ARRL Amateur Radio Education & Technology Program

Unit 6 - Repeater and Remote Operation

What does the word "remote" mean to you? It's likely that the first thing you thought of was the controller for your TV set or audio/video player. What does "remote" stand for in this case? It means *remote control*. Let's take this idea a little further. Have you ever operated a remote control (RC) car or a remote control model airplane? When you operate these devices you are able to control movement of different parts of the vehicle from a distance with radio waves. The basic unit consists of a radio transmitter, a receiver and a system of *servos* connected to the receiver. By attaching mechanical links to these servos it is possible to manipulate various parts of the vehicle and control its direction and speed.

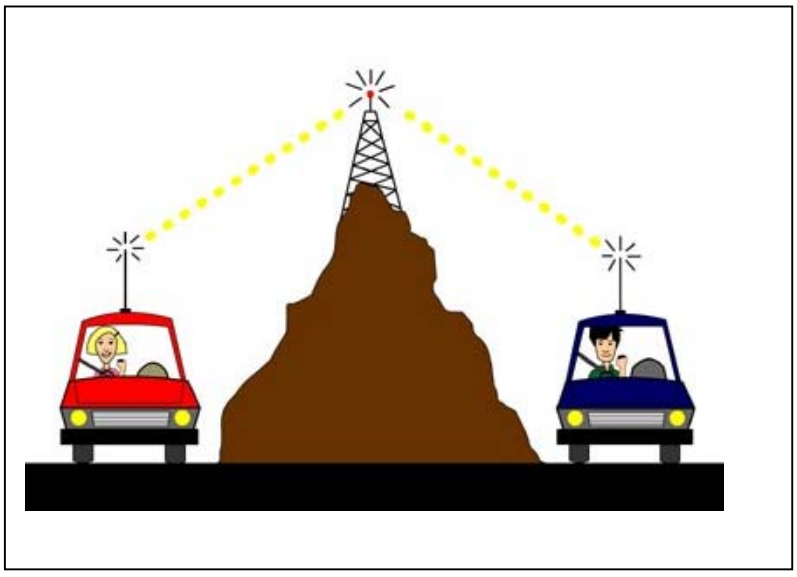
Remote control is used for operating a variety of vehicles from bomb disposal robots to Martian planetary rovers. All of these devices are controlled by radio transmitters when it is either dangerous, impractical, or impossible to be physically present to operate the device or vehicle.

Amateurs have experimented with communications technology for the past 100 years. As amateur operations have expanded, amateurs have employed remote control as well, especially on the higher frequencies. Two forms of remote operation in the VHF and UHF bands include repeater and satellite operations.

REPEATER OPERATION

VHF and UHF signals travel in a straight line. This is called line-of-sight propagation. This limits operating distance in many areas. Sometimes hills and buildings interfere with the signals. Even without obstructions, VHF and UHF signals won't travel much further than the horizon. In order to increase operating distances at these frequencies, ham operators started using devices called repeaters.

A *repeater* receives a signal and retransmits it, usually at higher power and from a better location, to provide a greater communication range. Repeaters are not only used by amateurs but are also used by police and fire departments, cell phone companies, and other private businesses that rely upon VHF or UHF radio communications. Repeaters are often located high atop buildings or mountains to increase their range. Any radio operators who can hear the repeater's transmitter on their radios can use it to retransmit their own



signals over greater distances. This is especially useful for amateurs using handheld or mobile radios.

A repeater receives a signal on one frequency and retransmits it (repeats it) on another frequency. The difference between the two frequencies is called the repeater's *offset*. This is called *duplex* operation. The repeater's receiving frequency is called the *input* and its transmitting frequency is called the *output*. An amateur operator who wants to use the repeater transmits on the repeater's input frequency and listens on the repeater's output frequency.

Repeater Input/Output Offsets

Band	*Offset*
6 meters	1 MHz
2 meters	600 kHz
1.25 meters	1.6 MHz
70 cm	5 MHz
33 cm	12 MHz
23 cm	20 MHz

Many repeaters won't work unless they are activated by a *subaudible* tone or a short "*burst*" of tones that are sent along with a transmission. These are called *CTCSS* (continuous tone-coded squelch system) or *PL* tones (Private Line - PL is a Motorola trademark).

Most amateur repeaters are said to be *open* repeaters. This means they are open to use by any licensed amateur operator. In this way they provide a public service. However, some repeaters are used exclusively by private radio clubs. A repeater like this is called a *closed repeater* and is only available for the use of club members. The club owns and maintains the repeater. Many clubs welcome new members. If you would like to become a member, call the control operator of the repeater, usually a designated club member.

How To Find A Repeater

Many communities in the United States have repeaters that are owned and maintained by amateur radio clubs or individual hams. Most of these operate in the 2 meter band, the most popular band for local amateur FM communication. Different repeaters in a local area operate on different frequencies as determined by someone called a frequency coordinator. Different frequencies are required so that the repeaters don't interfere with each other.

To find a local repeater, you can ask individual amateurs or contact local amateur radio clubs. To find a list of clubs in your area go to the Internet at **www.arrl.org**. Click on "club search." Another good resource is the *ARRL Repeater Directory*, a small handbook published by the American Radio Relay League (ARRL).

If you are using a repeater and an emergency call comes in, FCC rules require that you must try to establish communication with the station calling for help and pass on the information to the proper authorities. Also, if a repeater is already being used for emergency communications, you should not try to use the repeater for casual contacts. Once the emergency is over, the repeater can be used again for normal operation.

Simplex Operation

Sometimes when two amateurs are using a repeater, they realize they are close enough to use *simplex* operation. Simplex means the two communicating parties can talk on the same frequency without the use of a duplex repeater. This releases the repeater to someone else who may need to use it. There are certain frequencies set aside for simplex communication. How do

you know if you're close enough to use simplex? Listen to the repeater's input frequency instead of the output frequency that you would normally listen to. This is the same frequency the other station is using to transmit. If you can hear the other station on this frequency, then you are close enough to use simplex. This may sound confusing but after you've learned how to use a repeater it's not so hard to do.

Common VHF/UHF FM Simplex Frequencies

2-Meter Band	***1.25-Meter Band***	***70-cm Band***
146.52*	223.42	446.0*
146.535	223.44	
146.55	223.46	***33-cm Band***
146.565	223.48	906.5*
146.58	223.50*	
146.595	223.52	***23-cm Band***
147.42		1294.5*
147.435		1294.000
147.45		1294.025
147.465		Every 25 kHz to 1295
147.48		
147.495		
147.51		
147.525		
147.54		
147.555		

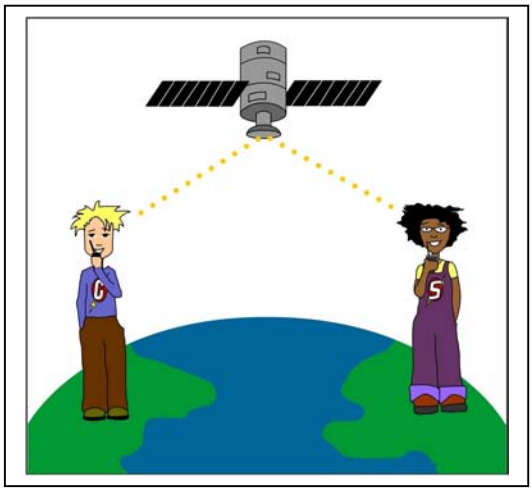
How The Autopatch Works

An autopatch allows repeater users to make telephone calls through the repeater. Not all repeaters have this function but many do. You can send the standard telephone company tones from your radio to the repeater. The tones are generated from a touch-pad on your radio similar to what you would find on a cell phone. The repeater is linked to a computer that makes the connection with the local telephone company. Usually, you are restricted to just a few minutes on your phone call before the repeater shuts off your connection. It's a service that provides a convenience to amateur radio operators but long conversations or financial business are inappropriate. Such calls should be placed over a standard telephone or cell phone. Also, since the autopatch is connected through a repeater, other amateurs can listen to your phone call so you won't have any privacy!

SATELLITE COMMUNICATIONS

Satellites have revolutionized wireless communications. Satellites are used to send pictures of weather systems and to monitor environmental conditions on the Earth. Satellites send radar signals to measure the shape of the ocean floor by detecting slight variations in sea level due to gravity differences. Satellites are used to spy on the military systems of other countries. Satellites provide a variety of commercial radio and television programming and are part of worldwide communications networks. It may surprise you to know that amateur radio operators have their own communications satellites as well.

Orbiting satellites provide another means of remote operation. They act somewhat like repeaters in the sky. Signals are transmitted up to a satellite on one frequency (called the uplink) and are retransmitted on another frequency (called the downlink). Because satellites are so far above the surface of the Earth, it is possible to communicate over great distances using relatively simple, inexpensive equipment.



At present, there are twelve amateur satellites and manned spacecraft in orbit. Over the years amateurs have enjoyed making contacts with Russian cosmonauts and American astronauts on amateur radio. Space communications is an exciting area of experimentation for amateurs in any license class. Amateurs have been launching their own satellites since 1961. Amateur satellites are called OSCAR satellites (Orbiting Satellite Carrying Amateur Radio). Satellites can use batteries or solar cells for power. OSCAR I and II were only beacons, transmitting identification signals from small transmitters in Morse code. Later OSCAR satellites were equipped with *linear transponders*. A linear transponder can receive a radio signal, shift its frequency, amplify the signal and then retransmit it back to Earth. Linear transponders can handle a large number of signals at once. As long as two Earth stations are within line of sight of the satellite, they can communicate with each other. The farther up above the Earth's surface the satellite is, the longer the stations can stay in contact. Also, stations can be further apart if the satellite is up higher. For example, low altitude satellites permit ground stations to be 5000 miles apart but high altitude satellites permit the stations to be 11,000 miles apart.

To better understand the distances involved, picture the Earth as being a ball with a 12-inch diameter (about the size of a basketball). The orbits of the U.S. Space Shuttle and International Space Station would be about 0.25 inch above the surface (the thickness of a pencil). A low Earth orbiting spacecraft (LEO satellite) would be about 0.5 to 1.5 inches above the surface. In comparison, a high altitude amateur spacecraft would be three *feet* above the surface (the length of a yardstick).

New amateur satellites are being designed with high-powered transmitters and sophisticated remote control systems. These have digital memory storage systems so they can receive messages and then relay the messages a little later than received. This greatly expands their communication capabilities. These are designed to be high altitude satellites. Some plans even call for geostationary satellites, such as those used by the government and communications industries. Geostationary satellites orbit the Earth at exactly the Earth's speed of rotation, so they are always above a single point on the Earth's surface. This is useful for wide coverage broadcasting and long distance communications. Although amateurs don't have a geostationary satellite as yet, when one is finally launched it will be possible for amateurs to talk over great distances. Someday, Amateur Radio may even play a part in interplanetary exploration.

AMSAT

No mention of amateur satellites would be complete without giving credit to the organization most responsible for the amateur space program: The Radio Amateur Satellite Corporation (AMSAT). AMSAT is a worldwide group of amateur radio operators who share an active interest in building, launching, and then communicating through non-commercial Amateur Radio satellites. Most of the people in AMSAT have volunteered their labor to design, build, launch and maintain amateur satellites. AMSAT has played an important part in helping to advance space science, space education, and space communications technology for many years.

International Space Station (ISS)

Would you like to try some radio that's "out of this world?" How about the International Space Station? Its first crew activated an Amateur Radio station aboard the ISS in late 2000. The ISS station sports a powerful signal that you'll usually hear on 2-meter FM. Some hams have been lucky enough to snag voice contacts with the crew on 145.800 MHz and there have been many scheduled contacts with schools as part of the Amateur Radio on the International Space Station (ARISS) program.

Working the ISS on voice is very similar to working a DX pileup, where many hams are trying to make a contact all at the same time. You sit with microphone in hand and wait until you hear the crewmember complete an exchange. At that moment you key the mike and say your call sign. Now listen. No response? Call again quickly! Keep trying until you hear him calling you or someone else.

Hams have worked the ISS while mobile in their cars and some have worked the ISS with hand-helds. As you might imagine, ISS QSL cards, the cards that get exchanged after a radio contact, are highly prized!

The major problem with working the ISS is its erratic schedule. The crew (Figure 6.4) has many duties and is not always able to find the time to operate their amateur station. They are sometimes forced to turn off their equipment to avoid interference to other systems during critical tests.

In these last two units we have covered a wide variety of information dealing with the Amateur Radio side of wireless communications. Learning how to communicate effectively is important to everyone, not just hams but all of us in everyday life. Taking time to improve our communication skills is time well spent. You never know when these skills will be called upon. Whether you are using Family Radio Service radios, ham radio or working for the government organization, good verbal skills one day could save someone's life.

REMOTE-CONTROLLED VHF/UHF AND HF

A third form of remote operation is just now becoming popular with radio amateurs. It involves connecting an amateur radio to the Internet through computers. Internet users have been communicating through the Internet using voice and video for years now. All that is required is a computer with a sound card, a microphone and a camera. It wasn't long before amateurs started connecting their VHF/UHF FM radios to their computer sound cards. Local repeaters were then linked to computers so that now amateurs around the world could talk to each other using repeaters linked to the Internet. This is an exciting form of "hybrid" technology that uses the best of what Amateur Radio and the Internet both have to offer. The audio quality is better than the usual Internet voice audio. Amateurs who only have a Technician license can now talk to amateurs around the world using high quality FM communication. Typical communication problems such as interference and fading found in traditional radio modes are eliminated.

What if you want to work HF? The same technology that is used to connect repeaters can be used to connect a computer to a remote HF station. So what is the advantage? If you live in an apartment with no possibility of putting up a tower and antenna, you can still operate HF through your computer.

In order to operate a remote base station, the following are required:

- Radio - any HF radio that is controllable from a computer;
- Internet Connection - ideally, a full time broadband connection with a fixed Internet protocol (IP) address;
- Computer - any 300 Mhz or faster IBM compatible system with a sound card, compatible microphone and headset, and with at least a 5 Gb hard drive and *MS Windows 95* or later operating system.

Because *Remote Base* operating is just becoming popular with the amateur community, there is a lack of information available for the time being. What follows is a list of articles and Web sites with information on remote base operating:

- Article in November 2001 *QST*, pages 47-48
- Article in July 2002 *Worldradio*, pages 6-7
- **www.lamonica.com**
- **www.w4mq**
- **www.irlp.net**
- **http://status.irlp.net**
- **www.qsl.net/ve6bpr/page2.htm**