The Challenge of 1750 Meters

No license required.

by David Curry WD4PLI/6

1750 meters is a hobby, just like amateur radio. In fact, it is much like old-time amateur radio; it separates the men from the boys! In the early days of radio, hams built their own equipment, and most operators did not even have licenses. 1750 meters is still true to that theme: "No license required, only skill desired."

Unfortunately, 1750 meters is a noisy, sometimes crowded, band filled with carriers and modulations. Well, guess what? Many of those carriers and modulations are European long-wave broadcast stations DXing over the Atlantic, and perhaps that code you hear in the background is actually a Lowfer sending his ID beacon. FCC rules limit transmitting antenna length to 50 feet and DC input to the PA to 1 watt. Even with these restrictions, surprising distances via ground-wave propagation occur regularly. Using a common noise blanker, audio filter, or even a phase-canceling device, an operator can clean up the band of light dimmers and power line noise that often can be discouraging. Simple receiving antennas such as an active whip or loop placed in a clear area and using a "virgin" ground (a separate, isolated ground that carries no power-line noise) can provide unimpeded reception.

Considering that communications technology has become so advanced, there is no reason why you can't enjoy the fun and challenge of 1750 meters just because the major ham manufacturers didn't include it in their rigs. Build your own radio, perhaps with a friend, and get on the air; it's that simple. You will find that you have more to talk about than the weather, and you'll share in the amazement of how a 1 watt signal can travel hundreds of miles under good conditions. Many hams can use their preexisting vertical ham antenna for 1750 meter operation using a loading coil at the base of the antenna. Most 160 meter antennas are ideal for work on 1750 meters.

1750 meters was originally set aside by the FCC as a frequency range for garage-door openers back in the early '60's, but as time passed, experimenters (many of them hams) found surprising success despite FCC limitations. These "experimenters" are referred to as "Lowfers," and are on virtually any day of the week. I can hear two or three of them on my TS-430S, loud and clear, from as far away as San Diego, 150+ miles away from my Burbank, California, QTH. In Hawaii, using a portable loop antenna, Sheldon Remington received Lowfer beacons Z2 and later H2, both located in California, over 3,000 miles away! SSB, AMTOR, RTTY, and packet have all been used successfully.

Design

Described here is a simple "introductory" CW two-way radio for 1750 meters. Antenna dimensions for 1750 meters can be found in *73 Magazine*, September 1991, in "Dual-Band Vertical" (for 160 and 1750 meters), page 38. Also of interest is "Noise Reduction Using Broadband Active Whip Antennas," *73 Magazine*, October 1992, page 38.

Please note Figures 1 and 2. The front-end preselector uses a tunable two-pole Chevy-chev bandpass filter to reduce unwanted signals, such as GWEN (Ground Wave Emergengy Network). The direct conversion receiver is an uncomplicated design using the NE602 chip. The NE602 Colpitts VFO provides the frequency reference for the transmitter section. The VFO can be PLL-controlled externally, facilitating CCW (Coher-

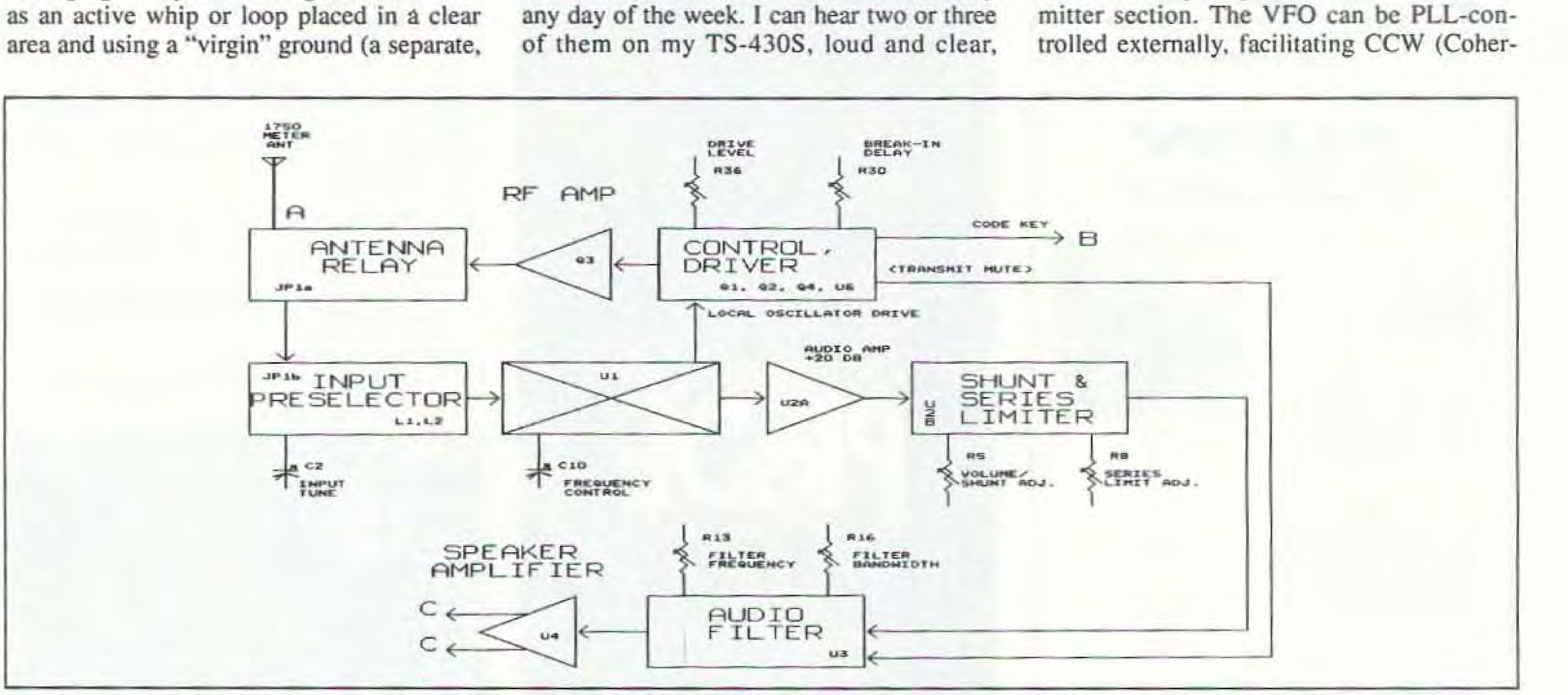

Figure 1. Block diagram.

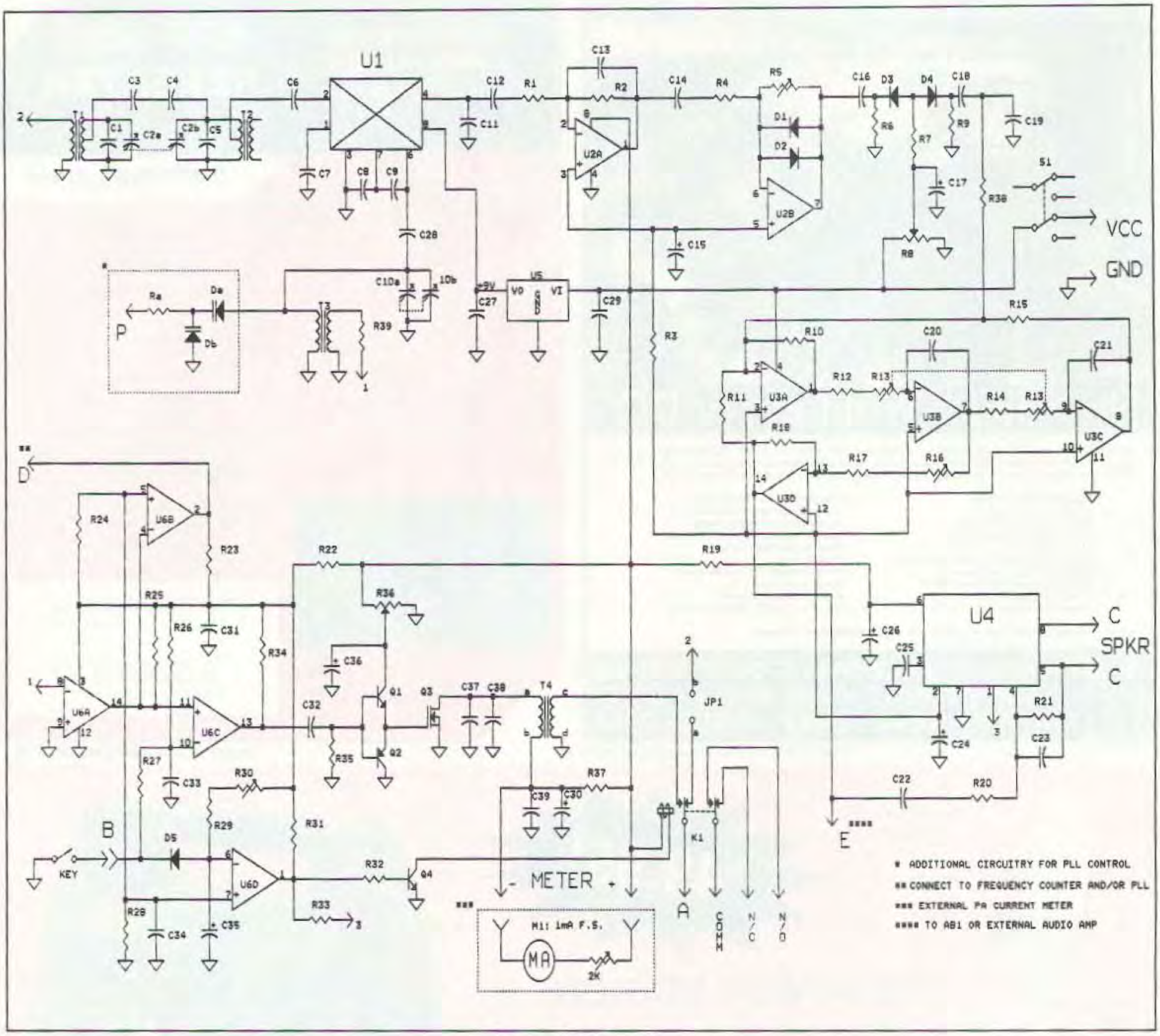

Figure 2. Schematic.

ent Continuous Wave) operation.

Noise is always a problem at these frequencies so two noise limiters are included to provide very effective limiting of high-amplitude man-made noise and static. A shunt limiter followed by a series limiter is used in this design, and this is superior to most designs found in commercial and military receivers. Audio filtering is included, with variable frequency and bandwidth control for precise filtering of the desired signal.

Ample audio output drives headphones and most speakers. This rig is capable of providing over 100 dB of gain with virtually no power supply hum. The transmitter section samples the VFO using a simple logic circuit, controlling the duty cycle and the keying of the amplified signal. The signal then drives a class E power output stage. This class of service is a very efficient 96%. Many thanks go to Mark Mallory for his excellent research into efficient class-E amplifiers and for sharing his information.

The transmitter section lends itself as an excellent beacon transmitter. Simply apply the beacon message to the code key input for reliable beacon transmission. As you probably know, purchasing components these days can be expensive; this was a major concern during the design of this project. All parts are "off the shelf," with the ordering part number given.

Beware: Simple "one-transistor" transceiver designs just do not work on 1750 meters. Don't be fooled!

Construction

Please note the component layout (Figure 3). You will notice that several component leads are soldered directly to the component side of the circuit board. This provides the ground connection for these components. When this occurs, be sure to solder the component lead to the ground plane *and* on the solder side. Note that capacitors are disc-shaped, while electrolytics are round and have the polarity marked. Transistors are designated by the half-moon shape, or round with a key. ICs are rectangular, with the "U" mark at the end.

I recommend soldering the ICs first. Notice that some pins must be soldered on the component side.

Next, solder transformers T1, T2, and T3. Dab some solder on the side of the transformer and ground plane to ensure a good ground.

Install all the capacitors, followed by the variables C1 and C10. C1 and C10 should be installed so that the side with five leads goes through the circuit board. Pull the leads firmly and bend at a 45-degree angle to hold while soldering. Note the small horizontal lead sticking out on the side of C1 and C10. Solder a wire from that lead through the hole in the circuit board under it.

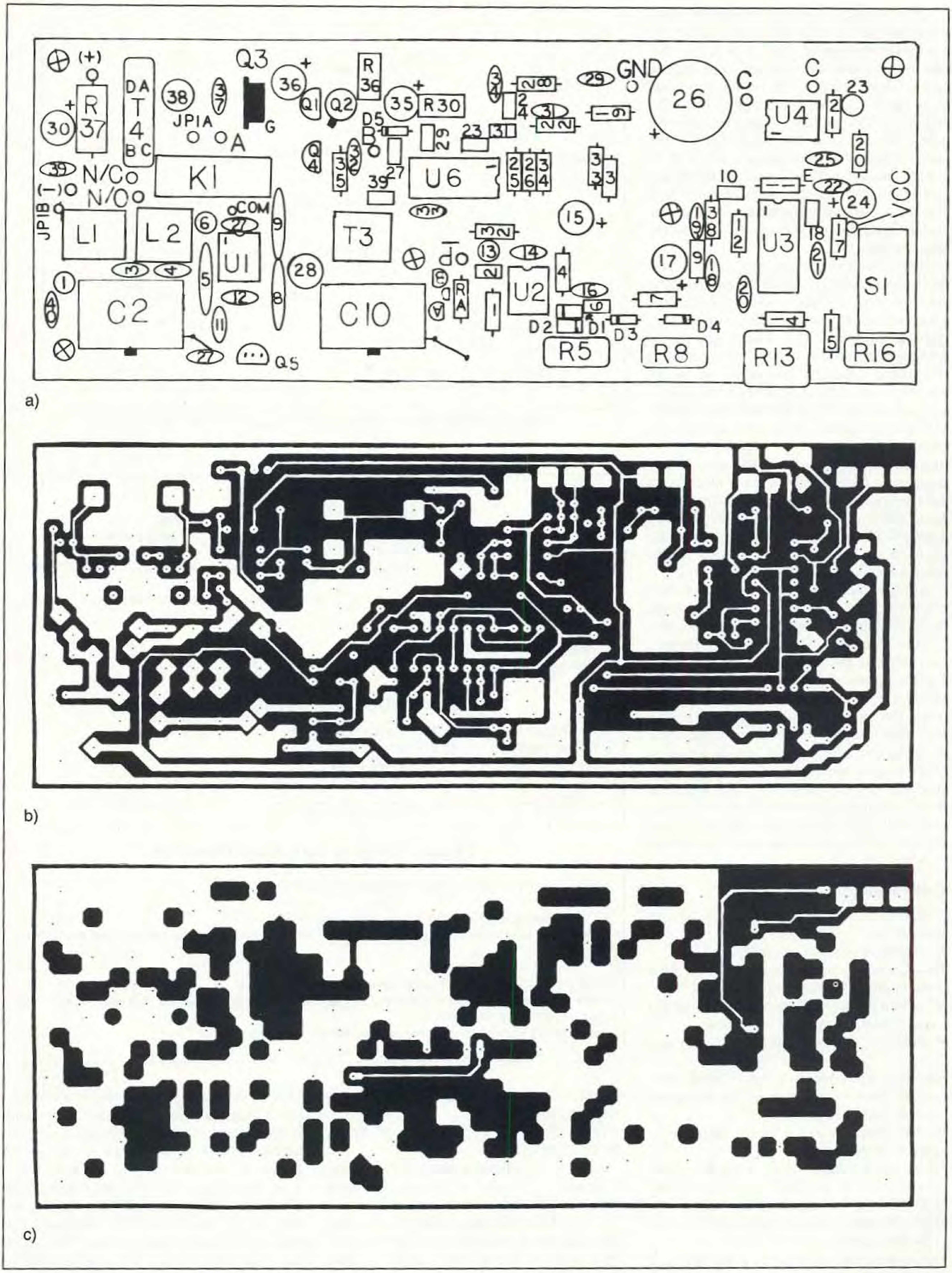

Figure 3. Double-sided PC board: (a)parts placement diagram, (b) top foil pattern, and (c) bottom foil pattern.

Transformer T4 must be wound by hand. Wind the turns evenly and firmly. After you are finished winding, cut the wires so that about 1" remains from the toroid to the end of each wire. Remove the enamel insulation from the 1" ends with sandpaper. The sidebar has all the winding information you will need. Notice that the holes for T4 are marked "a & b" for the primary, and "c & d" for the secondary. They crisscross on the circuit board. Use an ohmmeter to make sure the wires don't get mixed up and the secondary wind doesn't accidentally go into the primary holes!

Now solder the remaining components. Resistors installed horizontally are indicated by a rectangle shape, while vertically-mounted resistors are a small square. Any vertical resistor with a lead going to the ground plane should use the longer lead as the ground lead. You may decide to "go all the way" and install your transceiver in a box or chassis. The LMB box listed in the optional component list is a good choice. It provides extra room for a speaker, meter, or antenna switch. The meter is both a luxury item *and* a necessity. To make a nicer finish for the front of the chassis, templates for the front and rear face plates are provided in Figure 4. Go to a photocopy store and copy them to a transparency. Be careful not to scratch the black from the transparency.

Apply a thin film of clear epoxy glue over the front of the box. Size up the transparency so the top of the box on the transparency is even with the top of the chassis. Be sure you can *read* the transparency before pressing the transparency to the adhesive. After the epoxy has cured for a few hours, cut away the excess transparency around the box with a sharp knife. Tap and drill each hole to a size a little larger than each control shaft to give some play. Repeat the same procedure for the rear chassis face plate. Use 4-1/2" aluminum spacers between the bottom of the circuit board and the floor of the chassis, and four 4/40 nuts and bolts to secure the board.

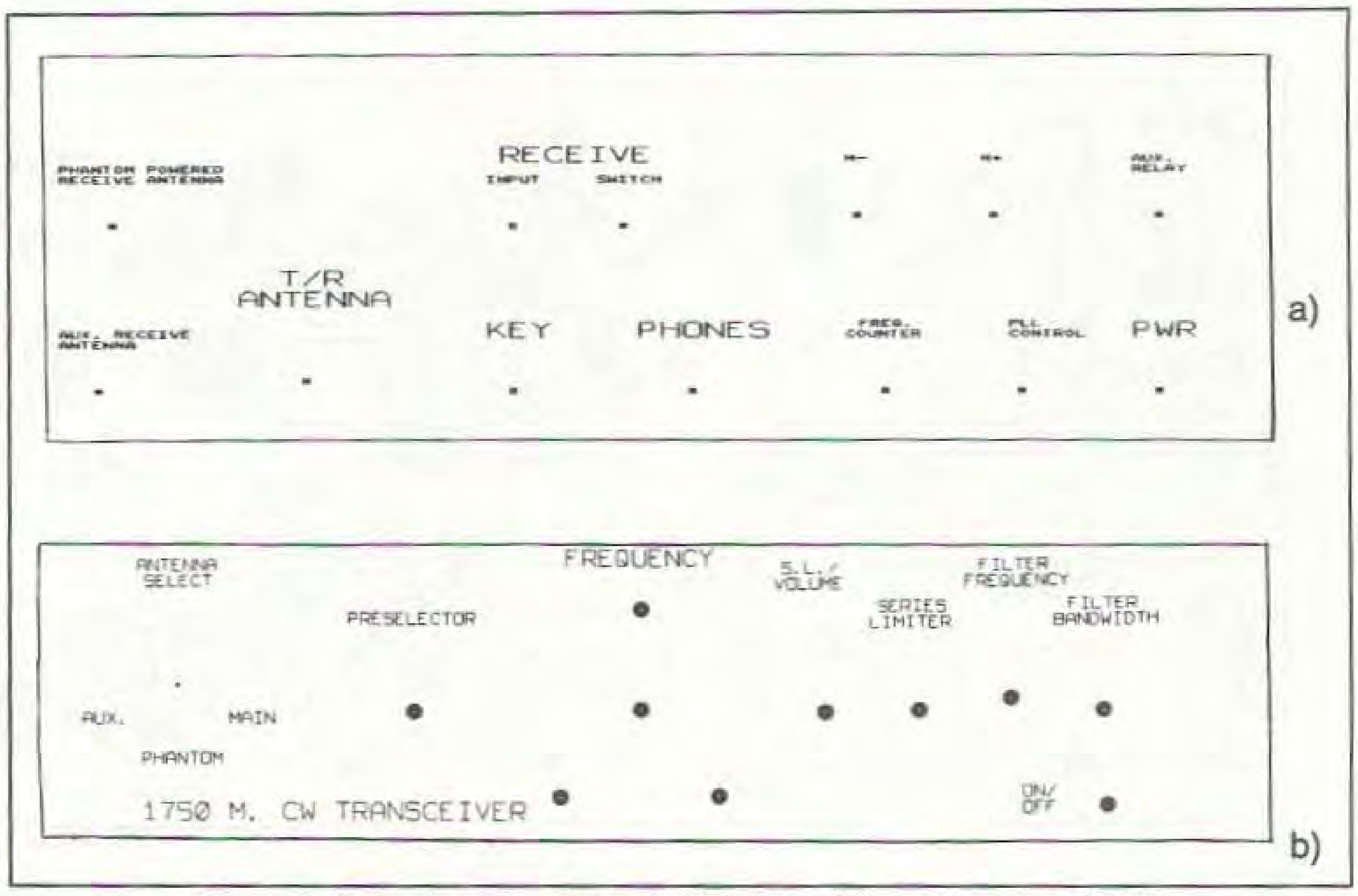

Figure 4. Face plate templates: (a) front, and (b) rear, reduced 50%.

T4 Winding Data

Power	C37	C38	VCC	T4a/b	T4c/d	Form
1 watt*	X	N/A	12 VDC	93 Turns #30 Ga.	49 Turns #24 Ga.	T-68-3
3.5 watt**	N/A	X	12 VDC	49 Turns #24 Ga.	48 Turns #24 Ga.	T-68-3
10 watts	X	X	18 VDC	33 Turns #20 Ga.	37 Turns #20 Ga.	T-130-3

N/A: Not used.
* Heat sink recommended.
** Heat sink required.

Formulas for Calculating Efficient PA Design

L: Tank inductance — C: Tank capacitance
Z: PA load resistance — V: VCC supply voltage
F: Operating frequency — P: Output/input power

$$L = \frac{.2085 \times V^2}{P \times F} \qquad C = \frac{1}{(2 \times pi \times 1.2915 \times F^2) \times L} \qquad Z = \frac{1.2638 \times V^2}{P}$$

T4 Inductance & Turn Ratio Formulas

T-68-3: Number of turns = $100 \times \sqrt{(\text{Inductance in uH}/195)}$

T-130-3: Number of turns = $100 \times \sqrt{(\text{Inductance in uH}/350)}$

To match the impedance at the drain of Q3 to a 50 ohm impedance, you will need to know the turns ration (Tr):

Tr: $\sqrt{(Zd/Z1)}$

Zd: Drain resistance — Z1: Load resistance (usually 50 ohms)

These formulas are included to help solve any particular matching requirement. The above table can be used to match most requirements.

The frequency value for "F" can work for frequencies +/- 10 kHz.

Calibration

Connect the antenna, power supply, etc. to these points:

- A—50 ohm transmit antenna port.
- B—Code key port. Transmit is initiated when point B is grounded.
- C—Both points marked "C" are connected to 8-32 ohm speakers or headphones.
- COMM—Common terminal for auxiliary relay.
- D—Frequency monitor port. CMOS level square wave output connects to frequency counter and/or PLL input.
- GND—Connect power supply negative or ground to this point.
- JP1—Receive input select. Short JP1a&b to use antenna at port "A" for receive. RECEIVE ONLY antennas connect to JP1b.
- N/C—Normally closed terminal for auxiliary relay control.
- N/O—Normally open terminal for auxiliary relay control.
- P—PLL or phase control of VFO. Section normally not used.
- VCC—12-18 volts, filtered DC or battery to the terminal.

Connect 12 volts of power to VCC points. A frequency counter or receiver covering 150 kHz to 250 kHz will be required.

Connect the frequency counter to point "D." Turn the transceiver ON. Turn the tuning capacitor C10 maximum clockwise. Turn the slug in T3 until the frequency reads 189 kHz. If no frequency counter is available, use a long-wave receiver, general coverage receiver, or ham radio that can accurately tune to 190 kHz. Place a small piece of wire from the receiver antenna input near U1. Tune the receiver for a center frequency of 189 kHz. Listen for a tone while turning the slug of T3. Slowly turn the slug until you hear a zero beat on the receiver. Next, align the preselector. T1 and T2 must be tuned to the same frequency. If you have a signal generator, place a low-level (approximately 100 μV) signal of 175 kHz to the input at JP1b. On the transceiver, turn the Preselector and the Filter Frequency controls to the 12-o'clock position. Rotate the series limiter and the filter bandwidth controls to full counterclockwise.

Tune the Frequency control for 176 kHz.

Turn the slugs on T1 and T2 for maximum volume, decreasing the signal generator output as the tone becomes louder. If no signal generator is available, connect the antenna to JP1b and listen for any carriers by adjusting the Frequency dial and volume controls. Turn the Preselector capacitor to the same setting as the Frequency capacitor. Turn the slugs in T1 and T2 for maximum signal strength.

Operation

The Volume control will limit the amplitude of all signals past a certain point. This can be used to increase the gain of a desired signal that is buried in man-made noise, cutting off the peaks of the noise while leaving the signal unaffected. The series limiter can be used to lower the volume when the volume/shunt limiter control is used for extreme limiting. You will find that the volume/shunt limiter is better at reducing high-level man-made noise, while the series limiter is better for reducing static and occasional high-impulse noise. The audio filter frequency and bandwidth are adjusted for the desired amount of filtering.

An important feature is the input Preselector control. The preselector filter is very sharp, allowing only a small slice of the band to be received. If, for example, the beacon you want to hear is on 180 kHz, tune the Frequency control for a frequency of either 179 kHz or 181 kHz. The beacon message will be heard at a 1 kHz tone: 180 kHz-179 kHz = 1 kHz, or 181 kHz-180 kHz = 1 kHz. The preselector must be tuned to the desired signal at 180 kHz for maximum pickup. Choosing whether the upper or lower VFO frequency is best depends on which provides the clearest reception. An example of two-way operation could be you transmitting on 182 kHz with the preselector peaked to your friend's frequency of 182.4 kHz. Your friend's preselector would be peaked to your frequency of 182 kHz. As you can see, tuning the preselector above and below your center frequency provides a lot of flexibility.

Transmitting a beacon is very useful while you're not on the air. It is especially helpful to other stations that want to know if they can hear you or not, and helps with antenna testing and band conditions. The transmitter is easy to use. Simply connect your beacon ID or code key or PK-232 CW to the key input. Adjust your time-delay potentiometer (R30) for the desired time delay. The PA drive control (R36) can be set for maximum VCC. The transmitter was designed for link or tap coupling, using 50 ohm coax from the transceiver to the antenna loading coil. Direct connection from the cold end of the loading coil to the secondary of T4 is fine.

A 1 mA meter may be used to monitor the PA current. However, meters can be expensive; you can use a VOM or VTVM instead. Connect this to the meter "–" and "+" points on the circuit board. The voltage indicated is the input current to the PA. 1 watt of input power is 83 mA at 12 volts, or 83 millivolts on the VOM or VTVM. Also remember to measure the PA voltage at the "-" meter point since there is a slight voltage drop across R37 when calculating input power.

Parts List

Part #	Description	Purchase
C1,C5	470 pF poly cap	Mouser: 23PS147
C11	0.047 μF film cap	Digi-Key: P4521
C13,C23	0.001 μF polystyrene cap	Mouser: 23PW210
C15,C17,C24, C30,C35,C36	10 μF/50 VDC elec. cap	Mouser: 140-XRL25V10
C18,C25,C31,C39,C27	1 μF monolithic cap	Newark: 90F1907
C19,C33	0.01 μF disc cap	Mouser: 140-CD50Z6-103M
C2,C10	400 pF tuning cap	Mouser: 24TR218
C20,C21	0.018 μF poly cap	Digi-Key: P3183
C26	2200 μF/16 VDC electro cap	Mouser: 140-XRL16V2200
C28,C38	0.01 μF polystyrene cap	Mouser: 23PW310
C3,C4	7.5 pF NPO disc cap	Mouser: 21CB008
C40	0.022 μF poly cap	Digi-Key: P3223
C6	0.0047 μF poly cap	Mouser: 23PW247
C7,C12,C14,C16,C22, C29,C32,C34	0.1 μF ceramic disc cap	Mouser: 140-CD12U6-104M
C8,C9,C37	0.0027 μF polystyrene cap	Mouser: 23PS227
D1,D2,D3,D4,D5	Diode	Mouser: 592-1N914A
K1	DPDT relay	Digi-Key: Z768-ND
Q1,Q4	2N2222A NPN transistor	Mouser: 511-2N2222A
Q2	2N2907A PNP transistor	Mouser: 511-2N2907A
Q3	Power MOSFET	Mouser: 511-IRF510
R1,R4,R20	3.3k ohm 1/4W	IME
R10,R11,R15	100k ohm 1/4W Metal 1%	Mouser: 29MF250-100k
R12,R14	4.02k ohm 1/4W 1% metal	Mouser: 29MF250-4.02k
R13	10k dual audio taper pot	Calrad: 25-396
R19,R22	12 ohm 1/4W	IME
R2	33k ohm 1/4W	IME
R23,R32,R33,R34	1k ohm 1/4W	IME
R25	560 ohm 1/4W	IME
R3,R7,R21,R29, R35,R38	82k ohm 1/4W	IME
R30	250k ohm PC trimpot	Mouser: 32RM503
R31,R39	2.2k ohm 1/4W	IME
R36	2k ohm PC trimpot	Mouser: 32RM302
R37	1 ohm 1W	Mouser: 29SJ901
R5,R16	500k ohm PC pot	Mouser: 31CW505
R6,R27,R28	6.8k ohm 1/4W	IME
R8	10k ohm PC linear pot	Mouser: 31CW401
R9,R17,R18,R24,R26	10k ohm 1/4W	IME
S1	DPDT PC switch & knob	Digi-Key: EG1003-ND
T1,T2,T3	0.63mH transformer	Digi-Key: TK1201
T4	Toroid transformer	Amidon: T-68-3
U1	NE602 mixer/amp	Digi-Key: NE602AN
U2	Low-noise op amp	Mouser: 511-LF353N
U3	Quad op amp	Mouser: 511-LF347N
U4	Audio PWR amp	Newark: MC34119P
U5	+9 VDC regulator	Mouser: 333-78L009AP
U6	Quad comparator	Mouser: 511-LM339AN

Sources:
Mouser Electronics—(800) 346-6873
Digi-Key Sales—(800) 344-4539
Calrad—(213) 465-3504
Newark Electronics—(818) 888-3718
Amidon Associates—(310) 763-5770
IME—(817) 473-1730

A drilled and etched PC board is available for $22 plus $3 S & H; and this project is available in a complete kit for $89 plus $3 S & H from: Curry Communications, 737 N. Fairview St., Burbank CA 91505; (818) 846-0617. Brochures are available; send SASE.