Voice repeater basics

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Introduction

Repeater operating is one of the most popular facets of amateur radio. For the Foundation licensee, restricted to low power, repeaters offer a means to make longer distance VHF/UHF contacts, especially when operating mobile and away from home. This article looks at the technical aspects of amateur voice repeaters.

Voice repeaters extend a station's transmitting range by receiving incoming transmission and simultaneously

retransmitting them on another frequency. They consist of a receiver, transmitter, filter, antennas and timing/control circuitry. Repeaters are normally situated on hill tops or high buildings for best coverage of a particular area. A list of repeaters can be found at http://www.wia.org.au

Operation

Repeaters use two frequencies; an input (or receive) frequency and an output (or transmit) frequency. These frequencies are 600 kHz apart for two metre repeaters and 5 MHz apart for repeaters operating on 70 centimetres.

For a repeater to transmit, it needs to be activated by a sufficiently strong signal on its input frequency. The presence of such a signal activates the repeater's squelch or mute circuit. This causes the repeater to start transmitting. The audio from the receiver is fed direct to the transmitter.

The result is that for as long as there is a strong enough signal on the repeater's input, the transmitter is activated. Those listening to the repeater's output frequency will then hear a stronger, retransmitted version of the signal on the input.

Repeater equipment

Ex-commercial VHF FM transceivers such as the Philips FM828 are often used in amateur repeaters due to their low cost, good performance, and easy availability.

Depending on the availability of power at a repeater site, wind, solar or 240 volt mains may be used to run the repeater. Rechargeable lead acid batteries are often used to provide backup during power failures.

Because their receivers are operating 24 hours per day, even very quiet repeaters draw appreciable currents. Antennas used in repeaters must be built to withstand adverse weather. This is because access to a site may be dificult or time-consuming, particularly if it is shared with other users or is in a remote location.

Desensing

The main difficulty when designing a voice repeater is the closeness of the transmit and receive frequencies. This small difference makes it very easy for the repeater's receiver to be overpowered ('desensed') by the strong signal from the repeater's own transmitter. Failure to cure this problem makes the repeater unable to receive weak input signals. Repeater builders separate the transmit and

receive antennas and install banks of cavity filters before the repeater's receiver and after the transmitter to eliminate desensing.

Cavity filters are simply very sharp (high Q) tuned circuits. Depending on how they are connected, they can be made to act like band pass or notch filters. The notch filter connection is used when you want to deeply attenuate signals on a particular frequency, but want little attenuation of signals on other frequencies. This would be useful at a repeater's receiver, where it is important to attenuate the signal transmitted by the repeater's transmitter (to prevent desensing) but allow good sensitivity at the repeater's input frequency.

Repeater control and timing systems

As well as transmitting, receiving and filtering equipment, repeaters include timing and control circuitry. The sophistication of this varies between repeaters. The following are some functions performed by these circuits:-

- Voice or Morse identification
- Time-out (Repeaters may not transmit for more than 10 minutes continuously)
- Fault protection - shuts down the repeater if it develops a fault
- A 'tail' - this keep the repeater transmitting even

when a station's signal temporarily drops below the repeater's receive threshold

- Subtone encoding of the repeater's transmissions to reduce the effect of pager interference to suitably equipped users
- Accessing links to other repeaters

Modern repeaters use a control board featuring an EPROM microprocessor IC to perform many of these functions. By programming this chip, repeater builders can customise the functions provided to suit their needs.

Repeater access

Most repeaters are open access. This means that a carrier signal on the right input frequency is all that is required to operate the device. However, a few repeaters are 'closed', ie they require special tones to be transmitted before they will operate.

For example, a UHF repeater may include a user-controlled crossband link to a repeater on 29 MHz FM. By transmitting a suitable tone to activate the link, the user can enjoy contacts on ten metres FM, even though they themselves do not possess HF equipment. Signals with no access tone will be retransmitted on the UHF repeater output only. Foundation licensees need to be aware that they do not inadvertently transmit access tones on

repeaters that may allow retransmission on a band they're not licensed to use.

Where a repeater is installed near high-powered VHF or UHF transmitters, it may be continually being triggered by spurious signals or mixing products. Making the repeater's mute tone-activated means that only amateurs sending the required tone can open the repeater. This makes monitoring the repeater more pleasant - an important consideration given that far more people listen to repeaters than actually talk on them!

Repeater builders may have other reasons for making their repeater tone access only. The frequencies of the tones used by these repeaters are given in the repeater section of the Australian Callbook.

So what are the main ways to control access to a repeater or repeater link? There are at least three methods. These are as follows:-

- **Toneburst.** Requires users to transmit a short 1750 Hz tone to open the repeater. Usually an audio oscillator on the correct frequency is required, though a high-pitched whistle may do the job. This system is technically primitive, unpleasant to the ear

and is not used in Australia. However, because it is common in Europe, many rigs have this feature built in. Owners of such rigs can be recognised by the very annoying high-pitched squeal at the start of each of their transmissions. If you have such a rig, do your fellow amateurs a service and ensure that this facility is disabled each time you transmit.

- **CTCSS subtone.** This stands for Continuous Tone Coded Squelch System and is more advanced than the toneburst system. Tones are transmitted continuously and are at frequencies below those of the human voice, so that their presence does not disrupt communication. A choice of standard tones gives the system greater versatility than the toneburst system. Typical applications include reducing the effects of 148 MHz pager transmitters on two metre receivers, activating links for WIA broadcasts and crossband repeater linking. Many modern VHF/UHF transceivers include this facility as standard.
- **DTMF**. Dual Tone Multi Frequency. A similar system to that used in modern tone-dial telephones. Each number has a unique combination of two tones. Useful for remote control of repeater sites due to the large number of combinations possible. DTMF may also be used for activating links to other repeaters. Many newer VHF/UHF amateur rigs include DTMF facilities as standard.

Repeater linking

As mentioned before, two or more repeaters may be linked together so that users of one repeater can talk to users of another. This is done for the following reasons:-

- To allow longer distances to be covered on the VHF/UHF bands
- To increase activity on two or more repeaters serving a sparsely populated area
- To promote activity on lesser used bands (such as linking 10m & 70 cm repeaters)
- For experimental purposes

In places where activity is sparse (eg country areas), repeater sponsors usually want to have the link operational at all times. Where there is more activity or links are used for special purposes only, users may wish to switch links on and off. This can be done by installing special tone decoding circuitry at the repeater. It is then up to the operator to decide whether to activate the link by transmitting the correct CTCSS or DTMF control tone.

Linked repeaters must have better than average receive and transmit quality. This is because each transmitter and receiver in the chain between the transmitting and receiving station degrades the quality of the signal

slightly. Generally speaking, the simpler the link, the greater its reliability and the better the recovered audio.

In repeater linking there is considerable scope for ingenuity and experimentation. The following are examples of the types of links that are possible:-

- **Conventional linking**. This method is used when linking two repeaters transmitting on the same band. The method requires an extra transmitter and receiver at each site to be linked. A typical application for conventional linking is when it is desired that a pair of two metre repeaters be linked. Installation of a link transmitter/receiver operating on 70 centimetres at each repeater site allows a station operating through one repeater to also be heard on the other.
- **Off-air linking**. This technique is useful when linking repeaters transmitting in different bands (for example, linking a two metre repeater to a seventy centimetre device). It is simpler than conventional repeater linking because only one extra transmitter/receiver installed at one site is required to link two repeaters. RF spectrum is conserved as no special link frequencies are required.

An off-air link does not have to be between two repeaters;

a remote link comprising a UHF transceiver connected to a two metre rig on a nearby hill could provide access to a 70 cm repeater from two metres without the need for a full 2 metre repeater. Such installations are particularly attractive for coverage of small geographic areas, or where activity is insufficient to justify the installation of a stand-alone repeater.

Simplex gateways. A simplex gateway is a means to allow access to a simplex frequency by users of a repeater, or vice versa. In its simplest form, it consists of a single frequency FM transceiver wired to a conventional repeater. A typical application is to provide access to ten metres FM to UHF repeater users. This allows UHF operators to enjoy interstate and overseas contacts given favourable conditions on 29 MHz.

With the spread of broadband internet, linking is often done via that means rather than the RF methods discussed above. However RF linking is still important where it is desirable to provide a stand-alone communications link independent of any external network.

Other types of repeaters

All repeaters listed in the Australian Callbook use at least two frequencies and operate on FM. However, not all

repeaters operate like this. This section introduces the reader to some lesser-known types of repeaters.

- **'Parrot' Repeaters**

A parrot repeater differs from a conventional repeater in that it uses one frequency only. Its name is very apt. Incoming signals are recorded on a digital voice recorder inside the repeater. When the user stops transmitting, the repeater switches to transmit and plays back the recording. This retransmission is heard by all stations monitoring the frequency. In other words, whereas conventional repeaters retransmit the incoming signal on a different frequency while the user is talking, parrot repeaters retransmit a recording of the signal immediately after the user has finished. Thus, unlike a normal repeater which transmits as it receives, the parrot repeater is either receiving or transmitting and does not do both simultaneously.

This need for repetition makes communicating via parrot repeaters slower than through conventional repeaters. As well, there is a risk of users accidentally transmitting over one another. For this reason, parrot repeaters are most useful during emergency-type communication exercises where transmissions are normally kept short.

Parrot repeaters are very simple to build - no cavity filters or separate antennas are required. Those with some constructional expertise may wish to build their own by adding a digital voice recorder and associated control circuitry to a standard amateur mobile or hand-held transceiver.

- **Linear Translators**

Conventional repeaters transmit and receive FM only and relay only one transmission at a time. Linear translators, in contrast, can relay many signals at once. They work by receiving a segment of frequencies in one amateur band and retransmitting it in another band. Any signal, whatever its mode, appearing within the linear translator's receive passband is retransmitted.

This means that a linear translator with a sufficiently wide passband (say 50kHz or more) can relay several Morse, voice and data transmissions simultaneously. Tuning across the output of a linear translator is a lot like tuning across an amateur HF band, where signals of several different modes can be heard.

Unlike FM repeaters, which demodulate the incoming signal and use the resulting audio to operate the

transmitter section, no demodulation takes place within linear translators. Instead, linear translators use a mixing, filtering and conversion process, similar to that which operates in a superhetrodyne radio receiver. Again like superhet receivers, linear translators incorporate automatic gain control (AGC) circuits to prevent strong signals from overloading the system.

Most amateur satellites incorporate linear translators. However, their use on land is limited, and none are licensed in Australia. Because they can relay SSB and CW signals alongside FM transmissions, a terrestrial linear translator could have better coverage than a conventional FM repeater at the same site.

As well, they make possible activities such as full-duplex voice operation (similar to speaking on a telephone) and transmitting slow-scan television images simultaneously with a voice commentary. For the experimenter, a linear translator would be an advanced project calling for a high level of expertise and access to test equipment.

- **D-Star**

D-star is a proprietary digital system popularised by Icom. It has provision for both digital voice and digital data

modes and linking via the internet. Repeaters operate in the major Australian capitals on 2 metres, 70 centimetres and/or 23 centimetres. Further information at http://www.dstar.org.au

Conclusion

This article has given the reader a quick tour of the various types of voice repeaters, with special emphasis given to repeater linking and control. More information about all aspects of repeaters can be obtained from your local repeater committee or group. I would like to thank Will McGhie VK6UU for his assistance in the preparation of this article.

Notes

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