

WITH ICOM RADIOS, CROSSBAND REPEATING HAS NEVER BEEN EASIER!



If you have ever wanted to know more about crossband repeating, turn to ICOM! Inside you'll find two QST Magazine articles on this subject, as well as more information on ICOM's crossband repeating radios!

- Use virtually any ICOM handheld (or other manufacturer with DTMF) to contact your ICOM dual band mobile back in your vehicle. Then your mobile can amplify and relay your transmission to a repeater in the vicinity for even greater range!

- Receiving a signal back is just as simple: the repeater sends it to your mobile, which in turn sends it to your handheld!

- To make it even easier, your ICOM handheld can remotely control your ICOM mobile! You can change the mobile's frequencies and can even get a *vocal playback* of that frequency (with optional accessories)!

(See the chart on the back of this brochure for ICOM handhelds and mobiles suitable for crossband repeat set-up, and information on remote control of your ICOM mobile.)

ICOM®

Frequency Agile Crossband Repeating and Remote Control

By Larry Macionski, WA2AJQ
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Royal Oak, MI 48067

This column has been prepared to help you understand how to use modern radios capable of frequency agile crossband repeating. Many amateurs may be confused by this type of operation.

Frequency agility is the ability to change frequencies by remote control. Several dual-band radios on the amateur market have crossband-repeater capability. These radios allow simultaneous retransmission of received signals on two bands. A few rigs have both capabilities.

The mobile VHF/UHF radio I own, the ICOM IC-2410H, is an example of a commercially marketed radio that allows the user to change frequency remotely. It's a powerful tool, but there are limitations. Let this scenario be an example:

I volunteer with others to search for a lost child. I'm assigned a gully area near a stream. The command post is the firehouse eight miles away. The search frequency is 146.52 MHz simplex. I go to my search area and set the radio in my car to repeat 146.52 to 445.0 MHz. I set my hand-held transceiver to 445.0 and descend into the gully to begin the search. I can talk to my car using low power on 445.0 and the car transmits it to the firehouse on 146.52, using higher power and the advantage of the car's antenna and location. Any signals the car receives on 146.52 are transmitted to me on 445.0. I can hear the command post and any other amateur in range on 146.52.

Now comes a catch: While I'm down in the gully, an amateur hundreds of miles away begins to make contacts while aeronautical mobile on 146.52. Now the frequency is congested with the aeronautical mobile working hundreds of hams no one in the search team can hear, but they can hear him. The command post asks the search team to change frequency to 146.55.

If I had only a crossband repeater, I would have had to quit the search and return to my car to manually change the frequency of the mobile rig to crossband repeat on 146.55. I don't have to change my hand-held radio's frequency of 445.0, but everybody else leaves

the 146.52 search frequency. So I trudge up out of the gully.

With a frequency agile transceiver in my car, such as the IC-2410H with the optional dual-tone multifrequency (DTMF) decoder (necessary for remote control and repeater functions), all I'd have to do is send a sequence of keypad commands to have the mobile crossband repeater change frequencies. There would have been no search time lost.

Sorting it Out

A crossband-repeating radio senses signals on one band's single frequency and retransmits it simultaneously on another band. Let's refer to frequencies as VHF and UHF. Anything heard on VHF is transmitted on UHF. When the VHF signal disappears, the UHF quits transmitting and reverts to receiving. Under no-signal conditions, the radio receives both bands. The first band that receives a signal transfers it to the other band, VHF to UHF or UHF to VHF.

This is different from *single-site repeaters*, the standard machines on fixed, coordinated frequencies. Those repeaters listen to one frequency and transmit on another frequency, generally in the same band. Some crossband repeaters transmit to another machine's input on another band, and receive the other way around. (It's like using two crossband repeaters "back to back.") That's a *split-site repeater*. It uses a radio link to separate the receive site from the transmit site. The end effect is that the user typically transmits and receives on the same band.

Most dual-band radios have a simple repeat function. Noise or intermod gets transmitted forever. Sometimes the only way to stop it is to remove power to the radio, connect a dummy antenna and turn the power back on. The radio now hears nothing and stops transmitting. The radio can then be unlocked from the repeater mode. This is a disadvantage with many crossband repeaters. This can also happen if you select a frequency that's a harmonic, such as 146.75 and 440.25 MHz, because 440.25 is the third harmonic of 146.75. The radio can lock up if it hears the weak third harmonic.

There's a second problem with crossband repeating: If you program a VHF repeater

frequency pair, you must wait for the repeater carrier to drop before UHF is terminated, so you can transmit on UHF. Think of it this way: The first signal to the radio becomes "master." Until it goes away, the radio is repeating. Obviously, you want to be that master, because only then will you have control.

If the 2-meter repeater you're linked to has a long carrier tail with a courtesy beep, you aren't going to be able to access your crossband repeater until after the beep. If the 2-meter repeater you're linked to has a short carrier tail (and few do), you'll operate fine. Remote flexibility can be best attained when you use a crossband repeater with a dual-band hand-held transceiver.

Good Operating Practice

Use the lowest power necessary to accomplish your communications. Not only is that the law, but low power means low heat to the radio. If your crossband repeater has a single antenna connection and you use a dual-band antenna, your receive coverage on both bands is almost identical. You may want to use a VHF/UHF duplexer and put a beam on one band for the distant communications and a ground plane on the other band for the local link.

A repeater requires identification every 10 minutes and radio control of a repeater must be done on UHF.

You can't retransmit out-of-band signals, such as those from NOAA weather, MARS or CAP. You should affix a copy of your license to the radio if it's used for repeater operation. If you're going to use the rig mobile, install it so that it can be used with the key out of the car and the doors locked. (Do you want your car to leave the area while you're away from it?) Place the radio where it can't be seen when in unattended operation.

Having a mobile minirepeater is great, especially for parades or walkathons. Park your car nearby and use your hand-held transceiver with a stubby duck and low power. You can even ask for those distant assignments because you have 25 or 45 watts and your mobile antenna to make contact.

Good luck and enjoy crossband repeating.

QST

Crossband-Repeater Operation

New dual-band VHF/UHF rigs offer flexible operating capabilities, as pointed out in the September 1992 FM/RPT column. Here's how to take advantage of this feature and avoid potential problems.

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Would you like to be able to check into that distant 2-meter repeater swap net while taking a walk in your neighborhood? How about monitoring 52.525-MHz FM simplex activity with your 440-MHz hand-held transceiver while tinkering with your car? Do you need quick repeat/relay capability for public service or emergency communications?

If you have a 440-MHz hand-held transceiver and one of the dual-band FM transceivers that offers crossband-repeater (CBR) operation, all of the above is possible with, in most cases, only a minor modification to the dual-band transceiver to activate the CBR mode. In some cases no modifications are necessary. See your rig's operating manual or contact the manufacturer for details on modifications and activation procedures.

What is Crossband-Repeater Operation?

Unlike normal repeater operation which takes place using two frequencies on one band (Fig 1A), a CBR uses one frequency on each of two bands (Fig 1B).

When CBR operation is activated, the transceiver's receiver switches between the two bands. When a signal is received on one band, such as 2 meters, it connects the audio output of the 2-meter receiver to the audio input of the 440-MHz transmitter and keys the 440-MHz transmitter. (On some equipment, such as the Yaesu FT-470 hand-held transceiver, there's no direct audio connection for CBR—the audio is acoustically coupled.) When the input signal disappears, the transmitter is unkeyed and the transceiver goes back to alternating receive on the two bands until a signal is again received and the transmit cycle is repeated (no pun intended).

Crossband-Repeater Operating Modes

Depending on the radio, there are three types of CBR operation:

Simplex-to-Simplex CBR

In simplex-to-simplex CBR operation (Fig 2), the transceiver is set for simplex frequency operation on both bands. This is a good way to keep track of activity on a local frequency when you're away from the base rig.

Simplex-to-Repeat CBR

In simplex-to-repeat CBR operation (Fig 3) the transceiver is set for simplex

operation on one band and repeater frequency offset operation on the other. On some transceivers, such as the Kenwood TW-4100A, simplex-to-repeat CBR is only possible with standard frequency offset repeaters—though this shouldn't be a problem for most users. In this mode, you're dependent on the characteristics of the repeater you'll be operating with.

One-Way CBR

An additional mode, one-way CBR, is shown in Fig 4. This mode, available on some late-model dual-band rigs, such as the Kenwood TM-741, provides a way to remotely monitor activity. Because this could be considered one-way transmitting, I recommend that the transmit side (band) of the rig be connected to a dummy load during

operation. This greatly limits the effective range of the transmitter, while still providing receive coverage close to the dual-band rig and dummy load.

Using It

Read the sidebar "The Law Says..." before you begin operation.

Base/Mobile CBR with Hand-Held Transceivers

Repeaters you can hit with a more powerful base or mobile rig may not be accessible from a hand-held radio. With CBR, you can extend the range of your portable rig. If you have specific areas or directions of operation in mind, choose antennas that favor those directions. For example, if there's a distant 2-meter repeater due west that you'd like to be able to reach via CBR and your primary hand-held transceiver operation is located due north of your CBR's location, you'd equip the CBR with a 440-MHz beam pointed north at your portable location and a 2-meter beam pointed west at the distant repeater to provide optimum operation with minimum operating power. If your operation is limited to your immediate vicinity, consider feeding the local—usually 440-MHz—transmit side of your dual-bander into a dummy load to limit the transmit range and limit the ability of undesired signals to access your system.

Hand-Held CBR with a Hand-Held Transceiver

You may be able to put a hand-held radio at a temporary location to provide CBR coverage where it wouldn't be practical to operate a higher-powered base or mobile transceiver.

The coverage advantage provided by a hand-held at a choice location may be superior to that provided by the location obtainable by a higher-powered mobile. As with any hand-held operation, battery consumption is an important consideration. If a particularly good location is available, CBR operation with a low power setting may be sufficient.

Application Examples

Operation from Inside a Partially Shielded Building

Fig 5 shows an example that, unfortunately, most of us are familiar with. Computers have brought an increasing level of RFI that's

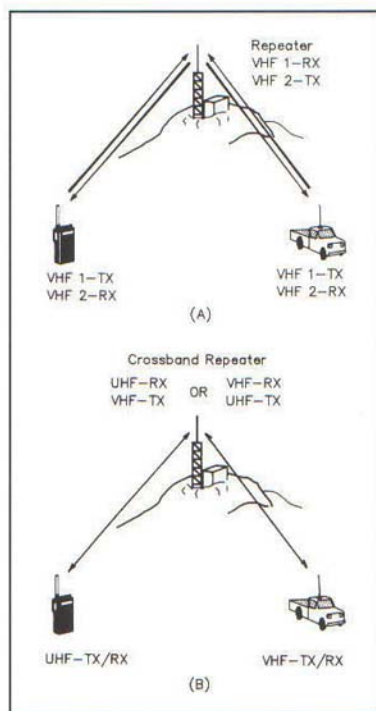


Fig 1—Normal Repeater Operation (A)
Crossband repeater operation (B)

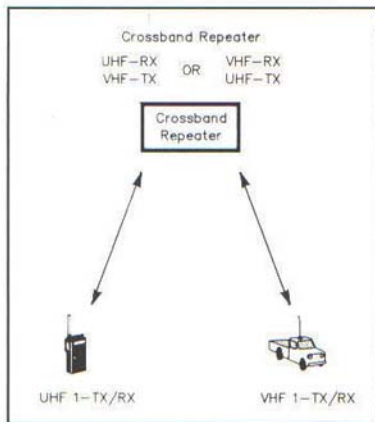


Fig 2—Simplex-to-Simplex Operation
In this mode, each band has the same frequency for input and output.

made operation near them difficult—especially inside a building that may already be partially shielded—providing difficult repeater operation. With a mobile rig operating as a CBR just outside in the parking lot, hand-held access to your favorite 2-meter repeater from inside the building is easy.

Access Assist

With the high sensitivity of modern hand-held transceivers and the increasingly tough RF environment provided at repeater sites, balanced repeater operation is often impractical, even with mobile equipment. It's often possible to hear a repeater easily but not be able to access it with a hand-held transceiver. Fig 6 shows how CBR operation with a dual-band hand-held can provide access-assist capability. Operating this way eliminates several problems associated with normal repeater-carrier tails. For example, CBR autopatch operation is possible when operating this way, provided your dual-band rig in CBR mode passes the DTMF tones without too much distortion. The disadvantage of this approach is that there may be audio feedback. You can minimize this by using an earphone or by operating CBR without simultaneous-receive/full-duplex operation.

Remote Monitor

One-way monitoring is possible. Fig 7 shows how, with the addition of a receive converter (in this case, a 6-meter converter), CBR can be used to provide remote-receive capability that lets you listen while walking around with a hand-held radio.

Fig 8 shows the concept of Fig 7 taken a step further. Instead of the receive converter, a transverter is used. In Fig 8, a 6-to-2-meter transverter used with a dual-band transceiver in CBR mode provides 6-meter remote-base capability.

Operating Practice: Avoiding Problems

Long Repeater-Carrier Tails

A major potential problem with simplex-to-repeat CBR is operation with repeaters that

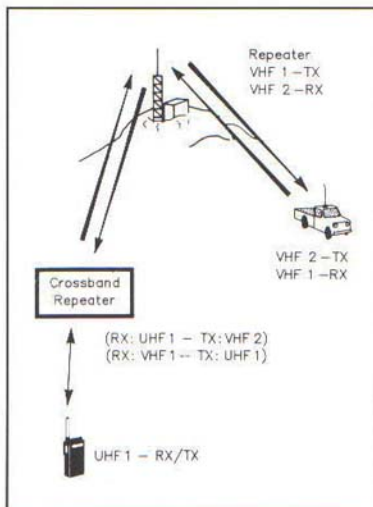


Fig 3—Simplex-to-Repeater Operation
In this mode, UHF has the same input and output frequency, and VHF has different input and output frequencies (differs by repeater offset).

have long transmitter carrier tails. The long repeater carrier tail (originally called a "squelch tail") came about when the reset function for repeater control system time-out timers switched from repeater carrier-transmitter drop to received signal-carrier drop, which spares users the squelch crashes associated with the repeater carrier dropping between input transmissions. The "courtesy beep" replaces this characteristic on many repeaters and the repeater carrier remains on the air. Because of the way CBR works, you can't respond to someone on a repeater until its transmitter carrier drops. It's frustrating to have to wait 10-15 seconds before being able to respond, and it sure limits rapid exchanges. A short (one-second) carrier-tail repeater facilitates rapid CBR mode exchanges.

Two-Way CBR and Repeater Autopatches

CBR makes it essentially impractical to

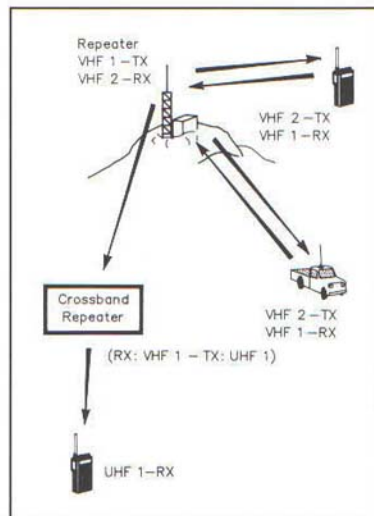


Fig 4—One-Way Repeat Operation
In this CBR mode, VHF is designed as receive and UHF as transmit. Reverse operation is not activated.

use an autopatch through a remote repeater. Initiating an autopatch call in this mode typically times out the patch. Once the patch is activated, it looks for signals from your transmitter for control. Unfortunately, your CBR's receiver still hears the repeater's transmitted carrier, preventing the transceiver's transmitter from functioning. Without a dial or disconnect signal, the repeater's autopatch will eventually (hopefully) self-disconnect.

Don't Link Two Repeaters

Because of the way CBR works, it isn't possible to link two normal repeaters. A "normal" repeater means a machine that has a carrier tail. If two such repeaters are CBR linked, once the first outside signal keys one of the repeaters, the repeaters will be ping-ponged on and off by each other's carrier tails—not a desirable condition.

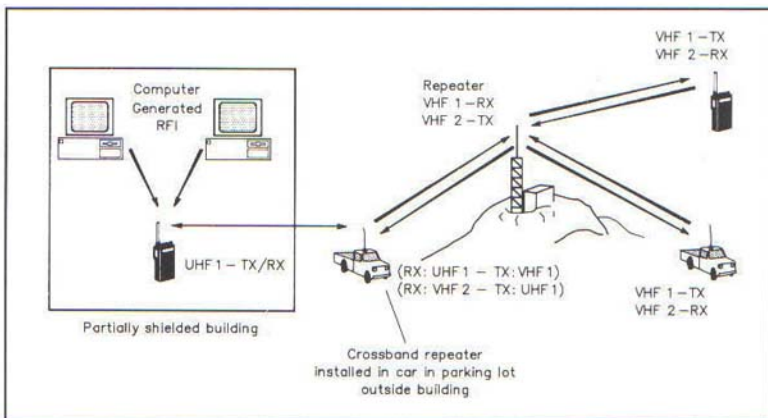


Fig 5—CBR Assists Operation From Inside Building

"Open" Transceiver Mike in CBR Mode

Check your dual-band transceiver's operating manual to determine the method for CBR audio connection and the effect of CBR operation on front-panel controls. Some radios require special consideration:

When operating the Kenwood TW-4100A in CBR mode, you'll probably want to disconnect the microphone because it's "live," though the push-to-talk switch isn't functional, when the transmitter is activated. If you don't disconnect it, local audio will mix with the repeat audio and possibly cause feedback, depending on factors such as your speaker volume setting. You could use this to mix in ID audio.

The same open-mike precaution applies to the Yaesu FT-470 hand-held transceiver. In the CBR mode, repeated audio is acoustically coupled, with no direct audio connection, so the microphone is open to all local audio, not just that picked up from the speaker.

Transmit Power and Duty Cycles

If a repeater you operate with in CBR mode has a lot of activity, lower your transceiver's transmit-power level. Most FM transceivers aren't designed for continuous high-power transmission. Consider the heat-dissipation environment of your rig's installation, too: The typical mobile installation on a hot summer day isn't an ideal environment! Check the rating of the power source you use to avoid overheating it or running down your car's battery in a stationary mobile situation with the engine off.

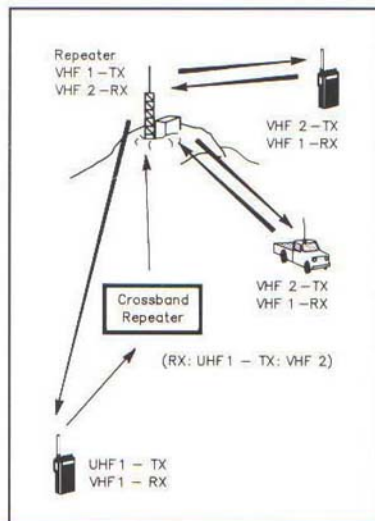


Fig 6—Access-Assist Operation

In this CBR mode, the crossband repeater permits access to a repeater not normally accessible by hand-held power levels, but within hand-held range.

Check Your Arithmetic!

Harmonically related frequencies won't work in CBR mode. For example, if you monitor the output of a repeater on 442.5 MHz using a simplex frequency of 147.5 MHz, you'll run into trouble because 442.5 MHz is the third harmonic of 147.5 MHz ($147.5 \times 3 = 442.5$), which will interfere with

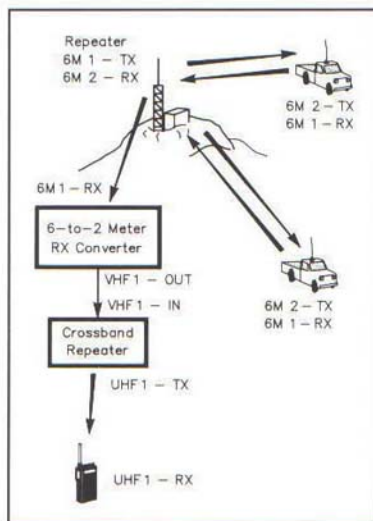


Fig 7—Remote-Monitor Operation

In this CBR mode, one band is designated as receive, with an external converter and the other band as transmit. Two-way transmit is not activated.

reception of the 442.5-MHz signal.

Finding a Clear Frequency

Observe the band plans when selecting your simplex frequency for CBR operation. Carefully select a CBR frequency to avoid interference problems. You're responsible for what's retransmitted by your station! The old

The Law Says...

A full discussion of the Part 97 rules covering repeater operation is beyond the scope of this piece, but the following review should help you avoid problems:

Part 97.3 (a)(35) defines a repeater as "An amateur station that automatically retransmits the signals of other stations." CBR operation is repeater operation. Because the CBR is a repeater, it's essentially under automatic control. Transmitters under automatic control must be able to be shut off if anything goes wrong. Wherever you set up your CBR, be sure you're in a position to turn it off in a timely manner if a problem arises. Review the following sections of Part 97 to avoid violating FCC rules:

Part 97.205 Repeater Station Requirements:

- Permitted control operator license classes (Novice not permitted).
- Permitted operating frequencies.
- Automatic control operation permitted.
- It's okay to limit repeater access to certain users and CTCSS access is allowed.

Part 97.119 Identification Requirements:

- You should identify the CBR by voice when operating, eg, "W3RW clear via W3RW Repeater."

Part 97.109 Station Control Requirements:

- Automatic control.

Although this article is targeted at CBR operation using 146/440-MHz dual-band rigs, the same type of operation is possible with 146/222-MHz dual-band transceivers. A Novice operator, however, may *not* be the licensee or control operator of any repeater.

Aside from the basic FCC rules, there are other important considerations to look at before you fire up your shiny new dual-bander as a crossband repeater. Established, recognized band plans set aside specific frequencies and band segments for repeater inputs and outputs. On top of this, your local repeater-coordination or spectrum-management group is responsible for keeping track of what repeaters are operating on which frequencies. In some areas, there are *no* available repeater frequencies on a given band.

Flipping a couple of switches on your mobile or hand-held rig may not seem like a major undertaking, but it *is* essentially the same thing as installing a regular repeater. If you suddenly appear on a well-known repeater input or output frequency, or one used for established simplex, packet, RTTY, weak-signal work, satellite contacts or other purposes, you aren't going to make many friends! Also, the FCC says that in matters of interference between repeaters, the repeater recommended by a recognized coordinator is given preference and the licensee of the noncoordinated repeater has primary responsibility to resolve the interference (ie, shut down, move or face possible charges of malicious interference). See the FCC rules, Section 97.205(c). Contact your local repeater coordinator for details; addresses are published in the latest ARRL *Repeater Directory*. The *Directory* also lists band plans and specific repeater frequency pairs.

Use your head—after carefully checking for a clear frequency (and one authorized for repeater operation), operating a low-power, restricted-range crossband repeater temporarily in a remote area may be okay. Randomly kicking your dual-band mobile into CBR mode while cruising through a congested metropolitan area is asking for trouble. Enjoy CBR operation when it's an advantage, not an annoyance.

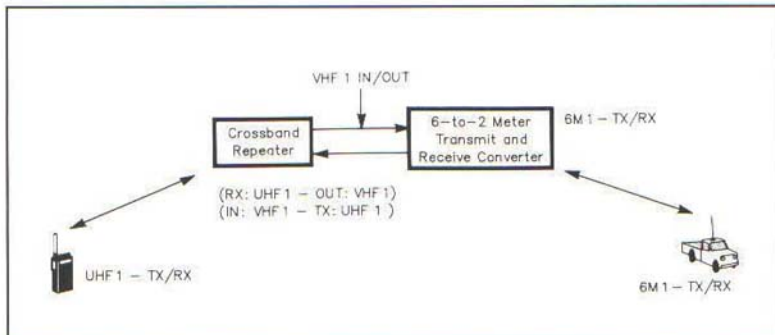


Fig 8—6-Meter CBR Remote Base Operation In this mode—a variation of simplex-to-simplex operation—a 2- to 6-meter transverter provides 6-meter operation.

adage applies: "Listen before transmitting!" Monitor your selected frequency for as long as possible—at least a few weeks or so, preferably a couple of months—to determine how clear it is of activity. Once you've picked a

relatively clear frequency, it may be your best bet to operate CBR using continuous-tone-coded squelch system (CTCSS) on your receive frequency to eliminate undesired access.

Do it Right and Have Fun

These are just a few uses for CBR. Many of these could be used to expand repeater access in emergencies and in normal operating situations.

The CBR capability available in many dual-band mobile and hand-held FM transceivers can be used to improve your communications capability. By following simple guidelines, potential operating, equipment and FCC problems can be avoided. Experiment and let me know if you come up with any new applications. This is one part of ham radio I find interesting, as do many operators of "regular" repeaters.

References

FCC Rule Book, 8th Ed (Newington: ARRL, 1991).

Kenwood USA Corp *TW-4100 Repeater Operation Supplement*.

Witmer, R., "Kenwood 4100A Crossband Repeater Operation," *73 Amateur Radio*, November 1988, p 39.

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MORE INFORMATION ON ICOM CROSSBAND REPEATING PRODUCTS:



These ICOM handhells are capable of contacting your crossband repeating radio.

| | | | |
|----------|---------|---------|-----------------|
| IC-02AT | IC-24AT | IC-Δ1A | IC-T22A |
| IC-2AT | IC-03AT | IC-P2AT | IC-V21AT |
| IC-2GAT | IC-3SAT | IC-P3AT | IC-W2A |
| IC-2GXAT | IC-4GAT | IC-P4AT | IC-W21A |
| IC-2iA | IC-4iA | IC-T2A | IC-W21AT |
| IC-2SAT | IC-4SAT | IC-T7A | IC-W32A |
| IC-2SRA | IC-4SRA | IC-T21A | IC-X2A/IC-X21AT |
| IC-T8A | IC-Q7A | IC-Z1A | IC-T81A |

Use these commands with your DTMF ICOM handheld to remotely control your ICOM crossband repeating mobile (except IC-901)

| | |
|---------------|------------|
| Remote On | B, 000, # |
| Remote Off | B * |
| Crossband On | DB * |
| Crossband Off | DB, 000, # |
| Call | 1 |
| Memory | 2 |
| VFO | 3 |



These ICOM handhells and mobiles can perform crossband repeating.

| | | | |
|----------|----------|----------|----------|
| IC-24AT | IC-2700H | IC-V21AT | IC-W32AT |
| IC-901A | IC-2710H | IC-W2A | IC-X2A |
| IC-2330A | IC-3230A | IC-W21A | IC-X21AT |
| IC-2340H | IC-3230H | IC-W21AT | IC-Z1A |
| IC-2350H | IC-Δ1A | IC-W31AT | |
| IC-2410H | IC-2800 | IC-32AT | |

Note: additional accessories may be required to perform certain specialized functions and more complex crossband repeating operations.

| | |
|------------|----|
| High Power | 6 |
| Low Power | 9 |
| Voice* | DC |
| Enter | D |
| Up | # |
| Down | * |
| Clear | A |

* The 000 may be your own 3 digit DTMF security code.

* Direct keyboard entry of frequency or memory channel.

* Not on all radios



REPEATER

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