Ham Tips

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Cross Band Repeater Applications

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This Ham Tip will explore several ways in which a dual-band mobile radio with cross-band repeater functionality can be used to facilitate communications. I'll begin by describing the basics of a cross band repeater, then move on to several ways a CBR can be used to extend the range of mobile radios and low-power HTs. Finally I'll show how a pair of CBRs can be used to simulate a conventional repeater that has been knocked out of service.

The Concept

You can think of a CBR as simply being a translator between a VHF channel and a UHF channel. It permits one or more handheld or mobile units operating on a UHF channel to take advantage of the CBR's better location and possibly higher power to communicate with stations on a VHF channel that would be impossible to reach otherwise. Once it's set up, no operator intervention is required.

Cross band repeating requires that both the mobile radio, which is being used as the cross band repeater, and the handheld radios have certain specific features so they can work in concert with one another. The mobile radio must have the capability to cross-band repeat, which is not a standard feature on most mobile radios.

Here's how it works. The HT operator transmits to the CBR on a UHF simplex frequency. The CBR receives the UHF signal and re-transmits it on a VHF frequency. When the operator releases the PTT switch on the HT, the CBR receives the transmission on the VHF frequency and re-transmits it on the UHF simplex frequency to the HT operator.

While the CBR is receiving a signal on the VHF channel, it will not be able to receive a transmission on the UHF channel because it's transmitting on that UHF channel; consequently, the HT operator has to wait for the VHF signal to drop before being able to transmit. This is a fact of life that can be annoying when the conventional repeater has a long tail.

Usually the CBR transmits on the VHF repeater's input frequency and receives on the VHF repeater's output frequency; however, there is no reason a VHF simplex frequency could not be used instead, such as 146.46 MHz with no PL tone. All of the examples shown in this Ham Tip, however, illustrate the use of CBRs with repeaters.

The advantage of using the cross band repeat mode is that it allows an operator who is too far away from a conventional repeater to access it with a strong enough signal to provide reliable communication. This mode also works well when an operator with an HT is inside a building and a mobile radio being used as a CBR is located in a nearby parking lot.

The UHF channel can be any available simplex frequency. PL tone should always be used on the UHF channel. Using a PL tone is absolutely necessary to prevent unwanted signals from unintentionally keying the CBR.

Requirements for handheld radios depend on the particular type of CBR being used. The simplest CBR requires only a UHF HT; another CBR requires a dual-band HT capable of being able to receive and transmit on different bands for the same memory channel; and the most complex CBR requires a dual-band HT with dual receive capability. To avoid extraneous on-channel signals from inadvertently keying the conventional VHF repeater, all of the HTs must have the capability to send and receive PL tones.

It's a good idea to program the Time-Out Timer feature in the mobile radio being used as the CBR. I recommend a value less than 3 minutes. Remember the longer the CBR transmits on the VHF channel, the longer that channel will be rendered useless to others. You don't want someone's radio with a stuck PTT button tying up an entire system.

You need to be aware that there is always a short, but noticeable, turn-around delay when using a CBR. If you press the PTT switch on either the VHF or UHF radio too soon,

your first word or two may not be re-transmitted through the CBR. It usually takes a hundred milliseconds or so for the receive-transmit-receive transitions to occur. So remember, push the button, wait a second, then speak.

The microphone on the radio being used as the CBR can be left connected for cross band repeater applications because circuitry inside the radio disables the PTT switch and microphone element. In order to use the local microphone, you have to take the radio out of cross band repeat mode.

If more than one CBR is being used within a network, make sure the CBRs are far enough apart so an HT operator situated between CBRs cannot activate both of them simultaneously. If this situation presents itself, the solution is to use a different UHF simplex frequency for each CBR.

Once you know what UHF and VHF channels will be used in your area, it's highly recommended you program all of their parameters into memory locations. You should do this for your HT as well as the mobile radio you'll be using as the CBR. That way they can be reliably recalled when cross band repeat capability is needed.

Putting a mobile radio into cross band repeat mode is radio dependent; consequently, you'll need to refer to your operator's manual for instructions on how to do that.

Now that we've covered the basics, let's move on to some practical ways you can use cross band repeaters as range extenders.

Range Extender #1

Consider, for example, a team of radio amateurs deployed in a valley. They cannot talk directly with the NCS of an emergency net being conducted on a conventional VHF repeater pair due to the terrain. This situation can be overcome by positioning a CBR such that it can communicate with both the NCS and the team.

Figure 1 illustrates how this works. The conventional repeater receives on 146.16 MHz with a PL tone of 100.0 Hz and transmits on 146.76 MHz with a PL tone of 100.0 Hz. The HT receives on 446.100 MHz with a PL tone of 141.3 Hz and transmits on 446.100 MHz with a PL tone of 141.3 Hz. The CBR is programmed to accommodate both the frequency of the VHF repeater and the UHF HT.

For this example, the CBR is programmed as shown in the table below.

Parameter	Left Side	Right Side
Receive Frequency	146.76	446.100
Receive PL	100.0	141.3
Transmit Frequency	146.16	446.100
Transmit PL	100.0	141.3

This application has a few shortcomings you need to be aware of. Since the CBR is either transmitting on the VHF or the UHF channel, it will have a high duty cycle. Consequently, the power levels on both bands should be reduced to the minimum necessary for reliable communications, otherwise the mobile radio being used as the CBR may overheat and be damaged.

Another shortcoming is that the HT operator has to wait for the VHF signal to drop completely before transmitting. The reason for this is that while the mobile CBR is receiving a signal on the VHF channel, it will not be able to receive a transmission from the HT on the UHF channel. The affect of this constraint ranges from being a little awkward to more of an issue when the conventional repeater has a long tail.

The HT can be a UHF-only model, i.e., a dual-band HT is not necessary for this application.

If team members need to talk among themselves without keying the CBR, there are a couple of ways they can do this. One way is to program a second channel for the HT which uses the same UHF frequency as the cross band repeater but with no PL tone.

To illustrate this point, suppose a cross band repeater was set up at an emergency shelter. In this case, when the operator of a low power HT wants to communicate with a distant station, e.g., an EOC, using a two meter repeater, he would select the memory channel, call it Channel A, for the cross band repeater. When that operator wants to talk with another station at the same shelter, he would select another memory channel, let's call it Channel B, which had been programmed to the same UHF simplex frequency as before but with the tone encode functionality disabled.

The advantage of using this strategy is that it doesn't matter whether the operator has Channel A or B is selected, he will be able to hear all radio traffic on the UHF frequency whether it originates from the EOC or any of the other operators at the shelter. As a result, there is no need for the HT operator to monitor two different frequencies simultaneously.

Range Extender #2

The second type of HT extender can be used when the HT operator can hear the conventional VHF repeater but does not have enough power to get into it reliably. This configuration may also work when the HT operator is inside a building and the CBR is located in the parking lot as long as the HT operator can hear the conventional VHF repeater.

Figure 2 illustrates how this method works. The conventional repeater receives on 146.22 MHz with a PL tone of 103.5 Hz and transmits on 146.82 MHz with a PL tone of 103.5 Hz. The HT receives on 146.82 MHz with a PL tone of 103.5 Hz and transmits on 446.200 MHz with a PL tone of 141.3 Hz.

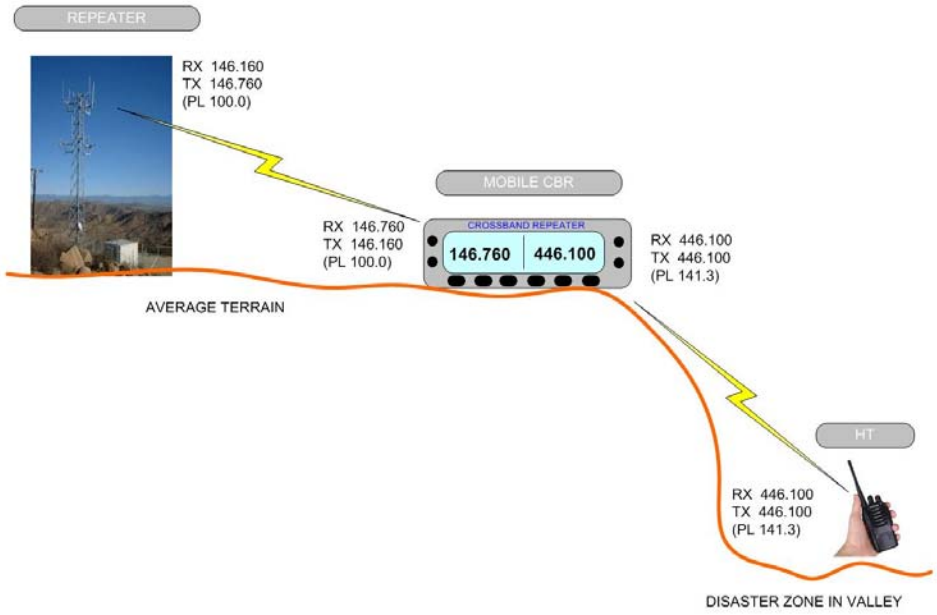

Figure 1 – The First Type of Range Extender

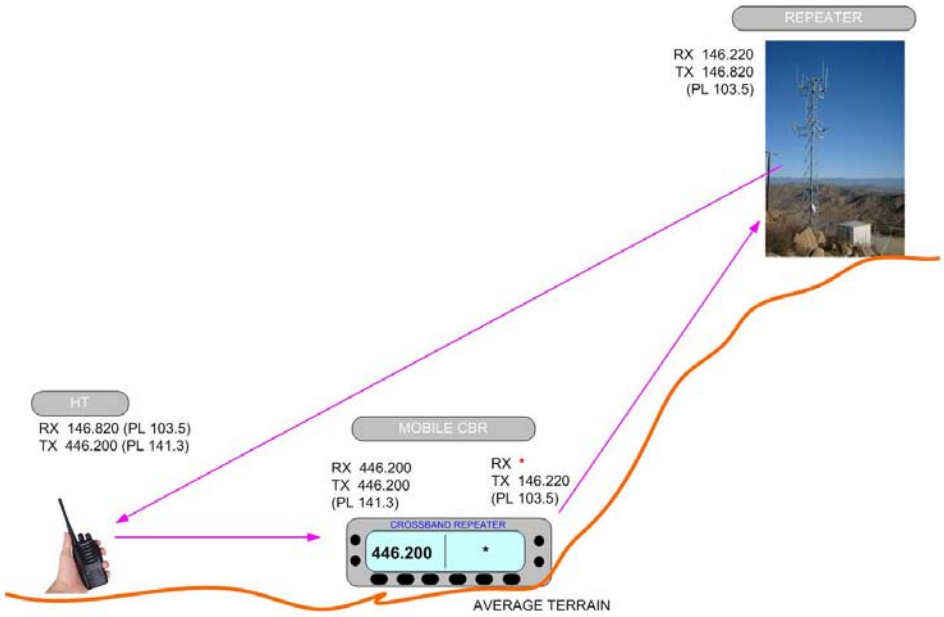

Figure 2 – The Second Type of Range Extender

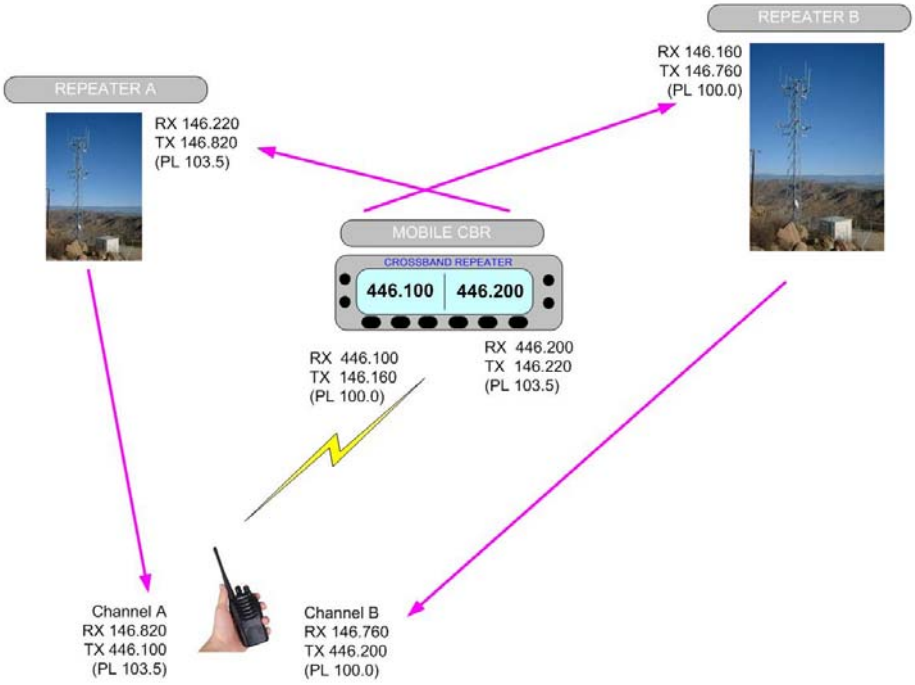

Figure 3 – The Third Type of Range Extender

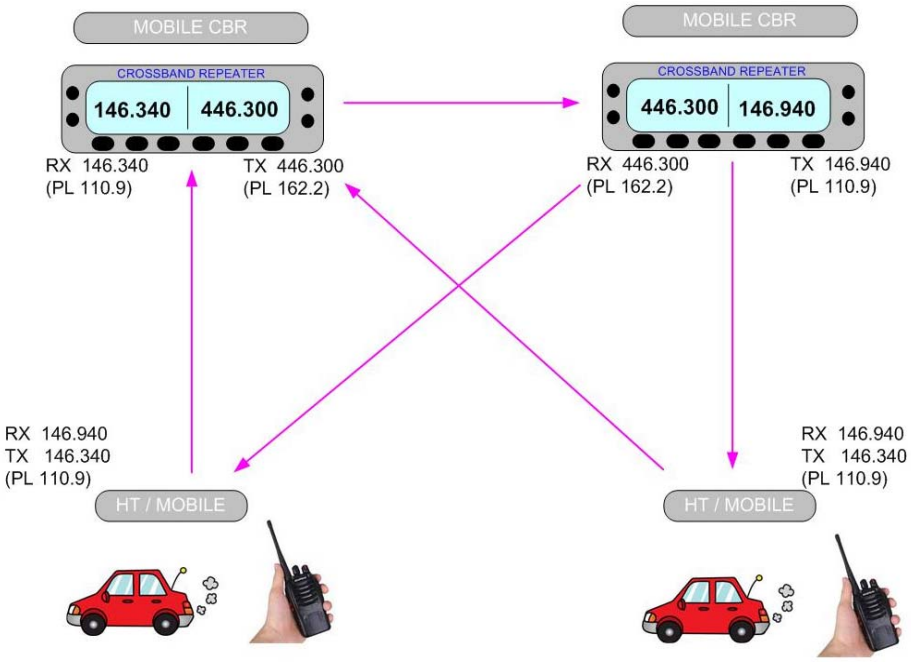

Figure 4 – An Ad Hoc Repeater

For this example, the CBR is programmed as shown in the table below.

Parameter	Left Side	Right Side
Receive Frequency	446.200	*
Receive PL	141.3	*
Transmit Frequency	446.200	146.22
Transmit PL	141.3	103.5

* Not 146.82 MHz. or 103.5 Hz.

The VHF side of the CBR must be programmed so it never receives a signal on the VHF repeater's output frequency. There are many ways this can be accomplished. You can set the repeater offset to simplex on the repeater input frequency; set a bogus PL tone for the Tone Squelch parameter; tighten the squelch as much as possible even by using the software programmable setting if available; and/or setting the receive frequency to a vacant frequency like 144.000, a frequency in the weak signal or satellite part of the band, or a frequency out of ham band entirely.

Since the CBR is not receiving a signal on the VHF channel, the HT operator does not have to wait for the VHF signal to drop before transmitting. Therefore, using this method effectively mitigates the latency problem resulting from a repeater that has a long tail. In addition, since the CBR's UHF transmitter is never keyed, a higher power can be set on the VHF channel if necessary.

A dual-band HT is needed for this application but it doesn't have to have dual receive capability. As long as you can program a VHF frequency into the receive portion of a memory channel and a UHF frequency into the transmit portion of the same memory channel, it will work. This technique is often called programming an odd split.

If team members need to talk among themselves without keying the CBR, there are a couple of ways they can do this. One way would be to use simplex on the VHF repeater's output frequency. That way the HT operators won't miss hearing any incoming calls from the VHF stations. Another way this could be accomplished, of course, is to use a different UHF channel but with the risk of missing incoming calls from VHF stations. In either case, the objective is to be able to talk among themselves without keying the CBR.

Range Extender #3

The third type of range extender is more complex but gives the HT operator the flexibility to access two conventional repeaters quickly by simply changing channels on the HT. This is a nifty solution if you find yourself in a situation where you can hear both conventional repeaters directly on your HT but can't get into them with a strong enough signal. This is the method I described in greater detail in Ham Tip 15.

Figure 3 illustrates how this HT extender works. One conventional repeater receives on 146.22 MHz with a PL tone of 103.5 Hz and transmits on 146.82 MHz with a PL tone of 103.5 Hz. The other conventional repeater receives on 146.16 MHz with a PL tone of 100.0 Hz and transmits on 146.76 MHz with a PL tone of 100.0 Hz.

When the CBR receives a signal on 446.100 MHz, it re-transmits it on 146.22 MHz. Conversely, when the CBR receives a signal on 446.200 MHz, it re-transmits it on 146.16 MHz.

For this example, the CBR and HT are programmed as shown in the tables below.

CBR		
Parameter	**Left Side**	**Right Side**
Receive Frequency	446.100	446.200
Receive PL	100.0	103.5
Transmit Frequency	146.16	146.22
Transmit PL	100.0	103.5

HT		
Parameter	**Channel A**	**Channel B**
Receive Frequency	146.82	146.76
Receive PL	103.5	100.0
Transmit Frequency	446.100	446.200
Transmit PL	100.0	103.5

In this configuration, the HT transmits to the CBR on one of two UHF simplex frequencies. The CBR receives that UHF signal and re-transmits it on the corresponding VHF repeater's input frequency. When the PTT switch on the HT is released, the HT receives the signal directly from the conventional repeater.

Most radios will only let you specify one PL tone frequency per memory channel. As a result, this governs the choice of PL tone frequency you can use for the UHF frequency. If your radio has the capability to specify different PL tone frequencies for receive and transmit, then you’re free to choose any PL tone frequency for the UHF frequency.

This application requires a dual-band HT that can be programmed to receive and transmit on different bands (often called odd repeater split) and one with the ability to program independent PL tone frequencies. These features are not standard on every dual-band HT. In addition, if the HT has dual receive capability, you can monitor both conventional repeaters simultaneously.

This method has a couple of advantages. You don’t have to wait for the carrier of the VHF repeater to drop before you can transmit; and, you only need one mobile radio configured as a cross band repeater to access two VHF repeaters or simplex nets. In essence, the mobile radio operates as two independent one-way (transmit only) cross band repeaters.

An Ad Hoc Repeater

If a conventional VHF repeater goes dark, two cross band repeaters connected back-to-back can be used to replace it. One CBR acts as the VHF receiver and the other as the VHF transmitter. They are linked together on a UHF simplex frequency.

The two CBRs must be situated close enough for the UHF link to work but far enough apart so the VHF transmitter does not desensitize the VHF receiver. This distance will depend on the quality of the radios being used. Generally speaking, commercial grade radios can be closer together; amateur grade radios will need to be further apart.

Let's assume the conventional repeater receives on 146.34 MHz with a PL tone of 110.9 Hz and transmits on 146.94 MHz with a PL tone of 110.9 Hz. So, as shown in Figure 4, one of the CBRs is programmed to receive on 146.34 with a PL tone of 110.9 and transmit on a UHF link frequency, say 446.300 MHz with a PL tone of 162.2 Hz. The other CBR is programmed to receive on that same UHF link frequency and transmit on 146.94 with a PL tone of 110.9 Hz.

For this example, the CBRs are programmed as shown in the tables below.

Mobile CBR #1		
Parameter	**Left Side**	**Right Side**
Receive Frequency	146.34 *	446.300
Receive PL	110.9	162.2
Transmit Frequency	146.34 *	446.300
Transmit PL	110.9	162.2

* The left side of the first CBR must be programmed for simplex operation. If the radio has automatic repeater offset enabled, it must be defeated for this application.

Mobile CBR #2		
Parameter	**Left Side**	**Right Side**
Receive Frequency	446.300	146.94 *
Receive PL	162.2	110.9
Transmit Frequency	446.300	146.94 *
Transmit PL	162.2	110.9

* The right side of the second CBR must be programmed for simplex operation. If the radio has automatic repeater offset enabled, it must be defeated for this application.

Now users with mobiles and HTs can use the same memory channel they normally use for the 34/94 repeater.

Engaging the Cross Band Repeat Mode

Putting a cross band repeater into service is quite easy. Just select the desired VHF memory channel for one side of the CBR and the desired UHF memory channel for the other side. Next adjust the Squelch on both sides so they're a little tighter than normal. Then, put the mobile radio into cross band repeat mode by following the instructions applicable for your particular radio. That's all there is to it.

Summary

This Ham Tip described four ways you can use a mobile radio as a cross band repeater to extend the range of a low power HT. The CBR can be a very effective tool in a variety of situations. If your mobile radio is cross band repeat capable, learn how to use it. It could come in handy.

When a catastrophic event occurs and you need to provide reliable communications very quickly, nothing beats using the mobile radio already installed in your vehicle as a CBR. You just drive to a suitable location, select the appropriate VHF and UHF channels, and engage the cross band repeat mode. You're good to go very quickly.

There is no time wasted erecting temporary masts, assembling antennas, running feed lines, and dealing with a battery bank. And, if you have to bug out, you can just get in your vehicle and leave. No time consuming teardown is required. This is an ideal solution for quick response teams.

When a cross band repeater is deployed as a tactical base station, a directional antenna may be desirable. A small Yagi, for example, would allow the CBR to access a conventional repeater further away and/or permit the CBR to provide a full quieting signal into the conventional repeater using a lower RF power setting which would conserve battery life.

Personally, I often use the dual-band mobile radio in my vehicle as a cross band repeater. It allows me to use my HT in its lowest power mode which yields the longest battery life.

For emergency deployments, I power the CBR from a marine battery placed on the floor in front of the passenger seat rather than the vehicle's battery so I don't run it down to the point where I can't start my vehicle.

If you do not already have a mobile and/or handheld radio, or are planning on buying new radios soon, you should seriously consider purchasing a dual-band mobile radio with cross band repeat capability and a duel-band HT that has duel receive capability.

Thanks to Joe, AH0A, for suggesting I write this article and Steve, KH6WG, for turning my crude pencil sketches into awesome technical illustrations.

73 from KH6CQ

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