An ATV Downconverter with a Difference

Keep FM voice repeaters out of your picture.

by Don C. Miller W9NTP

How many times have you been working ATV on 439.25 MHz lately and an FM voice repeater wiped out the incoming ATV signal? You probably either condemned your downconverter for not having good selectivity, or you thought a few uncomplimentary things about repeaters in general. Then, on closer investigation with a tunable receiver, you found to your horror that these repeaters were in the passband of the ATV signal. Why do they do this? Don't hams respect each other's rights anymore? The truth is that the repeater is operating legally within its allocation, and the ATV station is as well. Figure 1 shows the relationship between the ATV band and the voice repeaters.

This is just one of the many problems that ATVers face today. Fortunately there is a technical solution to this problem that is both inexpensive and easy to do. Members of the Indianapolis ATVers group figured out the solution about 10 years ago. As a result, FM voice repeater interference is virtually unknown to them.

Design Background

Before discussing the solution, let's look at the way an NTSC TV set receives a commercial channel. On Channel 3, for example, the video carrier frequency is 61.25 MHz. In order to conserve spectrum, TV channels were allocated 6 MHz. Since NTSC video signals are at least 3.58 MHz wide, it wasn't possible to fit both sidebands, the color NTSC spectrum, and the sound carrier into the 6 MHz bandwidth. The diagram in Figure 2 shows the normal video and sound spectrum used to modulate a TV transmitter.

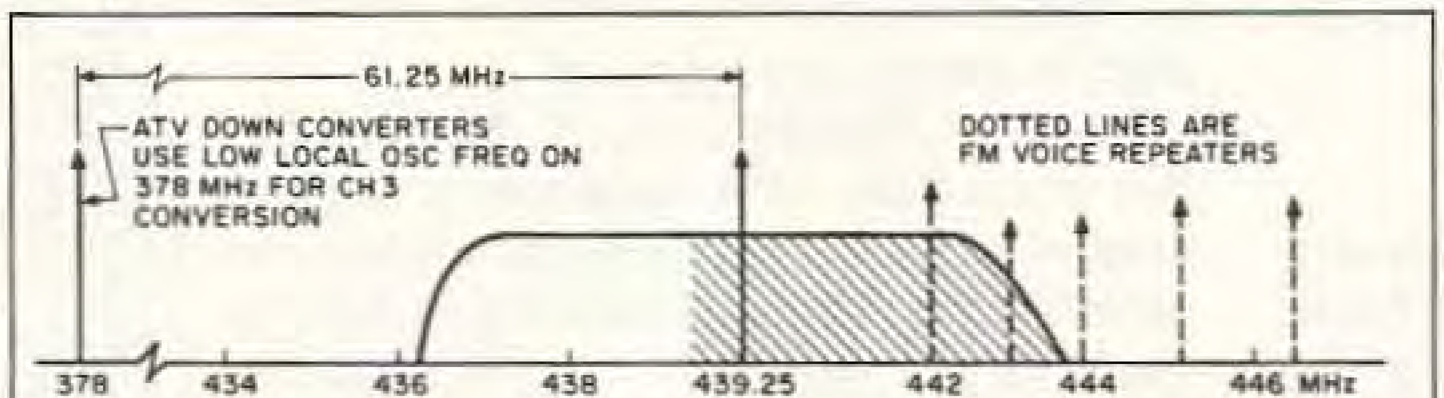

Figure 1. A typical ATV spectrum, showing FM repeaters and upper sideband detection normally used.

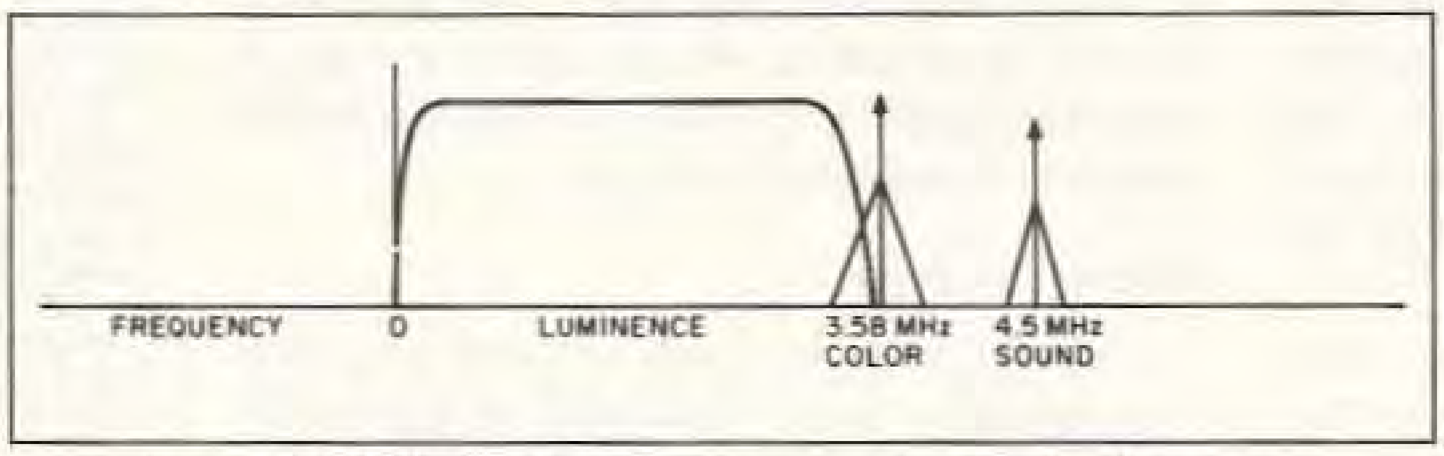

Figure 2. NTSC video spectrum with sound subcarrier.

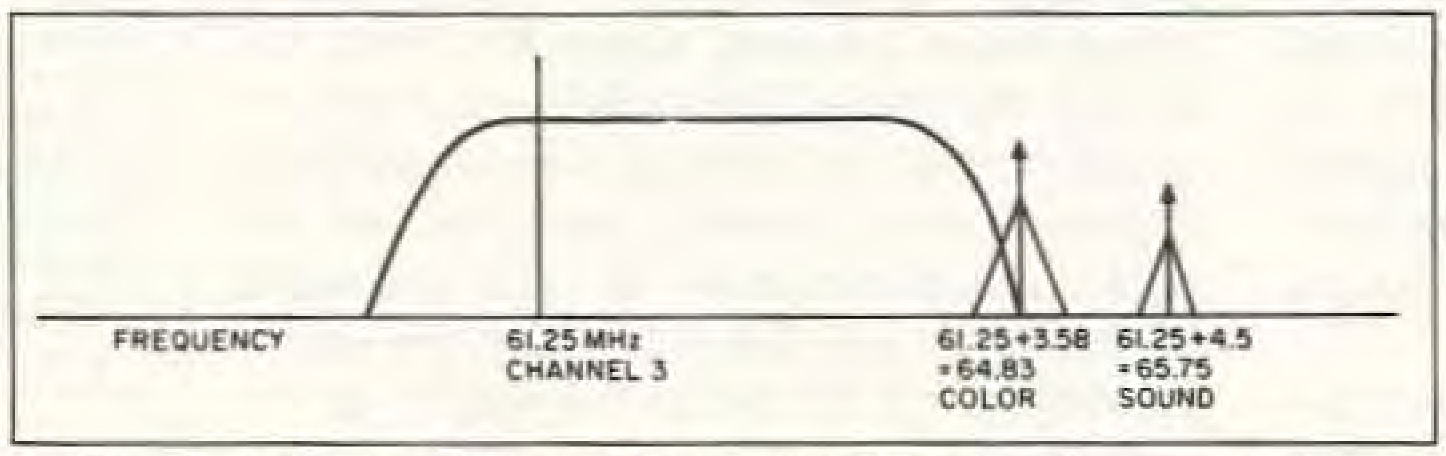

Figure 3. Typical Channel 3 vestigial sideband transmission.

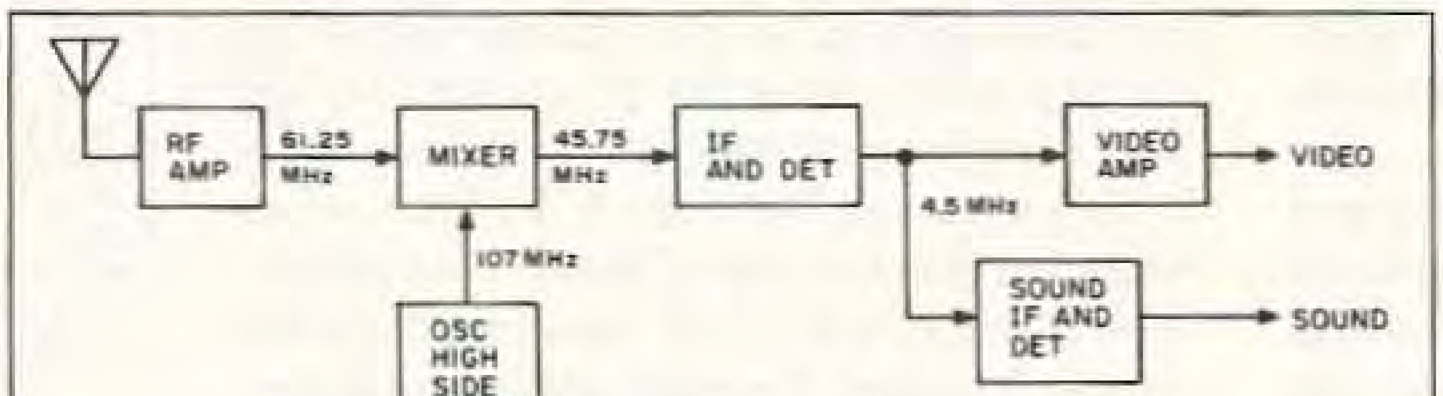

Figure 4. Block diagram of a typical TV receiver.

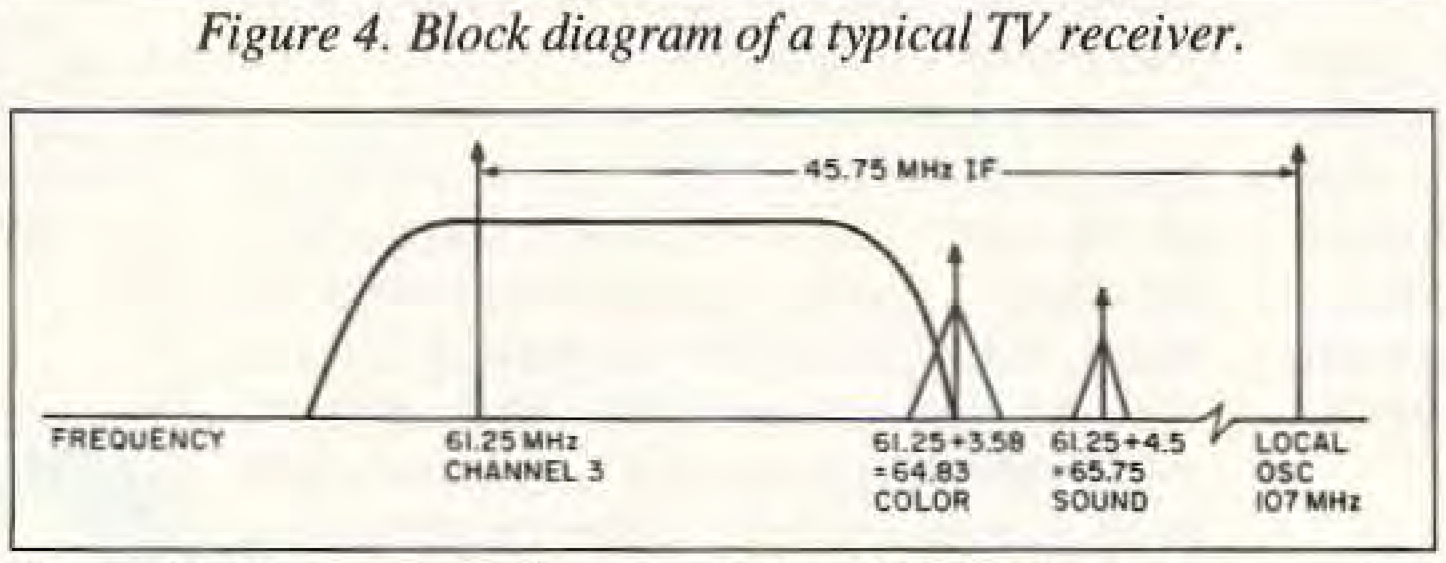

Figure 5. Conversion of upper sideband TV to lower intermediate frequency sideband by the use of a higher frequency local oscillator.

Early investigators found that if a system of vestigial sideband transmission was used, the TV signal could be transmitted with a total bandwidth not exceeding the allocated 6 MHz. The vestigial sideband system only used slightly more spectrum than a single sideband transmission system. SSB could not be used because of the need for a relatively accurate carrier insertion. They found that most of the energy of a video signal is in the first one megahertz of the bandwidth, and that if double detection of that portion of the transmitted signal was made, the total signal could be placed within the 6 MHz bandwidth.

In other words, the first one MHz of the spectrum is detected as double sideband with bandwidth attenuation, and the rest of the signal is detected as single sideband. The carrier is transmitted as part of the double sideband transmission. This spectrum is shown in Figure 3. Note that the upper sideband was chosen to be the preferred sideband, but the lower could just as well have been chosen.

All TV sets use the principle of superheterodyne, discovered in the late 1920s, which makes it possible to build just one amplifier to amplify any received frequency. Before this development, it was necessary to tune all the RF stages of a radio to every frequency that the listener desired to receive. This was partly solved by ganging all the RF stages together so that all the knobs did not have to be tuned carefully. This took a lot of the fun out of listening to the radio.

Figure 4 is a block diagram of a simple radio or TV set. The RF stage may be tuned, but tuning is not absolutely necessary. The frequen-

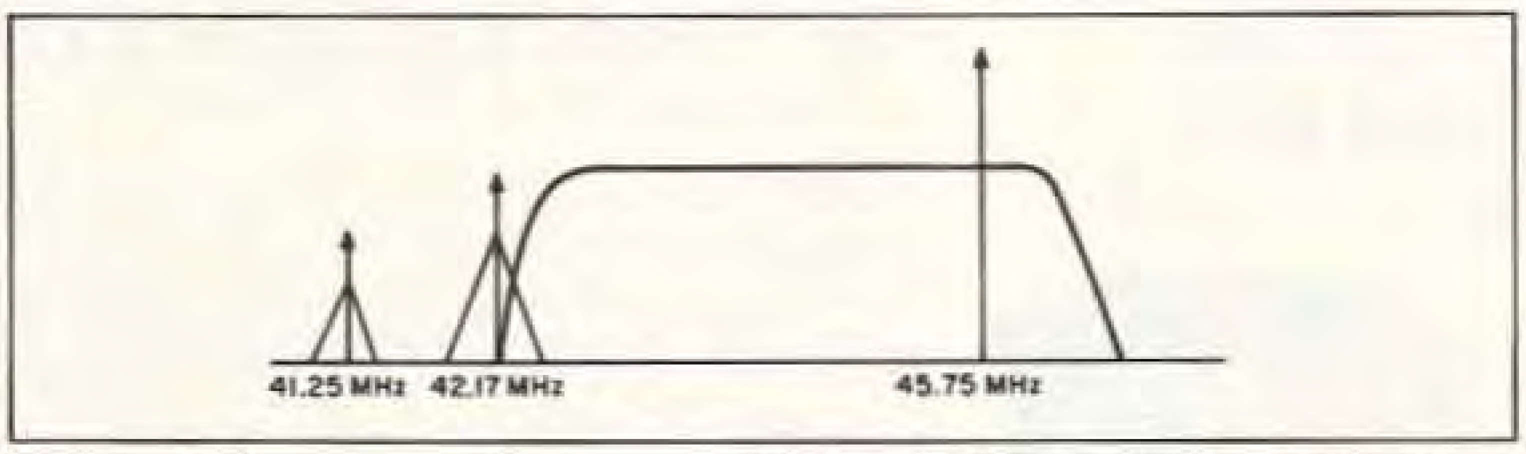

Figure 6. Spectrum of an upper sideband TV signal after it has been frequency-inverted by a higher local oscillator.

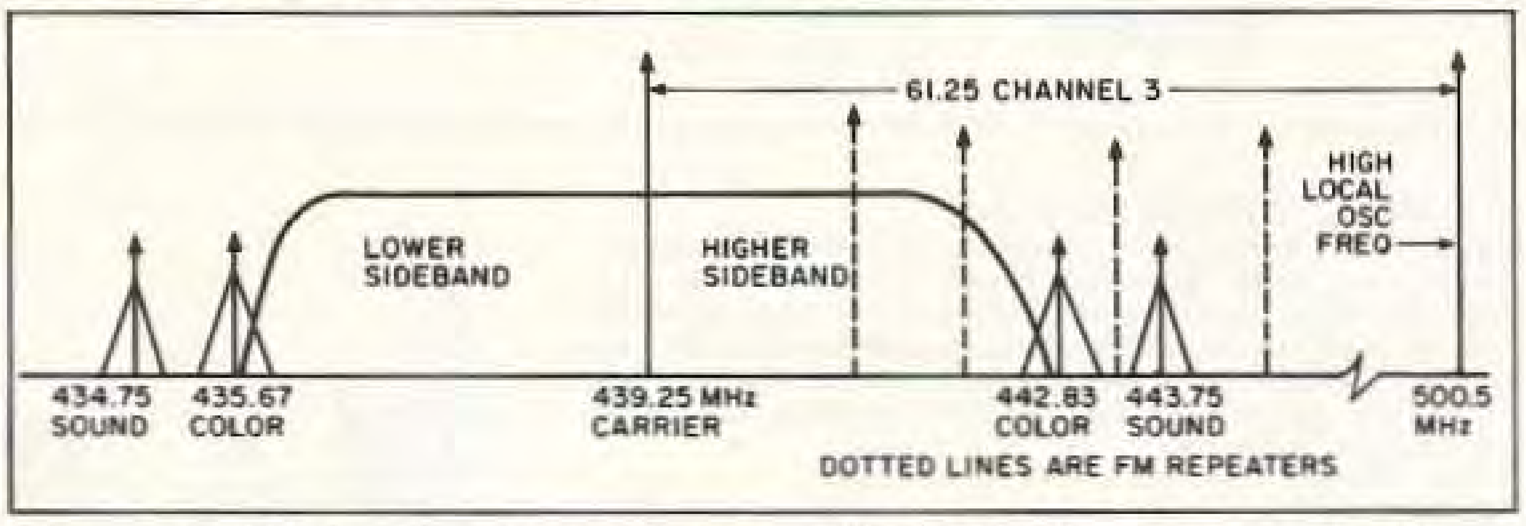

Figure 7. Higher local oscillator at 500.5 MHz converts the lower sideband of the ATV signal to an interference-free signal.

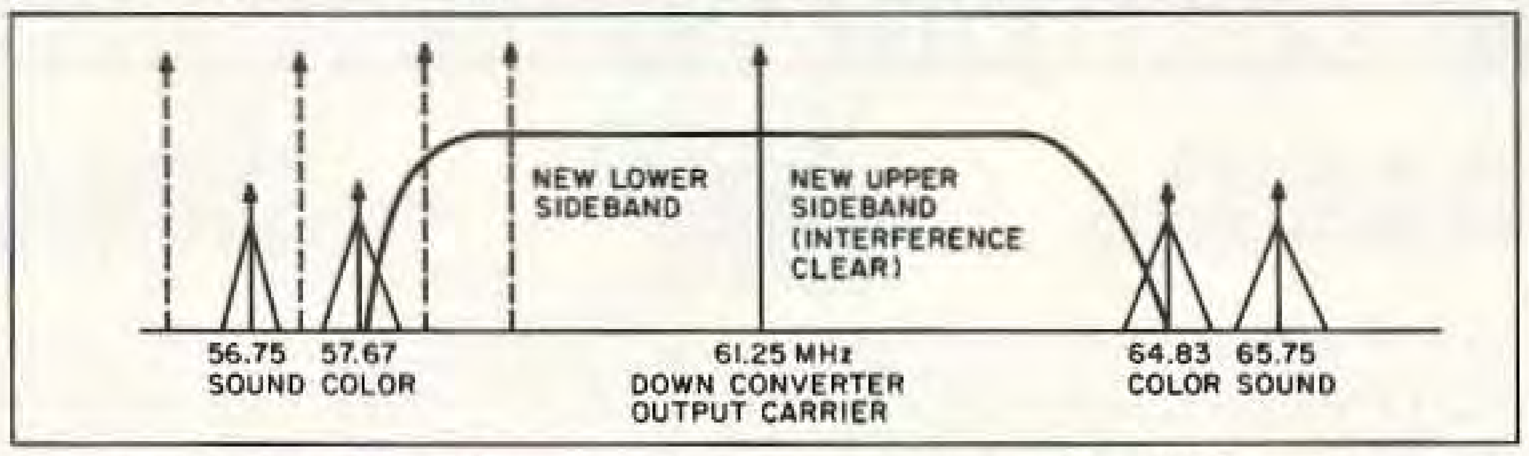

Figure 8. Resulting downconverter spectrum after higher frequency oscillator inverts spectrum.

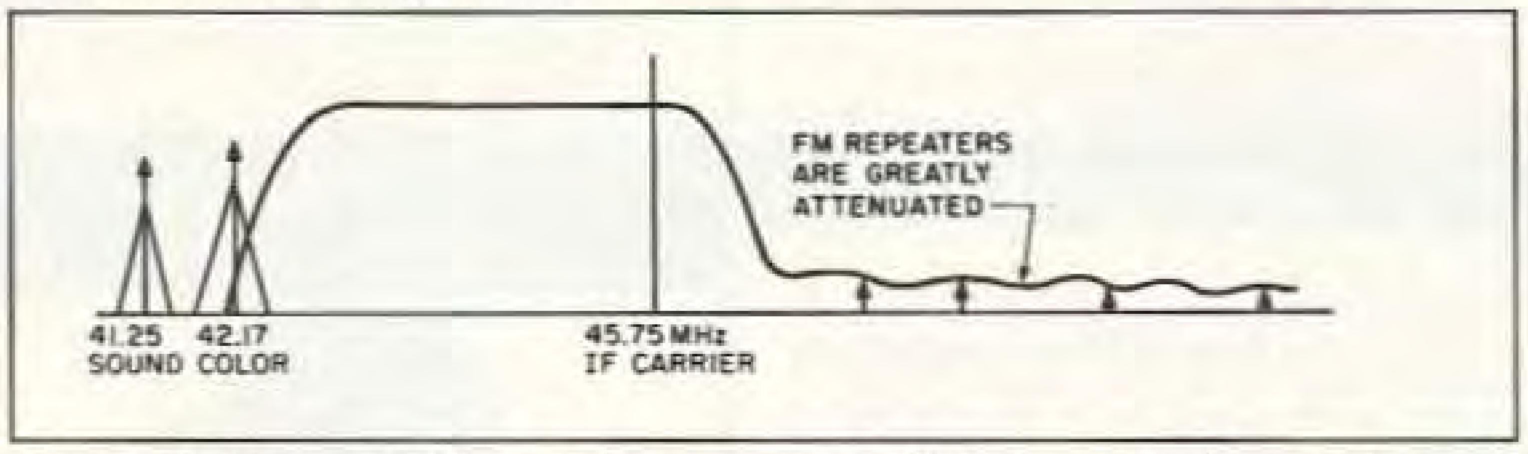

Figure 9. Lower sideband of transmitted ATV signal in the passband of the IF amplifier, showing the attenuation of the FM voice repeaters.

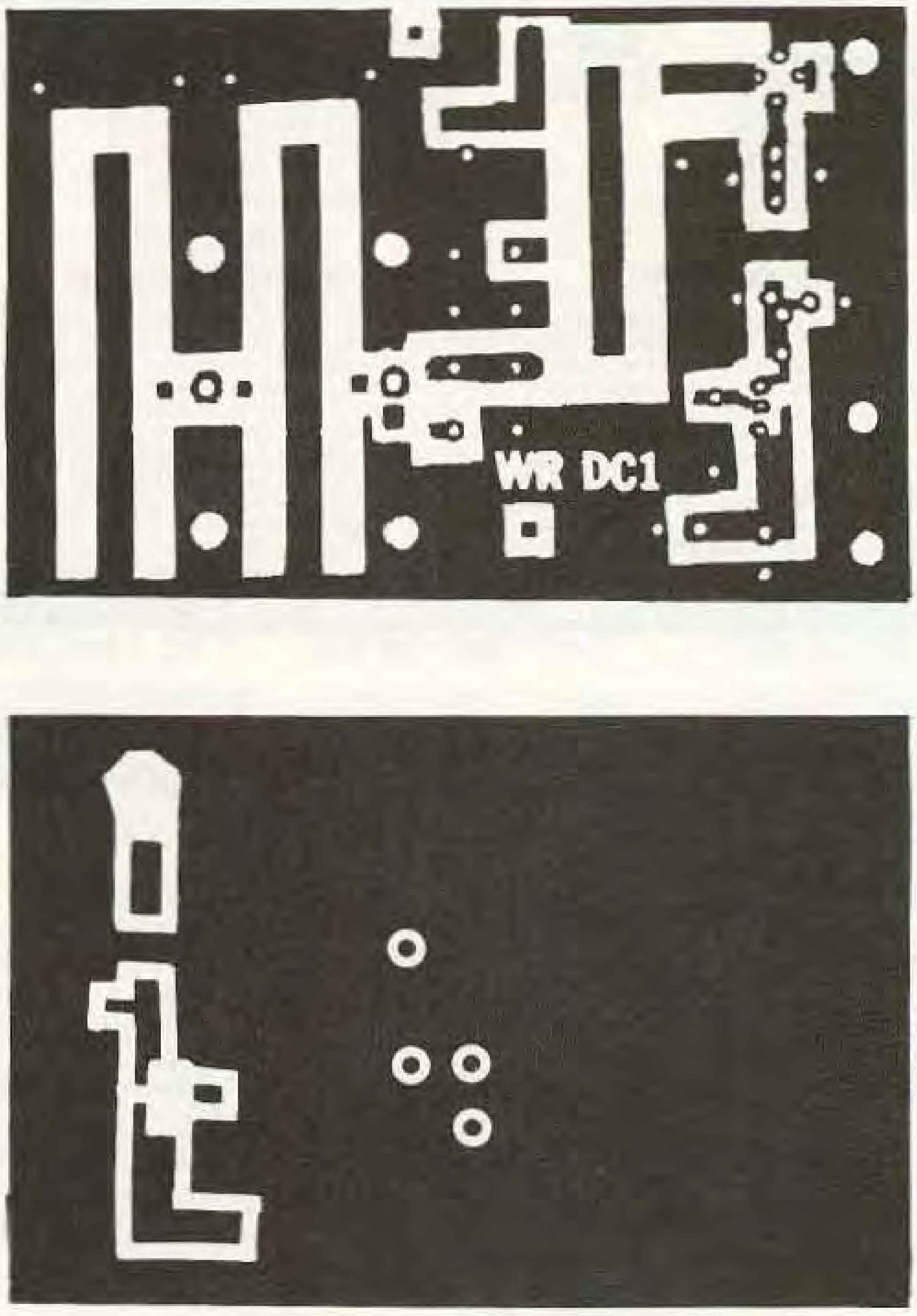

Figure 11. (a) PC board foil pattern (top layer). (b) bottom layer foil pattern.

cy selection tuning is done by the Local Oscillator (L.O.). In older TV sets, this frequency, as well as the RF tuning, was done by a channel selector, but in new sets, varactor electronic tuning eliminates the need for these mechanical nightmares. To receive an incoming signal, e.g., Channel 3, on 61.25 MHz, the vestigial one-sided spectrum must be converted to such a frequency that the intermediate frequency amplifier, known as the IF, can amplify it. Since all channels must be converted to this IF frequency, a frequency must be chosen that is least likely to be interfered with. Various intermediate frequencies were used in early TV sets, but interference from other services was found to be very bad. Later, an IF frequency near 45 MHz was chosen. It has worked very well for the last few decades.

The second design standard that must be set is placement of the L.O. A frequency above or below the IF is acceptable. The L.O. frequency can be 61.25 plus 45.75 = 107.00 MHz, or 61.25 minus 45.75 = 15.50 MHz. The TV receiver manufacturers decided to use the higher L.O. frequency. The IF amplifier cannot tell which L.O. was used. The higher L.O. ensures that the oscillator does not fall in any VHF TV channel when the receiver is tuned to VHF channels 2–13.

When UHF came along, the same standard was used. It was desired to use the unsymmetrical IF amplifier response set up for VHF reception. This is what has created a problem for ATVers on 439.25 MHz.

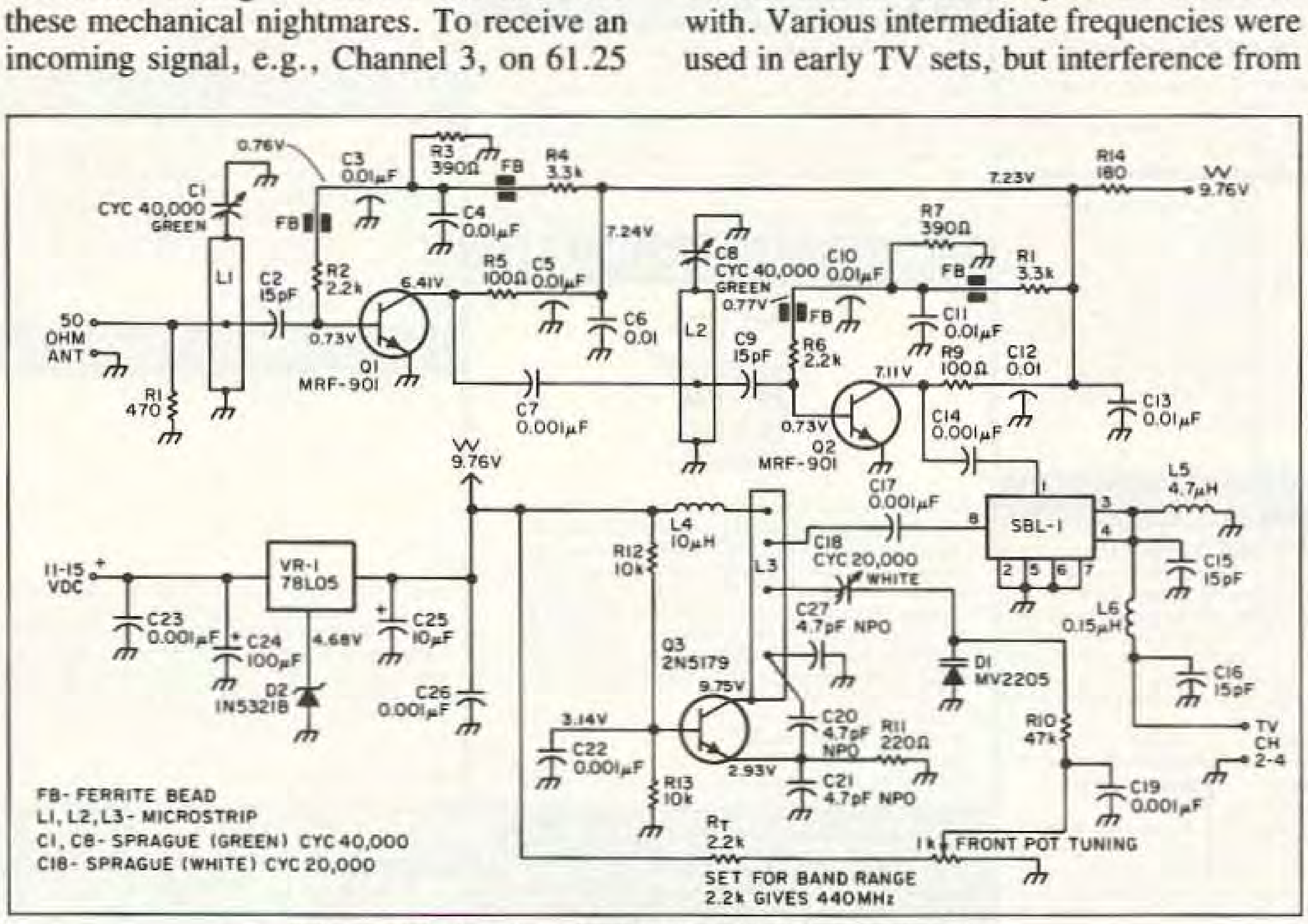

Figure 10. The lower sideband ATV down converter.

Now, the Fix

Figure 5 shows the conversion spectrum of the Channel 3 TV signal. Remember that the upper sideband is the chosen sideband transmitted commercially. When this upper sideband is received, it becomes LOWER SIDEBAND in the IF amplifier. This is shown in Figure 6.

When ATV came along, it was easy to build a downconverter that would convert 439.25 MHz to Channel 3 or some other low frequency channel. If Channel 3 was the choice, the designer of the downconverter had to decide where in the spectrum the downconverter L.O. would be placed. It is difficult to build oscillators in the UHF spectrum, so some manufacturers decided that the L.O. should be placed on the low side of 439.25 MHz, or 439.25 −61.25 = 378 MHz. The other choice would have been 439.25 + 61.25 = 500.5 MHz which would result in lower sideband detection.

The lower frequency L.O. choice was also influenced by falsely concluding that the upper sideband of the two-sided ATV signal *must* be the sideband that is received by the TV set. Another consideration was that it is more difficult and expensive to design and build a higher frequency L.O.

Both sidebands are transmitted by many ATV transmitters, and the picture is the same whether the upper or lower sideband is recovered. Figure 7 shows how an oscillator on the high side of the ATV carrier can detect the same picture.

If the choice had been to place the ATV L.O. on the high side of the incoming signal, the lower sideband would have been detected WHERE THERE ARE NO FM REPEATERS. This mostly eliminates the FM interference. The passband of a typical TV set rejects anything on its IF higher sideband. Remember that the sidebands REVERSE in the IF amplifier. The rejection of the upper sideband in the ATV spectrum is as good as the rejection of the TV set IF amplifier. This varies from TV to TV, but the rejection is good enough to reject adjacent channels on cable TV where channels are side by side. This is different from commercial RF transmitted TV, where adjacent channels are now allowed within a certain geographical distance.

The conversion is shown in Figure 8. A typical IF passband characteristic is shown in Figure 9.

Build your own Downconverter

It is easy to build a downconverter that receives the lower sideband. If you do not wish to modify your present downconverter, why not build one yourself? Figure 10 shows a circuit that works very well for ATV and operates with the oscillator on the upper side of the received frequency.

The incoming signal is amplified by two MRF-901 transistors. Stripline inductors are used on both stages of the RF amplifiers. The oscillator is also stripline, and is varactor tuned with a potentiometer on the front panel. The mixing between the incoming signal and the oscillator is done in a 4-diode mixer. The output is filtered and put out to an F-type connector that is connected to a TV set tuned to Channels 2–4.

Each of the RF stages are decoupled with well-filtered DC voltages supplied through feed-through capacitors. The noise figure of the downconverter is excellent, and rivals the performance of more expensive GaAsFET front ends. If desired, a small GaAsFET amplifier, such as the Hamtronics LNW-432, can be put in front of the downconverter. In this case, the first stage of the downconverter can be eliminated, and the GaAsFET output is connected directly to the base connection on the microstrip of the second stage in the downconverter. You'll see some improvement in performance when using the GaAsFET preamp, although the noise figure of the MRF-901 front end is very good. Figure 10 shows the circuit diagram of the lower sideband downconverter. Figure 11 shows the printed circuit board layout, top and bottom, and Figure 12 the parts layout.

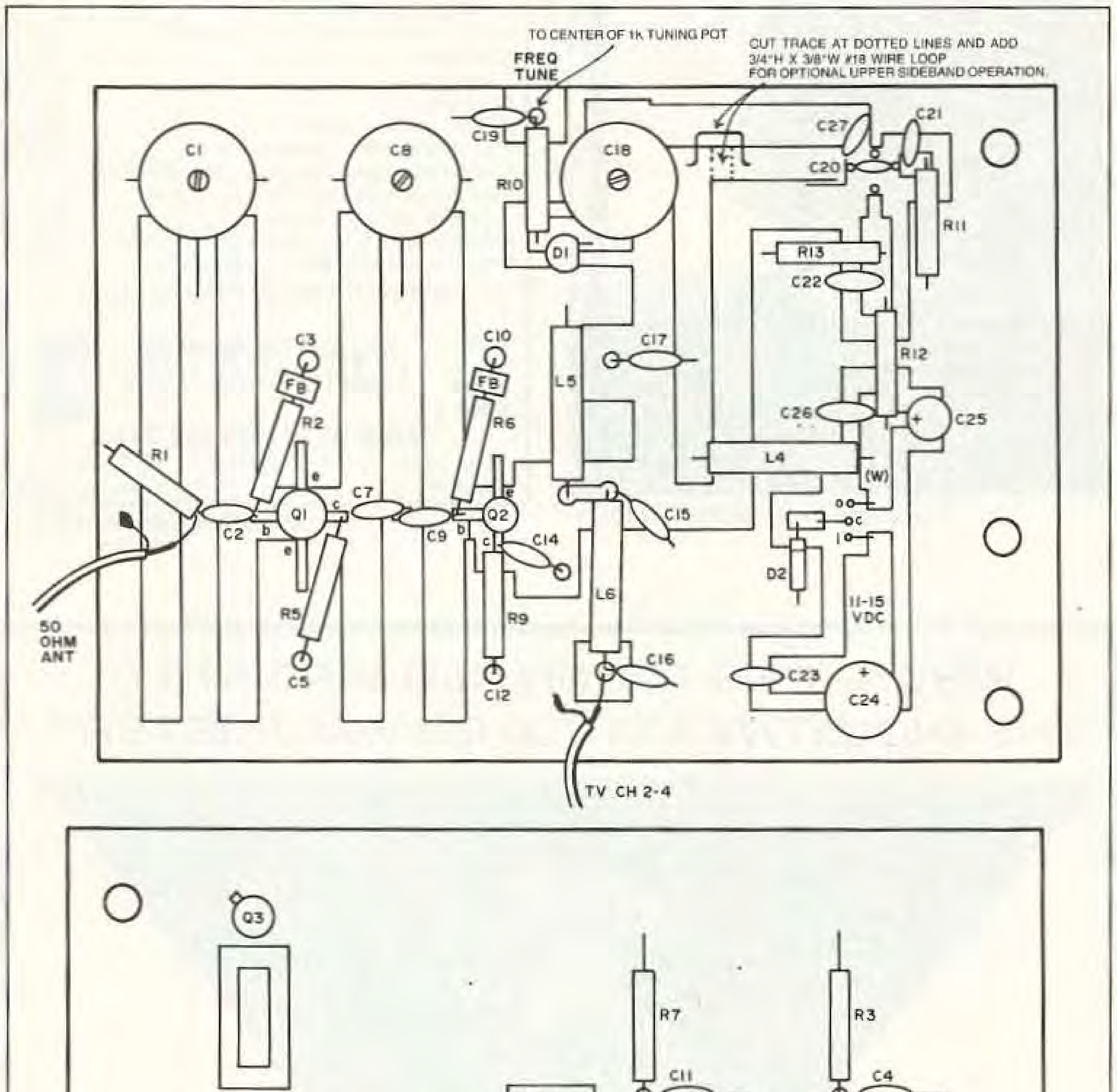

Figure 12. (a) The mechanical layout on top of the PCB. Mount components right on top of the board. To modify the circuit for upper sideband receive, cut the trace indicated by the dotted lines (L3) and attach a 3/4" high by 3/8" wide #18 wire loop to bridge the gap as shown in bold lines. (b) The bottom of the PCB. Note that Q3, the SBL-1 and the other components shown here are soldered to this side of the board.

Tune-Up and Operation

Mount your downconverter in a metal enclosure with a BNC or N connector for the antenna input and an F connector for the channel 3 TV output (you can use VHF channels 2–4). Hook up the downconverter to the VHF input of your TV set and attach a good 70 cm antenna to the BNC or N connector.

Power up the downconverter (use a 12-volt supply) and set your TV set for channel 3. Use channel 2 or 4 if you have a strong local station on 3. Have a nearby station who can transmit a low power signal on the low end of the band on either 421.25 or 426.25 MHz (or look for the output of an ATV repeater), adjust the front panel tuning potentiometer for the low end of its range and adjust capacitor C18 until you see a picture. If you find that you cannot tune high enough, you may have to use a lower value resistor for Rt (try 2.0k instead of 2.2k in this instance).

If you can't generate anything on the low end, just have someone send on 434 or 439.25 MHz, and tune the potentiometer to the upper end of its range. Then just adjust C18 for a picture.

Once you receive an image, have the transmitting station reduce his power or move his antenna until you have a weak, snowy picture. Now peak capacitors C1 and C8 for the strongest image.

Selectable Sideband Options

If you have no interference problems on 439.25 MHz in your area, or operate on other frequencies in the band (434, 427.25, 426.25 or 421.25 MHz), you can use this downconverter to receive regular upper sideband transmissions by cutting the trace to the right of C18 (see option in Figure 12a) and adding a 3/4" high by 3/8" wide #18 wire loop to bridge the gap. You will need to do this if you are receiving ATV transmitters or repeaters that use vestigial sideband filtering.

For the more adventurous, you can add the loop for upper sideband receive, then mount a small relay on the bottom of the PC board so that the pins short out this gap when activated. That way you can receive upper sideband ATV in one position, and lower sideband when the relay is closed. You'll have to experiment around to find the right length of the #18 wire loop so that you tune the same frequency whenever the relay is activated. Otherwise you'll have to readjust the tuning potentiometer or tweak C18.

The ATV LSB Downconverter

R1	470 ohms
R2,6	2.2k ohms
R3,7	390 ohms
R4,8	3.3k ohms
R5,9	100 ohms
R10	47k ohms
R11	220 ohms
R12	10k ohms
R13	10k ohms
R14	180 ohms
C1,8	1–10 pF variable, Sprague, CYC 40,000 (green)
C18	1–15 pF variable, Sprague, CYC 20,000 (white)
C2,9,15,16	15 pFdisc
C3,5,10,12	0.01 feed-thru noncritical value
C4,6,11,13	0.01 μF disc
C7,14,17,19,22,23,26	0.001 μF disc
C20,21,27	5 pF NPO
C24	100 μF electrolytic
C25	10 μF electrolytic
L4	10 μH choke
L5	4.7 μH choke
L6	0.15 μH choke
Q1,2	MRF-901
Q3	2N5179
VR1	78L05
D1	MV2205
D2	1N5231 Bzener
SBL-1	double balanced mixer Mini-Circuits

Note: A blank PC board is available for $10 from the author at Wyman Research, Box 95, RR #1, Waldron IN 46182, or call (317) 525-6452. The following hard to find parts are also available: Sprague CYC 40,000 and CYC 20,000 variable capacitors at $4 each and the SBL-1 double balanced mixer for $5.

After you've done your tune-up procedure, you should be ready to join in on all the ATV action and you'll keep the voice repeaters interference out of your picture in the process.

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