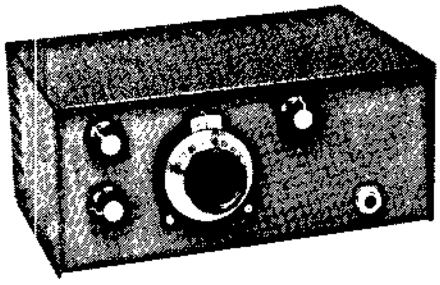
Misers dream PCB

BEGINNER'S BENCH



Getting Started on VHF: A Tunable I-F for VHF Converters

Part 2: This project provides a solid foundation for your 6-meter receiving setup.

By George Collins,* KC1V

Does successful vhf operation demand an adequate receiving system? Yes, and fortunately the vhf newcomer can put together a satisfactory receiving setup without having to forego a second car or the children's education! One of the simplest options available is also one that can provide high performance at low cost — a crystal-controlled converter followed by a tunable i-f (intermediate-frequency) unit.

Most commonly, the i-f unit is the regular station receiver operating at 10 meters. A 6-meter converter, for example could be used to convert signals between 50 and 52 MHz to the 28- to 30-MHz range. Any 10-meter receiver or transceiver could then be used as the tunable i-f. The 10-meter band is often chosen as the i-f because of the wide frequency coverage (28 to 30 MHz) provided on most receivers. If your interest is in only a small part of the vhf band, other hf bands can be used as the i-f.

This type of system has several advantages. First, if you have a suitable receiver available for use as the i-f unit, the cost of this approach can be very low. You need only buy or build the converter portion of the system. In addition, the overall system selectivity and stability are nearly the same as that of the tunable i-f receiver. The major disadvantage of using your hf receiver or transceiver as the i-f unit is that you must disconnect the converter when using the hf bands and reconnect everything before you can listen to the vhf band. The experienced vhf operator knows that he will be doing a lot of listening. A separate vhf receiver is far more convenient and allows you to monitor the vhf calling frequencies while using your hf equipment for normal operating. It should be noted that some current transceivers have provisions for the use of vhf transverters (a combination receiving and transmitting converter). These transceivers make convenient i-f units.

A 10-MHz Tunable I-F

The receiver described here serves well as a tunable i-f unit and, as a "plus," you can use it to listen to the new 10-MHz band! A 6-meter receiving converter, using 10 MHz as the output frequency, is being developed for use with this receiver. It will appear in an upcoming Beginner's Bench installment.

This receiver, originally called the Mini-Miser's Dream, was designed by Doug DeMaw, W1FB, as a portable 40-meter receiver.[1] It is a superheterodyne design using a crystal filter to provide good selectivity. Integrated circuits (ICs) have been used in the mixer, i-f amplifier and audio amplifier stages to reduce the number of components. As an aid to simplicity, agc (automatic gain control) has not been included. A front-panel potentiometer serves as a manual i-f gain control.

To change the receiver tuning range from 40 meters to 10 MHz, only two circuits require modification. The mixer (U1) input circuit is tuned to 10 MHz by changing the number of turns on T1 and retuning C1. To cover the 10.0- to 10.3-MHz range, the VFO (variable-frequency oscillator) must tune from approximately 6.7 to 7.0 MHz. This is accomplished by changing the oscillator tank circuit components (L2 and the associated capacitors). The buffer amplifier (Q3) output filter is also changed to the new frequency.

To make the receiver more compatible with the 6-meter VXO transmitter,[2] a muting circuit, audio-frequency gain control and sidetone input have been added to the original circuit. All of these modifications have been incorporated in Fig. 1.

Circuit Highlights

Mixer U1 converts the incoming 10-MHz signals to the i-f of 3.3 MHz. L1 and C2 tune the mixer output to the i-f, where FL1, a single-crystal filter, provides the selectivity. A phasing capacitor, C3 is used during alignment to adjust the filter for best selectivity. Following the filter is an IC i-f amplifier, U2. The amplifier output is tuned by T2 and C4 to the i-f. T2 also provided the necessary impedance match between the mixer and the two-diode product detector. Beat-frequency oscillator (BFO) injection voltage is provided by means of a crystal-controlled oscillator (Q1). After detection, the audio signal is amplified in U3. Approximately 300 mW of audio is available to drive headphones or an 8-Ω speaker.

The VFO section contains two transistors. A JFET (junction field effect transistor) is used as the oscillator. The circuit configuration used here is known as a series-tuned Colpitts. A buffer amplifier (Q3) is used to isolate the VFO from the mixer. Voltage regulation for the oscillator is provided by U4, a three-terminal regulator.

Construction Notes

Receiver assembly is simplified by using an etched-circuit board.[3] All components except the panel-mounted potentiometers and switches are contained on the single board. Component placement is shown in Fig. 2.

The VFO section is enclosed in a compartment made from double-sided circuit-board material. The compartment measures (HWD) 1-3/8 × 1-5/8 × 2-3/4 inches.[4] To form the enclosure, first cut the sections of board to size. Then carefully tack solder the pieces together, using a small drop of solder at each inside corner of the box. Make sure the box is square, then tack solder the outside seams. Now flow a bead of solder along each seam. With care, this can be done with a 27-W soldering iron, but a 40-W iron will make the job easier.

Place the finished shield compartment on the circuit board, using the component

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[1]Notes appear on page 34.

thesizer. Let's look at the basic divide-by-N synthesizer (Fig. 1A). It has the advantage of using only one crystal oscillator. Once this oscillator is properly calibrated, the synthesizer is on frequency for any setting. This scheme is not without drawbacks; a divide-by-N counter must be capable of high-speed operation (on the order of tens of MHz). This can generate objectionable spurious frequencies. A complex switching scheme is required to translate the dial setting to the proper N during reception and offset transmission. Nonetheless, practical circuits have been developed using this method.

Referring again to the technique of zero beating, we must have two carriers within the audio passband of a general-coverage receiver. The standard frequency we select will be one of the transmit frequencies of WWV. Most likely, it will be either 5, 10 or 15 MHz. Our other carrier will be related to the synthesizer reference oscillator. It can not be the reference-oscillator frequency, because 6 MHz is not harmonically related to any WWV frequency.

We look to the reference oscillator divider chain to see if a useful frequency is produced. After the divide-by-six counter, the output frequency is 1 MHz. Harmonics of this frequency are equal to our WWV choices. All synthesizers do not employ this scheme. Some dividers are binary, making it more difficult to uncover a portion of the circuit having a harmonic relationship to WWV. You might find frequencies as low as 10 kHz useful, if you reference them to the 5-MHz WWV transmission. If you are referencing to the higher WWV frequencies, you should not use a carrier frequency lower than 100 kHz.

Connect a capacitor (between 10 and 100 pF) to the output of the divide-by-six counter. Attach the other end of this capacitor to a wire that is placed near the terminals of a communications receiver. Tuning the receiver to WWV, you should hear a beat note. Adjust the frequency of the crystal oscillator to zero beat with WWV. This completes the calibration of the reference oscillator.

Offset Synthesizers

Offset synthesizers are more complex (Fig. 1B). Our representative circuit has a second offset oscillator, which must be properly adjusted, in addition to the first oscillator. Instead of the divide-by-N circuit counting the VCO frequency, it counts the difference frequency of the VCO and a second oscillator known as the offset oscillator (Table 1). This results in a VCO frequency that is the sum of the divide-by-N-counter and the offset oscillator frequencies. Many disadvantages to the simple synthesizer are overcome, but at the expense of a loss of simplicity as well as some sacrifice of frequency stability. Two oscillators, rather than one, are now controlling the VCO frequency. Should they drift in the same direction, both will add to the VCO frequency error.

Our adjustment of the offset oscillator is not as simple as that of the reference oscillator. The offset crystal frequency is 23.333333 MHz. I assure you that looking for some harmonic relationship to a standard frequency is pointless. We can take a "back-door approach" to adjusting this oscillator with great success. Let's assume this oscillator is on frequency and the synthesizer is operating properly. Examining the VCO frequency, we find it to be one-sixth the operating frequency, or 24.000000 to 24.666667 MHz for a transmitting frequency of 144.000 to 148.000 MHz, respectively.

Although 24 MHz is not harmonically related to any WWV frequency, we are not out of luck. Remember, the divide-by-six counter produces an output of 1 MHz from our 6-MHz oscillator. Since it is a square wave it will be rich in harmonics. Because we have calibrated this oscillator to WWV — just as we did with the simple synthesizer — it will become our new standard for adjusting the VCO frequency. Setting the synthesizer dials to 144.000 MHz, and placing the transceiver in the transmit (simplex) mode, causes the VCO to operate at 24 MHz.

Table 1

Transmit and Receive Frequency Formulas for Offset Synthesizers

VCO Transmit Frequency

$$\frac{F_d + F_o}{M} = F_{vco}$$

where
F_d = synthesizer dial frequency
F_o = transmit offset frequency (simplex, ± 600 kHz, etc.)
F_{vco} = VCO frequency
M = transmitter multiplication factor (M = 6 in text)

VCO Receive Frequency

$$\frac{F_d + F_{i\text{-}f}}{M} = F_{vco}$$

where
F_d = synthesizer dial frequency
M = transmitter multiplication factor
$F_{i\text{-}f}$ = frequency of first i-f amplifier (treat as a positive number if high-side injection is used, and as a negative number if low-side injection is used)

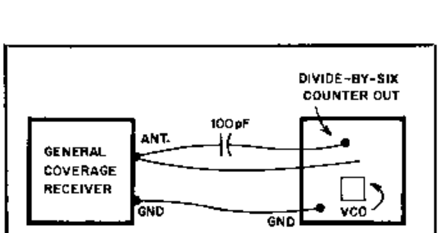


Fig. 2 — Hook-up diagram for aligning an offset synthesizer that uses only a communications receiver.

For this stage of the alignment we use the test set-up depicted in Fig. 2. Attach the wire from the 100-pF capacitor to the receiver antenna terminal, and then tune the receiver to 24 MHz. (Note: If the 100-pF capacitor seems to load down the output of the divide-by-six counter, reduce the value to one that does not, e.g. 10 pF or so.) Connect a second wire to the receiver terminal and route the other end near the VCO. Enough rf energy from the VCO and the 24th harmonic of the 1-MHz output should be present at the antenna terminals of the receiver to produce an audio beat note. If the offset oscillator is exactly on frequency, the VCO will be exactly 24 MHz and no beat note will be heard. Adjusting the offset oscillator while following the zero-beat procedure will bring the offset oscillator on frequency.

We now have adjusted the offset frequency for simplex operation only. We can adjust the −600-kHz offset by setting the synthesizer to the −600 mode and the transceiver to receive 144.60 MHz. This puts the VCO frequency at 24 MHz during transmission. Repeat the zero-beat procedure for this offset oscillator. We can align the +600-kHz offset oscillator in the same manner, except we set the transceiver frequency to 143.400 MHz. [Editor's Note: Some circuits will require extensive modification to enable coverage of this frequency.]

Adjusting the receiver offset is a bit more tedious. First of all, the frequency range of the VCO must be determined. My transceiver uses a 10.7-MHz i-f, resulting in a VCO frequency of 22.216667 to 22.883333 MHz for reception of 144.000 to 148.000 MHz, respectively. Several multiples of 100 kHz occur in this range, offering one method of alignment. With my radio I can take a simpler approach. I set the transceiver frequency for 142.700 or 148.700 MHz to provide a VCO frequency of 22.000 or 23.000 MHz, respectively. Tune the communications receiver to 22 or 23 MHz, corresponding to the transceiver setting, and zero beat. This completes the zero-beat method of alignment.

Although I used a specific synthesizer as an example, the technique is general. After spending some time with a calculator and the block diagrams of most of the common schemes, I determined that variations of this approach would work with any of them. Are you inventive? What other gaps can you fill?

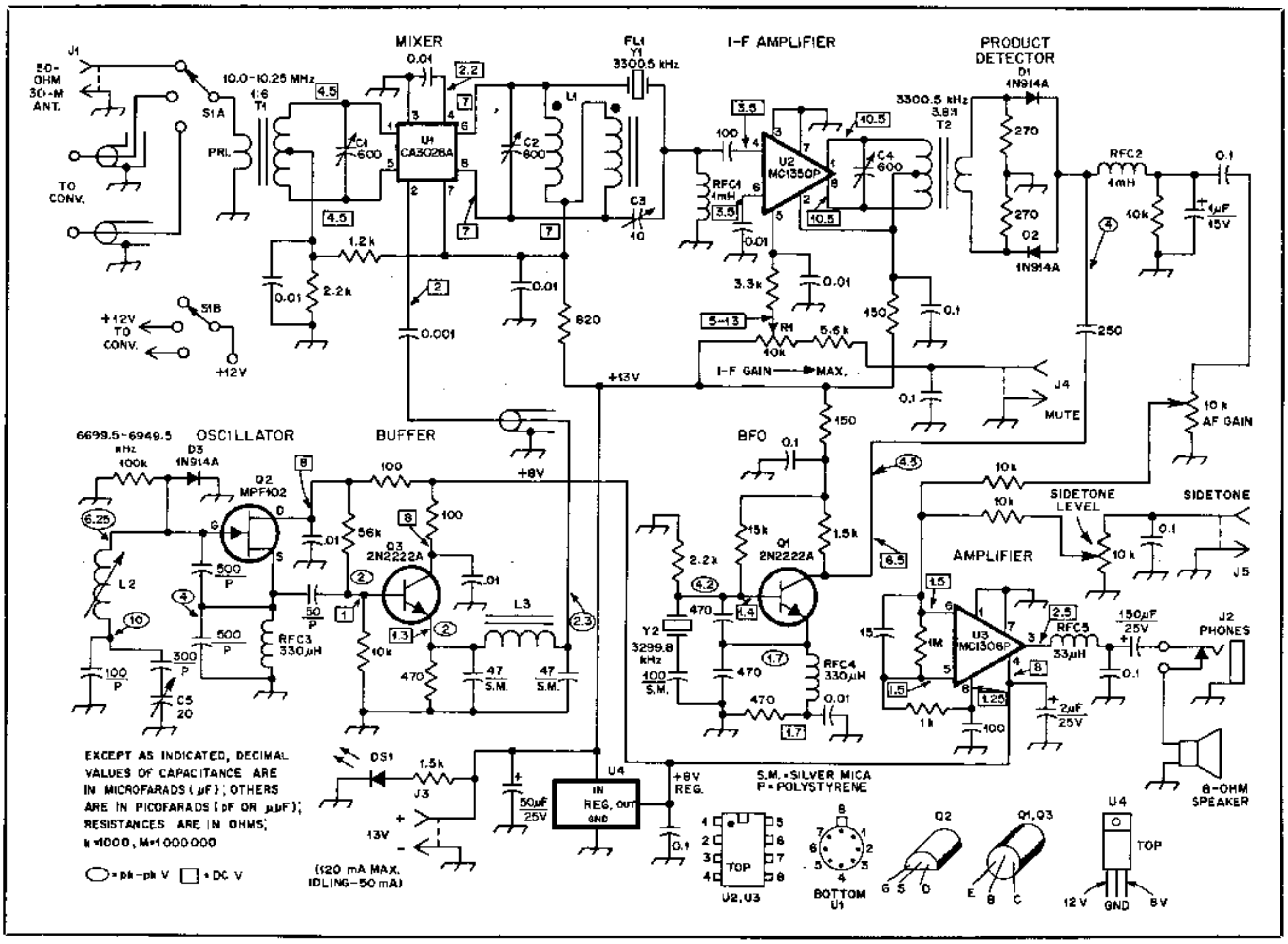


Fig. 1 — Schematic diagram of the Mini-Miser's Dream, modified to operate at 10 MHz.

C1, C2, C4 — 170- to 600-pF mica trimmer (ARCO 4213).
C3 — 10-pF miniature trimmer. Ceramic or pc-mount air variable suitable.
C5 — Miniature air variable, 2 to 20 pF.
D1-D3, incl. — High-speed silicon switching diodes, 1N914 or equiv.
J1, J3-J5, incl. — Single-hole-mount phono jack.
J2 — Closed-circuit phone jack.
L1 — 8 bifilar turns of no. 28 enameled wire wound on an Amidon FT37-61 ferrite core (L = 5.8 μH).
L2 — Slug-tuned inductor, 5-μH nominal inductance. Miller 42A686CBI (3.6 to 8.5 μH) or equiv.
L3 — 12 turns of no. 26 enameled wire wound on an Amidon FT50-61 ferrite core.
R1 — 10-kΩ panel-mount control, linear taper.
R2 — 100-kΩ panel-mount control, audio taper.
R3 — 10-kΩ pc-mount control.
RFC1, RFC2 — Miniature 1-mH rf choke (Millen J302-1000 or equiv.).
RFC3, RFC4 — Miniature 330-μH rf choke (Millen J302-330 or equiv.).
RFC5 — Miniature 33-μH rf choke (Millen J302-33 or equiv.).
S1 — 2-pole, 3-position rotary switch.
T1 — Toroidal transformer. Primary has 2 turns of no. 24 enameled wire. Secondary has 12 turns of no. 24 enameled wire on an Amidon, Palomar or RadioKit T50-2 core.
T2 — Toroidal transformer. Primary has 9 turns of no. 26 enameled wire (center-tapped). Secondary has 3 turns of no. 26 enameled wire on an Amidon FT37-61 ferrite core.
U1 — RCA IC. Bend pins to fit 8-pin dual-in-line IC socket.
U2, U3 — Motorola IC.
U4 — Three-terminal 8-V regulator IC.
Y1, Y2 — Surplus crystal in HC-6/U holder or International Crystal Co. type 433115. Specify exact frequency when ordering crystals. International Crystal Manufacturing Co., 10 North Lee, Oklahoma City, OK 73102.

mounting holes in the VFO area as a guide. Be sure the front of the box is parallel to the edge of the circuit board. Tack solder the compartment to the board, check the alignment and then flow solder along the seam between the compartment and the circuit board. Make a similar shield, 1/4-inch high, and attach it to the bottom side of the board, opposite the top partition. Finish the shielding by making a U-shaped metal cover for the compartment. The shielding will keep the VFO energy from straying into circuits where it doesn't belong.

Polystyrene capacitors are recommended for use in the VFO tank circuit. After the receiver has been assembled and tested, secure these capacitors to the circuit board with a small drop of hobby cement. This will prevent frequency shifts caused by capacitor movement. Be sure to use small-diameter coaxial cable, such as RG-174/U, when wiring S1 to the receiver board, antenna jack and converter (when it is added).

The receiver shown in the photographs is housed in a metal cabinet measuring approximately 3-1/2 × 8 × 6 inches. This is larger than necessary for the receiver, but the extra space can be used for mounting the vhf converter and other accessories. The circuit board is fastened to the cabinet bottom by using 1/2-inch spacers. If you don't have suitable spacers available, 3/4-inch long screws and nuts can be used to hold the board at the proper height. To prevent the board from flexing (causing backlash) when C5 is rotated, you should use six mounting screws. Four are located at the board corners and one is placed at the center of the front and rear edges of the board.

Alignment and Operation

Before you begin aligning the receiver, check the dc and rf voltages shown in Fig. 1. This will give you a good indication as to whether or not all stages are functioning correctly. The audio stage can be checked by applying a sidetone signal to J5. Sidetone volume should not be affected by the AF GAIN control, but you should be able to use the SIDETONE LEVEL control to set the sidetone volume at a comfortable level.

The first step in aligning the receiver is to adjust the VFO tuning range. This is most easily done with a frequency counter or general-coverage receiver. The frequency counter is connected to pin 2 of U1. If you use a general-coverage receiver, a short wire connected to the antenna terminal and placed near the VFO should produce a strong signal when the receiver and VFO are tuned to the same frequency. With C5 set for maximum capacitance, adjust L2 for a VFO frequency of 6.699 MHz. Tuning C5 to minimum capacitance should produce a frequency of approximately 6.949 MHz. The exact tuning range will depend on the actual values of the tank circuit components. You can change the VFO tuning range by using a different value of fixed capacitor in series with C5. A larger value will produce a wider tuning range.

To adjust the mixer and i-f stages, connect an antenna and tune the receiver to a weak signal near the center of the tuning range. Adjust C1, C2 and C4 for maximum response. C3 is adjusted for minimum response on the unwanted side of zero beat. To make this adjustment, tune in a fairly strong signal. You should be able to hear the signal on both sides of zero beat. Zero beat is the point at which the tone of the received signal becomes very low. On one side, the signal should be weaker. This is the unwanted response. Adjust C3 for minimum signal at this point. Because the selectivity is affected by the setting of both C2 and C3, you will have to experiment with these adjustments to obtain optimum performance. Always adjust C3 for minimum unwanted response.

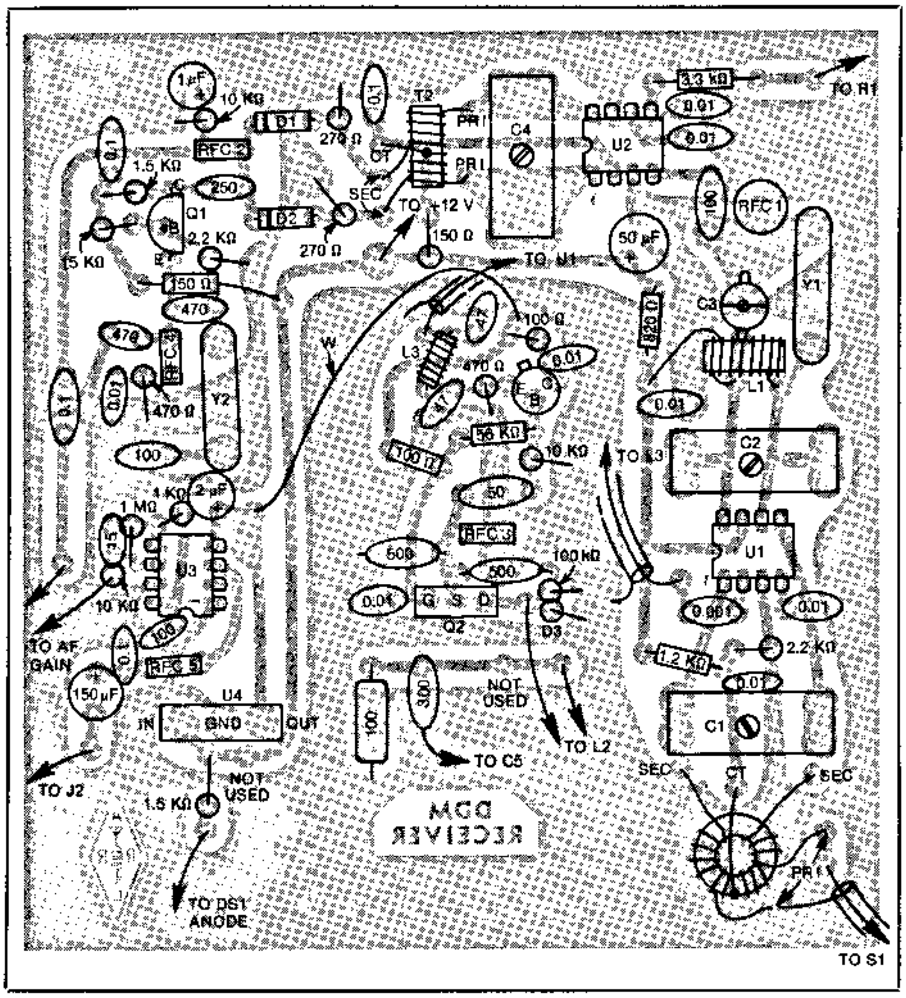
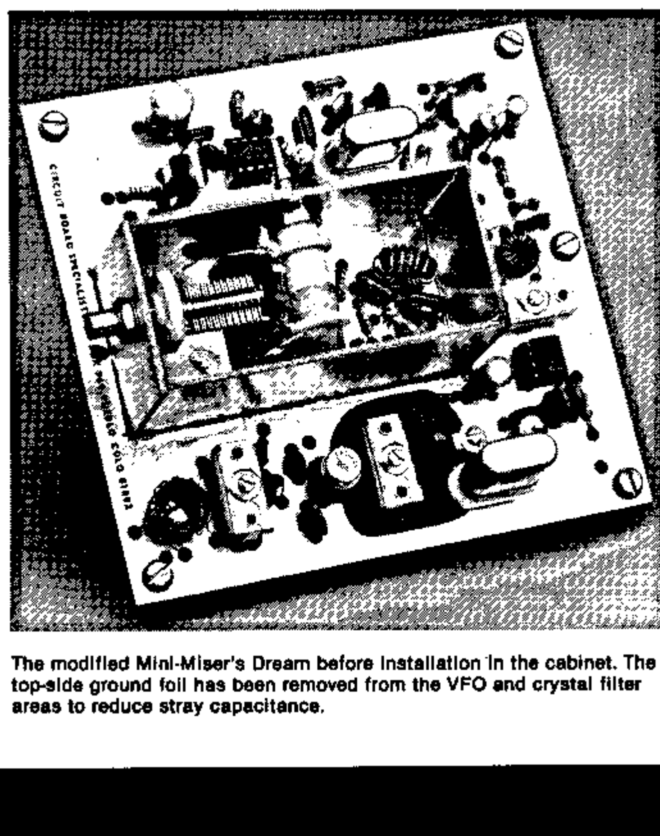


Fig. 2 — Parts-placement diagram for the 10-MHz receiver. The circuit board is shown from the component side with gray areas representing unetched copper. The etching pattern appears in Hints and Kinks, page 37.

During operation, the MUTE jack (J4) must be shorted to ground while you are receiving; it must be open during transmit. The optimum setting of the i-f gain control will depend on the strength of the signal you are listening to; the stronger the signal, the less i-f gain required. If you find that you have the audio gain set near maximum, you very likely have the i-f gain set too low.

With the alignment and testing complete, you are ready to put your receiver "in service." One of the first signals you are likely to hear is WWV transmitting at 10 MHz. This standard-frequency station, operated by the National Bureau of Standards, provides a handy reference point for checking your dial calibration (the adjustment of L2). WWV also transmits time and propagation information useful to amateurs. While the newly allocated 10.1- to 10.15-MHz band is not available for use by U.S. amateurs, several other countries have begun 30-meter amateur operation. The coming months should provide increased amateur activity for you to listen in on while you are finishing up your 6-meter station.



The modified Mini-Miser's Dream before installation in the cabinet. The top-side ground foil has been removed from the VFO and crystal filter areas to reduce stray capacitance.

Notes

[1]D. DeMaw, "The Mini-Miser's Dream Receiver," *QST*, Sept. 1976, pp. 20-23.

[2]G. Collins, "Getting Started on VHF: A 6-Meter Transmitter You Can Build," *QST*, April 1982, pp. 37-42.

[3]Circuit Boards, negatives and parts kits for this project are available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002.

[4]mm = in. × 25.4.

the center frequency was found to be approximately 400 Hz.

This filter will provide a worthwhile improvement in cw selectivity. For better performance, two filters can be cascaded.

With the indicated values, the voltage gain is 1, the Q is 20 and the passband center frequency is 400 Hz. Power for the unit is provided by two 9-V transistor-radio batteries. — *Howard Weinberg, WA6JCH, Montebello, California*

QSK WITH VOX CIRCUITS

☐ For several years I had operated a cw station with full break-in capabilities. When I moved up to a "state-of-the-art" transceiver I never felt comfortable using the VOX circuit for cw. The VOX delay had to be set long enough to keep the transmitter from dropping out between words, but this caused me to miss the beginning of the next transmission.

I decided to short the R-C network capacitor in the VOX circuit at the end of my transmission. This capacitor can be found by tracing the wiring from the VOX delay control. The control is wired across the R-C capacitor. I used a "spare" jack on the rear panel of my transceiver, connecting the R-C capacitor across the jack. I connected 0.01-µF disc capacitors across the lines to bypass stray rf to ground. Then I cemented a Micro Switch to my keyer paddle, connecting it to the jack with a piece of RG-58/U coaxial cable.

When I become impatient with the VOX delay, I simply depress the Micro Switch, putting my transceiver into the receive mode immediately. — *John Werner III, WB8IPG, Warren, Michigan*

TRANSMITTER-KEYING INTERFACE

☐ Radio amateurs have an interesting and enjoyable variety of ways to generate Morse code. Keyboards and computers share air time with straight keys and bugs. But interfacing the newest equipment with a transmitter may not be an easy task. Many of these new code generators are not specifically designed for transmitter keying.

The circuit shown in Fig. 7 can be used between any code generator that produces an audio signal and virtually all transmitters. New parts will cost about $10. This unit was originally built for the N4DR 10-MHz beacon, and it interfaces a tape-recorded cw message with the beacon transmitter.

U1A is a conditioning amplifier, which sets the level of the incoming signal. C1, C2, R4 and R5 allow the interface to operate from a single-polarity power supply. D1, D2, C3 and R6 form a rectifier circuit that changes the ac voltage into a dc voltage that varies with the envelope of the incoming ac voltage. U1B is wired as a Schmitt trigger. Voltage from the rectifier will cause the trigger output to go from low to high, lighting the LED and closing the reed relay.

Construction is straightforward. Use the maximum level setting that will allow the LED to flicker with the cw signal. It should be decreased only if the background noise level falsely triggers the interface.

An additional use of the interface is to key a transmitter that does not have a sidetone. Simply use a code-practice oscillator to drive the interface circuit. — *Tom Cook, N3AXN, Pittsburgh, Pennsylvania*

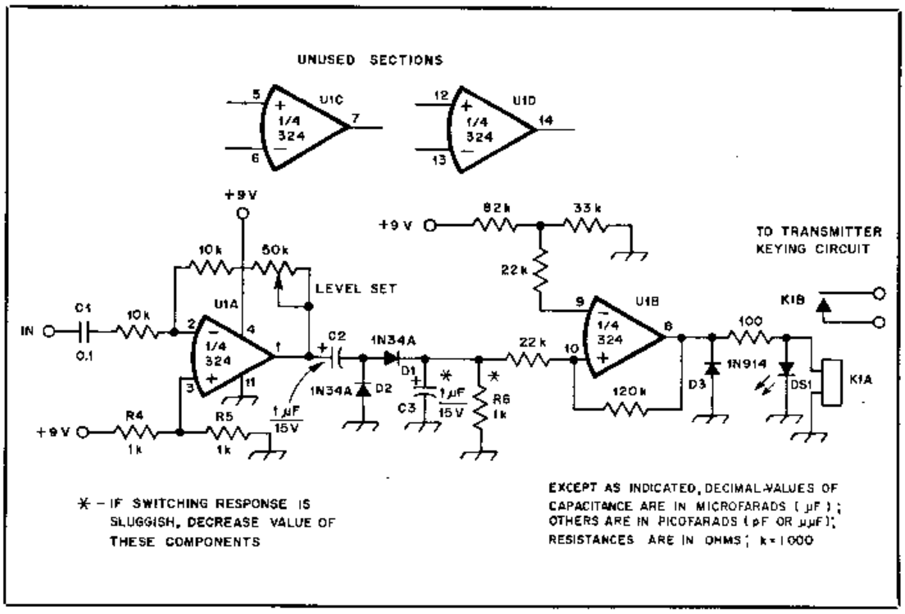


Fig. 7 — The schematic diagram of a simple transmitter-keying interface.
K1 — Reed relay (RS 275-229). **U1 — 324 quad op-amp.**

Etching pattern for the 10-MHz Mini-Miser's Dream. The black areas represent unetched copper viewed from the foil side of the board. Parts-placement guide appears on page 34.