What Is A Repeater

Stephen Ireland VK3VM / VK3SIR

A **Radio Repeater** is a device is an electronic device that receives a signal and retransmits it.

Repeaters are used to extend transmissions so that the signal can cover longer distances or be received on the other side of an obstruction (Ref: Wikipedia – 2020)

(Ref: https://www.strictlyham.com.au/media/catalog/product/cache/1/image/9df78eab33525d08d6e5fb8d27136e95/d/r/dr-2xe.jpg)

The image above shows what a typical piece of repeater hardware looks like.

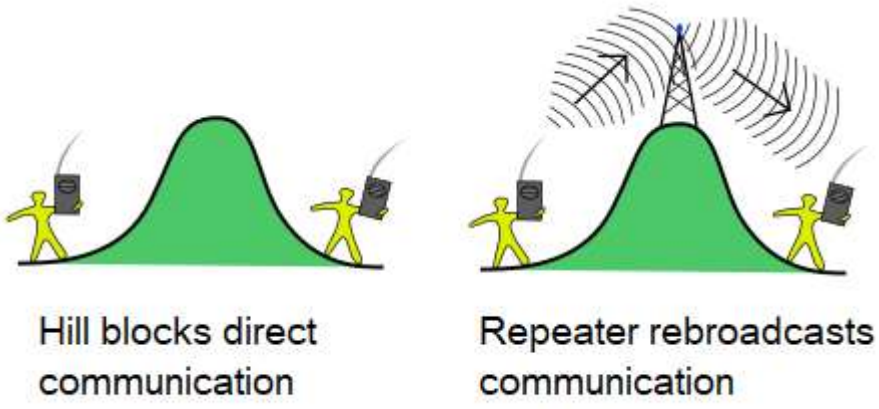
(Source: http://www.dstar.org.au/wp-content/uploads/2017/06/VK4RBD-tower.jpg)

Repeaters are often located in huts at the top of hills or on tall buildings. They usually have additional antenna and towers onto which hardware is mounted as shown in the image above.

Note that this article is focussed primarily on Analogue (voice) repeaters. There is a short introduction on Digital Repeaters at the end of this article.

When do we use Repeaters?

Repeaters are used when we want to extend the communication range of devices.



(after: https://clipartart.com/images/repeter-clipart-1.jpg)

In the example image there is a hill that prevents direct communications between the two users.

A repeater can be employed in a location where both the receiving station and the transmitting station can have direct, clear communication. Repeaters are often placed on top of high hills/mountains and or tall buildings.

General Radio Concepts

When using a radio, one usually has to press in a button (the Press-To-Talk or PTT button) to transmit. Most Amateur Handheld and Mobile Radios cannot receive and transmit at the same time.

(Ref: https://encrypted-tbn0.gstatic.com/images?q=tbn%3AANd9GcTsQ9oZfLlnN3F3dvpMcjtrqEfKrY6nM5Fb4g&usqp=CAU)

This mode of operation is what is called **half-duplex** operation.

If radios could receive and transmit at the same time – without employing special technologies that we will discuss – you would get the transmitted signal being received by the receiver and a self-oscillation would occur. A form of "self-oscillation" best known to most is the high-pitched squeal - **feedback** - that can sometimes be heard when a microphone too close to a speaker.

These feedback loops can build and build on each other and can destroying the hardware.

Radio frequencies are too high to hear. Though we cannot hear the signals that could be being “fed-back” into each other again the signals could destroy the radio hardware.

Thus, we have a limitation – most radios that end-user’s employ operates in a half-duplex mode such that they can only transmit or receive and cannot do both at the same time.

How Do Repeaters Work?

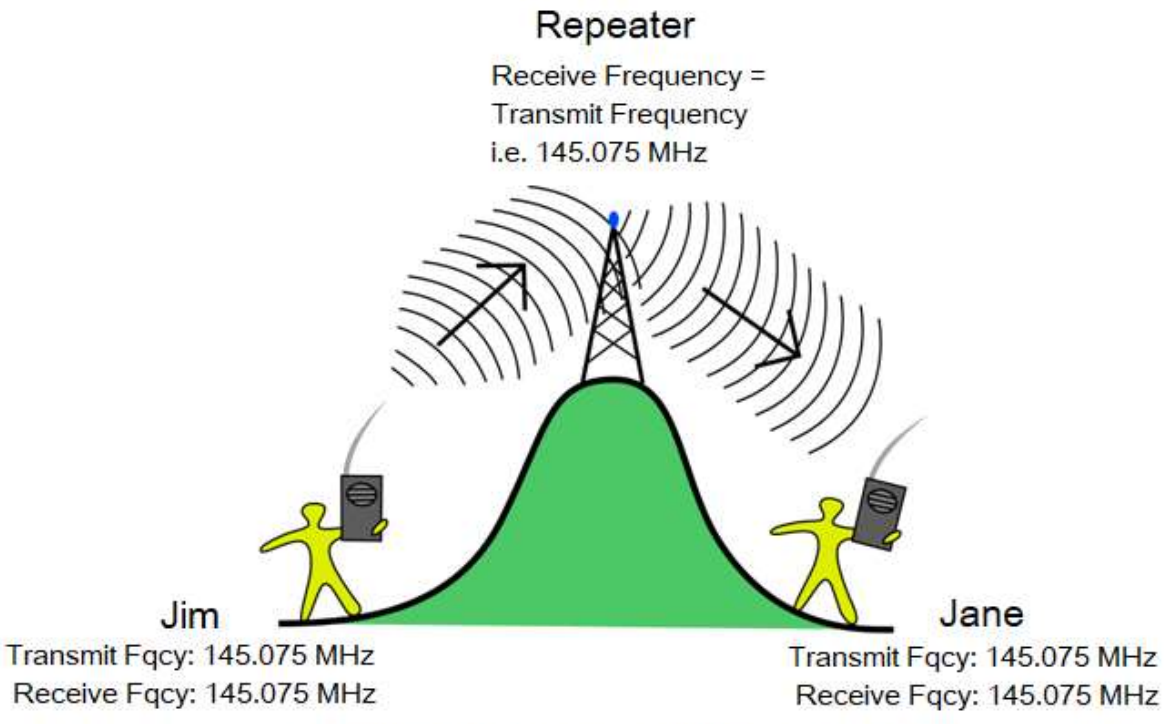
There are many and varied types of repeaters and modes of operation used in Amateur Radio.

Basically, there are two types of repeater:

(a) Half Duplex - **Simplex** Repeater
(b) **Duplex** Repeater

Simplex Repeaters

A **simplex repeater receives and transmits on the SAME frequency**.



(After: https://qrznow.com/wp-content/uploads/2016/11/Repeater-Operation.png)

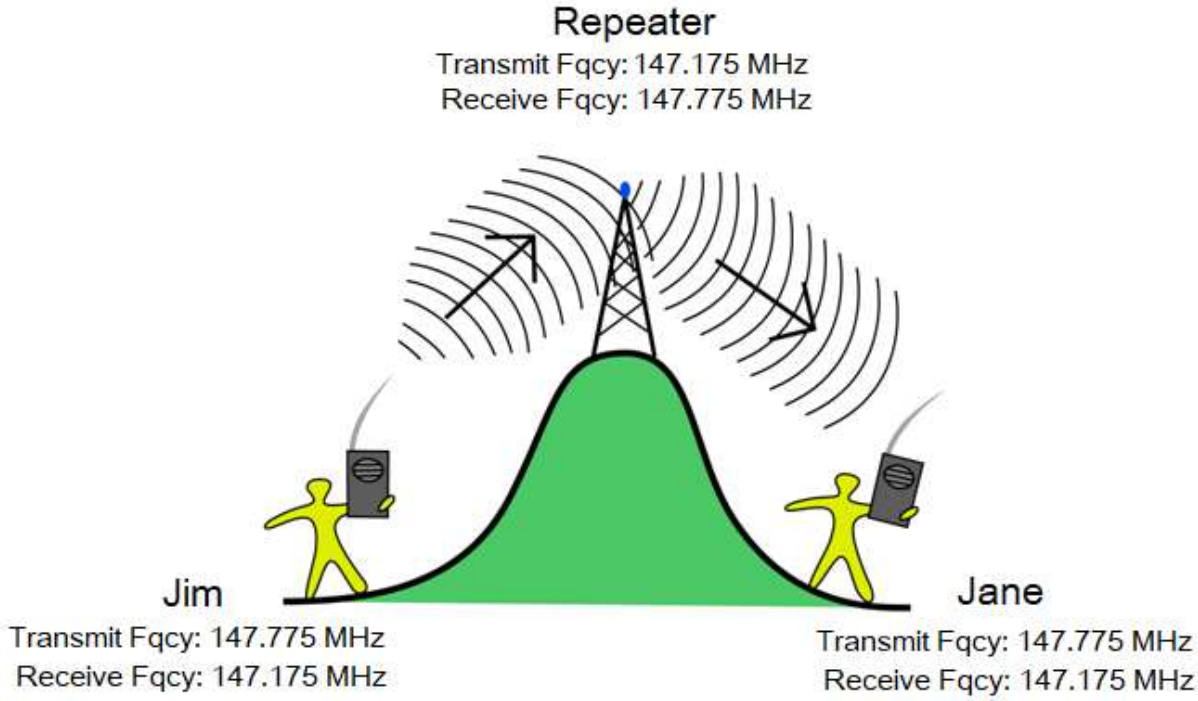
This means that the people transmitting (in the example above “Jim” and “Jane”) have their radios programmed so that they both receive and transmit on the same frequency.

This type of repeater cannot receive and transmit at the same time. These types of repeaters receive a signal and then often rebroadcast it to another site (either via a radio link or via The Internet).

Likewise, when a signal is received via a radio link or via the internet this type of repeater rebroadcasts the signal.

Duplex Repeaters

A **duplex repeater can receive and transmit at the same time**. These types of repeater listen on one frequency and then transmit on a slightly different frequency:



(After: https://qrznow.com/wp-content/uploads/2016/11/Repeater-Operation.png)

In the example above Jim wants to talk with Jane using a duplex repeater. Both Jim and Jane have their radios programmed so that they will transmit on 147.775 MHz and receive on 147.175 MHz.

You will notice that the two frequencies are different. There is a 600 KHz (0.6 MHz) difference between the transmitting and receiving frequency. This is termed the **repeater split**.

We document a split based on the repeater. In this case, the repeater is transmitting on 147.175 MHz and Receiving on 147.775 MHz – meaning that there is a POSITIVE split (i.e. + 0.6 MHz).

If Jim wants to talk with Jane, Jim presses the PTT button on his radio and begins to talk. Jim transmits on 147.775 MHz.

The repeater receives the signal transmitted by Jim on 147.775 MHz and then rebroadcasts the signal on 147.175 MHz at the same time.

Jane is not transmitting – meaning her radio is listening on 147.175 MHz. Jane is therefore able to hear Jim's signal relayed through the repeater.

When Jim finishes his transmission his radio now moves from the transmit frequency if 147.775MHz to the programmed receive frequency of 147.175 MHz. The repeater after a short-predefined period

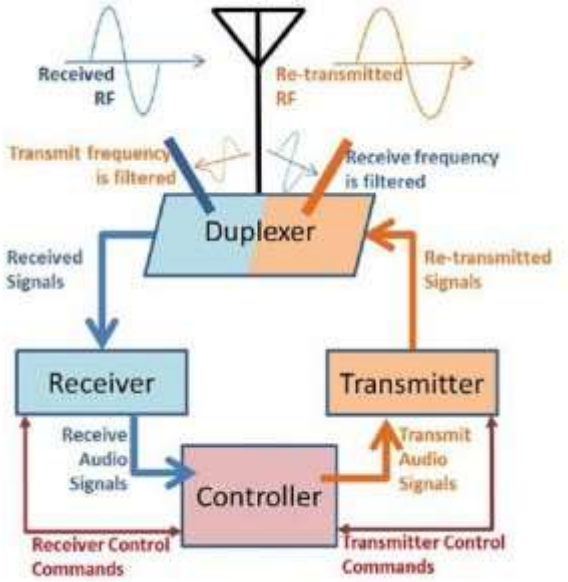
termed the repeater **tail** stops transmitting.

Then Jane can start Transmitting. For completeness, Jane transmits on 147.775 MHz. The repeater receives this signal on 147.775 and then rebroadcasts it on 147.175 MHz. Jim's radio, now in receive mode and listening on 147.175 MHz can then receive Jane's signal.

Duplex Repeater Hardware in More Detail.

The first diagram in this article shows a picture of what repeater hardware actually looks like. Yet how can a radio transmit and receive at the same time?

Refer to the diagram below:



(Ref: https://hamradioschool.com/wp-content/uploads/2014/03/duplexer_exampleWP-298x300.jpg)

Most repeaters are nothing more than multiple mobile radios with a microprocessor (termed a repeater controller) managing the radios.

(ref: http://yaesu-dr1x.blogspot.com/2016/03/yaesu-dr-1x-repeater.html)

One radio is configured and programmed for transmit, and the other radio to receive. The transmit and receive process is controlled by a repeater controller microprocessor to ensure that the repeater is not transmitting continuously or to manage some special features that the repeater can perform.

The repeater controller basically monitors the receiver and seeks out signals that the repeater should rebroadcast or respond to. It uses a setting called the “squelch” (mute sound) setting. The controller also “listens” for other tones – CTCSS and DTMF tones (that will be discussed later).

The repeater controller can also allow the repeater to put out an identification signal – either voice or morse – to identify the repeater’s callsign at a pre-defined interval. It can also restrict the repeater from rebroadcasting signals to prevent interference i.e. the length of each trans mission rebroadcast is usually restricted to around 3 minutes.

There are also some advanced features – such as repeater information and “linking” that can be controlled by tones (“DTMF Tones”) received by the repeater. More on this later.

It is the transmitter, receiver and repeater controllers that are found in the hardware box.

A set of very precise filters known as a “duplexer” is employed so that the same antenna can be used for transmit and receive. It also ensures that the transmitted signal does not get picked up by the receiver (causing a feedback loop –hence interference).

(ref: https://hamradioschool.com/wp-content/uploads/2014/03/duplexer_cavitiesWP-290x300.jpg)

The diagram above shows a picture if a typical duplexer. This type of duplexer employs “cans” known as “cavity filters”.

If you want to know more about this please refer to the article at:
https://hamradioschool.com/introduction-to-uhfvhf-fm-repeaters/

Programming Radios to Access Repeaters

There are many resources that you can use to get a list of repeaters that you can access. The Wireless Institute of Australia (WIA) provides a list for Australians and Australian Repeaters https://www.wia.org.au/members/repeaters/data/ .

A very good resource is Repeaterbook found at https://www.repeaterbook.com/ .

Shown below is a "snapshot" of some data found on the WIA repeater lists:

Output	Input	Call	Location	Service Area	S	ERP	HASL	T/O	Sp	Tone	Notes
147.100	147.700	VK3RPB	Mt Porepunkah	Bright	O	5	-	2.5	3WI	-	36
147.100	147.700	VK3RSG	Bass Hill	South Gippsland	O	40	-	3	3WI	-	
147.100	147.700	VK3RWA	Ben Nevis	Ararat	O	30	876	2.5	3WI	91.5	
147.125	147.725	VK3RDG	Mt Delegate	Delegate	O	-	-	-	3WI	-	
147.125	147.725	VK3RGC	Montpellier	Geelong	O	45	160	3	3ATL	91.5	
147.150	147.750	VK3RCV	Mt Alexander	Bendigo	O	20	730	3	3WI	-	
147.150	147.750	VK3REM	Maramingo Hill	Mallacoota WICEN 7/15	X	30	388	2.5	3EGC	-	35
147.175	147.775	VK3REC	Olinda	Melbourne	O	40	600	2.5	3ER	91.5	
147.200	147.800	VK3RBG	Dimboola	Wimmera	O	25	160	-	3KAY	-	
147.225	147.825	VK3RWG	Mt Baw Baw	West Gippsland	O	20	1563	2.5	3WI	-	
147.250	147.850	VK3RMM	Mt Macedon	Melbourne WICEN	O	100	1011	2.5	3WI	-	
147.275	147.875	VK3RMP	Caveat	North Central 8/17	P	100	670	3	VSA	91.5	
147.275	147.875	VK3ROW	Beech Forest	Otway Ranges 6/15	X	45	550	3	3ATL	91.5	
147.300	147.900	VK3RWE	portable	Statewide WICEN	O	-	-	-	3WI	-	
147.300	147.900	VK3RWR	portable	Statewide WICEN	O	-	-	-	3WI	-	
147.300	147.900	VK3RWP	portable	Statewide WICEN	O	20	-	-	3WI	-	
147.325	147.925	VK3RMC	Narre Warren Nth	Melbourne SE	O	50	-	-	3APC	-	
147.350	147.950	VK3RMS	Olinda	Melbourne East	O	-	600	-	3WI	-	
147.375	147.975	VK3RMU	Mt St Leonard	Melbourne	O	-	1028	2.5	3WI	91.5	
147.425	147.425	VK3RFY	Hillside	Melb West EchoL/IRLP	O	100	145	-	3HF	91.5	38,99

Highlighted is the data provided for Repeater "VK3REC". This means that to access this repeater you would program your radio to:

- RECEIVE on the repeater's "Output" frequency being 147.175.
- TRANSMIT on the repeater's "Input" frequency being 147.775 MHz.

Continuous Tone Coded Squelch System (CTCSS)

There is one additional piece of information needed to be programmed into the radio to access the repeater VK3REC. This data is listed in the "Tone" column. Some repeaters do not have a "Tone" value listed. If a repeater has a "Tone" value then it must also be programmed in to access that repeater.

In the example above for VK3REC, a figure of 91.5 (meaning 91.5 Hz) must also be programmed in so that when the radio transmits this 91.5 Hz sub-audible "tone" is also transmitted.

This tone is called the **Continuous Tone Coded Squelch System** frequency, or **CTCSS** Tone.

There are often many devices at a repeater site. Sometimes other device can accidentally trigger a repeater. To prevent this occurring, we insist that the repeater must receive a special tone – a Continuous Tone Coded Squelch System (CTCSS) tone. Radios receivers are designed so that they can pick up these tones but they do not amplify (i.e. filter) these tones out through the speakers.

This tone is not audible to any user or radio listening to the repeater system; it is a **sub-audible tone**.

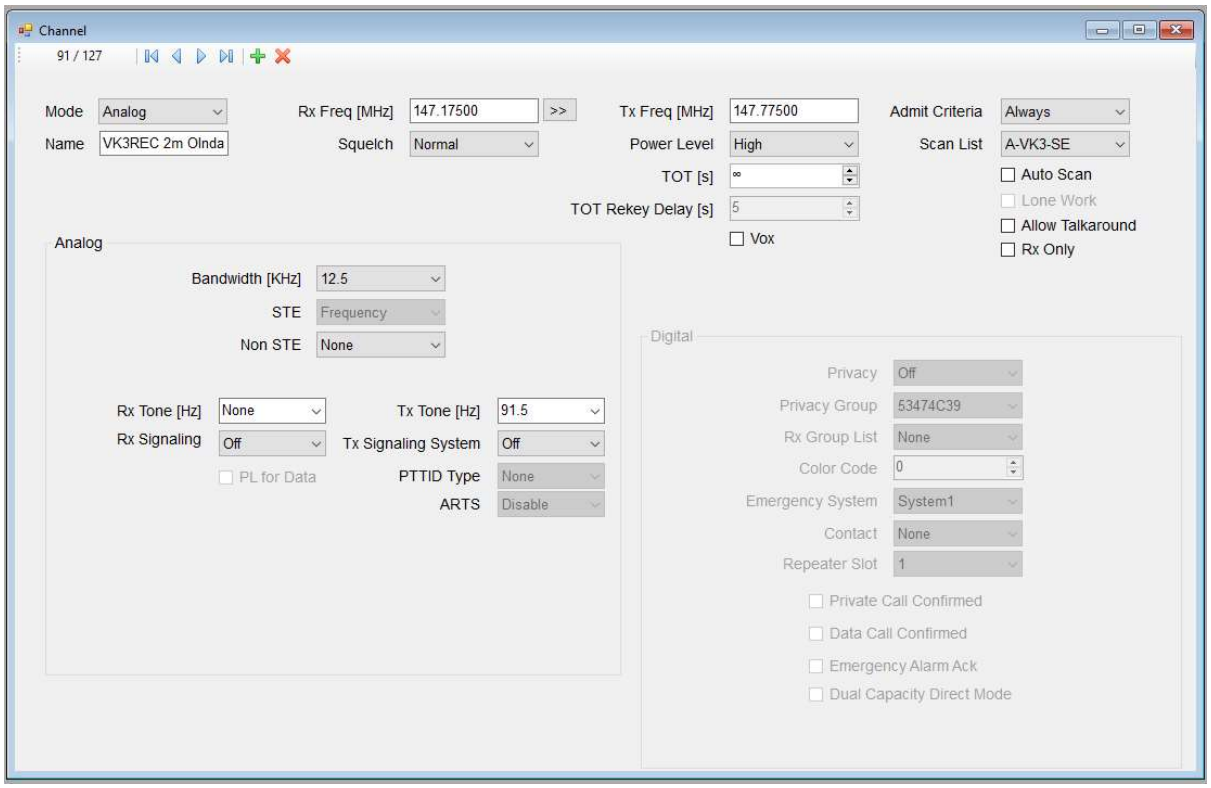
There are lots of “standard” CTCSS tones that can be programmed into our radios:

67.0	69.3	71.9	74.4	77.0	79.7
82.5	85.4	88.5	91.5	94.8	97.4
100.0	103.5	107.2	110.9	114.8	118.8
123.0	127.3	131.8	136.5	141.3	146.2
151.4	156.7	162.2	167.9	173.8	179.9
186.2	192.8	203.5	206.5	210.7	218.1
225.7	229.1	233.6	241.8	250.3	254.1

The most common tone frequencies used in Australia are 88.5 Hz, 91.5 Hz (the most common), 118.8 Hz and 123 Hz.

Example Radio Programming Screen

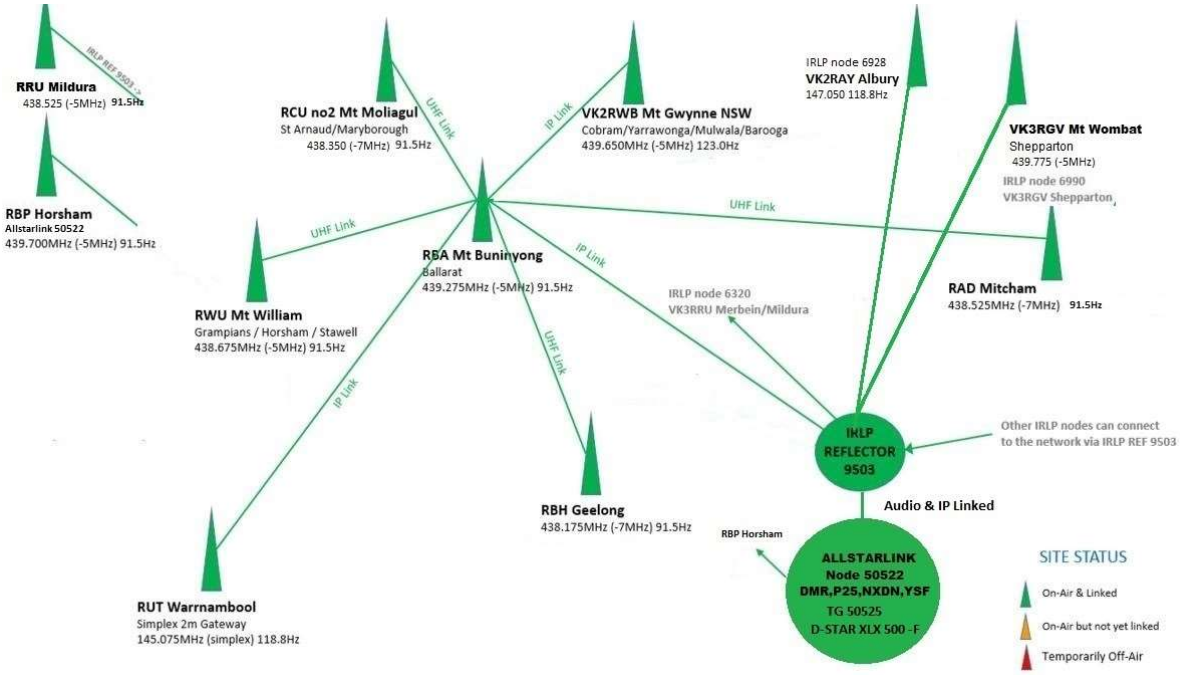
There are many makes and models of radio transceiver. It would be impractical to show images from all. The image below shows a standard configuration page from a GD-77 Radio for VK3REC:



(Source: Author – GD-77 Programming Software)

Accessing Special Repeater Functions – DTMF Tones

Repeaters in Australia often sit in remote locations. So how can we change the programming of their repeater controller?



Repeater Network Map for VK3RBA (See: https://www.qrz.com/db/VK3RBA)

Many repeaters are now linked over the air or via the internet as the map shows. How can we control the repeater linking process?

(Source: https://www.aliexpress.com/item/32879296237.html accessed 13/11/2020)

We use a series of **audible tones** known **as Dual Tone Multi Frequency** (**DTMF**) tones. These tones can be sent via a numeric keypad on the radio's body or microphone when the radio is transmitting.

They are the same tones that you may be familiar with when you push a number on a telephone's touch keys.

	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

(After: https://electronics.stackexchange.com/questions/348516/why-do-push-button-telephones-use-dual-tone-for-signalling)

You use a map of a repeater network (similar to the one shown earlier) and documentation for the repeater and network to get information as to how to link repeaters and/or access special repeater functions for some (not all) repeaters i.e. time and date, weather.

Further discussion of how to use these special repeater and network functions are beyond the scope of this introductory document. You should research the document pages for the repeater and its connected networks and possibly consult an experienced amateur who has knowledge of how to use these devices.

Digital Repeaters

The use of digital repeaters that mathematically encode voice and data is now very common in the Amateur Radio world. Many inexpensive digital-capable radios (such as the GD-77 shown in this document as examples) are now available.

The main advantage of digital repeaters is improved signal quality.

Many of these repeaters are linked into networks (i.e. DMR with DMR-Marc and Brandmeister) and connected via the internet.

A disadvantage is that sometimes a drop-out in repeater communications or a mis-configured radio can also make signals unintelligible.

(After: https://www.retevis.com/mmdvm-hotspot-wifi-digital-voice-modem/)

Devices known as “hotspots” are available and used by many Amateurs. These devices can be connected to the internet so that digital-capable radios can connect to repeater networks just as if they were connected directly to a repeater.

The main modes of digital repeater operation used by Amateur Radio operators today are:

- DMR (DMR-MARC, DMR+ and Brandmeister Networks)
- D-Star (Icom proprietary)
- Fusion (Yaesu proprietary)
- P25

Digital Repeaters are not really that smart and in many respects are not different to Analogue repeaters. It is the Transceivers and the way that they are programmed that really implements the digital technologies.

Further discussion of Digital Technologies is beyond the scope of this article.

Further References

- https://en.wikipedia.org/wiki/Repeater accessed 13/11/2020
- https://hamradioschool.com/introduction-to-uhfvhf-fm-repeaters/ accessed 13/11/2020