24 GHz

Over the last decade we have seen a significant increase in activity on 10 GHz. Available components, kits, and the activity itself has spurred more hams to give narrow-band microwave operation on 10 GHz a try. Those who were "early adopters" have since moved on to 24 GHz, and the activity there, and appearance of some surplus components are raising activity levels on 24.

Getting on 24 is much like getting on other bands, and in some ways different. Just as with all transverters, you need to connect a mixer, local oscillator, antenna and IF radio. However, unlike the lower bands, 24 GHz poses some challenges. Dimensions, for instance, need to be kept more precisely. In some cases, a few thousandths of an inch can make a measurable difference in performance.

Keeping on frequency is also more (twice) as difficult as on 10 GHz. Conventional LO "bricks" that usually are found to operate at frequencies up to about 13 GHz can be used in a frequency-doubling configuration and after sufficient warm-up are usually accurate and stable enough for narrow-band operation.

Circuit board materials are more specialized. Because of this, and the need to keep PCB line widths very precise, most amateurs opt to use pre-manufactured circuits or components.

SMA connectors are near or beyond their limit at 24 GHz, and more sophisticated connectors are rare and expensive. Coaxial relays, and coax for that matter can be very lossy on this band and should be avoided. Therefore, the vast majority of interconnects at 24 GHz are waveguide. The size that best matches this band is WR-42. Shown in Figure 1 are a coaxial to WR-42 transition (left) and an isolator (right). Isolators are one-way paths for RF, made from a three-port circulator fitted on one of the three ports with a load.

Transverters

There are two circuits in common use for 24 GHz transverters. The first, perhaps less common employs a conventional mixer, where an LO of 24.048 GHz is mixed with an IF of 144 MHz to produce 24.192 GHz. With an LO at about 12 GHz connected to a ×2 multiplier and subsequently to a mixer, a simple 24 GHz transverter can be constructed (see Figure 2). Along with an IF radio, this transverter, built by W1FKF, has been used to make contacts over 200 km. The components are mounted to an aluminum plate on the back of the dish. The upper left object is a "brick" LO operating at 12.012 GHz. It is followed by a doubler, which is connected to the mixer in the center. Below that is a 12 V dc to 24 V dc converter to supply the negative 20 V dc to the surplus brick. The black object on the right is for mounting.

Because it is quite difficult to produce LO power at frequencies near the operating band, and because fundamental mixers for this band are also rare, harmonic mixers are often employed—usually at half the LO. Mixers can be occasionally found that are designed to operate in a harmonic mode, and some mixers will perform this way even though they were originally designed for non-harmonic operation. Some packaged upconverters and downconverters have been found in abundance at flea markets. Examples are shown in Figure 3 where each converter is connected to an isolator. These packages each contain ×2 LO multipliers, amplifiers and filters. Power output levels in the order of a quarter watt are common.

In very simple transverters (such as Figure 2), no TR switching is required because the same mixer is used for both up and down conversion. In other low power systems, a circulator can be used to direct energy correctly between transmitter, antenna and receiver circuits. For example, in Figure 4 an LO "brick" is surrounded by an upconverter on the right and downconverter on the left. A WR-42 filter is connected to the upconverter. In this photo, the antenna connection comes up from a circulator. In a perfect world, all the energy leaving the transmitter would be radiated—however, there is always some power reflected from the antenna, and this will be fed (by the circulator) directly into the downconverter. To protect it, a waveguide shorting solenoid is employed in front of the downconverter and energized during transmit.

Filters are used in transverters to remove unwanted mixer products. This results in receiver noise improvement of up to 3 dB and prevents transmission on more than one frequency. Sections of waveguide with various pins and screws

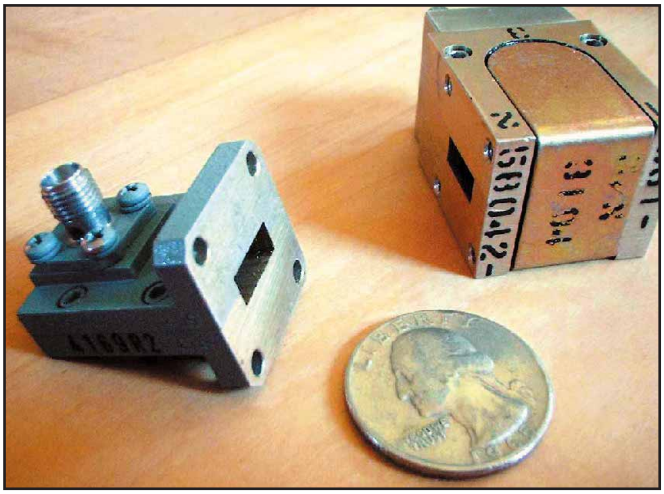

Figure 1— A coaxial-to-WR-42 transition (left) and an isolator (right).

Figure 2—This transverter, built by W1FKF, has been used to make contacts over 200 km.

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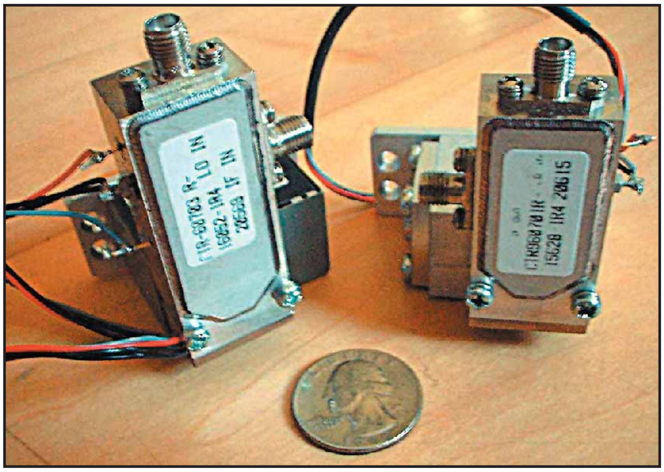

Figure 3—You can often find packaged upconverters and downconverters at flea markets.

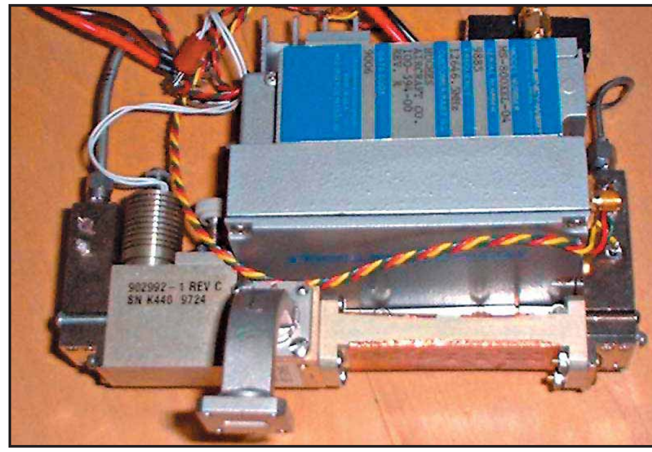

Figure 4— This LO "brick" is surrounded by an upconverter on the right and downconverter on the left. A WR-42 filter is connected to the upconverter.

function as a band-pass filter.

For TR switching in systems that have high power—such as a half to many watts—reliance on a circulator is not advised. Low loss coaxial relays that are effective at 24 GHz are very rare and prohibitively expensive. Furthermore, most components have waveguide interfaces and would have to be converted to coax using transitions that take space and present some loss. These switches are also rare, but when using high power some type of relay is necessary. There have been some enterprising amateur fabrications of WR-42 switches.

Kits, components and entire transverters have been described in *DUBUS* magazine, and offered by DB6NT (follow the links in the resources). Although they are somewhat costly, amateurs often report excellent results with these components and systems—designed and built by amateurs.

Amplifiers

Only recently have 24 GHz power amplifiers become available to amateurs. Some are surplus from the communications industry attempt to develop LMDS—a broadband RF system. Some amplifiers from these developments have been sold through popular on-line auctions and occasionally on microwave e-mail reflectors. Without an amplifier, a mixer is likely to produce no more than –10 dBm or 100 mW, whereas a modest amplifier could deliver a quarter of a watt or +24 dBm. This results in being heard with a 34 dB improved signal to noise ratio. Although this can easily make the difference between being heard and not, remember that both ends of a contact would have to be amplified in order to get the full DX advantage that the improved system margin provides.

A group of amateurs recently put together a small quantity development of 1 W amplifiers. This turned out to be a very tedious process, due to the difficulty in precise mounting of components and performing wire bonding to RF components. Such capability is out of the scope for most amateur assembly.

Resources

For microwave related information on waveguide sizes, connectors and links to other sites with information, newsletters and commercial sources, set your browser to **www.wa1mba.org/**.

You can also find information in *The ARRL UHF/Microwave Experimenter's Manual,* "Antennas, Components and Design" (Newington: ARRL, 1990-1997) Available from the ARRL Bookstore, **www.arrl.org/shop/**. ARRL order no. 3126.

Low noise amplifiers, much like power amplifiers, are usually found either as surplus or from special collaborative efforts. They are at least as much if not more rare than power amplifiers. A top performing LNA at 24 GHz might provide a noise figure of 2.5 dB, whereas a top-performing mixer may operate with a noise figure of 8 dB. The difference, about 5.5 dB, ends up in improved signal to noise ratio.

Dishes, Operating and Propagation

Most 24 GHz stations are tripod-mounted for hilltopping operation. Dishes are often used, and range in size from about 8 inches to 2 feet with 1 foot diameter being very common. Many dishes are surplus and fully constructed with feed systems for use in communications systems. Construction of a feed, and placement for optimum focus is very challenging.

Most upper-band contacts are made using liaison radios. In the US, we usually gather at 144.260 SSB, moving off from there to coordinate the 24 GHz contacts. Quite often stations will use liaison to establish contact at 10 GHz, and then move on to 24 GHz or higher bands during contests or other activity periods. Most systems have smaller diameter dishes on 24 GHz than on 10 GHz, resulting in similar pointing requirements.

Unfortunately, water vapor has an absorption line at 22 GHz that has an effect on the 24-GHz band. Therefore, the long-haul DX only happens when the air is dry. Although this can give disappointing results, there are many surprises where signals are quite strong. There is rain and snow scatter at 24 GHz, and in very light drizzle, when scattering is not effective on 10 GHz, rain can provide very good propagation at 24 GHz.

Getting Started

As with all microwave exploration, the best way to get on is to find someone else to work with. I advise you to get on 10 GHz first. With luck, there is a club or an organization in your area that has interest, or perhaps someone who has already managed to put together a 10 or 24 GHz system. Usually this happens in at least pairs! Join a microwave e-mail reflector, subscribe to microwave newsletters, get a copy of microwave experimenter's books from the ARRL.

Next Issue

This issue completes two years of publishing this column. The ARRL has continued to show support in the more technically advanced parts of our hobby by publishing this and other columns in *QST*, and in its technical publication *QEX*. As of this writing, I am not sure where the next column will lead me, but I anticipate that the next year will be as much fun as the last two have been.