

Breadboard a VCXO

Continuous 10 meter coverage from your CB.

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Novices, and Technicians, of which I am one, may operate CW and other digital modes from 28.1 to 28.3 MHz, and CW and SSB from 28.3 MHz to 28.5 MHz. All the reported activity on this band lately made me want to get involved.

CB-To-10

To successfully convert my Lafayette Tel-sat SSB-120 citizens band transceiver over to 10 meter operation, I needed to build a voltage-tuned variable-frequency crystal oscillator (VXO) that could be varied over a 5 kHz range without losing its crystal stability. What I built, however, might be useful to anyone who desires a VCXO (Voltage-Controlled Crystal Oscillator). This mod helps you get the most frequency swing possible with a voltage tuning range of 0.0 to 12.0 volts. In my case, it led to continuous 10-meter coverage.

On the amateur 10 meter band, only the upper sideband is used for voice modulation. For CW operation, the AM mode could be used to cause the transceiver to output a carrier by keying the PTT (push-to-talk) line and not applying any modulation via the microphone. The same offset crystal is used for both USB and AM modes in most, if not all, SSB CB radios (including the one that I con-

verted) so that, for a successful conversion, I had to worry only about getting one crystal frequency changed and working properly.

The Hitch

The CB channels, however, have a spacing of 10 kHz between them, and therefore the transceiver's PLL (phase-locked loop) circuit switches in 10 kHz steps. All SSB radios have a "fine-tune" or "clarifier" control on them for tuning in received signals, and there are conversions to allow that circuit to work during transmit as well. CB City International

(PO Box 31500, Phoenix, Arizona 85046) is a very good source of CB-to-10 meter conversion information. Also check with *73 Magazine* for their list of 35-40 articles on CB-to-10 conversions.

For operation on the amateur 10 meter band, you need continuous frequency coverage, and to get that, you need to make each channel frequency-agile to the tune of 10 kHz, plus fill in any "missing channels". Fortunately for me, the output of the oscillator is doubled by the radio's circuitry, so even if I could get only 5 kHz of total oscillator swing I could cover the entire 10 kHz-wide channel. Now all I had to do was try to build a crystal oscillator that could be voltage-tuned over a 5 kHz range.

The Answer

The approach I used was to "breadboard" an oscillator circuit. When I got everything

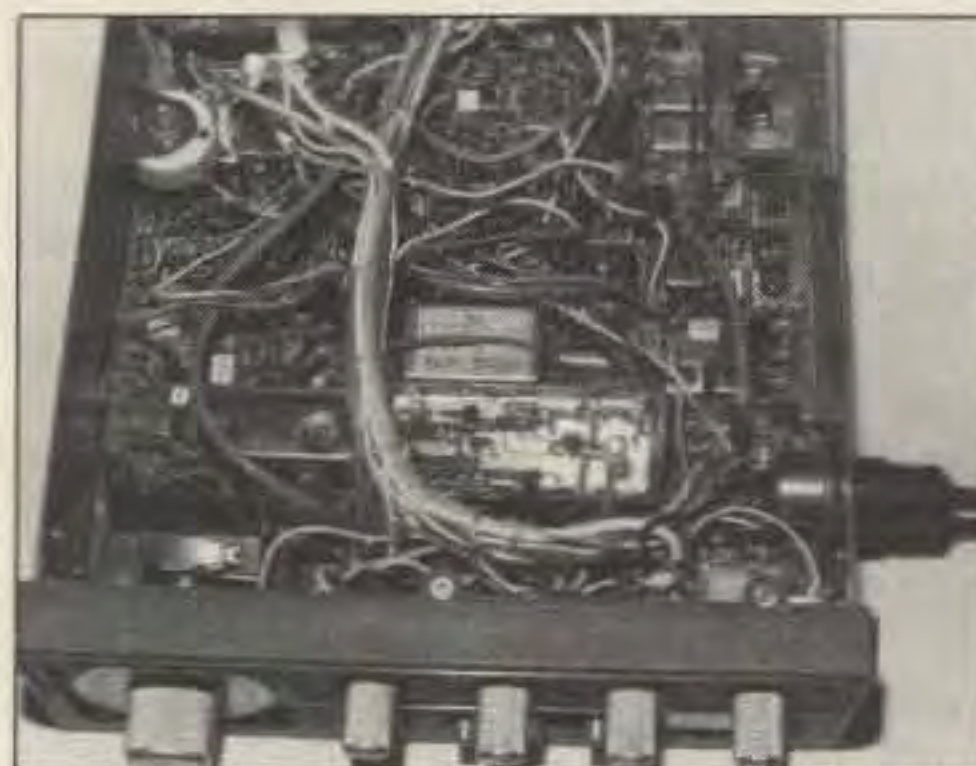


Photo A. The completed oscillator-buffer nestled in the converted CB transceiver, at front center of the rig. Tape the bottom of the board to prevent shorts.

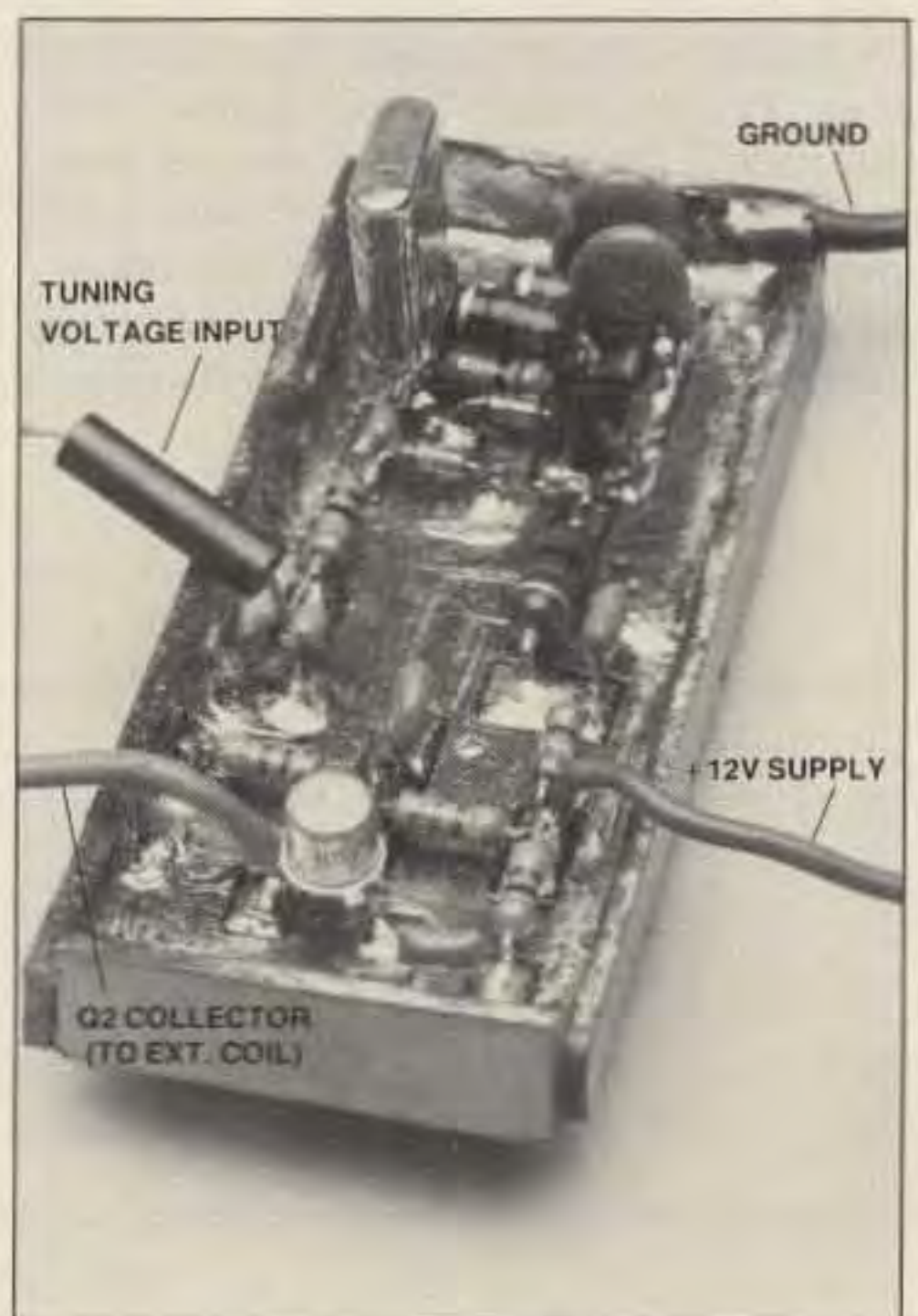


Photo B. The assembled VCXO mod.

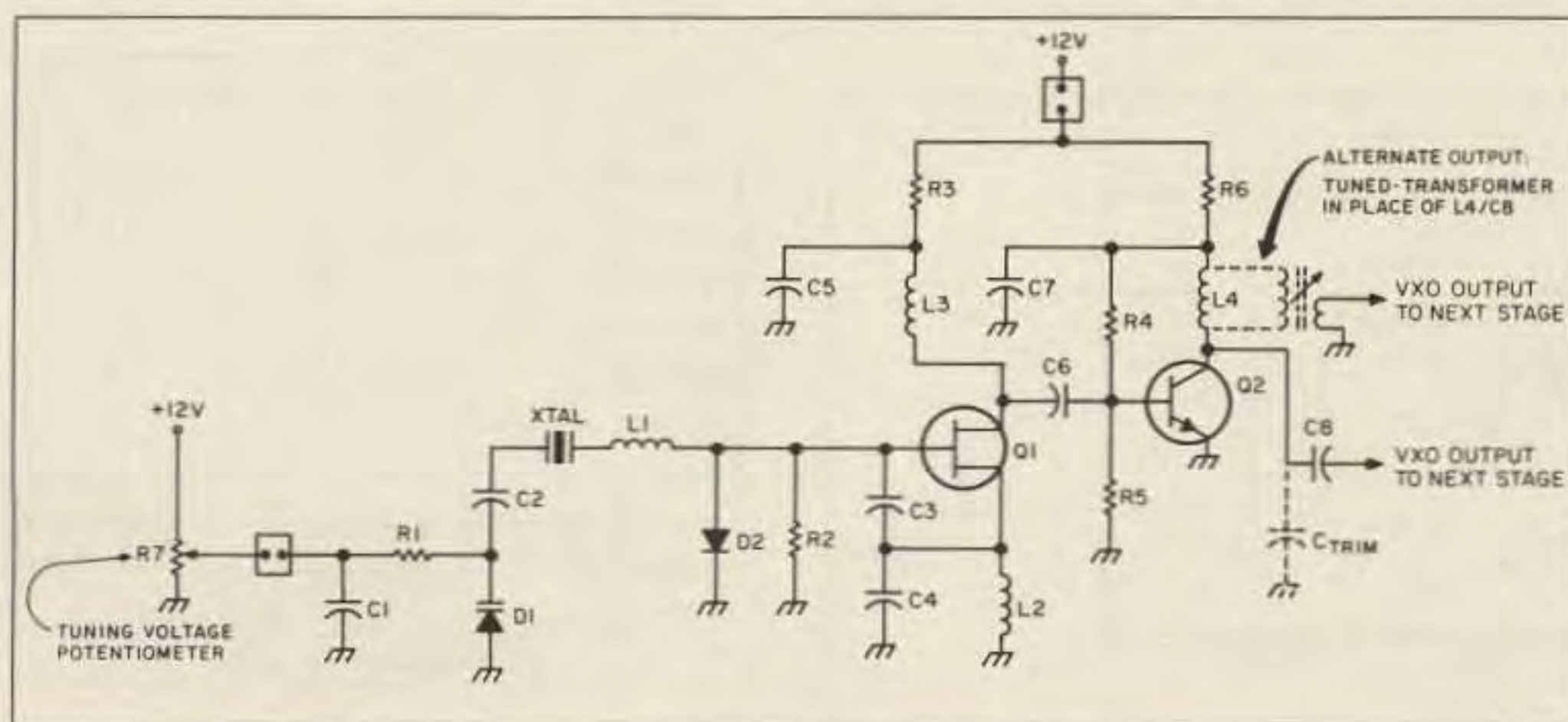


Figure 1. Schematic for the VCXO modification.

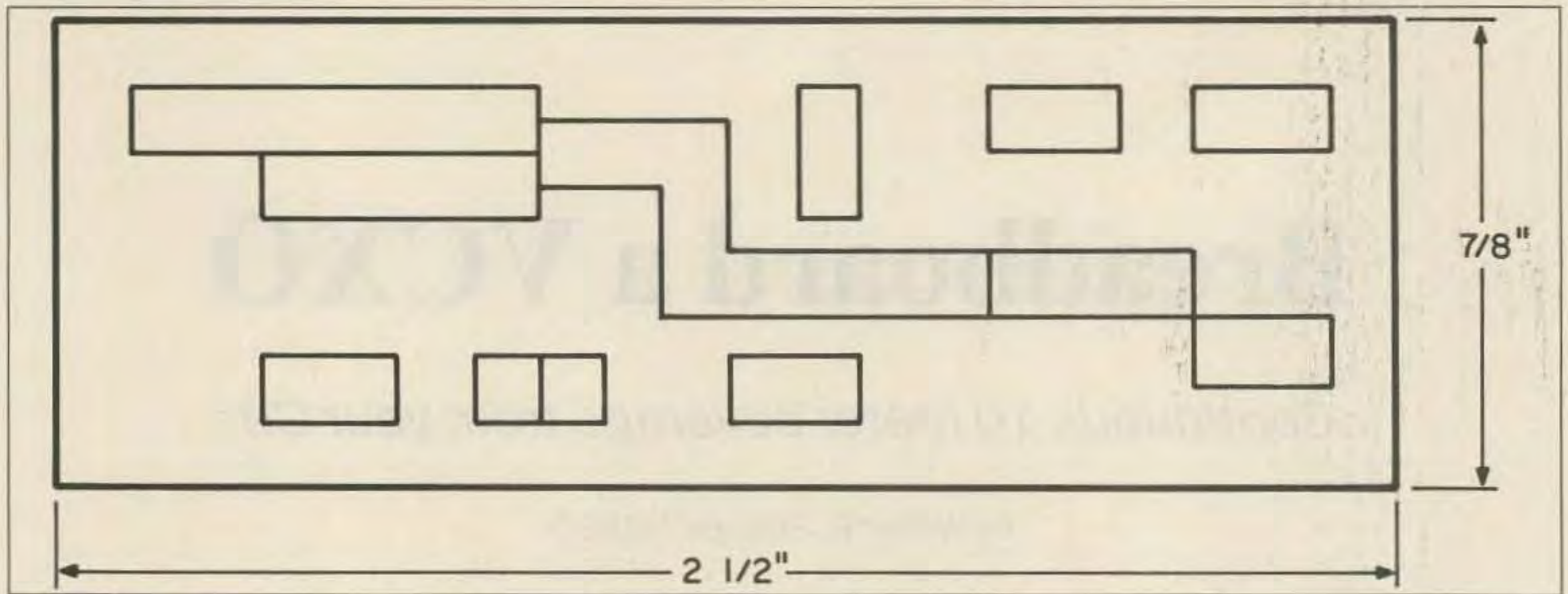


Figure 2. PC board foil diagram for the VCXO mod. The enclosed sections on the board are foil. Score between the sections with an X-acto knife.

working right (the frequency swing that I desired and sufficient output level), I installed it in the radio for the final test.

Figure 1 is the schematic of the VCXO mod. Figure 2 shows the etching pattern of the board. This can be "etched" with a ruler and an X-acto knife, or with a Dremel tool with a broken drill bit used as a router (my method). Figure 3 shows the parts placement on the board. Note that at the four sides of the board are strips of PC board soldered to join together the top and bottom ground planes of the double-sided printed circuit board. Photo A shows the completed oscillator-buffer installed in the converted CB transceiver. It may be necessary to put electrical tape on the bottom of the circuit board to prevent it from shorting anything out.

It is always good to first consult a reliable reference book when you are setting out to make a mod. Even if you don't find exactly what you are looking for, you may find something that does most of what you want, thereby making your job simpler. As my starting point, I looked under "VXO circuits" in the 1987 *ARRL Handbook*. (I believe that everyone who experiments with RF circuits should own a recent copy of the *ARRL Handbook*.) Included are "practical examples of crystal-controlled oscillators that can be frequency trimmed."

Crystals

I ordered two crystals of the same frequency—a 32 pF load capacitance (which is what

is commonly used), and a 10 pF load capacitance. Both were HC-18/U style holders with wire leads from Marden Electronics Company, Inc. (PH: 800-222-6093). Even with 5-day "rush shipping," the cost was pretty reasonable, and I've had good luck with crystals from them. As it turned out, under identical conditions, I got 300 Hz more swing from the 10 pF crystal (3.9 instead of 3.6 kHz) and, since it would oscillate higher in frequency, I could tune it above and below the desired center frequency. With a 32 pF crystal, all or most of my range would be below the desired center frequency.

Parts List		
Voltage-Tuned Crystal Oscillator		
Q1	MPF-102	FET
Q2	2N2222A	NPN
D1	MV-209	Varactor Diode
D2	1N4148	
XTAL	10.32625 MHz Crystal, 10 pF Load Capacitance	
L1	10 μ H	Coil
L2,L3,L4	100 μ H	Coil
C1,C2	0.001 μ F	Capacitor
C3,C4	25 pF	Capacitor
C5,C7	.01 μ F	Capacitor
C6,C8	100 pF	Capacitor
R1,R2	100k Ω 1/4 Watt	Resistor
R3	390 Ω 1/4 Watt	Resistor
R4	47k Ω 1/4 Watt	Resistor
R5	4.7k Ω 1/4 Watt	Resistor
R6	470 Ω 1/4 Watt	Resistor
R7	50k Ω	Tuning Potentiometer, Linear Taper

One 2 1/2" x 7/8" piece of double-sided printed circuit board
 Two 2 1/2" x 1/4" pieces of double-sided printed circuit board
 Two 7/8" x 1/4" pieces of double-sided printed circuit board

The Right Varactor

I used a varactor diode in series with a .001 mF cap in place of where the trimmer cap would go to make the oscillator voltage-tuned. A crystal will block DC, so the .001 mF cap may seem unnecessary, but I prefer to use it anyway to prevent applying DC tuning voltage to the crystal.

I tried several different varactor diodes in the circuit to see which would give me the most frequency swing over a 0.0–12.0 volt range, and the best was the varactor diode that was used to modulate the 1.7–1.8 MHz RF carrier of an old Radio Shack cordless phone base unit.

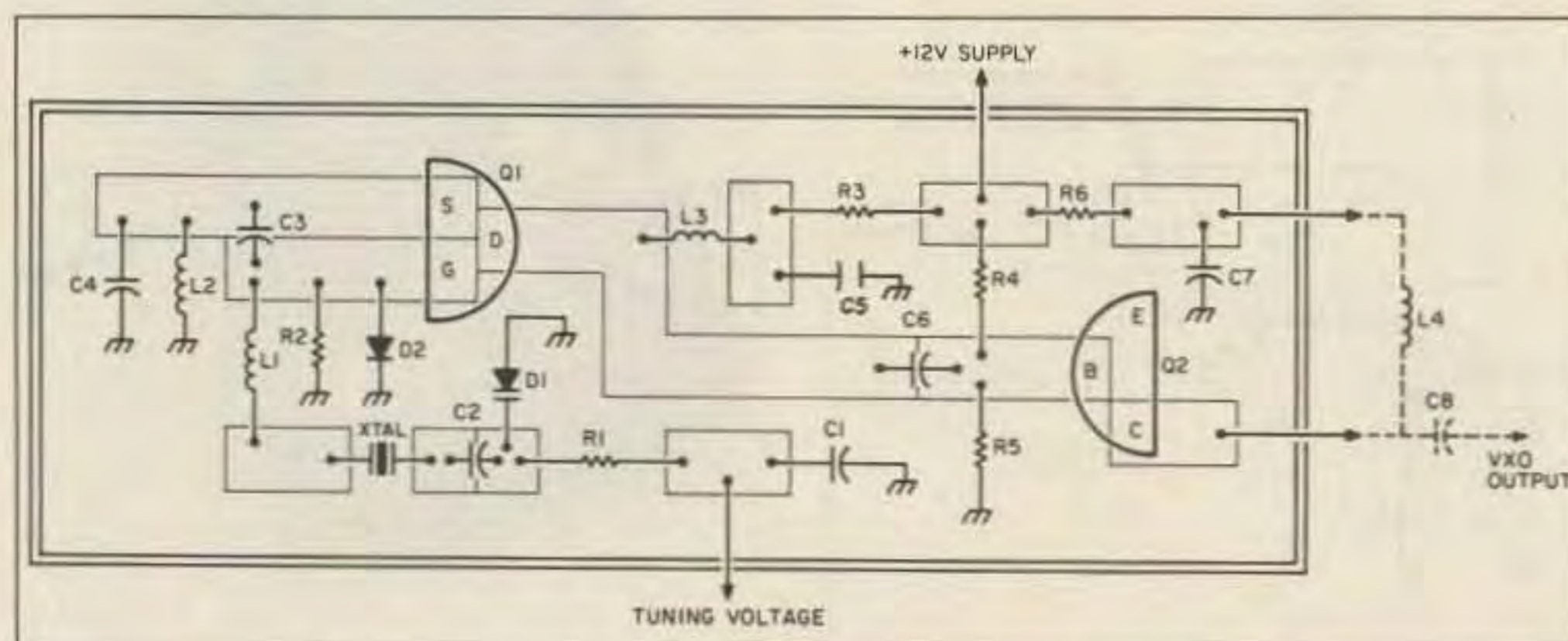


Figure 3. Parts placement for the VCXO mod.

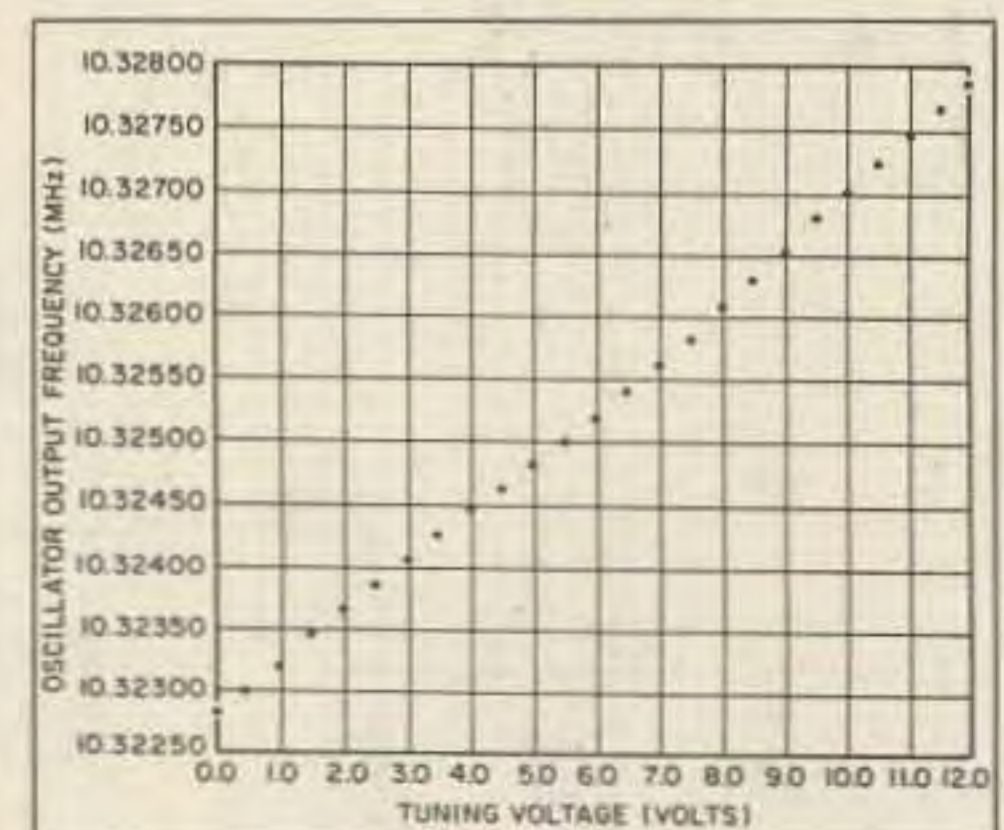


Figure 4. VCXO frequency output versus voltage tuning range. It is a very linear function.

A Motorola MV-209 varactor diode turned out to be almost as good. This is rated to up to 30.0 volts maximum. The diode is reverse-biased in operation. As the tuning voltage increases so does its capacitance, which in turn decreases the oscillator's frequency. If you wish to go up in frequency as you turn the fine-tuning (or clarifier) knob clockwise, you must wire the potentiometer up so that as you turn it the tuning voltage to the varactor diode decreases.

I experimented with the value of L1 until I got the most frequency swing without losing the crystal stability (this is obvious when monitoring the oscillator's output with a frequency counter, as the oscillator frequency will suddenly take off). L1 adds about 400 to 500 Hz additional frequency swing.

The 1N4148 diode (D2) limits the amplitude of the RF at the gate of Q1. While this does decrease the output level of the oscillator, it allows approximately 1 kHz more swing than without it (3.9 instead of 2.9 kHz).

Which Coil?

The coil (L2) in the source circuit of Q1 can be anything from 100 μ H to 1 mH. A 560 Ω resistor there in place of a coil will result in an output with much less harmonic content (great, if you are interested in only the crystal's fundamental frequency). Any coil within the above range will give a slightly better frequency swing than the resistor.

Capacitors C3 and C4 are in series with L1, the crystal, C2, and the varactor tuning diode. Since in a series circuit the total capacitance will not be any larger than the smallest capacitance, C3 and C4 should be as large as possible, which allows the varactor diode to be the dominant influence on the frequency of the oscillator. The other limitation on the values of C3 and C4 is that, since any kind of trimmer capacitor across the crystal would limit the frequency swing of the oscillator, they together tune the crystal to the desired center frequency. When using the Colpitts crystal oscillator, I prefer to keep both feedback capacitor values the same, although many other places specify that the "bottom" (source-ground) capacitor be 3 times the value of the "top" (gate-source) capacitor.

In Praise of Buffers

I built a buffer stage to follow the oscillator. When working with oscillators for RF, I recommend always building a buffer stage. The cost of the extra transistor and parts is next to nothing, and you can use the buffer stage to really build up the level of your signal and also to filter out unwanted harmonics. The buffer stage also serves as a constant load for the oscillator. This way, all the oscillator has to do is oscillate, which is very important if you are trying to optimize it for something, such as for maximum frequency swing. When I installed the oscillator in the radio, I took out L4 and instead wired into the circuit

the tuned RF transformer for the offset oscillator stage.

You can tune the buffer stage output by adding a trimmer cap, CTRIM, from the collector of Q2 to ground, which will resonate with L4. The same thing could be done with a trimmer cap from the drain of Q1 to ground, which will resonate with L3. At 12.0 volts, Q1 draws less than 0.5 mA, and Q2 draws 28 mA.

The oscillator's frequency output over the voltage tuning range is quite linear, as the chart (Figure 4) shows. Your "fine-tune" or clarifier potentiometer must be a linear type, however, as using an audio taper type will cause all of your range to be at one end of the dial.

Ultimately, with all of the experimentation, I was able to get 5.04 kHz of frequency swing out of the oscillator at the crystal's fundamental frequency.

Finis

During my conversion and troubleshooting I tested the rig in the AM mode with the PTT line keyed on and, with no modulation applied, measured all my frequencies on all my channels. A 10 meter SSB on-the-air test with my converted unit showed the conversion to be working fine.

So, there it is—a fun and cheap way to get a channelized CB on 10 meters. This band will be hot over the next few years, so I hope this mod will help you get in there and make good use of it! 