The Why and How of Microwave Transverters

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Introduction: A few days before the January 2008 VHF Sweepstakes, my friend, Joe Seibel WA3SRU, asked if he could visit my shack during the contest to see how microwave transverters are used. While operating in radio contests can be hectic at times, it was hard to say no to Joe. After all, he was kind enough to come out twice in the cold and snowy weather to help me raise my temporary antenna array in preparation for the contest. So Joe stopped by on Sunday for lunch and tour of the shack.

After he left, it occurred to me that Joe was not alone in his questions and concerns. So I wrote this article to share what I explained to Joe and to encourage more hams to move up from the "lower four bands" into microwaves. Among the highlights of the information that I passed to Joe were:

– It is not necessary to open and modify your radio to move up to microwaves
– Second-hand transverters are available and economical
– Hooking up transverters is straight-forward given a little basic knowledge

Why Transverters?: You can pay a visit to the "candy store" and walk out with a radio that will cover three or four of the lower VHF bands (50, 144, 222, and 432 MHz). A few high-end radios designed for satellite work may be equipped with an option to extend operation to1296 MHz. However, for practical purposes, few commercial "all mode" (SSB) radios are available to cover 222 MHz.

However, if you want to work other hams at 903 MHz and beyond, you'll probably need a transverter. In fact, some well-equipped hams use transverters because with some switching circuitry, it is easier to move from one band to another using a single "IF" rig (discussed later).

Part of the reason for lack of microwave-ready amateur transceivers is that the cost of the components and required engineering for radios operating at microwave frequencies is more expensive than creating a transceiver that operates only at VHF and UHF frequencies that most amateur radios are operated. Fewer hams operate beyond the 432 MHz so manufacturers have to spread fixed development costs among few units. Hence, the economics explains the scarcity of amateur microwave transceivers from major amateur radio manufacturers.

On the other hand, if we could bring the microwave radio signals down to the tuning range of common amateur radio VHF transceivers (e.g., 2 meters), a couple of good things start to happen. We eliminate the need to engineer, acquire, or make a lot of the circuits that would have to function at microwave frequencies. Second, we may get to reuse the all-mode receiver that we already own and know how to operate.

How Do Transverters Work? You may already understand the answer without realizing it. Consider the principle behind superheterodyne radio circuits. The output from a local oscillator is mixed with the incoming radio signal. A detector picks off the generated intermediate frequencies (IF) and converts the IF to audio.

Similarly, a transverter receives (or transmits) a microwave signal, mixes it with the signal from a crystal controlled oscillator. The resulting IF is fed to the antenna terminal of the IF rig, which tunes it just like an ordinary radio signal.

For example, a transverter designed for 1296 MHz might have a local oscillator that resonates at 1152 MHz. When combined with the signal from a 2 meter VHF IF radio tuned to 144 MHz, the transverter will operate in the 1296 MHz band. If we were to tune the IF radio up to 144.100 MHz, we would actually be operating at 1296.100 MHz, which is a popular frequency for this amateur microwave band.

Transverters are typically organized internally into transmit and receive "chains". Part of the reason for this is that the receive chain contains a pre-amplifier which could be damaged by the higher level RF generated by the transmit chain. Other circuits must be switched in or out as we move between transmission and reception. So either mounted in the transverter box or on the outside is a transmit/receive (T/R) relay. It switches between SMA or BNC connectors for the transmit and receive chains of the transverter.

How Is a Transverter Hooked Up? Transverters typical have the following external connections:

- Power: typical required voltages are 12-14 VDC and perhaps 24-28 VDC to power relays and other components
- N connector for connection to the antenna
- BNC connection to the T/R relay. The other end of the coax goes to the UHF (SO-239) antenna connector on the IF rig
- a phono jack to "key" the T/R relay to transmit

If you are new to transverters, you may be less familiar with N connectors (and perhaps BNC and SMA connectors). While PL-259 and SO-239 connectors are sometimes called "UHF" connectors, the truth is that they start to become unsatisfactory at 432 MHz and beyond. N connectors are a better choice at 432 MHz and higher frequencies. They are more moisture-resistant, too.

You will also see BNC ("bayonet"), SMA, and phono ("RCA") on transverters. BNC and SMA connectors often seen as antenna connectors on VHF/UHF hand-held ("HT") radios. They function well when channeling a few microwatts or watts of RF energy. However, when connecting your transverter to amplifiers or antennas, N connectors are the better choice because they handle more RF current without overheating.

On a commercial transverter, the key line will typically be a phono jack connection (other arrangements may be employed on a home-brew transverter). Many, if not most modern

VHF transceivers that you might employ as an "IF rig" have an accessory jack that can be connected to the key line. When the key line is connected to the IF rig, the transverter's relay(s) switch to transmit when you tap the code key or squeeze the PTT button on the microphone.

If you key your transverter via the IF radio's accessory jack, you'll want to add a sequencers. Sequencers help insure that the pre-amp is disconnected before transmit power is applied to the transverter.

If you cannot hook up the key line to the accessory jack of the IF rig, you can ground the key line with a toggle switch or alligator clip before you start to transmit. Just be sure be sure to wait a second or so after you key the transverter for transmission before hitting the PTT button or code key.

Attentuators. Depending upon the IF rig that you employ, the low power setting might be one watt or as much as 5 watts. Your transverter might be happy with one watt or it might be damaged by RF levels above 10 microwatts. Find out how much input power that your transverter is designed handle. Then put in an attenuator with enough db loss to drop the RF energy sent to the transmit chain to a safe level.

A good watt meter or Elmer could be helpful in working out what attenuator is required. Make that the attenuator is robust enough to dissipate the excess RF energy, which becomes heat. Also, make sure that you are only attenuating the transmit chain. There is little sense in making weak incoming microwave signals weaker.

Antennas and Feedlines. Looking at the antennas of hams working microwave bands, you will often see yagi antenna with loops instead of dipoles. This is because it is easier to fashion loops rather than dipoles that resonate at the target frequencies. General practice is to orient the antenna for horizontal polarization by placing the boom above or below the loops. Horns and dishes are often used at the higher microwave frequencies.

At microwave frequencies, feedline losses are also more significant. It is a good idea to use better quality coax cable (e.g., 9913 or LMR400). Heliax or hardline should be considered if you have a long run from the antenna to the transverter. After you set up your station, if you have appreciable slack in your feedlines, consider shortening them to minimize your feedline losses.

Amplifiers and Pre-Amps. Another strategy for compensating feedline loss at microwave frequencies is to incorporate amplifiers and pre-amplifiers. A mast-mounted pre-amplifier will boost the received signal before it travels through the feedline and will help you read faint stations. You will have to run power to the pre-amp for it to function.

A linear amplifier will boost your outgoing signal. For some bands, surplus commercial amplifiers can often be converted to amateur use for little cost. You'll probably want to also incorporate a 12 VDC relay to key the amplifier and transverter simultaneously. If you are using multiple relays, it may be necessary to wire a diode in series with each coil to prevent the relays from hanging after you key up to transmit.

How do I know my rig works and is on frequency? Okay, you have hooked everything up and turned on the power. How do you know that your transverter is working and on frequency? Fortunately, the Pack Rats and other clubs operate beacons on all of the amateur VHF, UHF, and microwave bands, up to 10 MHz. Just point your antenna in the direction of grid square FM29JW (more in a bit), and listen for the Morse for W3CCX.

Chances are that you will find that the frequency displayed on your IF rig is a little off. That is not a problem. Note how many KHz higher or lower is the received frequency beacon. Then add or subtract that differential when tuning to desired operating frequencies.

The beacons are also a good way to verify the aiming of your antenna and the calibration of your rotor. You can use W3KM's Squares program to calculate the true heading for the beacon and note the offset between that heading and what your rotor reports. You will want to give and receive the six digit grid when aiming your antennas on the microwave bands.

When talking to hams on the microwaves, start on 432 MHz if you can to peak the received signal and zero in on the rotor heading. If you have a code key handy, a series of dashes on the microwave frequency will help the other station zero in on the direction of your station when setting up a microwave QSO. If you are still on 432 MHz, you coordinate heading and signal reports on that band to help make that successful microwave QSO.

How do you know that your transmitter is working and your signal is getting out? A good quality watt meter is a start. If you have a scanner receiver handy that receives microwave signals, tune it to the frequency in use and see if you can hear it when you key up the transverter. If the scanner has an accurate digital display (verified by tuning in a beacon), then you can check to make sure that you are transmitting on the desired frequency.

One last caution: Crystal oscillators will drift as they warm up. Let your transverter warm up for at least an hour before you attempt to measure the operating frequency. If drift is a problem, you could solder a thermistor to the crystal case and wire it to a regulated power source to stabilize the oscillator.

Do I have to be rich to get on the microwaves? In ham radio, being independently wealthy is helpful but not essential. A new transverter kit for a given band might run you $200-$300 and a fully assembled model might go for $400-600.

However, early winter is the start of ham club auctions and spring brings the hamfest season The author picked up pair of working transverters (903 and 1296 MHz) for less than $50 at the Pack Rat "White Elephant" auction where members often unload surplus gear so they can find new appreciative owners. Pack Rats members also often have spare transverters and antennas for lending to other club members getting started with microwaves and at contest time to bolster the club score. Make your needs known at meetings and on the club reflector. You may be able to liberate the equipment you need to get started at little or no cost.

Conclusion. While working the microwaves is not as simple as squeezing the PTT button and talking on a repeater, the challenge of working the higher bands could be the spice that keeps you in the amateur radio game. You'll soon impress other hams with your technical prowess and be able to boost your own and the club scores in the VHF contests.