

Extract from the SERA



## **Getting Started - Crossband Repeat**

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# Getting Started

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## Crossband Repeat (clear as mud?)

This quarter, I'm going to punish myself. I'm going to attempt to write an article that explains **crossband repeating**. I've seen other articles that tried to explain this evidently complex subject, and most of them were terrible. It doesn't seem that complex to me, so I expect to add to the "terrible article" pile before I'm done. But I'm going to try, because crossband repeat is so useful, especially during public service and emergency events when you need the convenience of your HT, but the power of your mobile, to reach a distant repeater or simplex station. It's going to be worth the effort.

Crossband repeat is a feature that began appearing in many dual band radios almost ten years ago. It's even in some handhelds. It is simply the ability of these radios to take whatever is being received on one band and automatically retransmit it on the other band.

OK, from the quizzical expression I see on your face, I can tell that

1. you have a dual-band radio, and
2. you don't understand what I'm talking about already. Don't fret. You're in good company. Most hams who now understand and use crossband repeat, including me, had a hard time getting a handle on it at first. Let's do a step by step.

### CLASSIC CROSSBAND - Simplex to Simplex

For this example, you'll need a crossband capable mobile, a VHF handheld, a UHF handheld, and a friend. If you don't have a friend, perhaps you should check your personal hygiene. But you can complete the example by yourself with reduced effectiveness. And if I do a good enough job, you'll understand what I'm talking about even if you don't have a radio nearby.

Set your dual-band mobile up for simplex on both the VHF and UHF sides of the radio. For VHF, let's not pick 146.52, the national simplex channel. Pick something a little less likely to be occupied in your area - 146.55, 147.51 or something. And for UHF, pick a channel that's part of the SERA Band Plan for crossband repeaters. I'll give you details on that later in the article. For now, let's use 445.900 MHz. Make sure all repeater offsets are turned off, and for now, leave any tone encode/decode turned off as well. And put both sides of the mobile in low power. Finally, set the VHF and UHF handhelds for those same respective frequencies.

Put the mobile in crossband repeat mode.

Talk from one HT to the other, normally a difficult trick because they are on different bands, and.... *Whoa, hold up there, wait a minute!* We need to go back one step. Something about "put the mobile in crossband repeat mode..."? I'm hearing a chorus of SERA Associate Members and even a few Full Repeater Owner Members all saying "how do I do that?" Now I hear the flipping of manual pages, the checking of indexes, the stifled curses of "where the #\$\$% are the instructions!"

Alas, for many radios, the instructions are *not* in the manual! You may have to do some searching. The dealer you bought the radio from can probably help, or a friend, or a search on the Internet. I'll tell you one thing - you won't be able to guess. For most radios, it's a hidden function involving pressing two or more buttons at once, and maybe even cycling power off and on. I can help with a few models of Icom radios.

OK, let's assume that you've figured out how to get the radio in crossband repeat mode, and it's just sitting there, waiting. Some special icon on the display may be flashing to tell you you're in crossband repeat, and some radio models won't let you operate normal functions in this mode.

Key up the UHF handheld, and keep a sharp eye on the mobile radio. Each radio may show somewhat different symptoms, but generally you should be able to notice that the mobile is receiving your UHF

signal, and that the VHF transmitter is on. Talk into the UHF handheld, and you should hear yourself coming out of the VHF handheld. Like I said, a pretty neat trick.

Let go of the UHF handheld's transmit button, and keep watching the mobile. The UHF receiver squelch should close, and the VHF transmitter should drop. On most radios, it will drop instantly, but some models let the transmitter hang on a half-second or so. And the signal on the VHF handheld will drop. Hey, that works kind of like a... repeater!

So what just happened? When you keyed up the UHF handheld, the mobile UHF receiver came alive. Just like in the big repeater downtown, the receiver triggered a circuit that told the VHF transmitter to switch on. Audio was routed from the receiver to the transmitter, and voila! - you have a communications path from the UHF handheld to the VHF handheld. When you let go of the HT's transmit button, the mobile UHF receiver squelch closed, and the circuit told the VHF transmitter to turn off. The only thing missing that you hear on a real repeater was the hang-time that follows each transmission, and maybe a beep or an ID or something.

So let's turn things around and transmit on the VHF handheld. The same sequence of events occurs, but with the opposite bands in the mobile radio. The VHF squelch opens, causing the UHF transmitter to turn on, and audio passes from the VHF receiver to the UHF transmitter.

So now, you and your friend can talk between the two handheld radios, with the crossband mobile switching back and forth, repeating each one in turn. When the mobile is idle, it's waiting for a signal on either band, and when a signal is received, it will repeat out to the other band.

Now, each of you turn and face opposite direction, and start walking. Normally, you'd expect to be able to put about two or three miles between you before signals got too weak (well, OK, normally you wouldn't be able to talk at all, since

the handhelds are on different bands, so work with me here...). But with that mobile be-

tween you, running a few more watts and using a bigger, higher gain antenna, you're going to get some exercise! Each of you will get at least three miles from the car, probably more. So if you went in exact opposite directions, we're talking six to ten miles. And as usual with VHF/UHF, park the car up on a hill and extend the range even farther.



*This is my base station, a Standard C5900, set to crossband repeat between 146.55 and 445.90 simplex. The only clue is the "MAIN" band indicator that's showing on both sides of the radio. It's flashing to attract attention*

OK, that wasn't too tough, the concept is clear, you're all set, have a good time, enjoy, thanks for reading... oh, wait.

It gets tougher when you want to use your crossbander to work through a conventional repeater. Maybe a lot tougher. Let's go to part 2:

### CROSSBANDING TO A REAL REPEATER -

#### Hung Up On Hang Time

Our first example was simple. Simplex. Simple simplex. It worked because when you and your friend let go of your push-to-talk buttons, the crossband mobile immediately stopped transmitting and began waiting for the next signal to appear on either of its two receivers, VHF or UHF.

But the wicket gets sticky when we try to crossband to a conventional repeater. And this is something you're much more likely to want to do. Say you're heading into a shopping mall. You can hit your local repeater easily from out in the parking lot, but deep inside the building, your little HT just can't make it. You might not even be able to hear the repeater. So you decide to crossband through your car out in the parking lot.

Yes, you can dial the VHF side of the mobile radio to your local repeater, with an offset, and leave the UHF side on simplex, and then put it in crossband repeat mode. Let's see what happens now, and don't worry if you have to go back and re-read the description a few times. This causes confusion in everyone at first.

To get started, everything is quiet. The local repeater is not being used. Your mobile is just waiting. You head into the mall. And you decide to make a call. You key up your HT on UHF, and your mobile responds by rerouting your signal out to VHF, this time to your local repeater's input frequency. So far, so good.

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You finish your call and let go of the button. The mobile stops transmitting on VHF, and is instantly met with a big signal on its VHF receiver from the main repeater. The main repeater is currently in "hang time" - that several second pause when the repeater stays on the air before dropping. Maybe it beeps. Your crossband mobile reacts quickly, turns on a dime and kicks on the UHF transmitter, sending whatever is left of the VHF repeater's hang time, beep, ID or tail message back to your UHF handheld. So far, still so good, but we've sewn the seeds of the impending problem.

Notice that during the main repeater's hang time, your crossbander is still doing its repeat thing, sending the main VHF repeater's signal back to you. Your crossbander doesn't understand the difference between when the main repeater is repeating a mobile, and when it's in hang time. It's all a VHF signal to your mobile, so it dutifully sends that signal out its UHF transmitter. And with your mobile's UHF transmitter on, it is definitely NOT listening for your UHF HT. It is fully occupied, very busy. At the moment, this is a one-way street, and all the headlights are pointed at you.

**Beep. KerChunk.** The main repeater has finished its programmed hang time, and dropped off the air. And so has your crossband mobile. It is now sitting there, waiting for you to transmit back.

Well, the light bulb pops off over your head. All you have to do is wait for the hang time, and everything will be OK. As usual, KN4AQ is fretting the small stuff too much.

If only. Yeah, you've got it, the key concept, the Big Point. But you don't respect it enough yet. The severity of the problem is directly proportional to the length of the hang time on the main repeater. And some of them have l o o n g hang times. Imagine getting into a QSO on the repeater, with you walking around the bottom floor of the mall, going through your crossbander. Every time it's your turn, you have to wait for the repeater's hang time to quit. Five seconds worth. Ooops, somebody blipped the repeater during the hang time to see if they could make it beep, so there's another five seconds. It will become an eternity.

And it gets worse. Somebody breaks in to join the party. And your two friends begin talking. Neither one lets the repeater drop. Normally they don't have to - that's what the beep is for. But you are frozen out. Your mobile is stuck listening to the main repeater, and your UHF transmitter is locked on. We have a name for you: shortwave listener. What can you do?

There are some alternatives, but they all involve compromise.

Or money.

## ONE WAY CROSSBAND

If you can hear the main repeater on your HT, and you have the right kind of dual-band HT, you can employ a technique called one-way crossband repeat. But your HT has to be a **TWOBAAT**, not an **OBAAT**. That's Two Bands At A Time versus One Band At A Time. Your HT will have to let you listen on VHF while you transmit on UHF. That cuts the field back a little at HT buying time (my Icom W32 is ideal). If you are so equipped, you've got a good chance of being able to hear the repeater directly on the HT, since most repeaters out-talk their HT range significantly. You just need a little more oomph to hit the repeater, and the crossbander can help.

A few Kenwood mobile models have one-way crossband repeat modes built in. Most other mobiles do not. But you're not out of luck. Any radio can do one-way. Just don't tune the VHF receiver to the repeater! If it can't hear the repeater, it can't get stuck sending it out to you on UHF!

To set up one-way crossband, I usually tune the mobile receiver to the repeater's input. In other words, I make the VHF side of my radio simplex on the repeater input. It may repeat other mobiles out to me if they're in range, but that's no problem - those mobiles don't have hang time. And I'm not even listening to them on UHF. And there are other tricks to keep all signals out of my VHF receiver if I really want to. I can use CTCSS to guard it (unless the repeater I'm using needs me to send CTCSS). More on that in a minute. Or I can program my mobile for a non-standard repeater offset. The transmitter will still be on the repeater input, but the receiver will be off in limbo somewhere, in a quiet part of the band. Programming non-standard offsets is a fairly advanced concept most hams never touch in their radios, so you'll be digging out the manual for that one (at least it will be in the manual).

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One other point. You'll want a handheld that mutes both bands when you transmit, or you'll end up with feedback. Older radios, like my vintage Icom W2A, did NOT mute the VHF band when you transmit on UHF, and vice-versa. A few other older models didn't, either. If you've got one of those classics, you can solve the problem by using an earphone.

That's about all you can do from your end. Your next step is to plead with your repeater's technical wizard to make a:

## CROSSBAND REPEAT FRIENDLY REPEATER

There are a couple of things that can be done to make a repeater more "crossband repeat friendly." And not all repeater owners are interested in being crossband repeat friendly. Some owners think that crossband repeat is a nuisance or worse, and will run you off for doing it.

But if your repeater tech crew takes a more positive attitude, they can shorten the hang time to a second or less. This may instigate long, philosophical discussions of the nature and purpose of hang time. But the short of it is that a short hang time makes crossband repeat much easier.

Another more complex alternative is to use CTCSS on the repeater output to help control crossband repeaters. This takes some tricky engineering, but perhaps the repeater's CTCSS can be controlled to be present only when the repeater's receiver is active, and drop off during the hang time. Then you can use CTCSS decode in your mobile for receiving the main repeater and controlling your crossbander. Most dual band mobiles have this ability today. The result is that your crossband repeater ignores the main repeater hang time. When the CTCSS drops, so does the crossbander.

There are some interesting effects when this method is employed. You, using your UHF handheld, feel more like you're in a simplex QSO - no beeps, no hang time. And every repeater user with CTCSS decode can turn on their decoder for a unique experience. When there's traffic on the repeater, they hear voice, then silence, voice, silence. No squelch tails, no beeps.

Maybe the repeater gurus don't want to do all that, but you might be able to persuade them to at least set it up that way during a public service event. But if you don't get a chance to practice your crossband repeating, you'll be hard pressed to make it work the way you expect when it's crunch time.

## IN-BAND REPEATING (And Why It Can't Be Done)

You are really getting the swing of things. You're flipping on your crossbander and grabbing your HT any time you need that extra mobile boost. Two-way, one-way, take your pick, you have it knocked. And one day, you stare at your display and realize that your radio is good for VHF/VHF or UHF/UHF reception. That is, two channels in the same band at the same time. A neat trick many dual-banders are playing today. So you wonder, if my radio will cross band repeat, maybe it will in-band repeat? Why not?

The answer to 'why not?' is about the size of a two-drawer filing cabinet. It's called a duplexer (I believe W4FAL has a column on duplexers in this issue). What you're asking your little mobile radio to do - with the peanut size duplexer that lets you run both bands on the same antenna - is the same thing the big repeater on the hill is doing: receive with full sensitivity when there's a high power transmitter operating on the same antenna just a few hundred kilohertz away. That kind of magic takes big iron. A full size duplexer. And a lot of shielding in the radio. Fill your back seat with these tuned filters and you're almost in business. But even then, your radio isn't up to the task. You'll need to cut into the radio and bring out a separate receive antenna connection. So you probably get the message - it won't work. It's that wide separation of a few hundred Megahertz that lets your crossband repeater work its magic.

## OTHER CONSIDERATIONS IN CROSSBAND REPEATING

Now, a laundry list of additional considerations that a responsible ham will give due regard when crossbanding (did I say this was easy?):

**1. Permission.** Before you crossband repeat into another repeater, you should find out if that kind of thing is accepted or prohibited by the repeater owners. I don't think there's a legal question here, just an ethical one. A crossbander gone awry can render a repeater unusable. I've been net control for SKYWARN with tornados in the area when someone's crossbander began spewing open squelch noise into the main repeater.

I was not pleased. While I'm normally a big crossband repeat advocate, I wasn't that night. And not every repeater owner likes the idea. You might be surprised at the negative feelings out there toward crossbanding.

**2. Control.** Most dual-band mobiles have no provisions for remote control, yet you are required to be able to shut down the transmitter if something goes wrong (like on that SKYWARN net). If you are just a few steps away from the radio (down in the mall while it's in the parking lot), you're probably covered. Leave it unattended, and you're definitely not.

**3. Duty cycle.** Your mobile radio is not rated for full-time transmitting. But if you have it crossbanding the busy local repeater to you, it can be transmitting for hours. Definitely run your UHF side on low power, and don't expect it to be a link for you 10 miles away.

**4. Identification.** You are supposed to ID your transmitter every 10 minutes. Both the VHF and UHF sides of your crossbander are your transmitters, and you should ID both of them. Your verbal ID on UHF, repeated on VHF, covers that transmitter. But the UHF transmitter is busy linking the main repeater back to you - it never hears you, and never ID's with your call sign. Manufacturers have not added any ID circuitry to most dual-band radios, and adapting an external ID is very difficult. This makes long-term crossband repeating a questionable activity.

**5. Autopatch.** If you don't do it yourself, you'll hear someone do it - bring up an autopatch while using a crossband repeater. If you're doing one-way crossband, this will work. But if you're doing it while depending on the crossbander to hear the repeater, you'll be stuck once you've dialed the patch and let go of the button. Guess what - the main repeater stays on the air, and your crossbander is not listening for you! Hello? Hello? Click! Maybe another user will kill the patch for you.

**6. Band Plan.** Where do you stick your crossband repeater's UHF link? SERA makes this easy by band planning several channels for crossband repeaters, either at home or mobile. The fixed station crossband repeat channels are:

440.7375	440.7625	440.7750	440.7875	440.8125	440.8250
440.8375	440.8500	440.8625	440.8750	440.8875	440.9000

and the mobile channels are:

445.7375	445.7625	445.7750	445.7875	445.8125	445.8250
445.8375	445.8500	445.8625	445.8750	445.8875	445.9000

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SERA does not coordinate crossband repeater frequencies - you're on your own. But if a bunch of you will be using several crossband repeaters for a public service event, you might coordinate among yourselves to avoid interference (hey, the birth of frequency coordination all over again).

**7. CTCSS.** As I said earlier, a crossband repeater gone awry can really mess up the big repeater by jamming the input with junk picked up by the crossbander. You can reduce the problem by using CTCSS encode and decode on your UHF link side. That will keep most junk from opening your squelch on UHF and spilling out your VHF transmitter into the main repeater.

**8. Crossbanding to UHF Repeaters?** All my examples so far involved using UHF as your link, while crossbanding to a VHF simplex or repeater frequency. Can't it be done the other way, crossbanding from a VHF simplex channel to a UHF repeater? My opinion is that this isn't a good idea. The two-meter band is smaller, more crowded, and has a limited number of simplex channels. No channels are band-planned for crossband links. So you've got a greater chance of causing interference to existing activity. Suppose you use 146.55 for your link, and guard it with CTCSS. The UHF repeater you're linking to is quiet. A couple of local hams begin talking on 55, and after a few minutes the UHF repeater gets busy. Your crossband link will interfere with the contact on 55 unless you take action to stop it.

There's another issue to interpret. Is your crossbander an auxiliary link, or is it a repeater? The rules aren't all that specific. You can declare it to be a full repeater, I suppose, but tell it to Riley. Most people would consider the radio link between you and your mobile to be an auxiliary link, and as such it is not permitted below the 220 band.

If you do decide to declare it a full repeater, you must stay inside the segments of the two-meter band authorized by the FCC for repeaters: 144.5-145.5 and 146.0-148.0.

**9. Crossbanding two repeaters together?** *No, no, no!* Well, maybe. The *no!* part is the general rule. If the repeaters have hang time, you will create an endless loop of one repeater kerchunking the other. The "well, maybe" is possible if you are in charge of both repeaters (one UHF and one VHF) and have decided to link them this way temporarily. If the repeaters have zero hang time (or CTCSS as I described earlier), it might work. But SERA Frequency Coordinators will be very unhappy with this linking arrangement unless it's for a special, temporary use.

## A SUPER ELABORATE SYSTEM -

### Two Crossbanders Make a full Repeater

If you're one of those hams with more equipment than you know what to do with, and you happen to have an extra dual-band mobile or HT, you can set up two crossband repeaters and make what is essentially a full UHF repeater. That solves ALL the problems of hang time and being able to hear the main repeater on your HT. You can even make an phone call using the autopatch. You might have a local desense problem to solve, and you'll need a bunch of antennas to get it all done. But it works - Mark Freese WD4KSE has been doing that for the past several big bike tours we've handled here.

If you try that, SERA had two UHF "itinerant" repeater frequencies to pick from: 445.750 - 440.750, and 445.800 - 440.800.

These are reserved for itinerant and short-term use during a special event or emergency with no formal coordination required. Trustees/Owners are encouraged to notify their local coordinator to inform them of system parameters and expected duration of use. Note that they are surrounded by the other crossband repeater band-plan channels.

OK, that's it. Another attempt at explaining crossband repeat. Clear, or clear as mud? I can't tell, but I'm open to feedback at: [kn4aq@sera.org](mailto:kn4aq@sera.org).