license. This license shows your critical license information such as your call sign, grant date, effective data, FRN, and expiration date.



Order Here: <https://hamradioprep.com/shop/>

Resources

Our website: www.HamRadioPrep.com

Our Student Success Facebook group:
www.facebook.com/groups/HamRadioPrep

Facebook: www.facebook.com/HamRadioPrep

YouTube: www.youtube.com/c/HamRadioPrep

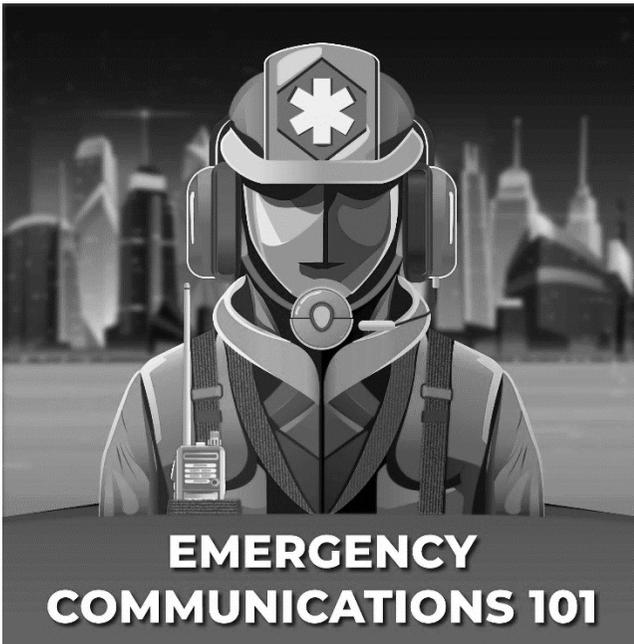
Scheduling your exam:
<https://hamradioprep.com/schedule-an-exam/>

Ham Radio Logbook:
<https://worldradioleague.com/>

Continuing Ham Radio Education

Emergency Communications 101:

Gain the critical skills needed to effectively communicate during events and emergencies, ensuring the safety of yourself, your family, and your community.



<https://hamradioprep.com/emergency-communications/>

HF Masterclass:

After taking this course, you'll be easily making long-distance and international (DX) ham radio contacts and making new friends all around the world.



<https://hamradioprep.com/hf-masterclass/>

