

Quality Repeater & Autopatch Communications

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While the principles discussed in this paper may seem elementary to most of you, it has become quite apparent from monitoring on-air conversations that many of our members don't understand Repeater or FM communications. What I have attempted to do is describe the rudimentary principles of operation with the hope and expectation that our membership will use this information to improve their personal knowledge to improve the performance of their amateur operation.

Repeater Operation:

In monitoring conversations on the 146.62 Repeater, we hear signal reports Like "All my lights are lit", when telling someone how well their radio is doing. Other times we have heard people arranging to point their beams at each other, rather than at the repeater site, thinking that will optimize their signals.

Simply speaking, the Western Washington Repeater Association repeaters are remote relay stations which are located on West Gold Mountain on the Kitsap Peninsula. All signals received by these repeaters are re-transmitted on an offset (nearby) frequency by the repeater. What you are hearing is the repeater's re-transmission of the conversation and not the individual's transmitter with whom you are communicating, less of course, you are listening to the repeater's input frequency. This means that you both should **point your antennas toward Gold Mt** (six miles west of Bremerton) for the best performance and not at each other's sites.

Many problems, with communications, are related to poor quality signals received by the repeater. To get a usable signal, you need at least one microvolt (One millionth of a volt) induced into the repeater antenna. Rubber duck equipped hand-held radios will only supply that signal level if they are located relatively close to the repeater site, and are operated in clear space, not inside a vehicle. Don't expect reliable communications more than 10 to 15 miles from Gold Mt. using a duck antenna equipped portable radio transceiver even in open space. You will hear the repeater just fine but it probably will not hear you very well. You will be effectively radiating less than one watt while the repeater will be transmitting 120 watts ERP. That's in excess of 40db (100:1) difference.

In designing the repeater, we matched the transmitter power of the repeater as to be reciprocal with a typical 25-50W mobile transceiver using a 3-db gain antenna. Those using this type of installation will cease hearing the repeater about the same range as the repeater quits hearing you. With some exception, this is about 70 miles from the repeater site or at the radio horizon from Gold Mt..

Audio Properties:

Many still confuse audio level and carrier

strength. While there is a correlation between these properties with amplitude modulation (AM) such as used in CB communications, frequency modulation (FM) as used on most VHF and UHF ham bands is much different. *Signal strength* is the actual strength of the transmitted carrier as received either by the repeater or the user. This property is what "Quiets" the receiver, breaks the squelch or quenches the internal noise generated in the receiver. Your "S" Meter also indicates relative signal strength.

The *loudness* or intelligibility of the voice is a property of the *modulation* and is virtually independent of the *signal strength*. When giving a signal report, you should define which of the two properties you are discussing. Telling someone he is weak, gives him no useful information. If he has little or no background hiss in his transmission, then tell him he is full quieting, not quite full quieting, what ever the case may be. If his audio is low, then say "Your signal is full quieting, however your audio is weak and barely readable". Improperly adjusted *modulation* or a bad microphone may account for his problem. Telling him that he is lighting all of your LED's gives him absolutely no useful information as it tells you how well you are receiving the repeater's *signal strength* and has nothing to do whatsoever with how his signal is being received at the repeater, which is the only parameter within his control.

Most transceivers have two controls for audio level adjustments. The Deviation control is most often located near the modulator and sets the maximum (peak) level of deviation. Another adjustment in the speech amplifier sets the microphone gain. Touch tone microphones usually have the DTMF level adjustment located inside the microphone itself in the tone generator circuit.

We do encourage everyone to check their modulation and have it properly adjusted. This way everyone in a QSO has the same audio level. This precludes the need of having to adjust your volume control at every handover.

Autopatch:

The Autopatch is simply a user controlled automatic interconnect to the telephone system. The signalling uses the standard Dual Tone Multi-

Frequency (DTMF) used by most modern telephone systems. DTMF, designed by the Bell Laboratories, was optimized for wired systems such as telephone service and office PBX's. It was not intended for radio use, but found its way into radio just because of its convenience and availability. Under most conditions DTMF works fine, however there are a few situations where it is unsuitable for radio use. Multipath, a condition where a signal is simultaneously received from more than one direction, can distort the tone as to make it undecipherable by the decoder. This usually results in wrong numbers being dialed or in most cases, the call simply does not get through.

The Micro-Controls MR-4 receivers used in our repeaters are highly selective and contain 16 poles of IF filtering. This is necessary to reject unwanted interference from the adjacent channels. The overall IF passband is about 12 KHZ wide which allows for a peak modulation acceptance of ± 5 KHZ and average deviation of ± 3 KHZ for speech. DTMF is a different situation, however. The mathematics of describing a DTMF signal are complicated, and are not discussed here. In simple terms, the important part of the DTMF frequency modulated signal gets lost when its bandwidth exceeds the allowable band width of the receiver. Distortion of the tones is the result. This confuses the tone decoder which then puts out false information resulting in mis-dialed numbers or phone company aborts. *Overdeviating is analagous to try driving a eight foot wide bus through a seven foot wide tunnel.* You don't usually make it. While the human ear can tolerate some IM distortion, the tone decoder cannot.

If you, as the user, send the repeater a weak, Multipath distorted or widely deviated DTMF signals, then don't expect the patch or other user functions to operate properly.

From experimentation, we have learned that the most reliable decoding occurs when a DTMF signal is modulated at $2.0 \pm 10\%$ KHZ, the received carrier level is ≥ 0.3 uv which provides at least 20db (90%) of quieting to the receiver, is on frequency, and is free from multipath distortion. These parameters are not within the control of the repeater but resides within the internal adjustments of your own radio and your location with respect to the repeater site. *You are responsible* for assuring that you are on frequency and your modulation is properly set. Off-frequency signals lower the tolerance of modulation acceptance, not to mention degrade the signal quality.

Both of our repeaters have a built in provision for checking signal quality. Refer to the Instruction for the codes and directions to use these. If the reported frequency error is more than one KiloHertz the speech modulation is more than 5KHZ, or the measured DTMF deviation is more than 2.5KHZ, then your radio needs adjustment. Don't assume that because you

bought a new radio, that it was properly adjusted at the factory. Most are not.

Proper adjustment requires the use of an instrument called a service monitor. Cushman, IFR, Motorola, and Wavetec are the most common units around. They are expensive (several thousand dollars) and most two-way shops have them. For a nominal charge they will properly adjust your radio. Look them up in the Yellow Pages under Radio, Communications Systems. Unless you are experienced and have access to the proper equipment, you should leave this to a professional.

Intermodulation and Desensitization:

Intermodulation is not a property of the repeater, but is caused by a mixing of signals either in the front end of your transceiver or by some nearby rectifying point such as a corroded drain gutter, wire fence or something else in close proximity to your location. To identify it, you will usually hear two or more conversations, paging tones, dispatching, or ham radio conversations obviously not on your preset frequency.

Control of internal intermodulation resides mostly with the quality of the transceiver which you have purchased. Hand-held radios have virtually no protection from Intermodulation. Front end filtering was not included in the design so they could be manufactured small and cheap. Many of the wide-band mobile transceivers do not have adequate front end out of band signal rejection qualities, either. More recently the radio manufacturer's have recognized IM a serious problem and have incorporated tracking front ends into their radio designs. Radio Shack and ICOM recently marketed transceivers with this improvement.

Receiver desensitization is caused by off frequency but strong RF signals either in or out of the ham band. These signals saturate the rf amplifiers but are rejected by the IF filter so you may not actually hear it. This RF amplifier saturation makes the front end insensitive to signals at the desired receiver frequency. Both desensitization and intermodulation will seriously degrade communications quality and make your favorite repeater annoying or outright impossible to monitor. Connecting to a better or outside antenna often makes the problem worse.

There are some after-market IM filters available which do a good job in eliminating or reducing desensitization and IM. These filters connect between your transceiver and transmission line. A high level of isolation to out of band signals can be obtained with this multi-section helical resonator filter. If you are plagued with intermod, then consider purchasing one of them. They will solve your desense and IM problem but will limit your receiver coverage strictly to the ham band.

73's.....Dick