I HAVE MY AMATEUR RADIO LICENSE
NOW WHAT DO I DO?

Revision 1.4
09 Feb 2021

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Overview

The purpose of this material, and associated classroom session, is to provide you, the new or inexperienced Amateur Radio operator, with:

- Guidance on the fundamentals of physical aspects of operating a radio properly
- Guidance on the fundamentals of radio communications protocols
- Establishing good operating habits, which will carry forward toward demonstrating proficient and competent station operation, and that will carry forward to public service and emergency communications operation.
- Setting up a station
- Operating within the regulations
- Amateur Radio's relationship to Public Service
- Amateur Radio's relationship to Emergency Communications
- The language of Amateur Radio
- Other facets of Amateur Radio operating

The material covers topics that you need to know, that is those topics that are critical to you being able to both communicate effectively and to be accepted into the Amateur Radio community as a competent and qualified radio operator. Our goal is, by introducing these guidelines and principles, to make you comfortable in operating your radio. With experience, and this knowledge, your self confidence in operating your radio will grow, until operating your Amateur Radio becomes second nature. It will also help you to identify and avoid accepting improper advice from those who are inexperienced but have the best of intentions.

The material covers topics that serve to expose you to Amateur Radio activities that are not apparent during license study, and may not become apparent until you are exposed to these activities by someone who is involved in them. These activities range from technology based activities to task based activities, all of which can and do have a social aspect to them.

This material strives to present an Amateur Radio perspective and stringently avoids promotion of views, practices and procedures that have their basis in other radio services. The goal, in avoiding material that is based on other radio services is to help you to gain acceptance and to allow you to seamlessly integrate into the community of Amateur Radio operators. Adherence to these guidelines and principles should allow you to effectively integrate into the Amateur Radio community, no matter where you go or who you are communicating with.

Finally, this document, and associated classroom session, is intended to be driven by a two way dialog that occurs between the new or inexperienced Amateur Radio operator and the Amateur Radio operator who is serving in a mentor role. As such, any questions or discussions that occur in the classroom setting, will be rolled back into this document.

As you gain experience and knowledge, it is our hope that you too will step into the role of mentoring new Amateur Radio operators that come up through the ranks behind you. You will find that this is one of the most rewarding and fun aspects of the Amateur Radio hobby.

Physical Fundamentals of Radio Operation

For most people entering the Amateur Radio hobby, entry occurs through the Technician Class license. At this introductory level, the first exposure to radio operating almost always occurs using the Frequency Modulation (FM) mode on the 2-meter VHF or 70cm UHF band. Even after an upgrade of equipment or license, FM operation on the 2-meter and 70cm bands remains the primary mode of operation for a large number of Amateur Radio operators.

What do the HF, VHF and UHF terms mean?

These terms are standard terms to describe ranges of frequencies:

TERM	LOWEST FREQUENCY	HIGHEST FREQUENCY
High Frequency (HF)	3 MHz	30 MHz
Very High Frequency (VHF)	30 MHz	300 MHz
Ultra High Frequency (UHF)	300 MHz	3000 MHz

There are other groupings of frequencies that include allocations for use by Amateur Radio, but these three, HF, VHF and UHF, are by far the most popular and are the easiest to obtain equipment for.

Types of radios

Most radios that you will encounter as an Amateur Radio operator are **transceivers**. These radios have both a transmitter and a receiver, with circuitry to automatically switch the antenna between the transmitter when transmitting, and the receiver when receiving. Some older equipment, which is intended to operate between 1.8 and 30 MHz, may consist of a separate transmitter and receiver. When a separate transmitter and receiver are used, an external device is required to switch the antenna between the transmitter and receiver.

Radios fall into three broad use categories:

- Base
- Mobile
- Portable

For VHF and UHF FM operation, the mobile radio is installed at a fixed location to implement a base station as there is no difference between the radios. For HF operation, this may or may not be the case. An HF radio that is intended for mobile use can be used as a base station radio but, due to size, weight and power supply requirements, some HF base station radios cannot be used for mobile applications.

Many VHF / UHF mobile radios implement a feature where the control head can be detached from the main body of the radio. This is to enable mounting the radio in a remote location while enabling mounting of the control head where it is conveniently accessible.

<u>What is the 2-meter and 70cm stuff?</u>

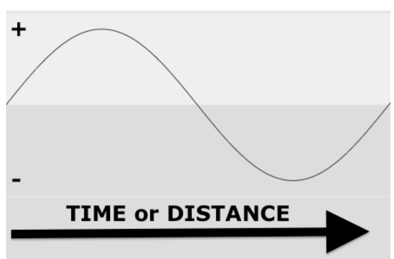
Amateur Radio operators may refer to a band of frequencies that they operate on by referring to the frequency or the wavelength associated with the frequency. When referring to a band of frequencies, usually the wavelength is referenced. The 2-meter and 70cm bands represent the two most popular bands in the VHF and UHF spectrum respectively.

The exact frequency is only referenced when the frequency of operation is channelized, or when a band-plan for a specific type of operation dictates a specific frequency, or when in non-channelized operation, a contact is arranged to operate on a specific frequency.

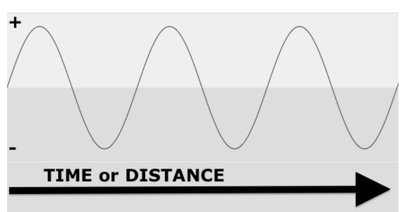
Radio waves travel at a RATE of the speed of light:

Unit	Time	Distance
Meter	1 Second	299,792,458
Kilometer		299,792.458
Feet		983,571,056
Miles		182,282.396

A wave has both a positive and negative component, shown on the vertical axis in the figure below, and a period or length, shown on the horizontal axis below.



The period of the wave, or wavelength, can be expressed in terms of time of distance. A higher frequency wave has a shorter period.



If we can determine the TIME period of the wavelength, and, already knowing that the wave travels at a RATE equal to the speed of light, we can determine the wavelength in distance using a RATE X TIME = DISTANCE calculation.

How do we determine wavelength?

First, we determine the TIME period of the wave by taking its reciprocal: 1 / FREQUENCY = TIME

Second, we multiply the RATE by the TIME to determine the DISTANCE

For example, an Amateur Radio station that is operating on 7.2 MHz, or 7,200,000 Hz. The TIME for on cycle of the radio wave is 1 / FREQUENCY or 1 / 7,200,000 or 0.00000013888889 seconds. The radio wave travels at a RATE of 299,792,458 meters per second. If the TIME of 0.00000013888889 seconds is multiplied by the RATE of 299,792,458 meters per second, the DISTANCE traveled, or wavelength, is 41.6378 meters. Because the frequency band spans a range of wavelengths, Amateur Radio operators apply a rounding to this number when referring to a band.

So, lets apply this to the frequency allocations that we enjoy on Amateur Radio:

Frequency Hz	Period (Seconds)	Wavelength (Meters)	Reference
1,800,000.000	0.000000555556	166.55	160-meters
2,000,000.000	0.000000500000	149.90	160-meters
3,500,000.000	0.000000285714	85.65	80-meters
4,000,000.000	0.000000250000	74.95	75-meters
5,330,500.000	0.000000187600	56.24	60-meters
5,403,500.000	0.000000185065	55.48	60-meters
7,000,000.000	0.000000142857	42.83	40-meters
7,300,000.000	0.000000136986	41.07	40-meters
10,100,000.000	0.000000099010	29.68	30-meters
10,150,000.000	0.000000098522	29.54	30-meters
14,000,000.000	0.000000071429	21.41	20-meters
14,350,000.000	0.000000069686	20.89	20-meters
18,068,000.000	0.000000055346	16.59	17-meters
18,168,000.000	0.000000055042	16.50	17-meters
21,000,000.000	0.000000047619	14.28	15-meters
21,450,000.000	0.000000046620	13.98	15-meters
24,890,000.000	0.000000040177	12.04	12-meters
24,990,000.000	0.000000040016	12.00	12-meters
28,000,000.000	0.000000035714	10.71	10-meters
29,700,000.000	0.000000033670	10.09	10-meters
50,000,000.000	0.000000020000	6.00	6-meters
54,000,000.000	0.000000018519	5.55	6-meters
144,000,000.000	0.000000006944	2.08	2-meters
148,000,000.000	0.000000006757	2.03	2-meters
222,000,000.000	0.000000004505	1.35	1.25-meters or 125cm
225,000,000.000	0.000000004444	1.33	1.25-meters or 125cm
420,000,000.000	0.000000002381	0.71	70cm
450,000,000.000	0.000000002222	0.67	70cm
902,000,000.000	0.000000001109	0.33	33cm
928,000,000.000	0.000000001078	0.32	33cm
1,240,000,000.000	0.000000000806	0.24	23cm
1,300,000,000.000	0.000000000769	0.23	23cm

Why is wavelength important?

- The design and implementation of an efficient antenna system is directly related to the wavelength (this will be covered in a later topic).

- This is the key to any discussion of radio bands and frequency allocation. And, since the terms for frequency and wavelength are related, and may appear even in the same discussion, understanding this basic principle is key to understanding discussions on this topic.

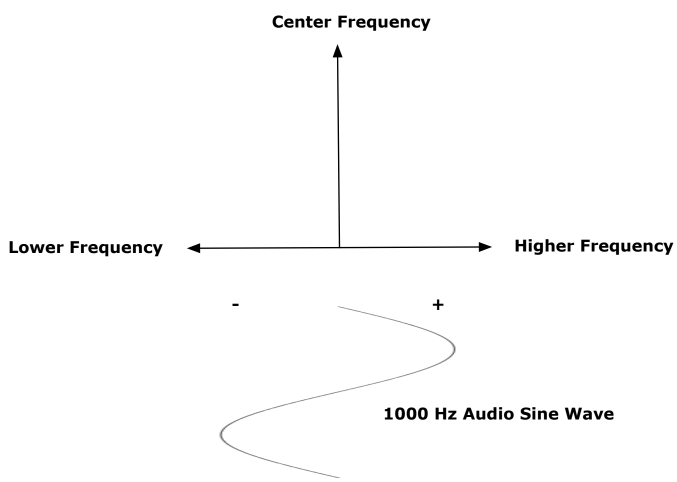
Well, what about this FM stuff, what is that about?

The radio wave is said to 'carry' information. Information, such as your speech, can be imposed onto a radio wave in one of two ways. These are:

- Amplitude Modulation
- Frequency Modulation

For bands that are lower in wavelength than 10-meters (or higher in frequency), the most popular method of applying information to the carrier wave is Frequency Modulation. With frequency modulation, the frequency of the carrier is varied at the frequency of the information (or speech), while the magnitude that the carrier wave is modulated with is controlled by the amplitude of the information.

In the following figure, the horizontal axis represents frequency, with a lower frequency appearing at the left and a higher frequency appearing at the right. The Center Frequency represents the carrier wave frequency when no modulation is present. The sine-wave that appears below the frequency axis is the information that we want to convey over the carrier wave. In this case, that information is a 1000 Hz audio frequency sine-wave.



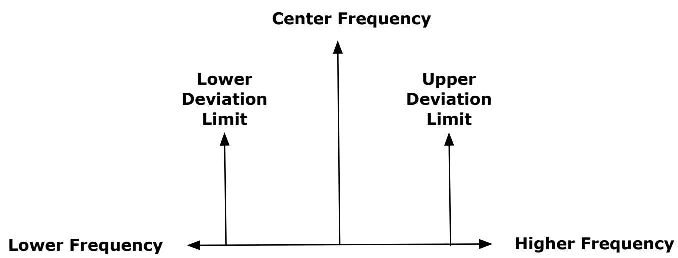
As the 1000 Hz sine-wave is applied to the carrier wave, through frequency modulation, the frequency of the carrier wave will move higher in frequency during the positive phase of the 1000 Hz modulating waveform, and lower in frequency during the negative phase of the modulating waveform. The distance that the carrier wave moves from its quiescent center frequency is directly proportional to the amplitude, or magnitude, of the modulating audio waveform. The modulating audio waveform is said to deviate the carrier waveform, with the magnitude that the carrier wave moves from the center frequency referred to as **Deviation**.

Why should I care about this Deviation stuff anyway?

Understanding the modulation scheme is critical to understand how you should handle the microphone when transmitting, and how loud you should speak. Improper use of the microphone has a direct impact on deviation, and can result in significant distortion, weak audio, and even interference to stations operating on adjacent frequencies.

For FM modulated signals, national, regional and local band-planning comes into play. There is a trade-off between the radio spectrum's ability to handle a number of simultaneous and distinct conversations and the fidelity of the audio. Higher fidelity requires higher deviation but higher deviation results in reducing the number of simultaneous conversations that the spectrum can handle. Therefore, the magnitude of deviation for a given Amateur Radio frequency band has a direct dependency on frequency congestion and the band-plan that is in place to mitigate that frequency congestion. Band-planning occurs at the national level, but also at regional levels. Since the requirements for mitigating congestion occur at a localized level, the band-plan that is determined at the local level, if it exists, takes precedence over national band-planning.

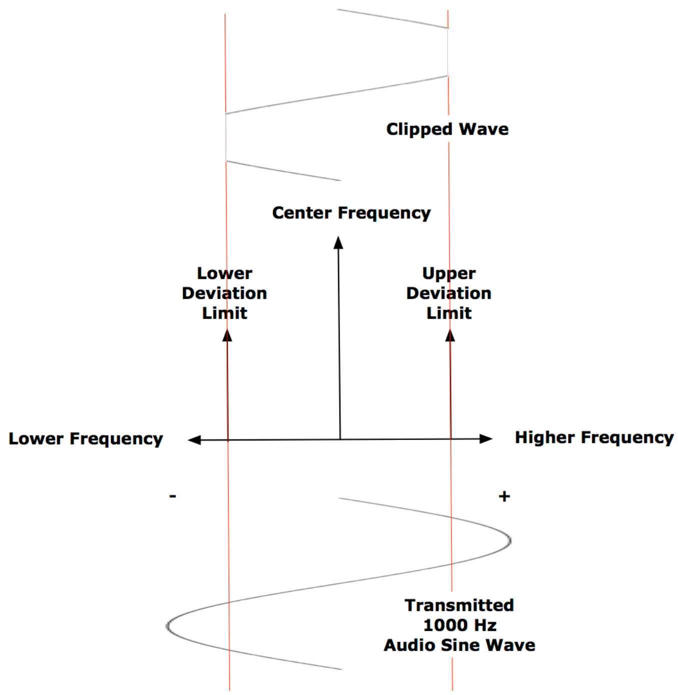
The band-planning sets the maximum deviation that you may use. For VHF/UHF operation on the 2-meter or 70cm band, the maximum deviation is ± 5 kHz. For example, a transmitter operating on 146.520 MHz with a ± 5 kHz deviation will occupy spectrum from 146.515 to 146.525 MHz.



If you were to speak too loudly, you could cause your radio to deviate beyond the ± 5 kHz deviation limit that is assumed in the band planning. There are two outcomes from this method of operating:

1. Over-deviation can cause interference to a station operating on an adjacent frequency as defined in the band-plan.

2. The nice waveform from your microphone that is being applied as the modulation signal on your FM transmitter may be restricted to the specified deviation limit, and any modulating signal that attempts to drive the carrier wave to a deviation beyond those limits will be clamped to those limits. This is heard as distortion on your transmitted signal.



Ideally, the magnitude of the audio signal that you want to apply in an FM transmitter is just enough audio to approach the deviation limits. This is controlled by:

a. The distance that the microphone is held from the mouth.

b. The level at which you speak into the microphone.

In general, the microphone should be held approximately 3 to 4 inches away from your mouth and you should speak at the same level that you would speak if you were engaged in conversation with someone in a quiet room. If your deviation is not loud enough, or is too loud and is exhibiting distortion, the station you are conversing with should tell you. If you're curious, ask. If you understood the background on this topic to this point, you probably have a greater understanding than most Amateur Radio operators. If the person you ask doesn't seem to understand at the same level as you do, or does not use the terms **deviation** and **quieting**, ask someone else for a qualitative report on your audio during transmit.

It should be noted that an over-deviated signal may extend beyond the receiver pass-band, and may cause the received audio to drop out.

Amplitude Modulation will be covered in another section. We want to concentrate on what you **need** to know first.

Why FM?

Noise sources, whether atmospheric or man-made, tend to be amplitude modulated. FM offers a wide signal to noise ratio, and the audio signal does not fade with signal strength fading. That is that a weak signal will have the same audio signal strength as a strong signal. That being said, noise may be present along with the audio signal that is being listened to.

I hear noise out of my receiver when nobody is transmitting

This is normal operation of your receiver, but there is a device that is built into your receiver that enables you to have the noise muted when no signal is present. That device is a squelch gate.

The receiver has audio filtering that separates the audio spectrum into three components:

- Frequencies below those normally used to convey speech
- Frequencies used to convey speech
- Frequencies above those used to convey speech

The squelch circuit is concerned only with those frequencies above those used to convey speech. Noise falls into this band of frequencies while voice content does not. The squelch circuit converts the noise level to a D.C. voltage that is proportional to how **quieting** the FM receiver is. The radio then provides a method to set a threshold of receiver quieting that the squelch circuit will allow audio to pass to the speaker or headphones. If the signal is too noisy, the squelch circuit allows no audio to pass to the headphone or speaker, making it comfortable to listen to the receiver when no signal is present.

Adjustment of the squelch is generally performed by one of two methods:

- Adjust the squelch threshold using a knob
- Adjust the squelch threshold using a menu item

The method that applies to your radio is completely dependent on manufacturer and model. Most mobile radios employ a knob. Hand-held portable radios may have either a knob or a menu setting. Consult your radio manual to determine which applies to your equipment.

How should the squelch be adjusted?

With no receive signal present, the squelch control on an FM receiver should be adjusted just to the point where the audio becomes muted. Man-made noise sources may cause the squelch to pass audio and it may be necessary to adjust the squelch control with a dependency on other equipment that may be operating in proximity to the FM receiver. For example, a computer or a cash register may present a weak signal that opens the FM receiver squelch, and you may need to temporarily increase the squelch threshold setting when in proximity with such devices.

You should not, however, get in the habit of running the squelch threshold at its highest setting as doing so will prevent you from hearing all but the strongest of signals.

Setting the squelch to a level where weak signals can be heard is referred to as **opening** or **loosening** the squelch. Conversely, setting the squelch level to where only strong signals can be heard is referred to as **closing** or **tightening** the squelch.

If you run with a tight squelch, and expect to converse with a weak station, be sure to loosen the squelch to enable hearing the weaker station.

About Giving & Receiving A Signal Report

Signal reports are given for the following reasons:

- To ascertain the effects of propagation
- To provide a qualitative indication of the performance of the signal path
- To provide a qualitative indication of audio quality
- To report anomalous behavior of the station equipment
- To report improper use of equipment, where correct operation will result in more efficient communications

Signal reports are never to be interpreted as a personal attack. Nor does a signal report imply that improper station performance is an intentional act. Signal reports are always intended to to be an aid to station operation. Most amateur radio operators place high value on receiving a signal report, and especially so when the report is accompanied by a technical description that explains how anomalous operation affects station performance and suggests possible root causes. In fact, most amateur operators desire to have any anomalous operation reported to them. Simply put, a problem cannot be fixed if its existence is unknown. Further, a technical problem **requires** a technical response. An emotional response is unacceptable, and can only lead to embarrassment.

If you receive a signal report, and somehow feel hurt by it, please research the technical explanation that is given. There are many good technical articles available on-line, and with proper study, you will be able to determine a proper course of action.

How to quantify signal quality on FM transmissions

Signal quality reports are always subjective. Use of the signal strength reading on your radio, under some circumstances, is completely pointless.

Signal quality reports on FM have two components, which describe:

- The degree to which your receiver is quieted by the received signal
- The level of deviation

If no noise is present in the audio on an FM receiver, the signal is said to be **full-quieting**. If the signal is so weak as to not provide any quieting of the receiver, and sounds similar to an open squelch, the signal is said to be of **no-quieting**. Signal strengths appearing between no-quieting and full-quieting are described by a percent of quieting as determined relative to a full-quieting signal. The percent quieting is subjective.

If the audio level presents the same audio level as other transmitting stations, does not require adjustment form the normal volume setting that you customarily use, and is distortion free, the audio is probably of the correct deviation. If the audio is lower in deviation than other stations and requires that the volume be increased then the audio is probably **under-deviated**. If the audio is higher in deviation than other stations and requires that the volume be decreased, or the audio sounds clipped (a phenomenon that requires experience to identify), the audio may be **over-deviated**. The word **modulation** is almost never used to describe the signal quality of an FM signal.

If the transmitting station has a transmitter that is not operating correctly, or if propagation effects are degrading the signal, additional descriptions may be warranted. Propagation effects can introduce a number of distortion effects, including:

- Rapid cyclic signal fading, with characteristic bursts of noise that occur at a frequency of several times per second (often referred to as picket fencing, due to the similarity of the beat produced by holding a stick against a picket fence while walking or running).
- Multi-path Phase Distortion
- Off-channel phase distortion

Picket fencing is exhibited by mobile stations, while in motion, when the mobile station does not have a good signal path to the receiver.

Multi-path phase distortion and off-channel phase distortion can sound almost identical. However, since most radios have very good frequency control, off-channel phase distortion is rare. Multi-path phase distortion occurs when there is no direct line of sight signal path between the transmitter and receiver, and where the transmitted signal bounces off of several objects, arriving at the receiver from multiple paths at the same time.

Oddly enough, multi-path phase distortion can sometimes be resolved by the transmitting station reducing power. The reduction in power will reduce the signal strength of some of the bounced paths, leaving the best path to the receiver at a strong signal level. Increasing transmit power can make the problem worse.

Since all of these signal reporting criteria require experience, it is ok to fess up and tell the other station that you are not experienced in giving signal reports prior to actually giving the signal report. They'll understand, and if the signal report is deemed critical to them, they will seek out a report from someone more experienced. Listen to experienced operators as they provide signal reports. If, when on FM, the operator does not use the terms expressed here, then don't put too much weight in their reports and seek out a more experienced operator to provide an example of signal reporting.

The mechanics of duplex radio communication

Most radio communication occurs in half-duplex mode. Before explaining half-duplex, let's talk about the mode of communications that we all use in our conversations that are not conducted over radio, that is full-duplex.

In full duplex operation, you can hear the person that you are talking to at the same time that you are talking. In this mode of communication, you can interrupt or interject into the conversation through the simple act of speaking. With the exception of Repeaters, a topic that we'll discuss in a later section, use of full duplex operation in Amateur Radio is **extremely rare**.

In half-duplex operation, you cannot hear the station that your are conversing with while you are talking. This is equivalent to placing your fingers in your ear whenever you are speaking with another individual, and they would do the same.

In half-duplex operation, you cannot interrupt or interject while another station is transmitting. Nor can the station that your are conversing with interrupt or interject while you are transmitting. We cannot talk and listen at the same time in a half-duplex system.

What happens if two stations talk at the same time?

When using FM, the stronger of two stations will be heard over the weaker station. This phenomenon is referred to as **capturing** the receiver. Even in these cases, there may be a low level tone or growling in the receiver, accompanied by some level of interference to the station that has captured the receiver. The low-level tone, growling or interference is evidence that another station wants to break-in, or, perhaps, the station breaking in captured the receiver and the station you were conversing was not heard.

There are two methods of describing the phenomenon of simultaneous transmission:

a. Announce on frequency that a **double occurred**.

b. Announce on frequency that a **station was captured**.

Usually, one of the two, or more, stations that interfered with each other will stand-by (i.e. delay transmission) to allow the other station to break in.

Note that doubling spawns doubling. That is that when doubling occurs, the stations that observe it almost always double when announcing that doubling occurred. Usually the message gets through so don't worry of this happens.

How do I avoid doubling or capturing another station?

Doubling, or capturing another station is a normal event that happens often. At times, it may even be desired or necessary in order to break into a conversation. However, there are operating procedures that you can implement to enable other stations to break in without having to resort to simultaneous transmission. These will be covered in the communications protocol sections that discuss Simplex and Repeater operation.

Making a transmission

The microphone, or a hand-held portable radio, includes a momentary contact switch, which, when depressed, activates the transmitter. This switch is the Push-To-Talk switch or PTT. For half-duplex operation, this switch controls whether you have your fingers figuratively in your ears or are listening to other stations.

Radio Operating Protocols

Again, the primary focus here on FM operation as FM operation will likely be the focus of your activities as a new Amateur Radio operator.

FM operation usually falls into two broad categories, as follows:

- Simplex Operation
- Repeater Operation

Other FM operation, including Remote Base operation, stems from a subset of Repeater Operation or Simplex operation and will be described after discussing Simplex and Repeater operation.

Simplex Operation

In FM simplex operation, both the transmitting station and the receiving station have either a line-of-sight signal path, or a signal path that approximates a line-of-sight signal path (see Fresnel Paths in the section on propagation).

In the simplex environment, you are in direct communications with the station that you are conversing with. As such, there are no equipment dependent operating procedures to be implemented while in conversation. Good operating practices would have you wait for one or more seconds when detecting that the other station has ceased transmission before you start transmitting in order to facilitate a pause that allows other stations to break in.

It is also good operating practice, when engaged in a conversation with multiple individuals, to establish an order of handing off transmission from one station to the next station in order. This is often referred to as a **round robin** hand-off. The downside of the round-robin hand-off is that a spontaneous response to a comment from another station has to be held off until your turn, and the conversation may have moved to an entirely different topic. Use of the round-robin hand-off is completely at the discretion of the participating stations.

Detection of the end of transmission can be performed audibly or visually. Remember the discussion on the squelch circuit? When a station stops transmitting, the receiver, which was quieted, now becomes unquieted. The squelch circuit will cut in and mute the audio when the unquieted condition is detected, but it takes a small amount of time for the charge in the circuit to change states, and this allows for a very short duration of noise to be heard through the speaker or headphones. This noise is the squelch circuit decay noise. When you hear this noise, the other station may have ceased transmission. The exception is that mobile flutter, or picket fencing, can exhibit the same sort of behavior. Experience will help you determine the difference.

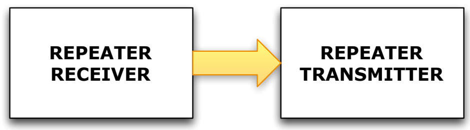
The other method is to observe the signal strength indication. This may be in the form of an analog meter, a digital simulation of a meter, or a Light Emitting Diode (LED) that ceases illumination when the station stops transmitting.

Either the squelch decay or the signal strength method can be used to provide a queue when the other station stops transmitting. Count off one second, to provide a pause to allow for breaking stations, and then, if no breaking station is heard, go ahead and transmit.

The use of roger beeps at the end of the transmission is largely unheard of and frowned upon in Amateur Radio. These devices, until recently, have never been available in Amateur Radio equipment, and only appear in recent equipment introductions coming from China. The use of these devices appears unprofessional, are largely viewed as annoying noise, and will not result in your station operating practices being viewed with respect. The use of such devices are best left to radio services other than Amateur Radio.

What is a repeater?

A repeater is, in its simplest form, an automated real-time relay system that provides increased range when compared to simplex operation. This capability comes from the repeater being located on top of the mountain. When using a repeater, your station is virtually placed on top of the mountain where the repeater is located.

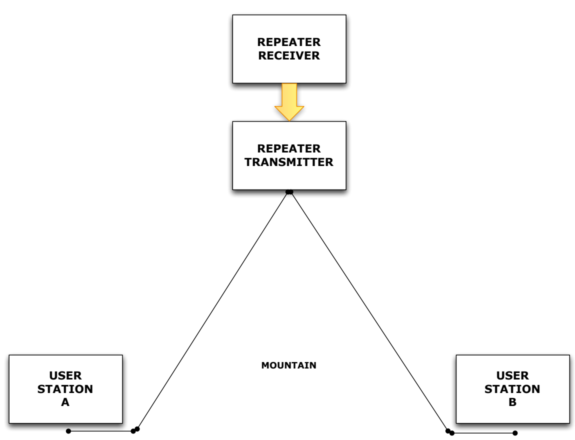


Repeaters, by definition, are full-duplex devices. That is to say that the receiver and transmitter operate simultaneously.

The repeater transmitter is always on a different frequency of operation than the repeater receiver. If this were not the case, the repeater receiver would always hear the repeater transmitter, and would result in capturing all stations that are attempting to use the repeater.

When discussing repeater frequencies, the repeater transmit frequency, which is the frequency that your station receives the repeater on, is always referred to. Your transmit frequency is then referred to as either a positive or negative offset, relative to the frequency that you receive the repeater on. The magnitude of the offset is standardized for each of the VHF or UHF bands.

A repeater, located on a mountain top, is able to support communications between stations that could not otherwise communicate via line-of-sight communications. As shown below, line-of-sight communications between stations A and B is obstructed by a mountain. Yet, both stations A and B are able to establish line-of-sight communications with the repeater, and with both stations A and B using the repeater, communications between these stations is possible.



Repeater Operation

Because of their increased range, repeaters become a focal point for frequency congestion. Users tend to congregate on the repeater system, and even when simplex operation might provide performance on par with a repeater when conducted among two stations, the ability of the repeater to forward a call that would otherwise be missed with simplex operation keeps most operators congregating on the repeater system.

Regardless, if two stations establish contact, and are capable of communicating with simplex mode while not expecting other stations to participate in the exchange of conversation, those stations should move off of the repeater and onto a simplex frequency to avoid prohibiting stations that could not otherwise establish and maintain communications, from using the repeater. This procedure is especially necessary on highly congested repeater systems.

Because of the frequency congestion that is inherent with repeater operation, propagation effects that mostly effect how mobile stations interact with the repeater system, and electro-mechanical considerations that have an impact on repeater maintenance cycles, repeater operation requires different operating protocols when compared to simplex operation.

What is a squelch tail?

Early repeaters used relays to key the transmitter in response to the receiver detecting that a signal is present. Some propagation effects, such as mobile flutter, or picket fencing, would cause the repeater transmitter to cycle on and off as the receive signal experiences fading and restoration of received signal. This cyclic operation would result in premature failure of the transmit relay. Further, the delay in keying the transmitter may itself be responsible for rendering a signal unintelligible when compared to leaving the transmitter keyed during periodic momentary signal fading conditions.

These problems were mitigated by implementing a squelch tail timer. As soon as the receiver detects a valid signal, the transmitter is keyed immediately. When the received signal drops out, a timer is started and the transmitter remains keyed until that timer times out. The squelch tail timer duration is longer than most periodic signal fading conditions, and is able to avoid un-keying the transmitter in instances of periodic fading conditions.

Secondary to this function, the squelch tail serves a second purpose in providing a queuing signal to indicate when a user station may begin transmission. Stations may begin transmitting after the repeater squelch transmitter drops. This can be identified by the sound of the repeater squelch decaying being retransmitted by the repeater transmitter when the receive signal drops out of the repeater receiver, followed by a delay that is equal to the duration of the squelch tail timer, and then the sound of the squelch decay heard directly on your radio when the repeater transmitter drops. Although the squelch tail timer duration typically is approximately 1.5 seconds long, shorter and longer squelch tail delays may be present on a given repeater system.

This double decay of squelch circuits, resulting in short noise bursts that are separated by a 1.5 second delay, is often referred to as a ker-chunk sound, or simply the squelch tail.

The squelch tail is used in repeater operating protocol to indicate first, that the transmitting station has ceased transmission as evident by the first squelch decay noise burst, and second, that the repeater transmitter has stopped transmitting as evident by the second squelch decay noise burst. Conversing stations should not start transmitting until the second squelch decay noise burst occurs. Breaking stations should transmit in the interval between noise bursts, as conversing stations will be standing by to wait for the repeater transmitter to drop, in order to make their presence known.

The sequence to hear is a **CH** sound, followed by silence for a count of one, one thousand, two, and then a **CH** sound.

If the audio queue from the squelch circuit decay is difficult for you, watch your signal strength meter or receiver active Light Emitting Diode for an indication that the repeater transmitter has dropped before keying your transmitter.

Why does the repeater drop out on long transmissions?

Individual repeater transmissions are limited to a maximum duration. This is enforced by a timer in the repeater control circuitry. If a transmission exceeds the maximum allowable duration, the repeater transmitter will drop at or before the maximum duration is reached. The repeater transmitter will stay un-keyed until the signal at the repeater receiver drops.

To avoid the timer invoking a drop out of the repeater transmitter, be sure to let the repeater transmitter drop at the end of the squelch tail.

Why do I need to transmit a tone to access the repeater?

Since the repeater receiver is usually located at a high level, and enjoys a much larger coverage footprint than the typical station that is using the repeater, the repeater receiver may hear interference sources or signals that should not be given access to the repeater transmitter. The repeater may even have a zone of overlapping coverage with another repeater on the same frequency, and may need to exclude the stations using the other repeater from gaining access to the repeater transmitter.

Transmission of a sub-audible tone, or a digitally encoded signal, allows the repeater to restrict access of signals present at the repeater receiver from gaining access to the repeater transmitter. The requirement of participating stations to transmit tone provides two features:

- Access to the repeater from non-coherent interference sources, such as man-made noise, will not be passed on to the repeater transmitter.
- Access to the repeater may be restricted to participating users, allowing more than one repeater to occupy the same frequency when small zones of overlapping coverage exist.

Tone transmission falls into two categories:

- Continuous Tone Coded Squelch (CTCSS). Motorola's proprietary name for this feature is Private Line (PL).
- Digital Coded Squelch (DCS)

Both capabilities are built-in to virtually every radio that is currently on the market. Radios manufactured a few years ago may have only CTCSS capability and no DCS capability. Earlier model radios did not include either feature and required installing a board in the radio to support either capability.

What Does Encode and Decode Mean?

When a transmitter includes the transmission of CTCSS, the transmitter is said to be operating in **encode**. When a receiver decodes the CTCSS, the receiver is said to be operating in **decode**.

Typically, your station will run in **encode** mode to access a repeater. The repeater typically operates in **decode**.

There are some cases where a repeater in both **decode** and **encode**. When a repeater operates in **encode**, it is possible for your station to run in **decode**. The advantage of being able to do this is that certain noise sources that are capable of opening the squelch, particularly when mobile, will not be heard when operating in **decode**.

It should be noted that DCS always runs simultaneously in **decode** and **encode**.

NOTE: The CTCSS & DCS decoders only indicate a valid signal several hundred milliseconds after transmission begins. Adding a small delay between beginning transmission and speaking is advised.

What is repeater linking?

Every repeater has an area of coverage, or coverage footprint, where the repeater can both hear stations attempting to work the repeater, and where the repeater can be heard. In a single repeater, the only methods of increasing the size of the coverage footprint is to increase both the receiver sensitivity and the transmitter power, increase the gain of the antenna, or increase the altitude of the antenna.

Most repeaters already implement receivers and antenna systems that are at the limit of technology, and increasing the transmitter power is pointless if the repeater can be heard by the station attempting to use it but cannot hear the same station. Further, repeater sites are usually located at a mountain peak and do not present an option to increase the altitude of operation. This is exacerbated by the difficulty in acquiring a repeater site, coupled with the demand and congestion that occurs at a repeater site.

The only other way to effectively increase the coverage of a repeater is to connect several repeaters together to form a repeater network. The coverage of the repeater network then becomes the composite of each of the individual repeaters comprising the network.

The method of interconnecting two or more repeaters to form a repeater network is referred to as linking. Linking is usually accomplished by one of the following methods:

- Radio Frequency Linking
- Dedicated Leased Telephone Line Linking
- Voice Over Internet Protocol (VOIP) Linking

Each individual repeater provides a cell of coverage. Ideally, the individual coverage cells abut or overlap adjacent coverage cells. The goal is to provide a composite coverage footprint that has no holes in the coverage area.

With all of the repeaters connected together through the link infrastructure, a transmission heard on one repeater in the network is forwarded to all repeaters in the network. This enables any station using any repeater in the network to be heard by any station using any other repeater in the network.

Mobile stations that are traveling from one coverage footprint of an individual repeater in the network, to the coverage footprint of another repeater in the network, need only change frequency to the repeater that is associated with the coverage footprint zone that they are driving into in order to maintain communications.

Of special consideration is that VOIP Linking allows repeaters, located anywhere world-wide, to be interconnected. This allows a station with a hand-held radio, to establish a contact with a station in any state, country or continent.

What Are All These Buttons On My Microphone?

When in transmit mode, the buttons on the face of a hand-held portable radio, or on the microphone for a base or mobile radio installation, will emit Dual Tone Multi-Function tone pairs when pressed. These tone pairs are identical to the tone pairs present on a land-line telephone.

These tones are used to invoke control sequences on equipment that has support for decoding sequences of tone pairs. The most common use is to support remote control of a repeater station. Most repeater control functions are restricted to use by the repeater control operator. However, some control functions, such as a phone patch or access to Voice Over Internet Protocol (VOIP) connections between radios.

The policy that is established by each repeater owner or organization will determine whether control sequences by stations other than the control operator are permissible. Check with the repeater owner, or check their web page (if available) to determine if any control functions are available for your use.

What about 97.205(e)

The Code of Federal Regulations, Title 47, Part 97.205(e) states: ***"****Ancillary functions of a repeater that are available to users on the input channel are not considered remotely controlled functions of the station.* ***Limiting the use of a repeater to only certain user stations is permissible."***

What does this mean? Amateur Radio repeaters can legally operate as **closed** systems, allowing only their own members to operate on the repeater system. Further, even on an **open** system, which generally allows all comers, a specific individual or group can legally be excluded from operation on a repeater system.

Is the FCC serious about this? You bet they are. There are many documented cases of enforcement action where dates and times of violations by an Amateur Radio operator have been forwarded to the FCC, along with documentation of the request to cease operation in accordance with 97.205(e), where the FCC issued a letter to advise the Amateur Radio operator of the alleged violation, request an explanation, and reminded the operator of the penalty for failure to comply.

Repeater directories, both printed and on-line, indicate whether a repeater is an open or closed system. If a closed system, and you do not obtain permission to operate on the system, avoid the system.

Why would a repeater operator want to do this? Repeaters represent a substantial investment of both time and money. Repeaters that offer capabilities that are not often available could have those capabilities unavailable to the repeater owners if access to those capabilities are not restricted. Further, the impact of either using those capabilities or denying their use to the owners by their use, may not at all be apparent to the casual user. You should always respect whether a repeater is open or closed, avoiding operation on a closed repeater.

With regard to a specific targeted denial of a station to operate on a repeater, that is based on 97.205(e), you would have to become a pretty big nuisance to have such a demand issued, and you'd be made well aware of it.

Remote Base Operation

A remote base is simply a half-duplex transceiver that is attached to a repeater system. This is used to enable communication between simplex stations and repeater users, to enable communications on other bands than that which the repeater is located, and in some cases, to connect to other repeater systems.

The remote base transmitter does not transmit a squelch tail.

If you are operating on a repeater with a remote base, you use the repeater as if it did not have a remote base. If you are a simplex operator and are contacted by someone who is using a remote base, operate exactly as you normally do during simplex operation.

Mitigation of Propagation Effects

Remember that wave-length thing? A station that is using portable operation and experiences cyclic signal fading, that occurs at intervals that are proportional to the wavelength of the frequency being used may be experiencing multi-path signal cancelation. In this scenario, the signal is taking more than one path from the transmitter to the receiver, and when the two signal paths are summed at the receiver, signals that are out of phase tend to cancel each other out, resulting in a fade, while signals that are in phase tend to sum. If you were to plot the phase of the two signal paths relative to the path of movement, you would find that the signals are out of phase when a fade occurs and in phase when the signal is heard. The distances between the various signal paths from the transmitter to the receiver result in this variation. You may be able to mitigate the signal fading by stoping movement in a position that presents the best signal to the receiving station (i.e. the least signal cancellation). If stopping results in the transmitting station being located in a fade zone, move in 1/2 wavelength increments to find a location that avoids the fade zone.

For portable operation, always hold your portable hand-held radio so that the antenna is oriented vertically. Cross-polarization of antennas between two stations that are communicating can result in as much as -25 dB of attenuation of the signal.

Public Service & Emergency Communications

The definition of Amateur Radio can be found in the Code of Federal Regulations, Title 47, Part 97.1, which states:

> **CFR Title 47, Part 97.1**
>
> Basis and purpose.
> The rules and regulations in this part are designed to provide an amateur radio service having a fundamental purpose as expressed in the following principles:
>
> - Recognition and enhancement of the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications.
> - Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.
> - Encouragement and improvement of the amateur service through rules which provide for advancing skills in both the communication and technical phases of the art.
> - Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.
> - Continuation and extension of the amateur's unique ability to enhance international goodwill.

As such, Amateur Radio has a very close relationship with Public Service communications and with Emergency Communications. In its Public Service and Emergency Communications roles, Amateur Radio operators work closely with and serve other agencies. The primary role here is to provide communications infrastructure and staffing to fill niches that may not otherwise be possible, and to free other agencies, such as Public Safety organizations, to focus on their primary tasks by providing communications infrastructure and staffing for areas that fall outside of the normal priorities of Public Safety organizations.

To be blunt, Amateur Radio is a service organization, and does not employ superior redundant technologies that would enable Amateur Radio to be there when everything else fails. Quite the contrary, Amateur Radio implements the exact same redundancies as Public Safety radio systems and offers only equivalent, not superior, capabilities. Many an Amateur Radio operator has made public statements to indicate a superior capability, much to the offense of the organizations and agencies that Amateur Radio intends to serve. Such comments have resulted in the loss of critical infrastructure, and even the exclusion of using Amateur Radio in its defined roles.

Please do not fall into this pitfall, as to take up this position as it is a perspective that has no basis in fact and does not serve Amateur Radio well.

What Amateur Radio service organizations exist?

The primary Amateur Radio emergency service organizations are:

- Radio Amateur Civil Emergency Service (RACES)
- Amateur Radio Emergency Service (ARES)

Both organizations operate under the Code of Federal Regulations, Title 47, Part 97.161, which states:

> **CFR Title 47, Part 97.161**
>
> The Radio Amateur Civil Emergency Service provides for amateur radio operation for civil defense communications purposes only, during periods of local, regional or national civil emergencies, including any emergency which may necessitate invoking of the President's War Emergency Powers under the provisions of section 606 of the Communications Act of 1934, as amended.

Both organizations are completely voluntary and there are no fees required to join either organization.

RACES appears to lack organizational structure in that there does not appear to be any national organization to oversee and guide local RACES organizations. Depending on the local implementation of RACES, it may be anywhere from easy to impossible to obtain information about an individual RACES organization. RACES, in Idaho, appears to have no internet presence what so ever.

Although ARES is an organization that is constructed, managed and maintained by the American Radio Relay League, the national organization for Amateur Radio operators, ARES does not require ARRL membership. ARES is a structured organization that is organized along ARRL Sections, Districts with an ARRL Section, and finally, the County level. ARES does not require, but recommends, that members obtain specific training and qualifications through the ARRL's ARES courses, and through the Federal Emergency Management Administration (FEMA). Many of these courses are available on-line.

The ARRL schedules a national training event each year, held between the beginning of October and the end of November, to allow all Amateur Radio operators to participate in an emergency drill. This event is called the Simulated Emergency Test (SET). Additional drills, sponsored by any level within the ARES organizational structure, are possible.

Both ARES and RACES may hold periodic networked gatherings on the air (NET) to conduct exercises, pass simulated traffic, and to familiarize the Amateur Radio operator with communications in a structured environment.

In many areas, both the RACES and ARES organizations are combined and managed as a single unit. Although this is not yet the case in Idaho, a desire has been expressed to make this transition.

For Idaho Amateur Radio Operators who wish to join Idaho ARES, simply go on-line to register at <http://www.idahoares.info>.

What Amateur Radio public service organizations exist?

Public service communications usually occurs at the local club level. This may include providing communications for local community sporting events or charity events. Public service event communication services are requested by the served organization.

These events are great opportunity to become acquainted with structured communications and network (NET) operations. They also afford an opportunity to create goodwill by not only addressing the requested communications, but to examine the request and then provide communications that the requestor may not have thought possible.

The Language of Amateur Radio

Because of Amateur Radio's close relationship to Emergency Communications, and to a lesser degree, Public Service communications, it is vital that we, as Amateur Radio operators, are understood by those agencies and organizations that we serve. The day to day operating habits that we establish will prevail in NET operations, or in an Emergency Communications or Public Service role. Further, since many Amateur Radio communications are international in nature, the use of anything other than standard english serves only to cause the break-down in communications.

This is why it is critical that we use Plain English. Further, training from the Federal Emergency Management Administration (FEMA) mandates that Plain English be used.

Slang, and lingo that is prolific in an another radio service, especially when intended to obfuscate the english language, is to be avoided. The following should be avoided and discouraged:

- CB Lingo
- 10-Codes
- Q-Signals, outside of a Network Traffic System or Morse environment

The goal here is to avoid confusion.

For example, the word **Handle** is regularly used in the Citizens Band service to refer to an alias (a practice that originated to avoid prosecution of unlicensed operators). And, although the dictionary defines the use of this word to be appropriate for that purpose, the use of the word **Handle** to describe a name is non-sensical. It is equivalent to saying my name is my alias. It is far better, and proper to say **my name is Bob** rather than saying **the handle is Bob**.

In another example, the use of the phrase **got a copy** is also prevalent on Citizens Band radio. But what does it mean? Does it mean: **Is anyone on frequency that can give me a signal report**? Or, does it mean: **Is there anyone on frequency that can render assistance**? Or, does it mean: **Is anyone on frequency?** The phrase has been used in all three contexts but it is ambiguous.

Most seasoned Amateur Radio operators are offended by the use of Citizens Band lingo, and in a case where assistance is needed, such a request may go unanswered because there is no sense of urgency conveyed in the phrase. Far better to say what you mean to say in plain english. For example, if a signal report is desired, simply key the transmitter and ask: **Is there anyone on frequency that can give me a signal report?** Similarly, if assistance is needed, simply key the radio and make a general request for the type of assistance required, such as: **Is there anyone on frequency who can call Idaho State Police to report a vehicle off the road?** Clarity of expression will get you what you need.

As one very experienced Amateur Radio operator has put it, **talk like you talk on the telephone, with no cussing, and you'll never get in trouble.**

Some would say that holding to such procedures are inappropriate and unnecessary, in the flavor of the post modern view that anyone can apply any meaning to any sentence or phrase and that is still right. This is neither rational or logical! When you apply your own meaning to a sentence or phrase, the sentence or phrase becomes meaningless. Meaningless communications has no place in either Emergency Communications or Public Service Communications.

In practical terms, any given frequency can only be used to convey a finite amount of information within a given time. This is an expression of bandwidth. When communications are confusing, and require repeating, the finite amount of information that can be conveyed is decreased due to the need to requests clarification or requiring repeated transmission. Quite literally, in an Public Service or Emergency Communications role, this can increase risk to property, of injury or even death.

The following table should help you avoid the use of CB lingo:

IMPROPER	PROPER
The handle is ____	My name is ____
Anyone got a copy?	Is anyone on frequency that can give a signal report? Is there anyone on frequency that can render assistance?
Thanks for the come-back	Thank you for responding to my call.
Bear / Smokey / County Mountie any slang used to describe Law Enforcement	Idaho State Police (or appropriate named agency, or just Officer)
Come back	This is <INSERT CALL SIGN>, is there anyone on frequency? When on Single Sideband (predominantly High Frequency bands): CQ or CQ DX. Who is calling? Repeat your call?
Do what?	Please repeat your last transmission
Got your ears on? How 'bout?	Make a direct call on frequency: <STATION CALLED> <MY STATION CALL>, then un-key transmitter
10-4	If a traffic message was handled, say message received. For all other contexts, if you wouldn't say it on the phone, just move along in the conversation.
All other 10-Codes	Avoid them or use a plain english equivalent. Since 10-codes are not standardized, there is no way to publish a translation key that applies to all contexts.

Just because you heard this language in the Contact movie or the Phenomenon movie or have friends with CB that use it, doesn't make it right.

If you came from CB, you are to be congratulated on your accomplishment, but you need to leave CB behind. You are now in an environment that, even though varying levels of structured communications apply, requires a more professional approach. Please do not propagate this growing problem...

Making & Responding to a Call

We now have a good understanding of the physical operation of the radio and the protocols for simplex and repeater operation. Next is to learn how to make or answer a call.

Calling a station falls into one of two broad categories:

- A directed call
- A general call

The procedures for each category of call has a unique application with respect to FM operation vs Single Side Band (SSB) or morse (CW) operation. Single Side Band (SSB) and morse (CW) operation have additional requirements with regard to the physical operation of the radio that are not necessary with FM operation. This section focuses on FM operation.

Always Listen First

Of the utmost importance is to listen to the frequency prior to making a call. If you observe that the frequency is already in use, wait until the frequency is no longer in use before making a call. If someone else made a call, allow time for the station that they called to respond before making your call (note that the calling station will likely repeat the call). If the call is an emergency, you may break in at any time to make an emergency call. If the call is not an emergency, but is urgent or time critical, you may break in and, when acknowledged, explain that you would like to make a quick call and will vacate the frequency shortly if allowed to make a quick contact (most Amateur Radio operators will accommodate such a request). If the frequency is not in use, you are free to make a call.

Breaking In With Emergency Call

To make an emergency break-in to a conversation:

1. Wait for a pause between transmissions

2. Key your transmitter by depressing the push-to-talk (PTT) switch on the microphone or the side of the hand-held portable transceiver.

3. Say "break break".

4. Un-key your transmitter by releasing the push-to-talk (PTT) switch on the microphone or the side of the hand-held portable transceiver.

5. Listen for a response.

Never use "break break" in other than an emergency situation.

Breaking In With Non-Emergency Traffic

To break into a conversation when no emergency situation exists:

1. Wait for a pause between transmissions

2. Key your transmitter by depressing the push-to-talk (PTT) switch on the microphone or the side of the hand-held portable transceiver.

3. Say your call once.

4. Un-key your transmitter by releasing the push-to-talk (PTT) switch on the microphone or the side of the hand-held portable transceiver.

5. Listen for a response.

Do not use the word 'break' to break into a conversation. The word 'break' is a pro-word that is used in network (NET) operation. Using 'break' to break into a conversation applies a second meaning to the word and introduces confusion.

Making a Directed Call

To make a direct call:

1. Key your transmitter by depressing the push-to-talk (PTT) switch on the microphone or the side of the hand-held portable transceiver.

2. Say the call sign of the station to be called once.

3. Say your call sign once.

4. Un-key your transmitter by releasing the push-to-talk (PTT) switch on the microphone or the side of the hand-held portable transceiver.

5. Listen for a response.

For example, a call by K7QRT to contact W7QRM would be spoken as follows:

W7QRM K7QRT

If the called station does not respond in a reasonable time, you can repeat the call. It is unusual to repeat a call more than three times in a short period of time.

Good uses for a directed call include contacting:

- A specific person who you know
- A person who you just heard

Responding to a Directed Call

To respond to a direct call:

1. Key your transmitter by depressing the push-to-talk (PTT) switch on the microphone or the side of the hand-held portable transceiver.

2. Say the call sign of the station that called once.

3. Say your call sign once.

4. Un-key your transmitter by releasing the push-to-talk (PTT) switch on the microphone or the side of the hand-held portable transceiver.

5. Listen for a response.

For example, W7QRM wishes to respond to K7QRT’s call and speaks:

K7QRT W7QRM

Making a General Call

Making a general call on FM can take one of many forms, and may depend on the context for making the call. A general call can have a specific purpose, and it is perfectly acceptable to make a general call while stating that purpose within the call.

For example, if you're traveling to the Idaho State Amateur Radio Convention, and need driving directions, it is perfectly acceptable to:

1. Key your transmitter by depressing the push-to-talk (PTT) switch on the microphone or the side of the hand-held portable transceiver.

2. Announce: "This is <INSERT YOUR CALL SIGN> looking for directions to the Amateur Radio Convention."

3. Un-key your transmitter by releasing the push-to-talk (PTT) switch on the microphone or the side of the hand-held portable transceiver.

4. Listen for a response.

Similar calls can be constructed for a number of reasons, including:

- Requesting a signal report
- Asking what is the best frequency to use when traveling to a specific location
- Asking if the repeater covers travel from a specified location to another specified location
- Asking for a time check

All would assume the same format. The key elements are to identify your station, and state the purpose of your call in plain english.

It is possible to make a general call without any purpose. These can be as simple as announcing your call sign with no additional information, or announcing your call sign and appending the word 'listening'. Other stations that are on frequency and are willing to strike up a conversation will usually respond by making a direct call to you.

Responding to a General Call

Responding to a general call uses the exact same procedure and language as responding to a directed call.

Calling Format

The format of saying the called station call sign once, followed by saying your call sign once, is referred to as a 1 by 1 calling format. This is the most common calling format on FM. Other modes may have requirements for different calling formats, such as a 3 by 3 format, which are structured to enable the radio operator to perform tasks that are not performed when using FM.

It is considered to be poor operating practice to use a 3 by 3 call format during FM operations.

What Do I Do When Nobody Responds To My Call

If you wish to make another call, you may do so. If you do not wish to make another call, you may simply cease operation. Clearing off the frequency is optional. Some amateur radio operators will clear off the frequency while others do not.

How Should I Identify My Station

When your transmitter is active, your station must be identified once every ten minutes. Identification, while in conversation, usually occurs under the following circumstances:

- When establishing initial contact
- Once every 10 minutes while in conversation
- When breaking off contact

Station identification simply requires that your call sign be transmitted. This can be done by reciting the letters and numbers of your call, speaking your call sign with the phonetic alphabet, by morse identification, and, in some cases, digitally.

Most Amateur Radio operators use voice identification when operating in a voice mode.

Prohibited Transmissions - Things to Avoid

Code of Federal Regulations, Title 47, Part 97.113 defines prohibited transmissions. In short, the following are prohibited:

- Broadcasting. The FCC defines broadcasting as: "Transmissions intended for reception by the general public, either direct or delayed."
- Transmission of Music.
- Encrypted messages.
- Communications to facilitate a criminal act.
- Retransmission of signals from other radio services (there are a few exceptions).
- Retransmission of the signals of another Amateur Radio operator (except a repeater, auxiliary station or space station).
- Transmission for hire or with pecuniary interest.

Tools To Clarify A Message

When passing a message, often referred to as **traffic**, there are tools available to help convey the spelling of words, or to provide clear delimiters in passing a message or in performing tasks that provide for validation and correction of a message. These are Phonetic Alphabets and Pro-Words.

Use of the Phonetic Alphabet

The use of the ITU/ICAO Phonetic Alphabet is the standard phonetic alphabet for Amateur Radio operations. Although some Amateur Radio operators make up phonetics, there is no proof that these achieve better results in achieving clarity. Further, making a habit of using non-standard phonetics can create the habit of using non-standard phonetics, and may carry over to emergency communications and public service communications. The standard ITU/ICAO Phonetic Alphabet is shown below:

CHARACTER	MORSE	TELEPHONY	PRONUNCIATION
A	•-	ALPHA	AL-FAH
B	-•••	BRAVO	BRAH-FOH
C	-•-•	CHARLIE	CHAR-LEE or SHAR-LEE
D	-••	DELTA	DELL-TAH
E	•	ECHO	ECK-OH
F	••-•	FOXTROT	FOKS-TROT
G	--•	GOLF	GOLF
H	••••	HOTEL	HOH-TEL
I	••	INDIA	IN-DEE-AH
J	•---	JULIET	JEW-LEE-ETT
K	-•-	KILO	KEE-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 or OO-NEE-FORM
V	•••-	VICTOR	VIK-TAH
W	•--	WHISKEY	WISS-KEY
X	-••-	XRAY	EKS-RAY
Y	-•--	YANKEE	YANG-KEY
Z	--••	ZULU	ZOO-LOO
1	•----	ONE	WUN
2	••---	TWO	TOO
3	•••--	THREE	TREE
4	••••-	FOUR	FOW-ER
5	•••••	FIVE	FIFE
6	-••••	SIX	SIX
7	--•••	SEVEN	SEV-EN
8	---••	EIGHT	AIT
9	----•	NINE	NIN-ER
0	-----	ZERO	ZEE-RO

Use of Pro-words

There are many definitions of pro-words that are applicable to clarify the passing of formal traffic. These are usually used in a structured communications environment, such as a network (NET) or during emergency communications. The use of specified pro-words may be dependent upon the organization that you are operating with. The following list is comprised of common pro-words, but is not to be considered a definitive set:

PRO-WORD	DEFINITION or USE
Affirmative	Means Yes, I agree or permission granted
Break	Used to separate message text from the address or signature block. Not to interrupt a conversation. Not to be used to interrupt a contact in progress.
Break-Break	Used to indicate that you have emergency or priority traffic that must be handled immediately.
Check-Break	Used to indicate that you are pausing to verify copy of your message.
Clear	Transmission completed, no response required.
Copy	Used to indicate transmission has been received.
Correct	Acknowledge that the transmission was correct.
Correction	Indicates that an error was detected and the transmission will resume with the last correct word.
Decimal	Indicates a decimal point.
Disregard	An error has been made and the entire transmission should be ignored.
Figures	Indicates that the following words are to be copied as numbers. Used to switch from Letters to Figures.
Go ahead	Used to indicate that a station may respond.
I Spell	Indicates the word will be spelled phonetically.
Initial	Single letter follows.
Letters	Indicates that the following words are to be copied as letters. Used to switch from Figures to Letters.
Negative	Used to indicate No, I disagree or permission denied
Numbers	Analogous in use to Figures
Numerals	Analogous in use to Figures
Out	Transmission completed, no response required.
Over	Used to let another station know when to respond
Roger	Used to indicate transmission has been received and understood.
Say Again	Used to request that the last message be repeated.
Say Again All After	Used to indicate that the portion of the message after the indicated word should be repeated.
Say Again All Before	Used to indicate that the portion of the message before the indicated word should be repeated.
Say Again Word After	Used to indicate that the word after the specified word should be repeated.
Say Again Word Before	Used to indicate that the word before the specified word should be repeated.
Stand-by	Used to indicate that all stations should hold transmission until notified otherwise.
This Is	Used to identify the station whose call sign follows.
Wait	Used to indicate that all stations should hold transmission until notified otherwise.
Wilco	Indicates that the command was understood and that the station will comply with the command.
XRay	Used to indicate that a period should be entered at the end of the line just copied.

Pro-words are generally used in a formal and structured network (NET) environment. However, they may be used at anytime where utility can be gained from their use.

VFO vs Memory

It is rare for a radio to not support both VFO and Memory operation.

VFO is an acronym for Variable Frequency Oscillator, and is used to tune to a frequency. The VFO is usually controlled by a single knob. On many radios, this is the largest knob on the radio, and this is particularly true of HF radios.

Because operation of the radio usually results in using a set of frequencies with specific utility to the Amateur Radio operator, and because tuning the VFO among each of these frequencies can be both cumbersome and slow, and the need to move from one frequency to another often requires that that occur with relative rapidity, most radios support Memory operation. Memory allows rapid and efficient movement between two frequencies.

When in memory mode, the VFO knob is re-tasked to support moving between memory channels.

For example, a 2-meter VHF radio might be configured so that each click of the VFO knob moves the radio 5 kHz. If you needed to move from the national calling frequency of 146.520 MHz to an idle channel on 147.540 MHz, you would have to turn the VFO knob a total of 1,020 steps. If these two frequencies were stored in adjacent memory channels, the knob would only need to move one step.

Further, there are additional setup requirements for operating on a repeater. These include:

- Setting the offset direction (i.e. does your transmitter need to transmit at a higher or lower frequency than your receiver).
- Setting whether your radio should operate in **encode** or **encode/decode** or **DCS** mode.
- Setting the CTCSS tone for encode mode (if applicable).
- Setting the CTCSS tone for decode mode (if applicable).
- Setting the DCS code (if applicable).

For a given repeater system, this is a lot of stuff to remember, and moving between repeaters in VFO mode could take several minutes to accomplish. Memory mode allows all of this information to be stored, along with the frequency of operation, in a memory channel, relieving the radio operator of having to perform several configuration steps, once the information is stored into memory.

Scanning

Most radios support scanning in either VFO or Memory mode. When in VFO mode, the entire band is scanned, including frequencies that are reserved to provide space between channelized operation to avoid interference. Do to VFO scanning including frequencies that are not used, VFO scanning is very inefficient.

Memory scanning scans only those memories that are programmed in your radio, avoiding unused frequencies and focusing only on the frequencies that you use. Further, memory channels can be programmed to skip specific memory channels, a useful feature should your memories include receive only frequencies that are outside of the Amateur Radio bands, such as NOAA Weather frequencies.

Scanning usually can be performed in one of several scan resume modes:

- Time Mode
- Busy Mode

In time mode, the scanning will stop for a few seconds when a busy channel or frequency is encountered, with scanning resuming after a brief pause.

In busy mode, the scanning will stop on a busy channel and remain there until the channel or frequency is becomes quiet for two seconds.

What Frequencies Can I operate On?

The FCC has long adopted an incentive licensing program, where you are able to acquire additional operating privileges, which includes expanded use of Amateur Radio frequency allocations, through upgrading to a higher class license. As such, the frequencies that you are allowed to operate on are dependent on your class of license.

The operating privileges for the Technician Class licensee (2014) are:

FREQUENCY ALLOCATION	BAND	MODE	POWER
28.000 - 28.300 MHz	10-METERS	CW, RTTY, DATA	200 WATTS PEP
28.300 - 28.500 MHz		CW, PHONE	200 WATTS PEP
50.000 - 50.100 MHz	6-METERS	CW	
50.100 - 54.000 MHz		CW, PHONE, IMAGE, MCW, RTTY/DATA	
144.000 - 144.100 MHz	2-METERS	CW	
144.100 - 148.000 MHz		CW, PHONE, IMAGE, MCW, RTTY/DATA	
222.000 - 225.000 MHz	1.25-METERS	CW, PHONE, IMAGE, MCW, RTTY/DATA	
420.000 - 450.000 MHz	70cm	CW, PHONE, IMAGE, MCW, RTTY/DATA	
902.000 - 928.000 MHz	33cm	CW, PHONE, IMAGE, MCW, RTTY/DATA	RTTY/DATA 5 WATTS PEP
1240.000 - 1300.000 MHz	23cm	CW, PHONE, IMAGE, MCW, RTTY/DATA	
2300.000 - 2310.000 MHz			
2390.000 - 2450.000 MHz			
3300.000 - 3500.000 MHz			
5650.000 - 5925.000 MHz			
10.0 - 10.5 GHz			
24.0 - 24.25 GHz			
47.0 - 47.2 GHz			
76.0 - 81.0 GHz			
122.25 - 123.00 GHz			
134.0 - 141.0 GHz			
241.0 - 250.0 GHz			
> 300.0 GHz			

As a matter of practicality, and due to the need for specialized equipment, the 10-meter through 23cm bands are the most accessible, with the 2-meter and 70cm bands among the most accessible and popular.

Keep in mind that national and regional band planning occurs on the 10-meters FM band through 23cm bands. Regional planning takes precedence over national planning. Stations operating outside of band planning, and causing interference to a coordinated repeater system, will not be viewed favorably by the FCC.

See <http://www.arrl.org/graphical-frequency-allocations> for more information.

Beyond the frequency allocations, each band of frequencies includes a band-plan and frequency coordinations. In order to avoid causing interference, you should always operate on frequencies in accordance to the band plan for the band you are operating on.

Within the state of Idaho, there does not appear to be a published band-plan. However, the following guidelines should be useful when operating on 2-meter VHF:

- The 2-meter VHF band uses 20 KHz channel spacing
- The spacing between repeater transmit and repeater receive frequencies on the 2-meter VHF band is 0.6 MHz
- The national simplex calling frequency on the 2-meter VHF band is 146.520 MHz
- Unoccupied spectrum appears between 146.400 and 146.600, and between 147.400 and 147.600

Deriving from a directory of coordinated repeaters, and observation of regional convention, the following frequencies appear to be available for 2-meter simplex operation in Idaho:

146.42	147.41
146.44	147.43
146.46	147.45
146.48	147.47
146.5	147.49
146.52	147.51
146.54	147.53
146.56	147.55
146.58	147.57

On 2-meters, the national simplex calling frequency is 146.520 MHz.

On 70cm, the national simplex calling frequency is 446.000 MHz.

Technician Class & 10-Meter FM

The 10-meter band includes an FM section of the band, located from 29.500 to 29.700 MHz. Since this frequency range falls outside the frequency allocations for the Technician License, the Technician Licensee cannot **directly** operate on these frequencies.

However, if a repeater happens to be linked to a 10-meter FM repeater, or uses a remote base to access a 10-meter repeater, and a Technician Class licensee is operating on that repeater while using a frequency that falls within their frequency allocation, the fact that the Technician Class licensee is being repeated onto a 10-meter repeater does not place the Technician Class licensee in violation of the FCC rules.

What does this mean from a practical perspective? If, as a Technician Licensee, you are operating on a 2-meter or 70cm repeater that retransmits your signal onto the 10-meter FM band, you are operating legally and you can work stations on the 10-meter FM band under this specific circumstance.

This opens up a lot of fun possibilities for the Technician Class licensee as the 10-meter FM band includes repeaters that can hear stations up to several thousand miles away from the repeater site. If a 10-meter remote base were connected to your local 2-meter repeater, and the 10-meter remote base was configured to work a 10-meter FM repeater on the east coast, you may find yourself working a station in Europe!

What is a Frequency Coordination?

Regional organizations exist to plan out the use of frequencies within a band of frequencies, under the umbrella of the National Frequency Coordinator's Council. This planning takes into account the regional need, frequency congestion, and propagation into regions managed by other frequency coordinating bodies. The goal is to structure frequency utilization to avoid interference.

The FCC looks favorably upon these organizations and their efforts to mitigate congestion and interference. The FCC rules state that when there is a frequency conflict between a coordinated repeater system and a non-coordinated repeater system, the non-coordinated repeater system is responsible for resolving the conflict. This is a kinder, gentler way, of saying that the non-coordinated repeater is at fault.

Where Can I find A Directory of Repeaters?

Printed repeater directories are printed annually and can be purchased through Amateur Radio dealers. Among the best of these is the Repeater Directory that is published by the Amateur Radio Relay League (ARRL). The ARRL Repeater Directory is compiled from data that is supplied by frequency coordinating bodies, making this directory among the most comprehensive and accurate.

Online repeater directories are also available. The data for online repeater directories is compiled by voluntary submissions, and if the submitter fails to maintain the data, the directory has the potential to contain stale and inaccurate data. Regardless, these are a great free resource, and can present additional capabilities and features when compared to a printed repeater directory.

For example, the on-line repeater directory at <http://www.repeaterbook.com> includes:

- Maps of coverage
- The ability to document a signal report on the map
- The ability to download a '.gpx' file that can then be installed on a GPS device, making it possible to display repeaters on a GPS device.

Where Can I Find Band Plan Information?

Band plan data may be available at:

- Repeater Directory
- Web site for the Frequency Coordinating Body
- American Radio Relay League (ARRL) web site

Band planning at the local or regional level always takes precedence over national planning. Further, the local or regional band plan may not be published or available (as is the case in Idaho).

When band planning information is not available, much of the structure of the band plan can be derived from a Repeater Directory, by compiling a list of repeater receive and transmit frequencies.

The difficulty here is determining where you can operate simplex. The following general assumptions should be applied to choosing a frequency for simplex operation:

- If a band plan exist, only use those simplex frequencies that are documented in the band plan.
- Always avoid operating on a repeater input frequency (ie. the frequency that the repeater receiver operates on).
- Always avoid operating on a repeater output frequency (ie. the frequency that the repeater transmitter operates on).
- Repeater frequencies are spaced evenly to avoid interference. Simplex channels should be spaced for the same reason, and should use the same magnitude of spacing as repeater frequencies. For example, if repeater input frequencies are spaced 20 KHz apart, the simplex frequencies should also be spaced 20 KHz apart.
- If picking a frequency on your own, due to the lack of a band plan, be sure to listen on frequency for a significant period of time, with the squelch set to enable hearing a weak station, to make sure that you aren’t going to cause interference.

My Dual Band Radio has a Cross-band Repeat Capability

Many dual band (i.e. 2-meter VHF / 70cm UHF) radios have the capability of repeating one band onto the other. This can be useful to extend the range of a portable hand-held radio, which may not have sufficient power to reach a repeater system, while a higher power dual-band mobile radio that is installed in a vehicle can reach the repeater. Placing the mobile radio on the repeater frequency might seem a good way of extending the range of the hand-held radio.

But be careful. It is extremely easy to run afoul of both the FCC regulations and to unintentionally cause interference to a coordinated repeater system.

First, when you configure a radio to perform cross-band repeating, you must consider the following:

- A radio in cross-band repeat mode is operating as an Auxiliary Station, and is subject to Federal Code of Regulations, Title 47, Part 97.201.
- Inherent in 97.201(c) is that operation of the Auxiliary Station must avoid causing interference to a coordinated repeater system.
- Inherent in 97.201(b) is that an auxiliary station may transmit only on the 2-meter and shorter wavelength bands, and are excluded from transmitting on 144.0 - 144.5 MHz, 145.8 - 146.0 MHz, 219 - 220 MHz, 222.00 - 222.15 MHz, 431.0 - 433.0 MHz, and 435.0 - 438.0 MHz.

Because of band-planning and frequency coordination efforts, there are very few frequencies where you can establish an auxiliary station without the expectation of causing interference to a coordinated repeater system.

In Idaho, the recommended simplex frequencies for operating an auxiliary station on the 70cm band are from 433.0125 MHz through 434.9875 MHz with a 25 KHz channel spacing, and from 445.0125 MHz through 446.9875 MHz with a 25 KHz channel spacing.

From a practical perspective, there is no unallocated or uncoordinated spectrum in the 2-meter band that is available for auxiliary use. This effectively limits you to using cross-band capabilities to access a 2-meter repeater from a 70cm simplex frequency but prevents you from accessing a 70cm repeater from a 2-meter frequency.

Further, you should always adhere to the following principles:

- Use both encode and decode to access the simplex channel used by your auxiliary station. This procedure is vital to avoid causing interference.
- Always get permission from the repeater operator before setting up an auxiliary station to access a repeater.

Note: Some multi-band radios have the capability to cross-band repeat between a VHF/UHF band and an HF band. This is illegal in the United States of America. A repeater may not operate on frequencies below 29.5 MHz. This means that such capability can be used within the 29.5 - 29.7 MHz portion of the 10-meter band but the use of any other HF frequency is not allowed.

Setting Up A Station

This section provides basic advice on setting up a radio station. In doing so, let's first address priorities when addressing station performance:

- Receiver Performance
- Antenna Systems
- Transmit Power

Receiver performance is far more important than having a powerful transmitter. You cannot work what you cannot hear, and it makes no sense, and may be contrary to regulations, to be heard when you cannot hear what is hearing you.

Receiver sensitivity is specified as SINAD, and indicates the signal to noise and distortion ratio. SINAD is expressed as the receiver sensitivity in microvolts or dB, for a signal that provides a predetermined level of quieting within the receiver. For Amateur Radio receivers, the expression is for a level of sensitivity (ie. in dB, dB / μV or μV) for -12 dB SINAD. The lower the sensitivity figure, the more sensitive the receiver.

The following table provides conversion between μV, dB / μV and dBm for receiver sensitivities that are in the range of what is available in the Amateur Radio market:

μV	dB / μV	dBm
0.15	-16.5	-123.5
0.16	-15.9	-122.9
0.17	-15.4	-122.4
0.18	-14.9	-121.9
0.19	-14.4	-121.4
0.2	-14	-121
0.21	-13.6	-120.6
0.22	-13.2	-120.2
0.23	-12.8	-119.8
0.24	-12.4	-119.4
0.25	-12	-119
0.26	-11.7	-118.7
0.27	-11.4	-118.4
0.28	-11.1	-118.1
0.29	-10.8	-117.8
0.3	-10.5	-117.5

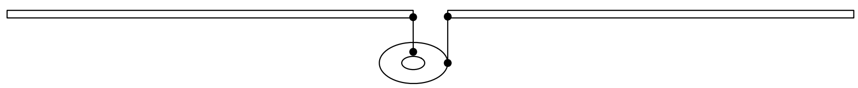
For 2-meter VHF and 70cm UHF operations, a receiver sensitivity of 0.25 μV is easily obtainable, and some mono-band 2-meter receivers can attain sensitivities of 0.16 μV for -12 dB SINAD. Receiver sensitivities that require a signal of 0.30 μV or higher are sub par and not recommended.

Antennas & Feed-line

Antenna length has a direct relationship to the wavelength for the frequency of operation. The simplest of antennas is the half-wave dipole. Reviewing the previous discussion of frequency vs wavelength, a half-wave antenna for the 2-meter VHF band is approximately 1-meter in length.

For VHF and UHF operation, the feed-line, which connects between the radio and the antenna, is coaxial in construction. That is to say that there is an inner center conductor, which carries the radio signal between the radio and antenna, and an outer shield.

The half wave antenna is actually made of two quarter-wave sections, arranged end-to-end, with the antenna feed-line, or coax, connected at the center of the antenna. The inner center conductor is connected to one of the two quarter wave antenna sections while the outer shield is connected to the other quarter wave section.



For VHF or UHF FM operation, the antenna should always be vertically polarized (in this case, stood on end).

Although simple, the half-wave dipole offers no gain (ie. unity gain). As such, it provides a reference point to compare other antennas.

Another simple antenna is the quarter wave ground-plane. In this antenna, the center conductor of the coaxial feed-line is attached to the base of a quarter wave vertical antenna section. At the base of the antenna, four horizontal quarter wave sections intersect and attach to the coaxial feed-line shield to form a ground-plane. Looking down at the ground-plane, the ground-plane quarter wave sections appear as an X.

More complex antennas can provide gain and / or directivity. Such antennas are beyond the scope of this discussion.

Vertically polarized non-directional antennas are referred to as omnidirectional, or just 'omni'. Directional antennas come in a variety of flavors, including beam, yagi, log-periodic, and quad. A directional antenna will require a rotor to enable the antenna to be pointed toward the station that you wish to work.

Antenna gain is typically specified in dB or dBd. The relationship between dB and dBd is that a value of 2.2 must be added to the gain figure that is specified in dBd to obtain the value in dB. Be careful here as many manufacturers use dBd so that their marketing material can indicate a higher number. For example, an 11.2 dBd gain antenna is only 9.0 dBd. When comparing antennas, always be sure that the gain figures are being viewed in the same units (ie. choose either dB or dBd and convert any gain figures that are not in the chosen units to the chosen units).

For best performance, a gain antenna is desirable. The following table provides a comparison of a wide variety of antennas:

2m VHF / 70cm UHF Antenna Comparison										
Manufacturer	Model	Grade	Frequency	Gain dBd	Vertical Beam Width (degrees)	Height	Weight (lbs)	Wind (mph)	Wind Loading (sq. ft.)	Price
Andrew	DB2222	C	143-150	3.0	38°	10'5"	16		1.6	$469.95
	DB224	C	138-150	6.0	16°	23'3"	38		3.15	$549.95
Cellwave	Super Stationmaster	C	142-150	5.3	18°	19"3"	25	160	125	$1008.00
Comprod Comm	872A-70TM	C	138-174	5.0	34°	10'6"	21		1.81	$599.95
	874A-70TM	C	138-174	8.0	16°	20'4"	68		4.65	$1199.95
Comm Scope	DB224-E	C	138-174	6.0	16°	23'3"	28		3.15	$730.00
Diamond	X30A	A	144-148 435-450	3.0 5.5		4'6"		135		$59.95
	X50A	A	144-148 435-450	4.5 7.2		5'7"	2.3	135		$79.95
	CP22E	A	144-148	6.5		8'11"	2.4	70		$49.95
	F22A	A	144-148	6.7		10'6"	2.9	112.5		$79.95
	F23H	A	144-174	7.8		15'	5	90		$129.95
	X200A	A	144-148 435-450	6.0 8.0		8'2"	2.6	112		$109.95
NGC Comet	CX333	A	144-148 220-225 440-450	4.3 5.6 6.8		10'4"	3.5	110		$179.95
	GP-1	A	144-148 440-450	0.8 3.8		4'1"	2.3	134		$74.95
	GP-3	A	144-148 440-450	2.3 5.0		5'10"	2.5			$99.95
	GP-6	A	144-148 440-450	4.3 6.8		10'1"	3			$149.95
	GP-9	A	144-148 440-450	6.3 9.7		16'10"	4.8			$199.95
	GP-95	A	144-148 440-450 1200	3.8 6.4 10.6		8'0"	2.6			$149.95
	GP-15	A	50-54 144-148 440-450	0.8 4.0 6.4		7'11"	3			$169.95
Sinclair	SD224	C	142-152	6.0	36°	18'	35		2.6	$1169.95
TeleWave	ANT150D6-9	C	138-174	6.0	18°	16'3"	28		3.3	$1089.95
Tram	1487	A	144-148	4.5		5'7"	2.5	135		$59.95
	1481	A	144-148 440-450	8.3 11.7		17'	5.6	90		$119.95
	1490	A	144-148	6.7		10'6"	3.7	110		$89.95
	1491	A	144-174	7.8		14'10"	5.1	90		$99.95

The choice of feed-line depends on the length of feed-line and the frequency of operation. You'll want to choose the feed-line with the lowest loss per 100 feet as affordable for feed-line installations that require a long run (such as a base station might have). The shorter lengths involved in mobile operation provide some relief for this requirement, but the same principles should be applied whenever possible.

COAXIAL FEED-LINE															
TYPE	ATTENUATION (dB per 100 feet)						POWER HANDLING (kW: +40°C; Sea Level)						IMPEDANCE Ω	VELOCITY FACTOR	BEND RADIUS INCHES
	30 MHz	50 MHz	150 MHz	220 MHz	450 MHz	900 MHz	30 MHz	50 MHz	150 MHz	220 MHz	450 MHz	900 MHz			
RG-58	2.5	3.1	6.2	7.4	10.8	16.5	0.40	0.30	0.16		0.06	0.05		0.66	
RG8/X	2.0	2.5	4.7	6.0	8.5	12.8	0.35	0.28	0.15		0.08	0.05		0.84	
RG214	1.2	1.6	2.8	3.5	5.2	8.0	1.8	1.2	0.62		0.30	0.18		0.66	
RG8/U		1.2				6.5		1.609				0.393		0.78	4.0
BELDEN 9913	0.8	0.9	1.5		2.7	4.19	2.2	1.7	0.9		0.45	0.28	50	0.84	
LMR-400	0.7	0.9	1.5	1.8	2.7	3.9	3.3	2.6	1.5	1.2	0.83	0.58		0.85	12
LMR-600	0.421	0.547	0.954	1.18	1.72	2.54	5.5	4.3	2.4	1.9	1.3	0.93		0.87	18
LDF4-50A	0.357	0.463	0.815		1.447		6.51	5.02	2.85		1.61			0.88	5.0
LMR-900	0.288	0.374	0.558	0.803	1.17	1.70	8.9	5.8	3.9	3.2	2.2	1.5		0.87	36

Within the Valley County Idaho, except where local regulations apply, Valley County ordinance 9-8-8 provides regulatory guidance with respect to a private tower or antenna structure, and specifically addresses Amateur Radio:

9-8-8: PRIVATE TOWER OR ANTENNA STRUCTURE:

1. **Applicability: The following regulations shall apply to tower structures for the purpose of private radio, television, or satellite reception and antennas for amateur radio. Towers shall not be subject to the accessory structure regulations of this chapter.**

2. **Amateur Radio Station Operators/Receive Only Antennas: This chapter shall not govern any tower, or the installation of any antenna, that is under seventy feet (70') in height and is owned and operated by a federally licensed amateur radio station operator or is used exclusively for receive only antennas.**

Local regulations and CC&Rs may apply restrictions. Check local regulations and CC&Rs to determine if restrictions apply to your location.

Transmitter Power

Most mobile radios provide a transmitter output power level of between 35 and 50 watts. These power levels are sufficient for most mobile operations. If you consistently operate in the fringe area of repeater coverage, and can hear the repeater well in those areas but have difficulty being heard, you may consider an external power amplifier for your mobile radio. Most stations will not require an amplifier.

For hand-held portable operation, transmitter power levels have a direct inversely proportional relationship to battery life. Running a portable transceiver at a 5-watt power level will lead to very short battery life, while running the same transceiver at 1-watt will significantly increase battery life. The goal should be to operate as a low a power level as possible in order to maintain communications while striving to preserve battery life.

Hand-held portable radios include a very inefficient antenna. Thinking back to the relationship between wavelength and frequency, and the quarter wave ground-plane antenna, the flexible vertical antenna that is included with the hand-held radio attempts to approximate a ground-plane antenna. However, its physical size is much shorter than a quarter-wave and introduces inefficiencies into the antenna. Purchase of a more efficient antenna, with a compatible connector, will greatly improve hand-held radio performance, enable the transmitter power to be reduced, and may result in increased battery life.

Transceiver Manufacturers

The most popular manufacturers of VHF / UHF transceivers are:

- Alinco
- Baofeng
- Icom
- Kenwood
- Yaesu

Surplus commercial radio gear that has been retired from Land Mobile Radio services may be able to be converted to Amateur Radio use, but this is beyond the capabilities of most radio amateurs.

Other Facets of Amateur Radio

This section contains information on other facets of Amateur Radio that you may not be aware of. In essence, these topics can be viewed as hobbies within the hobby.

Network (NET) Operation

NET operations are an on-air gathering of Amateur Radio operators to collectively fulfill a common purpose. NETs exist for a variety of reasons, including, but not limited to:

- On-air Swap Meets
- Informal social gathering
- To handle traffic, including radio-grams
- To perform exercises in preparation for emergency communications
- To perform public service communications

NETs offer a more structured communications environment than our day-to-day operating presents. NETs can be undirected or directed.

In an undirected NET, which often occurs for social gatherings, stations check in with the NET control operator without any specific order to the NET.

In a directed NET, order is maintained with the NET control conducting a structured roll-call, and with all participants required to go through the NET control operator to pass traffic, or to contact another station who is participating in the NET.

NET operation is available to any class of amateur radio licensee.

HF Operations

For the Technician Class license, the opportunities for High Frequency (HF) operation, the frequencies spanning from 3 to 30 MHz, are restricted to the 10-meter band. This band, however, does present many opportunities for world wide communications at very low power levels.

QSL Cards

Exchanging QSL cards can be a fun aspect of the hobby. The exchange of QSL cards serves to confirm contact with a station. These are primarily exchanged for HF contacts. The confirmation can be used to obtain awards, including Worked All States (WAS) and the DXCC certificate, which is awarded for working 100 countries.

QSL cards can be conveyed in a small sized post-card, or can be transmitted electronically.

Post-card QSL cards are the more costly option, especially when paying for postage to send a QSL card to a foreign country. For this reason, bureaus have been set up to handle bulk delivery of post-card QSL cards at reduced cost, and with increased delivery times.

Electronic QSL cards are available through the American Radio Relay League's (ARRL's) Logbook Of The World (LOTW), or via eQSL.

Only post-card QSL cards and LOTW are recognized for certificates that are awarded by the American Radio Relay League (ARRL).

Electronic QSL cards can be generated by manually entering data on a web site, or by uploading a log file to the web site.

Logging application programs are available, both free and paid, that will generate the file format appropriate for uploading to one of the electronic QSL card services.

HF Propagation

There are three types of propagation that are in use with HF operation:

- Ground Wave
- Direct Line of Sight
- Near Vertical Incidence Skywave (NVIS)
- Sky Wave

Ground wave operates out to approximately 60 miles, depending on terrain and frequency of operation.

Near Vertical Incidence Skywave (NVIS) operates from 30 miles to 600 miles, and is achieved by setting up the antenna to achieve a high angle of radiation. It is said to be like pointing the shower head straight up and having water hit the ceiling and come down everywhere around the source. In this case, the ceiling is the **F-Layer** of the ionosphere.

Sky Wave propagation is achieved by setting up the antenna to achieve a low angle of radiation, and achieves distances beyond 600 miles. Distances of many thousands of miles are common. Under extraordinary conditions, you may even hear yourself when you un-key, switching from transmit to receive, as your signal circles the globe.

How does this work? The ionosphere has several layers, which exhibit different properties with respect to radio waves:

LAYER	MINIMUM ALTITUDE	MAXIMUM ALTITUDE
D region	50 km	90 km
E region	90 km	140 km
F1 region	140 km	210 km
F2 region	210 km	

The D region absorbs radio waves, while the E, F1 and F2 regions are capable of refracting radio waves, returning them to the earth.

The D region only exists in the presence of sun light, and therefore, is not present at night. The D region tends to absorb (attenuate) lower frequencies, and the highest frequency that the D region can absorb varies with solar weather. The D region is not present at all during night time hours, which is one reason why frequencies at the lower end of the HF spectrum perform better at night than during the day.

Signals that are to be refracted by the higher regions, that is the E, F1 and F2 regions, must first pass through the D region on the way up, and again, after refraction on the way down. Using the E, F1 and F2 regions to our advantage requires operating on a frequency that is higher than the D region absorption frequency but lower that the maximum frequency that can be refracted back to the earth.

Radiation from the sun causes ionization of the ionosphere, producing free electrons. This occurs only in daylight hours. Free electrons are also lost during both daylight and daytime hours. The number of free electrons has a direct relationship on the ability of the ionosphere to refract radio signals.

Solar weather, including the 11-year sunspot cycle, is the driving force behind this phenomenon. As such, propagation varies from hour to hour, day to day, month to month, year to year, sunspot cycle to sunspot cycle, etc.

The maximum frequency that is useable for NVIS communications is called the foF2 frequency, or critical frequency. The maximum frequency that is useable for Sky Wave communications is called the Maximum Usable Frequency (MUF). Communications for NVIS must be conducted between the D region absorption frequency and the foF2 critical frequency. Communications for Sky Wave distances must be conducted between the D region absorption frequency and the Maximum Usable Frequency (MUF).

Well, all this propagation stuff seems too complicated. Isn't there an easier way?

Amateur Radio operators didn't always have all of this propagation data available. Tuning across the HF bands will rapidly give you an idea of conditions based on observed signals. It becomes somewhat obvious when a band **opens up** to Sky Wave communications. This is because you will hear signals that you don't usually hear, that is stations in countries that are not always easily heard may become very strong.

It is not so obvious as to what band is appropriate for NVIS communications. In part, this is because the number of Amateur Radio operators who understand NVIS and have their stations configured to use NVIS is relatively small. In fact, many Amateur Radio operators don't know that NVIS propagation exists, and don't believe in it when they are exposed to it. For reference, the military is highly dependent on NVIS propagation, have written manuals around it, have entire HF radio systems designed around it, and use it every day. NVIS is a reality and it does work - very, very well.

But, isn't there an easier way?

Prior to the internet, bulletin board systems were established to report hearing a DX station, that is a station in another country, by logging its call sign into the bulletin board system. As the internet evolved, these bulletin board services evolved to include internet access. Then, they began to share data. This has become what is known as the DX Spotting Network.

Support for the DX Spotting Network is built-in to many Amateur Radio applications that support keeping a log of your contacts (NOTE: Logging all contacts used to be an FCC requirement). There are also web sites that display data from the DX Spotting Network, including displaying the data on a map.

For Amateur Radio operators that are using digital communications, the digital communications application software is also capable of generating automated reports, through a process called **Reverse Beaconing**, of stations heard or worked. These also are available for viewing on the internet.

By examining the DX Spotting Network data, or Reverse Beaconing data, you can get a good idea of what HF bands are presenting favorable propagation. Please see:

- <http://www.dxmaps.com>
- <http://www.pskreporter.info>

Automatic Link Establishment (ALE)

But, isn't there a way to automate this? The simple answer is yes. The military has developed a technology, called Automatic Link Establishment, that uses digital protocols, in conjunction with the ability to control the frequency of the radio, to make periodic soundings on each of the bands of use. The radio then knows what frequencies are usable so that when a call needs to be made, the call is first established through a digital handshake that places the radios on both ends of the conversation on the best frequency for current propagation conditions.

Although ALE is built-in to military radios, it is not built-in to Amateur Radio HF equipment. There is a free Windows application, called **PC ALE**, which can interface to most Amateur Radio HF equipment and perform this function. However, if the HF equipment has band switching relays, the scanning and sounding process will cause a lot of relay chatter and will eventually wear the relays out. Use of this software ALE solution is best applied to radios that have electronic and not electro-mechanical band switching technology.

Icom, Kenwood, Vertex and Motorola all manufacturer ALE radios, but only the Motorola radio is available in the United States. The other manufacturers do not have an FCC type acceptance for their ALE radios, making them difficult to obtain. Some commercial equipment does not appear to fully implement the ALE specification and may not interoperate with other ALE radios.

Digital Modes

There are many different digital modes available to the Amateur Radio operator. Digital mode operation requires a computer, running Windows, Linux or Mac OS X, a specialized sound card to interface the radio to the computer, and free software to communicate in the digital mode.

The sound card interface must be isolated from the computer in order to avoid having the computer cause interference to the radio. The audio connections that provide transmit audio from the sound output and receive audio to the sound input must be coupled with transformers, while the push-to-talk and receiver signal detection (carrier operated switch) is isolated with an optical coupler.

The simplest of these to set up is a USB device, the SignaLink USB from TigerTronics.

A free software application, FLDIGI, is available for all three operating systems, and supports the following digital modes:

- Contestia
- CW
- DominoEX
- Hellschreiber
- MFSK
- MT63
- NAVTEX
- SITOR-B
- Olivia
- PSK
- BPSK
- BPSKR
- QPSK
- Radio Teletype (RTTY)
- Thor
- Throb

FLDIGI is also capable of receiving Weather FAX transmissions.

All of these modes can be very fun to operate.

Another free software application, available only for Windows, supports the JT-65 HF digital mode. This mode is not appropriate for having a conversation, but is capable of making a contact under the worst of conditions. This mode is often able to establish a contact when propagation conditions are terrible and when other modes are not able to establish communications.

Note that most software supporting digital mode communications includes automatic logging features.

Contesting

It seems that contests are scheduled nearly every weekend of the year. Sometimes, several contests are available on the same weekend.

Contesting involves making as many contacts as possible, in a specified period of time, while exchanging a message that is structured in accordance with contest rules. There are many categories of operation, including single operator, multiple operator - single station, multiple operator - multiple station, etc. Contests may occur with voice modes, CW or digital modes.

They can be both fun and intense, depending on your level of effort and preparation.

Contests also afford you with the concept of handling traffic rapidly and accurately, and this has direct application should you ever become involved in emergency communications.

In addition to the fun of operating a contest, contesting helps us all to preserve our Amateur Radio frequencies. One item that is looked at when considering frequency allocations, including the retention of frequency allocations, is whether the frequency allocation is being utilized. Contesting provides a huge boost to the numbers that describe the utilization of a frequency, and we all are the beneficiaries of those numbers.

Even if contesting is not your thing, we all should appreciate that contesters do help us maintain our frequency allocations.

Television

There are three television technologies in use in Amateur Radio. These are:

- Slow Scan TV
- Fast Scan Analog TV
- Fast Scan Digital TV

Slow scan TV is not live TV, but is able to transmit still images across long distances over the HF bands. Color slow scan is possible by sending the same image three times, with filters for red, green and blue. The three images are merged by software on the receive end to reproduce the original color image from the source.

Fast Scan Analog TV is the same technology that was used before commercial television went digital in the United States. This is generally restricted to UHF and higher frequencies, is line of site, and, due to the requirements of specialized equipment, is largely performed by Amateur Radio operators who are willing to construct their own equipment. Activity is found mostly in highly populated areas.

Fast Scan Digital TV is the same technology that is currently used by commercial television. Even more so, this technology is implemented by the experimenter.

Digital Communications Technologies

Amateur Radio is slowly moving toward digital communications technologies, predominantly on the VHF and UHF bands. The first arrival being Icom's D-Star technology. This was followed by Yaesu's Frequency Domain Multiplexing (FDM) radio technology and by the Digital Mobile Radio (DMR) Time Domain Multiplexing (TDM) technology.

D-Star

Icom's D-Star was Amateur Radio's first venture into digital communications technologies that had the backing of a major manufacturer. D-Star carries both a digital channel and a voice channel, supporting both voice and digital communications capabilities. D-Star also supports linking using Voice Over Internet Protocols. D-Star was developed using voice codec that presented a large expense for other developers, and this technology has not migrated to other brands. In addition to the large expense of the digital codec, the digital codec does not produce great audio.

D-Star radios are capable of operating on both a digital D-Star repeater, or on a conventional analog audio repeater.

Yaesu FDM

Yaesu released a document that detailed their road-map for digital communications technology. That road map indicated an initial release of an interim technology, to be followed by their final technology. The final technology, using Frequency Domain Multiplexing, a technology that is able to support two separate and distinct conversations on one repeater, seems compelling. In short, the channel is divided into two sub-channels, and either sub-channel can be used.

Yaesu released a hand-held transceiver without any repeater technology being available. Repeater technology has now been announced but is currently unavailable. Further, no mobile radio technology has been announced.

The lack of ability to have a full communications system may stifle Yaesu's efforts.

Yaesu FDM radios are also capable of operating on a conventional analog repeater.

Digital Mobile Radio (DMR)

Digital Mobile Radio uses a Time Division Multiplexed (TDM) technology, and like Yaesu's FDM, can support two distinct conversations on a single repeater. DMR was developed by a consortium of manufacturers, and as such, compatible radios are being built by several manufacturers. This helps keep the cost of these radios down.

TDM technology divides a single channel into two time slots. When using one of the time-slots, the transmitter is off during the other time-slot. This presents an obvious advantage of reducing the average power on the transmitter and may present significant battery savings for the portable operator.

DMR uses the a second generation of the same codec that is used in D-Star, but the audio sounds much, much better.

DMR also supports linking of radios over the internet.

DMR appears, from a technology perspective, to be the best of the three. DMR is just emerging in Amateur Radio, and is most prevalent in highly populated areas.

Other Activities

Public Service Communications

Public service communications serves to provide communications services for community events. Examples include:

- Walk-A-Thons
- Bike-a-thons
- Athletic events, including bicycle and foot races

What can Amateur Radio do to support these events?

- Amateur Radio can track participants and relay progress to event organizers
- Amateur Radio can be used to communicate the status of supplies and to organize logistical operations associated with an event
- Amateur Radio can be used to dispatch assistance, whether it be a sag-wagon to pick up fatigued participants, or a mechanic to render assistance with failed equipment
- Reporting of traffic or crowd problems, which are then relayed to public safety personnel

In essence, any service that can be conceived, or enhanced by radio communications services can be supported by Amateur Radio.

Emergency Communications Services

As previously mentioned, the two major organizations for Amateur Radio's involvement in Emergency Communications are:

- Radio Amateur Civil Emergency Service (RACES)
- Amateur Radio Emergency Service (ARES)

Both organizations use NETS to conduct training and exercises. For further reference with respect to ARES activities in Idaho, please visit the Idaho ARES web site at:

- <http://www.idahoares.info>

The web site contains information on Idaho ARES, including listings of activities, nets, training, and links to training resources. ARES membership is free. If you want to be involved, should an emergency arise, please take the time to register with the Idaho ARES organization on their web-site.

Military Affiliate Radio System

The Military Affiliate Radio System (MARS) has branches that are associated with each branch of military service. Although an Amateur Radio license is required to be certified as a MARS operator, operations do not occur within the Amateur Radio spectrum and do not use your Amateur Radio license, or call sign, during MARS operations. In fact, using your Amateur Radio call sign will get you dismissed from the MARS program, and is a violation of FCC regulations.

To operate in the MARS program, which primarily operates on HF frequencies that are located between the Amateur Radio bands, the transceiver will require modification.

MARS, a completely voluntary program, uses a highly structured communications environment to pass traffic. MARS operation applies better operating practices than are typically found in Amateur Radio, making MARS operation a great way to gain operating experience that can be brought back to Amateur Radio NET operations and emergency communications.

Automatic Packet Reporting System (APRS)

The Automatic Packet Reporting System combines a GPS receiver with a radio modem and radio to provide automatic position reporting. This allows the position of an Amateur Radio station to be plotted on a map.

The modem device periodically receives data from the GPS device via a serial connection, converts that data into packet format, and transmits the packet information. The packet information is received at a fixed station, and may be relayed through several stations, before reaching an internet gateway station. The data is then sent to a database, where the data can be accessed by software or web applications that render the data on a map.

The use cases for this are numerous:

- Plotting the position of the Incident Command Post associated with an emergency event, or exercise, where Amateur Radio is used to serve other agencies.
- Tracking progress of an Amateur Radio operator that is in transit, in any type of vehicle (ie. car, boat, airplane).
- Determining the last position of an Amateur Radio operator toward launching a Search And Rescue effort.
- Tracking members of a Search And Rescue team.

This technology is not without its short-comings. There is nothing to prevent packet transmissions from multiple stations from reaching the fixed station at the same time, causing the data from the weaker station to be lost. There is no error detection for such circumstances, and the transmitting station will not retransmit the data when the data is lost. The transmitting station may not be in range of a fixed station receiver, and especially so in mountainous terrain. All of these conditions can results in large gaps in station reporting.

To view maps with tracking, please visit:

- <http://www.aprs.fi>
- <http://www.openaprs.net>
- <http://www.aprs.org>

Radio Direction Finding

Radio Direction Finding (RDF) has a direct application in both Search and Rescue (SAR) and locating a source of interference. The exercise of practicing Radio Direction Finding techniques is both entertaining and competitive. Radio Direction Finding equipment for VHF and UHF generally falls into one of the following three categories:

- A directional antenna, a receiver with a signal strength indicator (S-Meter) and a step attenuator (Basic Equipment).
- Time Difference Of Arrival (TDOA) switched antenna
- Pseudo Doppler equipment

Basic Equipment

The simplest, and least expensive of these configurations is the directional antenna, receiver and step attenuator. With this equipment, the signal strength is observed on the receiver S-Meter while rotating the directional antenna in order to observe the direction that provides the strongest signal. If the signal saturates the signal strength meter, the attenuator is used to bring the signal strength down to a level where the direction of strongest signal can be determined.

VHF and UHF mono-band yagis are available for under $100.

Time Difference Of Arrival (TDOA)

Time Difference of Arrival requires an FM receiver, and consists two antennas are spaced no more than one half wavelength apart, and circuitry alternates which antenna is connected to the receiver. The act of alternating which antenna is connected occurs at an audio frequency, such as 1,000 Hz (1 kHz). When the line passing through the two antennas is 90° to the signal source, there is no phase difference between the received signal at one antenna when compared to the other and no tone is heard in the FM receiver. As the antenna is swung away from this 90° position, the radio signal will arrive at the two antennas in an out of phase condition, and this results in a tone being produced in the FM receiver. The goal is to swing the antenna until a null in the tone is produced. This results in a line of position that is 90° from the plane drawn through the two antennas.

TDOA equipment is available, in kit form, for around $30.

Pseudo Doppler Equipment

Pseudo Doppler requires an FM receiver, and simulates an antenna placed on a rotating disc, with a maximum diameter of one half wavelength. As the antenna approaches the signal source, the radio frequency appears higher than the transmitted frequency. As the antenna reaches the closes point to the signal source, the received frequency will be equal to the transmitted frequency. As the antenna moves away from the signal source, the received frequency appears lower than the transmitted frequency. And as the antenna reaches the furthest point from the signal source, the received frequency is equal to the transmitted frequency. Since it is not practical to place an antenna on a rotating disc, four (or more) separate antennas are configured at fixed points around the disc. If four antennas are used, the position of each antenna is 90° from the previous antenna relative to the center of the disc. Circuitry then switches in one antenna at a time, in sequence, as if the antenna were being rotated. When the signal is tuned with an FM receiver, this produces a tone in the receiver speaker that is equal to the frequency that the antenna is being pseudo rotated. The phase of this tone, relative to the phase of the signal rotating the antenna, produces a relative bearing to the antenna. Pseudo Doppler equipment will display this as an LED indication on a compass card, a digital representation of the relative bearing or both.

Pseudo Doppler equipment is available assembled, and in kit form, with prices ranging from $150 to several thousand dollars.

Radio Direction Finding Techniques

A good method is to take a bearing, or obtain a line of position, and draw the bearing or line of position on a map. Then move 90° from the bearing, or line of position, and obtain new bearing or line of position, plotting the new line on the map. Where the bearing lines or lines of position intersect, should be at or near the location of the transmitting signal source.

Laminating a map between sheets of plexiglass, and using a grease pencil to plot bearings or lines of position is a useful tool. Some Doppler Equipment is capable of sending information to a computer, which, when used in conjunction with a GPS, allows bearings to be plotted on the computer screen.

Radio Direction Finding Competition

When Radio Direction Finding is employed as a competition, it is often referred to as a Fox Hunt, with the transmitting station being referred to as the Rabbit. In competition, the transmitting station may implement various means of deception, including using a directional antenna that is pointed to a reflective structure that is not co-located with the transmitter, placing a transmitter along a medium that favors a unidirectional radiation pattern, such as a chain link fence, and physically disguising the transmitter so that it cannot be found. Creative transmitter disguises, including making a transmitter appear as a tree limb, log, or even a monument in a cemetery, have all been employed to make it more difficult to locate the transmitter.

Why Upgrade to a Higher Class License

The biggest benefit of upgrading your license class is that you receive additional frequency allocations with a higher class license. The benefits of additional frequency allocations are:

- Ability to escape congested HF frequencies where lower class licensees are restricted to operate on.

- For the DX hunter, that is working foreign countries, the most rare of DX stations are more likely to be encountered in the segments of the HF bands where a higher class license is required.

Another reason for upgrading is the knowledge gained through the process.

Yet another reason for upgrading, and maybe the most important, is that higher class licensees are able to conduct volunteer examinations for radio licenses of a higher class.

Conclusion

If you were able to follow along with the bulk of this material, congratulations. The majority of Amateur Radio operators are not provided with a practical reference to begin their activities in the hobby. Further, bad advice, from both uninformed and misinformed sources, is rampant on the air-waves.

This material was written and presented with the goal of helping you become more knowledgeable than the average Amateur Radio operator. Your application of this material already puts in in front of the pack.

Always remember that if you don't know something, asking is completely appropriate. If the answers you receive do not express an understanding of the fundamental knowledge that you now have, seeking out other mentors to obtain knowledgeable answers is prudent and appropriate.

May your Amateur Radio operating experiences always be enjoyable and full of new learning experiences.

Have fun!

Appendix A

HF Dipole Antenna Length Calculations

Band Meters (Actual)	Band Meters (Named)	Frequency MHz	Half Wave	Quarter Wave	Eighth Wave	0.15 Wavelength Reflector Spacing
81.61	**80**	3.6750	127.3	63.7	31.8	38.2
75.07	**75**	3.9950	117.1	58.6	29.3	35.1
56.27	**60**	**5.3300**	**87.8**	**43.9**	**22.0**	**26.3**
55.89	**60**	**5.3668**	**87.2**	**43.6**	**21.8**	**26.2**
55.51	**60**	**5.4035**	**86.6**	**43.3**	**21.7**	**26.0**
42.39	**40**	**7.0760**	**66.1**	**33.1**	**16.5**	**19.8**
41.66	**40**	**7.2000**	**65.0**	**32.5**	**16.3**	**19.5**
29.70	**30**	10.1000	46.3	23.2	11.6	13.9
29.55	**30**	10.1500	46.1	23.1	11.5	13.8
21.42	**20**	14.0000	33.4	16.7	8.4	10.0
21.31	**20**	14.0760	33.2	16.6	8.3	10.0
21.20	**20**	14.1500	33.1	16.5	8.3	9.9
16.60	**17**	18.0680	25.9	13.0	6.5	7.8
16.56	**17**	18.1100	25.8	12.9	6.5	7.8
16.51	**17**	18.1680	25.8	12.9	6.4	7.7
14.28	**15**	21.0000	22.3	11.1	5.6	6.7
14.23	**15**	21.0760	22.2	11.1	5.6	6.7
14.15	**15**	21.2000	22.1	11.0	5.5	6.6
12.05	**12**	24.8900	18.8	9.4	4.7	5.6
12.03	**12**	24.9300	18.8	9.4	4.7	5.6
12.00	**12**	24.9900	18.7	9.4	4.7	5.6
10.71	**10**	28.0000	16.7	8.4	4.2	5.0
10.68	**10**	28.0760	16.7	8.3	4.2	5.0
10.67	**10**	28.1200	16.6	8.3	4.2	5.0
10.56	**10**	28.4000	16.5	8.2	4.1	4.9
10.13	**10**	29.6000	15.8	7.9	4.0	4.7
6.00	**6**	50.0000	9.4	4.7	2.3	2.8
5.99	**6**	50.1000	9.3	4.7	2.3	2.8
5.71	**6**	52.5250	8.9	4.5	2.2	2.7

Skywave Antennas should be constructed at least 1/2 wavelength above ground in order to reduce the angle of radiation. This results in reducing the number of hops required to contact a distant station.

Near Vertical Incidence Skywave (NVIS) antennas should be constructed no more than 1/8 wavelength above ground in order to increase the angle of radiation so that a single hop (i.e. through the D-layer, to the F-layer, and back through the D-layer to the ground) results in propagation from a few miles out to a maximum of approximately 600 miles.

For improved efficiency of an NVIS antenna, a parasitic reflector may be placed on the ground, underneath the driven element. This constructs a 2-element antenna and has been demonstrated to improve NVIS capabilities. With this arrangement, the table shows the typical spacing for a 2-element Yagi antenna, with the spacing considered to be a maximum value. Good results have been demonstrated with a parasitic wire laid on the ground, directly underneath an NVIS dipole that is 1/8 wavelength above ground.