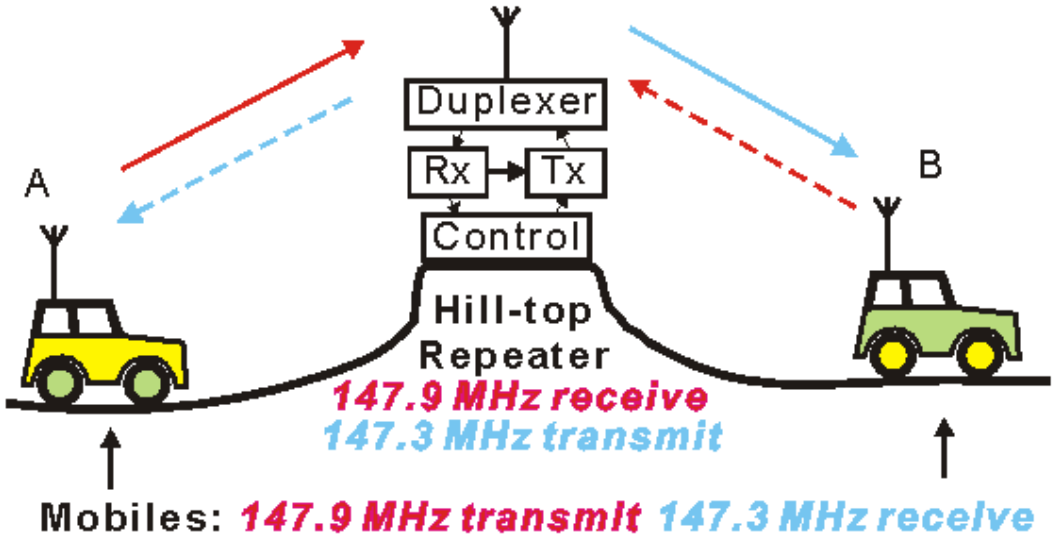
Amateur FM repeater basics.

What is an FM repeater and how does it work?

A repeater is a full-duplex radio system that receives signals on one frequency and simultaneously re-transmits them on another frequency, usually with higher power and from a better location with greater communications coverage range. A repeater greatly extends the operating range of mobile and hand-held portable transceivers. The repeater can consist of two quality transceivers back to back or a commercially made rack mounted system. One is the receiver and the other the transmitter. A power supply and optional battery backup is also required.

In the following drawing, the repeater is shown broken down into its main parts:

- a transmitter.
- a receiver.
- a duplexer filter.
- a common antenna.
- a repeater controller.



The duplexer allows the transmitter and receiver to both operate at the same time through a single antenna (prevents the repeater transmitter from desensitising the receiver). Have you ever tried to transmit and receive close to someone else who is also using radio transmitters in the same band? Try this and you will see why it is so hard to have simultaneous operation without interference or desensitisation.

The controller which takes care of operating the transmitter when a signal is heard at the receiver input, periodically transmitting identification in Morse code or adding tail beep. It is administered by the repeater trustee remotely, via DTMF control codes, for maintenance shut down purposes. A time out timer prevents transmitter burn out. The controller can add an “anti false trigger” circuit to prevent annoying noise interference and random inter-modulation triggering. This often occurs at shared repeater sites

with multiple commercial repeaters in operation. The controller can send a warning signal in the event of an antenna fault or a mains power failure.

The antenna has to be carefully chosen to recover signal loss caused by coax cable, duplexer losses and have a signal radiation pattern allowing users both distance and local coverage.

Technically there is a very good reason to use a common antenna:

1. There is only one coax cable, connector and antenna to maintain.
2. The radiation pattern from the antenna is almost identical on both transmit and receive frequencies. Almost as good as simplex.
3. Easier to monitor performance of both Transmit and Receive circuits.

Disadvantage of using a common antenna:

1. Signals lost passing through the duplexer. This is often acceptable compared with the difference when using a separate antenna system.
2. Any loose metal, antenna or connector faults create crackle noises as all signals pass through a common connected circuit. Faults are noticed sooner than when using simple lower performance repeaters.

When separate antennas are used the following issues arise:

1. Two coax cables, connectors and antenna resulting in increased maintenance.
2. Different radiation patterns as these antennas are usually stacked one above the other. This creates a situation where fringe area or hand-held portable stations can hear the repeater but not pass though it. Also the other way around that they pass through the repeater but cannot hear it. Local Line of Sight stations are not affected by this phenomenon.

What is the difference between Simplex and Duplex?

Simplex:
When you wish to talk to another station without using a repeater, a “simplex” frequency is used. Simplex refers to the fact that everyone involved in the radio communications are both transmitting and receiving on the same “single” frequency. In simplex communications, only one person can talk (transmit) at a time, and that person cannot hear (receive) anyone else while he is transmitting.

Buildings, trees and hills can block simplex signals after a few kilometres
- On the other hand, simplex signals can go as far as “line-of-sight” allows
- Transmitting from a mountain top allows simplex signals to go for hundreds of kilometres
- Roof-top (and car roof-top) antennas help simplex signals go farther
- Remember, when using simplex - “the higher altitude, the better”

Full Duplex and half duplex:
This mode is generally called duplex but is actually technically half-duplex for repeater use. Full duplex permits simultaneous transmitting and receiving (talking and

listening) the same as on a normal house telephone. In radio communications, separate transmit and receive frequencies must be used for full-duplex – note that there will be no "push-to-talk" microphone button. A repeater operates in a full-duplex mode at the repeater end only.

Half-duplex:
Used by operators when communicating through repeaters; where two separate frequencies are used for transmitting and receiving as in full-duplex, but the transceiver can only transmit or receive (not both simultaneously). A push-to-talk button on the microphone is used to switch the transceiver from the receive mode to the transmit mode.

In order to have your hand-held or mobile radio signal re-transmitted by the repeater, your radio must receive on the repeater's transmit frequency and transmit on the repeater's receive frequency. When in the receive mode, your radio will be tuned to the repeater output frequency. If you press the push-to-talk button, the radio will automatically change to the repeater input frequency and begin transmitting.

The repeater input (receive) frequency is higher in frequency than the repeater output (transmit) frequency in the example of Climie 730.

Standard FM repeater "offsets" (difference between output and input frequencies) are 1 MHz on 6m, 600 kHz on 2m, 5 MHz on 70cm, 20 MHz on 23cm.
Note that all modern transceivers will automatically select the proper offset for the repeater you use or select Duplex when the DUP button is enabled.
The "offset" has to be setup correctly first for DUP to operate.

With increase performance repeaters components have to be in top condition:

As mentioned above annoying crackle noise, especially on weaker or hand held transceiver signals, can be heard when a high performance single antenna duplexer system is used. Any loose metal to metal connections cause crackle when ever the wind is blowing. Noise can also result from poor quality connectors, water ingress and high resistance joints.

This happens because the coax cable, connectors and antenna are simultaneously transmitting power of at least 25 Watts while trying to receive weak signals on the same circuit. As high resistance joints or bad connections produce radio frequency noise then this noise is also heard by the receiver. This can confuse the receiver thinking it is not hearing a valid transmission. This then causes a cycling of the transmitter. "Kerchunck" "Kerchunk" pulsing can be heard as the repeater cycles on and off.

As soon as even small antenna high resistance joint starts the transmitter power aggravates the joint causing heating and resultant noise is produced.

Separated antenna systems do not suffer as much from this phenomena but not immune from this either.

Trustees are often aware of poor performance but due to poor weather conditions and site access users have to tolerate the annoying noises until faults are repaired.
If you think the trustee is not aware of a fault then contact them ASAP. Repeater problems can cause interference to other users at the same repeater site so it is important that faults are advised and repaired in a timely manor.

I hope that this document gives an insight about how repeaters work and the level of maintenance and expense involved in building and operating the equipment.

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