



# General Class Study Guide

Class Course Book for July 2019 to June 2023



## K4VRC

**The Villages Amateur Radio Club**  
**The Villages, Florida**  
**[www.k4vrc.com](http://www.k4vrc.com)**

## General Class Study Guide

All Amateur Radio Operators,

Amateur radio has been around for a long time and has grown itself into a worldwide community of licensed hams on the airwaves with all sorts of communications technology. Ham radio attracts those who have never held a microphone as well as deep technical experts who grew up with a soldering iron and computer. Your United States Amateur Service license gives you the most powerful wireless communications capability available to any private citizen anywhere in the world. In the United States, amateur radio licensing is governed by the Federal Communications Commission (FCC) under strict federal regulations. Licenses to operate amateur stations for personal use are granted to individuals of any age once they demonstrate an understanding of both pertinent FCC regulations and knowledge of radio station operation and safety considerations. December 2012 marked one hundred years of amateur radio operator and station licensing by the United States government. Operator licenses are divided into different classes, each of which correlates to an increasing degree of knowledge and corresponding privileges. Over the years, the details of the classes have changed significantly, leading to the current system of three open classes and two grandfathered but closed to new applicants. Today we have Technician, General and the top US license class is Amateur Extra Class. Upgrading to a General license--which conveys extensive HF privileges only requires passing a written examination. You must pass 26 of a 35-question multiple-choice exam. Those with General licenses are granted 98% of the privileges on US amateur bands. Once you do, the entire range of operating modes and the majority of the amateur spectrum below 30 MHz become available to you.

The General Class workshop is specially presented for those with amateur radio experience who want to learn and do more with amateur radio. The workshop will cover a vast amount of material in four classes. It is intended to help members advance in the hobby we love and give a little boost to those on the fence.

Looking forward to congratulating you in your advancement to General Class,

*Mike* KM4ZTE

Mike Regan  
President  
The Villages Amateur Radio Club

PS All amateur radio operators are welcome to use and share this document. Comments about this document can be sent by means of the club website contact form; <https://www.k4vrc.com/contact-us.html>. Please include; a detailed description of the issue with exam question ID and page number.

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## Revisions

Original Release – 6/24/18

Incorporated comments, errata updates and typographical errors – 11/2/18

Added Glossary, Cross Reference, Incorporated comments – 6/4/21

# Chapter 1 - Introduction

## Just Enough for Understanding

Studying for your HAM radio license is not easy for most people and this class is designed to help you with the difficult parts. Normally the class time is used to address the how and why questions. This is not intended to be traditional classroom experience instead you should expect a much more informal discussions about electronics as it relates to HAM radio in non-technical terms not Electrical Engineering. Too bad most of the well-known ham radio license manuals spend way too much content on theory and fail to stay within the scope of the exam. This is not to say just teach the test. A good example is the radio transceiver, you need to know what it does, not make one. You do not need a basic understanding of how radio works. Simply put there is only seven classes (about 12 Hours in class room time) to gain an introductory level understanding of the technology and the Code of Federal Regulations Title 47, Telecommunication. Part 97, Amateur Radio Service. The class format is just enough information for context and essential understanding needed to pass the licensing test.

## Less Math for more Comprehension

Historically most HAMs have problems passing the license exam due to the math required. It may relieve some of your concerns to know the question pool has reduced the number of questions requiring calculations in favor of comprehension questions in the last three releases. You still need to use a small amount of math to solve problems but just add, subtract, multiple and divide. This class will focus on thinking through the questions and avoiding the algebra to solve problems. Working the example problems in class will help you be at ease with using the math required. Thinking carefully about the wording of the question will often lead to the only correct answer without any math! This means many multiple-choice questions can be solved logically without doing the math and the discussion from this class will help you avoid selecting the wrong answer.

## Four Classes

The four classes will meet for about three hours once a week. Each topic begins with an overview of the homework assignment for context followed by review of the questions covered. Understanding is reinforced with your questions and discussion. To prepare for class;

- Reading of chapter prior to class
- Watch KE0OG Videos on YouTube
- Work chapter sample problems prior to class
- Review Class Study Guide to supplement your reading
- In class review of assignment, discussion and help with problems
- Take practice tests (online) at home between classes

## Memory Retention

If you attend all classes, keep up with readings, and take practice tests conscientiously, preparing can be a relatively pain-free process. Pain-free does not mean work-free! Take practice tests online from multiple sites or different APPs. Many past students have found that preparing for the exam for 60 minutes per day, five or six days per week, will leave them well-prepared at exam time. Don't cram at the end as hitting hard at the last minute simply don't work for most people and they experience declining returns on their efforts when they attempt to study for two and three hours straight.

## Learning Aids

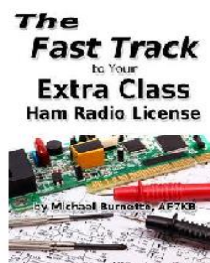
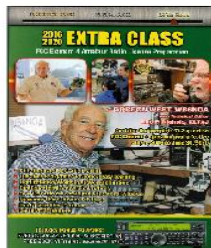
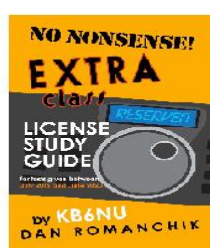
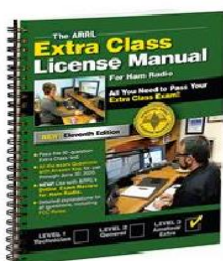
You are encouraged to use every study resource that works for you. In general people retain more details from a hard copy document. Print this study guide so you can take it with you to study, write on it, underline or highlight the text for reference later. Place a copy of this guide on an eReader. Other books are not required but if you do have questions from other sources, they will be discussed during the open review at the end of each class. The following are helpful sources of information;

[HAM Radio for Dummies \(free PDF Book\)](#)

[Operating Procedures for Amateur Radio \(free PDF Book\)](#)

[KB6NU No-Nonsense Study Guide \(free PDF Book\)](#)

Aide for practice test review: [ARRL's General Q&A 6th Edition \(~\\$20\)](#)



Take online practice tests online, but not more than once a day.

<http://arrlexamreview.appspot.com/>

<https://hamexam.org/>

<https://hamstudy.org/>

Many people have found using a test App on their phone or tablet is a helpful tool



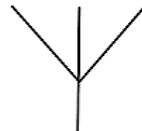
HamRadioExam - T  
Roy Watson  
★★★★★



Ham Test Prep (Neversoft.com)  
★★★★★



Free Ham Radio Prep  
HamRadioPrep.com  
★★★★★



Amateur Radio Exam  
CStructor LLC  
★★★★★



Ham Radio Exam T  
K1AUD  
★★★★★

<https://play.google.com/store/apps>

<https://www.apple.com/ios/app-store/>

Dave Casler KE0OG Videos lectures on YouTube are highly recommended.



Ham Radio Answers!  
from Dave Casler, KE0OG



<https://dcasler.com/ham-radio/>

## How to use this Study Guide

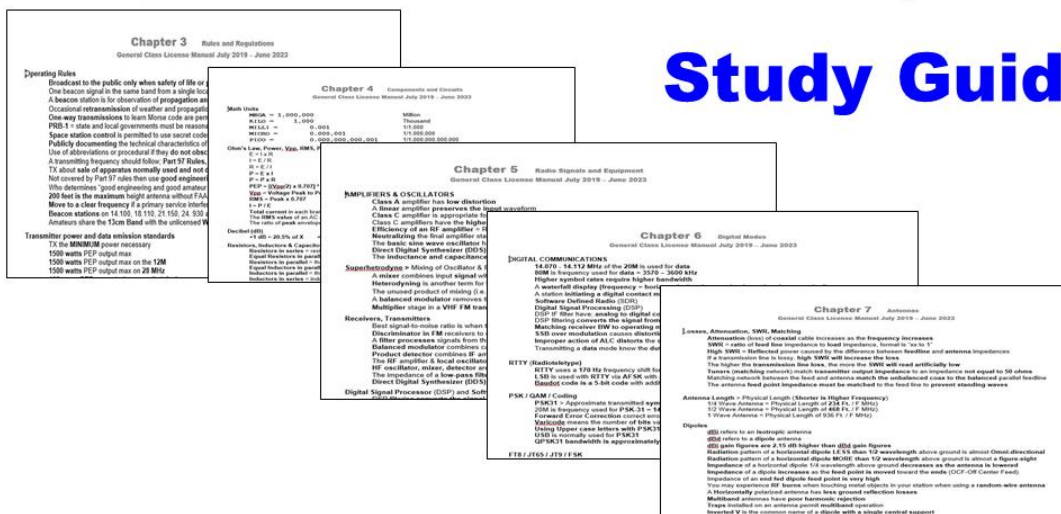
# General Class License Course

## Discovering the Excitement of Ham Radio



**ARRL** The national association for  
**AMATEUR RADIO®**

# Study Guide



**Use the Sudy Guide to supplement your reading**



## How to use this Study Guide

Studying for you first HAM radio license is not easy for most people and this class is designed to help you with the difficult parts. The class uses reading assignments, a staple of classrooms around the world, and the watching the KE0OG videos as a more in-depth reinforcement to get you going in the right direction. If you really want to delve deeply into the details look at the free books listed under Learning Aids. Use this Study Guide to help in keeping your thoughts organized. You need to review each chapter using this guide in your head. The key messages are listed and should give you enough of a sense of it. Sometimes, it's all too easy for things to get disorganized. This guide was prepared to make sure that everything's laid out in a way that makes it simple to find the notes you need.

When taking practice tests, use the Question Cross Reference section in this guide to review questions you answered incorrectly. The General Class Question Pool is sorted alphanumerically with the page number where the question is discussed in the text of the ARRL General Class License Manual and the KE0OG video that covered the question. Mark the questions missed, if a question is missed repeatedly be sure to address it during the class discussion.

Just treat this guide like someone had given you their class notes. All the important points from each class are neatly prepared for you. This Study Guide is one more tool like the text book and videos to help you succeed.



## Question Cross Reference

### G0

#### Question ~ ARRL Book ~ Video

G0A01 (Ch. 9, Pg. 9) KE0OG G9.2  
 G0A02 (Ch. 9, Pg. 9) KE0OG G9.2  
 G0A03 (Ch. 9, Pg. 12) KE0OG G9.2  
 G0A04 (Ch. 9, Pg. 10) KE0OG G9.2  
 G0A05 (Ch. 9, Pg. 13) KE0OG G9.2  
 G0A06 (Ch. 9, Pg. 13) KE0OG G9.2  
 G0A07 (Ch. 9, Pg. 11) KE0OG G9.2  
 G0A08 (Ch. 9, Pg. 12) KE0OG G9.2  
 G0A09 (Ch. 9, Pg. 12) KE0OG G9.2  
 G0A10 (Ch. 9, Pg. 13) KE0OG G9.2  
 G0A11 (Ch. 9, Pg. 14) KE0OG G9.2

#### Question ~ ARRL Book ~ Video

G0B01 (Ch. 9, Pg. 5) KE0OG G9.1  
 G0B02 (Ch. 9, Pg. 5) KE0OG G9.1  
 G0B03 (Ch. 9, Pg. 5) KE0OG G9.1  
 G0B04 (Ch. 9, Pg. 7) KE0OG G9.1  
 G0B05 (Ch. 9, Pg. 6) KE0OG G9.1  
 G0B06 (Ch. 9, Pg. 4) KE0OG G9.1  
 G0B07 (Ch. 9, Pg. 15) KE0OG G9.3  
 G0B08 (Ch. 9, Pg. 15) KE0OG G9.3  
 G0B09 (Ch. 9, Pg. 7) KE0OG G9.1  
 G0B10 (Ch. 9, Pg. 3) KE0OG G9.1  
 G0B11 (Ch. 9, Pg. 8) KE0OG G9.1  
 G0B12 (Ch. 9, Pg. 6) KE0OG G9.1  
 G0B13 (Ch. 9, Pg. 7) KE0OG G9.1  
 G0B14 (Ch. 9, Pg. 15) KE0OG G9.3

### G1

#### Question ~ ARRL Book ~ Video

G1A01 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A02 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A03 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A04 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A05 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A06 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A07 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A08 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A09 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A10 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A11 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A12 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A13 (Ch. 3, Pg. 8) KE0OG G3.3  
 G1A14 (Ch. 3, Pg. 2) KE0OG G3.1  
 G1A15 (Ch. 3, Pg. 9) KE0OG G3.3

#### Question ~ ARRL Book ~ Video

G1B01 (Ch. 3, Pg. 3) KE0OG G3.1  
 G1B02 (Ch. 3, Pg. 10) KE0OG G3.3  
 G1B03 (Ch. 3, Pg. 10) KE0OG G3.3  
 G1B04 (Ch. 3, Pg. 13) KE0OG G3.4  
 G1B05 (Ch. 3, Pg. 13) KE0OG G3.3  
 G1B06 (Ch. 3, Pg. 3) KE0OG G3.1  
 G1B07 (Ch. 3, Pg. 13) KE0OG G3.3  
 G1B08 (Ch. 2, Pg. 4) KE0OG G2.1  
 G1B09 (Ch. 3, Pg. 10) KE0OG G3.3  
 G1B10 (Ch. 3, Pg. 10) KE0OG G3.3  
 G1B11 (Ch. 3, Pg. 14) KE0OG G3.4  
 G1B12 (Ch. 3, Pg. 13) KE0OG G3.1

#### Question ~ ARRL Book ~ Video

G1C01 (Ch. 3, Pg. 15) KE0OG G3.4  
 G1C02 (Ch. 3, Pg. 14) KE0OG G3.4  
 G1C03 (Ch. 3, Pg. 15) KE0OG G3.4  
 G1C04 (Ch. 3, Pg. 15) KE0OG G3.4  
 G1C05 (Ch. 3, Pg. 15) KE0OG G3.4  
 G1C06 (Ch. 3, Pg. 14) KE0OG G3.4  
 G1C07 (Ch. 3, Pg. 16) KE0OG G3.4  
 G1C08 (Ch. 3, Pg. 16) KE0OG G3.4  
 G1C09 (Ch. 3, Pg. 16) KE0OG G3.4  
 G1C10 (Ch. 3, Pg. 16) KE0OG G3.4  
 G1C11 (Ch. 3, Pg. 16) KE0OG G3.4  
 G1C12 (Ch. 2, Pg. 6) KE0OG G3.3  
 G1C13 (Ch. 3, Pg. 16) KE0OG G3.4  
 G1C14 (Ch. 3, Pg. 15) KE0OG G3.4  
 G1C15 (Ch. 3, Pg. 14) KE0OG G3.4

#### Question ~ ARRL Book ~ Video

G1D01 (Ch. 3, Pg. 5) KE0OG G3.2  
 G1D02 (Ch. 3, Pg. 4) KE0OG G3.2  
 G1D03 (Ch. 3, Pg. 5) KE0OG G3.2  
 G1D04 (Ch. 3, Pg. 4) KE0OG G3.2  
 G1D05 (Ch. 3, Pg. 4) KE0OG G3.2  
 G1D06 (Ch. 3, Pg. 5) KE0OG G3.2  
 G1D07 (Ch. 3, Pg. 4) KE0OG G3.2  
 G1D08 (Ch. 3, Pg. 4) KE0OG G3.2  
 G1D09 (Ch. 3, Pg. 4) KE0OG G3.2  
 G1D10 (Ch. 3, Pg. 4) KE0OG G3.2  
 G1D11 (Ch. 3, Pg. 5) KE0OG G3.2

**Question ~ ARRL Book ~ Video**

G1E01 (Ch. 3, Pg. 11) KE0OG G3.3  
G1E02 (Ch. 3, Pg. 13) KE0OG G3.3  
G1E03 (Ch. 6, Pg. 13) KE0OG G3.2  
G1E04 (Ch. 3, Pg. 8) KE0OG G3.3  
G1E05 (Ch. 3, Pg. 11) KE0OG G3.3  
G1E06 (Ch. 3, Pg. 2) KE0OG G3.3  
G1E07 (Ch. 3, Pg. 8) KE0OG G3.3  
G1E08 (Ch. 3, Pg. 15) KE0OG G3.3  
G1E09 (Ch. 6, Pg. 14) KE0OG G3.2  
G1E10 (Ch. 3, Pg. 10) KE0OG G3.3  
G1E11 (Ch. 6, Pg. 13) KE0OG G3.2

**G2****Question ~ ARRL Book ~ Video**

G2A01 (Ch. 2, Pg. 9) KE0OG G2.1  
G2A02 (Ch. 2, Pg. 9) KE0OG G2.1  
G2A03 (Ch. 2, Pg. 9) KE0OG G2.1  
G2A04 (Ch. 2, Pg. 9) KE0OG G2.1  
G2A05 (Ch. 2, Pg. 9) KE0OG G2.1  
G2A06 (Ch. 2, Pg. 9) KE0OG G2.1  
G2A07 (Ch. 2, Pg. 9) KE0OG G2.1  
G2A08 (Ch. 2, Pg. 5) KE0OG G2.1  
G2A09 (Ch. 2, Pg. 9) KE0OG G2.1  
G2A10 (Ch. 2, Pg. 12) KE0OG G2.1  
G2A11 (Ch. 2, Pg. 5) KE0OG G2.1  
G2A12 (Ch. 5, Pg. 11) KE0OG G2.1

**Question ~ ARRL Book ~ Video**

G2B01 (Ch. 2, Pg. 2) KE0OG G2.1  
G2B02 (Ch. 2, Pg. 18) KE0OG G2.2  
G2B03 (Ch. 2, Pg. 4) KE0OG G2.1  
G2B04 (Ch. 2, Pg. 2) KE0OG G2.1  
G2B05 (Ch. 2, Pg. 2) KE0OG G2.1  
G2B06 (Ch. 2, Pg. 2) KE0OG G2.1  
G2B07 (Ch. 2, Pg. 2) KE0OG G2.1  
G2B08 (Ch. 2, Pg. 5) KE0OG G2.1  
G2B09 (Ch. 2, Pg. 17) KE0OG G2.2  
G2B10 (Ch. 2, Pg. 18) KE0OG G2.2  
G2B11 (Ch. 2, Pg. 18) KE0OG G2.2

**Question ~ ARRL Book ~ Video**

G2C01 (Ch. 2, Pg. 13) KE0OG G2.1  
G2C02 (Ch. 2, Pg. 13) KE0OG G2.1  
G2C03 (Ch. 2, Pg. 13) KE0OG G2.1  
G2C04 (Ch. 2, Pg. 2) KE0OG G2.1  
G2C05 (Ch. 2, Pg. 13) KE0OG G2.1  
G2C06 (Ch. 2, Pg. 13) KE0OG G2.1  
G2C07 (Ch. 2, Pg. 11) KE0OG G2.1  
G2C08 (Ch. 2, Pg. 13) KE0OG G2.1  
G2C09 (Ch. 2, Pg. 13) KE0OG G2.1  
G2C10 (Ch. 2, Pg. 11) KE0OG G2.1  
G2C11 (Ch. 2, Pg. 13) KE0OG G2.1

**Question ~ ARRL Book ~ Video**

G2D01 (Ch. 3, Pg. 3) KE0OG G3.2  
G2D02 (Ch. 3, Pg. 2) KE0OG G3.2  
G2D03 (Ch. 3, Pg. 3) KE0OG G3.2  
G2D04 (Ch. 7, Pg. 9) KE0OG G8.1  
G2D05 (Ch. 2, Pg. 5) KE0OG G2.1  
G2D06 (Ch. 8, Pg. 5) KE0OG G8.1  
G2D07 (Ch. 2, Pg. 2) KE0OG G2.1  
G2D08 (Ch. 2, Pg. 6) KE0OG G2.1  
G2D09 (Ch. 2, Pg. 5) KE0OG G2.1  
G2D10 (Ch. 3, Pg. 14) KE0OG G3.1  
G2D11 (Ch. 8, Pg. 5) KE0OG G8.1

**Question ~ ARRL Book ~ Video**

G2E01 (Ch. 6, Pg. 9) KE0OG G6.4  
G2E02 (Ch. 6, Pg. 7) KE0OG G6.3  
G2E03 (Ch. 6, Pg. 14) KE0OG G6.3  
G2E04 (Ch. 6, Pg. 2) KE0OG G6.5  
G2E05 (Ch. 6, Pg. 9) KE0OG G6.5  
G2E06 (Ch. 6, Pg. 5) KE0OG G6.2  
G2E07 (Ch. 6, Pg. 2) KE0OG G6.4  
G2E08 (Ch. 6, Pg. 2) KE0OG G6.5  
G2E09 (Ch. 6, Pg. 7) KE0OG G6.3  
G2E10 (Ch. 6, Pg. 12) KE0OG G6.4  
G2E11 (Ch. 6, Pg. 9) KE0OG G6.5  
G2E12 (Ch. 4, Pg. 40) KE0OG G4.3  
G2E13 (Ch. 6, Pg. 8) KE0OG G6.3  
G2E14 (Ch. 6, Pg. 9) KE0OG G6.2  
G2E15 (Ch. 6, Pg. 6) KE0OG G6.5

**G3****Question ~ ARRL Book ~ Video**

G3A01 (Ch. 8, Pg. 7) KE0OG G8.2  
G3A02 (Ch. 8, Pg. 11) KE0OG G8.1  
G3A03 (Ch. 8, Pg. 10) KE0OG G8.2  
G3A04 (Ch. 8, Pg. 7) KE0OG G8.1  
G3A05 (Ch. 8, Pg. 9) KE0OG G8.2  
G3A06 (Ch. 8, Pg. 11) KE0OG G8.2  
G3A07 (Ch. 8, Pg. 8) KE0OG G8.2  
G3A08 (Ch. 8, Pg. 12) KE0OG G8.1  
G3A09 (Ch. 8, Pg. 12) KE0OG G8.2  
G3A10 (Ch. 8, Pg. 8) KE0OG G8.2  
G3A11 (Ch. 8, Pg. 11) KE0OG G8.1  
G3A12 (Ch. 8, Pg. 9) KE0OG G8.2  
G3A13 (Ch. 8, Pg. 9) KE0OG G8.2  
G3A14 (Ch. 8, Pg. 12) KE0OG G8.2



**Question ~ ARRL Book ~ Video**

G3B01 (Ch. 8, Pg. 6) KE0OG G8.1  
 G3B02 (Ch. 8, Pg. 9) KE0OG G8.1  
 G3B03 (Ch. 8, Pg. 10) KE0OG G8.1  
 G3B04 (Ch. 8, Pg. 10) KE0OG G8.1  
 G3B05 (Ch. 8, Pg. 10) KE0OG G8.1  
 G3B06 (Ch. 8, Pg. 10) KE0OG G8.1  
 G3B07 (Ch. 8, Pg. 9) KE0OG G8.1  
 G3B08 (Ch. 8, Pg. 9) KE0OG G8.1  
 G3B09 (Ch. 8, Pg. 2) KE0OG G8.1  
 G3B10 (Ch. 8, Pg. 2) KE0OG G8.1  
 G3B11 (Ch. 8, Pg. 10) KE0OG G8.1

**Question ~ ARRL Book ~ Video**

G3C01 (Ch. 8, Pg. 2) KE0OG G8.1  
 G3C02 (Ch. 8, Pg. 2) KE0OG G8.1  
 G3C03 (Ch. 8, Pg. 2) KE0OG G8.1  
 G3C04 (Ch. 8, Pg. 2) KE0OG G8.1  
 G3C05 (Ch. 8, Pg. 5) KE0OG G8.1  
 G3C06 (Ch. 8, Pg. 12) KE0OG G8.3  
 G3C07 (Ch. 8, Pg. 12) KE0OG G8.3  
 G3C08 (Ch. 8, Pg. 12) KE0OG G8.3  
 G3C09 (Ch. 8, Pg. 12) KE0OG G8.1  
 G3C10 (Ch. 8, Pg. 12) KE0OG G8.1  
 G3C11 (Ch. 8, Pg. 5) KE0OG G8.1

**G4****Question ~ ARRL Book ~ Video**

G4A01 (Ch. 5, Pg. 20) KE0OG G5.4  
 G4A02 (Ch. 5, Pg. 20) KE0OG G5.4  
 G4A03 (Ch. 2, Pg. 4) KE0OG G2.1  
 G4A04 (Ch. 5, Pg. 15) KE0OG G5.3  
 G4A05 (Ch. 5, Pg. 15) KE0OG G5.3  
 G4A06 (Ch. 7, Pg. 22) KE0OG G7.5  
 G4A07 (Ch. 5, Pg. 15) KE0OG G5.3  
 G4A08 (Ch. 5, Pg. 15) KE0OG G5.3  
 G4A09 (Ch. 5, Pg. 14) KE0OG G5.3  
 G4A10 (Ch. 2, Pg. 13) KE0OG G2.1  
 G4A11 (Ch. 5, Pg. 20) KE0OG G5.4  
 G4A12 (Ch. 2, Pg. 4) KE0OG G2.1  
 G4A13 (Ch. 5, Pg. 19) KE0OG G5.4  
 G4A14 (Ch. 6, Pg. 11) KE0OG G6.2  
 G4A15 (Ch. 5, Pg. 22) KE0OG G5.3  
 G4A16 (Ch. 5, Pg. 20) KE0OG G5.4  
 G4A17 (Ch. 5, Pg. 20) KE0OG G5.4

**Question ~ ARRL Book ~ Video**

G4B01 (Ch. 4, Pg. 42) KE0OG G4.7  
 G4B02 (Ch. 4, Pg. 42) KE0OG G4.7  
 G4B03 (Ch. 4, Pg. 42) KE0OG G4.7  
 G4B04 (Ch. 4, Pg. 42) KE0OG G4.7  
 G4B05 (Ch. 4, Pg. 41) KE0OG G4.7  
 G4B06 (Ch. 4, Pg. 41) KE0OG G4.7

G4B07 (Ch. 5, Pg. 11) KE0OG G5.3  
 G4B08 (Ch. 4, Pg. 43) KE0OG G4.7  
 G4B09 (Ch. 4, Pg. 43) KE0OG G4.7  
 G4B10 (Ch. 4, Pg. 43) KE0OG G4.7  
 G4B11 (Ch. 4, Pg. 42) KE0OG G4.7  
 G4B12 (Ch. 4, Pg. 43) KE0OG G4.7  
 G4B13 (Ch. 4, Pg. 43) KE0OG G4.7  
 G4B14 (Ch. 4, Pg. 41) KE0OG G4.7  
 G4B15 (Ch. 5, Pg. 11) KE0OG G5.3

**Question ~ ARRL Book ~ Video**

G4C01 (Ch. 5, Pg. 24) KE0OG G5.5  
 G4C02 (Ch. 5, Pg. 24) KE0OG G5.5  
 G4C03 (Ch. 5, Pg. 24) KE0OG G5.3  
 G4C04 (Ch. 5, Pg. 24) KE0OG G5.5  
 G4C05 (Ch. 5, Pg. 23) KE0OG G5.5  
 G4C06 (Ch. 5, Pg. 23) KE0OG G5.5  
 G4C07 (Ch. 9, Pg. 8) KE0OG G9.1  
 G4C08 (Ch. 5, Pg. 24) KE0OG G5.5  
 G4C09 (Ch. 5, Pg. 23) KE0OG G5.5  
 G4C10 (Ch. 5, Pg. 23) KE0OG G5.5  
 G4C11 (Ch. 5, Pg. 22) KE0OG G5.5  
 G4C12 (Ch. 5, Pg. 18) KE0OG G5.4  
 G4C13 (Ch. 5, Pg. 22) KE0OG G5.5

**Question ~ ARRL Book ~ Video**

G4D01 (Ch. 5, Pg. 12) KE0OG G5.3  
 G4D02 (Ch. 5, Pg. 12) KE0OG G5.3  
 G4D03 (Ch. 5, Pg. 12) KE0OG G5.3  
 G4D04 (Ch. 5, Pg. 19) KE0OG G5.4  
 G4D05 (Ch. 5, Pg. 19) KE0OG G5.4  
 G4D06 (Ch. 5, Pg. 19) KE0OG G5.4  
 G4D07 (Ch. 5, Pg. 19) KE0OG G5.4  
 G4D08 (Ch. 5, Pg. 12) KE0OG G5.1  
 G4D09 (Ch. 5, Pg. 12) KE0OG G5.1  
 G4D10 (Ch. 5, Pg. 12) KE0OG G5.1  
 G4D11 (Ch. 5, Pg. 12) KE0OG G5.1

**Question ~ ARRL Book ~ Video**

G4E01 (Ch. 7, Pg. 6) KE0OG G7.1  
 G4E02 (Ch. 7, Pg. 6) KE0OG G7.1  
 G4E03 (Ch. 5, Pg. 21) KE0OG G5.5  
 G4E04 (Ch. 5, Pg. 21) KE0OG G5.5  
 G4E05 (Ch. 5, Pg. 21) KE0OG G5.5  
 G4E06 (Ch. 7, Pg. 6) KE0OG G7.1  
 G4E07 (Ch. 5, Pg. 22) KE0OG G5.5  
 G4E08 (Ch. 4, Pg. 36) KE0OG G4.6  
 G4E09 (Ch. 4, Pg. 36) KE0OG G4.6  
 G4E10 (Ch. 4, Pg. 39) KE0OG G4.6  
 G4E11 (Ch. 4, Pg. 39) KE0OG G4.6

**G5****Question ~ ARRL Book ~ Video**

G5A01 (Ch. 4, Pg. 21) KE0OG G4.4  
G5A02 (Ch. 4, Pg. 19) KE0OG G4.4  
G5A03 (Ch. 4, Pg. 19) KE0OG G4.4  
G5A04 (Ch. 4, Pg. 19) KE0OG G4.4  
G5A05 (Ch. 4, Pg. 20) KE0OG G4.4  
G5A06 (Ch. 4, Pg. 19) KE0OG G4.4  
G5A07 (Ch. 4, Pg. 22) KE0OG G4.4  
G5A08 (Ch. 4, Pg. 22) KE0OG G4.4  
G5A09 (Ch. 4, Pg. 19) KE0OG G4.4  
G5A10 (Ch. 4, Pg. 22) KE0OG G4.4  
G5A11 (Ch. 4, Pg. 22) KE0OG G4.4

**Question ~ ARRL Book ~ Video**

G5B01 (Ch. 4, Pg. 2) KE0OG G4.1  
G5B02 (Ch. 4, Pg. 15) KE0OG G4.1  
G5B03 (Ch. 4, Pg. 1) KE0OG G4.1  
G5B04 (Ch. 4, Pg. 2) KE0OG G4.1  
G5B05 (Ch. 4, Pg. 2) KE0OG G4.1  
G5B06 (Ch. 4, Pg. 6) KE0OG G4.2  
G5B07 (Ch. 4, Pg. 5) KE0OG G4.2  
G5B08 (Ch. 4, Pg. 5) KE0OG G4.2  
G5B09 (Ch. 4, Pg. 5) KE0OG G4.2  
G5B10 (Ch. 4, Pg. 3) KE0OG G4.1  
G5B11 (Ch. 4, Pg. 7) KE0OG G4.2  
G5B12 (Ch. 4, Pg. 6) KE0OG G4.2  
G5B13 (Ch. 4, Pg. 6) KE0OG G4.2  
G5B14 (Ch. 4, Pg. 6) KE0OG G4.2

**Question ~ ARRL Book ~ Video**

G5C01 (Ch. 4, Pg. 13) KE0OG G4.3  
G5C02 (Ch. 4, Pg. 14) KE0OG G4.3  
G5C03 (Ch. 4, Pg. 15) KE0OG G4.3  
G5C04 (Ch. 4, Pg. 17) KE0OG G4.3  
G5C05 (Ch. 4, Pg. 17) KE0OG G4.3  
G5C06 (Ch. 4, Pg. 14) KE0OG G4.3  
G5C07 (Ch. 4, Pg. 22) KE0OG G4.3  
G5C08 (Ch. 4, Pg. 17) KE0OG G4.3  
G5C09 (Ch. 4, Pg. 17) KE0OG G4.3  
G5C10 (Ch. 4, Pg. 17) KE0OG G4.3  
G5C11 (Ch. 4, Pg. 17) KE0OG G4.3  
G5C12 (Ch. 4, Pg. 17) KE0OG G4.3  
G5C13 (Ch. 4, Pg. 15) KE0OG G4.3  
G5C14 (Ch. 4, Pg. 15) KE0OG G4.3  
G5C15 (Ch. 4, Pg. 17) KE0OG G4.3  
G5C16 (Ch. 4, Pg. 14) KE0OG G4.3  
G5C17 (Ch. 4, Pg. 13) KE0OG G4.3  
G5C18 (Ch. 4, Pg. 13) KE0OG G4.3

**G6****Question ~ ARRL Book ~ Video**

G6A01 (Ch. 4, Pg. 36) KE0OG G4.3  
G6A02 (Ch. 4, Pg. 36) KE0OG G4.3  
G6A03 (Ch. 4, Pg. 24) KE0OG G4.3  
G6A04 (Ch. 4, Pg. 12) KE0OG G4.3  
G6A05 (Ch. 5, Pg. 24) KE0OG G5.1  
G6A06 (Ch. 4, Pg. 21) KE0OG G4.3  
G6A07 (Ch. 4, Pg. 25) KE0OG G4.3  
G6A08 (Ch. 4, Pg. 12) KE0OG G4.3  
G6A09 (Ch. 4, Pg. 25) KE0OG G4.3  
G6A10 (Ch. 4, Pg. 26) KE0OG G4.3  
G6A11 (Ch. 4, Pg. 22) KE0OG G4.3  
G6A12 (Ch. 4, Pg. 26) KE0OG G4.3  
G6A13 (Ch. 4, Pg. 12) KE0OG G4.3  
G6A14 (Ch. 4, Pg. 13) KE0OG G4.3

**Question ~ ARRL Book ~ Video**

G6B01 (Ch. 4, Pg. 12) KE0OG G4.1  
G6B02 (Ch. 4, Pg. 30) KE0OG G4.5  
G6B03 (Ch. 4, Pg. 28) KE0OG G4.5  
G6B04 (Ch. 4, Pg. 30) KE0OG G4.5  
G6B05 (Ch. 4, Pg. 30) KE0OG G4.5  
G6B06 (Ch. 4, Pg. 27) KE0OG G4.5  
G6B07 (Ch. 4, Pg. 40) KE0OG G4.3  
G6B08 (Ch. 4, Pg. 31) KE0OG G4.1  
G6B09 (Ch. 4, Pg. 31) KE0OG G4.5  
G6B10 (Ch. 5, Pg. 24) KE0OG G5.5  
G6B11 (Ch. 4, Pg. 40) KE0OG G4.3  
G6B12 (Ch. 4, Pg. 38) KE0OG G4.3  
G6B13 (Ch. 4, Pg. 39) KE0OG G4.3

**G7****Question ~ ARRL Book ~ Video**

G7A01 (Ch. 4, Pg. 33) KE0OG G4.6  
G7A02 (Ch. 4, Pg. 33) KE0OG G4.6  
G7A03 (Ch. 4, Pg. 32) KE0OG G4.6  
G7A04 (Ch. 4, Pg. 32) KE0OG G4.6  
G7A05 (Ch. 4, Pg. 32) KE0OG G4.6  
G7A06 (Ch. 4, Pg. 32) KE0OG G4.6  
G7A07 (Ch. 4, Pg. 32) KE0OG G4.6  
G7A08 (Ch. 4, Pg. 33) KE0OG G4.6  
G7A09 (Ch. 4, Pg. 7) KE0OG G4.2  
G7A10 (Ch. 4, Pg. 7) KE0OG G4.2  
G7A11 (Ch. 4, Pg. 7) KE0OG G4.2  
G7A12 (Ch. 4, Pg. 7) KE0OG G4.2  
G7A13 (Ch. 4, Pg. 7) KE0OG G4.2

**Question ~ ARRL Book ~ Video**

G7B01 (Ch. 5, Pg. 15) KE0OG G5.3  
 G7B02 (Ch. 5, Pg. 14) KE0OG G5.3  
 G7B03 (Ch. 4, Pg. 28) KE0OG G4.5  
 G7B04 (Ch. 4, Pg. 28) KE0OG G4.5  
 G7B05 (Ch. 4, Pg. 28) KE0OG G4.5  
 G7B06 (Ch. 4, Pg. 28) KE0OG G4.5  
 G7B07 (Ch. 5, Pg. 4) KE0OG G5.2  
 G7B08 (Ch. 5, Pg. 14) KE0OG G5.3  
 G7B09 (Ch. 5, Pg. 4) KE0OG G5.2  
 G7B10 (Ch. 5, Pg. 9) KE0OG G5.2  
 G7B11 (Ch. 5, Pg. 14) KE0OG G5.3

**Question ~ ARRL Book ~ Video**

G7C01 (Ch. 5, Pg. 9) KE0OG G5.2  
 G7C02 (Ch. 5, Pg. 9) KE0OG G5.2  
 G7C03 (Ch. 5, Pg. 16) KE0OG G5.4  
 G7C04 (Ch. 5, Pg. 17) KE0OG G5.4  
 G7C05 (Ch. 5, Pg. 5) KE0OG G5.2  
 G7C06 (Ch. 5, Pg. 23) KE0OG G5.5  
 G7C07 (Ch. 5, Pg. 16) KE0OG G5.4  
 G7C08 (Ch. 5, Pg. 18) KE0OG G5.4  
 G7C09 (Ch. 5, Pg. 7) KE0OG G5.2  
 G7C10 (Ch. 5, Pg. 7) KE0OG G5.2  
 G7C11 (Ch. 5, Pg. 3) KE0OG G5.2  
 G7C12 (Ch. 5, Pg. 4) KE0OG G5.2  
 G7C13 (Ch. 5, Pg. 4) KE0OG G5.2  
 G7C14 (Ch. 5, Pg. 4) KE0OG G5.2  
 G7C15 (Ch. 5, Pg. 4) KE0OG G5.2  
 G7C16 (Ch. 5, Pg. 5) KE0OG G5.2

**G8****Question ~ ARRL Book ~ Video**

G8A01 (Ch. 6, Pg. 4) KE0OG G6.2  
 G8A02 (Ch. 5, Pg. 2) KE0OG G5.1  
 G8A03 (Ch. 5, Pg. 2) KE0OG G5.1  
 G8A04 (Ch. 5, Pg. 7) KE0OG G5.3  
 G8A05 (Ch. 5, Pg. 1) KE0OG G5.1  
 G8A06 (Ch. 6, Pg. 5) KE0OG G6.2  
 G8A07 (Ch. 5, Pg. 2) KE0OG G5.1  
 G8A08 (Ch. 5, Pg. 11) KE0OG G5.3  
 G8A09 (Ch. 6, Pg. 9) KE0OG G6.3  
 G8A10 (Ch. 5, Pg. 10) KE0OG G5.3  
 G8A11 (Ch. 5, Pg. 10) KE0OG G5.3  
 G8A12 (Ch. 6, Pg. 9) KE0OG G6.4

**Question ~ ARRL Book ~ Video**

G8B01 (Ch. 5, Pg. 16) KE0OG G5.4  
 G8B02 (Ch. 5, Pg. 18) KE0OG G5.4  
 G8B03 (Ch. 5, Pg. 5) KE0OG G5.2  
 G8B04 (Ch. 5, Pg. 5) KE0OG G5.2  
 G8B05 (Ch. 6, Pg. 10) KE0OG G6.4  
 G8B06 (Ch. 5, Pg. 10) KE0OG G5.3

G8B07 (Ch. 5, Pg. 10) KE0OG G5.3  
 G8B08 (Ch. 6, Pg. 10) KE0OG G6.4  
 G8B09 (Ch. 5, Pg. 18) KE0OG G5.4  
 G8B10 (Ch. 6, Pg. 10) KE0OG G6.4  
 G8B11 (Ch. 5, Pg. 5) KE0OG G5.2  
 G8B12 (Ch. 5, Pg. 24) KE0OG G5.5

**Question ~ ARRL Book ~ Video**

G8C01 (Ch. 3, Pg. 8) KE0OG G3.3  
 G8C02 (Ch. 6, Pg. 9) KE0OG G6.3  
 G8C03 (Ch. 6, Pg. 7) KE0OG G6.3  
 G8C04 (Ch. 6, Pg. 5) KE0OG G6.3  
 G8C05 (Ch. 6, Pg. 7) KE0OG G6.13  
 G8C06 (Ch. 6, Pg. 14) KE0OG G6.4  
 G8C07 (Ch. 6, Pg. 7) KE0OG G6.3  
 G8C08 (Ch. 6, Pg. 6) KE0OG G6.3  
 G8C09 (Ch. 6, Pg. 5) KE0OG G6.2  
 G8C10 (Ch. 6, Pg. 7) KE0OG G6.3  
 G8C11 (Ch. 6, Pg. 4) KE0OG G6.1  
 G8C12 (Ch. 6, Pg. 5) KE0OG G6.1  
 G8C13 (Ch. 6, Pg. 11) KE0OG G6.4  
 G8C14 (Ch. 6, Pg. 13) KE0OG G6.5

**G9****Question ~ ARRL Book ~ Video**

G9A01 (Ch. 7, Pg. 21) KE0OG G7.5  
 G9A02 (Ch. 7, Pg. 21) KE0OG G7.5  
 G9A03 (Ch. 7, Pg. 21) KE0OG G7.5  
 G9A04 (Ch. 7, Pg. 21) KE0OG G7.5  
 G9A05 (Ch. 7, Pg. 23) KE0OG G7.5  
 G9A06 (Ch. 7, Pg. 23) KE0OG G7.5  
 G9A07 (Ch. 7, Pg. 22) KE0OG G7.5  
 G9A08 (Ch. 7, Pg. 22) KE0OG G7.5  
 G9A09 (Ch. 7, Pg. 21) KE0OG G7.5  
 G9A10 (Ch. 7, Pg. 21) KE0OG G7.5  
 G9A11 (Ch. 7, Pg. 21) KE0OG G7.5  
 G9A12 (Ch. 7, Pg. 23) KE0OG G7.5  
 G9A13 (Ch. 7, Pg. 23) KE0OG G7.5

**Question ~ ARRL Book ~ Video**

G9B01 (Ch. 7, Pg. 16) KE0OG G7.5  
 G9B02 (Ch. 7, Pg. 5) KE0OG G7.1  
 G9B03 (Ch. 7, Pg. 4) KE0OG G7.1  
 G9B04 (Ch. 7, Pg. 2) KE0OG G7.1  
 G9B05 (Ch. 7, Pg. 6) KE0OG G7.1  
 G9B06 (Ch. 7, Pg. 4) KE0OG G7.1  
 G9B07 (Ch. 7, Pg. 6) KE0OG G7.1  
 G9B08 (Ch. 7, Pg. 3) KE0OG G7.1  
 G9B09 (Ch. 7, Pg. 7) KE0OG G7.1  
 G9B10 (Ch. 7, Pg. 4) KE0OG G7.1  
 G9B11 (Ch. 7, Pg. 3) KE0OG G7.1  
 G9B12 (Ch. 7, Pg. 5) KE0OG G7.1

**Question ~ ARRL Book ~ Video**

G9C01 (Ch. 7, Pg. 10) KE0OG G7.2  
G9C02 (Ch. 7, Pg. 10) KE0OG G7.2  
G9C03 (Ch. 7, Pg. 10) KE0OG G7.2  
G9C04 (Ch. 7, Pg. 3) KE0OG G7.1  
G9C05 (Ch. 7, Pg. 10) KE0OG G7.2  
G9C06 (Ch. 7, Pg. 13) KE0OG G7.3  
G9C07 (Ch. 7, Pg. 10) KE0OG G7.2  
G9C08 (Ch. 7, Pg. 9) KE0OG G7.2  
G9C09 (Ch. 7, Pg. 17) KE0OG G7.4  
G9C10 (Ch. 7, Pg. 11) KE0OG G7.2  
G9C11 (Ch. 7, Pg. 8) KE0OG G7.2  
G9C12 (Ch. 7, Pg. 12) KE0OG G7.2  
G9C13 (Ch. 7, Pg. 13) KE0OG G7.3  
G9C14 (Ch. 7, Pg. 15) KE0OG G7.3  
G9C15 (Ch. 7, Pg. 3) KE0OG G7.1  
G9C16 (Ch. 7, Pg. 12) KE0OG G7.2

**Question ~ ARRL Book ~ Video**

G9D01 (Ch. 7, Pg. 7) KE0OG G7.1  
G9D02 (Ch. 7, Pg. 3) KE0OG G7.1  
G9D03 (Ch. 7, Pg. 15) KE0OG G7.3  
G9D04 (Ch. 7, Pg. 19) KE0OG G7.4  
G9D05 (Ch. 7, Pg. 17) KE0OG G7.4  
G9D06 (Ch. 7, Pg. 17) KE0OG G7.4  
G9D07 (Ch. 7, Pg. 17) KE0OG G7.4  
G9D08 (Ch. 7, Pg. 6) KE0OG G7.1  
G9D09 (Ch. 7, Pg. 17) KE0OG G7.4  
G9D10 (Ch. 7, Pg. 15) KE0OG G7.3  
G9D11 (Ch. 7, Pg. 19) KE0OG G7.4  
G9D12 (Ch. 7, Pg. 4) KE0OG G7.1  
G9D13 (Ch. 7, Pg. 13) KE0OG G7.2

## Chapter 2 - Procedures and Practices

### Bands

The **upper end of the voice** portion of a band is normally available to General Class licensees

**Secondary users** are permitted if they do not cause harmful **interference** to primary users

**Move to a clear frequency** if a primary service interferes with your contact

"**CQ DX**" is looking for any station **outside their own country**

**Break** into phone by **saying call sign during a break** between other stations

**60M** other than a dipole antenna, you must **keep a record of the antenna gain**

**No one has priority access to frequencies**, common courtesy should be a guide

If you notice **increasing interference** from another station **move to another frequency**

Use NATO Phonetic Alphabet = Alpha, Bravo, Charlie, Delta, Foxtrot, Golf, Hotel, India, etc

Avoid harmful interference >> ask if the **frequency is in use**, followed by your **call sign**

**Follow the voluntary band plan** for the operating mode you intend to use

**Log Contact** >> **Date, Time, Freq, Call Sign RST** & may be needed if the FCC requests information

### SOS > Emergency Communications

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

**RACES** = Radio Amateur Civil Emergency Service

The **FCC may restrict amateurs participating in RACES** when **War Emergency Powers** are invoked

**When normal communications systems are not available** an **amateur station** may **use any means** of radio communications at its disposal for essential in to the immediate safety of **human life** and **protection of property**

### SSB > Single Sideband is a form of Amplitude Modulated (AM) Signal

**SSB** uses **Less bandwidth** used and **higher power efficiency**

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

SSB most often used for **HF Voice**

**USB** is normally used for 30M (**10 MHz up**), VHF and UHF SSB

**LSB** is normally used for 40M & down (**7 MHz down**)

SSB **VOX** operation allows "**hands free**" operation

SSB most often used for weak signal VHF and UHF

SSB **frequency separation** to minimize interference is **3 KHz vs CW at 150 Hz**

In **Split Mode** the transceiver is set to different transmit and receive frequencies

**Dual VFO permits monitoring of two different frequencies**

### CW > Send Continuous Wave using; a Straight Key, an Electronic Keyer and a Computer Keyboards

Reply to a CQ **at the speed the CQ was sent**

"**ZERO BEAT**" is matching TX frequency to the received signal

CW **frequency separation** to minimize interference is **150 to 500 Hz**

"**C**" added to an **RST** report means **Chirpy** or unstable signal

CW has the narrowest bandwidth (150 Hz)

### Abbreviations and "Q" Signals

Can you hear me between your signals >>> **QSK**

I acknowledge receipt >>> **QSL**

I am ready to receive messages >>> **QRV**

Indicates send faster >>> **QSQ**

Indicates send slower >>> **QRS**

Indicates low power operation >>> **QRP**

Indicates that you are receiving interference from other stations >>> **QRM**

Indicates that you are changing frequency >>> **QSY**

Indicates listening only for a specific station >>> **KN**







Indicates the end of a formal message >>> **AR**





# US Amateur Radio Bands

Operator license classes: **E** = Amateur Extra **A** = Advanced **G** = General **T** = Technician **N** = Novice  
CW operation is permitted throughout all amateur bands. Except as noted, all frequencies are in megahertz (MHz).

 = RTTY, data, phone, image   
  = USB phone, RTTY, data and CW   
  = RTTY and data   
  = phone and image  
 = SSB phone   
 = CW only

## LF – Low Frequency band

### 2200 Meters (135 kHz) E,A,G 1 W EIRP maximum

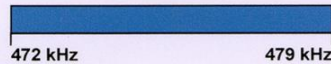


Amateurs wishing to operate on 2200 or 630 meters must first register with the Utilities Technology Council online at <https://utc.org/plc-database-amateur-notification-process/>. You need only register once for each band.

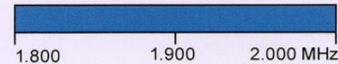
## MF – Medium Frequency bands

### 630 Meters (472 kHz) E,A,G

5 W EIRP max, except in Alaska within 496 miles of Russia where the limit is 1 W EIRP

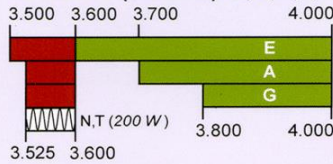


### 160 Meters (1.8 MHz) E,A,G

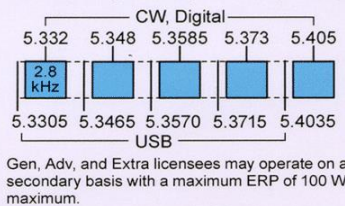


## HF – High Frequency bands

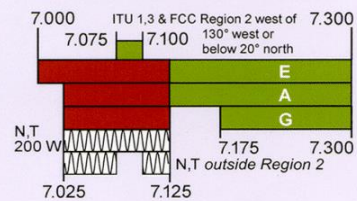
### 80 Meters (3.5 MHz) E,A,G,T,N



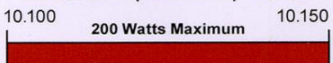
### 60 Meters (5.3 MHz) E, A, G (100 W)



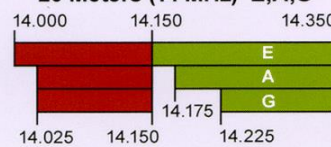
### 40 Meters (7 MHz) E,A,G,T,N



### 30 Meters (10.1 MHz) E,A,G



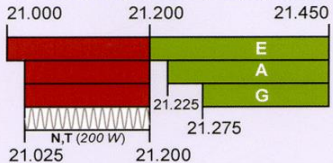
### 20 Meters (14 MHz) E,A,G



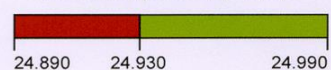
### 17 Meters (18 MHz) E,A,G



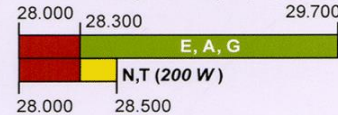
### 15 Meters (21 MHz) E,A,G,T,N



### 12 Meters (24 MHz) E,A,G

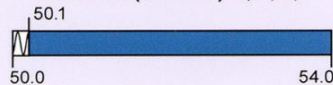


### 10 Meters (28 MHz) E,A,G,T,N

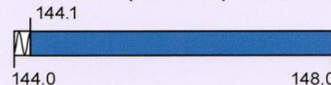


## VHF – Very High Frequency bands

### 6 Meters (50 MHz) E,A,G,T



### 2 Meters (144 MHz) E,A,G,T



### 1.25 Meters (222 MHz) E,A,G,T,N

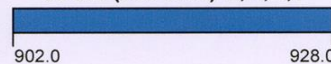


## UHF – Ultra High Frequency bands

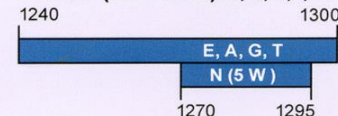
### 70 cm (420 MHz) E,A,G,T



### 33 cm (902 MHz) E,A,G,T



### 23 cm (1240 MHz) E,A,G,T,N



## SHF&EHF – Super and Extremely High Frequency bands

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

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

See [www.arrl.org/band-plan](http://www.arrl.org/band-plan) for detailed band plans.

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## Chapter 3 - Rules and Regulations

### Operating Rules

**Broadcast to the public only when safety of life or property and there no other means available**

One beacon signal in the same band from a single location

A **beacon** station is for observation of **propagation and reception**

Occasional **retransmission** of weather and propagation information is permitted

**One-way transmissions** to learn Morse code are permitted

**PRB-1** = state and local governments must be reasonably accommodate antenna structures

**Space station control** is permitted to use secret codes (encryption)

**Publicly documenting** the technical characteristics of a **digital protocol** required

Use of abbreviations or procedural if they **do not obscure the meaning**

A transmitting frequency should follow; **Part 97 Rules, band plans & avoid interfering**

TX about **sale of apparatus normally used and not done on a regular basis** is permitted

Not covered by Part 97 rules then use **good engineering and good amateur practice**

Who determines "good engineering and good amateur practice" **the FCC**

**200 feet is the maximum** height antenna without FAA

**Move to a clear frequency** if a primary service interferes with your contact

**Beacon stations** on 14.100, 18.110, 21.150, 24.930 and 28.200 MHz

Amateurs share the **13cm Band** with the unlicensed **Wi-Fi** on **2.4 GHz**

### Transmitter power and data emission standards

TX the **MINIMUM** power necessary

**1500 watts** PEP output max

**1500 watts** PEP output max on the **12M**

**1500 watts** PEP output max on **28 MHz**

**100 watts** PEP output is the power limit for **beacon** stations

**200 watts** PEP output max on **10.140 MHz**

**100 watts** PEP ERP using a dipole limit on the **60M**

**10 watts** PEP output max using **Spread Spectrum**

**2.8 KHz max BW** on USB frequencies in the **60M**

**300 baud** max for RTTY or data **below 28 MHz**

**300 baud** max for RTTY or data on **20M**

**1200 baud** max for RTTY or data on **10M**

**19.6 kilobaud** max for RTTY or data on **2M**

**56 kilobaud** max for RTTY or data on **1.25M & 70cm**

### Exams, Volunteer Monitoring, Volunteer Examiners and Coordinators

**Volunteer Monitoring Program** are volunteers who are formally enlisted to monitor for violations

**DF skills** are used to **locate** stations violating FCC Rules

**Volunteer Examiners (VE)** are accredited by **Volunteer Examiner Coordinator (VEC)**

A **Volunteer Examiner** must be **18 years old**

At **least three VEs** must be present for an exam

A VE holding a **General** may **administer a Technician** exam (must be higher or Extra for Extra)

A **non-U.S. citizen VE** must be a General Class or above (no difference than any other VE)

K4VRC / AG >> a new **General** with a **CSCE** may **operate** before FCC ULS shows upgrade

A Certificate of Successful Completion of Examination (**CSCE**) is **valid for 365 days**

**Expired** General, Advanced, or Extra **must pass element 2 (Tech)** to restore a previously-held license

### Control, Repeater, Third Party, ITU

A **Tech** may TX on a **2M** via a **10M** repeater when the **10M** control operator holds a **General**

A **third-party** is prohibited by an amateur who ever **had their license revoked**

A **third-party** TX is prohibited unless a **third-party agreement in effect** with that country

A **third-party** is messages must be **personal or emergencies or disaster relief**

Amateurs may communicate with any country except those that object to the ITU

**ITU 2 region** apply to radio amateurs operating in **North and South America**

You must avoid interference; one mile from **FCC Monitoring Station, secondary user & spread spectrum**

## Chapter 4 - Components and Circuits

### Math Units

MEGA =	1,000,000.	Million
KILO =	1,000.	Thousand
-----		
MILLI =	0.001	1/1,000
MICRO =	0.000,001	1/1,000,000
NANO =	0.000,000,001	1/1,000,000,000
PICO =	0.000,000,000,001	1/1,000,000,000,000
TO CONVERT    Δ    MOVE DECIMAL POINT		

### Ohm's Law, Power, Vpp, RMS, PEP

$$E = I \times R$$

$$I = E / R$$

$$R = E / I$$

$$P = E \times I$$

$$P = I^2 \times R$$

$$PEP = [(V_{pp}/2) \times 0.707]^2 / R$$

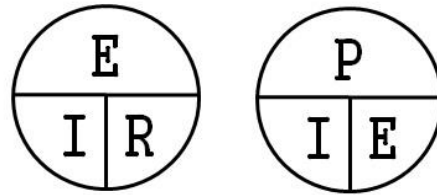
$$V_{pp} = \text{Voltage Peak to Peak} = 2 (1.41 \times \text{RMS})$$

$$\text{RMS} = \text{Peak} \times 0.707$$

Total current in each branch of a **parallel** circuit equals **sum of the branches**

The **RMS** value of an AC signal is the **power dissipation** as a **DC** voltage of the **same value**

The ratio of **peak** envelope power to **average** power for an **unmodulated carrier** is **1.00**



### Decibel (dB)

$$+1 \text{ dB} = 20.5\% \text{ of } X \quad +3 \text{ dB} = 2X \quad +6 \text{ dB} = 4X \quad +10 \text{ dB} = 10X$$

### Resistors, Inductors & Capacitors

**Resistors in series** = resistor values added

**Equal Resistors in parallel** = resistor value / number of resistors

**Resistors in parallel** = the reciprocal of (the sum of all the reciprocal resistor values)

**Equal Inductors in parallel** = inductor value / number of inductors

**Inductors in parallel** = the reciprocal of (the sum of all the reciprocal inductor values)

**Inductors in series** = inductors values added

**Capacitors in parallel** = capacitor values added

**Equal Capacitors in series** = capacitor value / number of capacitors

**Capacitors in series** = the reciprocal of (the sum of all the reciprocal capacitor values)

Inductors or Resistors in Parallel

$$L = \frac{1}{\frac{1}{L} + \frac{1}{L} + \dots + \frac{1}{L}}$$

Inductors or Resistors in Series

$$L = L + L + \dots + L$$

Capacitors in Series

$$C = \frac{1}{\frac{1}{C} + \frac{1}{C} + \dots + \frac{1}{C}}$$

Capacitors in Parallel

$$C = C + C + \dots + C$$

A **wire-wound resistor's inductance** could make circuit performance unpredictable

**Electrolytic capacitors** are used in **power supply** circuits to filter the rectified AC

**Reverse polarity** of applied to **polarized capacitors** may cause a **short-circuit, overheat and explode**

**Ceramic capacitors** are **low cost** compared to other types

**High capacitance for given volume** is an advantage of an electrolytic capacitor

**Lead inductance** in a capacitor **reduces** effectiveness at **VHF** and above

**Inter-turn capacitance** in an inductor may cause **self resonant** at some frequencies

**Mutual inductance** between inductors causes **unwanted coupling** between circuits

**Inductor** is operated **above its self-resonant frequency** becomes capacitive

A ferrite core toroidal has; **large inductance, freq optimized properties, magnetic field stay in core**

The "**mix**," determines the performance of a **ferrite core** at different frequencies



## Electrical Terms

**Impedance** is the **opposition** to the flow of current in an **AC** circuit

**Impedance** is measured in **Ohms**

**Reactance** is the **opposition** to AC caused by **capacitance or inductance**

**Reactance opposes** the flow of **AC** in an **inductor**

**Reactance opposes** the flow of **AC** in a **capacitor**

**Reactance** is measured in **Ohms**

## Electrical Properties

**Inductor** reactance **increases with frequency**

**Capacitor** reactance **decreases with frequency**

When the impedance of **load equals the source** the **maximum power** is delivered

To **maximize power transfer**, use an **impedance matching transformer**

Insert an **LC network to match impedance** between circuits

A **transformer, Pi-network or transmission line** can be used for **impedance matching**

## Digital Circuits, Integrated Circuits

**Linear voltage regulator** is an analog integrated circuit

Integrated circuit **operational amplifier** is an **analog** device

**MMIC** >> **Monolithic Microwave Integrated Circuit**

**ROM** >> **Read Only Memory**

**"NON-VOLATILE"** memory information is maintained even if power is removed

A microprocessor is a **computer on a single integrated circuit**

**CMOS** integrated circuits have **lower power consumption** compared to **TTL**

**Binary** "ones" and "zeros" are easy to represent with an **"on" or "off" state**

**AND gate** output is high only when **both** inputs are high

**NOR gate** output is low when **either or both** inputs are high

**Eight** states in a **3-bit binary** counter

A **shift register** is a clocked array that **passes data in steps** along the array

## Transistors, Diodes, Vacuum Tubes

**Saturation and cut-off regions** are **stable operating** points for a bipolar transistor used in a logic circuit

A **MOSFET gate** is **separated from the channel** with a thin insulating layer

**Control grid** of a triode tube **regulates the flow of electrons** between cathode and plate

A **screen grid** in a vacuum tube **reduces grid-to-plate capacitance**

**0.3 volts** junction threshold voltage of a **germanium diode**

**0.7 volts** junction threshold voltage of a **conventional silicon diode**

An LED is **Forward Biased** when emitting light (conducts)

A **liquid crystal display** **requires** ambient or back **lighting**

## Power Supplies

The **peak-inverse-voltage** across the rectifiers in a **full-wave PS** = **PS output voltage**

The **peak-inverse-voltage** across the rectifiers in a **half-wave PS** = **2 X PS output voltage**

**360 degrees** of the AC cycle is converted to DC by a **full-wave rectifier**

**180 degrees** of the AC cycle is converted to DC by a **half-wave rectifier**

The output waveform of a **full-wave rectifier** = Series of DC **pulses 2X freq** of the AC input

Capacitors and inductors are used in a **power-supply filter network**

**Filter choke smoothes DC output** from the rectifier in a power supply

A power-supply **bleeder resistor** discharges the filter capacitors

A **switch-mode PS** **high freq operation** allows the use of smaller components

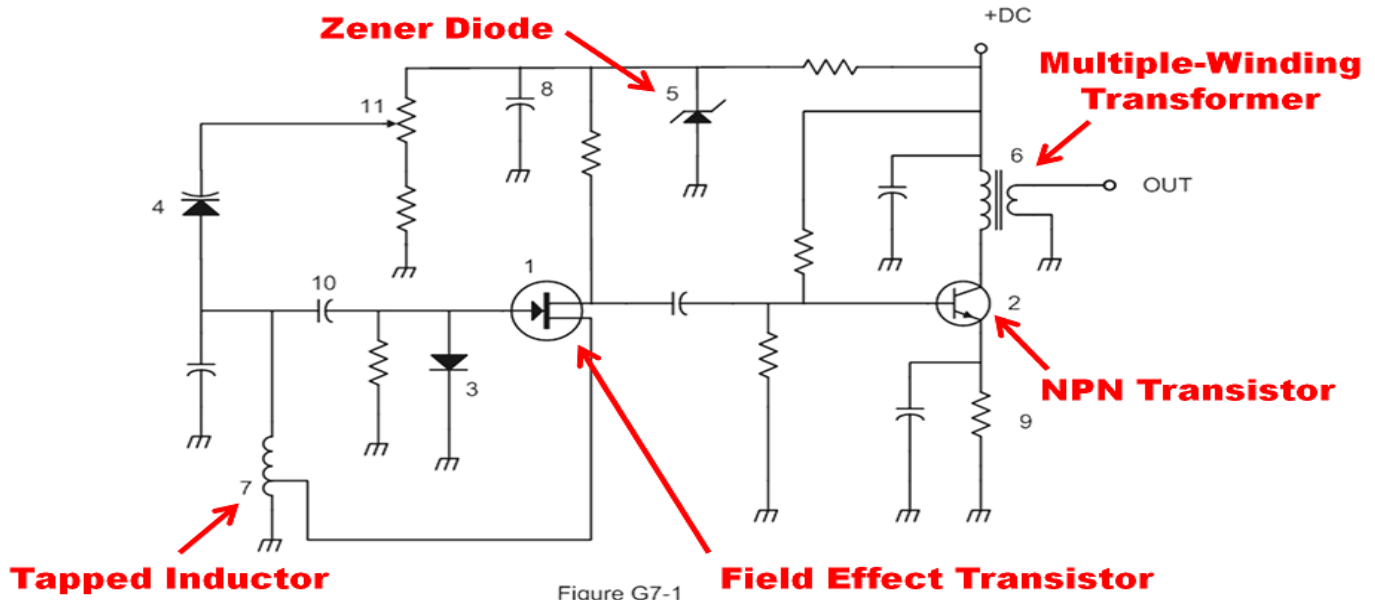
## Transformers

**Mutual inductance** causes a voltage to appear across the **secondary winding** of a transformer

The **primary** of a transformer is normally connected to the **incoming source**

The transformer **VOLTAGE** output = **Input x (Np/Ns)**

The transformer output **IMPEDANCE** = **Input x Square Root of (Pimp/Simp)**



### Solar, Wind, Batteries

**Nickel-Cadmium batteries** provide **high discharge current** and low internal resistance

**10.5 volts** is the **minimum discharge voltage** of a standard **12 volt lead acid** battery

**Photovoltaic** process turns sunlight is changed directly into electricity

The open-circuit voltage from a fully illuminated silicon **photovoltaic cell** is **0.5 VDC**

A **series diode** between a solar panel and a storage battery **prevents self-discharge** of the

**Wind turbines** require a large energy storage system (**batteries**)

### Connectors

**Computer and transceiver** might be connected using a **USB interface**

**DE-9 connectors** would be a good choice for a **serial data port**

**RCA Phono** connectors are commonly used for **audio signals**

**PL-259** connectors are commonly used for RF service at **frequencies up to 150 MHz**

**SMA connector** is a small threaded connector suitable for signals up to several GHz

**N connector** is a moisture-resistant RF connector useful to 10 GHz

### Test and Measurement Equipment

An **oscilloscope** contains **horizontal and vertical channel** amplifiers

An oscilloscope can **measure complex waveforms**

An oscilloscope can **check the keying waveform** of a **CW transmitter**

The attenuated TX RF is connected to the **vertical** of an **oscilloscope** to check **RF envelope**

A **high input impedance voltmeter** decreases the **loading on circuits** being measured

A **digital voltmeter** has **better precision** than an analog meter

A **field strength meter** can be used for **close-in radio direction-finding**

A **field strength meter** can be used for **relative RF output** on antennas and transmitters

A **field strength meter** can be used to **radiation pattern** of an antenna

An **antenna analyzer** is used for **antenna and feed line SWR** measurements

An **antenna analyzer** is used to **determine the impedance** of a **coaxial cable**

**Strong signals** can affect the **accuracy** of **antenna analyzer** measurements

An **analog** readout may be **preferred** when **adjusting tuned circuits**

**Standing wave ratio (SWR)** can be determined with a **directional wattmeter**



## Chapter 5 - Amateur Radio Equipment

### AMPLIFIERS & OSCILLATORS

**Class A** amplifier has **low distortion**

A **linear** amplifier **preserves the input** waveform

**Class C** amplifier is appropriate for amplifying **CW signal**

Class C amplifiers have the **highest efficiency**

**Efficiency of an RF amplifier** = RF output power / DC input power

**Neutralizing** the final amplifier stage of a transmitter **eliminates self-oscillations**

The **basic sine wave oscillator** has a filter & amplifier operating in a feedback loop

**Direct Digital Synthesizer (DDS)** is a high-stability **variable frequency oscillator** (VFO)

The **inductance and capacitance** in the **tank circuit** determines the **frequency** of an LC oscillator

**Superhetrodyne** > Mixing of Oscillator & RF SHIFTS to Intermediate Frequency (IF) STAGE

A **mixer** combines input **signal** with **oscillator** signal to produce **intermediate frequency (IF) = 455 KHz**

**Heterodyning** is another term for the **mixing of two RF signals**. (sum and difference)

The unused product of mixing (i.e. - 455 KHz) **Image Response causing interference in the receiver**.

A **balanced modulator** removes the carrier and leaves the **upper and lower sidebands**

**Multiplier** stage in a **VHF FM transmitter** uses a **HF harmonic** to reach RF frequency

### Receivers, Transmitters

Best signal-to-noise ratio is when the receiver bandwidth equals the signal bandwidth

**Discriminator in FM** receivers to convert signals coming from the **IF amplifier to audio**

A **filter processes** signals from the **balanced modulator before the mixer** in a SSB phone TX

**Balanced modulator** combines carrier **oscillator & audio** and the result to a **filter** in a SSB phone TX

**Product detector** combines **IF amplifier & BFO** and send the result to the AF amplifier in SSB RX

The **RF amplifier & local oscillator** are **mixed** and the result to the **IF filter** in a superheterodyne RX

**HF oscillator, mixer, detector** are basic stages of a superheterodyne RX

The impedance of a **low-pass filter should equal** the Impedance of the **transmission line**

**Direct Digital Synthesizer (DDS)** provides variable frequency with the stability of a crystal oscillator

**Digital Signal Processor (DSP)** and **Software Defined Radio (SDR)**

DSP filtering **converts the signal from analog to digital and using digital processing**

SDR performs most major **signal processing functions are performed by software**

**90-degree phase** difference between the **I and Q signals** for SDR Mod/Demod

**SDR or I/Q can create any modulation** the with appropriate processing (Software)

**AM** > Sends information by **varying the power** of the transmitted **RF Envelope** proportional to the microphone input

Modulator > Combines speech and RF

AM has a 6 KHz bandwidth

**SSB** > Single Sideband is a form of Amplitude Modulated (AM) Signal

**Transmitter power can be used more effectively** More transmitter power in one sideband

SSB has a **narrower (3 KHz)** bandwidth

**Overmodulation creates excessive bandwidth**

Signal distortion caused by **excessive SSB drive produces "flat-topping"** distortion

**Intermodulation** is two signals mixed in a non-linear circuit producing unwanted spurious outputs

**FM** > Frequency Modulation changes the **frequency** of an RF wave to convey information

RF carrier **frequency** changes proportionally to the **instantaneous amplitude of the modulating** signal

FM phone transmission with **5 kHz deviation** and a **3 kHz modulating** signal has a **16 kHz bandwidth**

$$(5 \text{ KHz} + 3 \text{ KHz}) \times 2 = (8 \text{ KHz}) \times 2 = 16 \text{ KHz.}$$

**FM 146.52 MHz** with **5 kHz deviation** using a **Reactance Modulator 12.21 MHz Osc** has a **416.7 Hz Dev**

$$5 \text{ KHz} / (146.52 \text{ MHz} / 12.21 \text{ MHz}) = 5 \text{ KHz} / 12 = 416.66 \text{ Hz}$$

**PM** > Phase Modulation changes the **phase angle** of an RF wave to convey information

PM is produced by a **reactance modulator** connected to an RF power amplifier

## Transceiver Functions

**TX RF picked up** in audio can cause **distortion, timeouts and stuck Tx VOX**

**Noise blanker** reduce receiver gain during a **noise pulse**

**Too much Noise blanker** may cause **distorted received** signals

**Digital Signal Processing (DSP)** removes **noise** from received signals

A **DSP IF filter** has a **range of filter bandwidths and shapes**

A **DSP filter** can perform **automatic notching** of interfering carriers

**"NOTCH FILTER"** reduces interference from carriers in the receiver passband

**Low-pass filter cutoff frequency** is the frequency above which a filter's output is **half the input**

**Ultimate rejection** specifies a filter's reject signals outside its passband

Upper and lower **half-power points** is the **bandwidth of a band-pass filter**

**Insertion loss** specifies a filter's attenuation inside its passband

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

**IF shift control avoids interference** from stations very close to the receive frequency

In **Split Mode** the transceiver is set to different transmit and receive frequencies

**Attenuator reduces signal overload** due to strong incoming signals

**Automatic Level Control (ALC)** reduces over drive distortion in an RF power amp

**Excessive drive power** may damage a solid-state RF power amplifier

**Max power out without exceeding max plate current** for control of a tube RF amp

**Plate current DIP** indicates correct adjustment of a tube amp plate tuning control

**Transmitter Linearity** performance is determined by a **two-tone test**

Two **non-harmonically related audio signals** are used to conduct a **two-tone test**

**TIME DELAY** keying allows RX / TX changeover to complete properly before RF output is allowed

## Speech processors; S meters; sideband operation near band edges

A **speech processor increases the intelligibility** of phone signals

A **speech processor increases average power** of a SSB phone TX

An **incorrectly adjusted** speech processor; **Distorted speech, Splatter, Excessive background**

**3 kHz LSB** with a carrier frequency 7.178 MHz occupies 7.175 to 7.178 MHz (3 KHz below)

**3 kHz USB** with a carrier frequency 14.347 MHz occupies 14.347 to 14.350 MHz (3 KHz above)

An **S Meter** measures **received signal strength**

**Receivers have S meters** (signal strength meters)

S Meter reading of **S9 = S8 times 4** (S Unit = ~6dB = 4X)

S meter **20 dB over S-9** = S-9 signal **X 100**

## Transmitter Interference

**Distorted speech** can be heard on telephone if there is interference from a **SSB TX** (Donald Duck)

**On-and-off humming or clicking** on telephone if there is interference from a **CW TX**

**Connect all grounds to a single point** to avoid a **ground loop**

**HUM** could be a symptom of a **ground loop** somewhere in your station

A **ferrite bead** on cables reduces RF interference (**common-mode current on an audio cable**)

A **bypass capacitor reduces RF interference** to audio-frequency devices

**Connect all equipment grounds together** to avoid unwanted effects of stray RF (**HOT SPOTS**)

**Grounding Metal Enclosures** ensures that **hazardous voltages** cannot appear on the chassis

**High RF voltages on station equipment** can be caused by a **resonant ground**

A **high impedance ground** on a frequency can cause an **RF burns** when HF TX

**Arcing can cause of interference** covering a wide range of frequencies

## HF Mobile Radio Installations and Emergency Power

Efficiency of the electrically **short antenna limits an HF mobile** operation

Vehicle **control computer** may cause **interfering signals** in the receiver of an HF mobile

Vehicle **fuel system** may cause **interfering signals** in the receiver of an HF mobile

Vehicle **charging system** may cause **interfering signals** in the receiver of an HF mobile

Wire a 100W HF mobile **directly to a fused battery connections** using **heavy gauge wire**

**Do NOT** wire a 100W HF mobile to an **automobile's auxiliary power socket** (too much current)

## Chapter 6 - Digital Modes

### DIGITAL COMMUNICATIONS

**14.070 - 14.112 MHz** of the **20M** is used for **data**

**80M** is frequency used for **data = 3570 – 3600 kHz**

**Higher symbol rates require higher bandwidth**

A **waterfall display** (frequency = horizontal, signal strength = intensity, time = vertical)

A station **initiating a digital contact must be under local or remote control** outside the auto control segments

**Software Defined Radio (SDR)**

**Digital Signal Processing (DSP)**

DSP IF filter have; **analog to digital converter, digital processor, digital to analog converter**

DSP filtering **converts the signal from analog to digital and using digital processing**

**Matching receiver BW to operating mode BW** results in the **best signal to noise ratio**

**SSB over modulation** causes **distortion** and occupies **more bandwidth**

**Improper action of ALC** **distorts** the signal and can cause spurious emissions

Transmitting a **data** mode know the **duty cycle** to prevent **damage to your transmitter's** final stage.

### RTTY (Radioteletype)

RTTY uses a **170 Hz** frequency shift for **Mark and Space**

**LSB** is used with RTTY via **AFSK** with an SSB transmitter

**Baudot code** is a **5-bit code** with additional start and stop bits

### PSK / QAM / Coding

**PSK31** > Approximate transmitted **symbol rate** is **31**

20M is frequency used for **PSK-31 = 14.070 MHz**

**Forward Error Correction** correct errors in received data by **TX redundant info with the data**

**Varicode** means the number of **bits** varies data bits in a **PSK31** character

**Using Upper case letters with PSK31** slows down transmission due to Varicode

**USB** is normally used for **PSK31**

**QPSK31** bandwidth is approximately the same as **BPSK31**

### FT8 / JT65 / JT9 / FSK

**USB** is used to generate **JT65, JT9, or FT8**

**"MFSK"** means Multi (or Multiple) Frequency Shift Keying

Typical **FT8** exchanges are limited to **call signs, grid locators, and signal reports**

**FT8 digital** mode requires a **computer time accurate** within approximately **1 second**

**FT8** is an **8-tone** frequency shift keying

**FT8** is a **narrow-band** digital mode that can receive with **very low signal-to-noise ratios**

### PACKTOR / WINLINK / WINMOR

The **Header** of a data packet contains the **routing and handling information**

Request the packet be **retransmitted** if **ARQ data mode packet contains errors**

Request the packet be **retransmitted** is meant by an **NAK response** to a transmitted packet

The approximate bandwidth of a **PACKTOR-III signal at maximum data rate** is **2300 Hz**

**Transmit a connect message to establish contact** with a digital messaging system gateway

A **PACKTOR modem in monitor** allows **monitoring** communications without a connection

**PACKTOR connections are limited to two stations**

**Signals interfering** with **PACKTOR** or **WINMOR** cause; **retries, timeouts and connection failures**

**Winlink** uses the internet to transfer messages

## Chapter 7 - Antennas

### Losses, Attenuation, SWR, Matching

If a transmission line is lossy, **high SWR will increase the loss**

**High SWR = Reflected** power caused by the difference between **feedline** and **antenna** impedances

**SWR = ratio** of **feed line** impedance to **load** impedance, format is "xx to 1" (Always > 1)

**SWR =  $Z_1 / Z_2$  or  $Z_2 / Z_1$  whichever is > 1**

The higher the **transmission line loss**, the more the **SWR will read artificially low**

**Tuners (matching network)** match **transmitter output impedance** to an impedance **not equal to 50 ohms**

Matching network between the feed and antenna **match the unbalanced coax to the balanced** parallel feedline

The antenna **feed point impedance must be matched** to the feed line to **prevent standing waves**

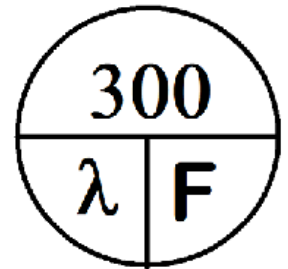
**Attenuation (loss)** of **coaxial cable** increases as the **frequency increases**

### Antenna Length > Physical Length (Shorter is Higher Frequency)

1/4 Wave Antenna = Physical Length of **234 Ft. / F MHz**

1/2 Wave Antenna = Physical Length of **468 Ft. / F MHz**

1 Wave Antenna = Physical Length of **300M. / F MHz**



### Dipoles

**dBi** refers to an **isotropic** antenna

**dBd** refers to a **dipole** antenna

**dBi gain figures are 2.15 dB higher than dBd gain figures**

**Radiation** pattern of a **horizontal dipole LESS than 1/2 wavelength** above ground is almost **Omni-directional**

**Radiation** pattern of a **horizontal dipole MORE than 1/2 wavelength** above ground is almost a **figure-eight**

**Impedance** of a horizontal dipole 1/4 wavelength above ground **decreases as the antenna is lowered**

**Impedance** of a dipole **increases** as the **feed point is moved** toward the **ends** (OCF-Off Center Feed)

Impedance of an **end fed dipole feed point** is **very high**

You may experience **RF burns** when touching metal objects in your station when using a **random-wire antenna**

A **Horizontally** polarized antenna has **less ground reflection losses**

**Multiband** antennas have **poor harmonic rejection**

**Traps** installed on an antenna permit **multiband** operation

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

### YAGI Antenna

A **Yagi** antenna consists of a **driven** element, **reflector** and **director** element(s)

The Yagi **driven** element is **1/2 wavelength**

The Yagi **director** is the **shortest element**

The Yagi **reflector** is the **longest element**

Increasing the **boom length** and **adding directors** to a Yagi antenna **increases the gain**

Using **larger diameter** elements will **increase** the **SWR bandwidth** of a Yagi

The "**main lobe**" is direction of **maximum radiated field strength** from the antenna

The "front-to-back ratio" (FB) means the "**main lobe**" compared to the opposite direction

The forward gain of a **3 Element Yagi** antenna is **9.7 dBi** on paper

The **boom length**, **number** of elements and element **spacing** determine gain, FB ratio, SWR BW

The Yagi antenna is used to **reduce interference** from other stations to the **side or behind** the antenna

A "**gamma match**" **driven element** is **NOT insulated from the YAGI boom**

A "**gamma match**" is used to **match** the **low impedance** Yagi to 50 ohms

A beta or **hairpin match** is a **stub placed** at the feed point of a Yagi to provide impedance matching

**Stacked Yagi** antennas spaced 1/2 wave have **3dB gain** more than a single Yagi

**Stacking Horz Yagi** antennas **narrows main lobe in elevation**

## Monopole Antennas

Place **radial wires** of a vertical antenna on the surface or buried a **few inches below the ground**  
**Downward sloping radials** ( ~ 45 Deg ) ref ground-plane brings the feed-point impedance to **50 ohms**  
The radiation pattern of a **quarter-wave, vertical antenna is Omnidirectional** in azimuth  
The **antenna limits an HF mobile** transceiver operating in the 75M  
A **shortened mobile** antenna has **limited BW** compared to a full size  
A **"screwdriver"** mobile antenna adjusts its feed-point impedance by **varying the base inductance**  
**"CAPACITANCE HAT"** electrically lengthens a physically short antenna  
**"CORONA BALL"** reduces high voltage discharge from the tip of the antenna

## Parallel & Coaxial Feedline Impedance

**Impedance** of a parallel conductor feedline is determined by the **distance between the conductors**  
Typical characteristic **impedance** of **coaxial** cables is **50 and 75 ohms**  
Characteristic **Impedance** of **"window line"** parallel transmission line is. **450 ohms**  
RF feed line **losses** is expressed in **dB per 100 ft**  
RF feed line losses increase with frequency

## Cubical Quad, Delta and Loop Antennas

A Quad is two **square loops** of **one wavelength** and separated by 0.2 WL  
A Quad has the **same gain** of a 3 element **Yagi** antenna ( **YAGI has better F to B ratio** )  
A Quad **feed** at the **bottom center** wire has **horizontal** polarization  
A Quad **feed** at a side **vertical center** wire has **vertical** polarization  
A **Delta** is two **triangular loops** of **one wavelength** and separated by 0.2 WL  
A **Delta** has the **same gain** of a **Quad** antenna  
The (Quad, Delta, Loop) **driven** element is **one wavelength** or 1/4 Wavelength per side  
The (Quad, Delta, Loop) **reflector** is the **longest element** or **5% longer**  
**Radiation** pattern of a **HALO** is almost **Omni-directional**  
**Radiation** pattern of a **horizontal loop** is almost **Omni-directional**  
An electrically **small loop** (1/3 WL) has **pattern nulls broadside to the loop**

## "NVIS" Near Vertical Incidence Skywave

The advantage of an **NVIS** is the **high vertical angle radiation for short skip** during the day  
An **NVIS** antenna typically installed between **1/10 and 1/4 wavelength above ground**

## Log Periodic Antenna

A **log periodic** antenna **spacing of elements** increases **logarithmically** along the boom  
A **log periodic** antenna has **wide bandwidth**

## Beverage Antenna

A **Beverage** antenna has high **transmit losses** compared to other types of antennas  
A **Beverage** antenna is used for **directional receiving** for low HF bands  
A **Beverage** antenna is a very **long and low receiving** antenna that is highly directional



## Chapter 8 - Propagation

### Propagation

A **Sudden Ionospheric Disturbance (SID)** disrupts on lower frequencies more than higher frequencies  
**HF communications are disturbed** by the charged particles from **solar coronal holes**  
**Near Vertical Incidence Skywave (NVIS)** is **Short distance MF or HF propagation**  
 If HF radio-wave **propagation (skip)** is **good** on now expect it **again 28 days later**  
 The **sun's rotation** causes **HF propagation** to vary on a **28-day cycle**  
**DX** Frequencies **above 20 MHz** are **least reliable** during periods of **low solar activity**  
**"LONG-PATH"** is opposite direction **180 degrees** from its **short-path heading**  
 A world map projection centered on a particular location is an **Azimuthal Projection map**  
 High atmospheric **noise is typical of the lower HF** during the **summer**

### Solar Disturbances

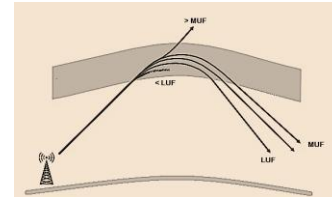
The **radio energy emitted by the sun** is measured by the **solar flux index**  
 The **solar-flux index** is a measure of solar activity at **10.7 cm** wavelength  
 The **sunspot number** is based on **counting sunspots** and sunspot groups  
 It takes **20 to 40 hours** for charged particles from **Coronal Mass Ejections** to affect Earth  
 The ultraviolet and X-ray **radiation** from solar **flares** take **8 Minutes** to affect Earth  
 The typical **sunspot cycle** is **11 years**  
**Higher sunspot** indicates **better propagation** at higher frequencies  
**DX** in the **upper HF and lower VHF** range is **enhanced** by high **sunspot numbers**  
**20 meters** supports worldwide propagation during **daylight** at any point in the **solar cycle**

### Magnetic Disturbances

The **K-index** is the **short term** stability of the Earth's **magnetic field**  
 The **A-index** is the **long term** stability of the Earth's **magnetic field**  
**Geomagnetic storm** is a temporary disturbance in Earth's **magnetosphere**  
 A **sudden change** in the **Earth's magnetic field** is a **geomagnetic disturbance**  
 North or South Latitudes **above 45 degrees** are **more sensitive to geomagnetic disturbances**  
**Degraded high-latitude HF** is caused by **geomagnetic storm** on radio-wave propagation  
**Aurora** from periods of **high geomagnetic** reflect **VHF signals** (good DX on VHF)

### Maximum Usable Frequency; Lowest Usable Frequency; propagation "hops"

**"MUF"** the **maximum usable freq** for communications between two points  
 The **best propagation** is a frequency just **below the MUF**  
**Beacons** are a way to determine if the **MUF is high enough** to support skip  
**Distance, location, Time, Season, Solar Flux & SID** all affect **MUF**  
**"LUF"** the **Lowest Usable Frequency** for communications between two points  
 Frequencies **below the LUF** are **completely absorbed** by the ionosphere  
 $LUF < \text{Freq} < MUF$  = **best propagation** is frequency is **bent back to the Earth**  
 $LUF > MUF$  = No HF radio frequency will support skywave communications  
**2,500 miles** is the maximum distance covered in **one hop** using the **F2 region**  
**1,200 miles** is the maximum distance covered in **one hop** using the **E region**  
 An **ECHO** can be heard when **both short and long path propagation** are received



### Ionospheric Layers

The **D layer** is **closest** to the surface of the Earth **absorbing** most long **skip signals**  
 The **D layer** absorbs lower HF frequencies during **daylight hours**  
 The **F2 region** will reach its **maximum height at noon** (sun is overhead)  
**F2 region** is the **highest ionospheric region** and provides the **longest distance propagation**  
**"Critical Angle"** is the highest takeoff angle that **bends RF back to Earth**  
 Combining of **several paths** makes HF scatter signals **sound distorted**  
**HF scatter signals are weak** as a small part of the signal get to the skip zone  
 A **wavering sound** is a characteristic of **HF scatter** signals  
**Scatter** allows a signal to be detected **too far for ground wave** but **too near for sky wave**  
**Signals heard above the MUF** are **scatter propagation**

## Chapter 9 – Safety / RF Exposure Hazard

### Radio Frequency Radiation Exposure Hazard

RF energy can **heat human body tissue**

RF **MAXIMUM PERMISSIBLE EXPOSURE (MPE)** is determined by **power density, freq & duty cycle**

Frequency, RF Power, Distance & Radiation Pattern of the antenna affect the RF exposure

You must **take action to prevent human exposure to the excessive RF fields**

A **lower TX duty cycle permits** greater short-term RF exposure levels

The total RF exposure averaged over a certain time is **"TIME AVERAGING"**

**Perform a routine RF exposure evaluation specified in part 97.13**

Re-evaluating the station whenever equipment is changed to ensure RF safety

A **calibrated field-strength meter** can be used to accurately measure an RF field

Take steps to **prevent directional antenna exceeding MPE** from point at neighbor

Installed ground-mounted antenna **to protected against unauthorized access**

Ensure **MPE limits are not exceeded** in occupied areas **with indoor transmitting antenna**

**FCC OET Bul 65, computer model or field strength meter** determine complies with RF

### Electrical Hazards

**ONLY Hot wires** in a four-conductor line cord **should be fused** from a 240-VAC single-phase source

**Ground** station equipment to ensure **hazardous voltages cannot appear on the chassis**

**Ground Fault Circuit Interrupter (GFCI)** disconnects when current is flowing directly to ground

**#14 AWG Wire >> 15 amperes** of continuous current

**#12 AWG Wire >> 20 amperes** of continuous current

**Disconnect the incoming utility power feed** when powering your house from an emergency generator

An emergency generator should be **located in a well ventilated area**

**Danger of carbon monoxide poisoning** using a placing a gasoline-fueled generator inside

When being **charged a lead acid** storage battery gives off **explosive hydrogen gas**

**TX power supply interlock** ensures that **dangerous voltages are removed if the cabinet is opened**

Lead (lead-tin solder) can **contaminate food if hands are not washed carefully after handling**

**Electrical safety** inside the ham shack is covered by the **National Electrical Code**

### Antenna Tower Safety

Confirm that the safety **harness is rated weight** of climber and within **service life**

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

**Turn off the transmitter and disconnect the feed line** when working on antenna

A **soldered joint** will likely be **destroyed by the heat of a lightning strike** (do not solder ground rods)

Good engineering practice requires **lightning protection grounds be bonded together**

## Glossary

<b>AC</b>	<b>Alternating Current</b> - Electric current flowing in alternating directions. In the US the frequency is 60 Hz.
<b>AGC</b>	Automatic Gain - This flattens the sound
<b>AM</b>	Amplitude - Amplitude is changed to add the modulation known as voice.
<b>Ammeter</b>	Measure's amps or electric current and is connected in series with the circuit.
<b>Amperes</b>	A measurement of the current. Current is measured in Amperes (or commonly referred to as amps).
<b>Antenna</b>	The apparatus used to send and receive radio signals.
<b>Antenna</b>	omnidirectional antenna. Many houses have a satellite TV dish installed which is a directional antenna.
<b>Antenna Analyzer</b>	Tests the antenna to show what frequency it works best at and many other features.
<b>APRS</b>	Automatic Packet - Real-time tactical digital communications using a map to show the locations of stations
<b>AR</b>	Automatic Repeat - A digital scheme whereby the receiving station detects errors and sends a request to send again
<b>ARES</b>	Amateur Radio Emergency Services
<b>ARRL</b>	The Amateur Radio Relay League. Originally messages were routinely passed from one operator to the next (relayed) to get information sent great distances.
<b>ATV</b>	Amateur Television - Hams using video cameras and TV's with their transceivers to have two-way video
<b>Auxiliary Station</b>	A special repeater generally devoted to extending coverage for an individual station.
<b>Band</b>	A segment of the radio wave spectrum, identified by the approximate wavelength. For example, a2 Meter Band signal is approximately 2 Meters long for one wavelength.
<b>Band Plan</b>	A description or illustration of how parts of each band or wavelength segment is appropriately used.
<b>Beacon</b>	An amateur radio propagation beacon is a radio beacon, whose purpose is the investigation of the propagation of radio signals. They continuously transmit signals to demonstrate how well the signals are traveling.
<b>Beam Antenna</b>	See Directional Antenna.
<b>CQ</b>	Calling Any Station
<b>Call Sign</b>	The letters and number assigned by the FCC to a given license holder. All call signs are unique, meaning only one person or entity may hold a valid call sign. If a license has expired and the grace period has passed, that call sign may be issued to someone
<b>Capacitor</b>	A component that can store energy in an electrical field.

<b>Carrier Signal</b>	This is like the foundation of a radio signal. This is the basis which is altered by the mixer to be the desired frequency and has modulation added upon it so communication works.
<b>Check sum</b>	A method of error checking. The "check" is the number of words in the message.
<b>Coax</b>	A feed line composed of a center wire which carries the RF signal surrounded by an insulating layer which is then surrounded by a braided wire mesh which is covered by a sturdy insulated covering. This is always round. Most Ham coax is 50 Ohm.
<b>Code</b>	Generally, this refers to Morse Code. Someone "talking code" is using Morse Code to communicate. This could also be part of a telecommand. Passing coded messages to hide their meaning is prohibited.
<b>Contesting</b>	A timed event where amateur radio operators try to contact as many other operators as they can within the time allotted.
<b>Control Operator</b>	The FCC licensed Amateur Radio Operator that has control of the transceiver.
<b>Control Point</b>	The point at which you control the transmitting on the radio. Usually the "PTT" or Push To Talk button.
<b>CTCSS</b>	Continuous Tone - Repeater stations generally require sending a CTCSS as part of the transmission. This
<b>Current</b>	A measurement of the flow of electrons in an electric circuit. A measurement of Amps shows the level of current.
<b>CW</b>	Continuous Wave, meaning Morse Code
<b>dB</b>	Decibel - A unit of measurement used to express the ratio of one value of a physical property to
<b>DC</b>	Direct Current - Electric current flowing in one direction. All batteries use DC. If there is a + and a -
<b>DCS</b>	Digital-Coded - Similar to CTCSS but this is digital where CTCSS is analog.
<b>Diode</b>	An electrical component like a one-way gate. Current can only flow in one direction through diode.
<b>Directional</b>	An antenna that focuses the signals in one direction.
<b>DMR</b>	Digital Mobile Radio - A digital radio standard originally designed for commercial users
<b>DMR Talk Group</b>	DMR is a digital method to communicate through a repeater which allows two conversations simultaneously occur. A talk group is similar to a chat room where multiple people take turns talking.
<b>Doppler Shift</b>	An observed change in frequency. The frequency of sound changes as the fast moving by. The radio frequency changes as the satellite rushes by.
<b>Double or Doubling</b>	When two stations transmit at the same time neither transmission works well. You know you were "doubled" when you stop talking only to hear someone else finishing their transmission.
<b>DTMF</b>	Dual-Tone Multi- - This is the audible tones used to dial a telephone number and is call "Touch Tone."
<b>Ducting</b>	VHF long distance path caused by temperature and humidity than the layers above and below it. This is similar to an "inversion" layer.
<b>Dummy Load</b>	A non-inductive resistor and a heat sink to be used in place of an antenna. This is used when testing transmitters so no actual signal is transmitted out.
<b>Duplex</b>	Receiving on one frequency and transmitting on a different one. This dual frequency use is called duplex, or duplexing. Repeaters use duplex.

<b>Duty Cycle</b>	The percentage of time that a transmitter is transmitting vs receiving.
<b>EchoLink</b>	A service where repeaters can be accessed through the Internet most anywhere in the world.
<b>Emergency, May Day, SOS</b>	The terms Emergency, Priority, May Day, SOS, and usually Break are serious words. Anyone hearing these should immediately help anyone that used the term. Those using these terms need to have an actual emergency such as a life-threatening problem.
<b>Farad</b>	A measurement of stored electrical energy.
<b>FCC</b>	Federal Communications Commission - The US agency regulates and enforces the rules for Amateur Radio Service.
<b>FCC Rules</b>	Always follow the FCC rules when transmitting. One rule is that all other rules can be ignored if violating those other rules will save human lives.
<b>Feed Line</b>	The wire that connects a transceiver to the antenna. Hand-held transceivers have no visible feedline.
<b>Ferrite Choke</b>	A passive electric component that suppresses high frequency noise in electronic circuits. These are often seen a cylindrical lump near the end of an electrical or signal cord.
<b>FET</b>	Field Effect Transistor - A special transistor. The leads are the source, gate and drain
<b>FM</b>	Frequency Modulation - Frequency is changed to add the modulation known as voice.
<b>Frequency</b>	How often something occurs. In radio, it is how often a radio wave completes one cycle. This is measured in Hertz (Hz). Higher frequencies are Kilohertz (kHz), Megahertz (MHz), Gigahertz (GHz), Terahertz (THz), etc.
<b>Frequency Coordinator</b>	A volunteer group that recommends frequency use for local repeaters.
<b>Fuse</b>	A device designed to stop the flow of energy if the flow exceeds the capacity of the fuse. Without a fuse, an electrical device could malfunction and burn or explode.
<b>Gain</b>	The change in performance. A transistor has gain which means it can amplify the current. An antenna can have gain which means it can amplify or improve the transmission.
<b>Gateway</b>	An amateur station allowing other stations to access the Internet through their station.
<b>Gin pole</b>	An attachment used to erect tall antenna supports called towers. This is a tall movable brace with a pulley at the top allowing heavy sections to be lifted into place at the top of the tower.
<b>Grid Locator</b>	A letter-number designator assigned to a geographic location. Class location is: EL88xu
<b>Ground</b>	A connection from an electric item to a ground rod driven into the earth.
<b>HAM</b>	Amateur Radio Operator - No one really knows where the term Ham came from or what it really means
<b>Henry</b>	A measurement of stored magnetic energy.
<b>Hertz</b>	The measurement of frequency and is defined as one cycle per second. Common household electricity operates at 60 Hz, or 60 cycles per second.
<b>HF</b>	High Frequency - This is from 3 MHz to 30 MHz. This is generally from the 10 Meter band to the 160
<b>Identify</b>	You identify yourself during transmissions by stating your FCC designation which is your call sign. The rules state it is done at the end of every ten minutes and at the end of the transmission.



<b>Impedence</b>	An opposition to the flow of AC current. Impedence is measured in ohms.
<b>Inductor</b>	A component that can store energy in a magnetic field.
<b>Ionosphere</b>	A layer of the atmosphere that can reflect HF signals back down to the earth. There are multiple layers within the Ionosphere.
<b>IRLP</b>	Internet Radio - This uses Voice-Over-IP (VoIP) custom software and hardware. Coupled with the
<b>ITU</b>	International - This the United Nations specialized agency for information and communication
<b>Keplerian elements</b>	Data inputs for satellite tracking.
<b>Ladder Line</b>	A special feed line composed of two wires separated by an insulator. This feed line looks like a rope ladder for an action figure toy.
<b>LED</b>	Light Emitting Diode - A diode which emits light. See Diode.
<b>LEO</b>	Low Earth Orbit - Most amateur radio satellites use low earth orbits.
<b>Linked Repeaters</b>	Connecting two or more repeaters is linking them. This link may be with a radio connection or by using an Internet connection. The radio linking is limited by the range of the signal while the Internet linking is only limited by the connection to the Internet
<b>Log Book</b>	This is your record of Amateur Radio communications. This should include the date, time, and frequency of the transmission, and the call sign of who you communicated with.
<b>LSB</b>	Lower Side Band - See SSB
<b>Memory</b>	Saving a frequency and other option within a transceiver.
<b>Meter</b>	A display. This could be a needle flexing or a series of lights. Either version offers a visual indication of the item being measured. These include a speedometer, a voltmeter, an ohmmeter.
<b>Mixer</b>	A component that changes the frequency generated by the oscillator. This allows one transceiver to access several frequencies.
<b>Modulation</b>	The addition of the sound inputs changed into RF. This get added to the carrier signal and transmitted. This is your voice spoken into the microphone and changed into electrical impulses.
<b>Morse Code</b>	A communications system where letters (or other characters) are represented by long sounds(dah) and short sounds (dit) transmitted over the air. For example, dah, dit dit, dah dah, dit would be the word "time."
<b>MPE</b>	Maximum Permissible Exposure - The MPE limits are based on whole-body specific RF absorption rates.
<b>MR</b>	Memory Recall - A setting to use the memorized frequencies.
<b>NB</b>	Noise Blanker - Reduces certain noises
<b>NCS</b>	Net Control Station - The station or operator directing the Ham radio net.
<b>Net</b>	An organized communication involving a group of Hams. This would either be a directed net which includes the NCS or an informal net which would be like a chat room.
<b>Noise Blanker</b>	A setting in the receiver to cut or reduce certain noise sources.
<b>NPN or PNP</b>	Negative and Positive - This transistor has three leads; emitter, base and collector

<b>NTSC</b>	National Television - The pre-1990 analog TV signal standard in the US.
<b>Ohm</b>	A measurement of the opposition to the flow of electrical current. The measurement of ohm is in both AC (measured as impedance) and DC (measured as resistance) circuits.
<b>Ohmmeter</b>	Measure's ohms or resistance. This is a powered setting on the meter so be sure there is no power in the circuit.
<b>Omnidirectional</b>	A normal antenna which sends the radio signal out equally in all directions
<b>Operator</b>	The person allowed to operate the radio.
<b>Oscillator</b>	A component that generates a signal or sound. The oscillator makes the carrier signal which is the transmission.
<b>Over-deviation</b>	An excessive level of modulation or voice input. A microphone should be held sideways to your mouth to avoid over-deviation. Think of a young child with a microphone; they often over-deviate by talking too close to the mic.
<b>Parallel</b>	An electrical connection where the current flows through multiple paths. Some components may not have the current flow through since an alternate path is available. Usually, the components share the current flow.
<b>PEP</b>	Peak Envelope Power - Peak envelope power is the maximum power at a given point in time
<b>Phone</b>	Speaking, as in Phonetic, using your voice.
<b>Phonetic</b>	Using words to represent letters. Like Alpha for A, Bravo for B, etc.
<b>PNP or NPN</b>	Transistor - either one negative and two positive or vice versa.
<b>Potentiometer</b>	A variable resistor. This has the ability to change the potential energy passing through.
<b>Power Supply</b>	A device to convert AC 110 V power to the DC 13.8 V (12 V) power the transceiver requires.
<b>Propagation</b>	The travel of a radio signal. Poor propagation means the signals are not traveling far. Good propagation means distant signals can be heard. Great propagation may include worldwide communication.
<b>PS</b>	heavier and more expensive than a switching PS, but it is also more accurate and dependable.
<b>PSK</b>	Phase Shift Keying - A popular computer-sound card-generated radioteletype mode.
<b>QRM</b>	Manmade noise - This means "I am receiving noise" which is not from nature
<b>QSY</b>	Switching to another frequency - This means "Follow me as I change to _____ frequency."
<b>RACES</b>	Radio Amateur Civil Emergency Service - Government activated only during the emergency and during the immediate aftermath
<b>Radio Horizon</b>	The point where a radio signal ends. Radio waves travel along the earth better than light waves, so radio signals can go slightly beyond the visible horizon.
<b>Radio Wave</b>	An energy wave consisting of Electrical energy and Magnetic energy; therefore, it is Electromagnetic energy. This travels at the speed of light which is stated as 300,000,000 Meters per second.
<b>Receiver</b>	Slightly adjusts the receive frequency up or down. This does not change the transmit frequency. Incremental Tuner

<b>Rectifier</b>	A component composed of diodes aligned to alter the flow of current from alternating current to direct current.
<b>Relay</b>	Retransmitting from one station to another. Generally, when distance prevents one station from hearing the other, a station within range of both can relay the messages back and forth.
<b>Repeater Offset</b>	This is the difference between the frequency a repeater receives on vs. what it transmits on. For 2M it is generally plus or minus 600 kHz and for 70 CM it is plus or minus 5 MHz
<b>Repeater Station</b>	A transceiver that receives a signal and immediately retransmits that signal. These are generally on mountain tops so they can transmit greater distances. Often just called a repeater.
<b>Resistance</b>	An opposition to the flow of DC current. Resistance is measured in ohms.
<b>RF</b>	Radio Frequency - The frequency of the Electromagnetic energy emission commonly called a radio wave.
<b>RIT</b>	Receiver Incremental - Slightly adjusts the receive frequency up or down. This does not change the transmit
<b>Schematic</b>	A drawing of symbols representing how electrical components are connected.
<b>Secondary User</b>	There is a primary user (often the government) who has priority. As long as they are not using the frequency, a secondary user can transmit. But the secondary user cannot interfere with the primary user.
<b>Selectivity</b>	The ability to choose. In a transceiver this chooses one signal over another.
<b>Sensitivity</b>	The ability to detect. In a transceiver this pulls in the weak signal.
<b>Series</b>	An electrical connection where the current flows through all components in order.
<b>Simplex</b>	Receiving and transmitting on the same frequency. This is simple.
<b>Space Station</b>	A repeater or Amateur Radio Station over 50 km above the earth, generally in orbit.
<b>Spin Fading</b>	An observed change in signal strength as a satellite rotates during its orbit.
<b>Squelch</b>	A setting where the receiver silences unwanted levels of sound. If the squelch is set too high, distant signals will not be heard. If it is not set high enough, steady static is heard.
<b>SSB</b>	Single Side Band - An amplitude modulation that uses one sideband with a carrier
<b>Stroke, Slant, Slash</b>	The separation between your call sign and a special designator like the slash in a date ("/").
<b>Switch</b>	A device to connect or open an electrical circuit, often used to turn on a light or other electrical device.
<b>Switching PS</b>	A small power supply that uses a rectifier to convert house current to DC.
<b>SWR</b>	Standing Wave Ratio - A measurement of how much radio wave energy is reflected from the antenna back to the transmitter
<b>Tactical Call Sign</b>	This is a term used to temporarily identify your station. You must still use your FCC call sign (see Identify) according to the rules.
<b>Telecommand</b>	A radio signal transmitted with the intent to control a device. Such as initiating, modifying, or terminating the functions of a device. This could be a repeater, a space station, or your RC vehicle.
<b>Traffic</b>	A specific organized message that is passed from one operator to the next intending to deliver the

<b>Transceiver</b>	A radio that both transmits and receives.
<b>Transformer</b>	This component changes or transforms AC power, usually from 120 V to a smaller value. These exchange the extra volts into heat which is why some transformers are hot when in use. The greater the energy difference, the hotter the transformer will be.
<b>Transistor</b>	A component consisting of three layers of semiconductor material. Transistors can amplify a signal and they can direct the flow of current.
<b>Transmit</b>	To send a radio signal.
<b>Tropospheric</b>	A phenomenon where a radio signal bounces up and down within a layer of the atmosphere
<b>UHF</b>	Ultra High Frequency - This is from 300 MHz to 3000 MHz
<b>Uplink or Downlink</b>	The radio transmission to or from a space station.
<b>USB</b>	Upper Side Band - An amplitude modulation that uses one sideband with a carrier
<b>Variable</b>	Some electrical components can be adjusted and have "variable" before their name. These include a variable resistor (potentiometer) and a variable inductor.
<b>VFO</b>	Variable Frequency - The ability to change to any frequency within the radio's capability. Radios used to use
<b>VHF</b>	Very High Frequency - This is from 30 MHz to 300 MHz. This is generally from the 2 M to the 6 M band
<b>VoIP</b>	Voice over Internet Protocol - A methodology for the delivery of voice communications
<b>Voltmeter</b>	Measure's volts or electromotive force and is connected in parallel with the circuit.
<b>Volts</b>	A measurement of the electromotive force.
<b>Watts</b>	A measurement of electrical power. Power is measured in watts.
<b>Wavelength</b>	The distance traveled by a radio wave during one cycle. This can be measured from the top (peak to peak), the bottom (trough to trough), or any other single point of the radio wave.
<b>Window Line</b>	A special feed line composed of two insulated wires running parallel separated by 1" of flat insulation which has squares cut out looking like windows.