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Pull in ATV transmissions on the 900 MHz and 1300 MHz bands

BUILD THIS UHF DOWNCONVERTER

THE MINIATURE, TUNEABLE UHF downconverter described in this article is designed to receive amateur television (ATV) signals in the 900–1300-MHz band and convert them for display on an ordinary TV set. The downconverter is the perfect match for the 900-MHz ATV transmitter described in last month's issue of *Electronics Now*. It is also used to receive signals from low-powered video links operating in the 900 (33-centimeter) band.

As a bonus, a design for 1300 MHz downconverter is also presented to allow reception of any ATV activity in the 23-centimeter (1240-1300 MHz) amateur band. Both the 900-MHz and 1300-MHz converters are mechanically nearly identical and appear the same unless inspected closely. They differ slightly with regard to the PC board microstrip tuned elements and minor difference in the local oscillator circuit. Otherwise the same circuit architecture and parts are used for both. Their theory of operation and construction are closely paralleled. In the discussion that follows, reference is made only to the 900-MHz unit unless differences between the two units are noted.

The downconverter is not intended for reception of narrowband FM or SSB signals since the converter uses a tuneable local oscillator covering a 30 to 60 MHz range. The 900-MHz and 1300-MHz versions are useable for wide-band modes such as AMTV, FMTV or FM audio reception using a conventional FM broadcast receiver tuned to 90 MHz or so on the dial.

Basic signal flow

The downconverter block diagram is shown in Fig. 1. Signals from the RF input are fed to low-noise RF amplifier Q1, which boosts the antenna signal and feeds it to mixer transistor Q2. There the amplified signal is mixed with the output of the tuneable voltage-controlled local oscillator Q5 to an intermediate frequency (IF) of 60 MHz. The IF signal is fed from the mixer to an IF preamplifier stage.

Three tuned circuits, Z1-Z4, are used in the RF amplifier stage. These are not discrete components—they are of PC board stripline construction, and consist only of circuit-board traces. Other tuned stripline circuits, Z5-Z6 are also used in the downconverter.

Voltage-controlled oscillator Q5 is tuned by a DC voltage. This DC voltage can be selected from either a PC board potentiometer or via an external, coaxial-fed power supply that allows the downconverter to be tuned remotely. This arrangement enables the downconverter to be mounted on the right at the antenna feed point to eliminate feed-line losses that are significant at this frequency range. No separate DC feed is necessary since the coax (RG59/U or RG6/U recommended) carries both DC power, tuning voltage and IF signal.

The downconverter's input impedance is 50 ohms, and any matching 900-MHz or 1300-MHz antenna can be used. The overall gain of the downconverter is about 37-43 dB. The

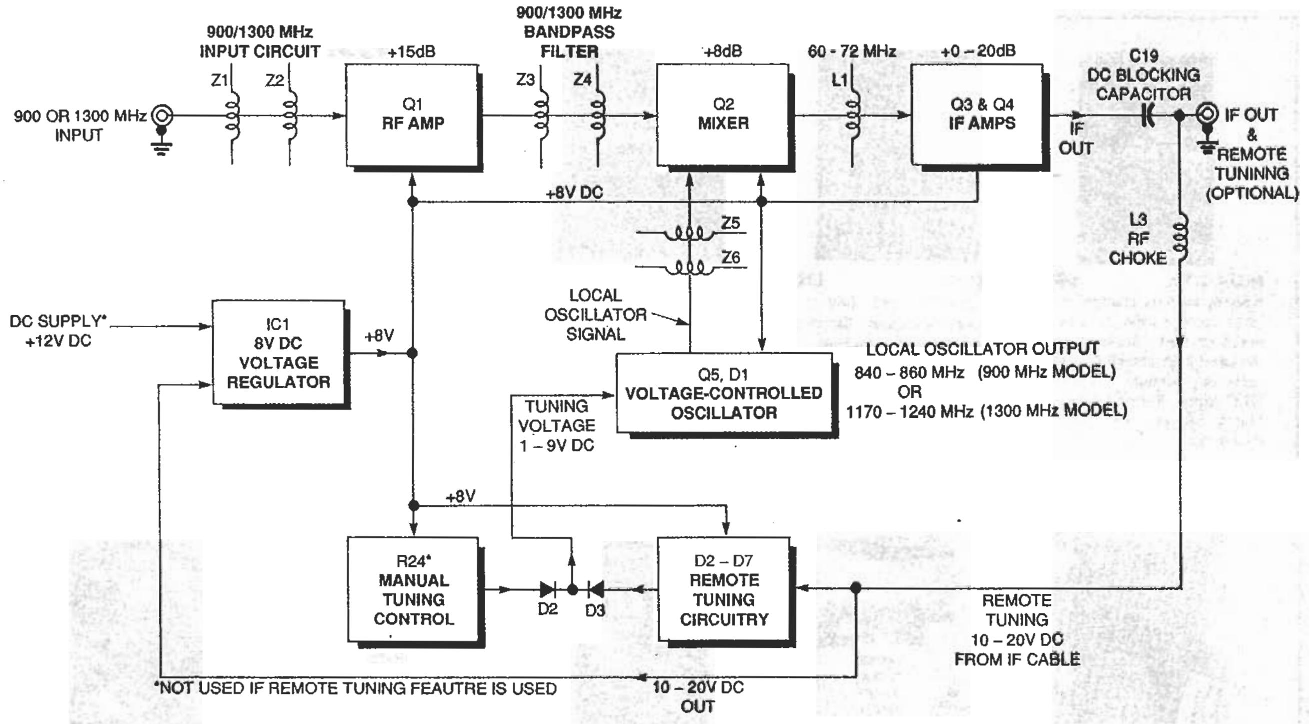

FIG. 1—BLOCK DIAGRAM for the downconverter serves for both the 900 and 1300-MHz versions.

gain can be changed as needed by changing a resistor value.

For portable operation or for use in a packaged ATV transceiver or a video handy talky (HT), the on-board tuning potentiometer may be used. The tuning voltage is tapped from the +8-volt DC voltage-regulator, IC1.

For on-board tuning, the external power supply must deliver a fixed 11 to 20 volts DC at approximately 30 milliamperes to the 8-volt DC regulator. For remote tuning, the supply must be variable.

Circuit operation

The downconverter schematic is shown in Fig. 2. The input signal from antenna jack J1 is fed to a filter made up of Z1, C1, and Z2. Microstrip lines Z1 and Z2 are part of the PC board foil surface and form a tuning circuit. (All six microstrip lines are given Z designations.) Trimmer capacitor C1 is adjusted for best reception of a weak signal. The signal is then fed to gate G1 of Q1. Transistor Q1 is a low-noise MESFET with a noise figure about 1 dB. Unavoidable circuit losses will raise the actual noise figure to typically 1.5 to 2 dB, which is fairly good for the intended application. The source S of Q1 is biased by R1. The other gate, G2, is biased by R2 and R3. Two pairs of 100-pF capacitors (C2 through C5) bypass both the source and G2 of Q1 to ground, providing the necessary bypassing for inductance Z3. Chip capacitors were chosen for C2-C5 because conventional 100-pF disc capacitors function poorly at 900 or 1300 MHz.

The amplified signal at the drain of Q1 is fed to a double-tuned coupling network consisting of Z3, C8, Z4, and C9. Trimmer capacitors C8 and C9 determine the bandpass characteristics of the network. Capacitors C6 and C7 provide RF grounding for the low end of Z4. The spacing of Z3 and Z4 on the PC board determines the amount of RF mutual coupling. This amount is fixed by the PC etched layout. The RF gain of the stage is about 12 to 15 dB. This gain figure is a net number that includes losses in the input and output tuned-circuit networks, and between the antenna input and the mixer input.

Transistor Q2 serves as a RF mixer. The bipolar transistor is biased by R5, R6, R7, R8, and a chip resistor network that consists of R14, R15 and R16. The mixer's emitter current is typically 1 milliampere.

The amplified RF signal from Q1 is fed via capacitor C10 to the base of Q2. The local oscillator's output signal is fed from Q5 to the emitter of Q2 via microstrip feedline Z5, R14, R15, and R16. Capacitor C13 provides a low impedance at the IF frequency (61.25 or 66.25 MHz) for the emitter of Q2. The local oscillator frequency is equal to the received RF signal *minus* the IF (low side). The signal gain from the mixer circuit is typically 6 to 8 dB. Overall gain so far is typically 20 dB.

The IF signal from the mixer is fed to a matching network consisting of C11, C12, L1, L2, and C14. The matching network rejects mixer-output signals above 100 MHz. The desired signal is then fed to an IF amplifier stage consisting of Q3 and Q4. Resistor R10 provides bias voltage while R9 provides termination for the matching network. Capacitor C16 blocks DC to the base of Q3. Current gain for the matching network is set by R11 and R12. Overall IF gain is about 20 dB.

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ATV DOWNCONVERTER

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The gain for the overall circuit can be adjusted by changing the resistive value for R11 (see Table 1).

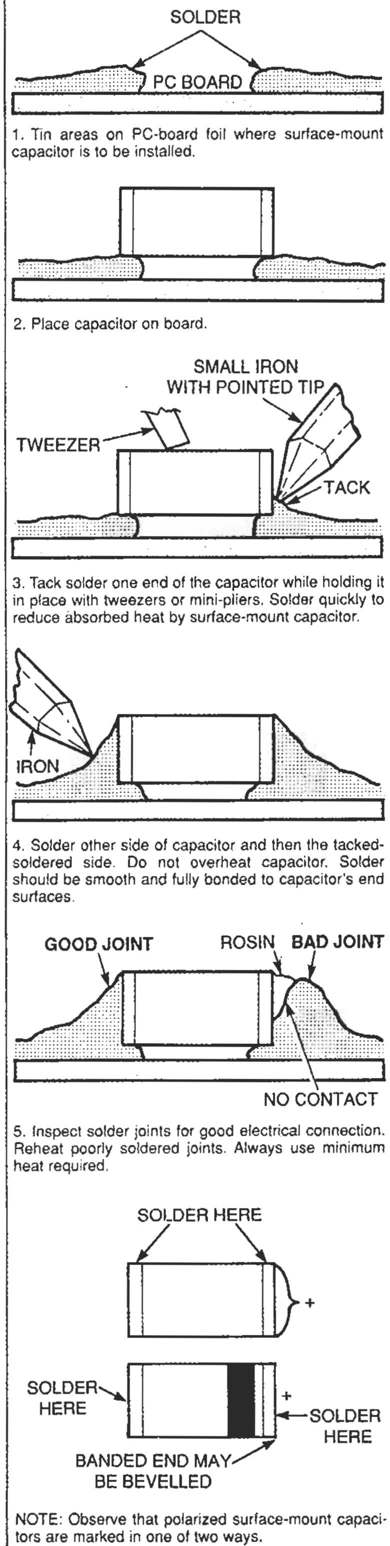
The IF amplifier directly feeds a 50 to 75-ohm load. Maximum downconverter IF output is around -2 dBm for 1 dB compression. This is 150 to 200 millivolts into a load of 50 to 75 ohms. Capacitor C18 and R13 provide decoupling of the IF circuits from the regulated 8-volt bus.

The local oscillator output signal is generated by Q5 in a typical Colpitts oscillator circuit. Bias for Q5 is provided by R17 through R21. Resistor R21 and surface-mount bypass capacitors C24 and C25 decouple the local oscillator frequency from the regulated 8-volt DC bus. The resonant circuit for the local oscillator is formed by C21, the internal base- emitter capacitance of Q5, and emitter-to-ground capacitance, stripline Z6, trimmer capacitor C22, and varactor diode D1 in parallel with C23. (Capacitor C23 is *not used* in 1300 MHz version.) The capacitance of varactor D1 is varied by a voltage applied to it via R22 that ranges from 1 to 8-volts DC.

The varactor D1 provides fine tuning of the local oscillator frequency because the setting of trimmer C22 has the major effect on oscillator frequency. Trimmer C22 will change the oscillator frequency by several hundred MHz. When set correctly, C22 sets the local oscillator frequency so that D1 can tune the circuit over the desired range. This will be a bandwidth of about 30 MHz for the 900 MHz downconverter, and 60 MHz for the 1300-MHz version.

Voltage for D1 is fed through isolating resistor R22 from either of two sources. The first source is the on-board tuning potentiometer R24, whose wiper provides 1 to 8 volts DC. Resistor R25, connected to the ground side of potentiometer R24, sets the low-voltage limit to about 1 volt. Diode D2 acts as half of a logical OR gate, and R23 and C26 provide a pull- down to ground and RF bypassing for the varactor tuning voltage. The second source is a tuning voltage derived from a remote-tuning setup.

HOW TO INSTALL SURFACE-MOUNT CAPACITORS



1. Tin areas on PC-board foil where surface-mount capacitor is to be installed.

2. Place capacitor on board.

3. Tack solder one end of the capacitor while holding it in place with tweezers or mini-pliers. Solder quickly to reduce absorbed heat by surface-mount capacitor.

4. Solder other side of capacitor and then the tacked-soldered side. Do not overheat capacitor. Solder should be smooth and fully bonded to capacitor's end surfaces.

5. Inspect solder joints for good electrical connection. Reheat poorly soldered joints. Always use minimum heat required.

NOTE: Observe that polarized surface-mount capacitors are marked in one of two ways.

Remote tuning

Remote tuning is an important feature of the downconverter because it allows the unit to be mounted directly at the antenna feed point, thus eliminating a coaxial feedline for 900-MHz signals. Feedlines have high losses at this frequency unless they are special, expensive types. Even then, losses are still high for long cable runs. For example, a good quality, expensive ($60 to $80 per 100 feet) coax feed-line such as 9913 has a loss of 5-dB per 100 feet of cable at 1000 MHz. The output of the downconverter can be fed via an inexpensive coaxial cable (such as the RG59 or RG66), which has an attenuation of about 2 dB per 100 feet at the output frequency and costs about $15 per 100 feet.

A DC Block Unit (see Fig. 3) allows a variable tuning voltage to be added into the IF coaxial feed-line to power and tune the downconverter. This voltage should vary from 10 to 20 volts DC to properly remote tune the downconverter. Capacitor C19 (Fig. 2) blocks this DC but passes the IF signal from Q4. Inductor L3 passes DC (only 10-ohms DC resistance) but blocks the IF signal because it has a very high impedance at 60 MHz. The input of 10 to 20-volts DC is passed to voltage regulator IC1 via blocking diode D7 (Fig. 2). Voltage regulator IC1 supplies +8-volts DC to the downconverter circuitry, insensitive to the 10 to 20-volt variation of the input DC voltage.

The 10 to 20-volts DC input is also supplied to Zener diode D6 and diode D5, dropping 9 volts across these diodes, resulting in 1 to 11-volts DC across pull-down resistor R27. Resistor R6 and clamp diode D4 limit the voltage at the input of D3 to 1 to 9 volts. This results in about 0.3 to 8.3 volts DC across R23 and C26. This voltage is fed to varactor D1 via R22 for tuning. As the DC voltage on the IF cable varies from 10 to 20 volts, the converter is both powered and tuned over its frequency range. If oper-

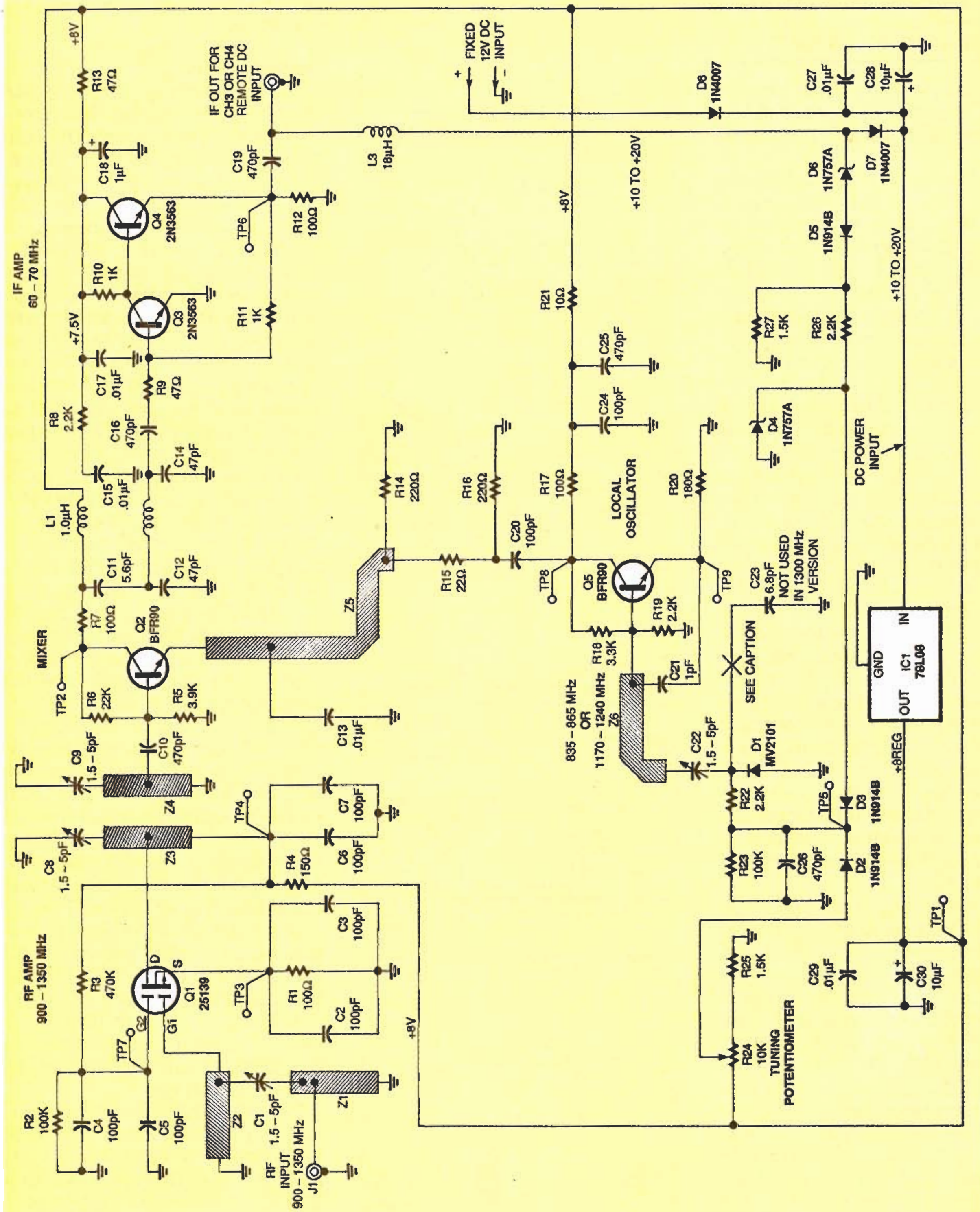


FIG. 2—SCHEMATIC DIAGRAM for the downconverter covers both the 900-MHz and 1300-MHz versions. Aside from slight foil modifications, the only difference is the elimination of C23 in the 1300-MHz version.

ation from a fixed DC power supply (11 to 15 V) is desired, the converter is powered with 12-volts DC via the DC input and blocking diode D8. In this case, tuning is done with the on-board tuning potentiometer, R24, and the DC Block unit is not needed.

When remote tuning is used, tuning potentiometer R24 must be set at its extreme counterclockwise position to set the voltage at the wiper to its lowest DC potential. All or part of the downconverter tuning range won't be obtained with R24 in any other position.

Clean power supply

Any hum or noise on the tuning voltage from an external power supply will modulate the local-oscillator frequency, thereby frequency modulating the IF signal. This effect is most degrading for the 1300-MHz model, where the tuning sen-

TABLE 1—TROUBLESHOOTING VOLTAGES AT TEST POINTS

Test Point Location	Volts DC	Localized Trouble Area
Junction of D8, IC2	+11.4	D8
Junction of IC1, C30 (TP1)	+7.6 to 8.4	IC1
Junction of R4, C6, C7, Z2 (TP4)	+6.2 to +7.2	Q1, R4, C6, C7
Junction of R1, C2, C3	(TP3)	+0.5 to +1.2 Q1, R1, C2, C3
Junction of R2, R3, C3, C4 (TP7)	+1.0 to +1.4	Q1, R2, R3, C4, C5
Collector Q2 (TP2)	+5.5 to 7.2	Q2, R5, R6, R7, R8, R13, R14, R15, R16, L1, C11, C15, C17, C18
Junction of D2, D3, C26 (TP5)	0.5 to >+7.0 as R24 is rotated	D1, R24, R25, D2, D3, R23, R22
Collector Q5 (TP8)	+6.5 to +7.2	R21,M C24, C25, Q5, C20, R18, R19, R20
Emitter Q4	+0.8 to +1.0	Q3, R10, R11, R12, C16, C19
Base Q4	0.7 volts more than base of Q3	Q3, R10, R11, R12, C16, C19

*Check all transistors and IC's for correct installation. Check diodes and electrolytic capacitors for correct polarized installation.

sitivity of the local oscillator is 10 MHz per volt of tuning voltage. Just 1 mV of hum will result in 10 kHz of frequency deviation. For FMTV use, this will be noticeable as video hum bars in the received picture. AM signals will be less susceptible to hum and noise from the power supply.

This power supply defect should not be tolerated because it is easy to build a *clean* external power supply from inexpensive readily available voltage regulator ICs.

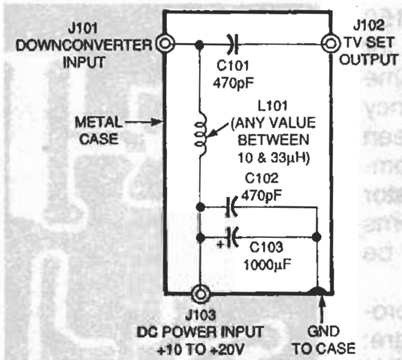


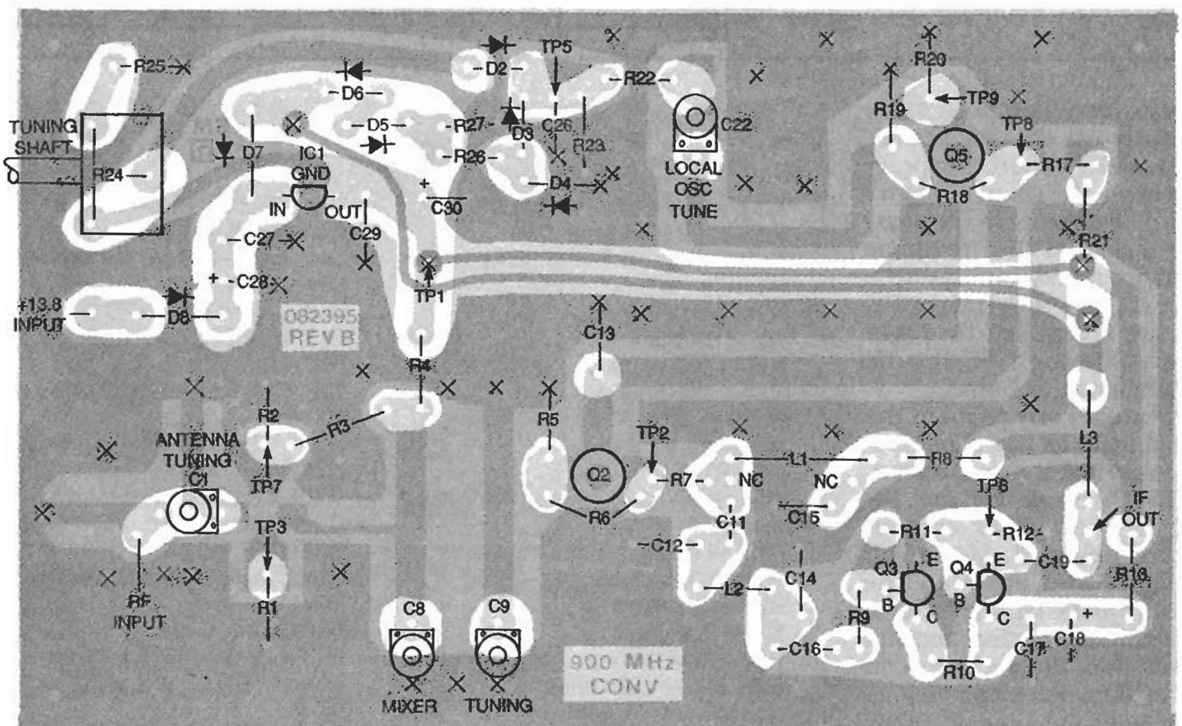
FIG. 3—DC BLOCK UNIT is required at the TV receiver or monitor site when remote tuning the downconverter.

Pre-construction details

Do not substitute parts specified in the Parts List or change the PC- board layout should you etch a PC board from the patterns shown.

Use good lighting while assembling parts on both sides of the 2.5 × 4-inch PC board. A magnifier lens is necessary because the parts are too small to check for markings and solder joints are too minuscule to inspect with the naked eye.

All trimmer capacitors and grounded leads of resistors



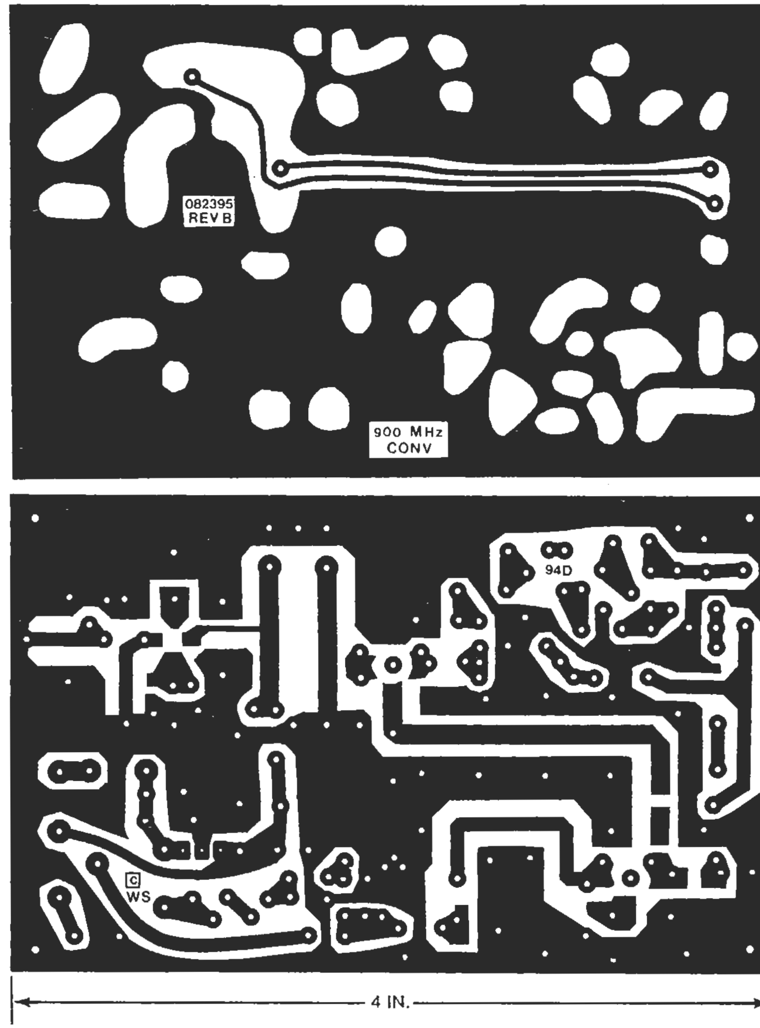
X GROUND PLANE JUMPER WIRES

FIG. 4—TOP SIDE OF PC BOARD for the 900-MHz downconverter is shown with parts locations identified. Be sure to install all ground jumpers where indicated and solder to both sides of the PC board.

FOIL DIAGRAMS FOR THE DOWNCONVERTER 900-MHz AND 1300-MHz MODELS

While it is possible to design the same printed-circuit board foil pattern for both Downconverter models (since the frequencies differ by 350 MHz), compromises are necessary in the RF microstrip elements which would result in performance sacrifice in RF gain and tuning rate. Therefore, individual foil patterns were designed for each model. The 900-MHz model can be re-tuned to cover up to about 1100 MHz, and the 1300-MHz model will cover about 1150 to 1450-MHz (in 60-MHz segments) for other applications, with almost the same performance. The IF output frequency can be changed to anywhere between 40 and 100 MHz by changing one component and shifting the local oscillator frequency as required. The foil patterns provided are actual size and can be copied.

Starting in the upper-left corner and proceeding clockwise, the foil patters are: 900-MHz top, 1300-MHz top, 1300-MHz bottom, and 900-MHz bottom. The PC boards are all the same size—4 X 2.5 inches.



must be soldered on both sides of the foils on the PC board. This is good RF grounding practice. Also, there are many ground-plane jumpers (approximately 3 dozen) that must be soldered in place, because the commercially available PC boards are not plated through, and plated-through PC boards cannot be made at home.

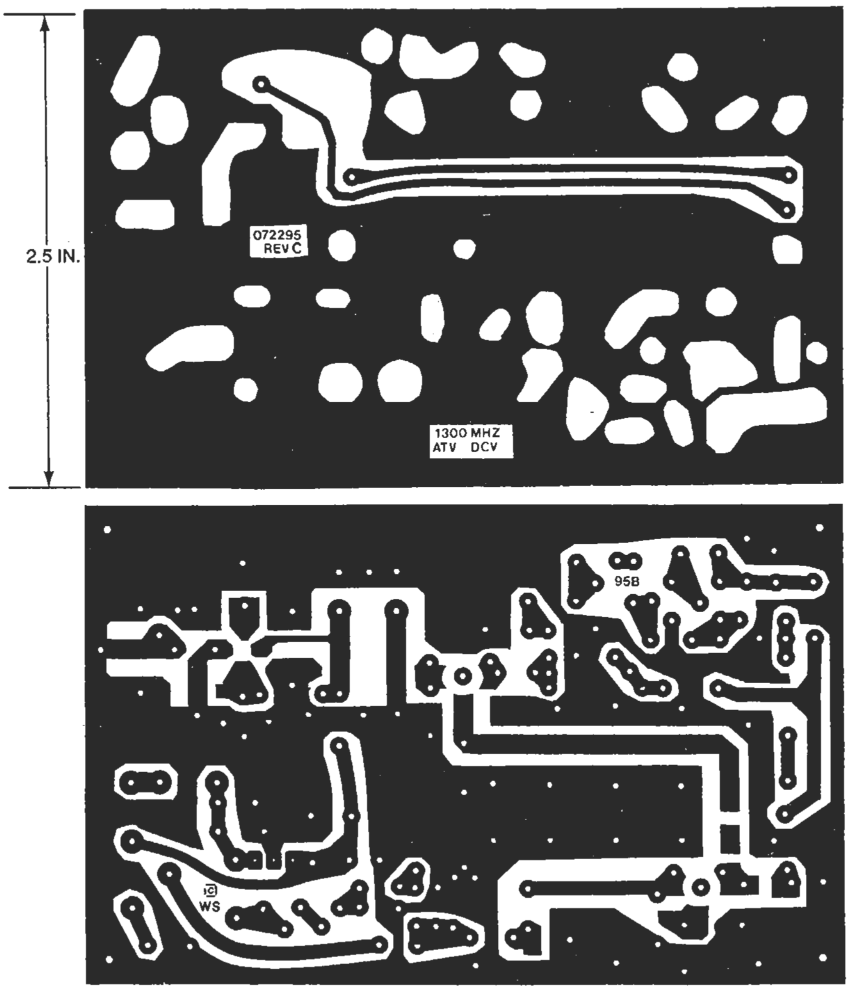
Do not solder any parts to the PC board until as many components as possible are inserted. Coils L1 through L3 are installed after all other components are inserted. Mount all parts tight and close to the board. Projects in the microwave frequency region require *zero-lead lengths* for parts in the RF circuit sections.

Start construction

Begin construction by inserting all trimmer capacitors in

PARTS LIST

All resistors are ⅛-watt, 5% unless otherwise specified
R1, R7, R12, R17—100 ohms
R2, R23—100,000 ohms
R3—470,000 ohms
R4—150 ohms
R5—3,900 ohms
R6—22,000 ohms
R8, R19, R22, R26—2,200 ohms
R9, R13—47 ohms
R10, R11—1000 ohms
R14, R16—220 ohms, surface-mount
R15—2 ohms, surface-mount
R18—3,300 ohms
R20—180 ohms
R21—10 ohms
R24—10,000-ohms potentiometer
R25, R27—1,500 ohms
Capacitors
C1, C8, C9, C22-1.5-5 pF trimmer, PC mount
C2–C7, C20, C24—100 pF, surface-mount
C10, C25—470 pF, surface-mount
C11—5.6 pF, NPO
C12, C14—47 pF, NPO
C13, C15, C17, C27, C29—0.01 µF, GMV disk, 50-volt
C16, C19, C26—470 pF, GMV disk, 50-volts
C18—1.0 µF, 35-volt electrolytic
C21—1 pF, surface-mount
*C23-6.8 pF, surface-mount
C28, C30—10 µF, 25-volt, electrolytic
*Used in 900 MHz downconverter only
Semiconductors
D1—MMBV2101T1 (Motorola) varactor, 6.8 pF at 4 volts, surface-mount
D2, D3, D5—1N914B, fast-switching diode



the PC board. See Fig. 4. Solder trimmer rotor terminals to the top side of the PC board. Be careful not to melt the plastic. Do not solder the bottom foil at this time.

Mount all ⅛-watt resistors. Only solder the top of the PC board where resistor lead passes through the ground foil. Solder as many as you can. Do not solder the bottom foil yet. Surface-mount resistors will be installed later. Install tuning potentiometer R24. Leave the thumbwheel of R24 in the center-rotation position.

Install the fixed capacitors. If any come with pre-formed leads, straighten the leads with pliers so the capacitor can fit as close to PC board as possible. Pull the leads through board so capacitor bodies are tight to PC board. Watch polarity of all electrolytic capacitors. Confirm that the capacitor values are correct prior to soldering them in place.

Do not install any of the surface-mount components yet. Install all transistors and diodes, except Q1 (25139) which will be installed later. See Figs. 4 and 5. Check polarized parts for correct orientation. All TO-92 transistors should be ⅛ inch from

D4, D6—1N757A, 9.1-V, 0.5-watt, Zener diode
D7, D8—1N4007, 1000-V, 2.5 A, rectifier,
Q1—NE25139 (California Eastern Labs.) low-noise, dual-gate RF-amplifier
Q2, Q5—BFR90, npn, low-noise, UHF amplifier, MESFET
Q3, Q4—2N3563, npn, RF/IF/Video bipolar
IC1—78L08, positive voltage regulator

Coils and Chokes
L1—RF choke, 1 μH, ±5%
L2—Fabricated coil (see text)
L3—RF choke, 18 μH with less than 10-ohms resistance

Miscellaneous
J1, J2—See text
1—Plastic shaft extension for R24
1—Length of #22 enameled, solid copper wire
1—Machine screw, #8-32, binding head
1—PC board for 900-MHz or 1300-MHz downconverter

DC BLOCK UNIT (OPTIONAL)
C101, C102—470 pF, disc ceramic, 50-volts
C103—1000 μF, 25-volts, electrolytic
J101, J102—Type F connectors, female, chassis mount
J103—DC power connector that can be shielded, 2.5 mm or RCA phono, female chassis mount
L101—Any value from 10 to 33 μH, less than 10-ohms DC resistance
1—Metal enclosure, RF tight

A complete parts kit for the 900-MHz or 1300-MHz downconverter, consisting of the PC board and all parts that mount on it, is available from: North Country Radio, PO Box 53, Wykagyl Station, New Rochelle, NY 10804. The 900-MHz model sells for $39.00, 1300-MHz sells for $41.00. Both models: $76.50 (must be ordered at same time). Please add $4.50 for postage and handling for one unit or $5.50 for both units. New York residents must include local NY sales tax. Be sure to specify which model (900 or 1300 MHz) you are ordering. Parts for optional DC Block Unit are not included in this kit.

A catalog containing information on transmitters, downconverters, video cameras and lenses, and a number of other kits and electronic projects is available from the above address. Please send SASE (75-cents postage) and $1.00 to cover handling and mailing (refundable with order).

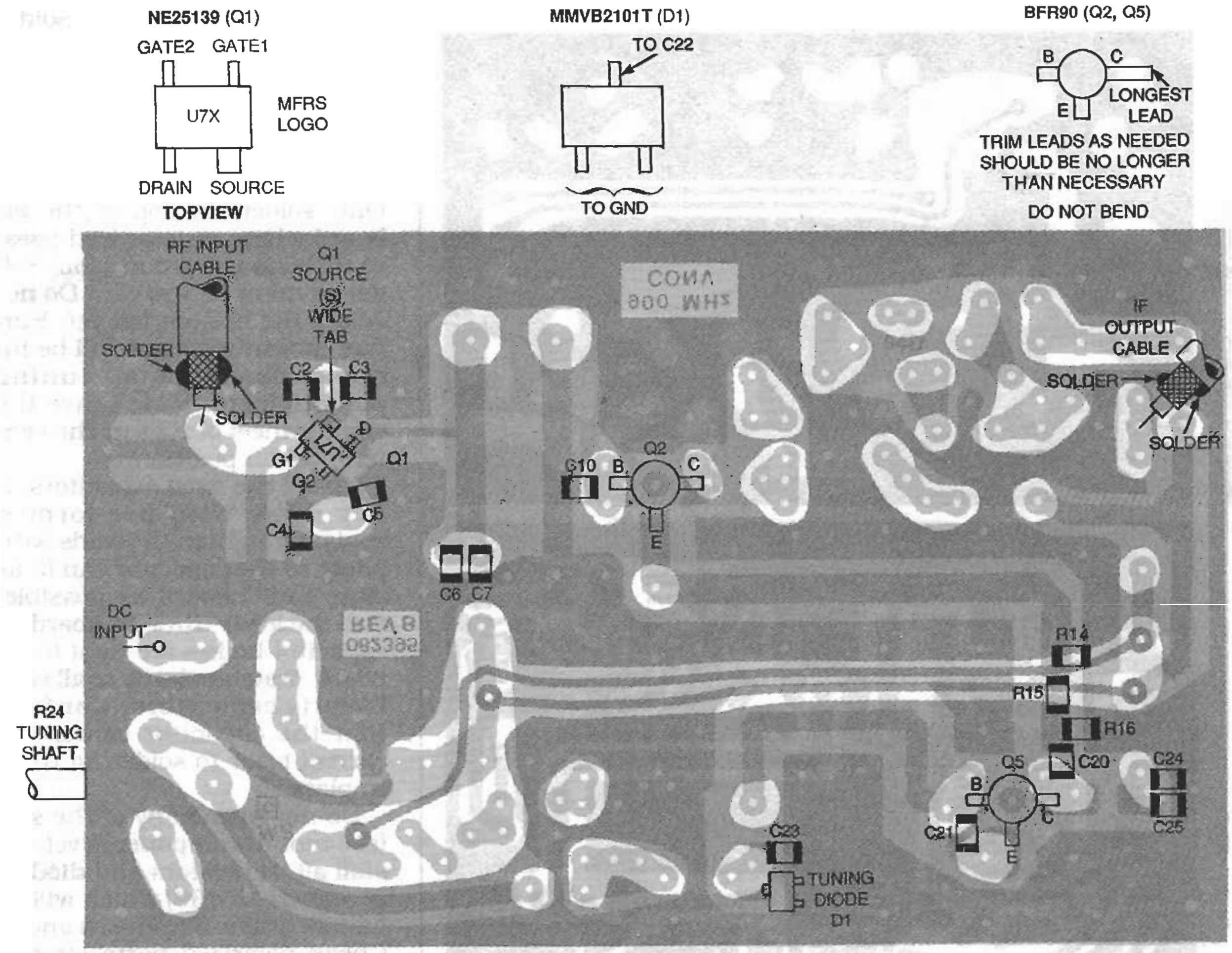


FIG. 5—BOTTOM SIDE OF PC BOARD for the 900-MHz downconverter is shown with parts locations identified. Cable lengths should be just long enough to provide suitable length when PC board is installed in a metal case.

the surface of board. Solder the emitter lead of Q3 to the top of the PC board where it passes through ground foil. Install voltage regulator IC1 and check its lead orientation. The flat end should face the edge of the PC board.

Check all work done so far for accuracy and orientation of components. Trim all component leads close to the PC board. Solder all bottom foil connections. (Do not plug any unused holes with solder.) Carefully fabricate L2 (see Fig. 6) and install in the PC board. Use an 8-32 screw as a tool to hold L2 during installation. After installing L2, remove screw by unthreading it from the coil. Coat L2 with clear lacquer, Duco cement, or clear nail polish.

Use left-over lead clippings or bare, solid, tinned wire to install ground plane jumpers in *all* open positions (see Fig. 4)—*this is very important.* Install a 1-inch length of bare tinned wire in +12v connecting hole near D8 to serve as a terminal. Place a piece of sleeving over it to avoid short circuits and make a small hook at the wire's end.

Install all surface-mount capacitors, as shown in Fig. 5, on the *bottom* foil of the PC board. Refer to detailed surface-mount instructions in sidebar *How to Install Surface-Mount Capacitors.* After installing all surface-mount capacitors, avoid flexing the PC board, which might crack the surface-mount capacitors.

Install the surface-mount resistors R14, 15, and 16 the same way as surface-mount capacitors (see Fig. 5). Resistors R14 and R16 are marked 221 (220 ohms) and R15 is marked 220 (22 ohms). Install the resistors with the marked side facing up from PC board so the markings are seen. Check the resistive values with an ohmmeter or DVM before installation.

Install Q1 as shown in Fig. 5. The thicker lead is the source (S) lead. Handle Q1 carefully; it is sensitive to electrostatic discharge (ESD). Check the orientation of Q1's leads before soldering in place. Then, install D1. The side of D1 with two leads is the ground side.

Tune-up and checkout procedures

The downconverter is aligned by peaking for maximum received signal. There is no tricky alignment procedure or specialized RF test gear necessary for good results and performance from the downconverter.

The successful tune-up of the downconverter requires either a known signal in the 900 or 1300 MHz band to act as a reference and tune-up aid, or access to a frequency counter and a signal generator covering this range. A sweep generator is excellent if you can obtain the use of one. If you have an ATV transmitter, it can be used as a signal source—but remember to use a dummy antenna and keep the transmitter at some distance to prevent overloading the downconverter. You will need a suitable TV receiver or monitor tuned to either VHF channel 3 or 4, (an old B/W portable TV will do), a variable power supply supplying 10 to 20-volts DC at 40 milliamperes or more (preferably one with a built-in voltage and current metering), a DMM, and clip leads and cables as needed. If you cannot obtain these items, find someone to help you. A frequency counter that is reliable to at least 100 MHz higher than the downconverter receiving frequency is a great help in setting up the local oscillator and finding out where you are during tune-up.

First, carefully check your work for accuracy, component placement, and correct orientation, and poor solder connections. Make sure that surface-mount capacitors are correctly installed—a malfunction can destroy the gain of a stage. Also check for inadvertent solder bridges. When you are sure everything is OK, connect a DC source to the 12-volt input (D8 and ground). Ground is negative. No damage will occur should the power supply be accidentally reversed. Note the current drawn from the power supply. It should be around 35±5 milliamperes. If higher than 40 milliamperes, check for possible short circuits. If lower than 30 mA, something may be open or missing.

Voltages checks

Refer to schematic diagram (Fig. 2) and parts layout diagrams (Figs. 4 and 5) so that you fully understand the circuit portions that will be tested. Unless specifically stated, the negative meter lead shall be grounded to negative terminal of power supply when making voltage measurements. If voltage discrepancies are noted, check the components indicated in Table 1 (page 69) for faults. Slight variations outside specified voltage limits specified may be ignored if component checks do not reveal anything wrong. If you experienced some deviation from the voltages measured but were not too far off, the downconverter may be OK, but remember and record these slight voltage deviations should any further problems be encountered. If trouble is experienced at a later step with that particular circuit, further investigation may be needed. Remember that the 8-volt on-board regulator has a 5% tolerance and this will affect all other readings. Also, your DMM could be a few percent in error as well.

1. Set the thumbwheel of R24 at its approximate center position, and set C22 so its plates are about ¼ meshed. Now measure the voltage at the base of Q2. Using a non metallic tool, slowly rotate trimmer C22. There should be some perceptible voltage change at base of Q2 as C22 is rotated from minimum to maximum and back. Touching a metallic screwdriver blade to the stripline Z6 should also produce some change in this reading if Q5 is oscillating. A change of 0.01 volt or more is about what you will see if all is OK. This confirms that the local oscillator circuit is oscillating and that the mixer is getting a RF signal from the local oscillator.

2. Check that no part is getting hot.

3. If steps 1 and 2 are successful, connect the positive lead from a variable-voltage supply to junction C19 and L3, and connect the negative lead to ground. Set the wiper of R24 at ground (extreme counterclockwise rotation as viewed from shaft side). Set the power supply to +11 volts. Check for following voltages:

- At TP1 a voltmeter should indicate +7.6 to +8.4-volts DC as measured before in step 1. If not OK, check L3, D7, C27, and C28.
- At TP5 a voltmeter should indicate less than +1.2-volts DC. If not OK, check D6, D5, R27, R26, D4, and D3.

4. Increase the power supply voltage to 19 or 20-volts DC. Repeat step 3. The reading at TP1 should still read the same, however TP5 should be about +9-volts DC. If not, check all components mentioned in step 3. Steps 3 and 4 check out the remote tuning circuitry. If OK, proceed with the alignment in next step.

5. Connect the center conductor of a 75-ohm coaxial cable to the junction of C19 and L3 and the shield braid to ground as shown in Fig. 5. Terminate the end of the cable to J2, a connector suitable for your TV or monitor. (This is generally a type F connector.) Tune the TV to channel 3 or 4—whichever is unused in your area—and set its controls for normal reception. If you have a sensitive RF millivoltmeter, use it as an output indicator instead of a TV

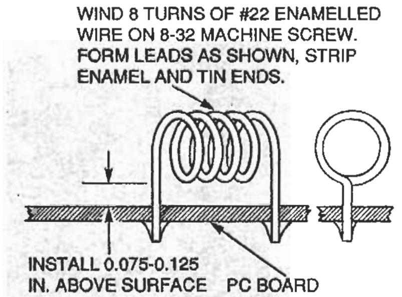


FIG. 6—COIL L2 FORMING and installation details. Wind 8 turns on 8-32 machine screw to form coil L2. Do not remove screw until after installation on PC board.

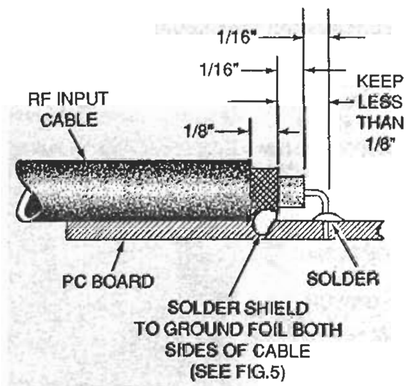


FIG. 7—INSTALLATION of RF input cable is critical. Keep recommended dimensions equal to or less than given in diagram, otherwise excessive losses will occur.

set. The meter is easier to interpret.

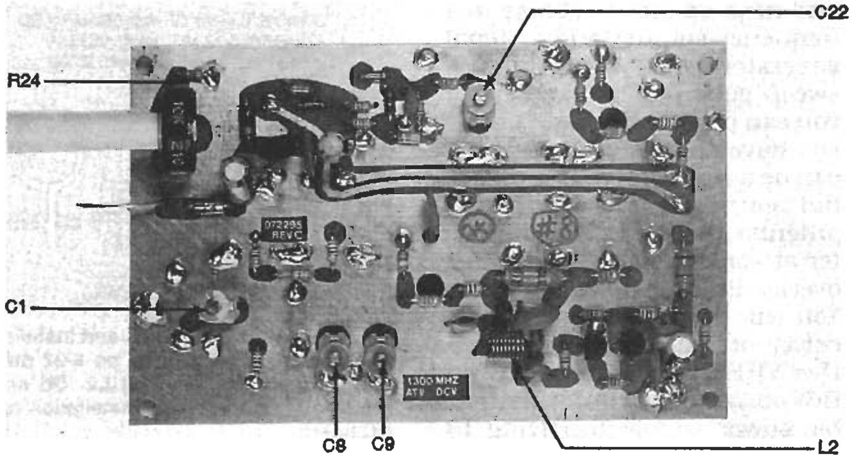
Connect a suitable signal source to J1, the downconverter input. Use 50- ohm low-loss cable and keep connections *short*. Refer to Figs. 5 and 7 for cable installation dimensions that are critical. The signal source can be either a generator or antenna. Preset all trimmer capacitors (there are four) to settings given in Table 2. Make sure to use the correct presets as the presets for 900 and 1300 MHz versions differ. Set the thumbwheel of R24 to its center position.

6. Connect +12 to +14-volts DC from the power supply to D8, the negative lead connects to foil ground. Keep the bottom of the PC board at least ½ inch above any kind of material which may detune the microstrip elements on the bottom of the PC board. Because both conductors and insulators can cause detuning, a set of four 1/2 or 3/4-inch plastic or brass standoffs installed in the four corner holes of the PC board should be used. Use only a nonmetallic tuning tool for all adjustments in the following steps.

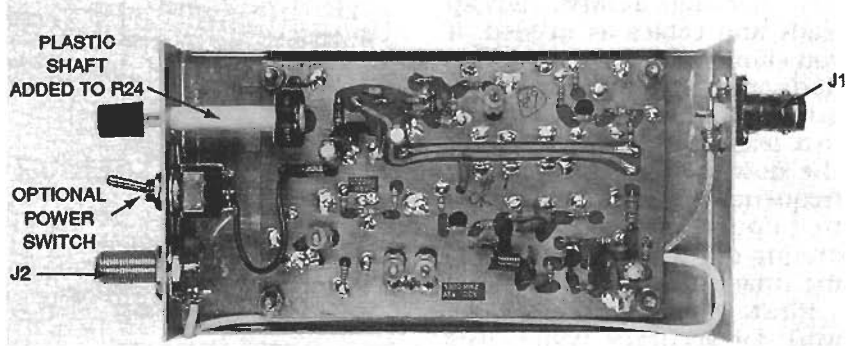
7. Activate the signal source and *slowly* rotate C22 until some indication of reception is seen on the monitor or RF voltmeter. Use a fairly strong signal at first. On confirmation of reception, decrease signal until it is just high enough for a reliable indication. As you remove the tuning tool from C22, undoubtedly some detuning will occur. You will have to compensate a little to get the tuning correct when the tool is removed. A frequency counter rated up to

TABLE 2
TRIMMER CAPACITOR PRESETS

Trimmer Capacitor	Percent of Mesh
Presets for 900-MHz model	
C1, C8, C9	25%
C22	80%
Presets for 1300-MHz model	
C1, C8, C9	10%
C22	20%



CLOSE-UP VIEW OF 1300-MHz downconverter board. Short lead lengths and neat construction techniques are a must!



MOUNT THE DOWNCONVERTER in a metal case for proper shielding. Use connectors to match your equipment.

1000 to 1500 MHz can indicate frequency shifts.

8. Next, couple the frequency counter to Q3. Stay at least ½ inch away from C22 and Q3. Set C22 for 850 ± 3 MHz with R24 at its center position (900 MHz model) or 1210 ± 3 MHz (1300 MHz model). You must have a steady reading, not a wildly jumping one. You may have to experiment with the coupling method, depending on your counter. We found loop coupling a little easier than the factory supplied whip antenna that came with our counter. *Do not* connect any probes, cables, or wires directly to the oscillator circuit or any of its components. A cable can be connected to the emitter of Q2 through a 220-ohm ⅛ or ¼-watt resistor for the frequency counter, if desired, but this may detune the oscillator 10 or 20 MHz. However, with certain counters that are low in sensitivity above 800 MHz this may be the only way to get a steady reliable reading. You can later compensate for this by touching up C22 once you are in the ballpark.

9. Once you obtain a steady reading and you are reasonably sure it is valid, proceed to check the local-oscillator tuning range. Rotate R24 through its entire range. For the 900 MHz model, the local oscillator should cover 840 to 867 MHz (assuming a channel 3 IF) and 1180 to 1240 MHz for the 1300 MHz model. Note that most ATV activity on 900 MHz is between 910 and 923 MHz, and in the case of the 1300 MHz, between 1240 and 1290 MHz (with gaps) so if you cannot quite achieve a 27 MHz range on 900 MHz, this should not be a problem. You can extend the range by replacing C23 on the 900-MHz model with a 5 pF chip NPO and retuning C22. The 1300 MHz model has somewhat wider tuning range (typically greater than 70 MHz). It is desirable to keep the tuning range as narrow as possible to improve the tuning

rate and ease of tuning a station. Adjust C22 as necessary to ensure desired coverage. For other IF frequencies, the local oscillator tuning range can be shifted lower (higher IF) or higher (lower IF). Note that the local oscillator must be *below* the signal frequency or else the IF signal will have its spectrum inverted with respect to the input signal spectrum. This will cause difficulties in TV reception in AMTV, and video and sync inversion in FMTV reception, unless the IF is designed for this.

If no frequency counter is available, you will have to depend on the reception of a known signal, or use a calibrated receiver covering the local oscillator range to pick up the local oscillator's signal.

If you dont have a frequency counter, receiver, or analyzer, dont worry. Use a known signal as follows. First set C1, C8, C9 and C22 to the presets shown in Table 2 if you have not yet done so. Set R24 at center of range. *Slowly* rotate C22 until some indication is seen on the TV or monitor, or other output indicator connected to junction of C19 and L3. Next, confirm that this is due to the signal source by shutting it off. If the indication disappears, this is the signal you want. Keep the signal level as low as possible for best results. If you get no results, make sure the signal has not gone off the air, and that trimmers are preset to correct settings, and the monitor, TV receiver, or indicating device is correctly set up and functioning. The presets are close enough to enable a strong signal to pass through the downconverter and give an indication.

10. Once you have an indication on the screen, peak C1, C8, and C9 for maximum signal as seen on the monitor. You should repeat this step as needed until no further improvement is obtained. Recheck setting of C22 to ensure correct tuning range is obtained. Check your final settings against presets. They should not be very different, as the tuning elements are printed on the PC board and therefore tuning should be close to presets shown. However, if you are setting up the downconverter for other than the specified frequency ranges, the presets will vary.

11. Your downconverter is now working. Now you can go over the adjustments again to further improve performance. If you can get access to a sweep generator, align the downconverter for a flat response within ±2 dB over the selected amateur band. The alignment is simple and straightforward so do not hesitate to experiment. You should be getting about 37 to 43 dB gain out of the downconverter and around 2 to 3 dB noise figure if everything is working properly.

12. The downconverter can be mounted in a shielded box with connectors of your choice. We recommend type N, TNC, SMA, or BNC for the input and an F connector for the output. Be sure to waterproof all connections for mast mountings. It is suggested that the alignment be checked after mounting the PC board in any enclosure since some slight detuning may result.

13. For remote tuning, make sure your variable supply is *clean*. Any noise or hum will cause FM on the local oscillator signal and a noisy received picture. Be sure also to set R24 fully CCW when remote tuning is used, or else the converter tuning range will be restricted or nil.

Variable gain

Both models of the downconverters develop 37 to 43-dB power gain from the antenna input to the RF output. This gain may be too much when strong TV signals are received, resulting in overload of the TV set. The unit's gain may be modified by changing R11 from the default value of 1000 ohms to other values as specified in Table 3.

A 1000-ohm potentiometer in place of R11 can be used for providing continuous variable gain. This portion of the circuit operates at the IF frequency, so a potentiometer and wiring techniques suitable at 70 MHz should be used. The IF output should be maintained below 150 millivolts rms in order to prevent overload of the converter. This is a very strong signal to feed into a TV receiver or video monitor.

TABLE 3—PRESET GAIN

Desired Gain (dB)	R11 Value (Ohms)
43	2,200
34	470
28	220
25	100

Resistor R11 values assume a nominal gain of 40 dB. Increasing the gain beyond an extra 3 dB is not recommended. To reduce RF gain for very strong signals, it is recommended that a negative bias voltage supply of 0 to -10 volts be applied to TP7 through a 220,000-ohm resistor. This can be obtained from a potentiometer that is connected across a -10 V DC supply.

The potentiometer functions as an RF gain control in this case. Reverse AGC from the TV receiver used as a monitor could be arranged so as to bias TP7 from +1.5 volts DC at zero signal to -3.0 VOLTS DC on strong signals. Typically 35 to 40 dB RF gain reduction may be obtained using either of these approaches. As TV receivers vary, the individual circuit arrangements for doing this are left to the ingenuity of the builder.

Another gain reduction method is the use of a manually operated switch to ground TP7. This will reduce RF gain approximately 10 dB. This switch can be a simple SPST switch. For greater reduction of gain the switch may be connected to a negative voltage of -1 to -3 V as needed.

The matching ATV transmitter for the downconverter appeared in the May, 1996 issue of *Electronics Now* and corner reflector antenna construction will be covered in a future issue of *Electronics Now*. Refer to the May, 1996 issue for details of the system's overall performance in field trials. Ω