

## From VC ACS Area 2 Site "Borrowed from N4UJW"

### What is a Repeater, Why is it Needed, and How Does It Work?

**What:** It's a two-way radio system that receives on one frequency, then re-transmits what it hears on another frequency; at exactly the same time. It's nothing more than a "dumb machine" with some smart people behind it.

**Why it's needed:** Your mobile or handheld transceiver, has a limited range due to it's antenna height with respect to the radio horizon and rf attenuating surroundings. Repeater systems are used to "transfer" your transmitted and received signals to much higher elevations electronically using large, very efficient antennas, low loss feedlines and a transmitter and receiver that is rated for heavy or continuous duty. A repeater "gets out" your signal and receives the station you are talking to with a far greater range and coverage area! You take advantage of the repeater's higher elevation to increase your effective transmitting and receiving coverage versus your mobile or hand held transceiver!

#### How does a Repeater work?

##### The Basic Repeater Components:

**Antenna** Most repeaters use only one antenna. The antenna is used on transmit and receive signals that are going into and out of the repeater. It usually is a high performance, heavy duty, and very efficient antenna located as high on a tower or structure as we can get it above the surrounding terrain. Lots of repeater system antennas are located on a high hill or mountain. Antenna systems for repeater use are usually very costly and have high gain.

**Feed line** The feed line used on most repeaters is not just a piece of standard coax cable. A type of specialized feed line called Hard line is used. It is very similar to cable tv line that you see strung between power poles around town. The signal loss with hard line versus regular coax is much lower than in standard coax, so more power gets to the antenna and weaker signals can be received.

**Duplexer** This device serves a major role in a repeater. The duplexer separates and isolates the incoming signal from the outgoing and vice versa. It prevents the receiver and transmitter from hearing one another by the isolation it provides. A duplexer has the shape of tall cans and is designed to pass a very narrow range of frequencies and to reject others. It helps to reject very strong nearby frequencies from other repeaters or rf producers from getting into the repeater system.

**Receiver** Receives the incoming signal. This receiver is generally a very sensitive and selective one which helps weaker stations to be heard better by the repeater. It is set to receive the input frequency. It's also where CTCSS (Continuous Tone Coded Squelch System) or "PL" decoding takes place.

**Transmitter** Most machines, as repeaters are sometimes called, have a transmitter composed of an exciter and a power amplifier. The exciter modulates the audio coming from the receiver which is tuned to the transmitting station's frequency at the proper transmit frequency, and the power amplifier simply boosts its level so the signal will travel further. Lots of repeaters use 100 watts or more. **It simply takes the weaker received frequency from say a mobile and re-transmits it (repeats) at a higher power level on a different frequency.**

**Controller** This is the brain of the repeater. It handles repeater station ID using either CW or voice, activates the transmitter at the appropriate times, and sometimes performs many other functions depending on the sophistication of the repeater. Some also have a DVR (Digital Voice Recorder) for announcements and messages. The controller is a small computer that's programmed to control a repeater.

**What is Offset?** In order to listen and transmit at the same time, repeaters use two different frequencies. One for it's transmit frequency and another for it's receive frequency. On the 2 meter ham band these frequencies are 600 khz (or 600 kilohertz) apart. On other bands, the offsets are different. As a general rule, if the output frequency (transmit) of the repeater is below 147 Mhz, then the input frequency (listening) is 600 kilohertz lower. This is referred to as a negative offset. If the output is 147 Mhz or above, then the input is 600 kilohertz above. This is referred to as a positive offset.

Virtually all ham radios sold today set the offset once you have chosen the operating frequency automatically. Example: If the repeater output is 146.840 Mhz. The input, or the frequency it listens on is 146.240 Mhz ( 600 kilohertz below). If you have your radio tuned to 146.840 Mhz, (the repeater's output frequency), when you push the mic button, your radio automatically transmits on 146.240 Mhz, 600kc's down from 146.840. When you release the mic button to listen, your radio switches back to 146.840 Mhz to listen on the repeater's output frequency. Note: There are exceptions to the rule so check local repeater listings.

**Standard Repeater Input/Output Offsets are:**

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



### **What Happens When You Key Your mic?**

Let's "key up" a repeater and see what sequence of events are created - within the repeater equipment when someone makes a transmission: You set your transceiver controls for the 146.84 "machine" and listen to see if it is in use...nothing heard. You key your mic and throw out your callsign...."This is KE5??? listening on the 146.84 machine". Then you release the mic button. Assuming your station is within range of the repeater...The repeater antenna picked up your signal with it's antenna on 146.24 (your transmit frequency set to the standard offset and the repeater's receive frequency) and sent it down the feedline to the duplexer.

From there it was sent to the repeater receiver and converted to an audio signal (just like the sounds coming from your speaker)....sent to the controller (the brains of the repeater), then sent to the repeater transmitter and turned back into a much greater amplified radio signal on 146.84mhz (the output of the repeater)....sent to the duplexer....then thru the feedline to the antenna and out over the air. A mobile or base station that happened to be within range and monitoring the .84 machine heard your transmission on 146.84mhz (the repeater output frequency). Since radio waves travel at about the speed of light....at the split second that you first keyed your mic, the above events took place and the repeater was receiving your signal on one frequency and re-transmitting your signal on a different frequency at the same time! The mobile station that was listening on the output frequency of the repeater heard your callsign....keyed his mic and came back to you starting the process all over again! A simple way of demonstrating what is going on with a repeater is to set a scanner or a second receiver tuned to the input frequency of a LOCAL active repeater...in the case above...146.24mhz and you can monitor it's input (and the stations using it if they are local). Then with your transceiver, monitor the output on 146.84mhz! You should be able to hear both the input signals and the output of the repeater as all this takes place on the air.

### **How do you make a call on an Amateur Repeater?**

First, LISTEN AND LISTEN SOME MORE..... to make sure that the repeater is not already in use. When you are satisfied that the repeater is not in use, **set your transmitter power to the minimum and increase only as needed to make contact with the repeater**, begin with the callsign of the station you are trying to contact followed by your callsign. e.g. " N4??? this is N3???". (The N3??? is your callsign). If you don't establish contact with the station you are looking for, wait a minute or two and repeat your call. If you are just announcing your presence on the repeater it is helpful to others that may be listening if you identify the repeater you are using AND your callsign. e.g. " This is N3??? listening on the 84 machine or you could also say This is N3??? listening on 146.84 Dallas or the location of the repeater if known. This allows people that are listening on radios that scan several repeaters to identify which repeater you are using. If the repeater you are

using is a busy repeater you may consider moving to a simplex frequency (transmit and receive on the same frequency..... see more below), once you have made contact with the station you were calling. Repeaters are designed to enhance communications between stations that normally wouldn't be able to communicate because of terrain or power limitations. If you can maintain your conversation without using the repeater, going "simplex" (both stations on same frequency in a different part of the band) will leave the repeater free for other stations to use that can't establish simplex communications!

### Repeater Etiquette and Reporting Emergencies

The first and most important rule before using a repeater is to LISTEN FIRST. Nothing is more annoying than someone that "keys up" or DOUBLES in the middle of another conversation without first checking to make sure the repeater is free. If the repeater is in use, wait for a pause in the conversation (watch your S meter and wait for it to drop indicating the repeater is listening) and simply say "Emergency, Emergency, Emergency", and wait for one of the other stations to acknowledge your call. If for some reason you are not heard, then repeat the 3 "Emergencies" again...then if you are still not heard, try another nearby repeater. This is not CB radio! Don't use CB lingo on any ham band such as 10-4,.....don't say BREAKER! Using the words BREAK, or BREAK, BREAK or BREAK, BREAK, BREAK or any combination of them on Ham radio can be misunderstood by an operator depending on his experience. The word "break" or combinations of it carries many different meanings in the ham community and in the English language. According to THE EMERGENCY COORDINATOR'S MANUAL Edited by Steven Ewald, WV1X and **Published by The American Radio Relay League, Inc.**, Quote from the "General Procedures section

<http://www.arrl.org/files/file/Public%2520Service/ECMANUAL.PDF>

*"16) The word "break" is never used **UNLESS** there is an emergency."*

*"Note: The practice of using "BREAK" or "BREAK BREAK" to announce distress traffic **should be strongly discouraged; it has no universally understood meaning.** So rather than have confusion...use plain language! **SO HOW DO YOU REPORT or ACT ON AN EMERGENCY ON A HAM BAND?** Many hams use the wording, "BREAK, BREAK, BREAK", (the word "break" repeated 3 times in a row). This is accepted practice on the hf bands where noise may be a problem but on repeaters, usually noise is not a problem, so using "plain" language such as "EMERGENCY", REPEATED 2 OR MORE TIMES can be used to announce that there is an emergency and the frequency is needed to relay vital information....if you hear an "Emergency" call during your conversation with another station....**stop transmitting**, acknowledge the station calling the emergency and let them*

have the frequency immediately! **Don't delay them** by saying something on the order of "Stand by breaker" and then carry on your conversation with your contact. **Seconds wasted doing this may save a life!** Listen to them carefully and write down the details of their emergency. They will give you the details of the emergency. Then pause for a moment and wait before you go back to him.....many other hams who heard the emergency call may be responding ALL at the same time. If someone "beats" you to getting back to him, let him take over. Do not break into the conversations UNLESS there is a need for a relay. Under certain situations due to distances involved with mobiles and repeaters, you may be able to hear a mobile BETTER than the repeater on the input frequency of the repeater. It is a good idea to monitor the input if possible if the station reporting the emergency is having trouble getting into the repeater. You may be closer to him than the repeater and can hear him better! Whether or not the station reporting the emergency is a base station OR mobile, try to monitor the input of the repeater if there is difficulty in the emergency transmission. **IF YOU ARE REPORTING AN EMERGENCY:** *When using VOICE, use the international standard "MAYDAY" or universally understood "EMERGENCY" to announce traffic of **life-or-death** importance. The procedure should be: 1. Select the repeater frequency. 2. Wait for a space between transmissions if the repeater is busy. 3. Key your mic and state..."Emergency, Emergency, Emergency" unkey. 4. Wait for a response from the repeater users. If you get no response, try another repeater. When you do make contact, state your call sign and give as many details as to the emergency as possible. **Don't panic, speak slowly and clearly** so the details will be understood the first time! Always give details as exact and specific. Give the details of the exact LOCATION of the emergency using enough description of the location so it can be found easily by first responders. Don't say....on highway 60 and leave it at that. The emergency vehicles need exact locations if at all possible. Remember, seconds or minutes saved equal lives in many cases! Give number of "victims" if possible. Is there is fire involved, downed power lines, immediate road blockage due to wreckage creating further dangers? DETAILS, DETAILS, DETAILS. The person on the other end of your transmission is most likely copying the info to paper so he can relay it to the appropriate authorities. Help him help you! **If by some chance you have to use Morse code when reporting an emergency, then:** The standard CW signal is "SOS," sent as a single character--**not spaced as three letters.**" EXAMPLE: DIT DIT DIT DAH DAH DAH DIT DIT DIT and NOT, dit dit dit SPACE dah dah dah SPACE dit dit dit. NOTE: Many repeater systems allow touch tone key pad entry of "911" DIRECT TO the 911 operators and the emergency reporting system. Check with your repeater system owners or trustees for info BEFORE YOU NEED TO KNOW. When making a 911 call direct from your station, make sure the 911 operator understands that you are calling via ham radio and she/he can not talk or (be heard by you) until you have unkeyed your radio. Use of the term "over" is very helpful between you and the 911 operator. It*

*is not like using cell phones. It is a one way (half duplex) transmission using a repeater and not simplex as with regular cell phones or land lines. Both parties CAN NOT talk at the same time!*

**Use plain language** on a repeater. If you want to know someone's location, say "Where are you.... or what's your location?" If you want to know whether someone you're talking with is using a mobile rig or a hand-held radio, just ask: "What kind of radio are you using?" You get the idea. Most repeater use is of a "local" nature so signals will be usually of very high quality. The use of the phonetic alphabet is very helpful at times. Don't call CQ to initiate a conversation on a repeater. Just simply listen to make certain the repeater is not in use and then key your mic and say your call sign. If someone happens to be listening and they want to talk to you they will respond. When you are using the repeater leave a couple of seconds between exchanges to allow other stations to join in or make a quick call. Most repeaters have a "Courtesy Tone" (a short...beep or series of beeps) that will help in determining how long to pause. The courtesy tone serves two purposes. Repeaters have a time out function that will shut down the transmitter if the repeater is held on for a preset length of time (normally three or four minutes). This ensures that if someone's transmitter is stuck on for any reason, it won't hold the repeater's transmitter on indefinitely. (Don't laugh, many microphones get lodged in the fold of car seats and keep a repeater busy until it times out. Of course if it is not noticed soon by the mobile operator.....the control operator of the repeater may have to shut down the repeater until the problem is corrected.) When a ham is talking and releases the push-to-talk switch on their radio, the controller in the repeater detects the loss of carrier and resets the time-out timer. When the timer is reset, the repeater sends out the courtesy tone. If you wait until you hear this beep (normally a couple of seconds), before you respond, you can be sure that you are pausing a suitable length of time. After you hear the beep, the repeater's transmitter will stay on for a few more seconds before turning off. This is referred to as the "tail". The length of the tail will vary from repeater to repeater but the average is about 2 or 3 seconds. You don't HAVE to wait for the "tail to drop" before keying up again, but make sure that you hear the courtesy tone before going ahead. Note: If you don't wait for the beep, the time-out timer may not reset. If you time-out the repeater, YOUR conversation AFTER the time-out will not be heard. The repeater time-out function does not care if you are still talking or not; and the station on the other end may rib you about hogging the machine and you will have wasted all those words! What is Doubling? When two stations try to talk at the same time on the same repeater, the signals mix in the repeater's receiver and results in a buzzing sound, squeal, distorted sound or severely jumbled and broken words. When you are involved in a roundtable discussion with several other stations it is always best to pass off the repeater to a specific person (station) rather than leave it up in the air. e.g. "W3??? to take it, this is N3???", then unkey;

or..... "Do you have any comments Fred?, this is N3???" ; un key. You could also say "OK...that's all I have.....back to you Fred" or the next person in rotation... (un key).... Failing to use this or other techniques is an invitation to total confusion. As a point of interest, a repeater will usually lock into the strongest of two FM signals. This is the nature of FM. The strongest signal usually wins.

**Signal Reports on a Repeater** Lots of new hams don't understand that the S meter on their radio is only reporting the relative strength of the repeater system and NOT the signal strength of the station they are talking to unless they are in the simplex mode. When the repeater is transmitting, it may have an output greatly exceeding that of the station IT is listening to. Remember the station it hears on the input frequency of it's receiver may be on a hand held radio and only a few blocks from the "machine" or it could be a mobile radio in a vehicle out on the fringes of the repeater coverage area or a base station running a high gain antenna and 100 watts from the next county or in some cases, the next state. To a third party, (another ham), listening to the machine on the repeater output, all of these stations would have the same S meter reading on his S meter! As long as the repeater can detect the signals and is working properly as it is setup, then all stations, (to the third ham), will "appear" to have the same signal strength on the S meter. **Remember, the S meter is only reporting the relative strength of the repeater when it is transmitting** and not the individual stations! So all that being said, how do you give an accurate signal report to the station you are talking to? **JUST USE PLAIN ENGLISH!**

Listen to the background sounds of his AUDIO coming from your speaker in between words and sentences. **Don't even look at your S meter.** (Assuming the repeater has a good strong signal into your location). If there is no noise other than room background, road, passenger or other sounds that could be picked up by his microphone, then he would be said to have a FULL QUIETING signal into the repeater.....receiver. NOT 50 OVER S9, S9, OR ANY COMBINATION on your S meter. The term "Quieting" refers to the carrier level of the transmitter being strong enough to "quiet" the background hiss on the frequency. If some background noise such as the hiss that is commonly heard in an FM receiver is heard on the transmitter signal, then it would not be considered "FULL QUIETING". There are times when either station using a repeater may be getting into the repeater receiver with very little signal and the repeated signal will have lots of noise on it. Although the repeater signal may be full quieting when the weak station stops transmitting, the weak station can not be considered to be full quieting into the repeater so you would give the other station a report on his signal and not the repeater. Don't get confused with this. If his audio is perfectly understandable with 100 % copy and there is NO "noise" in the background other than the above, then an accurate report for him would be, "You're full quieting and 100 % copy into the repeater. Anything less than the above is usually given in various ways using an exact

as possible description of his signal. "Audio" reports are a matter of interpretation by individual ears. We as hams are in the "business" of communications , not HI FI broadcast FM! We can only *sound* as good as the FCC will allow our transmitters to sound! If you are having extreme difficulty copying the other station, he may also be having the same problem with you, but remember he is hearing the repeater signal, not yours direct and so are you. Try to get him to go "simplex" if he is coming closer to you in a few minutes. See hint below. If the transmissions get so ruff that neither can copy the other, then just give your call sign and clear off the repeater for others to use while he gets closer or higher or changes his transmitting setup. Not all conversations are completed to the end under adverse conditions or operating situations....be patient. **HINT....**If the station is in and out of range of the repeater you and he were using and is coming in your direction...try him on a simplex frequency! He may be loud and clear direct on simplex and only a few miles away and getting stronger all the time but he is getting farther from the repeater! Another situation that can happen during a new contact is that you and he did not exchange locations at the first of the contact. Both you and he are using a repeater 50 miles away. Then after several minutes you discover in your conversation with the other station that he is in the same town as you and only a couple of miles away! Time for simplex! Don't hog the repeater. Simplex operation generally means station to station or direct communication on the same frequency between two stations and **not** using a repeater. Use the least amount of output power needed to carry on the contact. Simplex should be used when the two stations are close enough to carry on a conversation without the use of a repeater and will help in congested metro areas with a limited number of repeaters. **Simplex should always be used if possible rather than a repeater.**

See chart below for suggested simplex frequencies. (Highlighted in gray) Repeater input and output frequencies highlighted in yellow. 2 Meter Band Plan as suggested by the ARRL (144-148 MHz):

144.00-144.05	EME (CW)
144.05-144.10	General CW and weak signals
144.10-144.20	EME and weak-signal SSB
144.200	SSB National calling frequency
144.200-144.275	General SSB operation

144.275-144.300	Propagation beacons
144.30-144.50	New OSCAR subband
144.50-144.60	Linear translator inputs
144.60-144.90	FM repeater inputs
144.90-145.10	Weak signal and FM simplex (145.01,03,05,07,09 are widely used for packet)
145.10-145.20	Linear translator outputs
145.20-145.50	FM repeater outputs
145.50-145.80	Miscellaneous and experimental modes
145.80-146.00	OSCAR subband
146.01-146.37	Repeater inputs
146.40-146.58	Simplex
146.52	National FM Simplex Calling Frequency
146.61-146.97	Repeater outputs
147.00-147.39	Repeater outputs
147.42-147.57	Simplex
147.60-147.99	Repeater inputs

**YOUR FIRST CONVERSATION AND CONTACT ON A REPEATER!** That most exciting day just arrived! You now have passed your Technician Class exam and have been issued your first call sign by the FCC. You have your station all set up and you are ready for your first contact on a repeater! You chose a local repeater frequency and dial it up on your rig. You just keyed your mic, gave out your call sign and now you

hear.....your call sign and someone coming back to you with his call sign.....he un keys and the repeater is waiting for YOU! **BRAIN LOCK SETS IN!** "What do I do? What do I talk about? Will I remember all those rules, regulations, theory and all that other stuff I had to study? The simple answer is.....probably not.....but don't worry! First thing....try to write his call sign down and if he gives his name, that too. Lots of good operators recognize a new ham instantly on the air and they will guide you with patience, understanding, maybe some fun prodding and picking at you to get you to relax and have fun with your new license. He will **WELCOME** you! A good operator will never make you feel unwanted on the air. He may ask you to repeat your call sign just to make certain he understood who he is talking to and if you forget to give your name, he will ask for it. Most hams don't like to talk to a "call sign", so getting names and also locations helps to start the conversation. If you make mistakes....he will most likely let you know what you did wrong and inform you as to the correct way in a friendly manor. Don't be surprised if he asks you all the questions instead of the other way around. He is just trying to get you to feel relaxed on the air. As your experience grows in ham radio, always try to remember your first contact and how excited and nervous you were. Now it's your turn and you are the one responding to a new ham and his first contact! Make him feel at home and.....be a good operator.....like your first contact was! Repeater ID.....you and it! You must transmit your call sign at the end of a contact and at least every 10 minutes during the course of any communication. You do not have to transmit the call sign of the station to whom you are transmitting. Never transmit without identifying. For example, keying your microphone to turn on the repeater without saying your station call sign is illegal. If you do not want to engage in conversation, but simply want to check if you are able to access a particular repeater, simply say "(your call sign..... testing." **CONTROL OPERATORS**

All ham radio stations, including repeaters **AND YOUR STATION** are required by the FCC to have a control operator monitoring the station while it is on the air. **You** are the control operator of your station.

**DON'T FORGET.....ID YOUR STATION THE REPEATER WILL NOT ID FOR YOU....IT ONLY ID'S ITSELF!**

**After all.....it's only a dumb "machine"! HAVE FUN...73, N4UJW !**