How do I?

An occasional series

This week: Intro to Radio Repeaters

VHF and UHF (Very High and Ultra High Frequency) radios are primarily for short range use. The range is dependent on many factors, especially terrain. To increase the range, repeater systems are often used.

Many new amateur radio operators begin with a simple handheld transceiver (HT) and use repeaters to make contacts. This can be a challenging and frustrating process, or it can be easy! If you like easy, stick around!

Below is a diagram of a repeater system at its simplest.

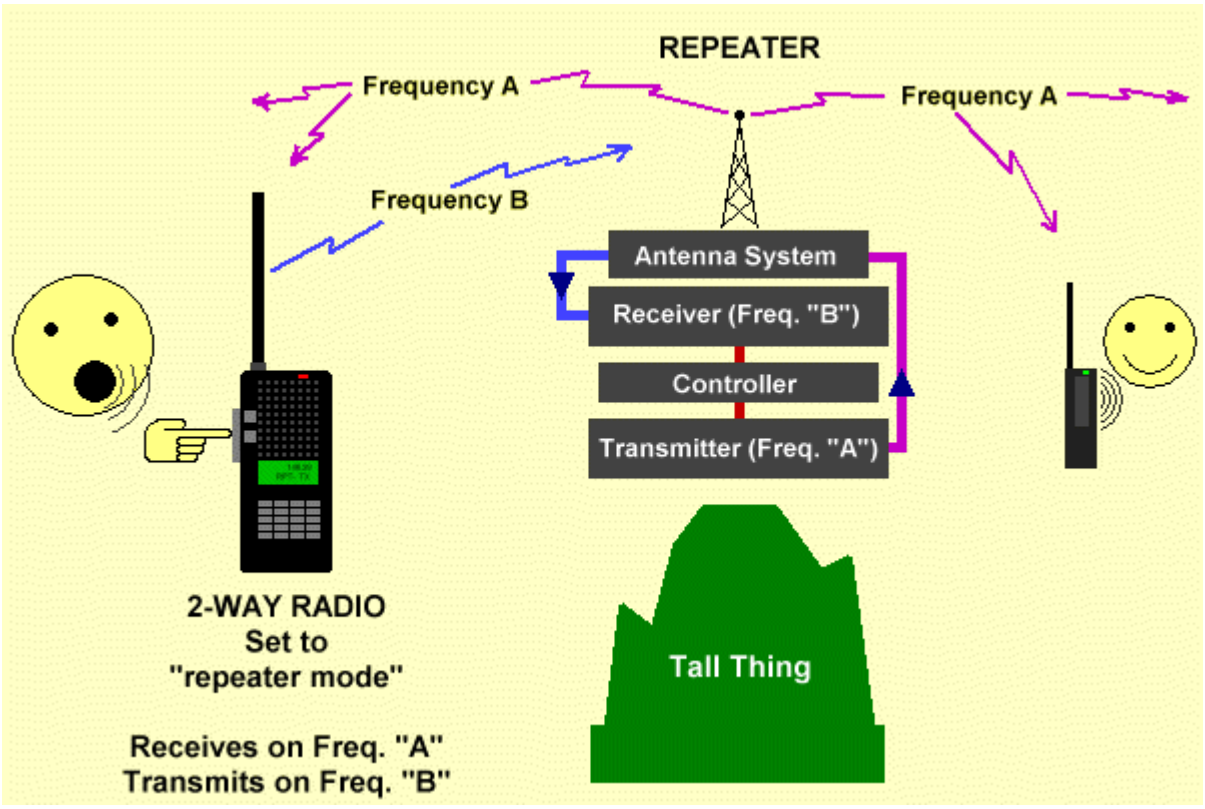

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Figure 1 University of Hawaii System

Configurations

The repeater receives a signal on one frequency and transmits at the same time on another frequency. Some people call this a FULL DUPLEX operation which is how your home telephone works. The repeater equipment can receive (listen) and transmit (talk) at the same time.

Most often, the receive and transmit frequencies are in the same VHF or UHF band. The notation V-V describes a repeater that receives and transmits on VHF frequencies such as the two-meter band. Likewise, the notation U-U describes a repeater that receives and transmits on UHF frequencies such as the 70 centimeter band. Some repeaters, especially in urban areas, are set to **cross band**, U-V or V-U.. The input signal may be on UHF in the 70 cm band while the output could be on VHF in the 2m, 6m, or 1.25m band. or even on the HF 10m band.

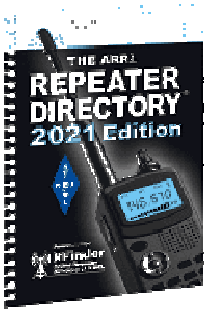
The most common configurations, by far, in amateur use are the V-V 2 meter repeaters.

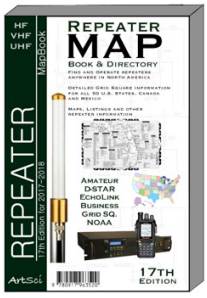
Repeater Information

For several decades, repeater directories have been published for the benefit of repeater users. Among the oldest directories is the *Repeater Boo*k, which is no longer in book form, Today it can be found at https://repeaterbook.com and is available as a smart phone app in the Google and Apple stores.

The American Radio Relay League (ARRL) publishes an annual repeater directory. The size of the 2021 version is about one half as thick as it was in the 2018 edition. See below, on the left.

Art Sci issues their own directory. It is “designed for travellers” and not only lists the repeaters, but also has maps of each state showing where the repeaters are located. This is useful information if you are not very sure what is close to you. I own more of the ARRL directories, but in some ways I prefer the *Repeater Map.* See below, on the right.





Regardless of the publisher, all repeater lists include the same basic information. Many of these modes have been covered in this ***How Do I…*** series, so please follow the trail to https://www.radioclub-carc.com/resources/ for more information.

Mode:

ATV	Amateur Television
DMR	Digital Mobile Radio
	DMR/BM — DMR-Brandmeister Network
	DMR MARC — DMR MARC network
D-Star	Primarily used by Icom and Kenwood radios equipped with the D-Star system
FM	Analog FM
FUSION	Yaesu System Fusion C4FM digital or analog
NXDN	Uses the NXDN system created for commercial users but also used by hams.
P25	The APCO P25 system, created for first responders initially and adopted by hams.

Repeater directories list the REPEATER OUTPUT frequency which frequency to which you set your own radio for listening.

Directories also list the REPEATER INPUT frequency, which is the frequency to which your own radio must be set when it transmits.

It is common for repeater directories to list the Repeater Input frequency as an offset relative to the Repeater Output frequency. Repeater offsets may be standard or custom.

Most often, repeaters use a standard offset which means the repeater is following the established practice for a given radio band. Often a **+** or **-** will be shown in the directory to indicate whether the Repeater Input frequency should be set higher (+) or lower (-) than the Repeater Output frequency. A custom offset will be represented in the directory by showing its frequency in MHz.

The standard repeater offsets are:

50 MHz	500 KHz
144 MHz	600 KHz
222 MHz	1.6 MHz
430 MHz	5 MHz
1200 MHz	12 MHz

Repeater Accessibility

Repeater Owners often are concerned with controlling access to the systems they construct.

- Sometimes their concern is based on limiting the use of their costly investment to the people who help purchase, build, and maintain the equipment and site facilities.

- Sometimes their concern is to help protect other nearby repeaters using the same frequencies from interfering with each other.

One method of controlling access to the repeater is through the use of access tones.

Back in the 1950s, Motorola invented the PL-Private Line® for commercial users. They used DTMF tones, which had been invented by Bell Labs in the 1930s, as a way of passing information between radios. If you remember the TV show *Emergency* from the early 1970s, the distinctive sounds that brought Station 51 to alert are Dual Tone Multi Frequency codes. DTMF consists of 8 different audio frequencies. Two specific tones are used in combination to represent which button on the numeric keypad has been pressed. While most radios today use memories to store repeater information, if you have a DTMF keypad (sometimes built into a hand held microphone), you can manually dial the tones to access a repeater.

Another tone-based access control is called Continuous Tone Coded Squelch System or CTCSS. However, you may hear ham radio operators refer to this feature as PL Tones. This access method is commonly used by repeaters today. CTCSS information is transmitted between radios using one of 42 different low-frequency, sub-audible tones in the range of 67.0 Hz to 254.1 Hz. When the CTCSS feature has been activated, the radio that receives an over-the-air signal will open its squelch (i.e. turn on the radio speaker) only if the received CTCSS tone matches the configured value in the radio. Any station transmitting a different CTCSS tone, or no tone at all, will leave the squelch closed and nothing will be heard on the receiver speaker.

DCS or Digital Coded Squelch was created as Digital Private Line ® and is simply a digital version of access control. DCS provides 104 coded values. When the DCS feature has been activated, the radio that receives an over-the-air signal will open its squelch only of the received DCS code matches the configured value in the radio. Any station transmitting a different DCS code, or no code at all, will leave the squelch closed and nothing will be heard on the receiver speaker.

When either CTCSS or DCS is used, the repeater essentially sleeps until it hears the appropriate CTCSS tone or DCS code to awaken it and it begins transmitting your signal,

It is common practice among ham radio operators to set up a series of memory channels in their handheld transceiver to store the desired information of each the commonly used repeaters in their area. The CTCSS tone or the DCS code can be included in the memory channel setup.

Programming Radio Memory Channels for Repeaters

Hams who use repeaters will soon realize there are quite a few configurable settings associated with repeaters – input frequency, output frequency or offset, CTCSS tone, power level, squelch type, and perhaps even more.

Saving these settings in the radio memory channels simplifies your job of getting on the repeater and making a contact. However, some radios can be a bit challenging when it comes to programming memory channels.

Any modern VHF or UHF radio equipped with the appropriate cables and software will make programming much easier.

- Every DMR radio manufacturer has its own proprietary software. If you use a DMR radio then you want the manufacturer's software.

- RT Systems developed an extensive line of programming software and interface cables for a wide range of amateur radio transceivers. Visit thei website at https://www.rtsystemsinc.com/

- CHIRP is a free, open-source tool for configuring your amateur radio options and memory channels. It supports a large number of manufacturers and models. Two well-known websites are listed below.

    https://chirp.danplanet.com/projects/chirp/wiki/Home

    https://www.miklor.com/COM/UV_CHIRP.php

    The above link seems to be the go-to resource for in-depth CHIRP How-To information.

Nearby Repeaters in Central Pennsylvania

Mount Holly Springs, PA has two repeaters.

> N3TWT has an analog FM repeater operating on the two meter band. The output frequency is 145.430 MHz. The input frequency is standard minus (-) 600 KHz, a 67.0 Hz CTCSS tone (PL Tone) is needed to access this repeater.
>
> N3TWT also has an analog FM repeater operating on the 70 cm band. The output frequency is 444.300 MHz. The input frequency is described as plus (+), which is a standard offset of 5 MHz, or 448.300 MHz. The CTCSS tone (PL tone) is 67.0 Hz.

DMR uses tones. They use different terminology to describe these tones and call them Color Codes. For example, the Harrisburg DMR repeater W3ND 147.375 output, + Input CC1

Linked Repeaters

Repeaters may be configured as stand-alone or linked. A stand-alone repeater simply receives a signal and transmits that signal over-the-air to whatever geographic area it has the capability to cover. Antenna height and the surrounding terrain play big factors in the coverage.

Linked systems are believed to have evolved in California. A user in say San Diego, with a simple HT can connect to a local repeater and through the magic of DTMF, CTCSS and some other hardware, talk to another ham located 500 miles or more away north of San Francisco.

Some repeaters use EchoLink, or one of the other VOIP protocols, such as D-Star®, Fusion®, or DMR to connect users located farther away, perhaps on other continents, via simple hand held HTs and an internet connection.

Repeater Hardware

The building blocks of a repeaters start out very similar to your fixed base or mobile radio. A repeater system has a receiver, a transmitter, an antenna, a feedline, and a power supply. The main differences involve the repeater's need for additional equipment -- a duplexer, and a controller.

Your author priced a few professional repeater units from Motorola and Icom on the Grainger.com website and the average price was around $3700. That makes the Yaesu System Fusion repeater a bargain at $1649! The Duplexer adds another couple thousand to the cost of either. In short, if you plan on regularly using a repeater, please donate to the organization providing it!

Your Own Repeater is Within Reason

If you do not need wide coverage, you can build your own repeater. The Yaesu FT8800R and FT8900R mobile radios have repeater capability built-in. Here is an example of how they can be your repeater. Suppose you are planning to hike in some out of the way location -- you can carry your HT with you set to a UHF frequency. Before setting out on your trek, make arrangements with a licensed friend or family member to monitor a particular VHF frequency. When you arrive at your hiking destination park your vehicle some place where it will have an unobstructed RF view of your home location. Configure your mobile radio for repeater operation using step-by-step instructions provided by the radio manufacturer. Your mobile radio will receive signals from your HT on UHF and transmit those signals back home on VHF. If a need arises, and if you want to contact someone who is located back at home out of UHF range, you can talk into your UHF HT and your words will be repeated on VHF where the transmitter range typically covers a greater area.

Some of the Kenwood HF radios can do cross band repeat between VHF and HF. One of the Virginia Fone Net members is known to set his Kenwood HF radio to the net frequency (3.947 MHz LSB) and then listen to the net on his 2 meter FM HT as he performs farm chores. He will check- in to the net from the barn when it is his turn. Very cool!

GMRS and Other Radio Services

Today we have looked at repeaters used in amateur radio. Repeaters are very common in commercial (Land Mobile Radio) and GMRS (General Mobile Radio) as well as public safety applications. The concepts are the same, only the frequencies vary. One wrinkle is that railroads in particular will receive and transmit on the same frequency. They call these a "fixed base". If a dispatcher cannot hear a train, you may hear them say, "let me try another base".

A great source for amateur radio information, and also radio frequency information of all kinds for licensed services, is Radio Reference https://www.radioreference.com/

Additional resources for GMRS repeater information can be found at:

https://mygmrs.com/
http://www.usagmrs.com/repeaterlistings.html

Did you know: Montana has no GMRS repeaters in the state. It has about 155 Amateur Radio repeaters.

Wrap Up / Summary

Hopefully you have enjoyed today's look at repeaters.
For more information follow the trail to https://www.radioclub-carc.com/resources/

Catch 'ya on the air!