# Atlanta Radio Club Main Repeater

What is a repeater?

Definition – (Encarta Dictionary) an electrical device that boosts and amplifies incoming communications signals and retransmits them

In the Ham Radio world, typically a repeater receives RF on an input frequency and transmits the received audio or data on a different frequency. The FCC requires that all transmitters be identified with a call sign at least every 10 minutes. The simplest repeaters are just a receiver and a transmitter with an automatic Morse code identifier.
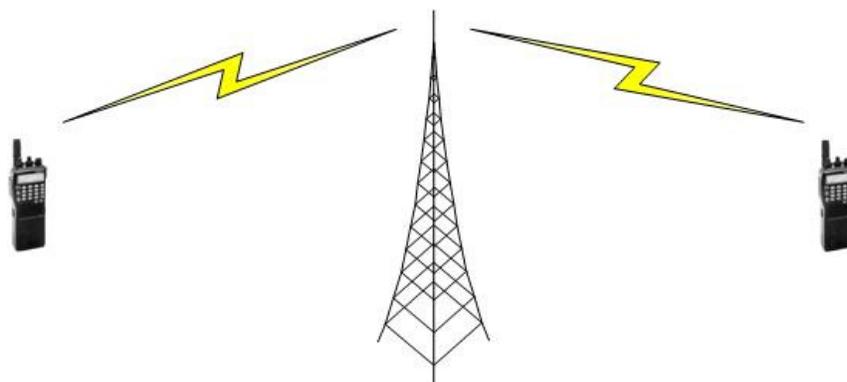
More complex repeaters have a controller between the receiver and transmitter. The simplest controllers offer little more than a way to identify the call sign of the repeater. Other controllers are able to manage multiple repeaters and links along with things like an autopatch, voice mailboxes and a host of other features to remotely and automatically control these functions.

The Atlanta Radio Club's Link Communications RLC-3 is just such a controller. From high atop the Bank of America building, it controls the 146.82, 224.34 and 444.825 repeaters as well as an autopatch and links to IRLP, Georgia Skywarn, The Southeastern Linked Repeater Net and several remote receivers for the 2-meter system.

It also has a library of spoken words that can be linked together into sentences and a Digital Voice Recorder (DVR) that can be used for voice mailboxes and announcements. All these things can be remotely controlled using DTMF (Touch-Tone) commands over the air.

The commands can be strung together into macros and the macros can be called by DTMF or automatically at certain times or in response to events such as a link coming active.

The controller is really the heart of a system of radios. Receivers and/or transmitters are plugged into radio cards, similar to expansion cards in a computer.

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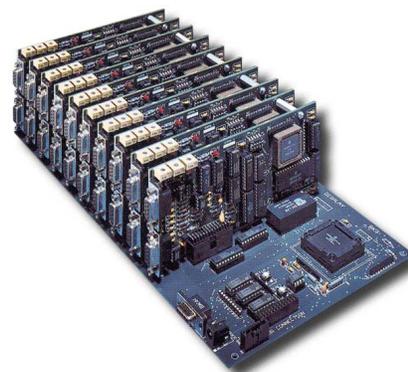
The 220 and 440 repeaters each just have one radio so they use one port each. The 2-meter repeater, on the other hand, has six receivers, one transmitter, an autopatch (for telephone calls), an IRLP (Internet Repeater Linking Project) node and a link radio for connecting to other repeaters such as the Skywarn system. Together, these use 4 ports.

The six receivers on the 2-meter repeater are what give it such good coverage. There are four 2-meter receivers at the main site. Each is connected to an antenna pointed in a different direction. Additionally, there is a link receiver with a beam antenna pointed at the remote receiver site at Sweat Mountain and another with a beam pointed at the Gwinnett water tower site. All of these receivers are fed into a Doug Hall Voter system which compares the Signal to Noise Ratio and selects the audio with the best quality. The output of the Voter is then fed into one of the ports on the RLC-3 Controller. (At this point, the Gwinnett site has some problems and does not work reliably.)

Another transmitter and receiver pair is used as a link to the Georgia Skywarn network and the Southeastern Linked Repeater Network. This link is set up in such a way that, with the proper codes, an operator on the other network can add the 146.82 repeater without need for any intervention on this end.

The IRLP node controller is connected to another port. When an operator, on the air in Atlanta, enters the proper code, the node number of the target repeater or reflector is passed out this port to the IRLP controller as DTMF audio and the connection is made by the node controller. (There is also an IRLP node connected to the 440 repeater, but it is physically at another location and connects as if it were just another local UHF simplex radio.)

And last, but not least, module instead of a radio module, one of the ports has an autopatch module connect to a phone line.
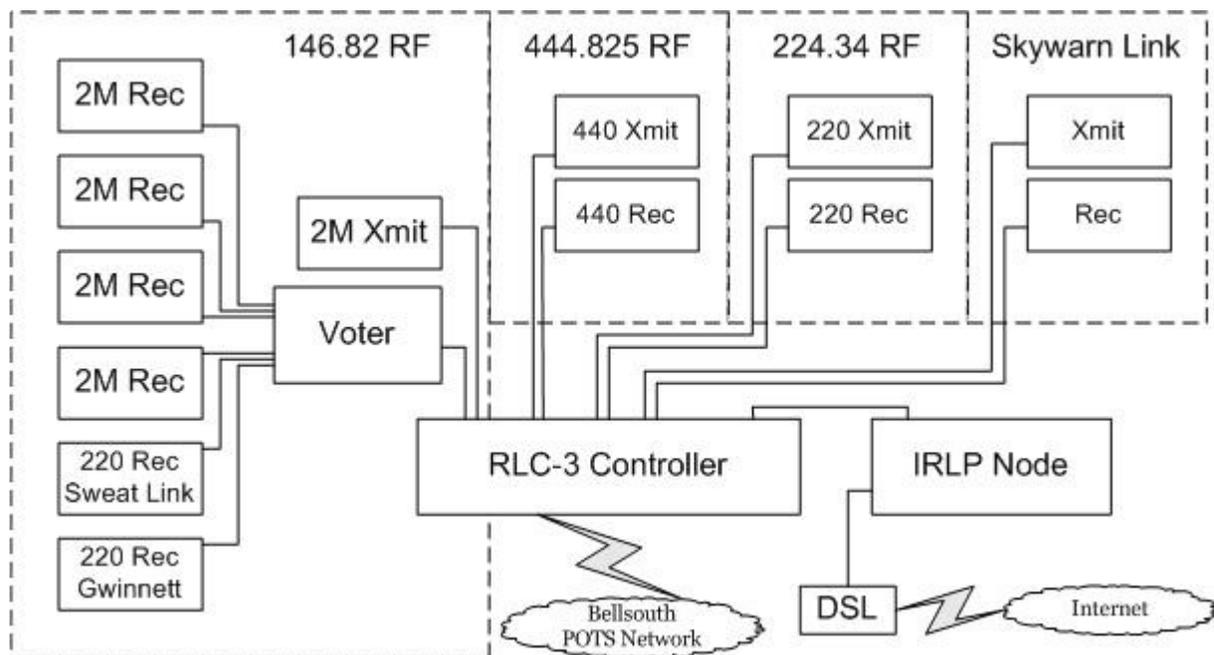
Most of the features of the controller work fine automatically, once configured. The only intervention required is to activate a link such as IRLP or the autopatch. This is done using the same type of DTMF commands that are used for configuration and setup. The system restricts certain commands to control operators while others are allowed by any logged in user and still others are available to anyone.

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Commands are 3-digit DTMF digits followed by other digits which vary by command. Macros are files containing a series of commands. Macros are executed simply by entering the macro name and releasing the transmitter key.

The controller is always listening for DTMF commands. Dual-Tone-Multi-Frequency tones are made up of two discrete audio tones played simultaneously. Sometimes the tone decoder finds the tones that it is looking for in the human voice. This is called Voice Falsing. On rare occasion, Voice Falsing can cause the controller to execute an unintended command, but usually it will hear either not enough or too many digits. The former results in "Error 201" and the latter in "Error 202".

When the system detects a DTMF digit, rather than playing the tone over the air, it instead plays a "Cover Tone" – a single tone sound played regardless of which digit is input. The Cover Tone is primarily a security feature so that listeners can not decode the commands.

Controller Commands

Commands open to the public include the following:
- #1 Echo Test – Dial #1 and release the PTT. Repeater will respond with "Echo Test" Key the mike and say something. Repeater will play back what you said.
- #2 Play Announcement – Dial #2 and release the PTT. Repeater will respond with the current announcement.
- #3 DTMF Test – Dial #3 for DTMF test instructions. The Repeater will respond with "Key in 4682 followed by the tones you wish to test." Then keyin 4682XXX where XXX is a sequence of DTMF tones. 4682 is actually a macro which listens for tones and then reads them back to you. If you don't want to hear the instructions, skip the #3 step and just enter 4682XXXX. For example, keying in 46821234 will result in the repeater responding with "One Two Three Four".
- #4 Time Check – Dial #4 and release the PTT. Repeater will respond with the current time and date.
- #11D Receiver Test – Dial #11D, Wait a couple of seconds and release the PTT. Repeater will respond with "RECEIVE ONE on/off, RECEIVE TWO on/off", etc This command provides a binary code of the receiver currently selected by the controller for your input signal. These are the receivers connected the Voter system as indicate in the table:

Receiver	Binary Code	Location
Receiver #1	0001	Vertex 5000 repeater at bank tower
Receiver #2	0010	Sweat Mountain
Receiver #3	0011	Lower antenna at the bank tower
Receiver #4	0100	Gwinnett Water tower
Receiver #5	0101	SW corner beam
Receiver #6	0111	Upper bank antenna
Receiver #7	1000	SE corner beam
Receiver #8	1001	Currently unused

Access to IRLP:
- Dxxxx where xxxx is the desired node number (see http://www.irlp.net for more information)
- D76 to take down the connection

IRLP links repeaters together via the Internet. You can use it to talk to amateurs all over the planet.

Access to the autopatch:
- *nnnnnnnnnn where nnnnnnnnnn is a local telephone number
- # to hang up

The autopatch may require you to log on with the userid and password provided to you when you joined the Atlanta Radio Club. Please read the information provided in your new member kit before using the autopatch or IRLP.

PL Tones

Private Line or PL is the friendly name that Motorola coined to describe CTCSS or Continuous Tone Controlled Squelch System. This system transmits an audio tone of a specific frequency in order to identify a desired transmission and keep the squelch closed when a signal other than the desired one is present. The tone is not heard because it is filtered from the audio by your radio. When you have multiple users on one channel carrying on independent conversations, it can be used to separate those conversations. A more common use, at least in ham radio, is to distinguish between a desired signal and one generated by harmonics and interference from other transmitters. It is used on the input side of a repeater to prevent the repeater from being activated by signals intended for other systems. On the output side, it can provide the very same protection against "interference modulation" or intermod to the end user's receiver.

The ARC repeaters all use a PL or CTCSS tone of 146.2 Hz on the input. This means that you must transmit that tone in order to open the squelch on the repeater. If this tone is not present, your signal will be treated as noise and not repeated.

The 146.82 machine also transmits the same tone on its output. If you so desire, you can configure your radio to ignore signals that do not contain this tone. In a big place like Atlanta, with thousands of transmitters coming and going all over town, doing this will help greatly to reduce the times when your radio comes active with nothing but noise.

Pretty much all amateur VHF and UHF FM radios manufactured in about the last 15 years have this feature, but you may have to look at your owner's manual to determine how to set it up.

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Thanks to Norm Schklar, WA4ZXV for most of the FAQ questions.

If you have additional questions, please feel free to contact me either on the air or at KE4FOV@Bruner.us.

Additional copies of this paper as well as links and other information are available at http://KE4FOV.com.

Glossary

ARC – Atlanta Radio Club (http://www.w4doc.org)

Autopatch – An automatic system that connects a repeater to the Phone system and places a call using DTMF commands sent over the air.

Cover Tone – an audio tone played over the air to indicate that DTMF tones are being decoded while masking the actual DTMF tones. Primarily used as a security precaution.

CTCSS – Continuous Tone Coded Squelch System – A system which enables a receiving system to accept or deny a transmission based on the presence of a specific discrete sub-audio tone. Commonly used in repeater systems to reject intermod and other signals not intended for the specific repeater or receiver. Also known as PL tone.

Doug Hall Voter – Voting system manufactured by Doug Hall Electronics (http://www.dheco.com) The system compares and selects one of a group of receivers with the best signal to noise ratio.

DTMF – Dual Tone Multi-Frequency – a set of 8 discrete audio tones which can be combined in a matrix fashion to indicate the hexadecimal digits 0-D plus * and #. Note that * and # are substituted for the true hexadecimal numbers E and F. Also called Touch Tones.

DVR – Digital Voice Recorder – a system which records and plays back voice messages by storing and retrieving them digitally on a random access medium. Because many short messages can be quickly retrieved and played back in any sequence, the system can be used to create voices messages from text.

Force-execution Digit – Tells the RLC-3 controller to execute the last command immediately rather than waiting for the carrier to drop. The default is "D". An example of its use is in the #11D command sequence which returns information about which receivers are active. Without the presence of the force-execution digit, the #11 macro would not be executed until you dropped carrier and at that time no receiver would be active.

Georgia Skywarn – The Georgia Amateur Radio Net that links statewide weather observers with the National Weather Service in Peachtree City. See http://www.georgiaskywarn.com/wx4ptc for more information.

Hexadecimal - the base-16 number system which consists of 16 unique symbols: the numbers 0 to 9 and the letters A to F.

Intermod - intermodulation distortion (IMD), or intermod for short, is the result of two or more signals of different frequencies being mixed together, forming additional signals at frequencies that are not, in general, at harmonic frequencies (integer multiples) of either.

IRLP – Internet Repeater Linking Project (http://www.irlp.net)

Link Communications RLC-3 - Link Communication, Inc. manufactures the RLC-3 repeater controller. See http://www.link-comm.com/ for more information.

Macro – A macro is a list of commands that are executed in order in response to one command from the user.

PL – Private Line – Motorola's "friendly" name for CTCSS - See CTCSS.

Reflector – Something which reflects heat, light or sound, especially something having a reflecting surface. An IRLP reflector receives audio from one linked repeater and reflects it back out to 1 or more other linked repeaters.

Repeater - An electrical device that boosts and amplifies incoming communications signals and retransmits them.

Signal-to-Noise Ratio - The ratio of a signal power to the noise power corrupting the signal. In less technical terms, signal-to-noise ratio compares the level of a desired signal (such as music) to the level of background noise. The higher the ratio, the less obtrusive the background noise is.

Southeastern Linked Repeater Net – is a Ham Radio net called each Wednesday night at 9:00 PM EST on a network of linked repeaters throughout the Southeastern U.S. See http://stoddard.homeip.net/SLRN/

Subaudio – In Ham Radio, a sound at a frequency below the audio passband of the radio system.

Voice Falsing – The term used to describe the condition in which a DTMF decoder incorrectly decodes tones in the human voice as valid DTMF digits.

Frequently Asked Questions

- Does a repeater have to use two frequencies?

  A Full Duplex repeater uses two frequencies because it is transmitting and receiving simultaneously. Such a repeater must use two frequencies because with only one, it wound feedback on itself.

  There is such a thing as a Simplex repeater. It uses a single channel and alternates between recording the audio and playing it back on the same channel. Each speaker has his turn to make a recording and then hears his words repeated back while the listeners hear them for the first time. Then the first speaker just sits and waits while the second speaker makes his recording and so forth. Needless to say, full duplex is much more desirable.

- Why can't more than one person speak at the same time?

  Repeaters receive on a single frequency. If there are two or more signals of similar power on the same frequency at the same time, they interfere with each other.

- Can I talk while the repeater is identifying?

  Yes. Many controllers have a "polite" ID system that will stop its audio when another signal is present. It will wait for a few seconds of silence before starting again. Amateur transmitters are required to identify themselves every 10 minutes. If the 10 minute limit gets close before a quiet time is found, the repeater will do an "impolite" ID. This is generally a Morse Code ID that is superimposed on top of the ongoing conversation.

- Do I need to give my call sign each time I speak, or just at a certain interval?

  FCC regulations require you to give your call sign every 10 minutes and on your last transmission. The repeater owner has the right to impose additional requirements in order to grant you permission to use the repeater. Most clubs ask that you also identify yourself whenever you issue a command to the repeater.

- Who has priority?

  Emergency communications always have priority. The FCC has no other restrictions among those properly licensed, but the repeater owner may set whatever criteria he desires.

- Do I need to pay a fee to use a repeater?

  It's up to the repeater owner. Most clubs allow their repeaters to be used by any properly licensed amateur, but may restrict certain functions such as autopatch use to club members only. Generally, it is considered impolite to use a repeater frequently without helping to pay for its upkeep.

- Can I put one at my QTH (home)?

  Yes. If you are serious about having a repeater that other people will use, you will not want to have someone else put up a repeater on a frequency that interferes with yours and you will not want to interfere with other repeaters. In the southeastern U.S., this problem is addressed by having repeater frequency pairs coordinated by the SouthEastern Repeater Association (SERA). Get more information at http://www.sera.org

- If VHF/UHF is called line of sight, why can we still use it in an auto or around a tall building?

    VHF and UHF are much more line of sight than HF, but the signals do manage to go over the horizon more than light. Signals also bounce and ricochet off of all sorts of buildings and even airplanes. VHF and UHF also penetrate buildings much more than HF. Line of sight still does make a lot of difference though. If you are 20 miles away from a repeater, at ground level, you may need a very good antenna and 50 watts to have a reliable signal. Then go to the top of a mountain or a tall building in the same area and you may be able to get in with 100 miliwatts.

- What's a phone patch? And how does it work?

    A phone patch is a mechanism that connects a radio to a phone line to allow at least one of the parties to the conversation to be connected by telephone. A phone patch is usually a manual device that requires an operator to manage the connection and dial the phone numbers. They were most often used on HF where either long distance charges were a concern or one of the parties was located in a remote area without reliable telephone service. An Autopatch, on the other hand, does a similar function usually on a repeater. The user transmits DTMF tones to manage the connection and dial the number. Both systems are being used less often today because of the widespread deployment of cell phones, satellite phones and the wider availability of wired lines.

- How do you use a common antenna for transmit and receive at the same time?

    By using RF filters tuned to a very specific pass frequency, you avoid having transmitted power fed back into your receiver. This is one of the reasons that repeaters use a separate input and output frequency.

- Why do we need CTCSS (continuous tone coded squelch system) to make it operate?

    Repeaters will work without CTCSS, but requiring it to open the squelch dramatically reduces intermod and interference from remote stations using other repeaters. ARC requires CTCSS because Atlanta is a big place with a lot of transmitters close by and interference has become a significant problem.

- Why do we have weekly nets when there is really nothing new to say?

    To practice our communication skills and because we like doing it.

- Sometimes I hear folks from other towns far away. Is that skip?

    Skip refers to reflections from various layers of the atmosphere. VHF and UHF generally do not skip. When you hear distant VHF and UHF stations, it is often a phenomenon known as atmospheric ducting in which radio waves are refracted or bent by the atmosphere in such a was that they follow the curvature of the earth.

- Are repeaters linked one to another to increase range?

    They can be. Sometimes repeaters are linked in a network so that the same conversation can be heard on multiple repeaters that blanket an area. In other cases, repeaters in two or more locations are linked, but the area between locations is not covered. It all depends on the goal of those setting up the links.

- What's the appropriate way to let others know I'm listening to the repeater? Can I call CQ?

  It's not a problem to call CQ on a repeater, but, by convention, operators usually just announce their call sign and perhaps add the word "listening" or "monitoring".

- Is there someone I can get to help me select a radio and get it working on the repeater?

  Most club members would be glad to help. Send email to the Yahoo Reflector and ask or go to a club meeting. Also, the ARC has a tech session at 3:00 PM on the second Sunday of each month precisely for this purpose. Various topics are presented, but the goal is to provide hands on help and get the answers to questions like this.

- Can my family use the repeater to talk to me if I'm licensed?

  Only if both parties are licensed.

- How do you know what the frequency split will be, and is it always the same?

  Most modern radios are programmed with the correct defaults, but it's always a good idea to check the repeater listing in the ARRL Repeater Directory, the SERA Repeater Directory, the club web site (http://www.AtlantaRadioClub.com) or other appropriate listing.

- Who watches out for the type of conversations and keeps it legal? What do I do if I hear someone using profanity or other illegal communication?

  This is everyone's responsibility. Ham Radio is "self-policing" to the extent possible. The most important thing is to not react in a way that motivates the perpetrator to continue. If the problem persists, contact a control operator for the repeater so he can take the appropriate action.