GETTING ON 24GHz- HOW I DID IT
(AND HOW YOU CAN, TOO!)
by Dave Hallidy K2DH

Beginnings

The members of the Rochester VHF Group have long been a group of folks interested in expanding the VHF/UHF horizons. A few years ago, a number of members took on the challenge of getting stations active on the 10GHz band. As a result, a couple of things have happened: the number of members actually *experimenting* with radio has gone way up (people building antennas, LNA's, power amplifiers, etc) and, the club's scores in recent contests have risen dramatically from the addition of another high-point value band. We have, as a club, played a bit with 24GHz in the past, but it was WBFM (Gunnplexer-type radios) and intended pretty much for short range QSO's in our big multi-op efforts. The main reasons (excuses?) for a general lack of activity on 24GHz include the following: Difficulty obtaining high transmit power; Need for accuracy and attention to detail; Difficulty obtaining feedline (waveguide); Need for use of a dish antenna- the list goes on. One *real* problem is that there can be VERY HIGH signal absorption due to water vapor in the air at this frequency, making long-haul QSO's a real challenge.

Until recently, the few Amateurs around the Country, and indeed around the World who have built stations and gotten active on 24GHz *Narrow Band* (SSB/CW), used equipment that was completely homebrewed from surplus. In 1998, Al Ward W5LUA wrote an article for Microwave Update in which he discussed the design of some needed components for the Amateur 24GHz Weak-Signal station: an LO Doubler/Mixer and an LNA using printed circuit techniques and commonly available semiconductors, and he described the construction of these and how to integrate them into a 24GHz transverter. The following year, the North Texas Microwave Society and the PackRats combined forces to develop a high-gain, one Watt output PA for 24GHz that was affordable to the serious microwaver (that project is still going on at this writing, with a growing number of happy Amateurs using those PA's in their 24GHz stations).

My own interest in the 24GHz band was piqued when I heard of the first 24GHz EME QSO between W5LUA and VE4MA, which took place on August 18, 2001. I'm not currently in a position to attempt EME on that band, but terrestrial contacts can be just as exciting, due to unknown propagation enhancements caused by weather formations (TROPO!). So, I set out to build a 24GHz SSB/CW station. Fortunately, several others in the RVHFG were also inclined the same way, so we each knew that we had someone to try to test with when the gear was built. The following is a description of my station, how I did it, and what you'll need to do something similar. In no way am I implying with this article that you should use my approach, as it may be the most expensive and not necessarily the best. I am merely telling you all I know about how I did what I did so that if you're interested, you can make a plan and get a station going on what is a very intriguing microwave band.

Equipment

My approach, as I said above, may not be the best. It may, however, be the simplest. I decided that I wanted to have gear on the air in time for the 2002 ARRL 10GHz and Above Cumulative Contest. So, I searched for ready-made components and found that Michael Kuhne DB6NT of Kuhne Electronic of Germany makes a complete line of 24GHz components- from the basic transverter/LO combination, to several different LNA's, to several designs of transmit Power Amplifiers (PA's). I purchased the following from them: the MKU24G Transverter, which includes the 12GHz LO (which is doubled in the transverter to 24048 MHz to provide a 144 MHz IF); the MKU243CS LNA (Preamp)- my unit has a Noise Figure of 2.1dB and Gain of 26dB; the MKU243C Driver Amplifier- this unit produces 30mW output with 0.1mW of drive; and the MKU245PAC Power Amplifier- this unit produces >1W output for 20mW of drive. The basic transverter CAN be used as is to make short-range contacts. It's drawbacks are: it only puts out about 0.3mW MAX; it has an 8dB Noise Figure; it has no LO/Image filtering, so the input/output is DSB (Double Sideband), with the image frequency falling outside the 24GHz Amateur allocation. But it does work, it's a very neat package, and with a little extra hardware, can be the heart of a high-performance 24 GHz station. The IF is 144 MHz, and the transverter is designed to work with 2m rigs of up to 4W output. It just so happened that I had an old ICOM IC-202 sitting around the shack. It turned out to be perfect for the job. DB6NT even provides details of a little modification to the '202 that will provide a keying signal on the RF output so no PTT line is required (the MKU24G transverter accepts this nicely).

Transverter/ Filter

Figure 1 is a block diagram of the transverter, and Figure 2 is a photograph showing my completed transverter, in it's weatherproof box. In the lower right corner of the box can be seen the MKU24G and the 12GHz LO.

Just to the left of (and attached to) the waveguide flange of the MKU24G is the LO/Image filter I used. By using a filter and getting the LO and Image down at least 30dB, you guarantee that you're only receiving a signal at 24192 MHz (and not also at 23904). This makes the Noise Figure 3dB better immediately. You also guarantee that all your transmit power is going out on 24192, instead of split between there, 23904, and 24048 (Image and LO, respectively). A word about filters: They seem to be in short supply, commercially. Mine (and a couple of the others around) were obtained on eBay and had to be retuned from lower frequencies. But there doesn't seem to be a ready supply of surplus filters available. Apparently, SSB USA offers a waveguide filter already tuned which will bolt right on to the flange of the transverter. I have not personally checked the performance of this filter to know how much LO/Image rejection it has. The units we were able to retune have at least 30 and more like 40dB rejection of the unwanted signals. It is also possible to make your own filter from information contained in the <u>RSGB Microwave Handbook, vol 3.</u>

Low-Level T/R

Now the question is: What do you do with the signal once it's been filtered? This is the low-level transmit signal, and while it may be fine for close-in work, we want to work DX! Therefore, we have to amplify the signal. And since the transverter/filter combination is bi-directional (used for both transmit and receive), the port on the filter away from the transverter in Figure 2 is also the amplified receive input. I used an SMA SPDT relay for switching the low-level signals (T/R), but you could use a waveguide circulator that would bolt right onto the flange of the filter, or you could make a dual-port waveguide transition, such as the one Kuhne describes in the information supplied with the transverter (see Figure 3).

Receiver LNA

The heart of any receive system is the LNA (Low-Noise Amplifier, or preamp). There are several sold by Kuhne, and depending on how you configure your system, you could use different models. I selected the MKU243CS, which is SMA in/out, because at the time I wasn't sure how I would configure my antenna switch. In retrospect, I should have gotten the 243RX, which is waveguide input and SMA output- it would have eliminated some extra hardware. The LNA can be seen just above the SMA relay and just below the waveguide switch. To connect the LNA I to the waveguide switch, I needed to use a waveguide to SMA transition and an SMA elbow. The output of the LNA connects to the SMA relay's receive port.

Transmitter Driver/ PA

The transmit Power Amplifier chain consists of two stages. The first stage is a MKU243C which takes the low-level signal from the transmit port of the SMA relay and boosts it to 20-30mW. The 243C can be seen just to the right of center in Figure 1. I could have stopped there, as 20-30mW is actually fairly respectable power on 24GHz. Many people have had long-haul QSO's with that power level. But, I decided to use the 243C as a driver, so it is followed by the MKU245PAC, MMIC Power Amplifier. This unit uses a number of GaAs MMIC's to develop over 1W output with about 20mW of drive. The saturated output is about 1.3W. It draws 2A whenever transmitting, so I only power it during transmit periods. Also, because of the high DC input power, a lot of heat is generated, so adequate heatsinking is a must. The 245 can be seen in the upper right corner of the box. The output of the 245 is SMA, so I used a short piece of .085" Semi-rigid coax to connect it to another SMA to waveguide transition, which is then bolted to the waveguide switch.

Antenna Switch

The waveguide switch is a unit I purchased from Eisch Electronics, also of Germany. These are units made for Amateur use and are very reasonably priced (if anything really is for this band). It is a SPDT switch, with a 12v coil and it can be seen attached to the top edge of the transverter case in Figure 2.

Antennas

The antenna I am using is a 13" dish I obtained from an ad on eBay. The guy is still selling the antennas, and they work well. He is based in Australia, so shipping is a bit expensive, but the antenna was cheap enough that the total price was within reason. For long-haul work, you *DO* need a dish. It doesn't have to be big- at 24GHz, my 13" dish provides well over 30dB gain! A horn will work for many contacts and is easy to mount/point, but a dish is better. One member (K2LDU) is using an 18" offset-fed DSS dish and it works very well. It was also very inexpensive. The only downside is that he had to design and build a feed for it, but there is information on doing this at W1GHZ's online antenna design website. The dish can be seen in Figure 4, which is a photograph of the complete 24GHz station mounted on a tripod and ready for action.

DC Power

The entire transverter is powered from 12-14v as would be supplied by the electrical system in an automobile. The SMA relay has a 24v coil, but the addition of a DEMI relay "kicker" makes it work just fine with a 12v supply (not all relays work well this way- their holding voltage requirement may be too high- test any relay you plan to use).

Miscellaneous Notes

Some notes here are warranted for those in the mode of parts acquisition for their 24GHz project: First, you *could* do the whole thing using SMA relays and coaxial (semi-rigid) cable. But, you must be careful about your selection of relays- many do not work well above 18GHz. In fact, some relays with SMA connectors that have been pulled from Cellular service may not work well above 2GHz because the only reason they were selected for their use in Cellular systems was their size. You should test any relay you want to use for both Insertion Loss and Isolation. I wouldn't use any relay with more than 1dB Insertion Loss, and/or less than 30dB Isolation (for the low-level stages) or 50dB Isolation (for the Antenna Switch). It turns out that many of the four-port "transfer" type relays work very well at 24GHz, so these are worth investigating.
Second, I would NOT use coaxial cable to connect the transverter to the antenna. Any significant length of coaxial cable will have so much loss that it will cost dearly in terms of lost performance. Waveguide for the feedline is the only real answer, unless the antenna is bolted *directly* to the antenna switch. Figure 4 shows my completed unit, with the antenna and waveguide feedline. I am using 18 inches of flexible waveguide to go from the box to the back of the dish. Another reason for sticking with waveguide- the feed of any good dish will be a waveguide feed and the elimination of more transitions from coax to waveguide will further reduce system losses.
Third, you will need some transitions from SMA to WR-42 waveguide if you use a waveguide switch and/or waveguide to the antenna. Plan on it- buy some- they are regularly available on eBay and from other places. Plan your transverter and figure out just how many transitions you'll need so you don't come up short. You could also build your own, if you're so inclined. Again, refer to the <u>RSGB Microwave Handbook, vol 3</u> for more information.

What To Expect

If you've tried 10GHz Weak-Signal communications, you know that path selection is important. If you're surrounded by trees and/or buildings, you're not going to work much. The same is true of 24GHz, but to an even greater degree. Path loss is greater, and as mentioned earlier, water vapor absorption can be very high, increasing the path loss dramatically in some instances (and shortening the maximum possible QSO distances accordingly). That said, there have been some amazing QSO's on the band. My own results have not been "amazing" yet, with a best DX of a little over 80 miles, but the signals at that time were "on the peg"- so loud that we knew there was a lot more range left in the systems. This summer, W5LUA and WW2R set a new distance record on 24GHz with a QSO at a distance of over 300 miles! Obviously, tropospheric ducting does take place at 24GHz and can be a great help. Rainscatter QSO's have been made at long distances and good line-of-sight paths can provide beautifully loud signals.

Conclusion

I've described an approach to getting on 24GHz SSB/CW. There are other ways to do it. For example, K2LDU completely built his own gear from the ground up and has worked me many times. This band is one where there hasn't been a lot of activity in the past, due to difficulty obtaining equipment. This problem has been eliminated with the availability of the DB6NT transverter and accessories. The band is yours to discover. The excitement is yours to enjoy. Will you accept the challenge and join us?

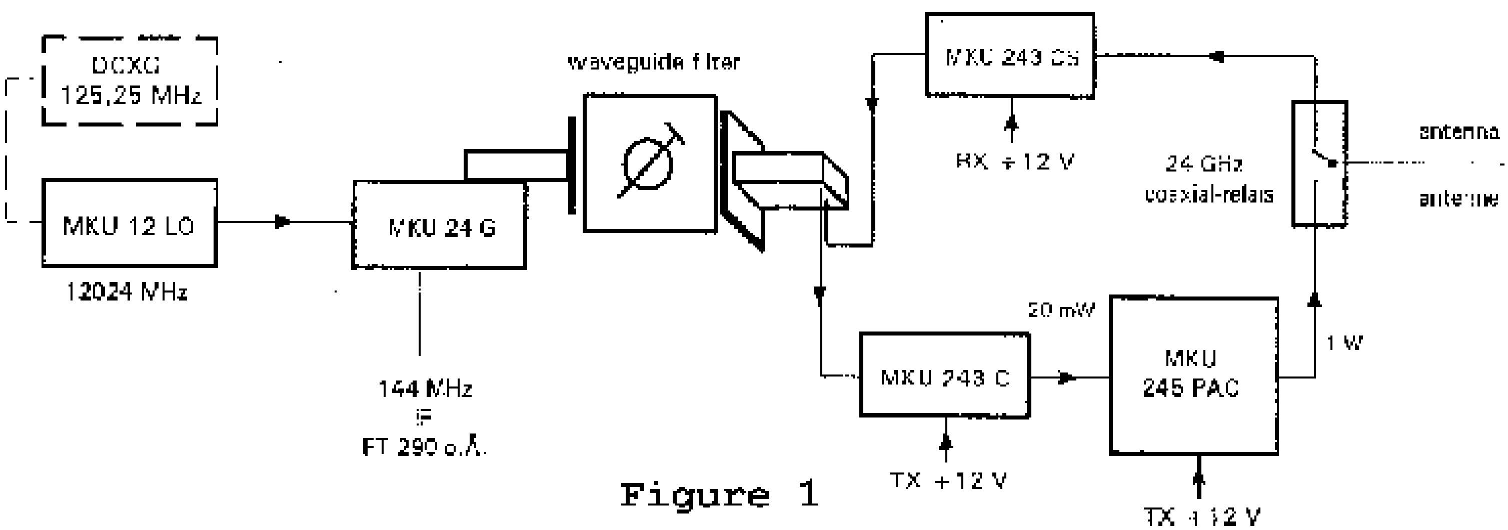

Figure 1

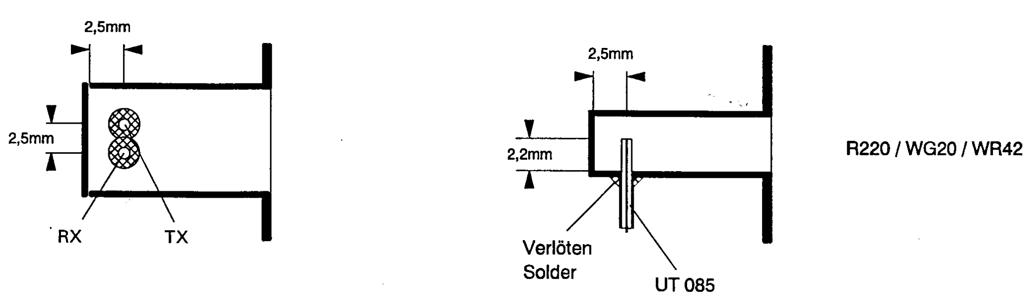

Figure 3

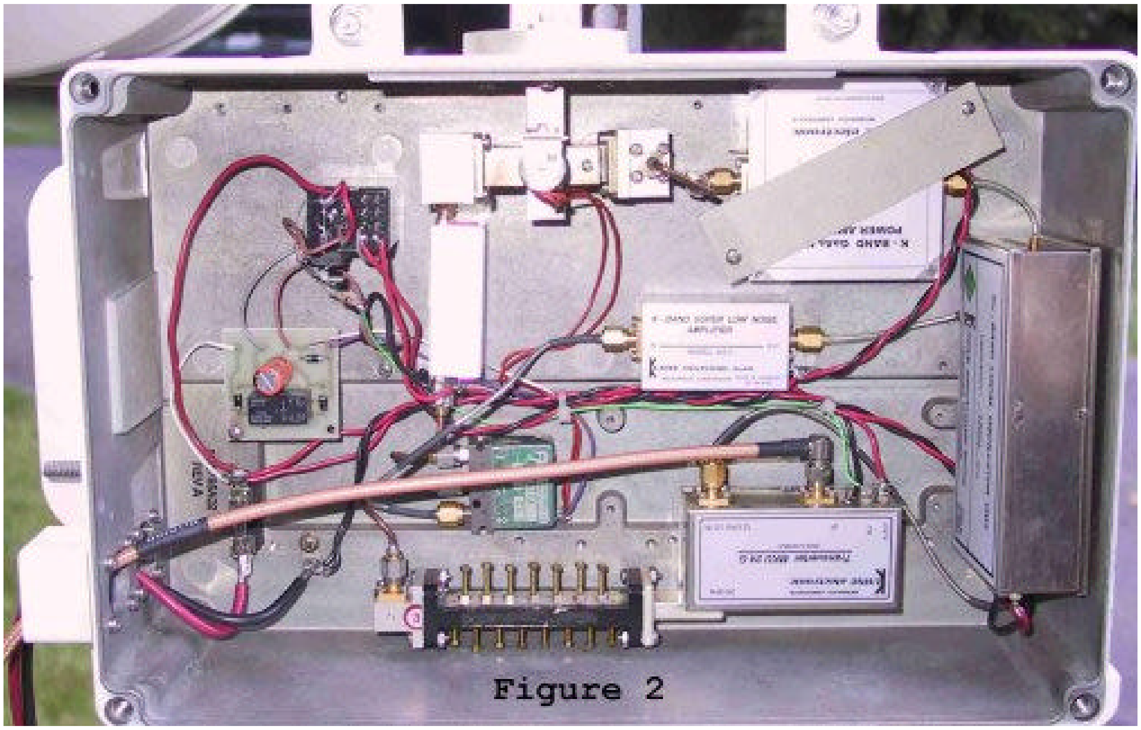

Figure 2

Figure 4