By Bill Wageman, K5MAT

The Transverter—An Introduction to a Useful Device

Ever wonder how a transverter works? Building one could get you on that new VHF, UHF or microwave band. You'll be better informed, too, about some of the basic building blocks and circuits used in your present transceiver.

A little background is necessary to fully understand what is meant by the term *transverter.* Modern radio receivers use a *superheterodyne* frequency conversion technique—RF amplification of the input frequency is followed by a *mixer,* which combines that signal with a local oscillator (LO). The output of the mixer (usually a sum and a difference frequency—the LO plus the input frequency and the LO minus the input frequency) feeds an intermediate frequency (IF) amplifier. This operates at a fixed frequency with a limited bandwidth to amplify the signal so it can be converted to audio for the speaker or headphones. This means that the LO must be a variable frequency oscillator if the IF amplifier is to receive signals from different frequencies as the receiver is tuned.

Band switching makes it possible to tune various bands and frequency ranges. There is an upper frequency limit to this, however, because of the complexity necessary in building a receiver that tunes from "dc to light." Today, it is not uncommon to find receivers and/or transceivers that tune from the 160 meter band up through 70 cm. Most of them don't, however, cover the fascinating VHF/UHF bands at 222, 902 or 1296 MHz and higher. So how can you get on a band that is not covered by that wonderful brand-new transceiver?

Fifty years ago, if someone wanted to listen to 6 or 2 meters, they had to homebrew a receiving *converter* to convert that VHF signal down to either a 7, 14 or 28 MHz frequency that their station receiver would tune to. [The editor is dating himself, but the names *Tecraft*, *Centimeg* and *Tapetone* come to mind!—*Ed*.] Today it is quite easy to convert 222 MHz to 28 MHz or 50 and 144 MHz to a lower frequency. Such a device is called a 135 cm receiving converter. It works exactly the way the receiver described above does, except that the LO frequency is fixed and the output amplifier (if any) is broadbanded so that the HF receiver can tune across the converted band of signals. Receiving converters are available commercially for a variety of frequencies or bands.[1]

But how can you *transmit* on 222 MHz, 902 MHz or the higher frequency bands? It is actually conceptually quite simple. Simply take a signal on 28, 50 or 144 MHz; feed it into a mixer (along with a local oscillator signal) to change the frequency to 222 MHz; filter (to get rid of the undesired mixer products) and then amplify to some reasonable power level so that other hams can hear you. The mode of the driving signal, such as SSB, is faithfully reproduced at 222 MHz. Since mixers generate many combinations of their two input frequencies, it is necessary to follow the mixer with a fairly narrow band-pass filter that allows only the desired transmit frequencies to be amplified. That is a considerable simplification of a transmitting converter but basically, that's it.

[1]Notes appear on page 42.

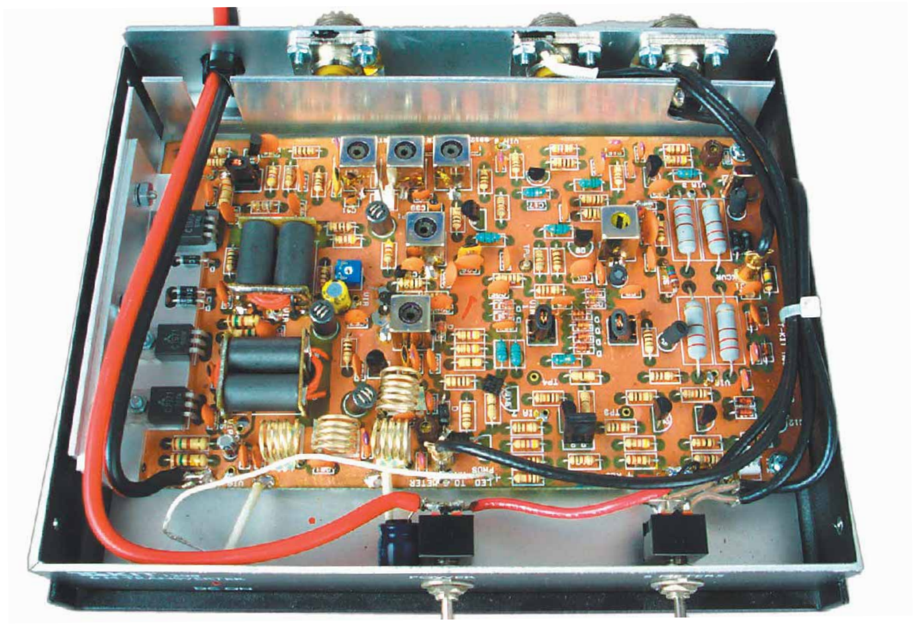

Figure 1—The Ten-Tec 1209, a commercial 20 to 6 meter transverter.

If you have both a receiving and transmitting converter, and you combine them in some way, you now have what is called a *transverter,* a contraction of the term *transceive converter*. Placing both receive and transmit converters in one enclosure can be tricky; there are good articles dealing with transverter construction and some pitfalls to be avoided.[2] A good example of a homebrew 222 MHz transverter built by P. Wade, W1GHZ, was described in January 2003 *QST*, pp 31-38.

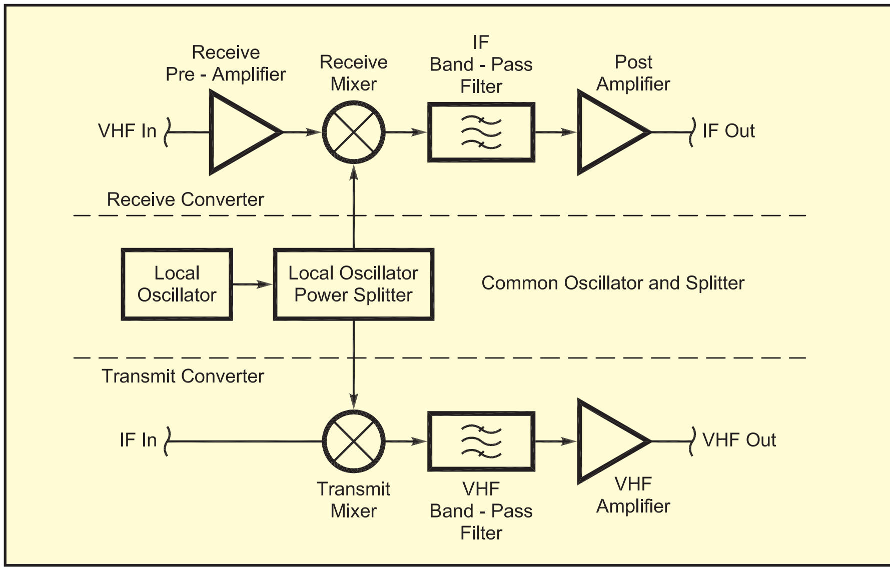

Figure 2—A block diagram for a typical transverter. The upper chain is the receiving converter, and the lower chain is the transmitting converter. Each block on the diagram has its own schematic and each can be built and tested separately—an asset during construction.

Why Use a Transverter?

Some newer transceivers, such as the ICOM IC-706, are relatively inexpensive and go all the way up through 70 cm, but unfortunately they skip the 222 MHz band. A disadvantage of those rigs is their receiver performance. I prefer to change an old adage to read, "You don't get anything you don't pay for." Let's say you want to work 144 MHz SSB, and you have strong nearby out-of-band signals or a neighbor ham who also works that band. That receiver will probably suffer from overload and filtering problems in the presence of very strong signals. A transverter offers a possible solution, with a choice to buy, to build or both. Figure 1 shows a commercially available 20 to 6 meter transverter, the Ten-Tec 1209.

Years ago, I owned a Yaesu FT-620B single-band transceiver for 6 meters. I built a receive RF preamplifier for it. That helped my receiving ability considerably, but it also caused me a rather serious problem. A friend had a big signal on 6 and he overloaded my receiver for more than 100 kHz either side of his transmit frequency. I constructed a receiving converter to use with my Drake R-4B receiver on 10 meters and… magic—I was unable to tell he was on the air until I tuned to within 4 or 5 kHz of him! Since I had similar problems on 144 MHz, I decided to build a receiving converter for that band, as well. I benefited from the same good results, bit the bullet and built a transmitting converter, emphasizing good engineering practice in order to keep the transmitted signal as clean as I could. After completing the design and tackling its construction, I was never sorry.

Much of that circuitry was taken from a design by W1JR.[3] My design was more costly than it might have been, but it performed very well. It is only slightly more difficult to build a 222 MHz transverter than one for 144 MHz and there is no easier way to get on SSB and CW on that band without incurring a considerable outlay of money. If you have a good HF station without 144, 222 or 432 MHz capability, building your own transverter can put you on those bands and result in better performance, at less expense, than buying a commercial unit or a new transceiver.

Where can you purchase a transverter? Occasionally, some Microwave Modules transverters for 144 and 432 MHz appear at flea markets. At times, the major Japanese manufacturers have made transverters that interface nicely with their own HF equipment. These are rare and they can be difficult to alter for operation with a transceiver other than the one for which they are designed. There are several manufacturers of transverters… Down East Microwave sells them completely assembled or as kits, and SSB Electronic USA sells complete transverters and kits designed in Germany.[4,5] Additionally, Hamtronics, Ten-Tec and Yaesu offer transverters and converters at various IF and input frequencies.[6,7,8] A search at the ARRL TIS database will reveal a few more (**www.arrl.org/tis/tisfind.html**).

I have built transverters for 50, 222 and 432 MHz with a 28 MHz IF and a 902 MHz kit with a 144 MHz IF.[9] Commercial transverters for amateur use are available through at least 24 GHz. There may be a limit to how high in frequency they can go—eventually components become prohibitively expensive or, given the present state of the art, are simply not available.

There are a few disadvantages to the use of transverters. First, they require a dedicated transceiver. Second, transmit-receive (T-R) switching of the transceiver and the transverter can be problematic. There are, however, "cookbook" solutions to this problem and Down East Microwave may be of some help.[10] The drive power to the transmit mixer must also be appropriate, but that isn't usually a big problem. [Many transceivers have transverter-level outputs.—*Ed*.] Interfacing to a separate transmitter/receiver duo (the scheme I have used) is usually quite easy. The milliwatts of drive power required can be obtained from a driver stage, eliminating the possibility of dumping too much power into the mixer and destroying it.

Construction

The heart of any of these converters is the LO and this is one place where scrimping to save money is going to make you pay in other ways. Use the best crystal you can buy (I recommend International Crystal Manufacturing) and treat it well.[11] Install it in an isolated enclosure of its own so other circuitry won't cause temperature-driven drift. For frequencies through 1296 MHz there is an excellent and easy-to-build published circuit for local oscillators.[12] Converters for the higher frequencies will probably require additional frequency multipliers.

If only a receiving converter is being built, there needs to be only one output from the LO. If you're building a transverter, however, it is necessary to have two LO outputs that may need to be at different power levels. Figure 2 shows a simplified block diagram of a basic transverter. Note particularly the LO and its power splitter. [Depending upon mixer level requirements, additional stages may be required before each of the mixer LO inputs.—*Ed*.]

Many kinds of mixers can be used, but,

for the best receive performance, the double-balanced mixer is a good choice. Standard units need +7 dBm (5 mW) of drive power from the local oscillator, but if you have trouble with strong signals it would be best to use a high-level mixer (+17 dBm, or 50 mW) or even a very high-level unit that needs +27 dBm (500 mW).

For receiving, double-balanced mixers have a relatively high noise level—too high for direct antenna input to the mixer—so it is almost always necessary to use a low-noise preamp ahead of the mixer. Some older receivers, when used with a receive converter, might even require another amplifier after the mixer, but it is unwise to have too much gain in the receiving system. Some sort of bandwidth limiting filter is absolutely necessary at the output of the mixer to remove unwanted mixing products. (Remember those sum and difference frequencies we spoke about earlier?) [Excessive gain compromises strong-signal and linearity performance—use the minimum amount of gain required. Band-pass filters at the converter input will also improve receiver performance by rejecting strong out-of-band signals. Some designs use only a passive mixer at the receive front end and make up gain at IF. This helps avoid front-end compression and non-linearity.—*Ed.*]

A second mixer might be used for the transmit converter, although with appropriate switching, it is possible to use one mixer for both. This saves money but is a complication that is probably not worth the effort. The transmit mixer must be followed by a good band-pass filter so that only the desired transmit frequency remains. The power level at this point might be as low as 100 µW (–10 dBm). Monolithic microwave integrated circuits (MMICs) are an almost painless way to raise the power level to 50-100 mW (+17-20 dBm).[13] Hybrid modular amplifiers can be used to easily reach the 10-25 W level. While they seem a bit expensive, they are easy to use and usually the only other components required are a few capacitors and chokes![14] It never hurts to follow the transmit converter with an appropriate low-pass or band-pass filter, but all the transverters I have built met FCC requirements without one.

There are two important issues for the constructor. It is important to control the power levels to all stages so that no device is driven into non-linearity and… tuning the band-pass filter that follows the transmit mixer can be difficult without the right test equipment. Studying construction articles carefully will help the builder determine what test equipment is needed.

Transverters can also be used in the other "direction." Suppose you would like to be active on 10 meter FM, but the only FM transceiver you own covers 2 meters. The same basic hardware can be used to convert a 10 meter SSB signal to 2 meters. The band-pass filter in the transmit side, however, would have to be tuned to 29.6 MHz rather than to 144.2 MHz. Similarly, the preamplifier on the receive side would have to be tuned to the 10 meter band. It would also be necessary to use a different crystal frequency for the LO. [Be very careful when transverting FM to HF—FM signals should be no more than 6 kHz wide on 10 meters.—*Ed.*][15]

And Finally...

This introduction to transverters isn't meant to be a construction article. Use the notes and references to get all the specifics and ask for expert advice if you don't have the background to tackle such a project. Don't be intimidated, though; building a transverter doesn't have to be a difficult project. There's a great deal of satisfaction to be had when you get on a new VHF or UHF band and you tell the person at the other end of the contact, "The transverter here is all homebrew!"

Notes

1. AR[2] Communications Products, Box 1242, Burlington, CT 06013; tel 860-485-0311; **advancedreceiver@snet.net**; **www.advancedreceiver.com/page11.html**.
2. J. Reisert, W1JR, "VHF/UHF World," *Ham Radio*, Mar 1984, pp 42-46.
3. See Note 2 and J. Reisert, W1JR, "VHF/UHF World," *Ham Radio*, Apr 1984, pp 84-88.
4. Down East Microwave, 954 Rte 519, Frenchtown, NJ 08825; tel 908-996-3584; **www.downeastmicrowave.com**.
5. SSB Electronic USA, 124 Cherrywood Dr, Mountaintop, PA 18707; tel 570-868-5643; **www.ssbusa.com**.
6. Hamtronics, Inc, 65-Q Moul Rd, Hilton NY 14468; tel 716-392-9430; **www.hamtronics.com**.
7. Ten-Tec, 1185 Dolly Parton Pkwy, Sevierville, TN 37862; tel 800-833-7373; **www.tentec.com**.
8. Vertex Standard (Yaesu), 10900 Walker St, Cypress, CA 90630; tel 714-827-7600; **www.yaesu.com**.
9. Bill Wageman, K5MAT, *Communications Quarterly*, Winter 1999, pp 25-30.
10. The ARRL *UHF/Microwave Experimenter's Manual*, the ARRL TIS Web page at **www.arrl.org/tis/info/microwave.html** and the ARRL *Periodicals Index Search* (**www.arrl.org/ members-only/qqnsearch.html**) have many references to transverter construction articles and product reviews.
11. International Crystal Manufacturing, 10 N Lee Ave, Oklahoma City, OK 73102; tel 800-725-1426; **www.icmfg.com**.
12. See Note 2.
13. Mini-Circuits, PO Box 350166, Brooklyn, NY 11235-0003; tel 718-934-4500; **www.minicircuits.com** or some of the advertisers in *QST* and other amateur journals. MMICs are available from several retail sources that advertise with some regularity. The main manufacturers are HP and Mini-Circuits.
14. Hybrid modules are available from RF Parts, 435 S Pacific St, San Marcos, CA 92069; tel 800-737-2787 (orders only), or 760-744-0700; **www.rfparts.com**.
15. *The FCC Rule Book*, 12th Edition, ARRL, p 4-27; ARRL order no. 7857; **pubsales@arrl.org**; **www.arrl.org/shop/**.

Bill Wageman, K5MAT, was first licensed in 1950 as WØBUR. Two years later, he followed that with an Extra Class license. He has also held the calls KØBYY and N5EE. A physics major in college, Bill met his wife of 48 years, Carol, WNØHQH (now W5TIK) on the air. He operates CW, enjoys DX work on VHF/UHF and operates the microwave bands. Bill enjoys building his own equipment and uses homebrew transverters and antennas on 144, 222 and 432 MHz. He's had articles published in several amateur journals, including QST, ham radio, Communications Quarterly *and* CQ. *Bill comes from an all ham family and proudly says that all of his children, their spouses and even one grandchild are licensed amateurs. He can be contacted at 7309 Avenida La Costa NE, Albuquerque, NM 87109.*

FEEDBACK

♦ In "The Load Shedder," Feb 2003 *QST*, Figure 2, pins 6 and 7 were reversed for U1A, along with their plus and minus symbols.

♦ In "New Products," May 2003 *QST*, page 58, the $19.95 price applies to the recently introduced Radio Warehouse index dividers for WAS. The DXCC index divider set costs $49.95 plus shipping.

♦ There is a discrepancy in the published results for third-order intercept points in the Product Review of the IC-746PRO [May 2002 *QST*, pages 74-75]. MDS method measurements were published for seven of the eight band-spacing combinations. The ARRL standard method uses an S5 reference. Correct third-order intercept figures using the S5 method are in the table. These figures are generally more favorable.

Spacing	*20 kHz Preamp off/one/two*	*5 kHz Preamp off/one/two*
3.5 MHz	+19.2/+7.2/–2.2 dBm	–17.6/–28.7/–33.7 dBm
14 MHz	+20.0/+9.3/–1.8 dBm	–18.2/–28.2/–35.5 dBm
50 MHz	+22.5/+12.3/–1.1 dBm	–13.5/–25.2/–31.1 dBm
144 MHz	–6.5/–5.4/NA dBm	–19.9/–39.1/NA dBm