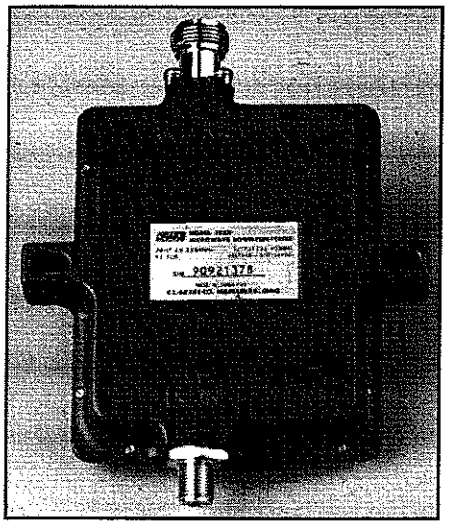
By Steve Ford, WB8IMY

Microwaves in Your Backyard

You can have 2.4-GHz receive capability for less than $300.



The Drake model 2880 microwave downconverter.

As a ham you must always be on the alert for unique opportunities. You never know when you'll get a chance to try something new—at substantially less cost than you thought possible!

Recently the R. L. Drake Company abandoned a product line that was designed for the consumer MMDS TV market. As a result, they wound up sitting on a large quantity of microwave downconverters. In their unmodified states, these devices convert 2.4 to 2.7 GHz to approximately 120 to 420 MHz, although most of the conversion gain is above 200 MHz.

Lyle Johnson, WA7GXD, broke the news on the AMSAT e-mail reflector about the availability of the downconverters and the fact that they could be easily modified for 2.4-GHz ham applications. He learned of this while on a trip to Japan (where the units were originally manufactured). I spoke with Mike Brubaker, WA8NOP, vice president of marketing at Drake, and he confirmed that the downconverters were indeed available for only $63.50. That's substantially less than the prices of the least expensive 2.4-GHz downconverter kits. I had to have one!

With my downconverter on the way, Tak Okamoto, JA2PKI, faxed the modification instructions in Japanese. Although I can't read a word of Japanese, Tak's English notes, and the drawings in the instructions, showed just how easy the modification really was.

If you plan to use the downconverter with a wide-range all-mode receiver (one that can tune down to 120 MHz), all you need to do is boost the conversion gain below 200 MHz. If you want a 2-meter IF beginning around 144 MHz, however, you need to replace the oscillator crystal. Although I own a rig that can tune to 120 MHz (my ICOM IC-706), I know that many hams are using less capable receivers or transceivers. With that in mind, I decided to try the 144-MHz IF mod as well.

The first step was to order a crystal for 8.8125 MHz from JAN Crystals. With the multiply-by-256 scheme the downconverter oscillator circuit uses, I figured it would put me on target ([2400 – 144 MHz] ÷ 256 = 8.8125 MHz). I specified a high-grade (10 ppm) crystal in an HC-49/U holder with a load capacitance of 24 pF. The total with shipping was $22.50.

From what I knew of the downconverter specifications, I figured that a 2.4-GHz preamplifier wouldn't be a bad idea. A call to Down East Microwave was all it took to order their model 13LNAH. Total cost: $125.

Assembling the Antenna

While I waited for the arrival of the crystal and the preamp, I ordered the SB-32DXC Mode-S parabolic antenna from R. Meyers Communications. The "barbecue grill" antenna arrived within days and was assembled in less than 30 minutes. This is a no-tune design complete with a subreflector feed and a coax "pigtail." That's perfect for a microwave newbie like me. You just assemble the pieces and it works. No test equipment required!

Once you have the antenna ready to go, you need somewhere to put it. I'm not blessed with an azimuth/elevation rotator, so the "armstrong" method of antenna aiming would have to do. I set up a small Radio Shack roof tripod in my backyard, but I still needed a mast that would allow me to rotate and tilt the antenna by hand.

A quick trip to the hardware store solved the problem. I bought a 12-foot section of 1½-inch diameter PVC pipe, along with some matching PVC elbows and Ts. An hour later I had cobbled together a contraption that resembled a giant old-fashioned

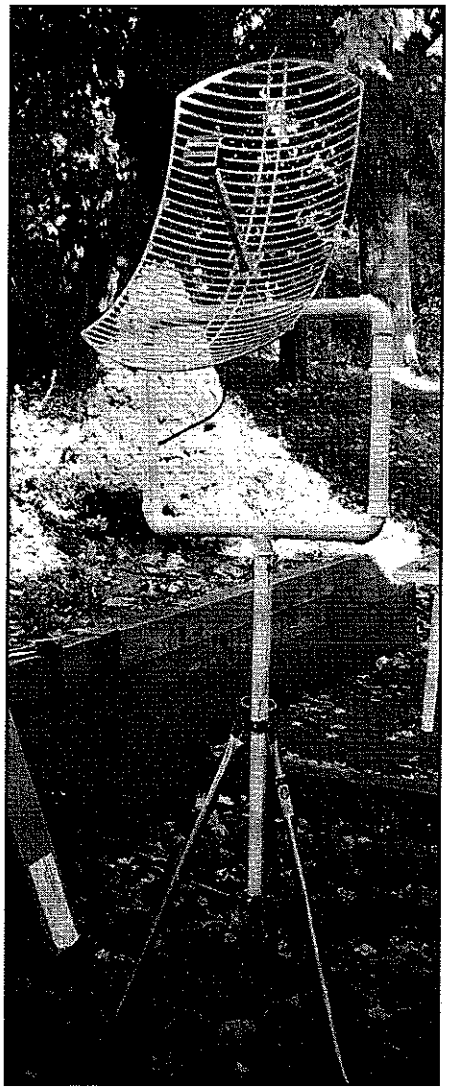


Figure 1—It's amazing what you can do with some PVC pipe, a hacksaw and some PVC cement. This contraption allows me to manually maneuver the antenna side to side and up and down.

Shopping List

These are *not* the only vendors who supply microwave equipment and other hardware. However, they are the ones I used for this particular project. See the advertising pages of *QST* for alternative sources.

Model 2880 downconverter: Available from the R. L. Drake Company, Sales Dept, 230 Industrial Dr, Franklin, Ohio 45005-4496; tel 513-746-4556 ext. 340; fax 513-743-4510; e-mail **sales@rldrake.com**. All major credit cards accepted. Total cost with shipping: $63.50.

Crystal: 8.8125 MHz, HC-49/U holder, 24 pF load capacitance, 10 ppm grade. Contact JAN Crystals at 800-JAN-XTAL. Total cost with shipping: $22.50.

13LNAH 2.4 GHz receive preamplifier: Down East Microwave, 954 Rt 519, Frenchtown, NJ 08825; tel 908-996-3584; fax 908-996-3702; **http://www.downeastmicrowave.com/index.html**. Total cost with shipping: $125.

SB-32DXC parabolic antenna: R. Meyers Communications, 37835 N 10th St, Phoenix, AZ 85027; tel 602-465-0936; e-mail **bmyers@primenet.com**; **http://www.primenet.com/~bmyers/**. Total cost with shipping: $64.95.

Double-male N adapter and N-female-to-F-male adapter: Cable X-Perts, 416 Diens Dr, Wheeling, IL 60090; tel 800-828-3340; **http://cablexperts.com**. Total cost with shipping $6.55.

Table 1
ARRL Lab Tests of the Modified Drake 2880 Downconverter

Frequency conversion: 2400.000 MHz to 143.785 MHz

Frequency (MHz)	*Gain (dB)*	*Noise Figure (dB)*
144	19.4	6.2
148	19.7	5.9
154	20.0	5.4
164	21.8	4.9
174	24.5	4.5
184	25.6	4.3
194	24.9	4.1

Draws 0.21 amps at 13.5 V. Works down to 12 V without significant degradation.

bottle-cap opener (Figure 1). Strange as it looked, it did the job. Later that same afternoon the crystal arrived in the mail. It was time to modify the downconverter!

Modifying the Downconverter

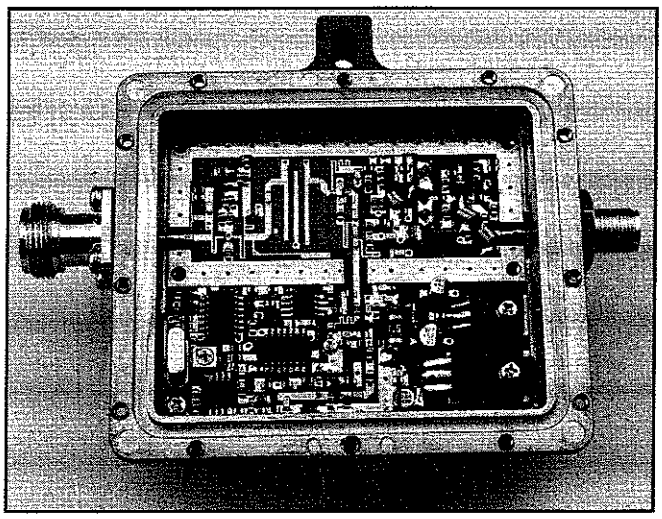
Many hams approach surface-mounted components, such as those found in the Drake downconverter, with apprehension. I'm one of them! When you're manipulating capacitors the size of crushed bacon bits, it's easy to become a bit frayed around the edges. Because I was testing the simplicity of this modification, I deliberately avoided using magnifiers to help me spot the little devils. Despite the handicap, the entire modification was finished in less than 30 minutes.

I kept notes and, in the end, I realized that it all boiled down to just four easy steps...

Step 1: Remove all the tiny screws and open the protective case. Don't lose the thin rubber gasket! Now remove the four small screws that secure the internal metalized plastic shield.

Step 2: Locate the red coils (Figure 2). You'll find them near the **F** connector. Using a soldering iron with a fine tip, remove the two red coils and the two chip capacitors immediately beneath them. I used a pair of tweezers to gently pull away the coils as I melted the solder. I was considerably less gentle with the chip capacitors. As I melted the solder connections I simply flicked them off the circuit board with a small screwdriver. This modification dramatically improves the output gain of the downconverter below 200 MHz.

Step 3: The Drake downconverter is designed to accept its dc supply through the coaxial cable itself. If you intend to feed 12 V dc to the downconverter through your coax, skip this step. I wanted to use a separate line to power both the downconverter and the preamp, so I removed the "power feed coil" as shown in Figure 2 and soldered a lead to the cathode side of the diode shown in Figure 3 using RG-174 coax. I attached the braid to the nearest ground point I could find. I also drilled a hole in the lid of the case to pass the power lead to the outside world. A little silicone sealant sealed the hole against moisture intrusion.



The cover plate and internal shield are removed. The downconverter is ready for modification.

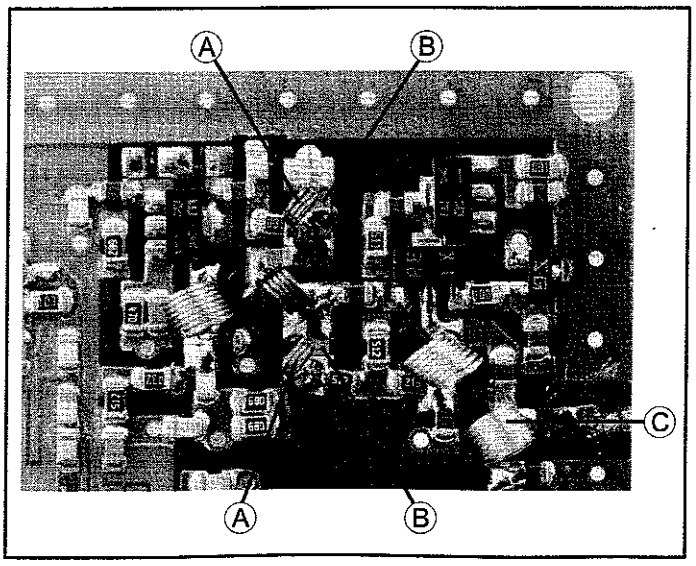


Figure 2—You must remove the red coils (A) and the chip capacitors underneath them (B). If you plan to feed 12 V to the downconverter from an external source (rather than through the coax), remove the coil in the lower right corner as well (C). This coil is directly adjacent to the inside of the **F** connector.

If you don't intend to replace the crystal, stop here. You're done!

Step 4: Remove the circuit board by first unsoldering and removing the **N** connector. Unsolder the inside tip of the **F** connector, but don't remove it. Remove the corner screws, the screw beneath the thin vertical shield (just bend the shield over to reach it) and the two heat-sink screws.

Once you have the circuit board out of the case, unsolder the existing crystal and replace it with your new 8.8125 MHz rock (see Figure 4). Install the leads so that you can bend the crystal horizontally over the trimmer capacitor. The HC-49U holder is too tall to fit inside the case if you stand it straight up.

Zack Lau, W1VT, ARRL Senior Lab Engineer, was kind enough to test my modified downconverter. His results are shown in Table 1. As you can see, the gain is about 19 dB at 2.4 GHz, which is not bad. The noise figure, on the other hand, is about 6 dB at the 144 MHz IF. That's quite high compared to microwave downconverters that hams are accustomed to using. But keep in mind that this unit was never intended for amateur use; this is a *consumer* product. According to Zack, the high noise figure wouldn't be a problem for satellite monitoring, especially with my preamp and gain antenna.

You'll also see in Table 1 that the modification of the downconverter's oscillator worked as anticipated. It now converts 2400 MHz to 143.785 MHz, just below the bottom edge of 2 meters. Many 2-meter all-mode rigs will receive slightly below 144 MHz. If your rig refuses to do so, however, you can tweak the trimmer capacitor and bring the 2400 MHz conversion up to 144 MHz exactly.

With Zack's blessing in hand, my experiment was good to go.

Listening for DOVE-OSCAR 17 and OSCAR 11

While I was awaiting the arrival of the preamp, I installed the downconverter at my antenna and routed a length of 50-Ω coax from my transceiver. I used an N-female-to-F-male adapter to connect the coax to the downconverter. (The impedance of the output stage of the downconverter is actually 75 Ω, but the slight mismatch isn't worth worrying about.) I also threaded a dc power line back to my shack. I applied power to the system and heard a very satisfying roar in my headphones.

According to my satellite-tracking software, the next DOVE pass would occur across my western horizon, peaking at an elevation of about 50°. I aimed my dish at the peak point and waited.

DOVE came screaming through the sky right on time. Its carrier rose suddenly out of the noise as it passed within the antenna pattern. DOVE's S-band beacon is at 2401.221 MHz, but I started listening with my rig set at 145.06 MHz, which corresponded to 2401.275 MHz ([145.06-143.785] + 2400). It took a steady hand on the **VFO** knob to compensate for the incredible Doppler shift. In my excitement I kept overcompensating, creating a disconcerting "police siren" effect. (Thankfully, we won't experience this degree of Doppler shift when operating through Phase 3D!)

It was obvious that my system was working like a champ! If I could receive DOVE this well using the downconverter by itself, I imagined what a low-noise preamp could do. I didn't have to wait long to find out.

The preamp arrived a week later and I installed it right away. I used a double-N connector and attached the preamp right at the input of the downconverter. The difference was astonishing. DOVE's data beacon wasn't just audible, it was *loud*. I could also hear the very weak S-band beacon from OSCAR 11.

I shared my results with Lyle Johnson, WA7GXD, and Ed Krome, K9EK. Both were confident that I would have no problem obtaining "armchair" copy from Phase 3D with this inexpensive little system.

Crude Radio Astronomy

But Phase 3D isn't scheduled to fly until later this year. What to do until then? Darrel Emerson, AA7FV, supplied an intriguing idea—radio astronomy! He said that the receive bandwidth of my IC-706 was too narrow to perform neat tricks such as detecting emissions from stars. Even so, Darrel suggested that it might be possible to detect other extraterrestrial signal sources. "Just point the antenna skyward and see what happens!"

Using a copy of AF9Y's *FFTDSP* software (see his page at **http://www.webcom.com/af9y**), I was gratified to discover that I could detect interesting noises and signals (see Figure 5). I'm currently teaching myself more about astronomical coordinates so that I can determine what the sources might be. If I could get my hands on a wide-bandwith VHF receiver and the software necessary to measure noise variations over time ... hmmm! This could be grist for another project!

Conclusion

If you don't own a 2-meter all-mode rig or a wide-range all-mode receiver to use with this downconverter, you have a couple of alternatives. One is to find a *used* all-mode radio such as the Kenwood TS-700 (selling for about $250). The other is to use *another downconverter* to step the 2-meter IF down

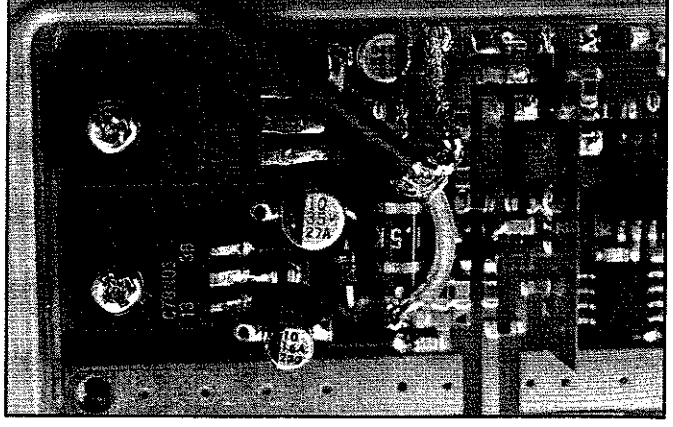


Figure 3—I used thin RG-174 coax as a dc power cable. The center conductor is soldered to the cathode of the diode as shown. The shield is soldered to a nearby ground point.

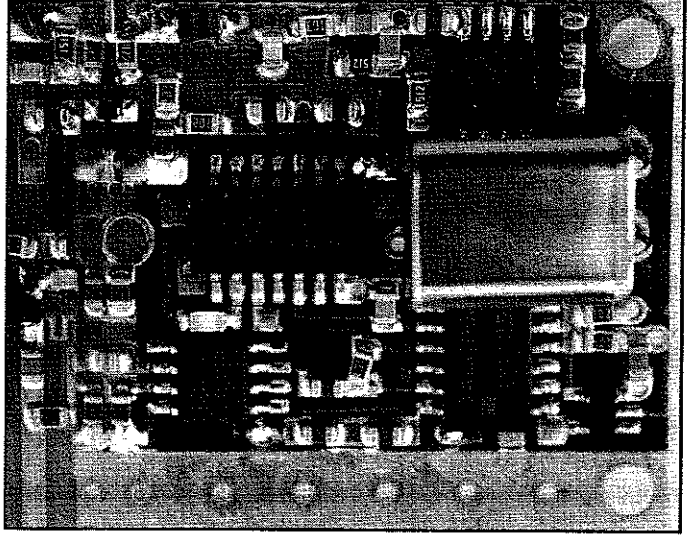


Figure 4—The crystal comes with long leads, which is a good thing because you need to bend the holder horizontally to squeeze it into the downconverter case.

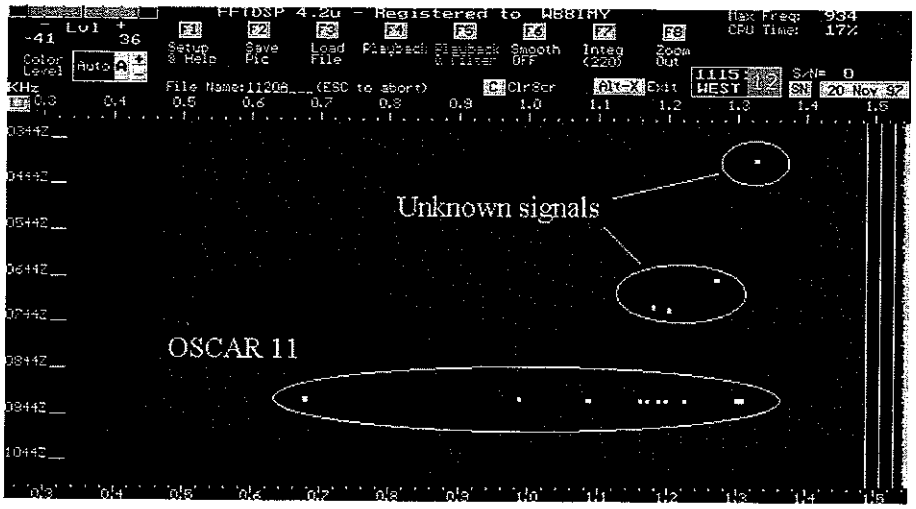


Figure 5—On the night of November 20, 1997 (UTC), I pointed my antenna straight up, started AF9Y's *FFTDSP* software and went to bed. In the morning I was greeted with the display you see here. The cluster of dots indicates detection of unknown signals in the late evening and early morning, possibly reflections from aircraft. The thin line of dots marks the detection of OSCAR 11's S-band beacon as the satellite zipped through the antenna pattern directly overhead at about 0920 UTC. (Because the receive frequency and antenna were fixed, OSCAR 11 was detected for only a very short time.)

to the HF bands (typically 10 meters) where you can listen with a transceiver or shortwave receiver. The costs and noise levels will increase, but this approach *does* work. SSB Electronic (tel 717-868-5643) and Down East Microwave both sell 2-to-10 meter converters that will do the job.

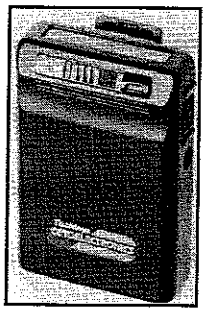
If you want a more sensitive system with a lower noise figure, SSB Electronic, R. Myers Communications and Down East Microwave all sell "ham-grade" 2.4 GHz downconverters and preamps. But remember that the purpose of this experiment was to explore microwaves *on a budget*. With a total cost of less than $300, I'm one very satisfied "customer"!

When Phase 3D flies, I'll be ready. With 10 W on 70-cm to a small 10-element beam, I'd have more than enough muscle to work Mode U/S. In the meantime I'll be listening to DOVE, OSCAR 11 and...who knows?

Special thanks to Lyle Johnson, WA7GXD, Ed Krome, K9EK, Darrel Emerson, AA7FV, Tak Okomoto, JA2PKI, Mike Brubaker, WA8NOP, and Zack Lau, W1VT. QST

New Products

MICRO DTMF DECODER FROM OPTOELECTRONICS



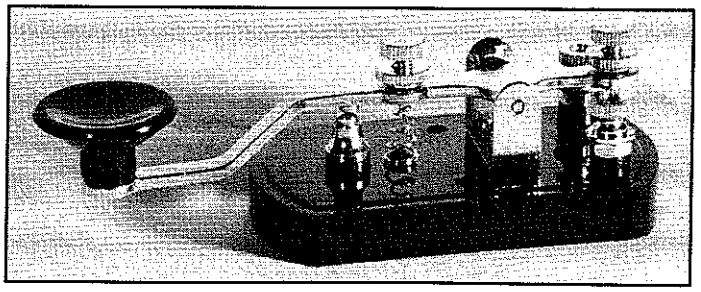
◊ Housed in a stylish pager-style enclosure, Optoelectronics' Micro DTMF Decoder is the first product to be released in the company's Techtoyz line. Designed for portable, hands-free operation, the unit features a built-in mike, an audio input jack, a 12-digit LCD and a 2000-character non-volatile scrolling memory. Other features include 200-hour battery life; a decoding speed of 12.5 characters per second; and automatic decoding.

Price: $89. For more information, contact Optoelectronics at 5821 NE 14th Ave, Ft Lauderdale, FL 33334; tel 800-327-5912, fax 954-771-2052.

A MORSE CODE STRAIGHT KEY FROM MFJ

◊ MFJ's "antique-look" straight key features adjustable contact spacing and solid construction. The MFJ-550 Morse key is a handsome "back-to-basics" product that celebrates the company's 25th year in business.

Price: $7.95. The MFJ-550 is covered by the company's "no matter what" one-year unconditional warranty. If the telegraph key isn't available at your favorite ham radio dealer, contact MFJ at PO Box 494, Mississippi State, MS 39762; tel 800-647-1800; fax 601-323-6551; **http://mfjenterprises.com.**



WEATH\ERLINK DATA LOGGER FROM DAVIS INSTRUMENTS

◊ Designed for SKYWARN, APRS, ARES and advanced hobbyist applications, Davis Instruments' WeatherLink data logger stores monitored weather data when your computer is turned off and transfers information when the unit's graphical software is activated.

Features include integrated database functions; graphical charts and displays; calculated averages; summaries; trend identification and more. Davis' BBS has APRS-compatible software for SKYWARN/ARES interconnects.

Price: $165. For more information, contact Davis Instruments at 3465 Diablo Ave, Hayward, CA 94545; tel 510-732-9229, fax 510-732-9188; **http://www.davisnet.com.** QST