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CB to Six

Why stop at 10 meters? KB5LF's Hy-Gain conversion will take you to VHF just as easily.

Several years of converting CB sets to ten meters makes one really appreciate the built-in ability of these little rigs. Those of us who are operating them now on single sideband or FM can attest to their stability, sensitivity, and clean output. It was for these reasons I began experimenting with the possibility of converting a CB to six meters. Since I had several Hy-Gain boards on hand, that's what I selected for conversion.

My basic criteria for a successful conversion were:

a) Simplicity—The conversion should be no more difficult than to ten meters.

b) Quality—The receiver should maintain its original sensitivity/selectivity; additionally, the transmitter output should be very clean!

c) Cost—I firmly believe a conversion loses its appeal when the price is too high or when exotic parts are used and can't be easily obtained.

After the conversion was completed, I felt that the criteria had been met. The little rig operates beautifully on six meters!

My objectives in writing this article include:

a) Offering specific information to convert the Hy-Gain board to six meters.

b) Giving enough general information to allow you to begin converting the CB of your choice.

c) Increasing the use of our six-meter band.

I must tell you in the beginning that I will not describe the hookups required to make the board operate nor specifically detail FMing the rig. I'll just refer you now to the many excellent *73* articles that have detailed this part of the conversion. Your main obstacle to six-meter operation is moving the radio from eleven meters AM to six meters AM. Sidebanders, take note—I'll not forget you, either. Your conversion may also be surprisingly simple.

Examine the basic block diagram of Fig. 1. To move any CB in frequency, the master frequency source (vco, crystal synthesizer) *must* be made to operate at a new frequency. We know from our ten-meter conversions that we must increase the frequency. The question is, how much? Keep in mind that, generally speaking, the master frequency source (vco, synthesizer) of most CBs does not change frequency between transmit and receive. If we can determine the correct vco frequency to inject into the first receive mixer, we will also have found that this same frequency is used for transmit.

Refer again to Fig. 1. Three incoming frequencies are shown. The first is an incoming original CB frequency; the second is a 10-meter FM frequency; the third is a new frequency in the six-meter band. Note also that these frequencies are in the center of their respective bands. The frequencies generated by our master frequency source that mixes with the incoming signals is also shown. Let's examine how the master frequency is determined.

If we examine Fig. 1, we see that a 27.185-MHz signal is amplified by one or more rf stages before it is mixed with the master frequency. During the mixing process, the first i-f frequency is selected. In our case, the first i-f frequency is 10.695 MHz. In almost every case, the receive-mixer circuitry selects the *difference* frequency. Our equation:

For 11-meter operation—master frequency = incoming frequency + first i-f frequency = 27.185 MHz + 10.695 MHz = 37.880 MHz.

For 10-meter operation—master frequency = 29,600 MHz + 10.695 MHz = 40.295 MHz.

For 6-meter operation—master frequency = 52.525 MHz + 10.695 MHz = 63.220 MHz.

The equation in a different form: master frequency − incoming frequency = first i-f frequency.

If your particular radio

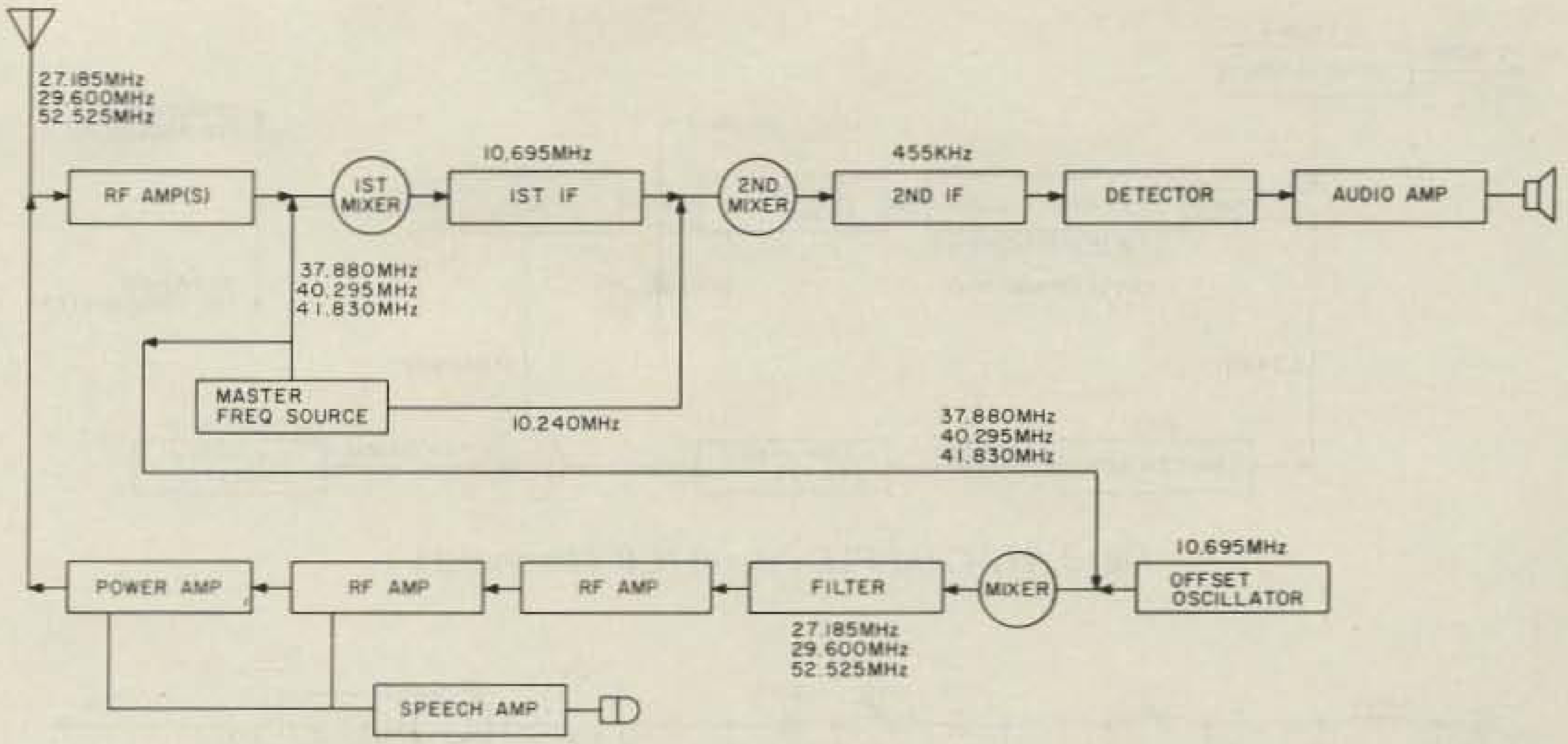

Fig. 1. Hy-Gain CB block diagram.

uses a different i-f frequency (10.7 MHz, 7.8 MHz, etc.), change the i-f frequency in the formula and crank out the new master frequency. During the change to 10 FM, the Hy-Gain's vco frequency was increased about 2.5 MHz, an increase of approximately 6%. This change is not excessive. There is enough adjustment range in the circuitry to handle this increase in frequency. Examining the percent change from 11 to 6 meters, we find that increasing the vco frequency from 37.880 MHz to 63.220 MHz involves increasing the frequency approximately 25 MHz. The percent change in frequency is approximately 67%. This is asking too much of the circuitry. Without major modification to the vco circuitry, it will not operate in the 60-MHz region.

Any time two frequencies are injected into a mixer, many different frequencies are produced in the output. Of special importance are the sum and the difference frequencies. The tuned portion of the mixer's output will determine which of these two frequencies is emphasized. As an example, using Fig. 1, 27.185 MHz and 37.880 MHz are injected into the first mixer. The sum of these two frequencies is 65.065 MHz. The difference is 10.695 MHz, the frequency of interest. In our case, the mixer selects the difference frequency. The reader may verify the frequencies used for 10-meter operation. Note that in both 10- and 11-meter operation, the master frequency is higher than the incoming frequency; hence the term *high-side injection*.

There is another frequency that will mix with the 37.880-MHz signal to produce the 10.695-MHz output. In this case, a 48.575-MHz signal mixed with the 37.880-MHz signal will also produce the required 10.695-MHz i-f output. This frequency is called the *image frequency* and will be detected if allowed to enter the mixer. Fortunately, the designers incorporated the proper circuitry beginning at the antenna input and in the rf amplifier stage(s) to reject the image frequency. If you desire, you can determine that the image frequency on 10 meters falls within the 6-meter band.

The problem I had to solve was on what frequency must the master frequency source operate to receive a 52.525-MHz signal and produce a 10.695-MHz output. I rejected using the 63.220-MHz frequency as described above. I elected to run the master at 41.830 MHz. Again, the difference frequency (52.525 MHz − 41.830 MHz) gives us the required output from the mixer. This mixing scheme is called *low-side injection* because the frequency of the master is lower than the incoming frequency. Using 41.830 MHz as the master frequency will allow the receiver to also detect a 31.135-MHz signal (the image frequency) if our tuned circuitry at the input will allow it to pass. We will cure any image frequency interference in this conversion.

The modification to 6 meters of the Hy-Gain vco is exactly like that required for 10-meter operation (refer to Fig. 2). Only the 11.8066-MHz crystal need be changed and the vco retuned to operate properly in the 42-MHz range. I'll briefly describe its operation and then recommend a replacement for the original crystal.

The 10.240-MHz oscillator is fed into pin 3 of the PLL02A chip. It is internally divided by 1024 to give us a reference frequency of 10 kHz. This means that our channel spacing will also be 10 kHz. Notice also that the 10.240-MHz signal is sent to the receiver section and mixed with the 10.695-MHz i-f, resulting in a second i-f frequency of 455 kHz (10.695 − 10.240 = 455 kHz).

The vco frequency of 37.660 MHz (CB channel 1) is fed to both the receiver and transmitter sections of the radio. Since we are dealing with a PLL circuit, this frequency must be fed back to the PLL02A chip and compared with the reference frequency (10 kHz) to see if any change in frequency is needed. Since the PLL02A has an upper limit (at pin 2) of approximately 3 MHz, some method of mixing the signal down to less than 3 MHz is needed. This is the reason why the 11.8066-MHz oscillator/tripler is in the circuit.

In Fig. 2 we see the 11.8066-MHz frequency being tripled to 35.4198 MHz. The tripling occurs within the circuitry associated with Q105. This frequency is mixed with the 37.660-MHz signal from the vco, and the difference frequency of 2.24 MHz is selected by the use of the low-pass filter (C108, L101, etc.). A mixer buffer (Q103) follows to ensure that the PLL02A does not load the circuitry and gives additional gain to the 2.24-MHz signal.

Assuming the vco is operating exactly on 37.660 MHz, a signal of 2.24 MHz will appear on pin 2 of the PLL02A. If the programming pins (7 through 15) on the PLL02A are set to divide by 224, a 10-kHz signal (2.24 MHz ÷ 224 = .010 MHz) will be generated. This is exactly the same frequency as the reference. The system is said to be "phase-locked." If the vco tries to change frequency or programming to the PLL02A changes, the frequencies generated internal to pins 2 and 3 will no longer be identical. The PLL02A senses this and changes its output voltage across the varactor diode (D101) to steer the vco to a condition where again both signals internal to pins 2 and 3 are 10 kHz. For you that experiment, I have found that by changing crystals and retuning the vco coil (T101), I could lock the loop from about 28 to 48 MHz. Not bad for this little circuit!

I wanted the mid-band frequency to be 52.525 MHz, one of the simplex calling frequencies for 6 meters. I knew the vco would probably be capable of maintaining lock over a

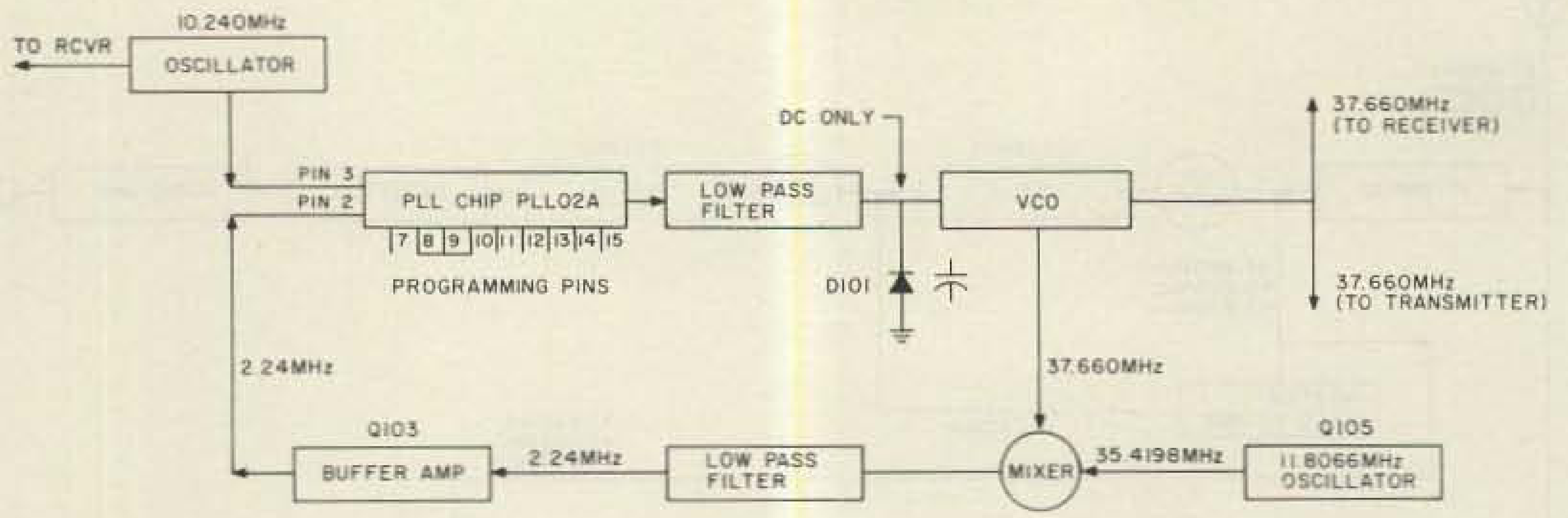

Fig. 2. Hy-Gain PLL circuit (CB channel 1).

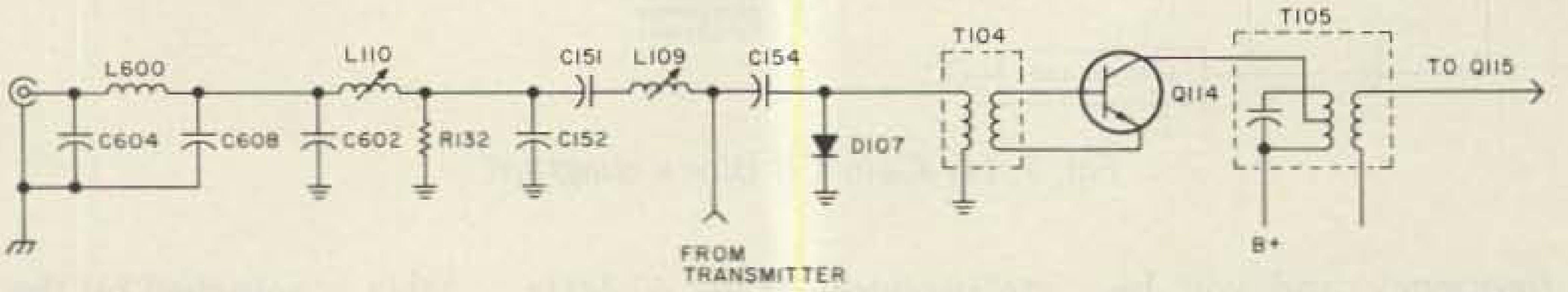

Fig. 3. Hy-Gain receiver front end.

540-kHz range. Therefore, I subtracted 270 kHz from 52.525 MHz to give a channel 1 frequency of 52.255 MHz (PLL02A set to divide by 224). The high end frequency would be at least 52.795 MHz.

If channel 1 was to be 52.255 MHz, my only problem was to decide what crystal frequency was necessary such that when it is first tripled and then subtracted from the vco frequency, the difference would be 2.24 MHz. Using our low-side-injection scheme, 52.255 MHz minus the vco frequency should equal the 10.695 i-f frequency. With scratch paper handy, a quick calculation gives us a channel one vco frequency of 41.560 MHz. If we now subtract 2.24 MHz from 41.560 MHz, we will have the oscillator frequency in tripled form. This subtraction yields 39.320 MHz. Dividing this by 3 yields the correct oscillator frequency of 13.1066 MHz. If you use another division scheme or elect to cover a different portion of the band, all numbers must change accordingly. Any of the crystal manufacturers can supply you with the correct crystal if you specify the make/model of CB and the old/new crystal frequencies.

When the new crystal (13.1066 MHz) arrives, install it in place of the 11.8066 crystal and begin the vco alignment. Access to a frequency counter and a good oscilloscope are required for proper alignment. I won't detail the vco alignment procedure as this is covered in the *Photofact* and in many of the articles appearing in *73*. A few words of caution may prevent problems:

a) All oscillators must be on frequency.

b) On some of the boards there are two positions of the vco coil slug that will give you a 1.5-volt reading. Only one is correct. If you've selected the wrong one, the vco will not track as the channels are advanced. Other radios may exhibit this same problem.

c) Ensure that the vco does not change frequency when the transmitter is keyed.

d) Ensure that T111 is set for maximum. Much of the performance depends on it.

One last word on PLL circuits may aid those of you who will convert a different radio. If you follow the low-side-injection scheme, you will keep the vco operating near the original design frequency. This greatly simplifies the conversion!

Receiver Conversion

Once again referring to Fig. 1, it is seen that once the signal passes the first mixer, we are into the i-f frequencies. I might as well tell you now that no modifications are required beyond the input to the first mixer! In simple language, once the desired signal is into the first i-f stage, the radio couldn't tell you if the original incoming frequency were 27 MHz or the new 52-MHz signal.

Fig. 3 shows the Hy-Gain input circuitry from the antenna through the first and only rf amplifier stage (minus a few parts). If you are converting a different CB, it will probably surprise you to find your input circuitry very similar to the one shown. Disregard for now all the components from the antenna connector through L109. We will work with these later. Our concern will be with C154 and the coil which is the primary of transformer T104. A grid-dip meter will verify that this combination is resonant in the 11-meter band. There is enough tuning range in the primary coil to tune 10 meters, but not enough to tune 6 meters. Changing C154 from 27 pF to 10 pF will let this combination resonate in the 52-MHz region.

Fig. 3 also indicates a tuned-collector output which is coupled into the base of Q115, the first receive mixer. Since the capacitor is inside the can, T105 must be removed and the capacitor leads clipped. There is no need to remove the capacitor from its seat inside the can. Just be sure that the leads are trimmed so they do not touch anything. Be careful unsoldering the can or you may damage the foil trace. This is good practice as this same bit of surgery will be required a time or two in the transmitter section. Install an 18-pF capacitor across the primary terminals on the foil side of the board.

A basic tune-up can now be accomplished using the receiver alignment instructions supplied in the *Photofact*. Don't expect the receiver to be extremely sensitive, as we have not yet corrected the majority of the input circuit. You will get enough signal through to satisfy yourself that the receiver is now on 6 meters. Don't forget to use a mid-band frequency for the alignment.

The receiver conversion for a different radio will closely parallel this discussion. A few tips may save you some time and effort:

a) Performance-test the CB prior to conversion. Record signal levels. Be sure these levels exist after the conversion.

b) You will have to grid-dip the transformers to find the correct value of capacitance for resonance.

c) Examine the general specifications for the transistors in the front end of the receiver (Q114 and Q115 were questioned in this case). Hy-Gain used two transistors which have a large bandwidth (F_t) and high current gain (h_{fe}). If you will look these up in a transistor manual, you will see what I mean. Examining several CB schematics did not

Fig. 4. Hy-Gain transmitter block diagram.

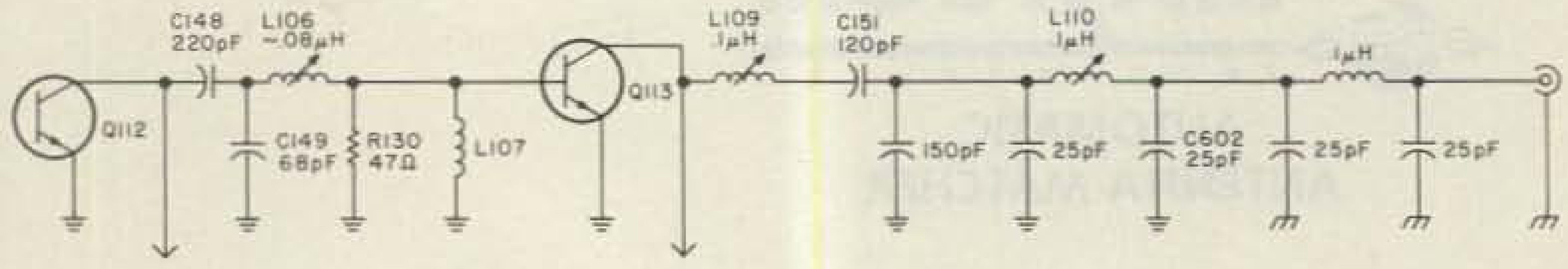

Fig. 5. New driver/final circuitry (simplified).

reveal a problem here, but it's worth checking.

d) Any time you modify the capacitor values in a tuned circuit to change the resonant frequency, the value of capacitance found is only approximate. You may need to change the value slightly in the actual circuit. This is due to the dynamic loading effect when a circuit is in operation.

Transmitter Conversion

Fig. 4 shows a block diagram of the Hy-Gain transmitter section. Also shown are the vco frequencies for both an original CB frequency and a new 6-meter frequency. Since the vco is already on frequency, all that remains is to modify the circuitry following the mixer. In the case of the CB frequency generated (26.965 MHz), the filter (L103, L104, and T102) selects the *difference* frequency (37.660 − 10.695 = 26.965 MHz). After conversion, L103, L104, and T102 will select the *sum* frequency (41.560 + 10.695 = 52.255 MHz).

Remove L103, L104, and T102 one at a time. Remember which one goes where so there is no confusion when they are reinstalled. The following steps will allow these cans to select the sum frequency:

a) Remove C124 (100 pF). Remove the small capacitor internal to L103. Reinstall L103 and solder a 33-pF capacitor across the same pins the original capacitor was across, on the bottom (foil side) of the board. Be sure to keep the capacitor leads very short. On this can you may simply place the 33-pF capacitor in the C124 location.

b) Perform step 1 to L104. Install a 15-pF capacitor across the proper terminals on the foil side of the board.

c) Perform step 1 to T102. Install a 15-pF capacitor as in steps 1 and 2.

d) Remove C141 (68 pF). Replace C141 with a 39-pF capacitor. This is required to enhance the impedance match into the base of Q111. Grid-dipping the secondary of T102 shows the secondary resonant in the 55-MHz region (with the 68-pF cap).

Next remove T103. If you glance at the schematic, you might wonder why. It would appear that since resonating capacitor C143 (100 pF) is external to the can, one might just remove it and install a 25-pF cap in its place. This will resonate the can in the 52-MHz region; however, the transformer turns ratio is now wrong. Examining the primary and secondary windings of T103 revealed a 6-turn primary and a 1-turn secondary. I could have rewound T103, but I had no wire that small. I used a ¼-inch coil form using an 8-turn primary and a 2-turn secondary. Grid-dip the primary to find the amount of capacitance needed to resonate at 52.5 MHz in the middle of the coils tuning range.

C146 (470 pF) is removed next. This enhances the impedance match at the base of Q112. Now we are ready to modify the driver and final circuitry.

Perform the following steps:

a) Remove R203 (560-Ohm resistor).

b) Remove C149 (220 pF).

c) Remove L106.

d) Remove C153 (82 pF).

e) Install a 68 pF capacitor in place of C149 that you have just removed.

f) Examine L106. We must lower its inductance by removing 2 turns. It looks factory formed, and it is. Locate the low side of the coil. Using a sharp carpet knife or similar instrument, you can cut the wire leg loose. The wire can then be unwound. Remove 2 turns and form a new leg for the coil. As a guide, the reactance of the coil should be 25 Ohms at 52.5 MHz.

g) Remove C151 (100 pF) and install a 220-pF cap in its place.

h) Remove L109. Remove enough turns to give 33 Ohms of reactance at 52.5 MHz. Its inductance should be .1 uH.

i) Remove R132 (47k Ohms) and C152. Replace C152 with a 150-pF cap. Replace R132 with a 22-pF cap.

j) Remove L110. Remove 2 turns. It should now have .1 uH inductance. Reinstall L110.

k) Remove C602 on the foil side of the board (if installed). It's attached between board ground and the antenna side of L110. Replace it with a 25-pF cap.

l) Additional filtering is needed to doubly ensure a clean output. A pi-filter will now be installed going from point 5A on the circuit board to the antenna terminal. Install an airwound coil similar in size to L116 between the board's output (5A) and the center of the antenna connector. I used an extra L116 off a broken Hy-Gain board and removed all but 3 turns. If you fabricate your own coil, the inductance should still be .1 uH. Install two 25-pF caps. One should be installed from the center of the antenna connector to chassis ground. The second cap should be installed from either point 5A or 5B to chassis ground.

m) We are now almost finished. Remove Q112 and replace it with Q113. Obtain a 2SC1307 transistor to use in the final. The original Q112 (2SC1760) does not have enough gain in the 50-MHz range. If you are converting a different CB, be sure to check the performance of the transistors. After completing the above steps, your circuit should look like Fig. 5. Notice I did not show R129, L105, L116, L108, etc. These remain unchanged!

You can now perform the alignment of the transmitter using the steps listed in the *Photofact*. As other authors have said, the alignment of L103, L104, and T102 is *critical!*

By using single-pole, single-throw switches to program pins 1 through 15 of the PLL02A, you can expect at least 1-MHz band coverage. My conversion gave me about 1.1 MHz, but the recommended voltages were not followed at the edges of the band. The vco, however, remained very stable over a voltage range of .9 to 4.5 volts. Average transmitter output averaged 3 Watts across the band, and its output is very clean.

The standard FM techniques can now be applied exactly like the conversions to 10 meters.

Several improvements can be added to enhance the capability of your conversion:

a) The standard bells and whistles that have been used with the 10-meter conversions (Delta-tune, scan, frequency programming, wide audio filter, etc.).

b) Repeater offset may deserve some special mention. I have discovered that by switching transmit offset crystals, I could achieve up to 400-kHz offset without problems. If you elect to install the offset, please note that a 400-kHz split is not possible across the entire band. If you exceed the frequency limits on transmit or receive, the vco will lose lock.

I think you will find that many other used CBs operate using this same scheme. Many are practically identical! I hope this article heats up some soldering irons and sharpens a few pencils. I am sure the circuitry presented here can be improved.

For those of you interested in converting an SSB CB, I recommend staying away from those radios whose vco operates in the 19-MHz range. They can be modified, but the conversion is much more difficult. Select one that operates in the 38-MHz range and utilizes a fairly high first i-f. If you do this, you can be reasonably sure it will convert. As a bonus, the SSB generating circuitry prior to the transmit mixer will require no modification.

Completing this project confirmed my belief that 50 MHz is possible from a CB. I will be happy to answer any questions concerning this conversion if you will send an SASE. I'll send my recommendations on any other CB conversion to 6 meters if you will send me a copy of the schematic. Let's use our six-meter band! ■