Technician Class Study Guide

Class Course Book for July 2022 to June 2026

K4VRC

The Villages Amateur Radio Club
The Villages, Florida
www.k4vrc.com

Message from The Villages Amateur Radio Club President

Future HAMs,

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 computers. The United States Amateur Service license is required similar to a driver's license and grants you the most wireless communications privileges 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. 2012 marked one hundred years of amateur radio operator and station licensing by the United States government. 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. 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.

The Villages Amateur Radio Club classes are about HAM Radio from mentors in a positive learning environment and welcoming to people who have not been in a classroom for decades. The Technician class license is the entry-level license for most new ham radio operators. To earn the Technician license requires passing a written examination totaling 35 questions on radio theory, regulations and operating practices. The license gives access to all Amateur Radio frequencies above 30 megahertz, allowing these licensees the ability to communicate mostly within North America. It also allows for some limited privileges below 30 megahertz (also called "short wave") bands used for international communications.

Looking forward to congratulating your success,

George K2DM

George Briggs
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.

Table of Contents

MESSAGE FROM THE VILLAGES AMATEUR RADIO CLUB PRESIDENT 2

CHAPTER 1 – INTRODUCTION AND HOW TO USE THIS STUDY GUIDE 4

CHAPTER 2 - RADIO AND SIGNALS FUNDAMENTALS 7

CHAPTER 3 - ELECTRICITY, COMPONENTS AND CIRCUITS 9

CHAPTER 4 - PROPAGATION, ANTENNAS, AND FEED LINES 15

CHAPTER 5 - AMATEUR RADIO EQUIPMENT 18

CHAPTER 6 - COMMUNICATING WITH OTHER HAMS 22

CHAPTER 7 - LICENSING REGULATIONS 26

CHAPTER 8 - OPERATING REGULATIONS 27

CHAPTER 9 – ELECTRICAL, MECHANICAL AND RF SAFETY 29

GLOSSARY 31

Revisions

2022 – 2026 Question Pool Original Release - June 21, 2022

Chapter 1 - Introduction

Just Enough for Understanding

Studying for your first 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 15 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.

Seven Classes

The seven classes will meet for about two 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

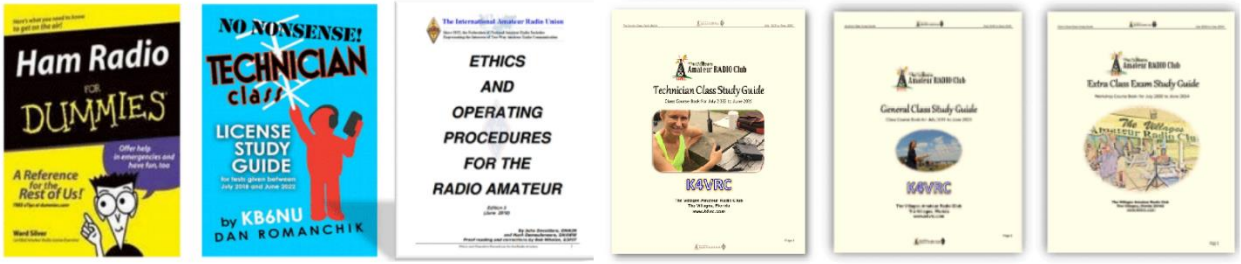
If you attend all classes, keep up with readings, and take practice tests conscientiously, preparing can be a relatively pain-free process. Pain-free does not mean work-free! Take practice tests online from multiple sites or different APPs. Many past students have found that preparing for the exam for 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;

Class Resources Online
www.k4vrc.com "Interest in becoming a HAM?"

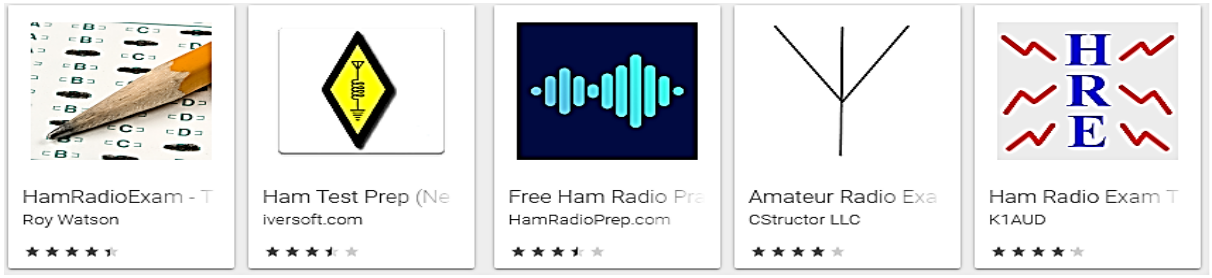
Free Books about HAM Radio and Class Study Guide



Class Resources Online
www.k4vrc.com "Interest in becoming a HAM?"

Practice Exams for this course

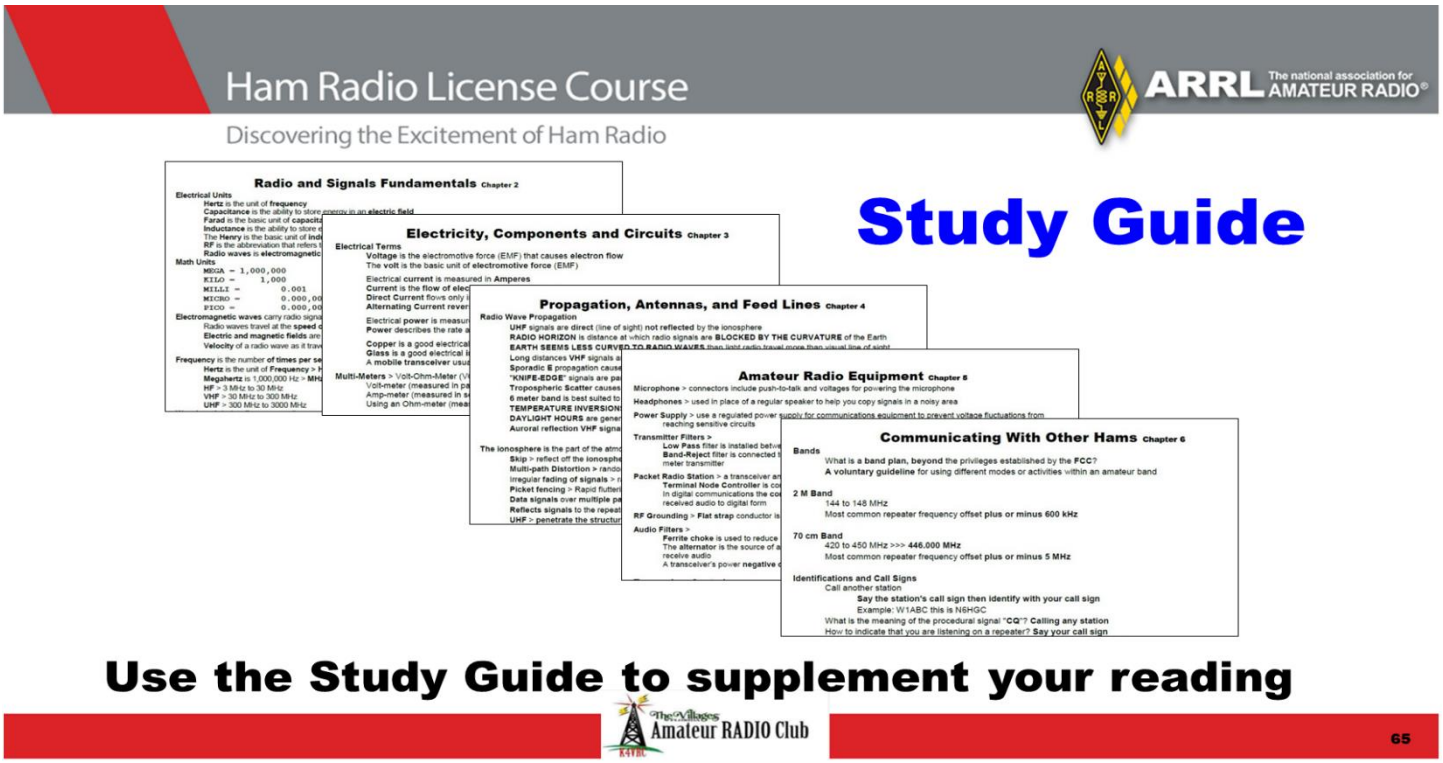
Take online practice tests online, but not more than once a day.



Dave Casler KE0OG Videos lectures are highly recommended.

Dave Casler KE0OG Videos

How to use this Study Guide



How to use this Study Guide

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 the ARRL Ham Radio License Manual to review questions you answered incorrectly. The Technician Class Question Pool is sorted alphanumerically with the page number where the question is discussed in the text of the ARRL Technician Class License Manual 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 by chapter. This Study Guide is one more tool like the text book and videos to help you succeed,

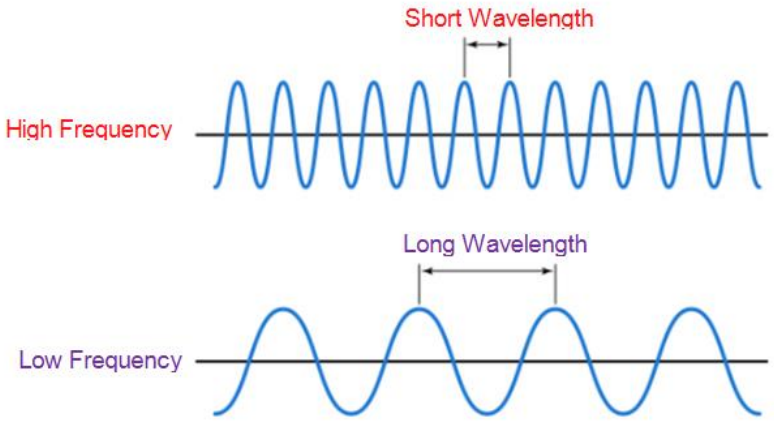
Chapter 2 - Radio and Signals Fundamentals

Wavelength and Frequency Relationships

Wavelength Calculation

$$\text{Wavelength} = \frac{\text{Speed of Light}}{\text{Frequency}}$$

$$\lambda = \frac{300}{\text{MHz}}$$



Electromagnetic waves

3–30 Hz	30–300 Hz	300–3000 Hz	3–30 kHz	30–300 kHz	300 kHz – 3 MHz	3–30 MHz	30–300 MHz	300 MHz – 3 GHz	3–30 GHz	30–300 GHz	300 GHz – 3 THz
10^5– 10^4 km	10^4– 10^3 km	10^3– 100 km	100–10 km	10–1 km	1 km – 100 m	100–10 m	10–1 m	1 m – 10 cm	10–1 cm	1 cm – 1 mm	1 mm – 0.1 mm
ELF	SLF	ULF	VLF	LF	MF	HF	VHF	UHF	SHF	EHF	THF

Chapter 2 - Radio and Signals Fundamentals

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 ⌂ MOVE DECIAL POINT

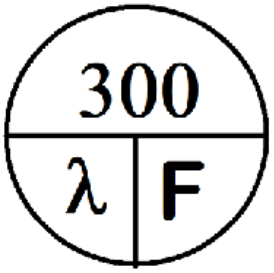
Frequency is the number **of times per second** that an alternating current reverses direction

Hertz is the unit of **Frequency > Hz**
Megahertz is 1,000,000 Hz > **MHz**
HF > 3 MHz to 30 MHz
VHF > 30 MHz to 300 MHz
UHF > 300 MHz to 3000 MHz

Electromagnetic waves carry radio signals

Radio waves travel at the **speed of light**.
Electric and magnetic fields are the two components of a **radio wave**.
Velocity of a radio wave as it travels through free space is **300,000,000 Meters per second**

Wavelength is the **distance** a radio wave travels during **one cycle**



The symbol for Wavelength is λ

Wavelength is the inverse of frequency

When the wavelength gets shorter the frequency increases
Higher in frequency the shorter the distance between each wave.

The formula for **converting frequency to wavelength** is;

λ or Wavelength = Speed / Frequency

λ or Wavelength (Meters) = 300 Meters / Freq in Megahertz

λ or Wavelength (Meters) = 300 / Freq (MHz)

λ = 300 / F

300 = λ x F

F = 300 / λ

Frequency bands are the approximate Wavelength of the band: 2 meters; 20 meters; 40 meters, etc

Electrical Units

Hertz is the unit of **frequency**
RF is the abbreviation that refers to **radio frequency** signals of all types
Radio waves is **electromagnetic waves** that travel through space

Radio Terms

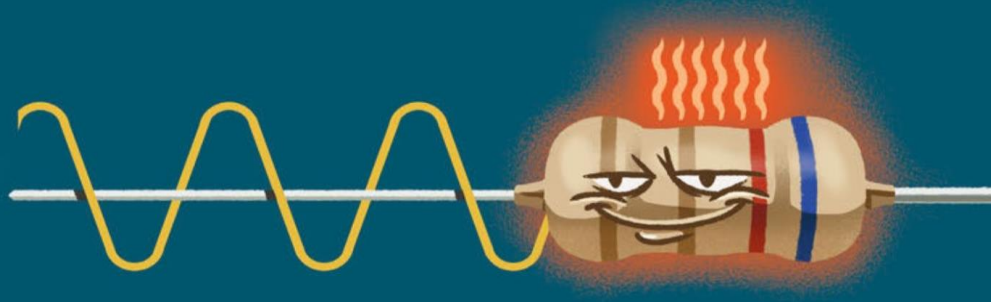
A **transceiver** is a device that combines a receiver and transmitter
Repeater station simultaneously retransmits the signal of another station on a different frequency

Chapter 3 - Electricity, Components and Circuits

Impedance — The Loyal Opposition

You'll hear a lot of talk in amateur radio circles about *impedance*. Defining impedance gets a bit complicated, because it's a combination of what a psychologist might call three "oppositional behaviors." Some of these behaviors can be quite stubborn and uncooperative, but in the end they all work together to create impedance.

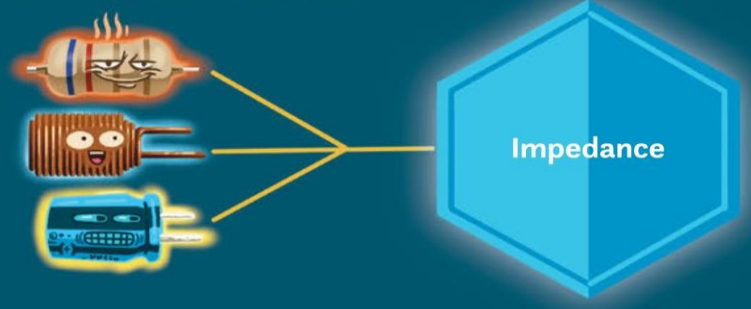
Resistance
Resistance is the tough guy of the electronics world. It won't allow a signal to move without turning at least some of it into heat. Resistance is everywhere, but it is concentrated in familiar devices known as *resistors*.



Inductive Reactance
When a signal encounters a circuit component known as an *inductor* — which often takes the form of a coil of wire — the inductor reacts by creating a magnetic field. As that field expands and collapses along with the signal, it generates a voltage in the coil that effectively opposes the flow of the signal.

Capacitive Reactance
This is first cousin to inductive reactance. When capacitance is present, such as in a component called a *capacitor*, the signal causes an electric field to appear. The field then acts to oppose the signal.

These three oppositions combine in a mathematical way to create impedance.

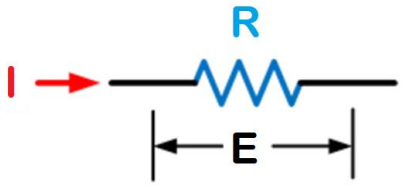


Impedance can be headstrong, but it's not all that bad. As long as the impedance in one circuit matches the impedance of the circuit it is connected to, signals flow and everyone is happy. For more about impedance and the all-important match, see "Untangling SWR" and "Antenna Tuners: Making a Match," in the January/February 2021 issue of *On the Air*.

Chapter 3 - Electricity, Components and Circuits

Electrical Terms

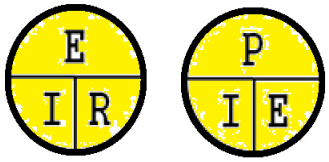
Voltage is the electromotive force (EMF) that causes **electron flow**
Electrical **current** is measured in **Amperes**
Current is the **flow of electrons** in an electric circuit
Direct Current flows only in **one direction**
Alternating Current alternates between positive and negative directions
Electrical **power** is measured in **Watts**
Power describes the rate at which electrical **energy** is used
Metals are good conductors as they have many **free electrons**
Glass is a good electrical **insulator**
Farad is the basic unit of capacitance
Inductance is the ability to store energy in a magnetic field
The **Henry** is the basic unit of inductance
Series circuit has the **same DC current** through all components
Parallel circuit has the **same DC Voltage across** all components



Electrical components

Resistance (Resistor) to **oppose the flow** of current in a DC circuit **> Measured in Ohms**
Resistance is controlled by a **potentiometer**
Potentiometer is used as an **adjustable v**olume control
Capacitor stores energy in an **electric field**
Capacitor consists of two or more **conductive surfaces separated by an insulator**
Capacitor is used together **with an inductor** to make a **tuned circuit**
Inductor stores energy in a **magnetic field**
Inductor is usually composed of a **coil of wire**
Impedance opposes the flow of current in an AC circuit > Measured in Ohms
A **Capacitor and Inductor combined make a tuned circuit** in an AC circuit
A SPDT switch is connects between one of two circuits
Relay is a electrically controlled switch
Fuse is used to protect other circuit components from **current overloads**
Transformer changes 120 V AC power to a lower AC voltage for other uses

OHMS LAW

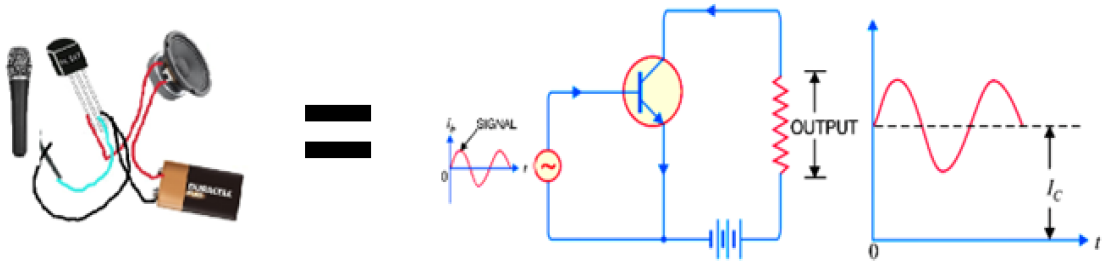


E = I x R Voltage = Current x Resistance
I = E / R Current = Voltage / Resistance
R = E / I Resistance = Voltage / Current

P = E x I Power = Voltage x Current
I = P / E Current = Power / Voltage

Semiconductors

Transistor can be used as an electronic **switch or amplifier**
Transistor can **amplify** signals
Gain is a transistor's ability to **amplify a signal**
Transistors can provide **power gain**
Regulator controls the amount of **voltage** from a power supply
Transistor is made of three **layers of semiconductor** material
Bipolar transistor has an **emitter**, base & collector electrodes
"FET" stands for **Field Effect Transistor**
Field effect transistor has a gate, drain, and source
Diode forward voltage drop is lower in some diode types
Diode allows current to flow in only **one direction**
Diode's cathode lead usually identified with a **stripe**
Anode and cathode are the names of the two **electrodes of a diode**
Rectifier changes an **alternating current** into a varying **direct current** signal
Integrated circuit combines several semiconductors and other components into one package
"LED" stands for **Light Emitting Diode**
LED is commonly used as a **visual indicator**
Forward current causes an LED to emit light



Schematic Circuit Diagrams

Schematic symbols are standardized **representations of components** in an electrical wiring diagram
The **symbols** on an electrical circuit schematic diagram **represent electrical components**
Schematic diagrams represent the way components are **connected**
A Mixer converts a radio signal from one frequency to another
Oscillator generates a signal at a specific frequency
A Modulator combines speech with an RF carrier signal

Multi-Meters > Volt-Ohm-Meter (VOM), Digital-Volt-Meter (DVM) Using a;

Meter displays an electrical quantity as a **numeric value**
Volt-meter (measured in parallel)
Amp-meter (measured in series)
An **ammeter** is used to measure **current**
Attempting to measure voltage when using the resistance setting can damage a multimeter
Using an Ohm-meter (measures resistance WITHOUT power DO NOT DAMAGE METER)
You would use a **VOLTMETER** to measure electric potential or **electromotive force**
Voltage and resistance measurements are commonly made using a **multimeter**
An **ohmmeter** shows low resistance then **increasing resistance** with time the circuit contains a **large capacitor**

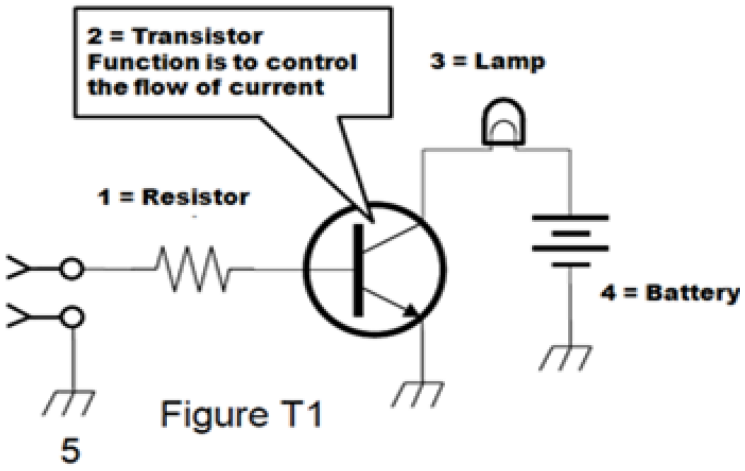


Figure T1

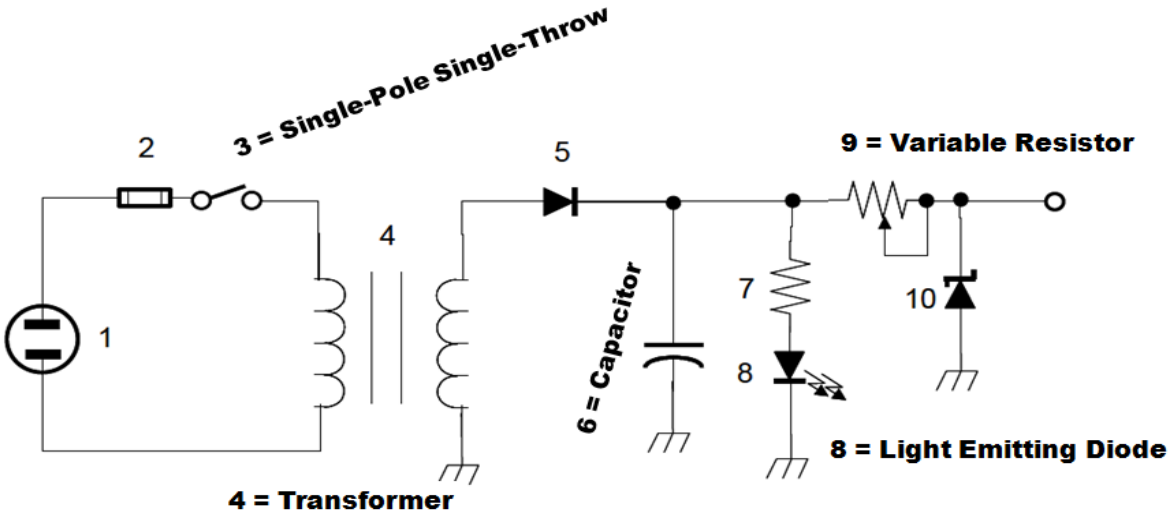


Figure T2

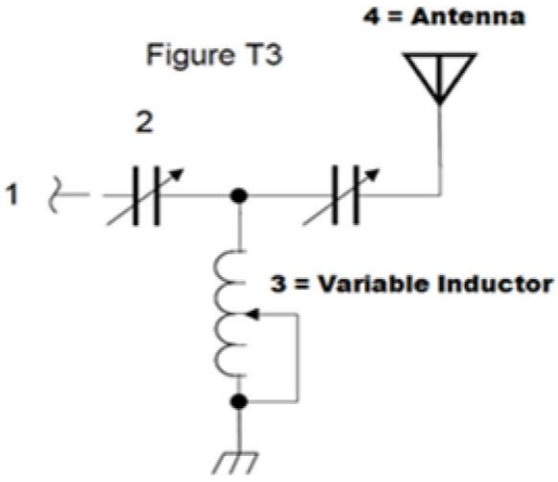


Figure T3

The ABCs of the Digital Multimeter

Paul Danzer, N1II

A digital multimeter (DMM) is an excellent tool to add to your amateur radio station. This single device can measure voltage, current, resistance, and sometimes much more. When something goes wrong, such as when your transceiver will no longer switch on, your meter will often help you track down the problem. For example, if the multimeter shows that the output voltage of the power supply is too low — or not present at all — that's a strong hint that it has failed.

Most DMMs are very similar to each other. The better the accuracy, the more expensive the meter. Each model has basic features you want around your ham station, and some additional capabilities. For all-around use, an inexpensive meter selling for less than $20 is all you need.

Figure 1: The display tells you the numbers represent a dc voltage, and the meter is automatically selecting the meter range. A negative voltage would include a minus sign on the left.

A Quick Tour of the Front Panel

Figure 1 shows a typical low-cost DMM. The measured value is displayed digitally. The dial has separate positions for ac volts and dc volts, and separate positions for ac current and dc current.

There is an OFF position to save battery wear, a position to measure resistance — symbolized by the Ω (omega) or ohms marking — a diode symbol for checking diodes, and a set of concentric curves symbolizing sound for a continuity check (a way of checking to see if there is an electrical connection between two points).

The markings around the three input jacks near the bottom (see Figure 2) are most important. The lines linking the three jacks are there to remind you where to connect the test leads, in case you don't remember or haven't read the instruction book. Most measurements are made with the common (ground) pin in the center (coded black) and the right-hand jack (coded red) for all the marked functions, such as measuring a dc voltage.

Figure 2: The center black jack is used as the return for measuring the items listed above the right-hand red jack, plus low-current dc. The left-hand red jack is used only for high-current dc.

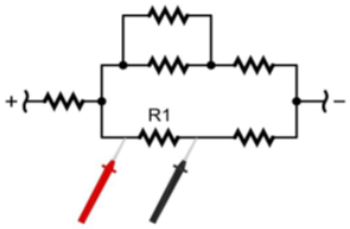


Figure 3: Voltage is measured by putting the probes across the points to be measured. [QS1710-Danzer04]

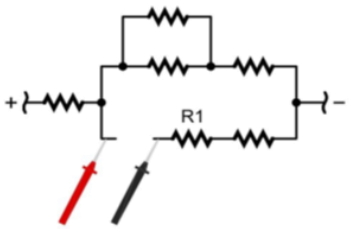


Figure 4: Current is measured by breaking the wire carrying the current and putting the probes in series with the wire across the break. [QS1710-Danzer05]

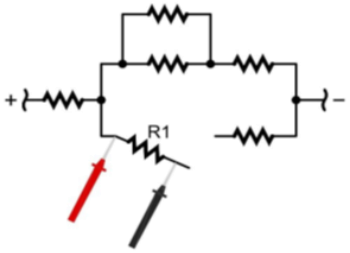


Figure 5: Resistance is measured with one end of the resistor disconnected from the circuit. [QS1710-Danzer06]

Using the DMM Safely

As long as you do not place your fingers on any circuit that contains a high enough voltage to be a danger to you, the "safety" here is safety for the meter. You need to know how much current and voltage your meter can handle. If you connect the meter to measure values over these limits, you may just pop a fuse in the meter, or you may do "terminal damage," meaning you've broken your meter!

Next, select the proper dial setting — ac or dc. Typically, selecting ac when you should have selected dc, or dc instead of ac, will not damage anything, but the reading will not be correct. Also, if you are measuring a voltage and suddenly move the meter dial to, say, a resistance measurement, this can result in a blown fuse or a dead meter.

For measuring voltage, the test probes should be connected to the common terminal (usually coded black) and the voltage terminal (in Figure 2, the terminal for measuring voltage is on the right-hand side, and is coded red). Finally, the probes are connected across the points to be measured. In Figure 3, they are across a resistor — R1 — that is part of a circuit.

Current, ac or dc, is measured by breaking the circuit, as shown in Figure 4. The two probes are connected in series with the resistor or other device that you want to measure. This is a chance to accidentally blow the fuse or damage the meter. Often when checking a circuit, you might make several voltage and current measurements, one after another. The probes stay connected to the red and black terminals for all the tests. It is common to measure a current and then decide to measure another voltage. If you forget to move the selector switch from current to voltage, you will definitely blow something!

Resistance is measured by connecting the probes across the resistor — one probe touching one end of the resistor, and the other probe touching the opposite end. However, you do have to cut or unsolder one end of the resistor (see Figure 5), or else you will not measure the resistor alone, but the parallel combination of that resistor with whatever other components are connected across the resistor.

The continuity position (shown as concentric curves at the lower right of the dial in Figure 1) is just a variant of the resistor measurement. If two points in a circuit are linked with a very low-resistance connection, the ohmmeter function in your multimeter will detect this low resistance and a buzz or beep will tell you the connection is good. This means the connection is capable of passing voltage and current.

To measure a higher dc current than the 200 mA maximum allowed on the current scale — perhaps if you wanted to see how much current your radio is drawing from a battery, which could be several amps of current or more — you have to use the left-hand terminal with one lead and the center terminal with the other. In addition, you must set the function switch to DC10A. Notice the line drawn under the center and left terminal (see Figure 2) to remind you that this is the connection to use. While the low-current measurement circuit is protected by a fuse, the high-current circuit is not. So, if you misconnect the meter using the high DC10A terminal, the meter will be damaged.

The diode position is again just a variation of the resistance measurement. With the probe connected as shown in Figure 6, this meter will read the voltage drop that a diode causes at that point in the circuit. The voltage-drop value depends on the type of diode. Some other meters read the forward resistance in place of the voltage drop. When the probes are reversed, the meter will show the letters OL (see Figure 7), meaning overload. In other words, the resistance measurement in this position exceeds the capability of the meter (but not in a dangerous way). This indicates a good diode, assuming the first measurement was okay.

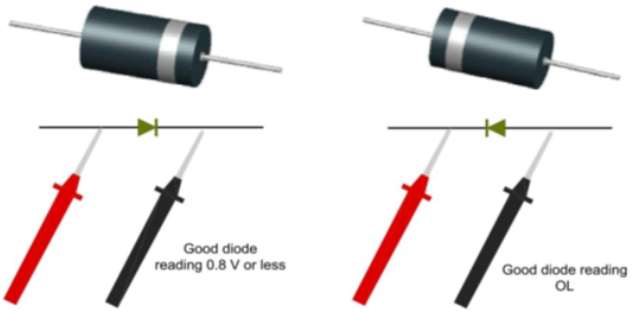


Figure 6: Reversing the red and black probes allows you to check the forward and reverse bias conditions of the diode. [QS1710-Danzer07]

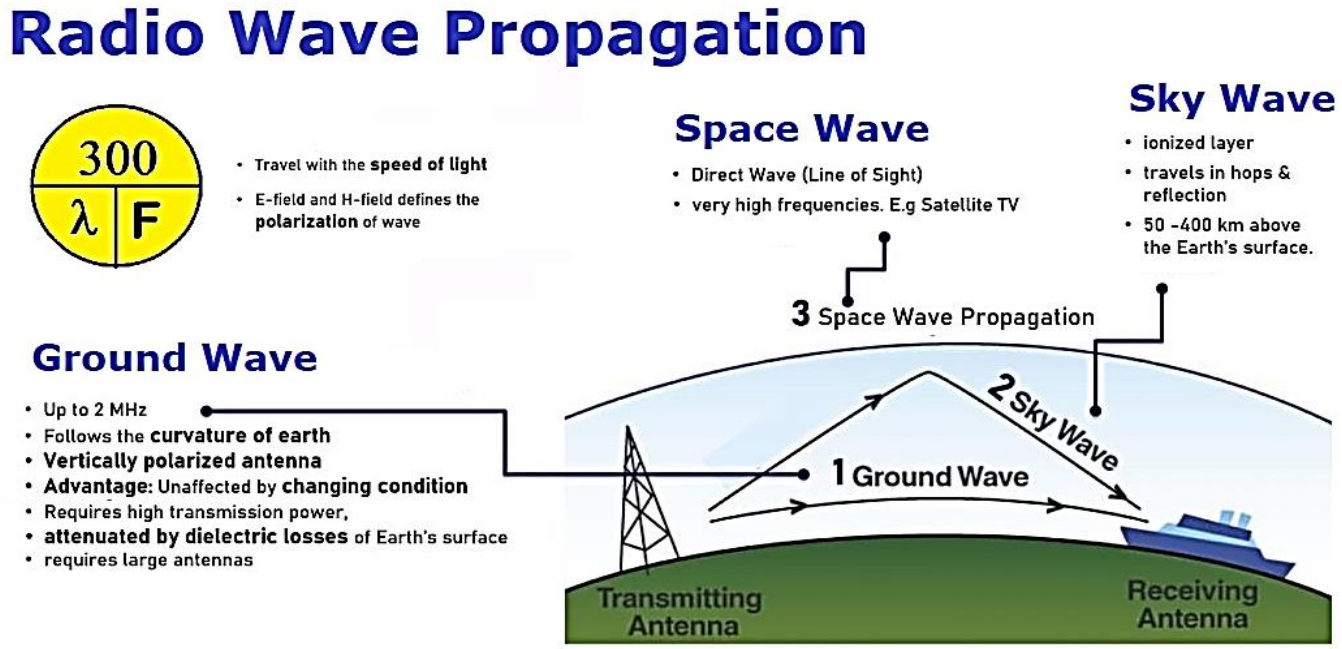
Figure 7: An out-of-range measurement results in this OL (overload message).

Paul Danzer, N1II, was first licensed as KN2DGR in 1953, and credits his ham radio experience with leading to a long career as an electronics engineer.

Chapter 4 - Propagation, Antennas, and Feed Lines

Radio Wave Propagation

Radio Waves are Electromagnetic (electric and magnetic fields)
Electromagnetic waves have electric and magnetic fields at right angles
RADIO HORIZON is distance at which radio signals are **BLOCKED BY THE CURVATURE** of the Earth
Atmosphere refracts VHF-UHF radio waves **more distant radio horizon** than the visual horizon
VHF-UHF line of sight **signal strength is reduced when polarizations are opposite**
Long-distance ionospheric propagation is far more common on HF than VHF-UHF
TEMPERATURE INVERSIONS in the atmosphere causes "**TROPOSPHERIC DUCTING"**
Fog and light rain will have **little effect** on 10 and 6-meter bands
DAYLIGHT HOURS are generally the best time for long-distance **10 METER BAND PROPAGATION**
Precipitation decrease range at microwave frequencies
Absorption by vegetation reduces the range of **VHF and UHF signals**



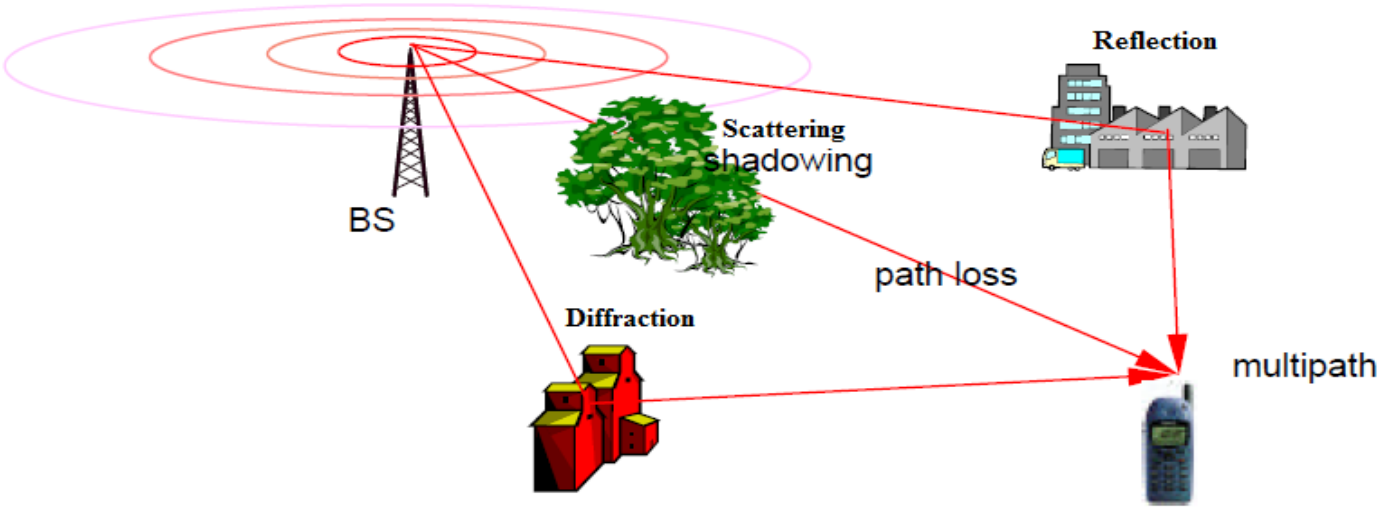
The ionosphere is the part of the atmosphere that enables the propagation of radio signals around the world.

UHF signals are usually **not propagated** by the ionosphere
The **ionosphere enables the propagation** of radio signals to bend **on HF & VHF**
Long distances **VHF** signals are being **refracted** from a **sporadic E layer**
Sporadic E propagation causes occasional **strong over-the-horizon** signals on **10, 6, & 2 M** bands
6 & 10 M provide long distance communications during the **peak of the sunspot cycle**
Tropospheric Scatter causes VHF & UHF communications **over-the-horizon** (~300 miles)
6M band is best suited to communicating via **meteor scatter**
Auroral reflection VHF signals exhibit **rapid fluctuations** of strength and often **sound distorted**

Decibel (dB) **+3 dB = 2X** **-3 dB = X/2**
+6 dB = 4X **-6 dB = X/4**
+10dB = 10X

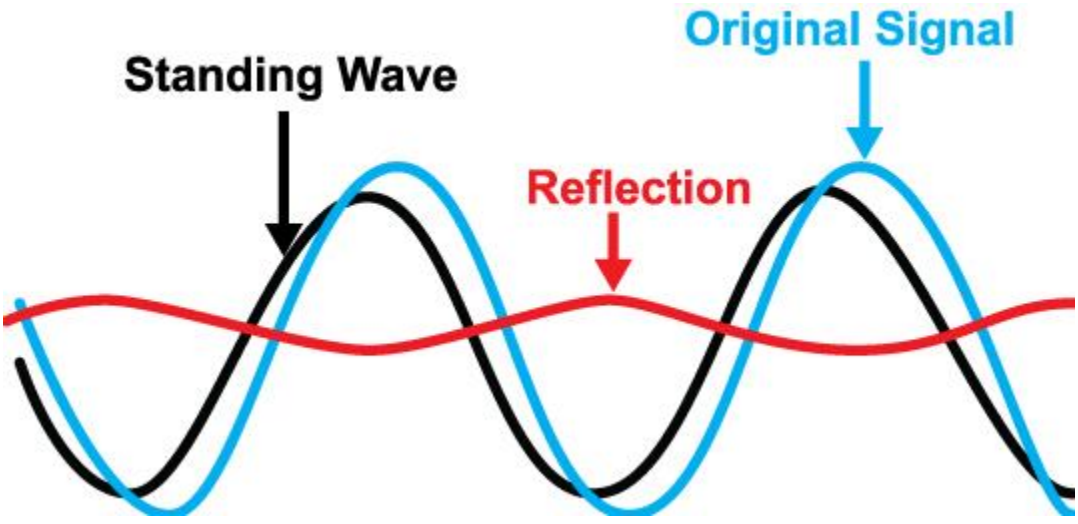
Multi-path Distortion > random reflections

Random combining of signals arriving via different paths cause of **irregular fading** of signals
Picket fencing > Rapid fluttering sound from mobile stations
Data signals over **multiple paths > Error rates** increase
Reflects signals to the repeater using a **directional antenna**
VHF signals are **become weak or distorted are multi-path** move a few feet or change direction
"**KNIFE-EDGE**" signals are **partially refracted** around solid objects exhibiting sharp edges



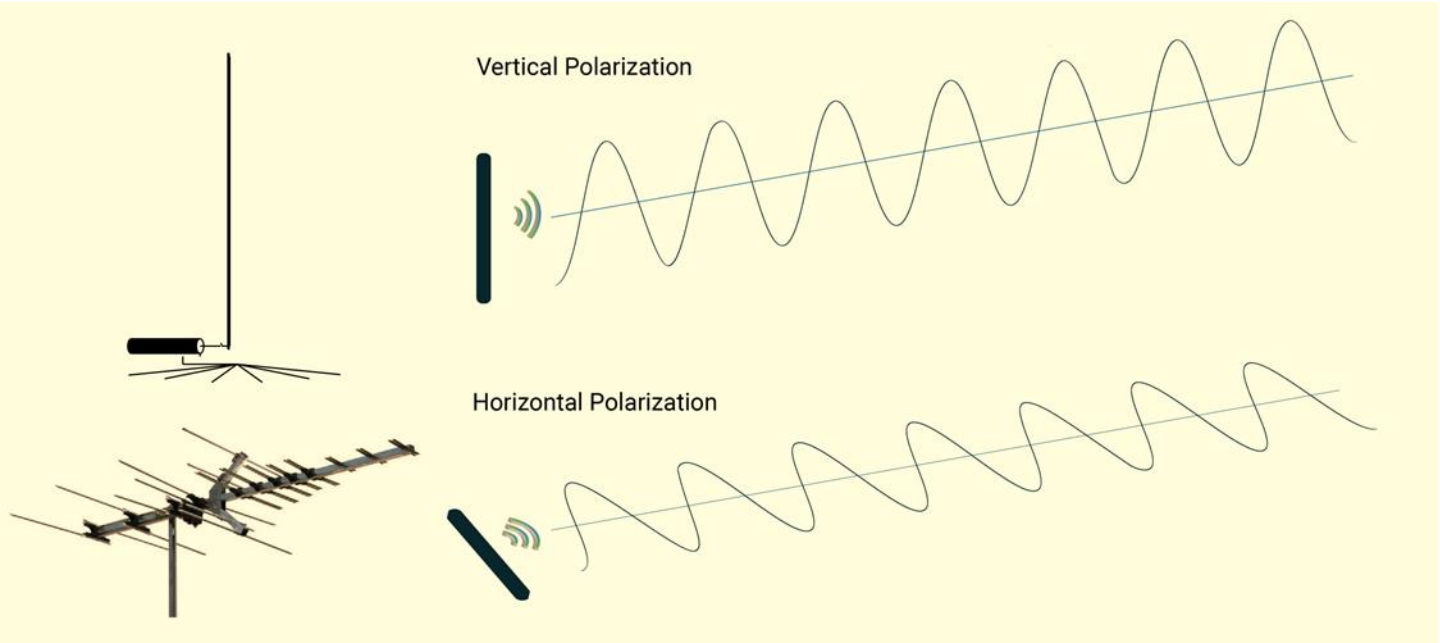
SWR > Standing Wave Ratio

The **FREQUENCY AND POWER LEVEL** should be considered when selecting an accessory **SWR METER**
SWR is how well a load is **matched** to a transmission line
LOW SWR indicates reduced or **LESS SIGNAL LOSS**
1:1 SWR indicates a **PERFECT IMPEDANCE MATCH**
4:1 SWR indicates an **IMPEDANCE MISMATCH**
Erratic SWR indicates a **loose connection** in the antenna or feed line
TRANSMITTERS REDUCE POWER as SWR increases to protect the output amplifier transistors
RF POWER METER BE INSTALLED IN THE FEED LINE, between the transmitter and antenna
A **DIRECTIONAL WATTMETER** can be used to determine SWR



Antenna

Antenna gain is the signal strength compared to a reference antenna
A beam antenna concentrates signals in one direction
HF signals propagated by the ionosphere are elliptically polarized (Horz or Vert antenna both work)
Polarization (Horz or Vert) is the orientation of the electric field
A **horizontally polarized antenna** is a dipole oriented **parallel to Earth's** surface
A **horizontally polarized antenna** is used for long-distance CW and SSB on VHF-UHF
Electrically lengthening an antenna by inserting inductors is **ANTENNA LOADING**
HT (**Rubber Ducky)** antennas are **not very efficient**
Wavelengths equal the Speed of Light / Frequency or **(300 Meters / MHz)**
A half-wave **dipole** antenna radiates the strongest signal **broadside to the antenna**
A 5/8 wavelength whip antenna has more gain than a 1/4-wavelength antenna
A **YAGI** antenna has **greater gain**
An **ANTENNA ANALYZER** is used to determine if an antenna is resonant
An **ANTENNA TUNER** matches the antenna impedance to the transceiver's impedance



Coaxial Cable > Connection between Antenna and Transceiver
Easy to Use, Requires few special installation considerations Low SWR allows efficient transfer of power
Coax > Damaged by Moisture, UV cracks & leaks water
Power lost in a feed line is **converted into heat**
Commonly **50 Ohms** Impedance,
Loss increases with frequency
RG-58 (smaller) more feedline loss used at HF
RG-213 (bigger) **less feedline loss**
Air-Core (Hard Line) requires special techniques to **prevent moisture** in the cable
Air-Core (Hard Line) **lowest feedline loss** at VHF-UHF
"N" connector types is most suitable for frequencies **above 400 MHz**
PL-259 type coax connectors are commonly used for **HF and VHF**

Chapter 5 - Amateur Radio Equipment

Transceivers

Sensitivity is the ability of a receiver to detect the presence of a signal
Selectivity is the ability of a receiver to discriminate between multiple signals
Transverter converts the RF input and output of a transceiver to another band
A **DUMMY LOAD** prevents transmitting signals over the air when making tests
A **DUMMY LOAD** is a non-inductive resistor mounted on a heat sink
An **RF PREAMPLIFIER** is installed between the antenna and receiver
An **RF POWER AMPLIFIER** increases the transmitted output power from a transceiver
SSB/CW-FM switch on a VHF power amplifier sets the proper mode

Transceiver Controls

PTT (push-to-talk) function switches between receive and transmit
VFO > The keypad or VFO knob can be used to **enter** the operating **frequency** on a modern transceiver
Microphone Gain > If a transmitter microphone gain set **too high**, output signal becomes **distorted**
Talking to Loud causes your FM transmission audio to be **distorted**
Squelch > The squelch control is used to **mute** receiver output **noise** when **no signal** is not present
Channel Memory > A way to enable quick access to a **favorite frequency** on your transceiver
Receive Incremental Tuning > **RIT** or clarifier is used if the **voice pitch** of a SSB signal seems too high or low
Bandwidth Control > permits noise or interference reduction by selecting a bandwidth matching the mode
2400 Hz is an appropriate receive filter to minimize noise and interference for **SSB** reception
500 Hz is an appropriate receive filter to minimize noise and interference for **CW** reception

Modulator > Combines speech and RF into transmitted signal

SSB > Single Sideband is a form of Amplitude Modulated (AM) Signal
Most often used for weak signal VHF and UHF
The UPPER sideband is normally used for 10M, VHF and UHF SSB
SSB has a **narrower (3 KHz)** bandwidth than **FM (15 KHz)**

CW > Send Continuous Wave using; a Straight Key, an Electronic Keyer and a Computer Keyboards
Morse Code is used for CW
CW has the **narrowest bandwidth** (150 Hz)
An **ELECTRONIC KEYER** is a device that assists in manual sending of Morse code

Modulation vs Bandwidth	
CW	150 Hz
SSB digital	500 to 3000 Hz
SSB voice	2 to 3 kHz
AM voice	6 kHz
AM broadcast	10 kHz
FM voice	10 to 15 kHz
FM broadcast	150 kHz
AM Fast TV	6 MHz

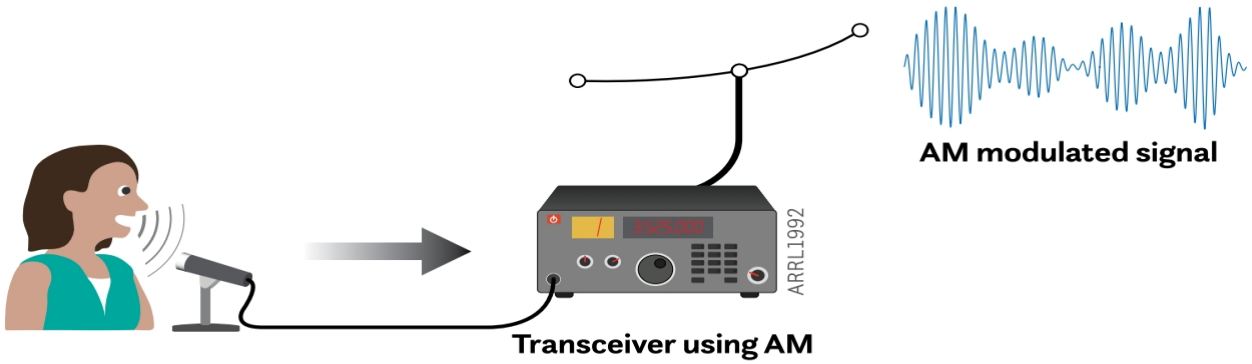
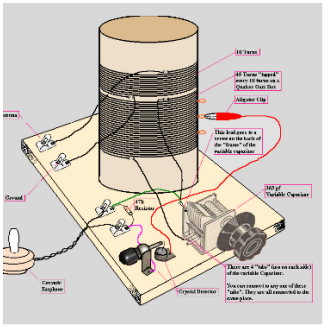
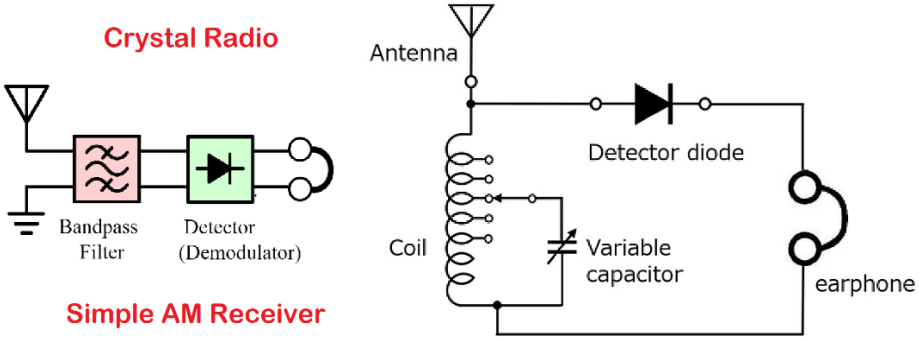
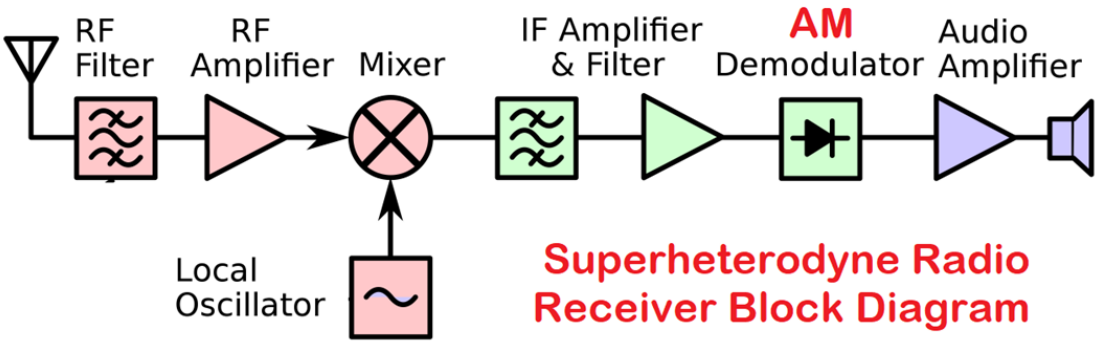


Figure 1: AM signals are *amplitude* modulated, which means that the signal amplitude, or strength, changes rapidly along with your voice. Notice how the heights and shapes of the waves in the output signal are changing. Look closely, however, and you'll see that the horizontal distances between one wave and another never change. This means that while the amount of power in the signal is changing, its frequency remains the same.





The **CRYSTAL** receiver uses an LC "tank" to selected frequency and a diode to demodulate the signal.



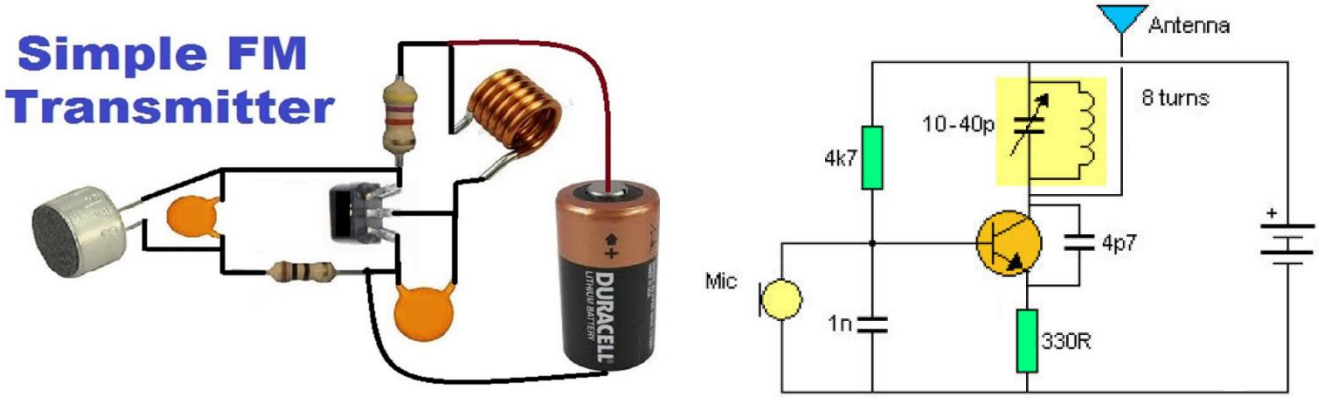
The **SUPERHETRERODYNE** receiver mixes the selected frequency with an oscillator to produce an IF (difference) and a diode to demodulate the signal. This combination provides improved **SELECTIVITY** and **SENSITIVITY**.

FM > Frequency Modulation

Commonly used for VHF and UHF voice (phone) repeaters
Commonly used for VHF packet
FM has a **10 to 15 KHz** bandwidth

FM Modulation & Deviation

Only one FM signal can be received at a time compared with SSB (FM Capture Effect)
Talk farther away from the microphone if you are told your FM transceiver is **OVER-DEVIATING**
AUDIO DISTORTION is the result of tuning an FM receiver above or below a signal's frequency



A simple **FM TRANSMITTER** is an LC oscillator for a specific frequency plus a condenser microphone (capacitor microphone). The sound waves change the microphone's capacitance in the LC "tank" oscillator to produce FM.

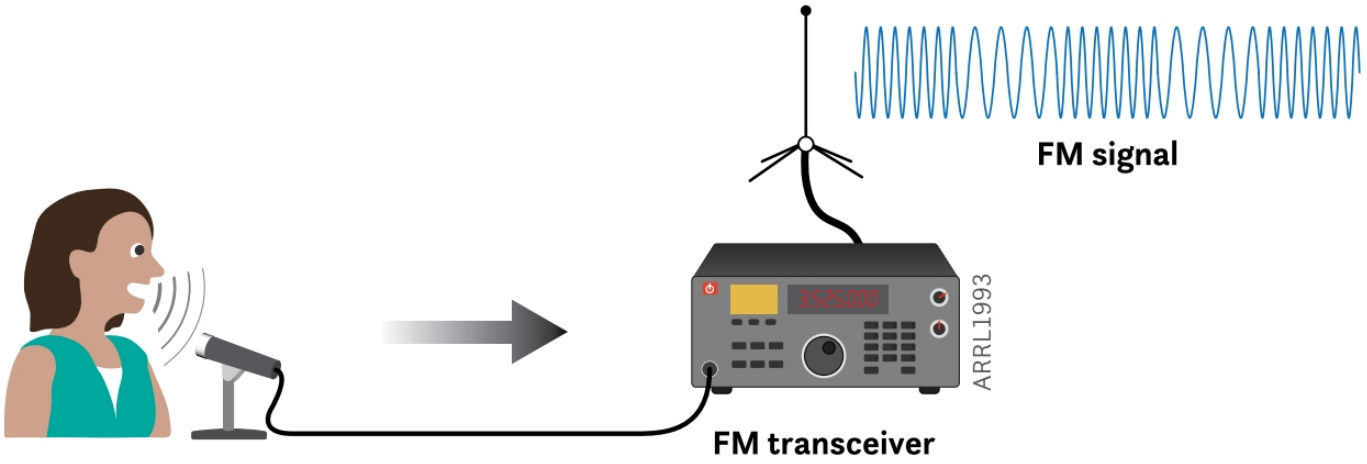


Figure 2: In this example the operator is speaking into the microphone of an FM transceiver. Look at what happens to the output signal's *frequency* as she speaks. Notice that the horizontal distances between the waves keep changing. This means the frequency of the signal is changing while the power remains constant.

Computer operation of Transceivers

A computer Microphone or **line input** is connected to a **transceiver's speaker** digital modes
Computer sound card provides audio to the radio's mic input and converts received **audio to digital**
Receive audio, transmit audio, and push-to-talk (PTT) are connected to a computer for digital modes
A **GATEWAY** is an amateur radio station that connects other amateur stations to the internet

Rig control via CAT (Computer Aided Tuning) allows a computer to control functions of a transceiver just you would operate and read the displayed information. The audio input and output of your transceiver are connected to a computer sound card to produce the digital modulations such as APRS, Packet or FT8.

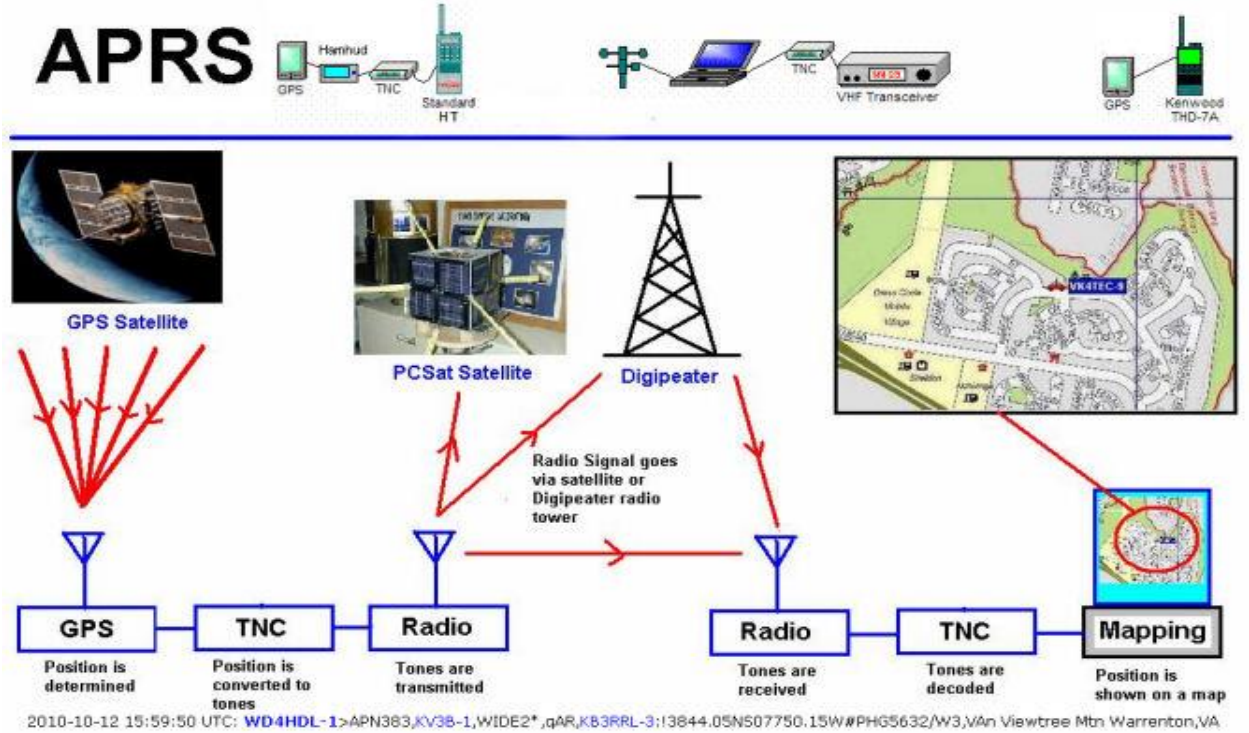
Digital Communications > Packet, PSK31, IEEE 802.11, WSJT (JT65, FT4, FT8) are digital communications

PSK31 > A low-rate data transmission mode (**Phase Shift Keying)**
Packet digital communications includes;
- Check Sum for error detection and automatic repeat requests
- The Header includes the call sign of the intended station
- **ARQ** is an Automatic repeat request in case of error

WSJT is used for Earth-Moon-Earth, Weak-signal propagation beacons and Meteor scatter
FT8 Is a digital mode capable of low signal-to-noise operation

Automatic Packet Reporting System > **APRS**

GPS position, text messages weather data are transmitted by APRS
Real-time map showing the **locations of stations**

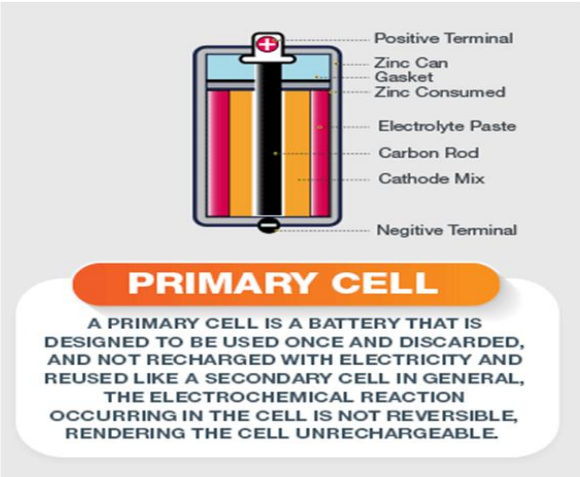


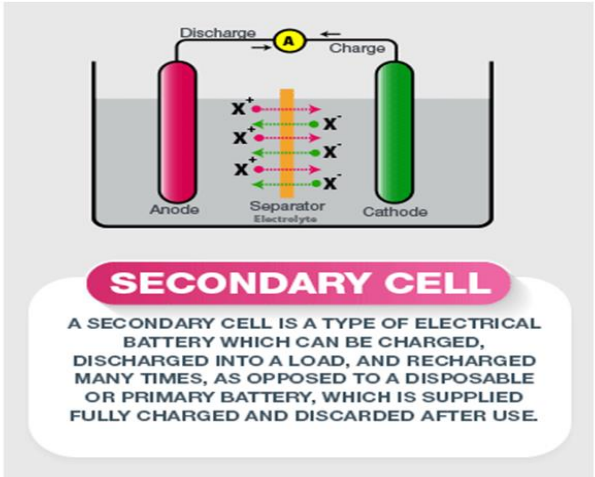
MESH NETWORK is a high-speed multi data network using Wi-Fi gear with modified firmware

Fast Scan Images > Uses **NTSC** format (1940-90 analog TVs), **6 MHz** bandwidth is used in the **70 cm** band

Power Supply & Batteries

13.8 VOLTS @ 12 AMPERES POWER SUPPLY rating for a typical 50-watt FM transceiver
A **REGULATOR CIRCUIT** controls the amount of voltage from a power supply
OVERHEATING OR OUT-GASSING is caused by charging or discharging a battery too quickly
SHORT, HEAVY-GAUGE WIRES are used for a transceiver's power to minimize transmit voltage drop
Divide the battery ampere-hour rating by the average current draw to determine **BATTERY OPS TIME**
The negative power of a transceiver should be **CONNECTED AT THE 12-VOLT BATTERY GROUND**
Rechargeable batteries are lead-acid gel cell, nickel-metal hydride, and lithium-ion.
Carbon-zinc and Alkaline batteries are **not rechargeable.**





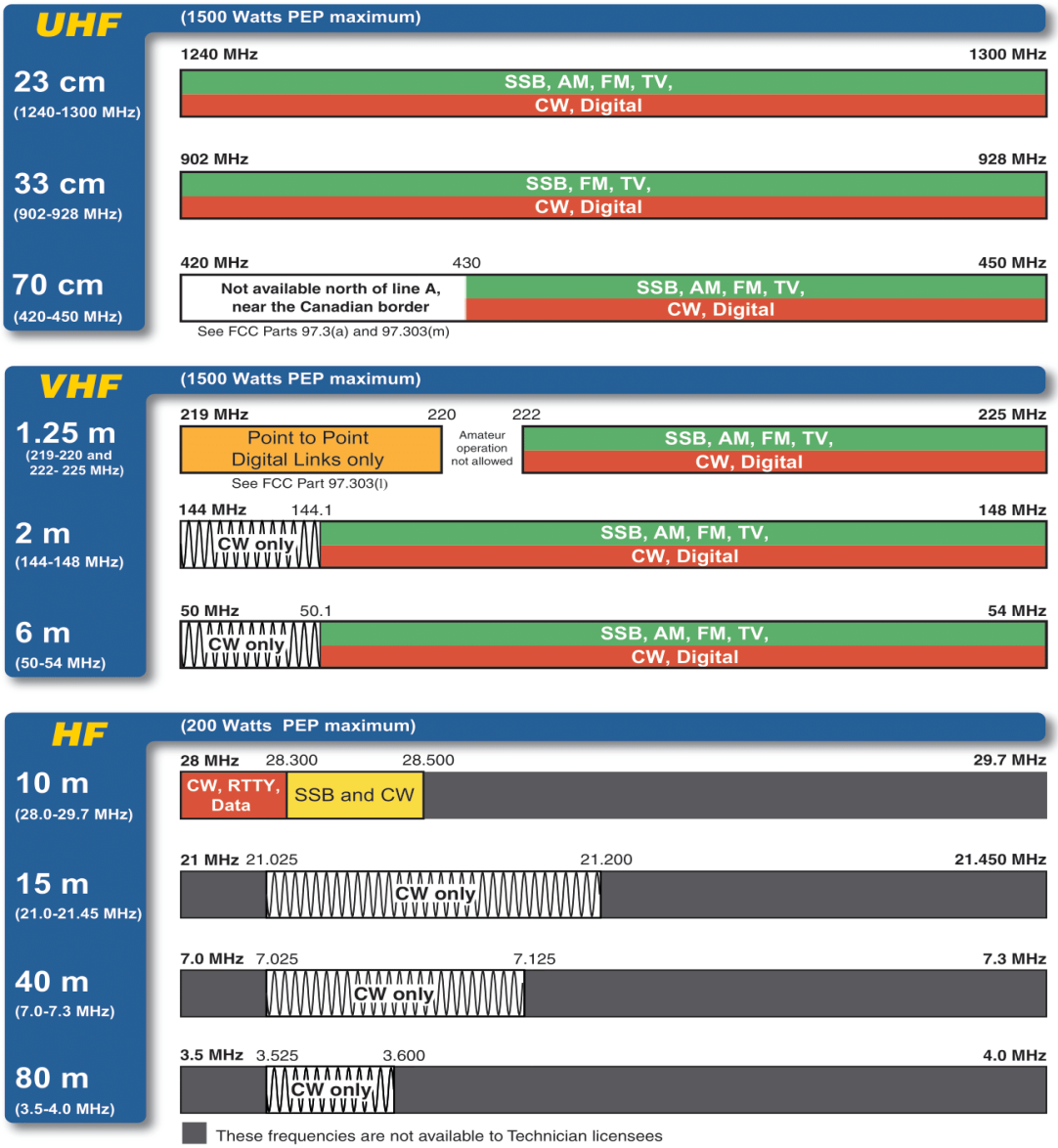
Chapter 6 - Communicating with Other Hams

US Amateur Radio Technician Privileges

This chart shows privileges and band plan recommendations for each of the frequencies, as granted by the FCC to the Technician licensee. It is good amateur practice to follow the band plan established by the Amateur Radio community. The band plan is developed so that spectrum allocated for our use is used most effectively. You'll find a complete description of the band plan online at wwww.arrl.org/band-plan.

Effective Date March 5, 2012

Published by: ARRL The national association for AMATEUR RADIO® www.arrl.org



Notes:
Technician Licenses may use up to 1500 Watts PEP on the VHF and higher bands, but are limited to 200 Watts on the HF bands.
You also have privileges to explore these microwave bands with CW, Digital, SSB, AM, FM and TV:

2300-2310 MHz	2390-2450 MHz	3300-3500 MHz	5650-5925 MHz	10.0-10.5 GHz	24.0-24.25 GHz	rev. 10-29-15
47.0-47.2 GHz	76.0-81.0 GHz	122.25-123.0 GHz	134-141 GHz	241-250 GHz	All above 275 GHz	

Bands

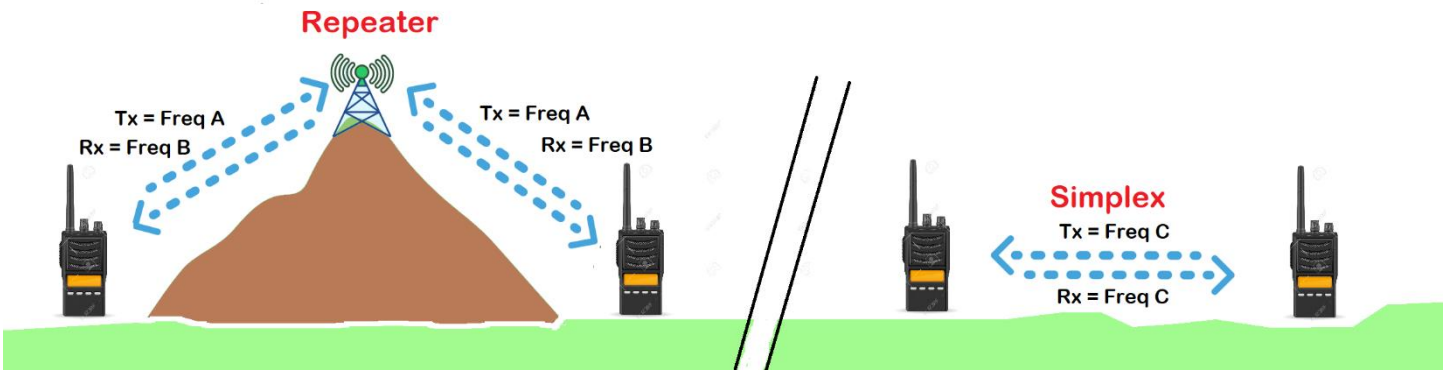
BAND PLAN is more than the privileges established by the **FCC**
BAND PLAN is a voluntary guideline for using different modes or activities within an amateur band
SSB PHONE may be used in at least some segment of bands above 50 MHz

2 M Band >>>> 144 to 148 MHz
National calling frequency for FM simplex **146.520 MHz**
Most common repeater frequency offset **plus or minus 600 kHz**

70 cm Band >>>> 420 to 450 MHz
National calling frequency for FM simplex **446.000 MHz**
Most common repeater frequency offset **plus or minus 5 MHz**

Simplex & Repeaters

Transmitting and receiving on the same frequency >>> **Simplex** communication
Simplex VHF-UHF freq are in band plans so you can **COMMUNICATE WITHOUT TYING UP A REPEATER**
Sub-audible tone transmitted with normal voice audio to open the squelch of a receiver >>> **CTCSS**
DTMF commands use pairs of audio tones
Listening on a repeater's **input freq** is a use for **"reverse function"** function on VHF/UHF TxRx
Linked repeater network is signals received by one repeater are repeated by all the repeaters
Digital mode **HOT SPOTS** communicate voice or data systems via the internet
A **"talk group" on a DMR digital repeater is** a way for **"GROUP'S ID"** users to share a channel
DMR users to share a channel at different times **WITHOUT HEARING OTHER USERS (TDMA)**
There are 15 **COLOR CODES** used to designated **DMR "GROUP'S ID"**
CODE PLUGS are the term for the information needed to access **DMR "GROUP'S ID"**
Your **CALL SIGN** must be programmed into a **D-STAR** digital transceiver before transmitting
ECHOLINK enables transmission through a repeater without a radio
Register your **call sign and proof of license** is required before using **ECHOLINK**



I can hear but not access a repeater even when transmitting with the proper offset?
A. The repeater receiver requires **audio tone burst** for access
B. The repeater receiver requires a **CTCSS** tone for access
C. The repeater receiver may require a **DCS tone** sequence for access
D. All of these choices are correct

What might be a problem if your audio through an FM repeater is distorted?
A. Transmitter is slightly off frequency
B, Batteries are running low
C. In a bad location
D. All of these choices are correct

Internet Radio Linking Project > IRLP is radio VoIP via a radio GATEWAY
IRLP operators connect to repeaters via the internet using Voice Over Internet Protocol (VoIP)
Voice Over Internet Protocol (VoIP) voice communications over the internet using digital techniques
Select a specific IRLP Node by using your keypad **(DTMF)** to enter the **GROUP'S ID CODE**

Identifications and Call Signs

BEFORE YOU CALL; Check authorized Freq, listen for others then ask is the frequency in use
Call another station
Say the station's call sign then identify with your call sign
Example: W1ABC this is KK4XYZ
What is the meaning of the procedural signal "**CQ**"? **Calling any station**
How to indicate that you are listening on a repeater? **Say your call sign**
How to respond to a CQ? Say the **other station's call sign** followed by **your call sign**
What is the "Q" Signal?
Indicates that you are receiving interference from other stations >>> **QRM**
Indicates that you are changing frequency >>> **QSY**

Public Service Communications

What rules applies to your station at the request of public service officials? >>> **Only FCC Rules**
ARES = Amateur Radio Emergency Service
Registered amateur radio volunteers who assist emergency public services
RACES = Radio Amateur Civil Emergency Service >> **FCC amateur radio service for civil defense**
Service using amateur stations for government emergency or civil defense communications
An amateur station may **OPERATE OUTSIDE THE FREQUENCY PRIVILEGES** of their license class in situations involving the **IMMEDIATE SAFETY OF HUMAN LIFE OR PROTECTION OF PROPERTY**

Terms

Direction Finding > A directional antenna is used to find noise interference or jamming (Fox Hunt)
Contest > Contacting as many stations as possible in a specific period of time
Send minimum information for station identification and contest exchange
Grid Locator > A letter-number designator assigned to a geographic location
NTSC is an analog fast-scan color TV signal modulation
SCANNING FUNCTION of an FM transceiver tunes a range of frequencies to check for activity

Formal Traffic Messages

Net Control Station (NCS) calls the net to order and directs communications between stations checking in
"TRAFFIC" is formal messages exchanged by net stations
Passing messages **EXACTLY AS RECEIVED** is a characteristic of **good traffic handling**
What is the **preamble** in a formal traffic message?
Information needed to track the message through the amateur radio traffic handling system
What is the term "**check**" in reference to a formal traffic message? >>> **count of the number of words**
Unless an emergency occurs wait to TX until asked to do so by the net control station
PHONETIC ALPHABET is used to ensure that voice messages are received correctly

Satellites > Use amateur radio satellites to talk to operators in other countries on FM, SSB, CW, Data
An amateur station located more than **50 km above Earth's surface is a space station**
Anyone may receive telemetry from a space station
Any **Technician class or higher license** may contact the **International Space Station (ISS)**
Any amateur whose license privileges transmission on the satellite uplink frequency can be the operator
Always use the **minimum power** to complete the contact
Too much power to may block other users
Correct power means your signal strength on the downlink is about the **same as the beacon**
The **beacon** is a transmission from a space station that contains **Health and status of the satellite**
A **Satellite Tracking Program** gives map, times, doppler freq shift, azimuth, and elevation for the satellite
Keplerian elements are inputs to a satellite tracking program
Doppler Shift is the frequency change caused by the motion of the transmitting station
U/V Mode is the satellite uplink is in the 70 cm band and the downlink is in the 2 meter band
Spin Fade is caused by the rotation of the satellite and its antennas
LEO stands for Low Earth Orbit

Communicating with Other Hams

Contact Basics: Good Amateur Practices

Q-Signals

Q-signals are a system of radio shorthand as old as wireless and developed from even older telegraphy codes. Q-signals are a set of abbreviations for common information that save time and allow communication between operators who don't speak a common language. Modern ham radio uses them extensively. The table below lists the most common Q-signals used by hams. While Q-signals were developed for use by Morse operators, their use is common on phone, as well. You will often hear, "QRZed?" as someone asks "Who is calling me?" or "I'm getting a little QRM" from an operator receiving some interference or "Let's QSY to 146.55" as two operators change from a repeater frequency to a nearby simplex communications frequency.

Q-Signals

Abbr.	Questions
QRG	Your exact frequency (or that of _____) is _____kHz. Will you tell me my exact frequency (or that of _____)?
QRL	I am busy (or I am busy with _____). Are you busy? Usually used to see if a frequency is busy.
QRM	Your transmission is being interfered with _____ (1. Nil; 2. Slightly; 3. Moderately; 4. Severely; 5. Extremely.) Is my transmission being interfered with?
QRN	I am troubled by static _____. (1 to 5 as under QRM.) Are you troubled by static?
QRO	Increase power. Shall I increase power?
QRP	Decrease power. Shall I decrease power?
QRQ	Send faster (_____wpm). Shall I send faster?
QRS	Send more slowly (_____wpm). Shall I send more slowly?
QRT	Stop sending. Shall I stop sending?
QRU	I have nothing for you. Have you anything for me?
QRV	I am ready. Are you ready?
QRX	I will call you again at _____hours (on _____kHz). When will you call me again? Minutes are usually implied rather than hours.
QRZ	You are being called by _____ (on _____kHz). Who is calling me?
QSB	Your signals are fading. Are my signals fading?
QSK	I can hear you between signals; break in on my transmission. Can you hear me between your signals and if so can I break in on your transmission?
QSL	I am acknowledging receipt. Can you acknowledge receipt (of a message or transmission)?
QSO	I can communicate with _____ direct (or relay through _____). Can you communicate with _____ direct or by relay?
QSP	I will relay to _____. Will you relay to _____?
QST	General call preceding a message addressed to all amateurs and ARRL members. This is in effect "CQ ARRL."
QSX	I am listening to _____ on _____kHz. Will you listen to _____on _____kHz?
QSY	Change to transmission on another frequency (or on _____kHz). Shall I change to transmission on another frequency (or on _____kHz)?
QTC	I have _____messages for you (or for _____). How many messages have you to send?
QTH	My location is _____. What is your location?
QTR	The time is _____. What is the correct time?

ITU Phonetic Alphabet

Letter	Word	Pronunciation
A	Alfa	**AL** FAH
B	Bravo	**BRAH** VOH
C	Charlie	**CHAR** LEE
D	Delta	**DELL** TAH
E	Echo	**ECK** OH
F	Foxtrot	**FOKS** TROT
G	Golf	GOLF
H	Hotel	HOH **TELL**
I	India	**IN** DEE AH
J	Juliet	**JEW** LEE ETT
K	Kilo	**KEY** LOH
L	Lima	**LEE** MAH
M	Mike	MIKE
N	November	NO **VEM** BER
O	Oscar	**OSS** CAH
P	Papa	PAH **PAH**
Q	Quebec	KEH **BECK**
R	Romeo	**ROW** ME OH
S	Sierra	SEE **AIR** RAH
T	Tango	TANG GO
U	Uniform	**YOU** NEE FORM
V	Victor	**VIK** TAH
W	Whiskey	**WISS** KEY
X	X-Ray	**ECKS** RAY
Y	Yankee	**YANG** KEY
Z	Zulu	**ZOO** LOO

Note: The **boldfaced** syllables are emphasized. The pronunciations shown in this table were designed for those who speak any of the international languages. The pronunciations given for "Oscar" and "Victor" may seem awkward to English-speaking people in the US.

Chapter 7 - Licensing Regulations

Amateur Radio Services

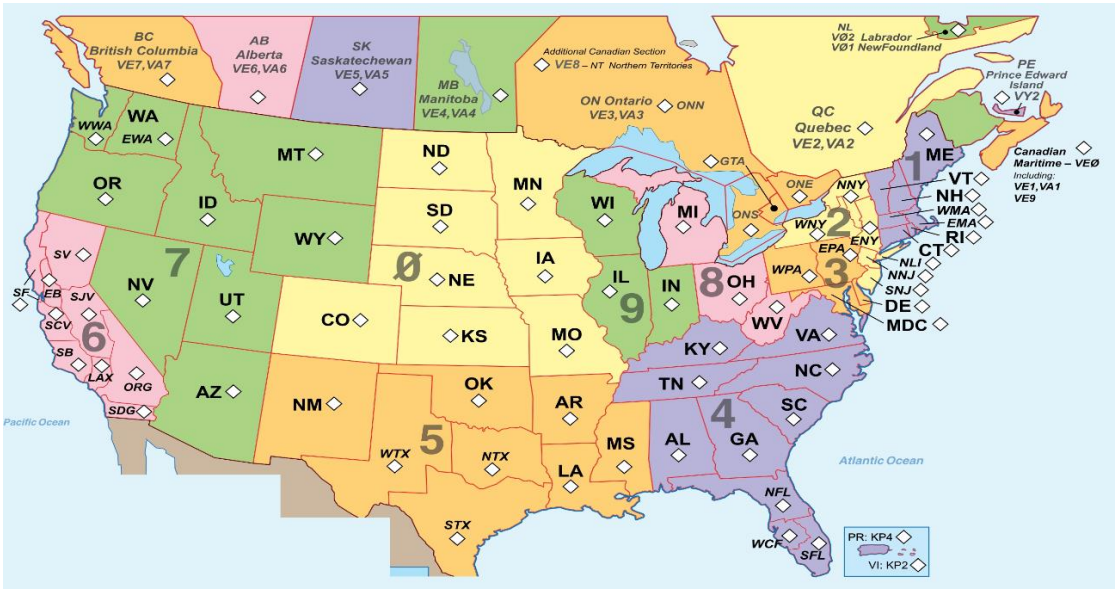
Amateur Radio Service is for advancing skills in the technical and communication phases of the radio art
FCC regulates and enforces the rules for the Amateur Radio Service
Volunteer Frequency Coordinator recommends T/R channels/parameters for **repeater stations**
Amateur operators select a **Frequency Coordinator**
The purposes of a **BEACON** is for observing propagation or related experimental activities

Operator Classes and Station Call Signs

Current new **Operator Classes are:** Technician, General, Amateur Extra
Only one operator/primary station license grants may be held by any one person
You may **operate** from any **vessel in international waters** registered in the **US**
FCC requires your **correct EMAIL address** > **Revocation** of license
Operate as soon as your name and call sign appear in the **FCC's ULS database**
Ten years is the normal term for a license
Two years grace period following expiration license to renew
The **ULS DATABASE** proves that the FCC has issued an operator/primary **LICENSE GRANT**
You **cannot operate** during the **grace period** until renewed in the ULS database
A station and its records must be made available for anytime requested by FCC Representative
Amateur radio stations prohibited from communicating with any country who objects to ITU
K1XXX is a valid call sign for a Technician class amateur radio station
Any licensed amateur may request a desired call sign under the **vanity call sign** rules
A club must have at least **four members** for a club license
INTERNATIONAL COMM for purposes of Amateur Radio Service and remarks of a personal character

Authorized Frequencies

Technicians have phone privileges on a subpart of 10M
Technician Phone **28.300 MHz to 28.500 MHz**
52.525 MHz MHz is in the **6 M** band
146.52 MHz is in the **2 M** band
Fixed digital message forwarding on the frequencies 219 and 220 MHz
Only CW permitted on **50.0 to 50.1** MHz and **144.0 to 144.1** MHz
Secondary basis frequency band is available without causing interference
HF Technician are limit to **200 Watts on HF Bands**
HF Technician are limit to **1500 Watts above 30 MHz**



Chapter 8 - Operating Regulations

Control Operator

A station must have a **control operator** when **transmitting**
A **license** appears in the **FCC database** is eligible to be the **control operator**
Control Operator determines the transmitting privileges of an amateur station
The station licensee **must designate** the station **control operator**
FCC presumes the **station licensee** to be the control operator unless in logged differently
The **control operator and station licensee are equally** responsible for the operation
The station **control point** is the location at which the **control operator function** is performed
Local control is being used when transmitting using a handheld radio
Remote control is when the control operator can **indirectly manipulate a station (over internet)**
Remote control requires a **CONTROL OPERATOR AT ALL TIMES TO OPERATE** (indirectly) controls
Repeater operation is **Automatic control**
Control operator of the **originating station is accountable for repeater** TX violation

Station Identification & Misc

English is used for station ID use of a **phonetic alphabet is encouraged**
A station required to **ID every 10 minutes and at the end of TX**
CW or phone ID is required for a station transmitting phone signals
Phone ID must be in ENGLISH
Identify the transmitting station when making on-the-air **TEST TRANSMISSIONS**
Acceptable Phone ID: " KL7CC stroke W3" or " KL7CC slant W3" or "KL7CC slash W3"
A station may **transmit without ID** when transmitting signals to control model craft
Tactical call is used when identifying a station as "Race Headquarters"
When using tactical identifiers, you must **ID your station every ten min** & end TX
A **Technician cannot be the control operator** in exclusive Extra Class segment bands
TX of **third party communications is authorize** to foreign stations permitted by that govt
At least **4 persons** are required for a **club station license**
Repeater station simultaneously retransmits the signal of another station
Upon request the station licensee make the station / records available for **FCC inspection**

Authorized and Prohibited Transmissions

Operator may receive compensation when incidental … **A SCHOOL TEACHER**
Stations may **sell or trade amateur equipment** but not on a regular basis
Amateurs can TX **NEWS** related to **immediate** safety of human **life** or protection of **property**
Music maybe TX when incidental to retransmission of **manned spacecraft** comm
Automatically retransmit signals from an **auxiliary, repeater, or space station**
Codes or Ciphers allowed only controlling **space stations** or **radio control** craft
When transmitting control signals **model craft station ID is not required**
NO one has the right to an amateur frequency, **STATIONS SHOULD NEGOTIATE** use of the frequency
3rd Party message from a station on behalf **of another person**
3rd Party message must be **permitted by the foreign country**
Transmissions that contain **obscene language are prohibited**
Willful interference is prohibited
Definition **Broadcasting** (FCC rules) is TX intended for the **general public** is prohibited

Chapter 9 – Safety / RF Exposure Hazard

Electrical Hazards

Electric current in the body causes tissue **heating, disrupts cell functions, involuntary contractions**

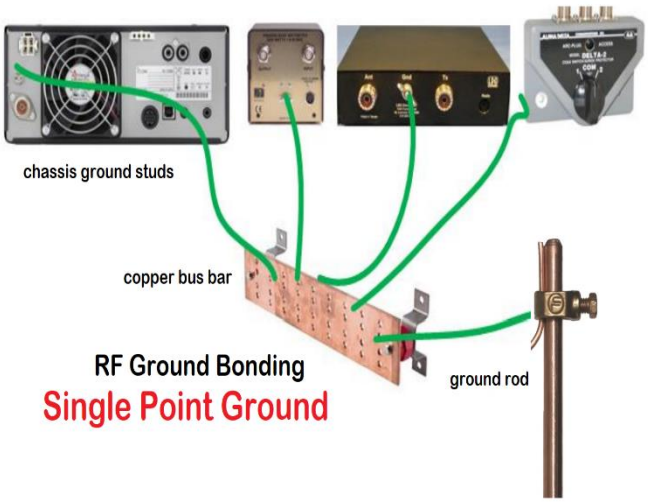
Electric shock can occur from **capacitors in power supply** when it is turned **off**

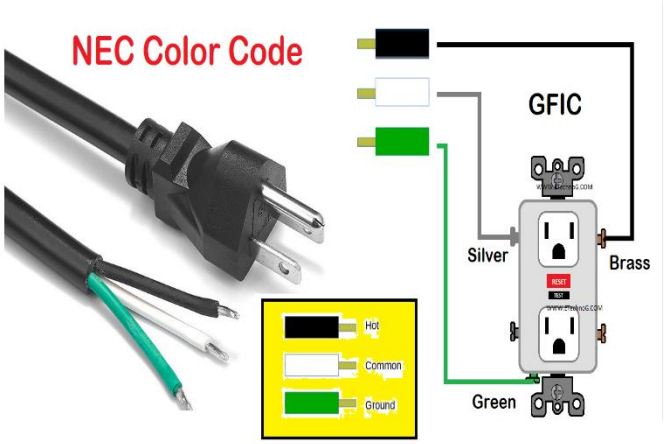
Guard against electrical shock at your station

Use three-wire cords and plugs for all AC powered equipment

Connect all AC powered station equipment to a common safety ground

Install mechanical interlocks in high-voltage circuits





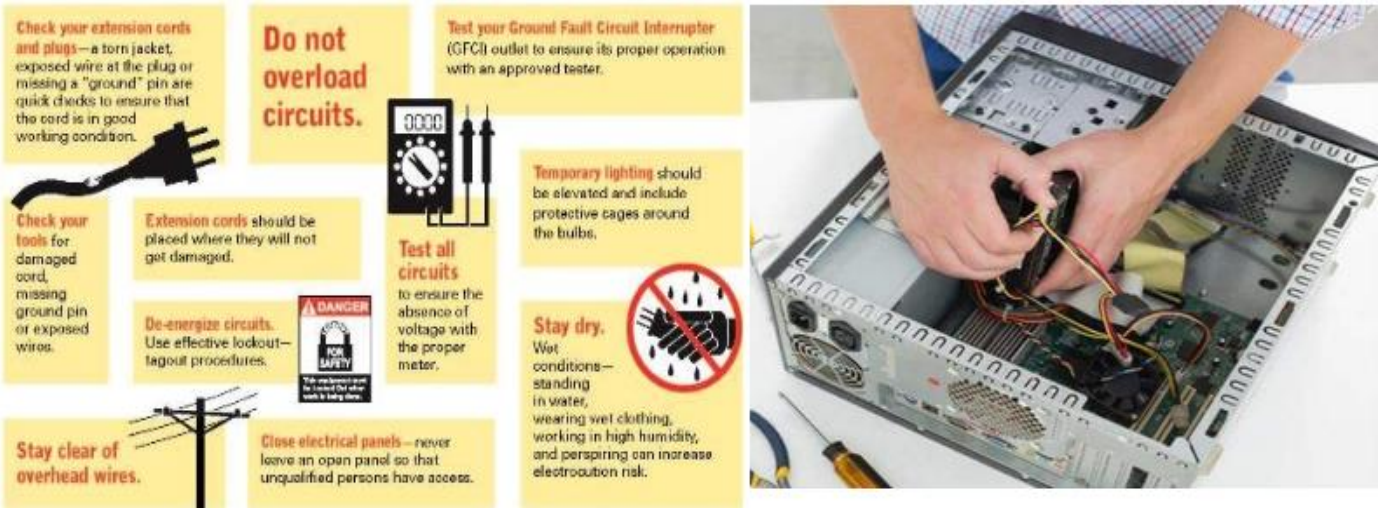
A **fuse interrupts power** in case of overload

A120V AC **"HOT"** conductor is connected to the **BLACK WIRE** in a three-wire electrical AC plug

A120V AC **"HOT"** conductor **fuse / circuit breaker** in should always be in home-built equipment

Shorting a 12-volt storage battery can cause burns, fire, or an explosion

FLAT COPPER STRAP conductors are preferred for **RF BONDING**



Radio Frequency Radiation Exposure Hazard

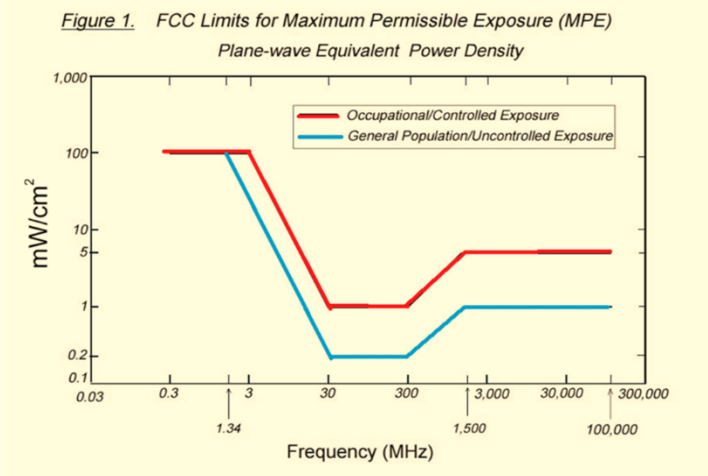
Radio signals are **NON-IONIZING RADIATION**
RF radiation does NOT have sufficient energy to cause genetic **(DNA)** damage
The **LICENSEE IS RESPONSIBLE** for ensuring that no person is exposed to RF exposure limits
50 MHz has a low **Maximum Permissible Exposure limit**
Frequency, RF Power, Distance & Radiation Pattern of the antenna affect the RF exposure
Human body absorbs more RF energy at some frequencies than at others
FCC OET Bul 65, computer model or field strength meter determine complies with RF
A painful **RF SKIN BURN** could happen if a person accidentally touched your antenna
Relocating antennas might prevent exposure to RF radiation in excess of FCC limits
Re-evaluating the station whenever equipment is changed to ensure RF safety
Duty Cycle affects the average exposure of people to radiation **over 6 Minute Average**
DUTY CYCLE is the ratio of transmit time compared to total time
DUTY CYCLE changes from **100%** to **50%**then the max **EXPOSURE LEVEL DOUBLES**

Radio Frequency Exposure Considerations

- **Frequency**
- **RF Power**
- **Gains & Losses**
- **Duty Cycle**
- **Ground Reflections**

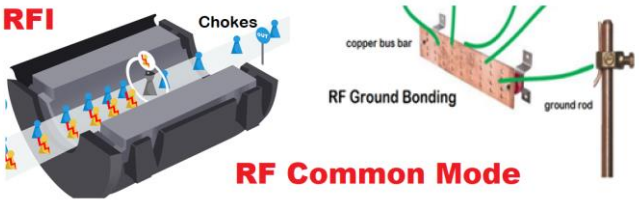
FCC OET Bulletin 65 Evaluation Methods

- **Interpolation using FCC Tables**
- **Power Density Calculations**
- **Field Strength Measurements**



Radio Frequency Interference

Causes of radio frequency interference;
- Fundamental overload
- Harmonics
- Spurious emissions

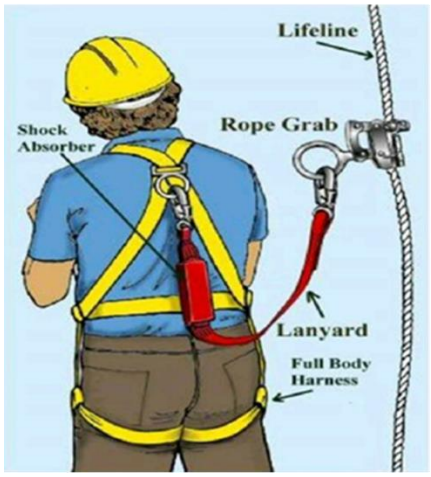


When a receiver is **unable to reject strong signals outside its band** it may receive amateur TX unintentionally
Cable TV interference from your Tx maybe caused by **loose TV coaxial connectors**
Correct **OVERLOAD** of a non-amateur receiver with a **FILTER** at the antenna input of the affected receiver
BAND-REJECT FILTER can reduce **OVERLOAD** to a VHF transceiver from a nearby FM broadcast station
If something in a neighbor's home is causing harmful interference;
- Work with your neighbor to identify the offending device
- Check your station and make sure it meets the standards of good amateur practice
- Inform your neighbor rules that prohibit the use of devices that cause interference

If a neighbor tells you that your station's transmissions are interfering make sure that your station is functioning properly and that it does not cause interference to your own radio or television
Reports of **garbled, distorted, or unintelligible** voice transmissions maybe **RF feedback**
Use **SHIELDED WIRE TO PREVENT COUPLING** of unwanted signals to or from the wire
Use a **FERRITE CHOKE** to cure distorted audio caused by RF current on the shield of a microphone cable

Antenna Tower Safety

Always have **TOWER CLIMBING SAFETY TRAINING** before climbing
Put on a **CLIMBING HARNESS AND TIE-OFF** before climbing an antenna tower
Always have an observer or helper when climbing a tower
A **crank-up tower must never be climbed** unless it is in the fully retracted position
SAFETY WIRE THROUGH A TURNBUCKLE prevents loosening of the guy line from vibration



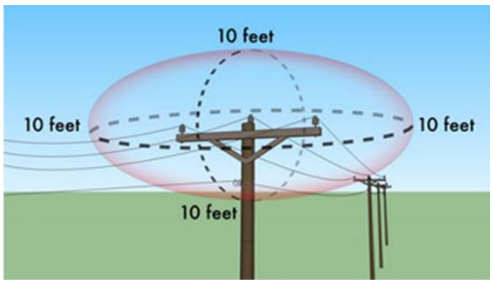
Tower climbing Safety Gear

- Training Classes
- Full body harness
- Fall restraint
- Safety hardhat
- Eye protection
- Observer, 2nd Person

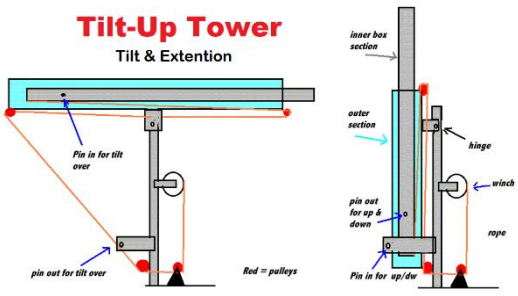
Never attach an antenna to a utility pole the antenna could contact high-voltage wires
10 feet to the power wires is the min safe distance from a power line when installing an antenna
Look for and **stay clear of any overhead electrical wires** when putting up an antenna tower

Tower / Antenna Sites

- Stay Away from Power Lines
- Clear Antenna Fall Arc / Area



Ground a tower with separate **EIGHT-FOOT LONG GROUND RODS FOR EACH TOWER LEG**
GROUND COAX Cable feed to **LIGHTNING PROTECTION** / external ground at building penetration
Bond ground rods with heavy wire or conductive strap
Sharp bends must be avoided in grounding conductors used for lightning protection
Local electrical code establishes grounding requirements for an amateur radio tower or antenna



Glossary

A	ampere (unit of electrical current)
A/D	analog-to-digital
AC	Alternating Current - Electric current flowing in alternating directions. In the US the frequency is 60 Hz.
ac	alternating current
ADC	analog-to-digital converter
AF	audio frequency
AFC	automatic frequency control
AFSK	audio frequency-shift keying
AGC	Automatic Gain - This flattens the sound
AGC	automatic gain control
Ah	ampere hour
ALC	automatic level control
AM	Amplitude - Amplitude is changed to add the modulation known as voice.
AM	amplitude modulation
Ammeter	Measure's amps or electric current and is connected in series with the circuit.
Amperes	A measurement of the current. Current is measured in Amperes (or commonly referred to as amps).
AMRAD	Amateur Radio Research and Development Corporation
AMSAT	Radio Amateur Satellite Corporation
ANT	antenna
Antenna	The apparatus used to send and receive radio signals.
Antenna	omnidirectional antenna. Many houses have a satellite TV dish installed which is a directional antenna.
Antenna Analyzer	Tests the antenna to show what frequency it works best at and many other features.
APRS	Automatic Packet - Real-time tactical digital communications using a map to show the locations of stations
AR	Automatic Repeat - A digital scheme whereby the receiving station detects errors and sends a request to send again
ARES	Amateur Radio Emergency Services
ARES	Amateur Radio Emergency Service
ARQ	Automatic repeat request
ARRL	The Amateur Radio Relay League. Originally messages were routinely passed from one operator to the next (relayed) to get information sent great distances.
ARRL	American Radio Relay League
ARS	Amateur Radio Society (station)
ASCII	American National Standard Code for Information Interchange
ATV	Amateur Television - Hams using video cameras and TV's with their transceivers to have two-way video
ATV	amateur television
Auxiliary Station	A special repeater generally devoted to extending coverage for an individual station.
AWG	American wire gauge

AZ- EL	azimuth-elevation
BALUN	balanced to unbalanced (transformer)
Band	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.
Band Plan	A description or illustration of how parts of each band or wavelength segment is appropriately used.
Baud	baud (bids in single-channel binary data transmission)
BC	broadcast
BCD	binary coded decimal
Beacon	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.
Beam Antenna	See Directional Antenna.
BER	bit error rate
BFO	beat-frequency oscillator
bit	binary digit
bit/s	bits per second
BPF	band-pass filter
BPL	Brass Pounders League
BW	bandwidth
C	coulomb (quantity of electric charge); capacitor
Call Sign	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
Capacitor	A component that can store energy in an electrical field.
Carrier Signal	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.
CCTV	closed-circuit television
Check sum	A method of error checking. The "check" is the number of words in the message.
CMOS	complementary-symmetry metal-oxide semiconductor
Coax	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.
coax	coaxial cable
Code	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.
Contesting	A timed event where amateur radio operators try to contact as many other operators as they can within the time allotted.
Control Operator	The FCC licensed Amateur Radio Operator that has control of the transceiver.
Control Point	The point at which you control the transmitting on the radio. Usually the "PTT" or Push To Talk button.
CPU	central processing unit
CQ	Calling Any Station
CRT	cathode ray tube

CTCSS	Continuous Tone - Repeater stations generally require sending a CTCSS as part of the transmission. This
CTCSS	continuous tone-coded squelch system
Current	A measurement of the flow of electrons in an electric circuit. A measurement of Amps shows the level of current.
CW	Continuous Wave, meaning Morse Code
CW	continuous wave
D	diode
D/A	digital-to-analog
DAC	digital-to-analog converter
dB	Decibel - A unit of measurement used to express the ratio of one value of a physical property to
dBi	decibels above (or below) isotropic antenna
dBm	decibels above (or below) 1 milliwatt
DBM	double balanced mixer
dBV	decibels above/below 1 V (in video, relative to 1 V P-P)
dBW	decibels above/below 1 W
DC	Direct Current - Electric current flowing in one direction. All batteries use DC. If there is a + and a -
DCS	Digital-Coded - Similar to CTCSS but this is digital where CTCSS is analog.
DDS	direct digital synthesis
deg	degree
DET	detector
DF	direction finding; direction finder
Diode	An electrical component like a one-way gate. Current can only flow in one direction through diode.
DIP	dual in-line package
Directional	An antenna that focuses the signals in one direction.
DMM	digital multimeter
DMR	Digital Mobile Radio - A digital radio standard originally designed for commercial users
DMR Talk Group	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.
Doppler Shift	An observed change in frequency. The frequency of sound changes as the fast moving by. The radio frequency changes as the satellite rushes by.
Double or Doubling	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.
DPDT	double-pole double-throw (switch)
DPST	double-pole single-throw (switch)
DS	direct sequence (spread spectrum); display
DSB	double sideband
DSP	digital signal processing
DTMF	Dual-Tone Multi- - This is the audible tones used to dial a telephone number and is call "Touch Tone."

DTMF	dual-tone multifrequency
Ducting	VHF long distance path caused by temperature and humidity than the layers above and below it. This is similar to an "inversion" layer.
Dummy Load	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.
Duplex	Receiving on one frequency and transmitting on a different one. This dual frequency use is called duplex, or duplexing. Repeaters use duplex.
Duty Cycle	The percentage of time that a transmitter is transmitting vs receiving.
DVM	digital voltmeter
DX	long distance; duplex
E	voltage
EchoLink	A service where repeaters can be accessed through the Internet most anywhere in the world.
EHF	extremely high frequency (30-300 GHz)
EIRP	effective isotropic radiated power
ELF	extremely low frequency
EMC	electromagnetic compatibility
EME	earth-moon-earth (moonbounce)
Emergency, May Day, SOS	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.
EMF	electromotive force
EMI	electromagnetic interference
EMP	electromagnetic pulse
EOC	emergency operations center
EPROM	erasable programmable read only memory
F	farad (capacitance unit); fuse
Farad	A measurement of stored electrical energy.
FCC	Federal Communications Commission - The US agency regulates and enforces the rules for Amateur Radio Service.
FCC	Federal Communications Commission
FCC Rules	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.
Feed Line	The wire that connects a transceiver to the antenna. Hand-held transceivers have no visible feedline.
FEMA	Federal Emergency Management Agency
Ferrite Choke	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.
FET	field-effect transistor
FFT	fast Fourier transform
FL	filter
FM	Frequency Modulation - Frequency is changed to add the modulation known as voice.
FM	frequency modulation

Frequency	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.
FSK	frequency-shift keying
Fuse	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.
G	giga (prefix for 109); conductance
GaAs	gallium arsenide
Gain	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.
Gateway	An amateur station allowing other stations to access the Internet through their station.
GB--gigabytes	
Gin pole	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.
GND	ground
Grid Locator	A letter-number designator assigned to a geographic location. Class location is: EL88xu
Ground	A connection from an electric item to a ground rod driven into the earth.
H	henry (unit of inductance)
HAM	Amateur Radio Operator - No one really knows where the term Ham came from or what it really means
Henry	A measurement of stored magnetic energy.
Hertz	The measurement of frequency and is defined as one cycle per second. Common household electricity operates at 60 Hz, or 60 cycles per second.
HF	high frequency (3-30 MHz)
Hz	hertz (unit of frequency, 1 cycle/s)
I	current, indicating lamp
IARU	International Amateur Radio Union
IC	integrated circuit
Identify	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.
IF	intermediate frequency
IMD	intermodulation distortion
Impendence	An opposition to the flow of AC current. Impendence is measured in ohms.
Inductor	A component that can store energy in a magnetic field.
Ionosphere	A layer of the atmosphere that can reflect HF signals back down to the earth. There are multiple layers within the Ionosphere.
IRLP	Internet Radio - This uses Voice-Over-IP (VoIP) custom software and hardware. Coupled with the
ITU	International - This the United Nations specialized agency for information and communication
ITU	International Telecommunication Union
J	joule
JFET	junction field-effect transistor
k	kilo

kBd	1000 bauds
kbit	1024 bits
kbit/s	1024 bits per second
kB--kilobytes	
kbyte	1024 bytes
Keplerian elements	Data inputs for satellite tracking.
kg	kilogram
kHz	kilohertz
km	kilometer
kV	kilovolt
kW	kilowatt
kΩ	kilohm
Ladder Line	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.
LC	inductance-capacitance
LCD	liquid crystal display
LED	Light Emitting Diode - A diode which emits light. See Diode.
LED	light-emitting diode
LEO	Low Earth Orbit - Most amateur radio satellites use low earth orbits.
LF	low frequency (30-300 kHz)
Linked Repeaters	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
LO	local oscillator
Log Book	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.
LP	log periodic
LSB	Lower Side Band
lsb	least significant bit
LSB	lower sideband
LUF	lowest usable frequency
mA	milliampere
Memory	Saving a frequency and other option within a transceiver.
Meter	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.
MF	medium frequency (300-3000 kHz)
mH	millihenry
MHz	megahertz
mic	microphone
MIX	mixer
Mixer	A component that changes the frequency generated by the oscillator. This allows one transceiver to access several frequencies.

MOD	modulator
modem	modulator/demodulator
Modulation	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.
Morse Code	A communications system where letters (or other characters) are represented by long sounds(dah) and short sounds (dit) transmitted over the air.
MOS	metal-oxide semiconductor
MOSFET	metal-oxide semiconductor field-effect transistor
MPE	Maximum Permissible Exposure - The MPE limits are based on whole-body specific RF absorption rates.
MR	Memory Recall - A setting to use the memorized frequencies.
ms	millisecond
msb	most-significant bit
MUF	maximum usable frequency
mV	millivolt
mW	milliwatt
MΩ	megohm
NB	Noise Blanker - Reduces certain noises
NBFM	narrow-band frequency modulation
NC	no connection; normally closed
NCS	Net Control Station - The station or operator directing the Ham radio net.
Net	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.
nF	nanofarad
NF	noise figure
nH	nanohenry
NiCd	nickel cadmium
NM	Net Manager
NMOS	N-channel metal-oxide silicon
NO	normally open
Noise Blanker	A setting in the receiver to cut or reduce certain noise sources.
NPN	negative-positive-negative (transistor)
NPN or PNP	Negative and Positive - This transistor has three leads; emitter, base and collector
ns	nanosecond
NTSC	National Television - The pre-1990 analog TV signal standard in the US
Ohm	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.
Ohmmeter	Measure's ohms or resistance. This is a powered setting on the meter so be sure there is no power in the circuit.
Omnidirectional	A normal antenna which sends the radio signal out equally in all directions
op amp	operational amplifier
Operator	The person allowed to operate the radio.
OSC	oscillator

Oscillator	A component that generates a signal or sound. The oscillator makes the carrier signal which is the transmission.
Over-deviation	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.
p	pico (prefix for 10-12)
PA	power amplifier
PACTOR	digital mode combining aspects of packet and AMTOR
Parallel	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.
PEP	Peak Envelope Power - Peak envelope power is the maximum power at a given point in time
PEP	peak envelope power
pF	picofarad
pH	picohenry
Phone	Speaking, as in Phonetic, using your voice.
Phonetic	Using words to represent letters. Like Alpha for A, Bravo for B, etc.
PIN	positive-intrinsic-negative (semiconductor)
PIV	peak inverse voltage
PLL	phase-locked loop
PM	phase modulation
PMOS	P-channel (metal-oxide semiconductor)
PNP	positive negative positive (transistor)
PNP or NPN	Transistor - either one negative and two positive or vice versa.
pot	potentiometer
Potentiometer	A variable resistor. This has the ability to change the potential energy passing through.
Power Supply	A device to convert AC 110 V power to the DC 13.8 V (12 V) power the transceiver requires.
P-P	peak to peak
PROM	programmable read-only memory
Propagation	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.
PS	heavier and more expensive than a switching PS, but it is also more accurate and dependable.
PSK	Phase Shift Keying - A popular computer-sound card-generated radioteletype mode.
PTT	push to talk
Q	figure of merit (tuned circuit); transistor
QRM	Manmade noise - This means "I am receiving noise" which is not from nature
QRP	low power (less than 5-W output)
QSY	Switching to another frequency - This means "Follow me as I change to _____ frequency."
R	resistor
R/C	radio control
RACES	Radio Amateur Civil Emergency Service - Government activated only during the emergency and during the immediate aftermath

RACES	Radio Amateur Civil Emergency Service
Radio Horizon	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.
Radio Wave	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.
RAM	random-access memory
RDF	radio direction finding
Receiver	Slightly adjusts the receive frequency up or down. This does not change the transmit frequency. Incremental Tuner
Rectifier	A component composed of diodes aligned to alter the flow of current from alternating current to direct current.
Relay	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.
Repeater Offset	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 is plus or minus 5 MHz
Repeater Station	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.
Resistance	An opposition to the flow of DC current. Resistance is measured in ohms.
RF	Radio Frequency - The frequency of the Electromagnetic energy emission commonly called a radio wave.
RF	radio frequency
RFI	radio-frequency interference
RHC	right-hand circular (polarization)
RIT	Receiver Incremental - Slightly adjusts the receive frequency up or down. This does not change the transmit
RIT	receiver incremental tuning
RLC	resistance-inductance-capacitance
RMS	root mean square
ROM	read-only memory
RST	readability-strength-tone (CW signal report)
RTTY	radioteletype
RX	receiver, receiving
S	siemens (unit of conductance); switch
S/N	signal-to-noise ratio
Schematic	A drawing of symbols representing how electrical components are connected.
SCR	silicon controlled rectifier
Secondary User	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.
Selectivity	The ability to choose. In a transceiver this chooses one signal over another.
Sensitivity	The ability to detect. In a transceiver this pulls in the weak signal.
Series	An electrical connection where the current flows through all components in order.
SHF	super-high frequency (3-30 GHz)

Simplex	Receiving and transmitting on the same frequency. This is simple.
Space Station	A repeater or Amateur Radio Station over 50 km above the earth, generally in orbit.
SPDT	single-pole double-throw (switch)
Spin Fading	An observed change in signal strength as a satellite rotates during its orbit.
SPST	single-pole single-throw (switch)
Squelch	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.
SSB	Single Side Band - An amplitude modulation that uses one sideband with a carrier
SSB	single sideband
SSTV	slow-scan television
Stroke, Slant, Slash	The separation between your call sign and a special designator like the slash in a date ("/").
Switch	A device to connect or open an electrical circuit, often used to turn on a light or other electrical device.
Switching PS	A small power supply that uses a rectifier to convert house current to DC.
SWL	shortwave listener
SWR	Standing Wave Ratio - A measurement of how much radio wave energy is reflected from the antenna back to the transmitter
SWR	standing-wave ratio
sync	synchronous, synchronizing
Tactical Call Sign	This is a term used to temporarily identify your station. You must still use your FCC call sign (see Identify) according to the rules.
Telecommand	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.
TNC	terminal node controller (packet radio)
Traffic	A specific organized message that is passed from one operator to the next intending to deliver the
Transceiver	A radio that both transmits and receives.
Transformer	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.
Transistor	A component consisting of three layers of semiconductor material. Transistors can amplify a signal and they can direct the flow of current.
Transmit	To send a radio signal.
Tropospheric	A phenomenon where a radio signal bounces up and down within a layer of the atmosphere
TTL	transistor-transistor logic
TTY	teletypewriter
TU	terminal unit
TV	television
TVI	television interference
TX	transmitter, transmitting
U	integrated circuit
UHF	Ultra High Frequency - This is from 300 MHz to 3000 MHz
UHF	ultra-high frequency (300 MHz to 3 GHz)

Uplink or Downlink	The radio transmission to or from a space station.
USB	Upper Side Band - An amplitude modulation that uses one sideband with a carrier
USB	upper sideband
UTC	Coordinated Universal Time (also abbreviated Z)
UV	ultraviolet
V	volt; vacuum tube
Variable	Some electrical components can be adjusted and have "variable" before their name. These include a variable resister (potentiometer) and a variable inductor.
VCO	voltage-controlled oscillator
VFO	Variable Frequency - The ability to change to any frequency within the radio's capability. Radios used to use
VFO	variable-frequency oscillator
VHF	Very High Frequency - This is from 30 MHz to 300 MHz. This is generally from the 2 M to the 6 M band
VHF	very-high frequency (30-300 MHz)
VLF	very-low frequency (3-30 kHz)
VoIP	Voice over Internet Protocol - A methodology for the delivery of voice communications
Voltmeter	Measure's volts or electromotive force and is connected in parallel with the circuit.
Volts	A measurement of the electromotive force.
VOM	volt-ohmmeter
VOX	voice-operated switch
VSWR	voltage standing-wave ratio
W	watt (kg m2s-3), unit of power
Watts	A measurement of electrical power. Power is measured in watts.
Wavelength	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.
WBFM	wide-band frequency modulation
Wh	watthour
Window Line	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.
WPM	words per minute
XFMR	transformer
XIT	transmitter incremental tuning
XO	crystal oscillator
XTAL	crystal
XVTR	transverter
Y	crystal; admittance
Z	impedance; also see UTC