A One-Stage 80 Meter CW Transmitter

Home-Brew Fun

by Mark A. Boucher WB3ELL

After your first contact with a rig you've built yourself, you'll understand why old-time hams make such a fuss about the fun they had building their own ham gear in the old days. You may be starting to pale on your several kilobuck all-band transceiver, but I'll bet once you start making contacts with this 80 meter transceiver, you'll be hooked.

I've tried several circuit variations and found that this one uses the fewest parts and gives the best performance. Even better, if anything ever does go wrong with it, you'll be able to fix it yourself. You won't need a modern laboratory to check microprocessor controls.

The only major problem with this transceiver will be getting you to shut up about the fun you're having with it and to stop driving your ham club members bananas. You might just talk'em into making a club project out of it.

Overview of the 80 Meter Transmitter

During receive this radio is basically an 80 meter crystal-controlled self-excited direct conversion receiver; during transmit it is a power RF oscillator. The weakest audible signal is 0.1 to 0.3 microvolts. The power out during transmit is in the 1 to 3 Watt range, and runs on 12 volts DC.

The single stage that this unit uses is an IRF-511 high gain power MOSFET (RS 276-2072). I screwed two Caltronics HS-109 heat sinks to the MOSFET, after spreading thermally conductive paste between them. During receive, this stage acts as a low-level RF oscillator with the RF coupled to a 3-diode detector circuit. The audio output from this is amplified back through the same power FET, going through a 1k to 20kΩ step-up transformer to a quality crystal earphone. This audio output configuration is far more sensitive than anything else that I have tried.

During transmit, the receive section is switched out with the 6-pole T-R relay, and the same tuned circuit is switched back in to become a simple power oscillator. This unit also has a single red/green Tx/Rx LED.

Construction Details

During receive, the antenna (50Ω) is connected to J2 and switched from pins 2–20 of the 6-pole double-throw TR relay through C7 to the 8-turn tap of T1. T1 has 30 turns, tapped at 8, of #26 enameled wire on a T50-2 toroid. The high side of T1 is switched from pin 3 to 19 during receive. From there it goes to C15 to the diode detector combination D1,2,3. These are standard germanium detector diodes. The signal injection is through C16, a 2 pF capacitor, to the junction of crystal Y1 and crystal trimmer C2. The output of the detector goes through the parallel combination of RFC1-C14. This combination provides audio coupling and the right amount of RF to cause an increase in sensitivity due to regenerative gain. This is coupled through C5 to pin 13 to 9, which goes directly to the gate of Q1.

Photo A. The completed DMOS 80 meter CW transceiver.

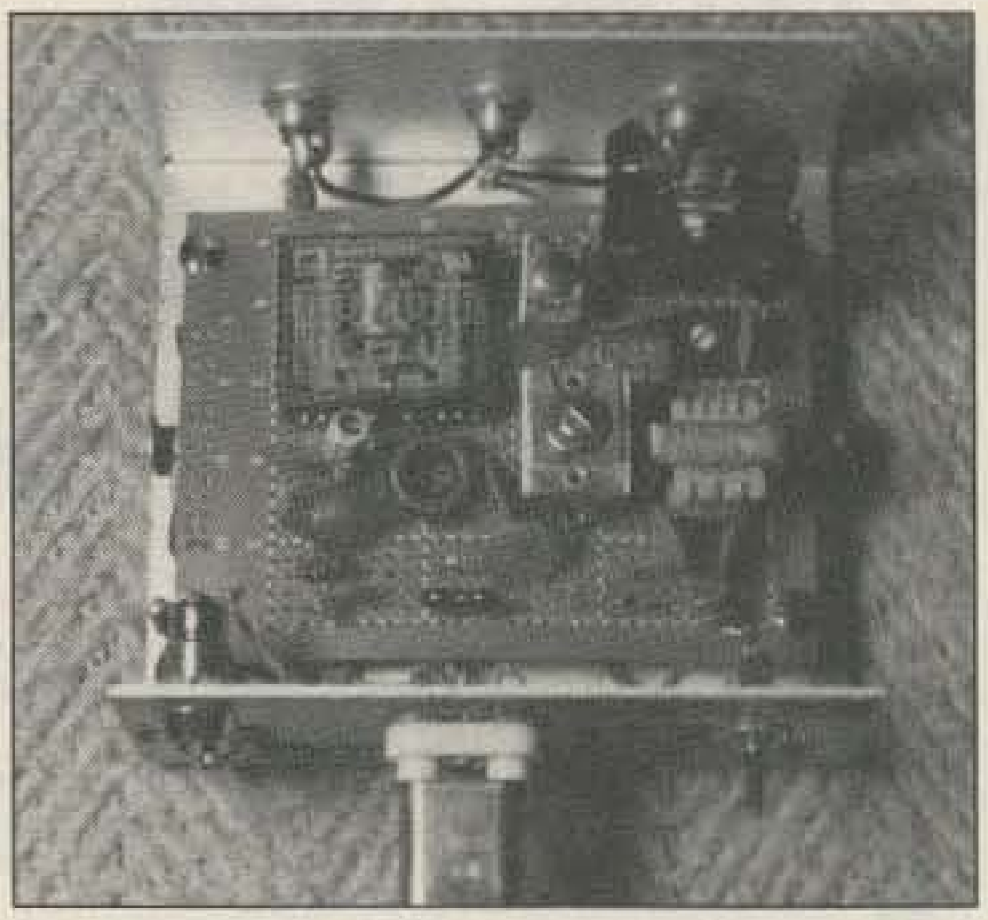

Photo B. An inside view of the DMOS 80 meter transceiver.

Q1 gets the right amount of bias with R1, a megohm trimpot. The drain of Q1 goes to pin 8, which is switched to pin 14 during receive. Pin 14 goes to the 1k ohm primary of audio transformer T2. The 20k secondary goes to the crystal earphone through C20 to J4. Also at this point are C17-C18, which attenuate the higher audio frequencies for a narrower receive bandwidth, and D4-D5 that limit the amount of audio going to the earphone and eliminate a severe transmit-receive keying click.

Crystal Y1 is a general purpose, higher drive fundamental 80 meter crystal (I.C.M. p.n. 031080). This crystal is switched in series with the parallel combination of C2-C19 during receive. C2 is the crystal trimmer adjustment. The receiver is most sensitive when the trimmer is at the minimum capacitance the oscillator will consistently start at. When adjusted to this point, the oscillator frequency is shifted higher by several hundred Hertz. During transmit, this is shorted out to give the oscillator more power and to provide the necessary sidetone shift between transmit and receive to be able to hear stations transmitting on your frequency.

During transmit, the +12 volt supply to the drain of Q1 is switched from T2 to T1 through pins 8 to 16 and pins 3 to 17. The transmit antenna is connected from pins 2 to 18, which then go to C8 and the drain of Q1. The high side of T1, which is already connected to the drain, also has the low side of the 3 transmit tuning caps C11, C12, C13 switched to ground through pins 10 to 11. Also, during transmit, the source of Q1 is grounded through pins 22 to 1.

This radio also has a red/green transmit/receive LED indicator. The +12 volts go through two 1.2k resistors R2 and R3, each to the red or green elements. During receive, voltage to the red LED is shorted to ground through pins 21 to 1. During transmit, voltage to the green LED is shorted to ground through pins 11 to 10, which are isolated from the transmit capacitor ground line by RFC2, the other 330 μH choke.

On the +12 volt input line, through J1, I put D6, a 3A, 50 volt silicon rectifier for reverse polarity protection, and from there to the power switch and filter caps C3,C4.

The keyline comes in through J3, and goes to pin 5, the minus side of RY1, the TR relay. The other side, pin 6, has +12 volts on it. This relay keys normally

Continued on page 30

Continued from page 28
with either a hard or an electronic keyer.

I mounted the parts on top of a Radio Shack 276-16B printed circuit board, and soldered wire jumpers between the different components on the bottom of the PC board. The bottom is quite a mess! It is also important to keep the crystal leads as short as possible, or to mount the crystal on the board itself, as with longer leads. The crystal has lower RF drive going to it, and a tendency not to start. I found this out when I mounted the crystal on the front panel.

Tuning the 80 Meter Transmitter

As for tuning the unit up, make sure that the crystal oscillator is running. The best way is by listening to it on another 80 meter receiver. You would want to make sure that the crystal trimmer capacitor is tightened down all the way, at maximum capacitance, and then adjust the 1 megohm trimpot R1 to the point where the crystal oscillates, which should be about mid-range. Then put an RF signal generator in on the antenna input. Or you could hook the antenna up to it and run a different 80 meter transmitter into a dummy load as a signal source. You then adjust receive tuning trimmer C1, a 600 pF trimmer, for a peak in the audio tone in the earphone. If you do not get a peak you may have to increase or decrease the value of C10, a 150 pF fixed cap.

When you have a peak, the next step is to adjust the crystal trimmer C2 for the least capacitance that the oscillator will consistently run at. You may have to readjust R1 slightly to do this. The next step is to hook this up to a wattmeter, preferably with a dummy load on it. I have a Heathkit HM-9 QRP wattmeter and an HFT-9 antenna tuner that work fine with this unit. Now, with the unit keyed, it should read about 1-5 Watts out during transmit. You should, of course, listen to the transmitter with an 80 meter receiver to make sure that the keying is clean. If the oscillator starts a little too slowly during transmit, readjusting R1 slightly should take care of it.

Transmitting

Next, hook it up to the antenna and try transmitting. If you have a high SWR, Q1 will get quite warm. When this happens, the gain drops slightly. During receive this could cause the oscillator to cut out. You might have to increase the crystal trimmer C2 capacitance or change R1 slightly to make this work correctly. So initially, there is a kind of balancing act between these controls, but when adjusted correctly it is sensitive, stable, and has enough power out to make more than local contacts.

If you have a frequency counter, you might want to make sure that the output during transmit is on 80 meters. If you use a cheap, low-drive crystal, such as a 3579 kHz TV, you could have 40 meter and higher harmonics during transmit, due to the high gain of Q1. You may have to add an 80 meter bandpass filter at the antenna, but with the ICM crystal, and the right values of switched-in parallel tuning capacitors C11, 12, and 13, this is not a problem for me.

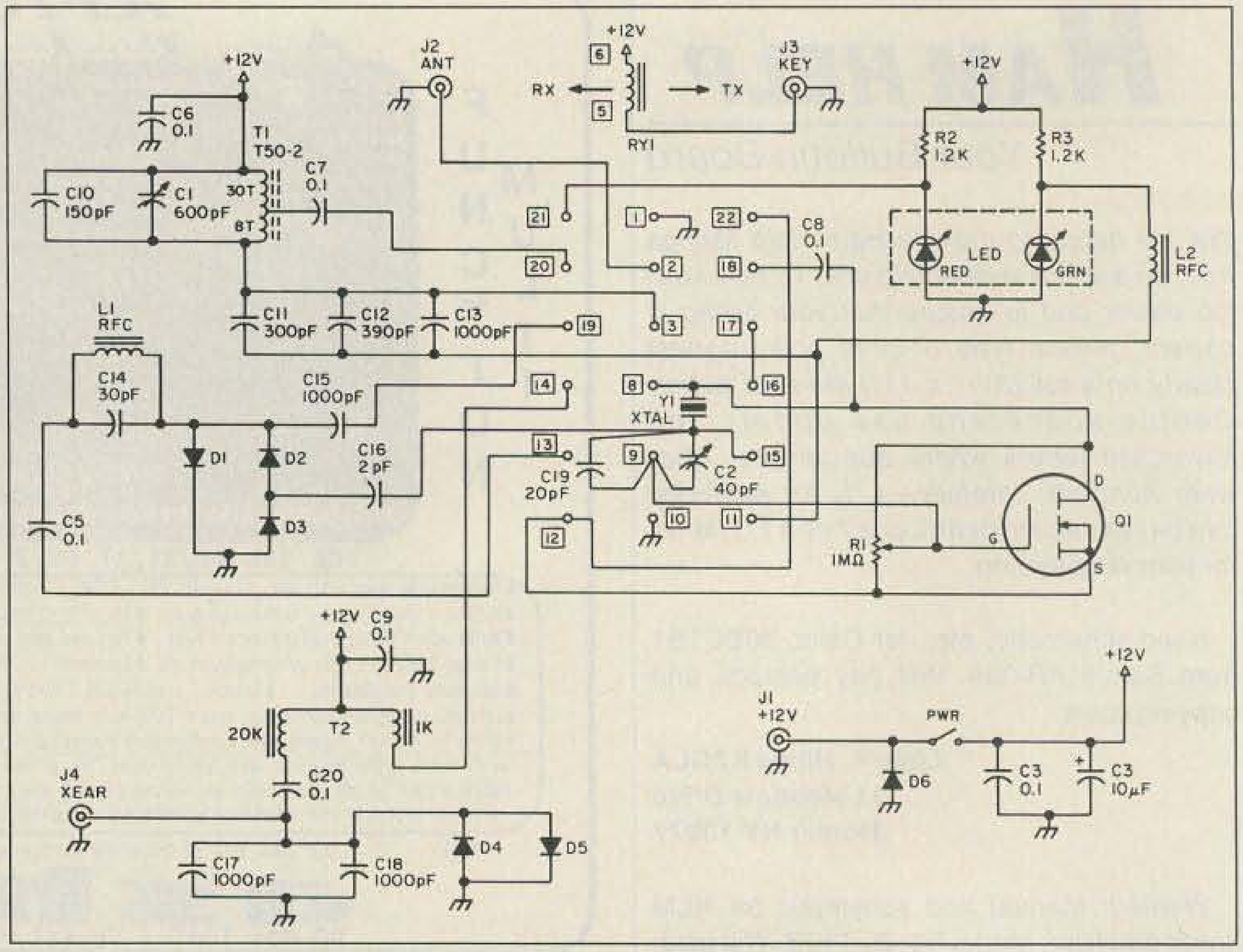

Figure 1. Schematic of the WB3ELL DMOS 80 meter CW transceiver.

Operating the 80 Meter Transmitter

For actual operation, I have a 66-foot, low long-wire, grounded only by water. But I have, even during daytime, contacted KA3CKS, a cousin of mine who lives 12 miles south of here. He has a similar antenna, and a typical 100 Watt output transceiver. At

Parts List

1 Stage 80 Meter CW Transceiver

Symbol	Supplier	Part No.	Description
Q1	Radio Shack	276-2072	IRF-511 N-Channel Power MOSFET
LED 1	Radio Shack	276-025	Red/Green LED
D1,2,3	Radio Shack	276-1123	Germanium Detector Diodes
D4,5	Radio Shack	276-1101	1A,50 V Silicon Rectifiers
D6	Radio Shack	276-1144	3A, 50 V Silicon Rectifiers
RY1	Aromat Corp.	NL6EX-DC5V	6PDT TR Relay
Y1	Intl. Crystal	031080	80 M Experimenters' Crystal
XEAR1	Philmore	747	Crystal Earphone
T1	Amidon Assoc.	T50-2	Toroid
T2	Calectro	D1-719	1k/20k Audio Transformer
RFC1,2	J W Miller	9230-80	330 µh RF Choke
R1	JIMPAK	840P1 Meg	1 Megohm, ½ Watt PC Pot
C1	Calectro	A1-249	600 pF Compression Trimmer
C2	Calectro	A1-246	40 pF Compression Trimmer
C3	Panasonic	A1CV100	10 µF, 100 V Electrolytic Cap.
C4,5,6,8,9,20	Panasonic	21CM100	0.1 µf, 100 V Cap.
C7	Panasonic	21CM010	0.0l µF, 100 V Cap.
C13,15,17,18	Panasonic	21CM001	0.00lµf, 100 V Cap.
C12	Elmenco	DM10-391J	390 pF Cap.
C11	Elmenco	DM10-301J	300 pF Cap.
C10	Elmenco	DM10-151J	150 pF Cap.
C14	Elmenco	DM10-300J	30 pF Cap.
C19	Elmenco	DM10-200J	20 pF Cap.
C16	Elmenco	DMIO-020D	2 pF Cap.
SW1	Radio Shack	275-625	Micro Power Switch
J1,2,3	Radio Shack	274-376	Phono Jacks
J4	Radio Shack	276-24B	Mini Phone Jack
YS1	Steatite	33302	Crystal Socket
HS1,2	Caltronics	HS-109	Crystal Heat sinks
PCB	Radio Shack	276-168	Printed Circuit Board
CASE	Ten-Tec	TG-24	Enclosure

night, there is rarely a lack of signals in the 80 meter Novice band. The crystal I have at the moment is 3725 kHz, but I would recommend getting a 3710 kHz, because that is the QRP frequency and, at 3725 and above, there are Canadian SSB stations that cause interference.

The other 80 meter QRP frequencies are 3560 and 3535 kHz, but I rarely hear much activity on those frequencies with this radio. I have made contacts on the Novice band at night, when QRM happened to be at a lull at 3725, with local signals being loud and weaker signals coming from stations further away. With this radio I could not make any more contacts on 3725 than with my Ten-Tec Argonaut using the antenna I have, even though it is a vastly better radio.

One of the possible improvements to this radio would be to add a varicap in place of the crystal trimmer. You could give a crystal high drive to start it switching from transmit to receive, then reduce the drive by cutting back on the capacitance to the point of just oscillating. Also, low drive crystals might work with this and series resistance to the crystal. With this, the radio could work better on 24 volts, where now it has a reduction in gain instead of an increase.

You do not have to use the 6-pole double-throw TR relay. You could, of course, use a front panel 4-pole double-throw switch, and a 2-pole TR relay as long as you put the relay on the source-to-ground contacts, pins 1, 21, 22 and 10, 11, 12. Or you could have three 2-pole, double-throw DIP relays hooked together. Another solution would be to use a 4-pole front panel TR switch, switching the right bias in to the gate of Q1 with the key down.

"As for tuning the unit up, make sure that the crystal oscillator is running."

Personally, I am quite poor at copying CW, but the furthest contacts were in the 200-mile plus range. I had to struggle to pass my 13 wpm code test 12 years ago, but I still enjoy listening to CW and trying to make an occasional contact. I mainly enjoy low-band HF phone contacts.

Since this radio has a direct conversion receiver with a high gain audio amplifier, it will require either a battery with +12 volt supply, or a properly filtered supply to eliminate direct conversion common-mode hum. The Ten-Tec supply I have now works perfectly well as is, with absolutely no hum whatsoever. Any recent *ARRL Handbook* shows the circuitry required to stop this hum.

Problems and Possibilities

Now for a few of the radio's inherent problems. First, I was quite surprised when I hooked this radio up to two different RF signal generators and found that the weakest audible signal was actually 0.1 microvolts. From the volume of received signals, I personally thought it would be in the 10 microvolt range. That is, the receiver is fairly sensitive, but the actual volume is on the low side, unless you are receiving stronger signals. Also, since this has an unbalanced diode detector circuit, it radiates a low-level oscillator on the antenna during receive, and does a great job of detecting AM signals. What this means is that while you can hear the CW signal you are trying to copy, you will also hear any strong local 75 meter SSB, and any strong local or foreign AM short-wave broadcasts.

On 40 meters and higher at night, this radio is totally saturated with AM short-wave BCI. Because this radio has a fairly low volume to begin with, any selective audio filter causes too much of a decrease in volume. The same thing occurs when putting a balanced diode detector on the front end of this receiver: too much of a loss in volume, so the oscillator is stuck with some antenna radiation during receive.

I have spent a lot of time trying to make simple improvements on this radio by adding additional stages. I had a dual-gate MOSFET mixer in place of the diode detectors. It had a slightly higher gain and a greatly reduced tendency to pick up unwanted AM BCI, but it still had the other drawbacks of the original radio. I also tried using the dual-gate MOSFET as a self-oscillating mixer, and the IRF-511 as the audio output. This had a substantially higher gain, but it had problems causing strong receive signals to cut off the oscillator, creating a squeal.

The Solutions

The combination that ended up working the best was a dual-gate MOSFET mixer, an IRF-511 oscillator/audio preamp, and an IRF-511 audio output. During transmit, they easily switched to 1 RF-511 as a power oscillator, and the audio output to a sidetone generator. This, of course, was a lot more sensitive. The signals on the low end of 40 meters at night were quite loud, only occasionally being wiped out by AM BCI, because there was enough audio output to use a CW audio filter. Still, signals on 40 meters daytime were rather weak. So these radios worked, but they still had the major inherent problem of being single frequency crystal-controlled direct conversion receivers. Using a sharp enough audio filter to cut down on interference, you could not tune the signals to a peak because there was no VFO, and a VCXO on 80 or 40 meters is really no good.

Originally, I had planned to sell this idea, or to sell these radios as kits. But given the inherent problems these CW transceivers have, I decided to make the lowband voice transceiver kit that I had started before I began playing around with this. If you decide to make this radio, have fun with it! 73