By J. G. "Bunky" Botts, K4EJQ

Get On 222 MHz with a Ten-Tec 1210 Transverter!

Here's a quick way to explore 222 MHz using your 10-meter transceiver!

If you operate on 6 and 2 meters, you know how popular the Ten-Tec 1210 transverter units are.[1] They remind me of Heath's popular Heath Benton Harbor "Lunch Boxes" that gave 6- and 2-meter activity a much-needed shot in the arm some decades ago. The 1210 allows you to operate on 2 meters with a power output of 10 W using your 10-meter transceiver. A while ago, a friend and fellow VHF enthusiast, Bill, WB4WEN, approached me with an idea. He wanted to increase the local activity on 222 MHz. One way to do this, he suggested, was to try converting a Ten-Tec 1210 transverter to operate on 222 MHz. Bill had studied the unit's schematic and it looked like a good candidate for the job. Besides, he already had a nonworking unit he had picked up at a bargain price! Other than a new crystal for the band change, the other additional components needed for the modification are a few disc-ceramic capacitors and some RF chokes to retune the circuits to 222 MHz.

Later-production models of the 1210 transverter use a Motorola MRF-2628 transistor in place of the BLW-81 device in the early transverter PAs. The modifications we made to the transverter's PA stage are the same for either device. However, because the MRF-2628 has lower gain at 222 MHz, the power output of a unit using this transistor in the PA is about 3 W.

Before we began the conversion, Bill and I set the following criteria for a successful project:

- Low cost
- Few (if any) modifications to the PC board. The unit should be able to be returned to 2-meter operation with a minimum of effort, if need be.
- Stable operation
- A power output of 5 W across the band (with a BLW-81 in the PA stage) using a 12.6 V power supply.
- Require just a few simple hand tools and a minimum of test equipment

Initial Steps

Before you start heating up your soldering iron, I suggest you read this entire article and familiarize yourself with the original 1210 tune-up procedure as outlined in the Ten-Tec manual. If you don't have the manual, get one! Also, get and use the proper tuning tool for the slug-tuned coils and get the feel of tuning the unit's different stages. (If you don't use the proper tool for tuning these coils, you're likely to break their powdered-iron slugs.) For receiver alignment, you'll need a signal generator or a local beacon to provide you with a stable, constant signal level. To tune the transmitter, you'll require an RF-output meter; the more sensitive, the better. Consult the Ten-Tec manual for references to aid you and refer to the description of the duplicated RF detector mentioned later. Take a look at the "Parts List" sidebar and gather the components you'll need. In addition to your soldering iron, you should have a solder-removing tool and/or wicking as you'll need to remove some components and replace them with others having different values.

Pay attention to the tuning of the local-oscillator (LO) output stage and how that tuning affects the transverter's power output and the receiver section's performance. After conversion, you'll likely find that the most critical tuning is that of the LO's push-pull output stage. That's because we'll then be using it as a tripler to reach 222 MHz. As outlined in the T-Kit instruction manual, make some voltage measurements at various points in a properly working unit while it is still operating on 2 meters. If you have not already done so, record these readings for reference; there's space provided on page 27 of the manual. Pay particular attention to the voltages in the LO chain, especially the levels measured at TP1 and the emitters of Q4 and Q5 during the **Phase 1.0 Progress Test** described in the manual before the mixer components are added. Once the mixer components are added, making measurements at TP1 is extremely difficult. When the conversion is complete, your records can be used to aid tune-up on 222 MHz.

Getting to Work

In the following steps, refer to the schematic in Figure 1, the other accompanying graphics and those in your Ten-Tec 1210 manual. The components involved in the modification and their new values and/or wiring are shown in heavy lines and bold type in Figure 1.

First, remove the PC board from its enclosure. This involves removing the regulator IC and the driver and PA transistors from their heat-sink shelf. Remove the screws near two corners of the PC board, the two screws at the PA transistor and one screw at the regulator IC and driver transistor. Remove the large nut on

[1] Joe Bottiglieri, AA1GW, "Ten-Tec 1210 10-Meter to 2-Meter Transverter," Product Review, *QST*, Jun 2000, pp 73-74.

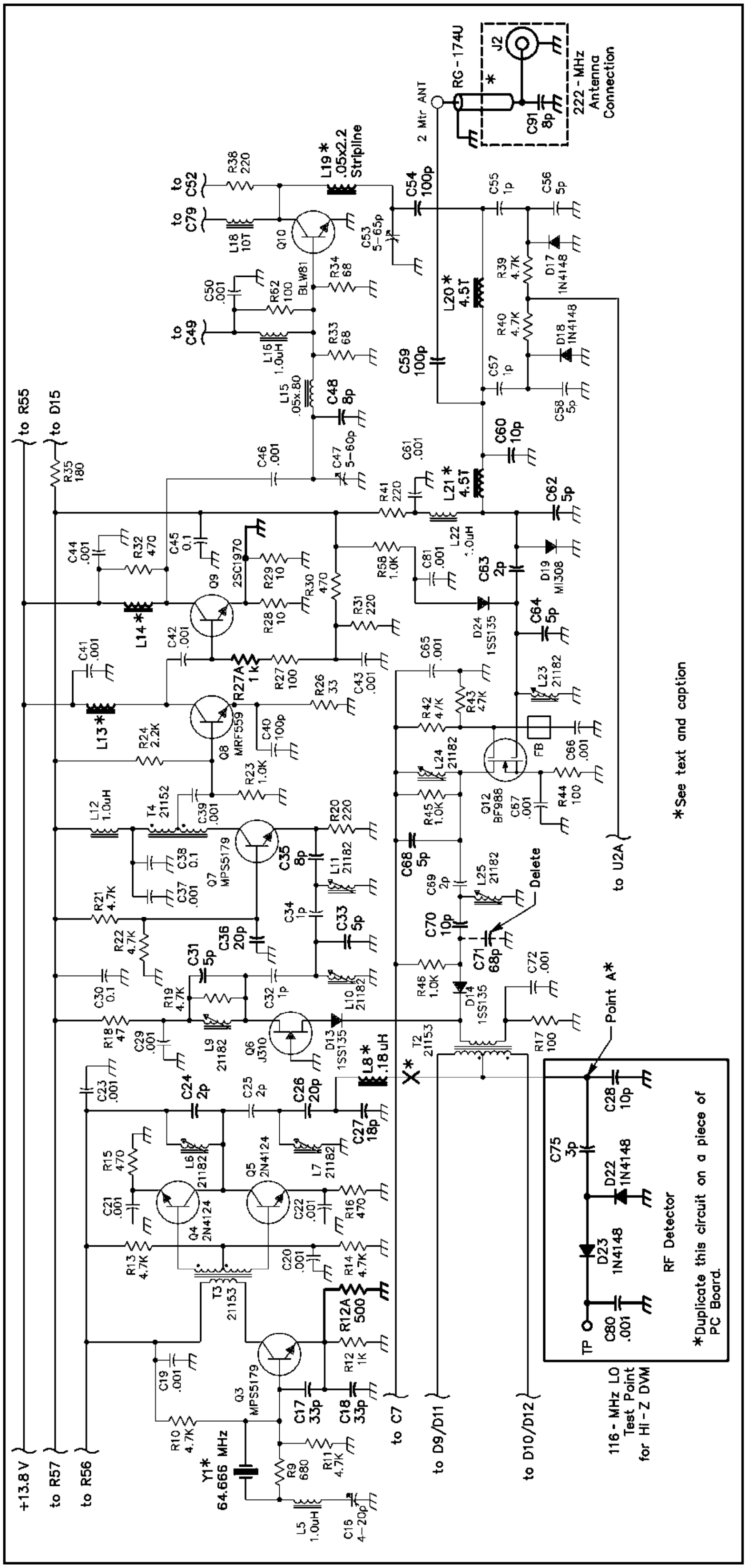

Figure 1—Schematic of the Ten-Tec 1210 10-meter to 2-meter transverter prototype modified for 222-MHz operation. The components involved in the modification and their new values are shown in heavy lines and bold print. Parts are available from a number of suppliers; see the "Parts List" sidebar. Equivalent parts can be substituted; n.c. indicates no connection.

Parts List

Components with an **A** suffix are either added units or duplicates of existing components. Other components listed are either direct replacements for existing parts or are modified parts. See text. Equivalent components can be used.

(All capacitors are 25-V disc-ceramic units)

C17, C18—33 pF
C24, C63—2 pF
C26, C36—20 pF
C27—18 pF
C31, C33, C62, C64, C68—4.7 or 5 pF
C35, C48, C91—8 pF
C54, C59—100 pF
C60, C70—10 pF
C71—Remove this capacitor.
C75—3 pF
L8—$^{1}/_{8}$-inch-ID air-wound inductor: 5 turns #24 or #26 enameled wire closely wound; see text.
L13—0.18-µH molded inductor (Ten-Tec Co 865-453-7172.*); see text.
L14—See text.
L19—See text.
R12A—500 Ω, $^{1}/_{8}$-W carbon-film or carbon resistor
R27A—1 kΩ, $^{1}/_{8}$-W carbon-film or carbon resistor
Y1—64.6666-MHz, fifth-overtone series resonant crystal, HC-49 holder, 0.001% tolerance; JAN Crystals, 2341 Crystal Dr, PO Box 60017, Ft Myers, FL 33906-6017; tel 800-JAN XTAL, 941-936-2397, fax 941-936-3750; **www.jancrystals.com**.

Duplicate RF-Detector Circuit

C75—3 pF
C28—10 pf
C80A —0.001 µF
D22A, D23A—1N4148 diode
1—Piece of PC board (RadioShack 276-150 or similar); see text.

Parts are available from a number of suppliers including Digi-Key Corp, 701 Brooks Ave S, Thief River Falls, MN 56701-0677; tel 800-344-4539, 218-681-6674, fax 218-681-3380; **www.digikey.com** and Mouser Electronics, 958 N Main St, Mansfield, TX 76063-4827; tel 800-346-6873, 817-483-4422, fax 817-483-0931; **sales@mouser.com**; **www.mouser.com**. See the References Chapter in *The ARRL 2001 Handbook* and the on-line database at **www.arrl.org/tis/tisfind.html** for additional part suppliers.

*Ten-Tec, 1185 Dolly Parton Pkwy, Sevierville, TN 37862; tel 800-833-7373; information tel 865-453-7172, fax 865-428-4483; **sales@tentec.com**; **www.tentec.com/**.

the PA-transistor stud; it's accessible through the large hole in the bottom plate. Note which hardware goes where and be careful not to misplace any of the hardware or the driver transistor's insulating pads and shoulder washer. Other than the wires to the front-panel LEDs, the other wiring can be left intact; be careful not to break any wires. With the PC board out of its enclosure, you are ready to begin the modification. Of course, when removing and installing any components, ensure power is not applied to the transverter.

Modifying the LO

First, we modify the LO to provide a stable injection frequency to the double-balanced mixer at 194 MHz at a power level of approximately 15 mW (+12 dBm). This is accomplished by substituting a 64.6666-MHz third-overtone crystal at Y1 for the original crystal and modifying the push-pull doubler stage that follows the overtone oscillator to operate as a tripler. To increase the LO output-stage efficiency, make the following changes to the oscillator portion of the LO: Change C17 and C18 to 33 pF each. Change the value of R12 to approximately 330 Ω by placing a 500-Ω 1/8-W resistor (R12A) in parallel with the original 1-kΩ resistor; see Figure 2. Next, change the value of C24 to 2 pF, C26 to 20 pF and C27 to 18 pF (all are disc-ceramic capacitors). Remove and save L8, the original molded choke. Make a replacement for L8 by winding five closely spaced turns of #24 or #26 enameled wire on a 1/8-inch form (the shank of a 1/8-inch-diameter drill bit will do). Slip the coil off the form and temporarily set it aside. *Do not install the new L8 until told to do so!*

RF Detector Duplication

Next, duplicate the RF-detector circuit that provides the relative output reading at TP during the initial LO tune-up. This circuit (within the box at the bottom of Figure 1) consists of two 1N4148 diodes (D22, D23), one 0.001 µF capacitor (C80) and one 2- or 3-pF disc-ceramic capacitor (C75) and one 10-pF capacitor (C28). You can build the replicated detector on a small piece of PC board. The duplicate parts of this detector are identified in the "Parts List" with an **A** suffix. Keep the interconnecting leads as short as possible. By duplicating this circuit, you'll save time and not need to unsolder a number of mixer-circuit components that would have to be reinstalled later. The duplicate circuit also takes the load off the LO output circuit allowing you to tune that stage with a simple VOM connected to point TP of the *duplicated* detector. You can use this little detector circuit later during the transverter's transmitter-alignment procedure and for other projects involving low-level RF detection at VHF/UHF.

PHOTOS BY JOE BOTTIGLIERI, AA1GW

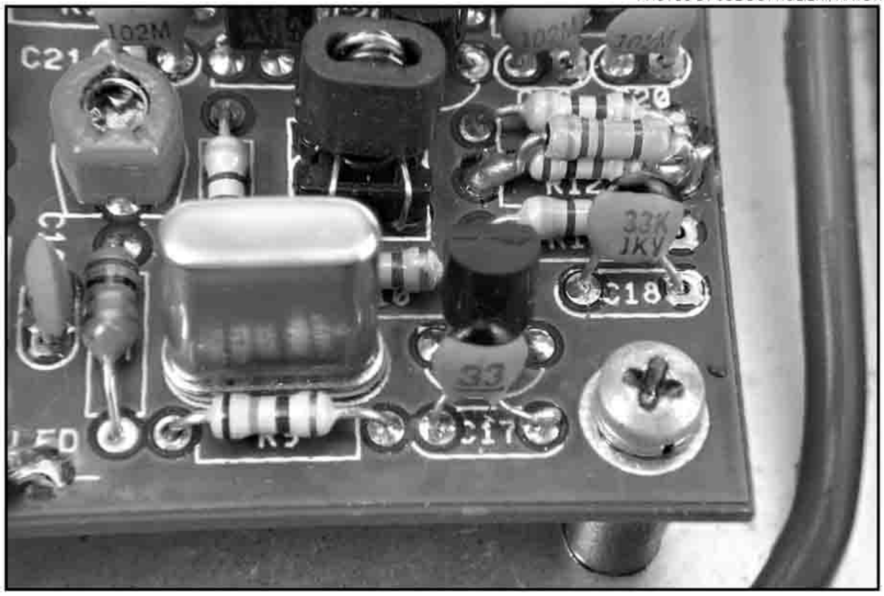

Figure 2—Change the value of R12 to approximately 330 Ω by placing a 500-Ω, 1/8-W resistor (R12A) in parallel with the original 1-kΩ resistor. C17 and C18 are also shown here.

Make sure that the crystal is operating on its third overtone.

Retune the LO to its new output frequency of 194.000 MHz. Begin by installing the replacement L8 you made earlier; connect it between L8's original connection at the junction of C26 and C27 and the *duplicated* RF detector Point A using the shortest wire length possible. See Figure 3. With power applied to the transverter, connect a frequency counter to the collector of Q3 via a 47-pF capacitor. Make sure that the crystal is operating on its third overtone and adjust its frequency to 64.6666 MHz (or as closely to that frequency as you can get) using trimmer capacitor C16. If the oscillator fails to start each time power is applied

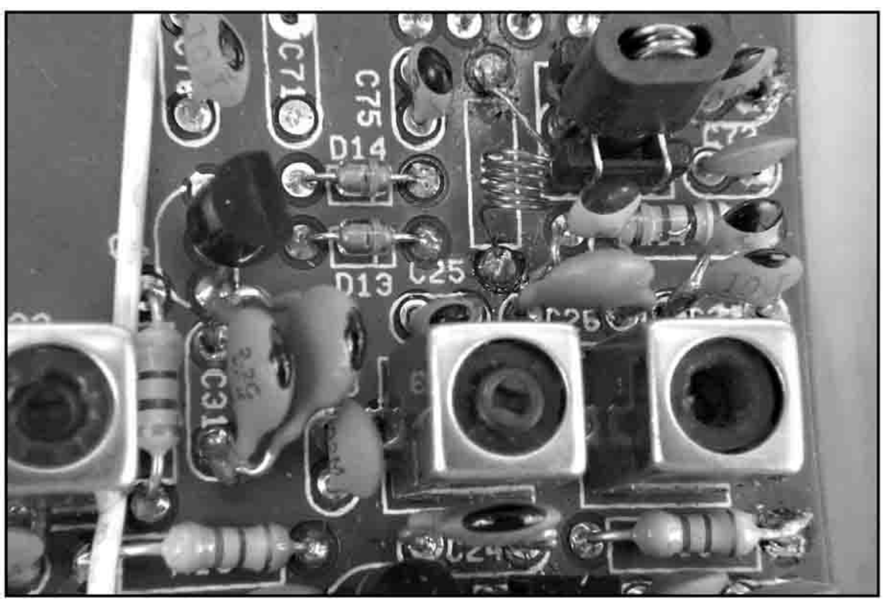

Figure 3—A homemade inductor replaces the original L8 as described in the text. C71 is removed. In this prototype, the new value for C31 (as those of some other capacitors) is created by soldering smaller capacitor values in parallel. C7, C26 and C70 are also in this general area.

to the transverter, you may have to retune C16 to a value that sustains oscillation. Doing so will cause the frequency readout of the unit used as the IF to be in error. You can either live with this situation (compensating by noting the frequency difference), or purchase a higher-accuracy crystal.

With power applied to the transverter, connect a high-impedance dc voltmeter to the *duplicated* detector's test point (TP) and alternately tune L6 and L7 for maximum indicated output. With all circuits peaked, you should see a minimum of 2.5 V dc at TP. (You may need to slightly spread the turns of the new L8 to optimize the LO output.) The emitter voltages of Q4 and Q5 should range from 4.1 to 4.4 V dc. If the voltages are less than 4.0 V, try adjusting the value of R12 slightly to increase the amount of drive from the oscillator stage.

The values of C24 and C26 are chosen to allow their associated inductors, L6 and L7, to tune to 194 MHz near the midpoint of their tuning range. Check the output with a frequency counter coupled to the LO output at Point A (*not* TP) to verify the operating frequency of 194.000 MHz. These adjustments are most important in assuring maximum overall performance of the modified unit. After peaking all the circuits for maximum output, make the following test: With power applied to the transverter, briefly detune C16 to the point at which the crystal stops oscillating and verify that there is *no* indicated output from the LO chain. If there is output, it's an indication of instability. Find and correct the instability problem *before* continuing. Once you're satisfied that the LO is operating properly, you may disconnect L8 from its temporary connection to the duplicated RF detector and reconnect it to its original point on the PC board, the junction of the center tap of T2 and capacitor C28.

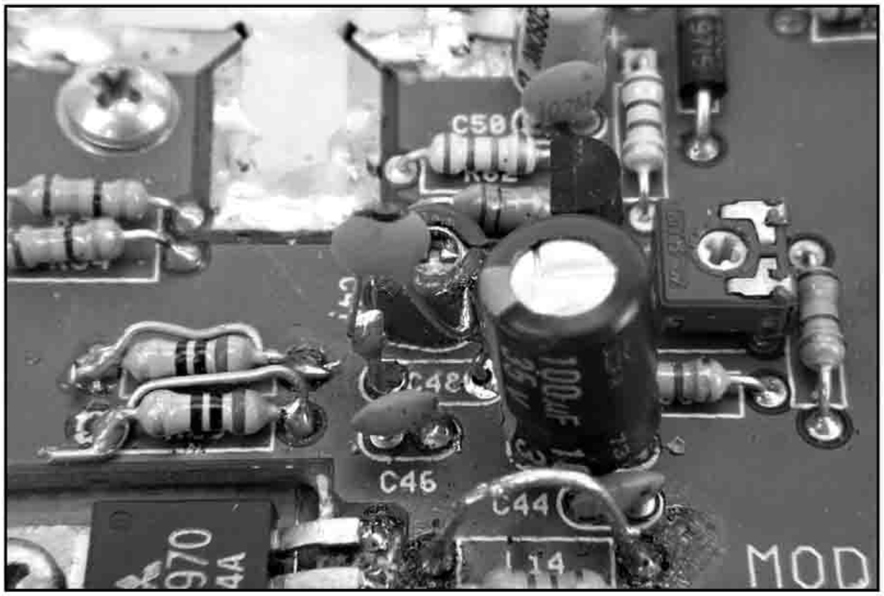

Figure 4—L14 is replaced by a U-shaped loop of #22 or #24 tinned solid hookup wire, the width of its open end determined by the distance between the solder pads that secured the original molded inductor; see the text. The loop height is ³/₈ inch centered between the pads. Small jumper wires short R28 and R29. The C48 replacement is visible to the right of these resistors.

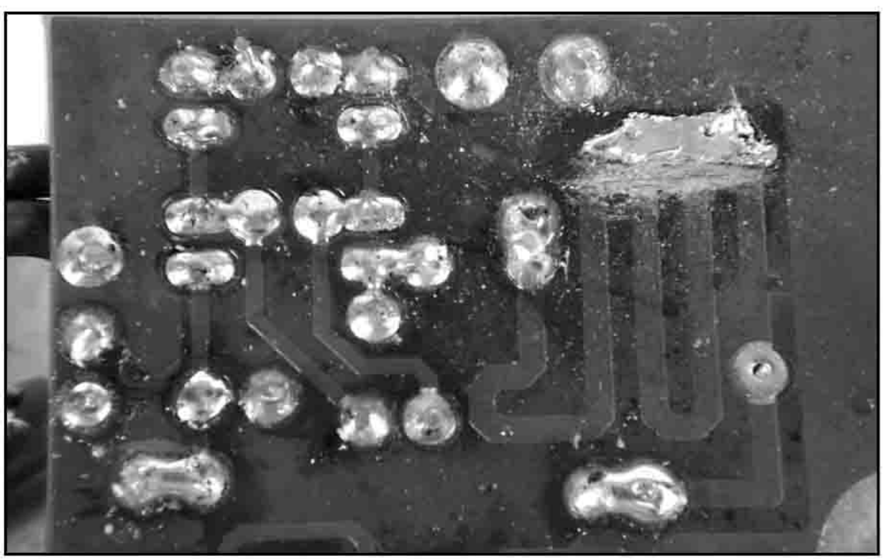

Figure 5—As described in the text, you can reduce the inductance of L19, a stripline inductor etched on the PC board, in either of two ways. In the approach used here, a length of wire or braid is soldered across the two loops of this stripline.

Transmitter Modifications

Continue with the conversion of the transmitter section. This involves changing the value of capacitors C31 and C33 to 4.7 or 5 pF each; C35, C48 and C91 (see text) to 8 pF each; C36 to 20 pF; C59 and C54 to 100 pF each and C60 to 10 pF.

Once that's done, make the following inductor changes. Change L13 to a 0.18 µH molded inductor. You can use the original L8 you removed from the LO portion earlier. (Note: In later transverter production models, this molded inductor's value was changed from 0.47 µH to 0.10 µH. If a 0.10-µH choke is present, there's no need to change L13.)

Replace L14 with a U-shaped loop of #22 or #24 tinned solid hookup wire. The width of the loop's open end is determined by the spacing of the solder pads that held the original molded inductor. The loop is ³/₈ inch high and centered between the pads. See Figure 4.

You can reduce the inductance of the stripline inductor in either of two ways.

Stripline Inductor

You can reduce the inductance of L19, a stripline inductor etched on the PC board, in either of two ways. The first approach is shown in Figure 5. At one open end of the two loops of this stripline, use a sharp knife to carefully remove a ¹/₁₆-inch-wide area of the foil's protective covering on both sides of an open end (mouth) of a loop trace. *Be careful not to cut the stripline itself.* Tin the cleaned areas; don't overheat or damage the trace. Solder a piece of wire or narrow-width copper braid across this end of the loop.

Reducing the stripline inductance allows the PA output to tune 222 MHz with the original output-tuning capacitor, C53. If need be, the inductor can be returned to its original state by removing the jumper.

The second way to decrease the stripline inductance involves cutting traces. This method exhibits a 10% power-output increase over the first approach. Carefully cut through the trace on both sides of the loop with a sharp knife for a width of 1/32 inch. These cuts can be repaired with jumpers if the unit must be returned to 144-MHz operation.

Reduce the inductance of L20 and L21 by using a solder bridge to short the first two turns of each coil (from the PA-transistor end). Place the bridge across the top of each coil as shown in Figure 6. These solder bridges can be removed to return the unit to 144-MHz operation.

Feedback Network

In later 1210 production models, Ten-Tec added a feedback network consisting of a small disc-ceramic capacitor in series with a resistor that connects from the base to the collector of the PA transistor, Q10. This network is physically across the top of the transistor. We removed this network and saved it just in case instability showed up later in testing. Removal of the network netted us a bit more amplifier gain. If you experience amplifier instability, reinstall these components as a first step in correcting the problem.

Notch Filter

Next, modify the third-harmonic notch filter. This originally consists of a four-inch piece of RG-174 subminiature coaxial cable that connects the RF output of the PC board to the output connector (J2) and C91. Shorten this cable to a length of three inches plus a short pigtail used to reconnect the cable to the output connector. Change the value of C91 to 8 pF.

Make the following resistor-value changes in the transmitter section: Add a 1-kΩ, 1/8-W carbon resistor between the base of Q9 and in series with R27 (see Figure 7). Place short jumper wires across R28 and R29 (see Figure 7). This completes the required changes to the transmitter section.

Receiver Modifications

To modify the receiver portion of the transverter for 222-MHz operation, make the following changes: C70 to 10 pF; C63 to 2 pF; C62, C64 and C68 to 4.7 or 5 pF each (whichever value is available) and remove C71 (the empty C71 pads are visible in Figure 3).

Repackaging

To aid circuit stabilization, I removed the paint from inside the mating surfaces of the enclosure along the top and bottom where they attach to the PC-board mounting plate. Remove the paint on the sides of the mounting plate also. This enhances the unit's RF shielding when it is reinstalled in its enclosure.

When reinstalling the PC board on the heat-sink shelf, ensure all the hardware is in its proper place, including the three brass washers used as spacers (if they have not already been soldered to the underside of the PC board during initial transverter construction). Pay particular attention to the reinstallation of the "silipad" and shoulder-washer insulators on the driver transistor and the fiber-board-insulating sheet between the PC board and shelf.

When reassembling your unit, use care when tightening the nut on the PA-transistor stud. *Do not overtighten it!* If you have any doubts as to what is considered "sufficient tightening," consult page 42 of the transverter manual.

External Filter

When the modified transverter prototype was tested locally, it appeared clean. When tested in the ARRL Lab, however,

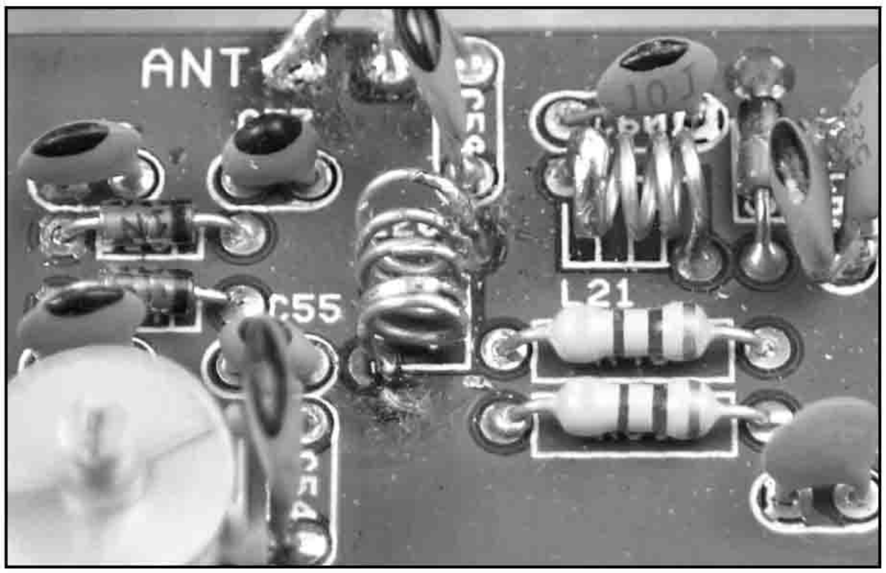

Figure 6—Reduce the inductance of L20 and L21 by using solder bridges to short the first two turns of each coil (from the PA-transistor end) at the top of each coil as shown here. These solder bridges can be removed to return the unit to 144-MHz operation.

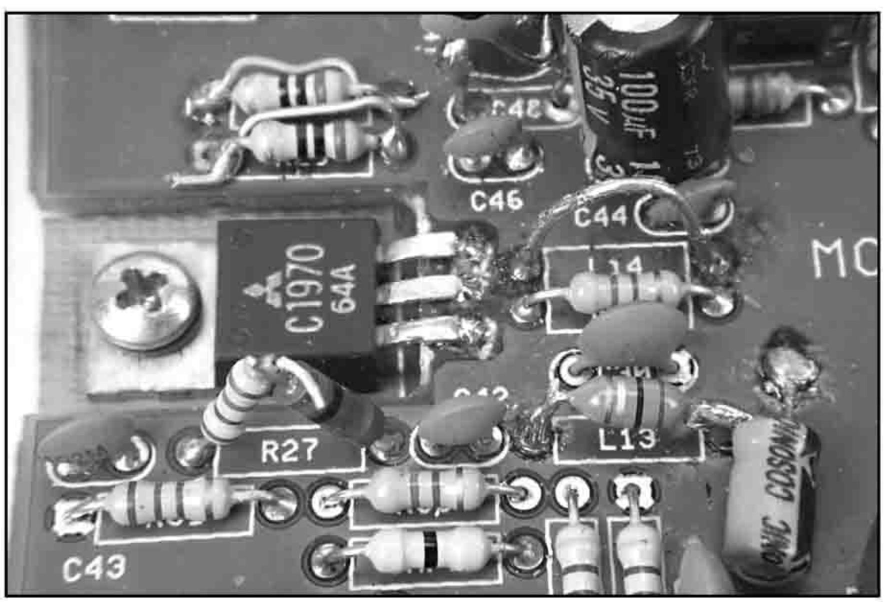

Figure 7—Here you can see R27A added in series with R27 and the jumper wires added across R28 and R29. L13 and L14 are also visible in this photograph.

External-Filter Requirements

♦ The spectral purity of the modified transverter (without adding external filtering) does not comply with FCC spectral-purity specifications for commercial equipment. The levels measured in the ARRL Lab for the two highest spurs are 30 and 35 dB below the carrier at 5 W output. The frequencies of these spurs are about 28 MHz above and below the output frequency ($f_{carrier}$ ± IF).

The FCC specification for spurious-signal suppression at 5 W on 222 MHz is –53 dBc. Although this project is not a commercially manufactured unit, following good engineering practice means complying with FCC specifications. To this end, the ARRL Lab recommends adding an external narrow-bandpass filter to the transverter. A commercially available filter suitable to the task is the four-pole DCI-223.5-3H.* This filter provides 50 dB of attenuation at 10 MHz above the passband and 60 dB at 10 MHz below the passband. Another means of meeting FCC spectral-purity specifications is to build a homebrew filter with an attenuation of at least 23 dB at the spur frequencies.—*Mike Tracy, KC1SX*

♦ Reducing the value of C34 to a 0.5-pF chip capacitor improves the modified transverter's spectral purity, but the 194-MHz LO signal at the output is still at –39 dBc and the 260-MHz mixing product is at –44 dBc. (I used a tiny 0402-cased chip cap, but larger sizes should also work.) The DCI filter Mike mentioned earlier will easily clean up the modified transverter's output with a typical insertion loss of about 1 dB, according to manufacturer's specification. A simple homebrew, two-pole filter for this application is described in my "RF" column in the May/June 2001 issue of *QEX*. This filter has an insertion loss of about 1 dB. Its rejection at 194 and 260 MHz is about 35 dB.—*Zack Lau, W1VT*

*Digital Communications Inc, Box 293, White City, SK, Canada, S0G 5B0; tel 800-563-5351, 306-781-4451, fax 306-781-2008; **dci@dci.ca**; **www.dci.ca/amateur_pricing_us.htm**.

the modified transverter failed to meet FCC specifications for spectral purity. (For more details, see the sidebar, "External-Filter Requirements.") To comply with the FCC specifications, you should use an add-on filter as mentioned in the sidebar. The filter addition has an additional benefit of suppressing strong out-of-band received signals that could cause "birdies" and images in the receiver. Adding the filter externally aids in isolation and simplicity of construction. Connect the filter to the 222-MHz output of the transverter (J2) through a short length of coaxial cable.

Tune-Up

Tune up the transverter on 222 MHz following the general alignment procedures outlined in the Ten-Tec manual. The low-level RF output detector circuit you duplicated earlier, used in conjunction with a VOM, can aid in tuning up the transmitter section should you not be able to obtain any indicated output on your VHF wattmeter initially. Keep in mind, however, that this RF detector circuit is not capable of handling more than a few hundred milliwatts or so for short periods.

When reassembling your unit, use care when tightening the nut on the PA-transistor stud.

Acknowledgements

My thanks go to the engineering staff of Ten-Tec, Inc, in particular, Allan Kaplan, W1AEL, for his interest and assistance with this project. Thanks also to Bill, WB4WEN; Ed Walker, WA4DFS; Dave Saul, WA4QYK, and to Mike Tracy, KC1SX, and Zack Lau, W1VT, of the ARRL Lab for their help. Don't consider the modifications presented here as the last word on the subject, but rather as a whetting stone for your imagination that will lead to more experimentation!

J.G. "Bunky" Botts, K4EJQ, was first licensed in 1955 at the age of 12. Bunky spent 35-plus years in the radio and TV broadcasting technical field. His main Amateur Radio interests include CW "ragchewing," home-brewing and a bit of DX chasing on all bands. Bunky and his wife, Linda, WB4SNW, have two daughters. You can contact Bunky at 220 Hillsboro Rd, Blountville, TN 37617; **bunkybotts@juno.com**.

NEW PRODUCTS

PREFABRICATED INTERCONNECT CABLES FROM CABLE X-PERTS

◊ Cable X-Perts assembles and stocks coaxial cable jumpers in a wide variety of connector configurations. Connector types that are available are SMA, TNC, BNC, N and UHF. Genders and special configurations include male (plug), female (jack), reverse polarity and right angle. Cable options include RG-58A/U, RG-142/U, LMR-400, 9913Fx type, RG-8/U and RG-213/U.

For more information contact Cable X-Perts Inc, 416 Diens Dr, Wheeling, IL 60090; tel 800-828-3340; fax 847-520-3444; **www.cablexperts.com**.

NEW LOW-NOISE RECEIVER PREAMPS FROM HAMTRONICS

◊ A new LNK series of preamps is replacing Hamtronic's popular LNG units. As with the earlier products, several different models—covering bands of frequencies between 28 and 470 MHz—are available. Gain is specified at 18 to 26 dB with noise figures from 0.6 to 0.8 dB, depending on the specific frequency range.

The preamps use a new low-noise MOSFET designed for best performance at VHF and UHF frequencies. The device has built-in diode protection and very low feedback capacitance. The manufacturer claims good stability and rugged performance over a wide range of voltage, signal and load impedance conditions.

The LNK preamps are enclosed in a small aluminum case and can be installed at the antenna or in the shack. Input and output connectors are type BNC. For remote mount applications, provisions are included on the PC board for installing an RF choke, allowing the dc supply voltage (12 to 15 V dc at 10 mA is required) to be delivered through the coax.

The LNK series preamps sell for $59 each and come factory assembled. For more information contact Hamtronics Inc, 65-F Moul Rd, Hilton, NY 14468; tel 716-392-9430; **jv@hamtronics.com**; **www.hamtronics.com**.

Next New Products

FEEDBACK

◊ In the April 2001 *QST* "Test Your Knowledge!" quiz, question 10, the E.F. Johnson Thunderbolt amplifier used *4-400* tubes, not 4-1000s. In addition, in question 2, Leo *Myerson* was the proprietor of World Radio Labs, not Leo Myers.