Number 9 on your Feedback card

The SP-10 "Senior Spider" Transceiver

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You may have heard (or know firsthand) that transmitter power levels of 1 watt or less can indeed "get out" and have accounted for some remarkable feats of DX. It's true.

It's also true that 1 watt, in HF skywave service, has little endurance to spare. You get lucky and snag a good one when the band is optimum and two minutes later, you're talking to yourself because of QSB or QRM at the other end! Clearly, some extra holding power is called for if you want to chew the rag or make 5-WPM Novice QSOs that, of necessity, take longer to complete. The question is, how much will it take to do the job?

When it comes to transmitter power, the sky's the limit of course, up to the legal limit for your license class, but here we also want easy construction and minimal cost to encourage beginners so we'll just split the difference between a measly 1 watt and the widely effective 100 watt levels. And the answer is...10 watts! That's right. To judge the effect of a power change, you must think in terms of dB (decibels) and not be mislead by the watts. Ten watts is 10 dB better than 1 watt and 10 dB worse than one hundred, placing it on middle ground theoretically and in terms of on-the-air readability.

The rig to follow is a simple 10-watt, crystal-controlled CW transceiver that may be built for 80, 40, or 30 Meters. You can build it and learn a little about how it works. Should it ever malfunction, just fix it yourself. There's no need to rely on the service of a distant repair facility. That's independence!

The SP-10

The SP-10 presented here is functionally very similar to its predecessor, the SP-1 (Jan. 1993 issue of *73*) which has enjoyed popularity in the QRP world. The receiver front end is triple-tuned to improve in-band sensitivity and out-of-band rejection. The dual-gate MOSFET receive mixer has been retired and its job turned over to a multifunction IC that also includes an op amp for audio bandpass filtering and a very effective audio muting switch. A low-noise audio preamp stage for increased gain rounds out the receiver improvements.

The transmitter section is pretty much the same as the original "Spider" except here it drives a power MOSFET "afterburner" producing 8 to 12 watts of RF output. Physically, the highly successful SP-1 layout has been retained wherever possible. The additional circuitry requires a larger circuit board which fits comfortably in the next size up enclosure, an RS #270-232 measuring about 8" w by 4" d by 2" h.

"Your brain needs a change of pace and here you get it whenever you close the key!"

The net effect of these changes is a quantum leap in overall transceiver performance and just a modest increase in cost and complexity. By strictly avoiding "dinosaur" and one-of-a-kind components in the design, easy duplication and maintenance for years to come is almost assured. So get with it and, next time, you'll be the one to say "Rig here is home-brew!"

Circuit Description

The heart of this radiotelegraph transceiver is continuous wave oscillator Q1 (refer to the schematic, Fig. 1). You plug a quartz crystal (more on crystals later) for the desired operating frequency into the top panel socket and Q1 circuitry provides the needed gain and feedback to sustain crystal vibration and supply RF drive to other circuits via the secondary link on T1.

Photo A. Top view of the SP-10.

During receive, incoming signals pass through L5, L4, L3 and series resonant C23/L6 to receiver input circuits T2/C32 and T3/C33 (which are top coupled by C34) and onward to the receive mixer at U3 pin 18. There, in conjunction with oscillator signal via C18 to U3 pin 1, they are converted directly to audio at U3-3, filtered by C59 to remove unwanted RF byproducts and then audio bandpass filtered by the op amp at U3-12 and U3-13, which provides a distinct peak at about 400 Hz. In receive, the audio muting transistor at U3-16 is off (open) allowing signal passage to AF preamp Q6, volume control R47 and AF power amplifier U1 (pin 2 in, pin 5 out). U1 employs a small amount of negative feedback (C52) to roll off unnecessary high-frequency components in the AF output.

Receiver fine-tuning is accomplished by using RIT control R23 to vary the tuning voltage (via R1) to D1. This special tuning diode transforms RIT rotation into variable capacitance which, in conjunction with L1 and Y1, alters the oscillator frequency. Normally, this receiver is properly tuned when there is a 400-Hz difference between signal and oscillator. The resulting beat note provides peak output because it is centered in the audio bandpass response. Frequencies higher and lower receive less amplification. This is how selectivity is provided; the desired signal is louder unless interference is overpowering.

Automatic receive-transmit switching (QSK) is initiated by closing the key. Q8 switches on, rapidly energizing the 12T bus which, in turn, accomplishes the changeover to transmit by switching several circuits. 12T via D8 mutes receive audio by placing a short circuit at U3-16. It turns on sidetone generator Q7 (a unijunction transistor or UJT) via R38 and R39. Sidetone allows you to monitor your telegraph sending quality by providing a nice, tight feedback loop that includes ear, brain, fist, and key. The sidetone in this rig also provides an important secondary function. Its complex, harmonic-rich output soothes your brain by dispersing all those headache-forming neural knots that may come from excessive sine wave exposure during receive. Your brain needs a change of pace and here you get it whenever you close the key!

Moving onward, 12T via R25 and Q5 grounds D1 tuning voltage to provide transmit offset which allows same-frequency transmit-receive with other stations. It switches Q3 on, enhancing oscillator output level via R5 and assisting transmit offset with C3. Finally, 12T keys Q4. which permits Q2 to amplify the incoming oscillator signal. Q2 output via low-pass filter L2 and resistive pad R14-17 then drives final RF power amplifier Q9 to full output of 8 to 12 watts, depending on band, power supply and transistor grade.

Harmonics present in this raw power are attenuated to insignificance by low-pass filter L3-L4-L5 and associated capacitors. Since the receiver input is tied directly to transmitter output at C23, D4-D7 are included to protect the receiver. Transmit RF turns them on and, while in conduction, they place a near-short at the junction of C23 and L6, breaking up the series resonance and forcing C23 and C22, because of their relatively low capacitance, to look like a high impedance during transmit, thus blocking most of the RF. This technique was actually developed for radar equipment where a sensitive receiver and high-power transmitter had to share a common waveguide. What you see here is the same principle in a less pure but still adequate form.

Photo B. *Bottom view of the SP-10.*

Construction

In the top view photograph of the SP-10, you can see the octal-type crystal socket in the left-rear corner. Since this socket holds two FT-243 or similar crystals, DPDT switch S2 is provided just in front to select one or the other. TB1, a four-lug terminal board, mounts along the rear edge of the top panel, near the right-rear corner. Its terminals are numbered 1 to 4 going from left to right. Connections to TB1 are DC power to 1 (+) and 2 (-) and antenna system to 3 (coax shield) and 4 (center). Along the right edge are 3.5-mm jacks for speaker/headphones (J2-rear) and external telegraph key (J1-front).

The built-in telegraph key is just left of the jacks. Its arm, a 3" strip of .025" thick brass or aluminum, is mounted on 1/4" spacers and grounded to the top panel by its two mounting screws. The key knob, a rubber or plastic equipment foot, is fitted or glued to the hex nut attached with machine screw, up through the arm. The head of this screw is the upper contact. The key contact beneath the arm is a 6-32 brass machine screw with head filed flat. This screw is insulated from the top panel with a shoulder washer above and fiber washer below, and secured with flat washer, solder lug (for connecting to) and hex nut.

The two knobs front and center on the top panel are Volume control R47 on the right and receiver incremental tuning (RIT) R23 on the left. Just left of RIT is slide switch S3, unused here but available for extra audio filtering (to improve selectivity) or other contingencies. Left of S3, in the left-front corner is DC-power control switch S1.

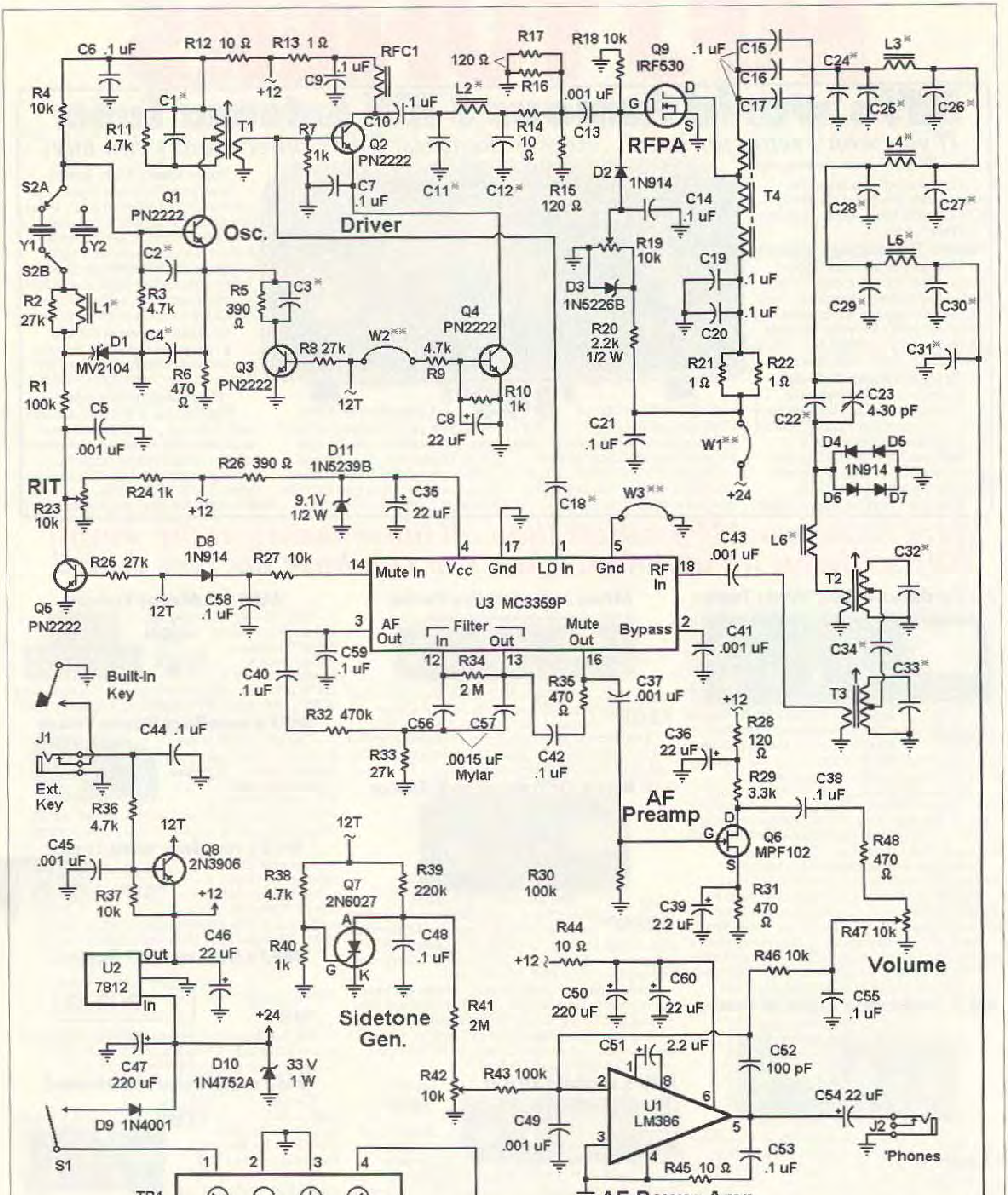
Running front to rear between RIT and Volume, and below the top panel, is a 1" wide by 3" long by 3/8" thick solid aluminum slab that provides heat sink and mounting platform for RF power amp Q9. This slab, to further increase heat dissipation, is attached directly to the aluminum top panel with three machine screws, heads visible in the photograph.

Most of the project is contained on the PC board depicted by the etching pattern in Fig. 2 and the parts overlay, Fig. 3. Of special note on PC board assembly, voltage regulator IC U2 needs 2 to 3 square inches of heat radiator coupled to its mounting flange. I cut and bent a piece of .025" aluminum sheet as shown in photo B (inside view) and on the parts overlay, and installed it between U2 and the PC board.

T4, the trifilar-wound matching transformer, uses two of the specified core placed side-by-side. The wire winding holds them together, no problem. Don't be intimidated by "trifilar winding." All you do is cut three equal length wires and twist them into a bundle. Thread the bundle onto the core until you have the specified turns count. It should look like an octopus with six tentacles coming off the bottom. Trim excess wire but allow enough for connections and installation. Now you have three wires on the core, arbitrarily designated A, B and C, and color-coded or tagged for easy identification. Connect the end of A to the beginning of B. Connect the end of B to the beginning of C. The beginning of A and the end of C remain single and go to "Com" and "Out" at T4 on the PC board. The two cross-connections go to "X" and "in." Voilà!

Because Q9 is the last part installed, even after the PC board is mounted to the top panel, provision must be made for connecting it to the top side of the board. I used short "flea clips" as mounting posts at holes G, D, and S. Anything snug enough to remain tight when reheated will do the trick here. In other words, you don't want the mounting posts to come loose from the PC board when you're attempting to solder the leads of Q9!

With the PC board complete, use it as a template to mark its corner mounting holes on the inside of the top panel as shown in Photo B. The heat sink slab mentioned earlier runs from beneath the rectangular Q9 cutout to the area between Volume and RIT. Drill and tap a 6-32 mounting hole for Q9's flange in the heatsink, positioned so Q9 leads will bend and reach the PCB mounting posts.



Notes:

1. ✻ denotes part value varies with band. See Table 1.
2. ✻✻ W1-3 represent bare wire jumpers needed with the accompanying pcb layout.
3. Both Q9 and U2 require a heatsink. See text and photographs for details.
4. Component ratings: Unless specified, resistors are 1/4 W, electrolytic capacitors are 35 V and ceramic disk capacitors are 100 V.

Figure 1. Full schematic diagram of the SP-10 "Senior Spider."

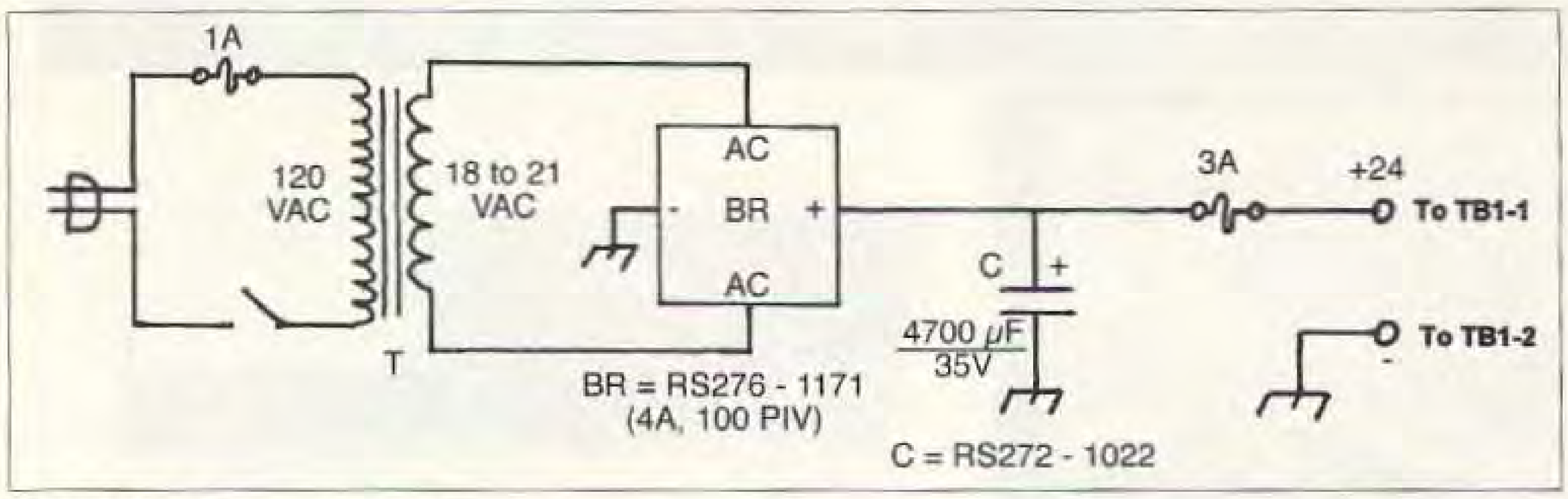


Fig. 4. SP-10 power supply.

Follow the photos to lay out and install the remaining top panel parts, the positioning of which is much less critical than the need to keep Q9 cool.

Except for the short ANT/GND and Y1 wires, connect the PC board to top panel components as shown on the schematic diagram or parts overlay. Hinge the board over and mount it to the top panel on 5/8" metal spacers, and then connect the short wires to TB1 and S2. Check to ensure the copper side of the PC board is not touching any panel components like potentiometers or jacks. Lastly, install Q9 to the heat sink using a heat conductive insulator pad and 6-32 Teflon or nylon screw or a TO-220 transistor mounting kit, to couple the flange thermally but not electrically to the heat sink slab.

Power Supply

A suitable power supply for the SP-10, one supplying 18 to 28 VDC at 1 amp, can be as simple as a DC wall adapter or a pair of 12V batteries wired in series. There's no need for a fancy, electronically regulated unit. Precise regulation, where needed, is already supplied by U2. The external supply should, however, be beefy enough to hold its output voltage within 20%, going from key-up to key-down. For example, a source measuring 25 VDC should drop no lower than about 20 volts when you close the key. The no-load input can be as high as 32 VDC; beyond that point, protection zener D10 may conduct and if it does, it will probably short circuit in the process of protecting the SP-10 from overvoltage.

If you wish to build a power supply from scratch, the classic transformer-rectifier-filter arrangement shown in Fig. 4 will work just fine. Regardless of the power supply you choose, be sure to provide an inline fuse in the plus lead running to TB1-1. Start off with a 1-amp fuse if possible and, if all goes well, upgrade it to 2 or 3 amps for normal operation. This conservative approach to firing up new, untested equipment will minimize casualties should anything be amiss.

Crystals

The operating frequency of the SP-10 is controlled by a single crystal in transmit and receive. With crystals, you give up the ability to wander (or drift!) around the band in exchange for excellent frequency stability, intrinsic dial readout (frequency is marked on the crystal) and simplified project tune-up, requiring very little test equipment. For the beginner, or the old-timer into "radio karma," crystal control is a good way to go.

The actual crystal is a thin square of quartz too fragile and sensitive for direct handling. Rather, it is mounted in a holder which, depending on type, plugs into a crystal socket or is wired directly into the equipment. The octal crystal socket on the SP-10 accepts two of the popular FT-243 holders, having a pin spacing of .486" and a pin diameter of .093." Types HC-17 and Petersen Z-9 are also compatible. In general, any fundamental crystal with a frequency in the chosen band will work if you can adapt it to plug in. For example, even the miniature HC-18 holder with leads instead of pins may be wired to the base salvaged from an unneeded octal vacuum tube, which will then plug in.

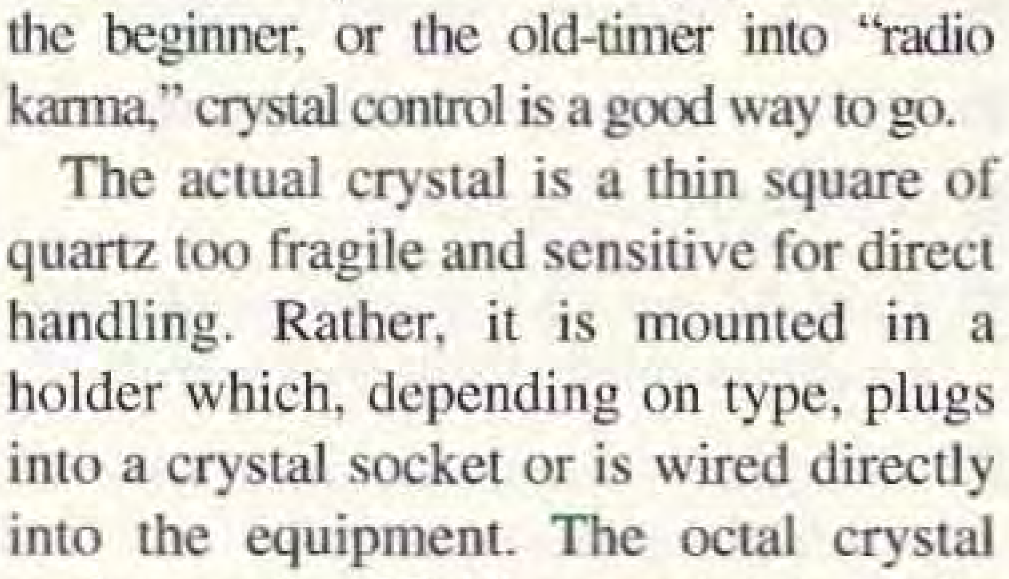


Photo C. The SP-10 at an angle.

Getting crystals is like ordering pizza. Unless you are buying a stock or popular frequency, they are tailor-made by a manufacturer upon receipt of an order. That's why delivery can sometimes take 2-3 weeks or more; you must allow for lead time! Some manufacturers require the Y1 specifications provided in the Parts List while others will do the job if you merely order "amateur-grade crystal" and specify the frequency.

If you're a Novice, don't crowd the edges of your subband when ordering crystals, unless you have the means to ensure the crystal you're using is "in-band." The reason is, a general purpose or amateur-grade crystal ordered for, say, 7102 kHz, may actually put out on 7100. It's a matter of manufacturing tolerance and circuit correlation. If in doubt, give band edges a wide berth.

Tune-Up

The key to a smooth, uneventful tune-up is to do a careful job during construction. Having done your best, let's see if it works! On the PCB, set R19 Bias and R42 Sidetone each to midrange. Connect the power supply to TB1-1 (+) and TB1-2 (-) and a 50-ohm dummy load with relative power meter or wattmeter in line to TB1-3 (coax shield) and TB1-4 (center conductor). Lacking this test equipment, build the simple terminating RF indicator shown in Fig. 5 and connect it to TB1-3 and TB1-4. This gizmo provides a suitable resistive load for low power transmitter testing, as well as a visual (and thermal—it gets warm to hot!) indicator of RF output.

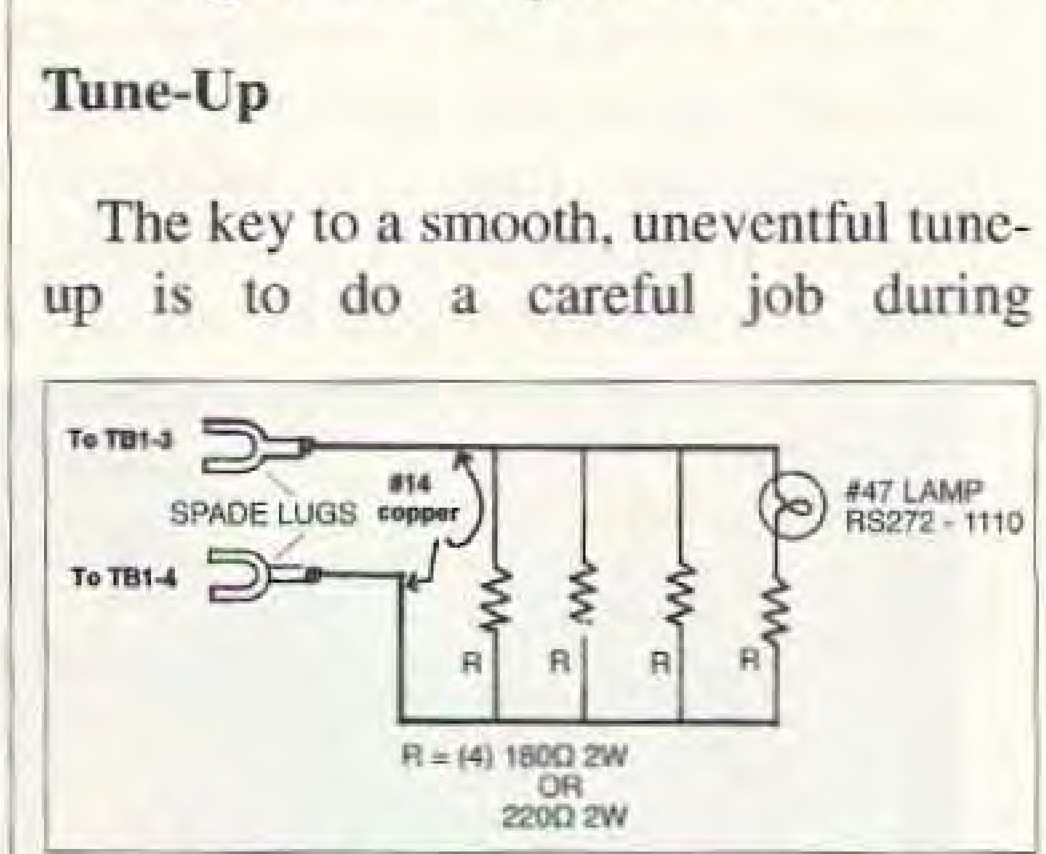


Fig. 5. Terminating RF detector.

Plug a speaker into J2. Insert a crystal into the socket and select it with S2. Switch on power with S1, close the telegraph key and adjust T1 for maximum RF output indication. Adjust R42 on the PCB for desired sidetone level. Replace the dummy load with an antenna or signal generator at the crystal frequency and adjust C23, T2, and T3 for best reception.

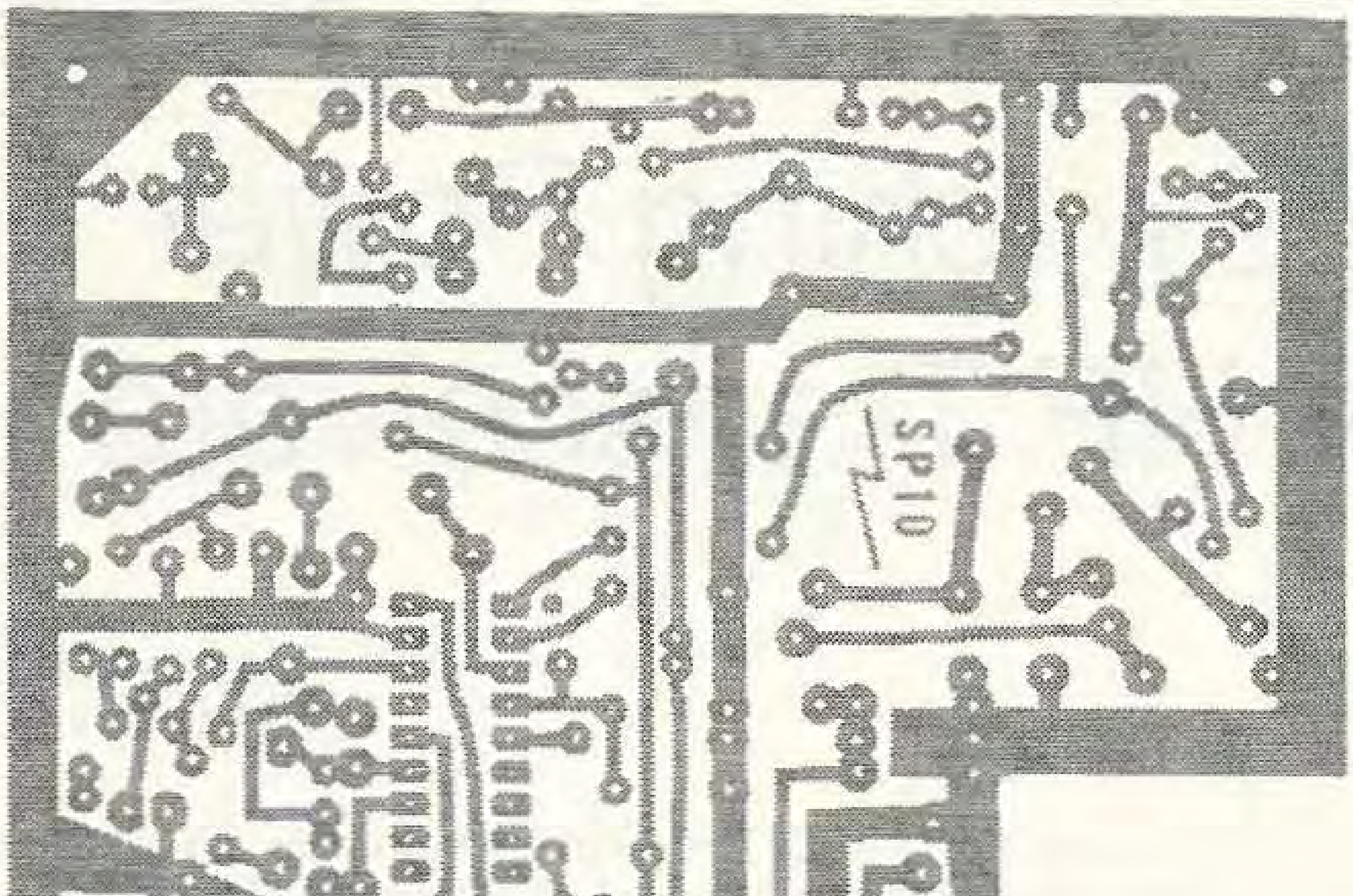


Fig. 2. PC Board foil pattern.

Some patience is called for with the antenna method; you may need to wait for a signal strong enough to be heard through the as yet unpeaked front end. A temporary clip-lead jumper from the anode of D6 to the upper lead of C34 may help by allowing you to get T2 and T3 in the ballpark first. Then remove the jumper to peak C23 and touch up T2 and T3.

On the Air with the SP-10

Like all modern transceivers, the SP-10 prefers to see a 50-ohm antenna system with low SWR. The classic half-wave dipole comes close to ideal without the use of extra matching techniques. Other antennas like the G5RV or random wire will require an antenna tuner to provide an acceptable load. If operation into a less than perfect match is unavoidable, it might be wise to reduce the operating voltage from, say, 24 VDC to 18 VDC. This will reduce the adverse effect (Q9 overheating) of a somewhat high SWR.

With its rather broad selectivity, it can be questionable whether or not signals heard on the SP-10 are close enough to your crystal frequency for a QSO. Those that decrease in pitch and approach zero-beat with RIT control moved fully counterclockwise are very close. Others may be workable if the operator tunes around for your signal.

Though 10 watts is considered low power, it's right up there with the popular one-tube 6L6 transmitter (and countless variations) that propelled tens of thousands of hams into the ether in their early radio careers. The receive section is certainly no worse (and probably better) than those "drifty," broad-tuning superhet Novice receivers we once cherished and still remember fondly. They did the job! And on most any night the SP-10 can be your doorway into a wonderful world of Morse and static, faceless names, exotic places, and colorful QSL cards—all the more exciting when you build the rig yourself!

SP-10 Condensed Parts List

C1-C4, C11-C12, C18, C22, C25-C34	(see table 1)
C23	4-20 pF trimmer, Mouser 24AA022
C56, C57	0.0015-µF Mylar™
D1	MV2104, ECG612
D2, D4-D8	1N914, RS 276-1122
D3	3.3V .5W zener diode (1N5226B)
D9	1N4001, RS 276-1101
D10	33V 1W zener diode (1N4752A)
D11	9.1V .5W zener diode (1N5239B)
J1-J2	3.5 mm closed circuit mini phone jack
L1-L6	(see table 1)
Q1, Q3-Q5	PN2222, ECG123AP, RS 276-2009
Q2	2N2219A, ECG128, RS 276-2030
Q6	MPF102, ECG312, RS 276-2062
Q7	2N6027, ECG6402
Q8	2N3906, PN2907A, ECG159
Q9	IRF530
R19, R42	10k PC trim potentiometer, RS 271-282
R23, R47	10k audio taper potentiometer, RS 271-1721
RFC1	22-µH epoxy coated, Mouser 43LS275
T1-T3	Mouser 42IF123
T4	8 turns #24 enamel wire, trifilar wound on two FT50-43 (Amidon) cores
TB1	4-lug terminal board, Mouser 534-4190
U1	LM386 audio amp, RS 276-1731
U2	7812 voltage regulator, RS276-1771
U3	MC3359P (Circuit Specialists)
Y1	Fundamental crystal, specify desired frequency, parallel / 32-pF load, .005% tolerance, holder type FT-243, HC-17/U or equivalent.

Note: Check the advertising in this magazine for parts suppliers. For a free list of parts sources for this project, send the author an SASE requesting SP-10LST. PC boards and project kit for the SP-10 "Senior Spider" are available from Lectrokit, 401 W. Bogart Rd., Sandusky, OH 44870 (no telephone).

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The SP-10 "Senior Spider *Continued from page 15*

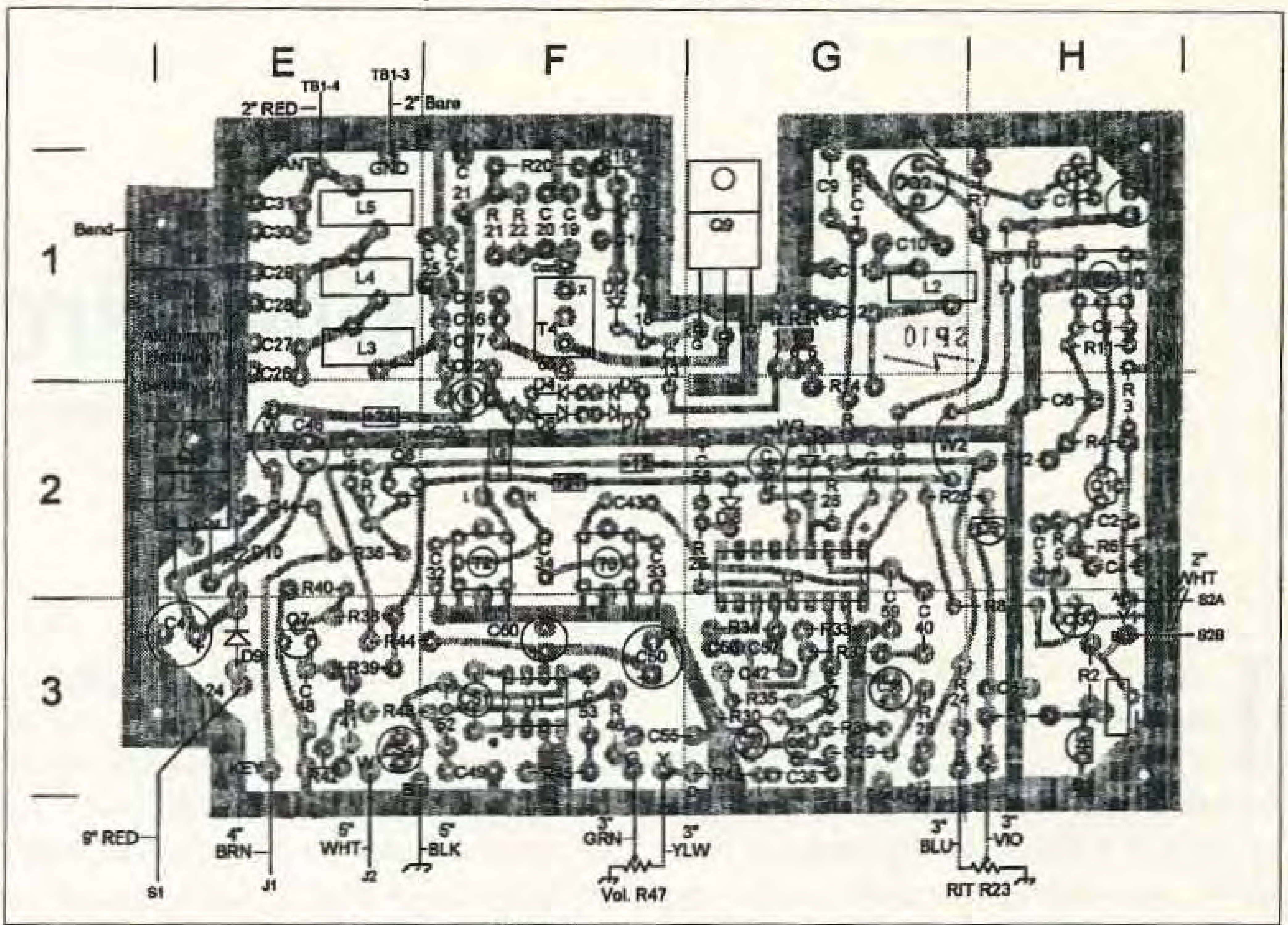

Fig. 3. Parts overlay.

Table 1 Band Data

Component	80-M	40-M	30-M
C1	390 pF	68 pF	Not used
C2	18 pF	5 pF	Not used
C3	680 pF	270 pF	Not used
C4	820 pF	680 pF	390 pF
C11, C12	820 pF	390 pF	270 pF
C18, C34	39 pF	18 pF	10 pF
C22	18 pF	Not used	Not used
C25, C31	390 pF	270 pF	180 pF
C26, C28	390 pF	Not used	390 pF
C27, C29	820 pF	680 pF	68 pF
C30	68 pF	Not used	Not used
C32, C33	390 pF	68 pF	Not used
L1 (FT37-61)	40T #30	23T #28	17T #28
L2 (T50-2)	22T #24	14T #24	12T #24
L3, L5 (T50-2)	22T #24	17T #24	14T #24
L4 (T50-2)	25T #24	19T #24	16T #24
L6 (FT-37-61)	30T #28	25T #28	15T #28

Capacitors are 100v ceramic disk type. For inductors, wind turns using the enamel wire gauge given on the toroid core specified.

SP-10BBM, $16 ppd. US/CAN, includes bare PC board and step-by-step construction manual. PC board and parts (including band parts for 80, 40, 30 meters), and case parts including drilled and tapped heat sink. The RS 270-232 case and crystal(s) are not included but a mailer for sending in your top panel for free master template marking (with metal work option extra) is included. This pricing is valid within four months of publication. Order direct or send an SASE for current details.