CRYSTAL SETS TO SIDEBAND



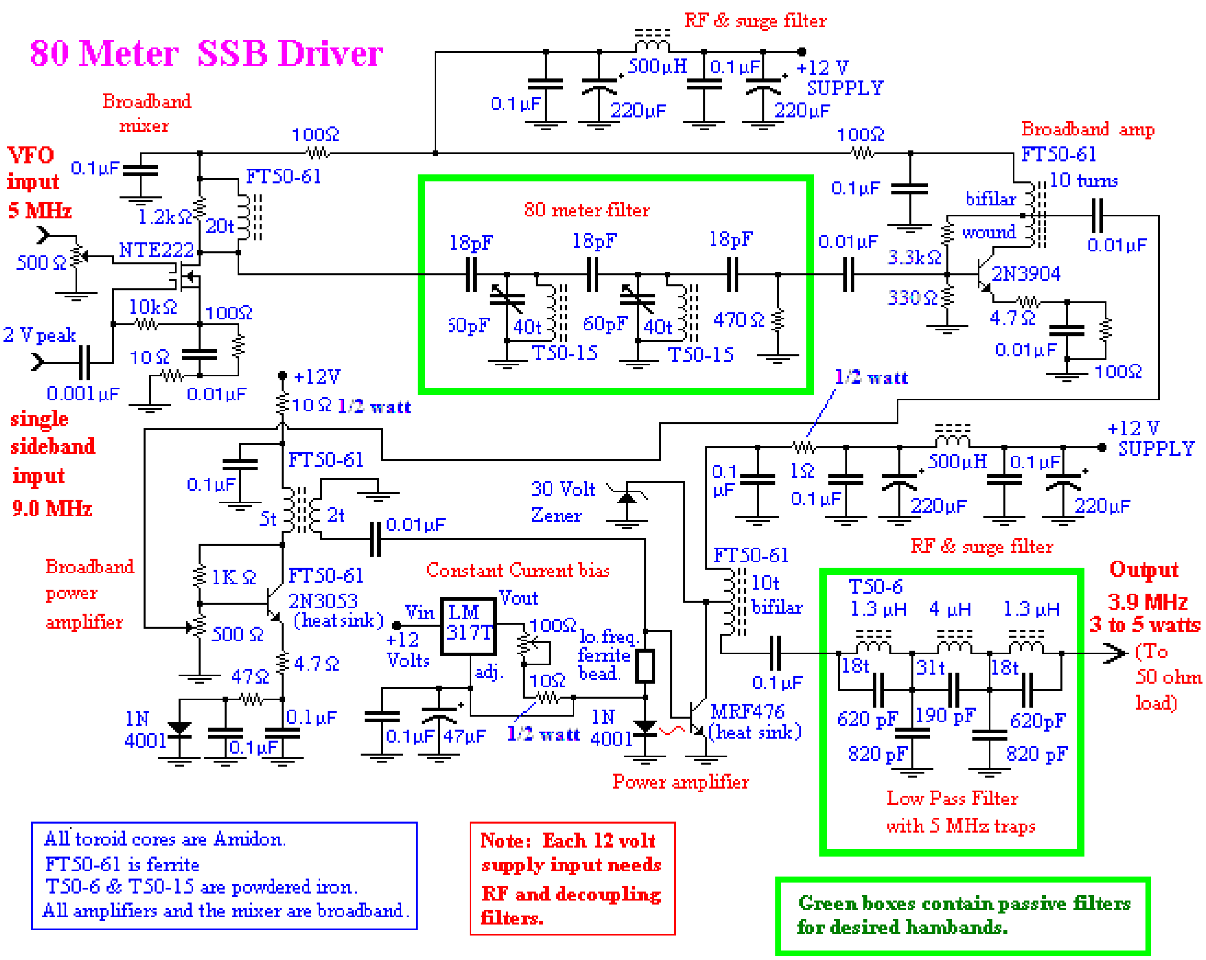
# Chapter 15B

# THE NOBEL PRIZE FOR SIDEBAND

## Moving the SSB signal to the HF bands

### An 80 meter sideband QRP driver

As explained above, an untuned mixer should be followed by a ***totally passive filter***. That is, the filter should be just a network of LC circuits. It should have no transistors. Instead, the gain is provided by two or ***three untuned stages in series with the passive filters***. Three high-gain broadband amplifiers in series can work without oscillating, provided that their input has very little noise. ***The basic design shown below has the advantage that, it can be used on any HF band.*** To change bands, you plug in different filter sections shown in the green boxes below.



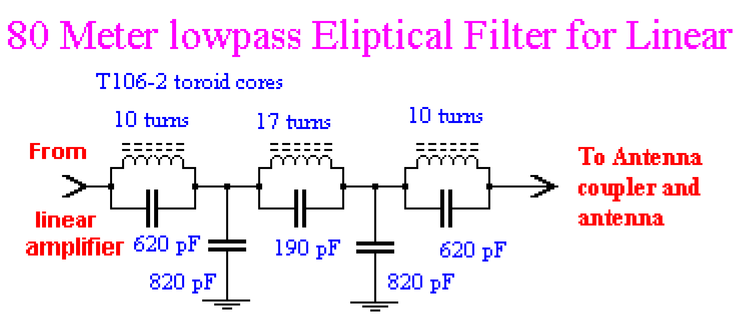

All transistor stages are broadband, including the mixer. Note the 1.2K resistor across the primary of the mixer ferrite core transformer. Without this or other feedback device, the broadband amplifiers tend to generate an uncontrolled signal whenever the SSB input drops to zero between spoken words. The un-bypassed 4.7 and 10 ohm emitter resistors in three of the amplifiers also help prevent oscillations. To reduce surging and RF feedback to the driver module I filtered my +12 volt input leads with RF chokes, big capacitors and small ceramic capacitors.

Unlike the CW QRP modules, the SSB module output stage needs forward bias to operate in linear mode. The LM317 circuit current source supplies the needed current. This temperature compensated circuit was used in the 50 watt linear in Chapter 12 and is overkill for this 5 watt final, but what the heck! With experimentation I found that just 20 milliamperes of forward bias is plenty to operate linear and give good speech quality. In theory, a 560 ohm one watt resistor can provide this bias much more cheaply. However, I haven't tried this.

A passive high impedance (500 ohm) 80 meter filter is placed between the mixer and the first broadband amplifier. The output stage filter is the usual 50 ohm Chebyshev low pass except that capacitors have been placed in parallel with the inductors. These make the inductors resonate at 5 MHz and provide extra attenuation to get rid of the 5 MHz VFO signal. Notice that the equivalent of five parallel and series LC circuits were used to clean up the 80 meter signal. In contrast, as you'll see on the next page, a 20 meter QRP (5 MHz + 9 MHz) can be done with just two LC circuits and an output high pass filter.

**Beware of residual VFO signal**

Once I had the 80 meter driver (shown above) working well, I fed it into my linear amplifier described in Chapter 12. With the amplifier it produced 60 to 100 watts on voice peaks. However, whenever I stopped talking, the frequency counter probe on my antenna shifted to the 5 MHz VFO frequency, even though the amplitude of the signal on the scope screen looked negligible. When I turned up the scope amplitude, sure enough, there was a 5 volts peak sinewave on the output. That represented about 0.25 watts of 5 MHz sinewave. To get rid of it, I rebuilt the final (high power) amplifier 80 meter low pass output filter using another “elliptical” filter design. Once again each inductor has a parallel capacitance that resonates at 5 MHz and keeps the 5 MHz out of the antenna. I used the values shown below. After that change the residual, no-speech signal was only 1 volt peak and the counter measured it as the correct output frequency, 3.9 MHz.




Yes, adding the capacitors achieved the object of getting rid of the 5 MHz signal. Unfortunately, it also degraded the low-pass performance of the filter. Higher harmonic frequencies are now able to motor on right through those three series capacitors. In short, be sure to use a high frequency TVI filter like the one in Chapter 9. Alternatively, you could add another low pass stage to the final amplifier filter to suppress the harmonics.

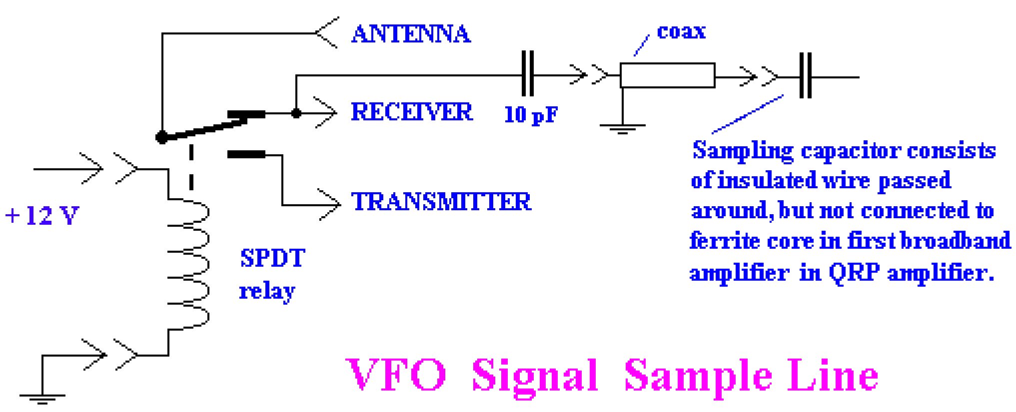
**Achieving 5 watts output power**

The basic QRP driver shown above has two broadband stages that are biased ON with 1K or 3.3K resistors and turned off with a 500 ohm pot or 330 ohm resistor pulling the base down to ground. As shown this circuit works and may provide enough drive for 5 watts. On the other hand, some of my broadband amplifiers worked noticeably better when I increased the turn ON resistance from 1K to 3.3K and eliminated the turn-OFF base resistor altogether. Some amplifiers worked better with a 330 ohm turn-OFF base resistor. Experiment!

If you are like me, you will have a devil of a time getting your SSB drivers to produce intelligible speech without hissing and noise problems. All I can tell you is to keep your brain mulling over your difficulties. Shield and filter your prototype until the darn thing works. Keep careful notes so you don't make the same mistakes twice. Persistence will win in the end.

**Hearing the transmitter VFO in your receiver**

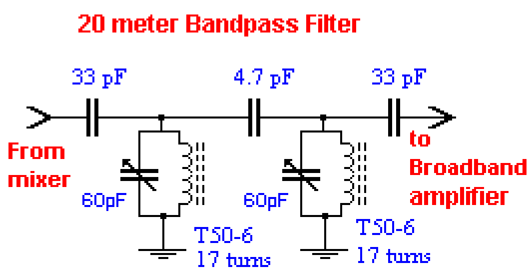
One consequence of shielding and filtering every low power module of my SSB transmitter was that I could not hear my own VFO signal. This made it impossible to tune the VFO to a station I might wish to talk to. Eventually I solved the problem by connecting a tiny capacitor, 10 pF, to the receiver antenna terminal on the antenna relay. This capacitor is connected to a shielded cable that runs over to my QRP module and plugs into a shielded phono connector on the side. Inside the QRP module an open-ended wire runs over to the first of the three broadband amplifiers (not the mixer) and passes one turn through the ferrite toroid core. This sampler wire is not a complete winding turn. It is *NOT* soldered to ground or anywhere else. The wire just serves as a tiny capacitor or antenna to sample a bit of VFO signal for the receiver. During transmit the antenna relay disconnects the sampler wire from the transmitter to prevent it from causing feedback from the antenna into the transmitter.

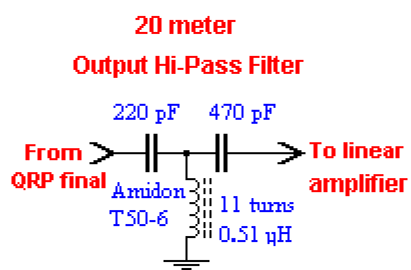



When I push the "Spot" button on my transmitter, +12 volts power is connected to all the low power modules of the transmitter. During "Spot" mode, the 12 volt power is *NOT* connected to the last two power amplifier stages of the QRP. The 12 volts goes to the 5 MHz VFO, the SSB generator, the VFO frequency converter (if one is used on that particular band), the mixer and first broadband amplifier of the SSB QRP module. The first broadband amplifier after the mixer is the first place in the transmitter where the actual broadcast frequency is available for sampling. Because the final frequency depends on the 9 MHz signal from the SSB generator, there will be essentially no signal from the SSB generator unless you are actually talking or the generator is set to "CW." In summary, to hear the VFO without transmitting, the SSB generator must be set to "CW," the "Spot" button must be pushed, and the receiver antenna needs a tiny capacitive coupling to the first broadband amplifier. In SSB, even simple things are complicated. See the fun most hams are missing?

**Adding 20 meter capability to the 80 meter QRP module**

In the 80 meter module above there are two filter networks. You can put this same QRP module on 20 meters by switching in a 14 MHz filter after the mixer and by replacing the low pass on the output with a high pass filter. On 80 meters the unwanted 9 MHz and 5 MHz signals are above 4 MHz. Therefore, the 80 meter QRP module has a low pass filter. In contrast, on 20 meters the unwanted frequency components are below 14 MHz. Therefore, a high pass is desirable for 14 MHz. The filters to put the module on 20 meters are shown below. My module uses two DPDT switches to switch back and forth between the 80 and 20 meter bands.




**Feedback and distortion – don't overdrive!**

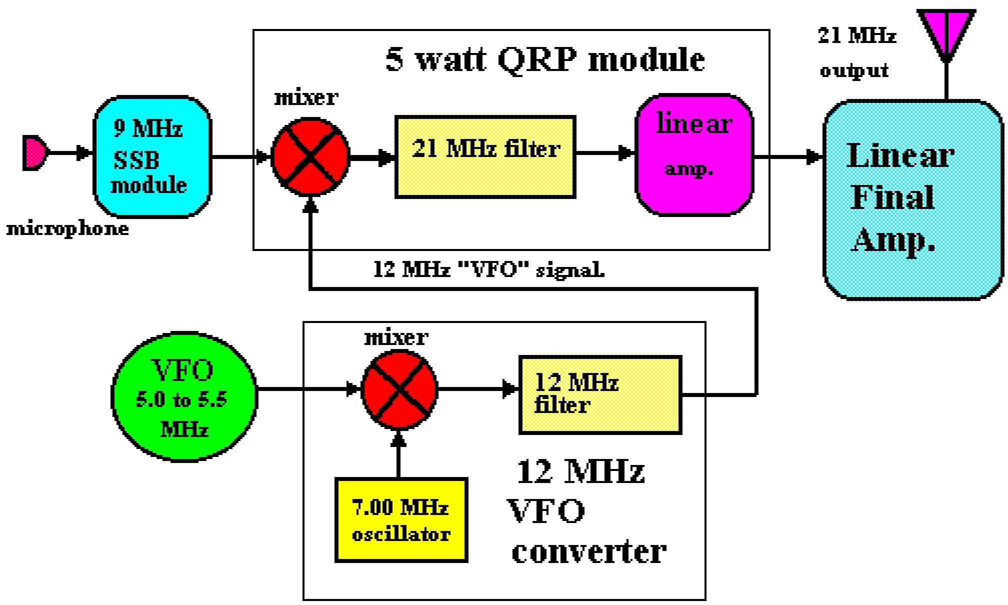
A frequent problem I ran into was using too much drive on a stage. For example, I built my first prototype for 20 and 80 meters. And after many changes and fussing I got it to work. Then I reproduced the circuit for use on 17 and 12 meters. However, the second time I knew what I was doing and the new circuit was much "cleaner." The result of my compact, pretty wiring was higher efficiency and more power out of each amplifier stage. Instead of 3 watts output, now I had 6 or 8 watts or more and I was overdriving the linear final. Excess drive gave my signal a rough, rasping sound and made the speech hard to understand. To fix this, I had to go back and decrease the output by various methods. I decreased transformer turns driving bases, used more negative feedback (emitter resistance), etc. Finally I put the 500 ohm pot in front of the 2nd broadband amplifier. This enabled me to deliver just what I needed and no more. Now the voice quality was acceptable. The pot worked so well, I went back and installed one in my 80/ 20 meter driver module.

**Moving an SSB signal to the "difficult" hambands**

As explained above, the easiest hambands to reach with your 9 MHz SSB generator are 80 and 20 meters. Unfortunately, on weekends 20 meters is the most crowded ham band. It's full of guys running 1,500 watts peak into Yagi beam antennas over 50 feet in the air. If that weren't bad enough, their sideband transmitters are exquisitely designed to get the most modulation out of every watt. If you do get on 20 meters with your little homebuilt, it may only average 20 to 40 watts on voice peaks. Combine that with your dipole antenna and it's going to be hard for those big guys to hear you. On the other hand, a band like 15 meters (or possibly 17 meters) is less crowded and you are more likely to make solid, enjoyable contacts there.

# Getting on 15 meters

How do we move the 9 MHz to 21 MHz with a 5 MHz VFO? My solution was to move the 5 MHz VFO to 12 MHz. Then I added my 12 MHz VFO to 9 MHz to get 21 MHz. (12 MHz + 9 MHz = 21 MHz) After mixing, the 21 MHz signal was 43% different from the nearest frequency component and filtering was relatively easy. Unfortunately, moving the VFO to 12 MHz is quite cumbersome. However, you can use technology you have already mastered. So, in the long run, I believe moving the VFO is the easiest way to go.



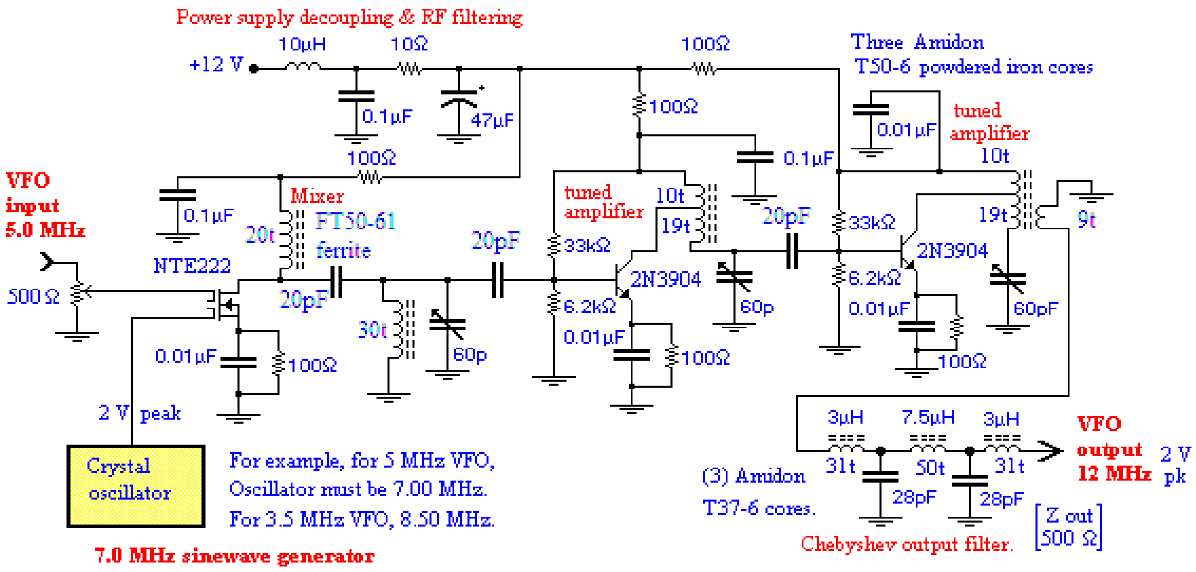

### Generating a 12 MHz VFO signal

The VFO signal is just a sinewave. Therefore, compared to moving sideband, moving a 5 MHz sinewave to 12 MHz is relatively easy. There are no amplitude modulation components present, so the 12 MHz signal is easily filtered and purified. To move the 5 MHz VFO to 12 MHz, mix it with a 7.00 MHz signal from a crystal oscillator. Think of the VFO mover as a primitive frequency synthesizer.

### A 5 MHz to 12 MHz VFO converter

The frequency converter below contains the same circuits I used in my CW QRP boards in which I used an 80 meter VFO to drive a CW signal on each HF band. I used the dual gate mixer because it was simpler than the bipolar transistor mixers I used in my first QRP boards. If you start with an 80 meter VFO, it can be combined with a 8.5 MHz sinewave to give 12 MHz. You get the idea.

## 12 MHz VFO Converter for 15 Meters




**The VFO converter moves the 5 MHz VFO up to 12 MHz**

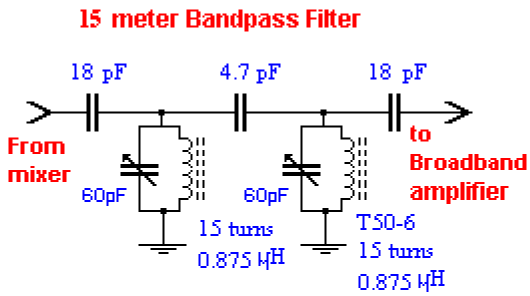
When I first built this module, I used the tuned mixer design explained in Chapter 11. It worked OK for a few years. But then the 15 meter band went dead for several years during the sunspot minimum. When 15 meters became active again, I fired up the converter. But inexplicably the tuned mixer insisted on oscillating on 12 MHz, independent of the VFO and 7 MHz crystal. I soldered resistors across the inductor on the drain but it still oscillated. I changed the mixer to the untuned mixer shown above and added a passive, tuned LC circuit after it. That killed the oscillation and, once again, I relearned not to trust tuned mixers in transmitters. The 17 meter VFO converter shown next is simpler than the one above.

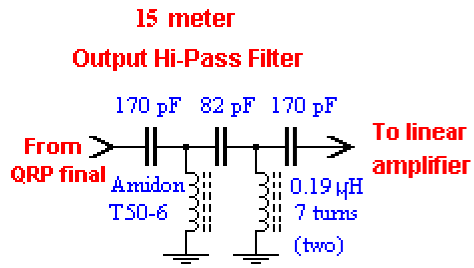

The 12 MHz VFO converter is on the left side of the circuit board. I later added the 26 MHz VFO converter for 17 meters on the right side. The blue DPDT switch to the left of center switches between the two converters. One operational difficulty I had with the 15 meter VFO on the SSB portion of the 15 meter band is that 21 MHz, is the fourth harmonic of the 5.250

MHz basic variable VFO signal. Therefore I can hear two VFO signals in my receiver. Obviously, the correct signal is the upper one, but it is still disconcerting. I may resort to a frequency synthesizer chip yet!

**A linear sideband QRP module for 15 meters**

Once you have generated a stable 12 MHz VFO, it needs to be mixed with the 9 MHz sideband signal to get on 21 MHz. Using the same design as the 80 meter QRP shown earlier, now all you need are the two passive filters to go into the QRP module. The bandpass filter is the same design as before, but I used a 5-element high pass filter on the output to get rid of the signals below 15 meters that tend to appear when I'm not talking. The two filters are shown below.

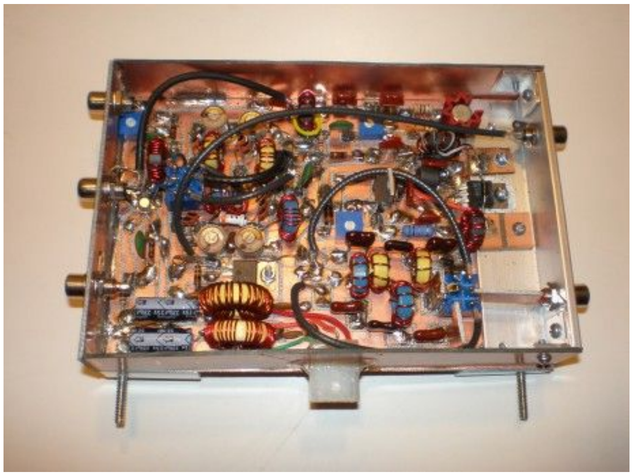



Notice that the output of the QRP driver described above has a *HIGH PASS* filter designed for 50 ohms that works best for driving a final amplifier. If you wish to run the driver "barefoot" and go on the air with just 5 watts peak, you may also need a low pass filter, just like the ones you built for the CW QRP drivers. This will keep harmonics out of your neighbors' TV sets, but if you're already using a TVI filter (as in Chapter 9), you probably don't need another. The most troublesome unwanted frequencies are the second harmonic of the 12 MHz VFO (24 MHz) and the second harmonic of the SSB generator, 18 MHz.

The high impedance bandpass filters, such as the one on the left, nearly always have a small capacitor in the center. This acts a high pass filter to eliminate low frequency noise. If the sinewave coming from this filter has rogue large and small sinewave peaks that recur at a lower rate than the desired frequency, these are examples of low frequency contamination. They might be leftovers from the 9 MHz input. If these artifacts can't be tuned out, try reducing the center capacitor to as little as 1 picofarad. Yes, really! 1.0 pF. Along with a clean sinewave, you may even find that your output power goes up.

As explained earlier, a simple pair of 2 cm long pieces of solid hookup wire twisted together can make a tiny variable capacitor. One loose turn of wire is about 1 pF, one and a half turns is 2 pF. As suggested above, un-twisting the wires sometimes produces an immediate improvement in the filter output quality. More turns of twisting increases output but also the low frequency contamination.



A 21 MHz and 28 MHz SSB Driver module. The center phono connector on the left is for the "VFO sample" signal that allows the receiver to hear the VFO signal. A short piece of RF-174 coax goes over to the final broadband toroid of the VFO portion of the circuit. A short piece of yellow wire passes through the toroid as an antenna to pick up the VFO signal. The yellow wire is not soldered to anything - it's just serves as an antenna or capacitor. The aluminum lid that covers and shields the box is not shown. Apparently my aluminum lid is an effective shield or I would not have needed the yellow VFO sample wire.

My original 21 MHz SSB driver just covered one band. It had a “pigtail” power supply cable like the ones used in the CW QRP modules. This was an invitation to RF interference because the cable acts like an antenna. I later rebuilt the module and imbedded the Molex connector at the bottom so that it is shielded from stray RF. Now the module plugs directly into the metal transmitter chassis with no exposed cable. RF feedback has not been an issue.

The wiring in my original module was a sloppy mess by the time I got it to work. So I later started over and built another one that works on both 15 and 10 meters. The circuit is essentially the same as the QRP module shown for 80 meters earlier. The filters shown in the green boxes on the schematic must be selected for each band. Two double pole DPDT switches select the correct pair of LC filters.

**5 MHz VFO converter for 40, 60, 12 and 10 meters**


**All bands with one QRP driver?**

So why didn't I install a big turret switch and make the module select all the phone bands? Each of the 4 two-band modules I have built so far is different. It would be extremely optimistic to try to build a single circuit that works on all bands. I kept modifying each circuit until it worked. None of them worked without tweaking and compromising between the two bands. Some modules have more turns on the broadband amplifier secondary coil, different drive levels to each stage and different transistor types. For example, the 2N5109 output driver was needed on the 10 meter band, but has too much gain on the low bands where the 2N3053 worked better. Obviously the commercial manufacturers mastered the multiband challenge decades ago. Unfortunately, I'm not there yet.

**17 meters can be really tough**

My first problem with 17 meters was that the sweep oscillator in my oscilloscope makes an 18 MHz signal that my receiver picks up right in the middle of the 17 meter band. Another peculiar problem with 17 meters was that it interferes with my cordless phone and my stereo. The other bands don't cause this interference so it's a mystery to me. More importantly, I'm nervous about what might be happening over at the neighbors.

Anyway, even without those troubles, 17 meters is particularly difficult when starting with a 9 MHz SSB generator. 18 MHz is the second harmonic of the 9 MHz SSB signal. Therefore the 17 meter frequency converter will also amplify the second harmonic of the sideband signal. This means that, although there may be a good signal on 17 meters where it is supposed to be, (for example, 18.130 MHz), there will also be a small sideband-like signal on 18.000 MHz. Of course the frequency deviation of the unwanted signal will have twice the audio frequency modulation. In the old days it was routine to move low frequency VFOs to high frequencies using frequency multiplier-amplifiers. It is difficult to avoid building a multiplier- amplifier here and it will be hard to get rid of unwanted 18 MHz signals with simple filters.

In addition, if you generate a 9.130 MHz VFO signal to add to the 9.000 MHz SSB to get 18.130 MHz, you will also be transmitting the second harmonic of the 9 MHz VFO sinewave signal. That is, if the desired frequency is 18.130, there will also be another small second harmonic sinewave transmitted on 18.260.

**Practical approaches to getting on 17 meters**

In spite of these harmonic troubles I first pressed on with 9 MHz. To avoid the 2$^{nd}$ harmonic of a 9 MHz VFO, I added my 5 MHz VFO to a 22 MHz oscillator producing a 27 MHz VFO signal. Then I subtracted the 9 MHz from 27 MHz to get 18 MHz. ***Notice that when you subtract an SSB signal from a higher frequency, the upper sideband becomes the lower sideband and vice versa.*** The VFO worked fine and I even talked to a few folks. But occasionally I discovered that I was loading up on 18.000 MHz, the second harmonic of the SSB generator signal, not the correct frequency component. In short, the behavior with a 9 MHz SSB generator was too flaky to trust.

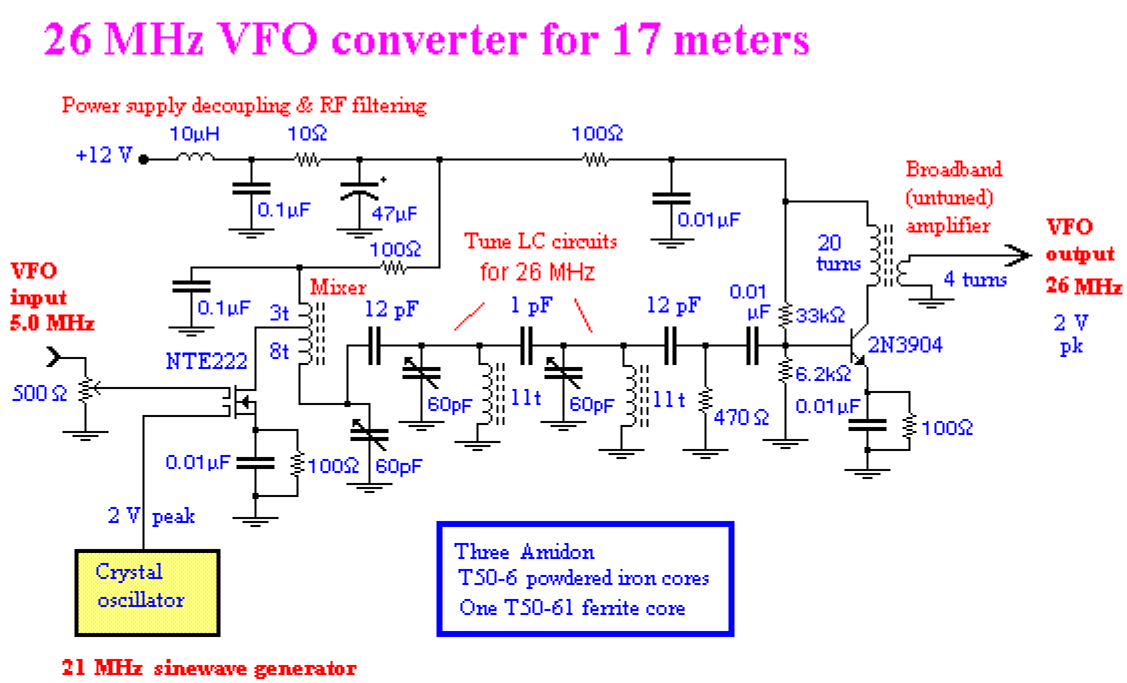
***The best way to get on 17 meters is to start over with a different SSB generator frequency, say 8.0 MHz.*** Then you can combine that with a 26 MHz VFO and it will work OK. In other words, 26.13 MHz - 8 MHz = 18.13 MHz. With this approach you aren't using any 9 MHz frequency components and second-harmonic, out-of-band emissions will be far less likely. I strongly recommend this approach. I really don't think a 9 MHz SSB generator can be reliable on

17 meters without first moving the 9 MHz SSB signal up above 18 MHz. That is, you would have to move the sideband signal twice. My solution was to start over and build a new SSB generator with two filters switch-able between 8 MHz and 9 MHz. My 8 MHz crystal filter was just like the 9 MHz filter, but the 91 pF capacitors were proportionately increased to 100 pF.

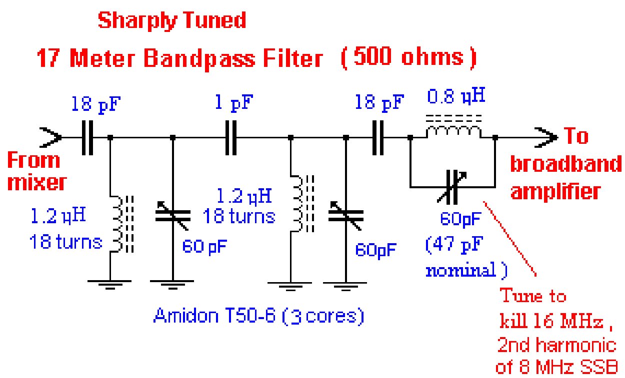
There are lots of ways to screw up on 17 meters. For example, ***start with a 6 MHz SSB signal and the 3rd harmonic of the signal will be on 18.000 MHz and will be just as bad as 9 MHz.*** You can also screw up with 8 MHz. For example, the 8 MHz SSB can be added to a 10.15 MHz VFO to get 18.15 MHz. Unfortunately, the 2nd harmonic of 10.15 MHz is 20.30 MHz. This continuous sinewave is close enough to 18 MHz to go right out over the air whenever you stop talking.

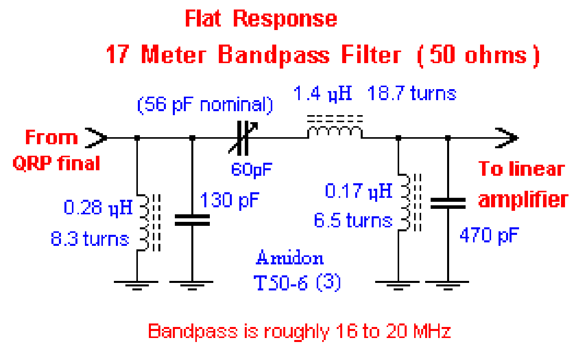
**17 Meters with an 8 MHz SSB generator:**

As shown below, I eliminated most of the VFO harmonic problem by generating a 26 MHz VFO. The second harmonic of an 8 MHz SSB generator is 16 MHz. Fortunately it wasn't hard to avoid accidentally tuning it to 16 MHz. Notice again that the SSB is subtracted from a higher frequency so ***the SSB generator must be set to the lower sideband to get upper sideband on 17 meters.***




The output of the 5 watt driver needs both a low-pass to get rid of the 26 MHz artifact and a high pass filter to avoid the low frequency “bursting” problem. Rather than choosing between high pass or low pass, I used a second 18 MHz bandpass filter that severely attenuates both 8 MHz *and* 26 MHz. This flat response bandpass filter is designed for 50 ohms which is needed to deliver relatively high power. In contrast, the sharply tuned bandpass filter following the mixer is designed for high impedance, 500 ohms input and output. The 500 ohm bandpass filter is much easier to design, but it can't handle any significant power and the impedance is incorrect for the QRP output. So far, I have gotten away with the tuned mixer in this converter.



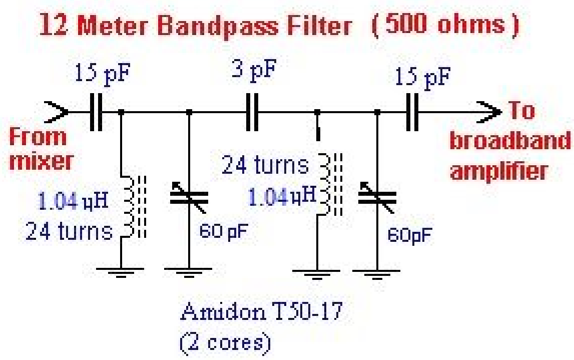



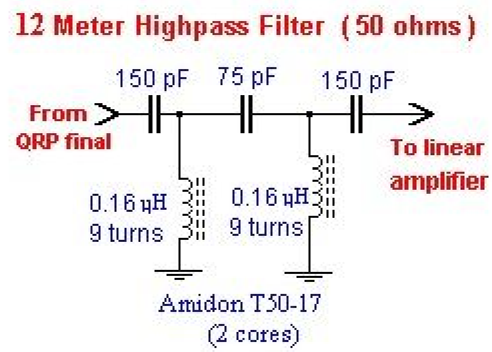

The filter on the right has a flat response from about 16 MHz to 20 MHz. In order to get the flat response, the three LC resonant circuits all have different values. And, of course, the three L-Cs interact, so a simple calculation wouldn't work anyway. I derived this circuit by trial and error using my Spice program. The component values must be rather precise otherwise the response has sharp peaks. Notice the fractional turns on the cores. These should help you be aware that wrapping the wire a tad more or less might make a difference. I found that making the smallest capacitor(s) variable was useful for final tune up. A few picofarads can make a big difference. Anyway, it was a struggle but eventually it worked. Tuning the series variable cap peaks it up nicely on 18 MHz.

One surprise I had tuning these drivers is that the broadband amplifiers pass along the signal quite accurately, flaws and all. ALL tuned circuits in the entire system can effect which of the many frequency components go out the antenna. Even your antenna tuner can be tweaked to emphasize the wrong frequency. For example, I had my 17 meter driver tuned up nicely into a 50 ohm dummy load with what appeared to be perfect 18.15 MHz sinewave. Then when I connected it to the final amplifier, low pass TVI filter and antenna tuner, I discovered I could mistune the antenna tuner so that it resurrected the 16 MHz SSB generator harmonic. These unwanted frequencies are like horror movie monsters that keep returning from the swamp! If this is a problem for you, tweak the QRP driver filters with a 50 ohm dummy load before you broadcast.

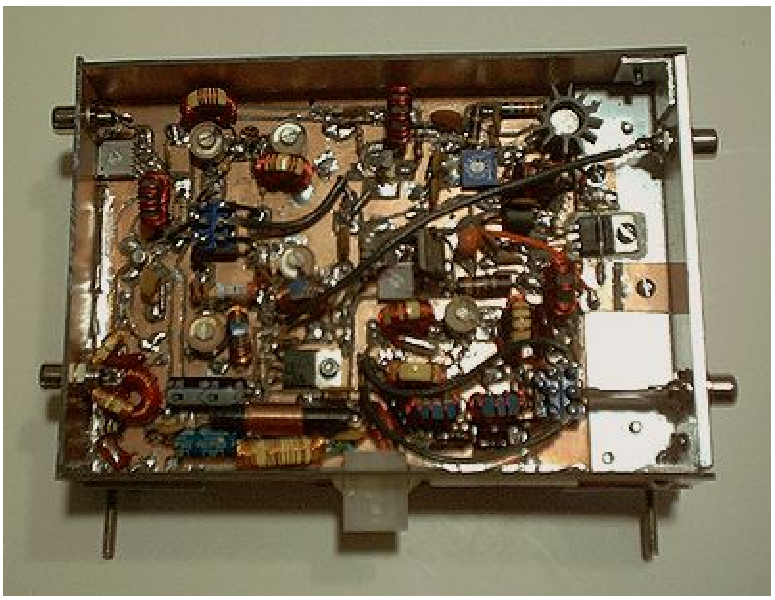
**Filters for 12 meters**

In contrast to 17 meters, 12 meters was much easier. I generated a 15.9 MHz VFO signal by adding my 5 MHz VFO to a 10.700 MHz crystal oscillator. The QRP combines the 9 MHz SSB signal with the 15.9 MHz VFO to produce 24.9 MHz. The high impedance bandpass filter following the mixer is tuned for 24.9 MHz. At the output of the QRP module all the unwanted frequencies are well below 12 meters. Therefore the low impedance output filter is a simple high pass.



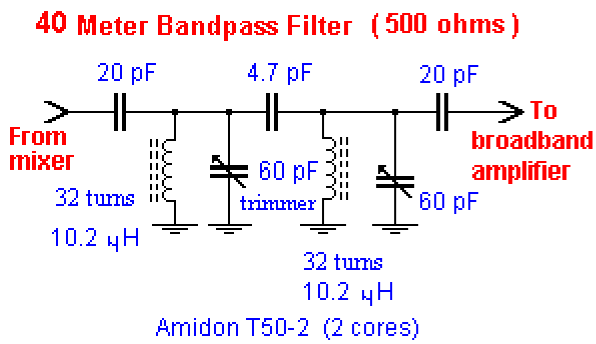

**The SSB QRP driver for 12 and 17 meters is shown below.**

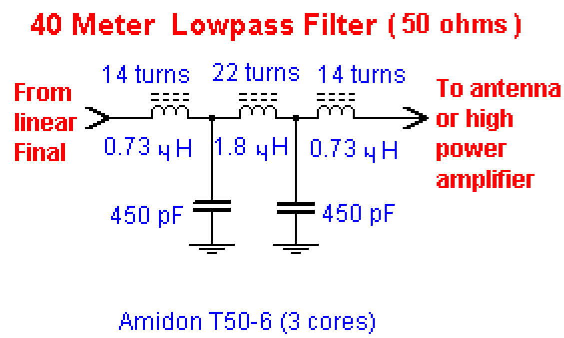


The two large RF choke inductors at the lower left filter the separate 12 volt DC lines for the frequency generator circuits and the final amplifier stages. The large P-channel MOSFET transistor just above the Molex connector and RF chokes turns on the power to the final amplifier keying when the microphone is keyed.

**Getting on 40 meters SSB**

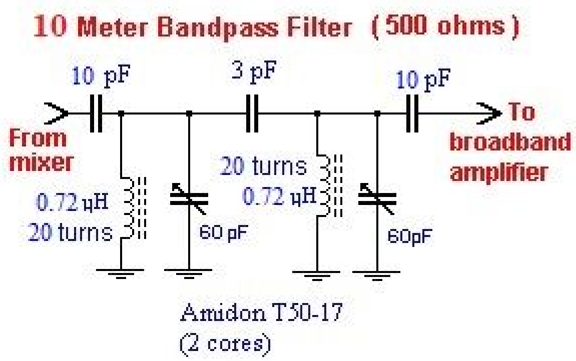
Forty meters was also straight-forward. I generated a 16 MHz to 16.5 MHz VFO signal by adding the 5 MHz VFO to an 11.000 MHz crystal oscillator. Then I subtracted the 9 MHz SSB to get 7.00 to 7.50 MHz. Because of the subtraction, the upper sideband 9 MHz SSB signal generated the lower sideband signal on 40 meters. The 40 meter QRP mixer filter uses almost the same tunable bandpass filter used in the DC receiver in Chapter 7. Since all the frequency components are well above 7 MHz, a low impedance lowpass filters the output. As usual, 40 meters was kind to me and it worked right away. I was immediately able to check into my local state-wide 40 meter noon net.

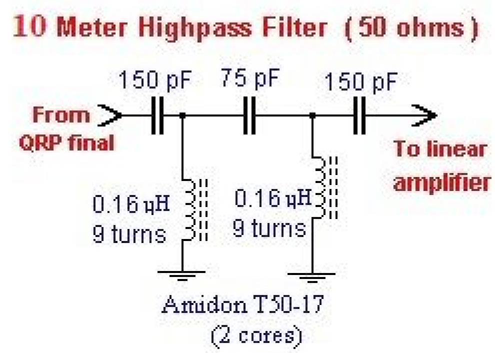



## SSB on 10 meters

Here are the filters needed for 10 meters.




To build a VFO for 10 meter SSB, I was able to add a 14 MHz crystal oscillator signal to the 5 MHz VFO to produce 19 MHz. Then the 9 MHz SSB signal was added to 19 MHz to reach 28 MHz. I used 4 separate crystals to span the entire band. This worked well for me.

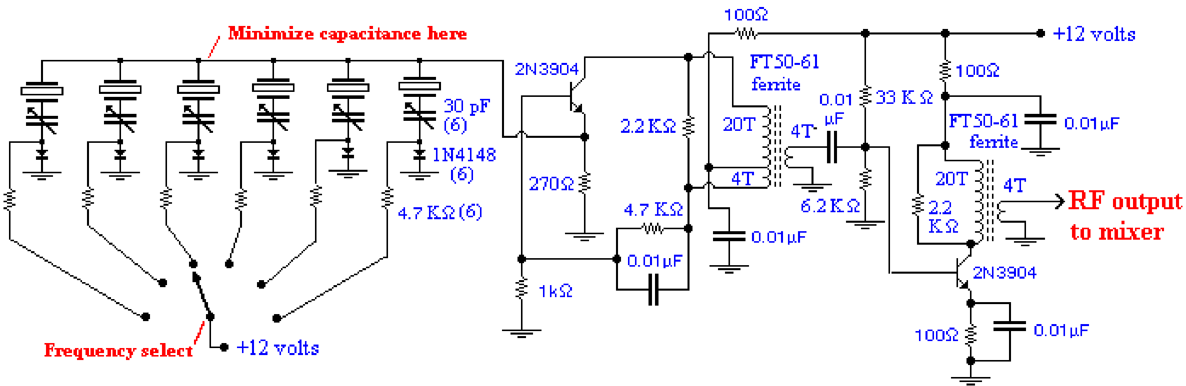
## 10 meters is much wider than the lower bands

Another tricky challenge with 10 meters is that it's 1.7 MHz wide, 28.0 MHz to 29.7 MHz. My VFO in my original SSB transmitter only tunes a range of 0.5 MHz. Therefore it needed 4 crystal PMOs to cover the whole band in my VFO mover module. In my experience, hardly anyone is above 28.5 MHz, so not covering the entire band may not be a sacrifice. 29.3 to 29.7 is usually used by satellite downlink and FM.

However, I solved the frequency range problem with a quadruple frequency crystal oscillator. A 6 position rotary switch switches in the four appropriate crystals for 28, 28.5, 29.0 and 29.5 MHz. The other two switch positions cover other bands. If you order custom crystals, you should order primary frequency 10 meter crystals, not the cheaper harmonic crystals. The cheaper kind will oscillate at 1/3 the nominal frequency when plugged into the untuned oscillator shown below.

The crystals aren't switched directly, but rather, they are grounded one at a time by means of diodes that are biased *ON* by means of a 12 volt DC signal passed through the 4.7 K resistors. The advantage of this DC switching method is that, if you wish, the rotary switch can be far away from the oscillator up on the front panel.

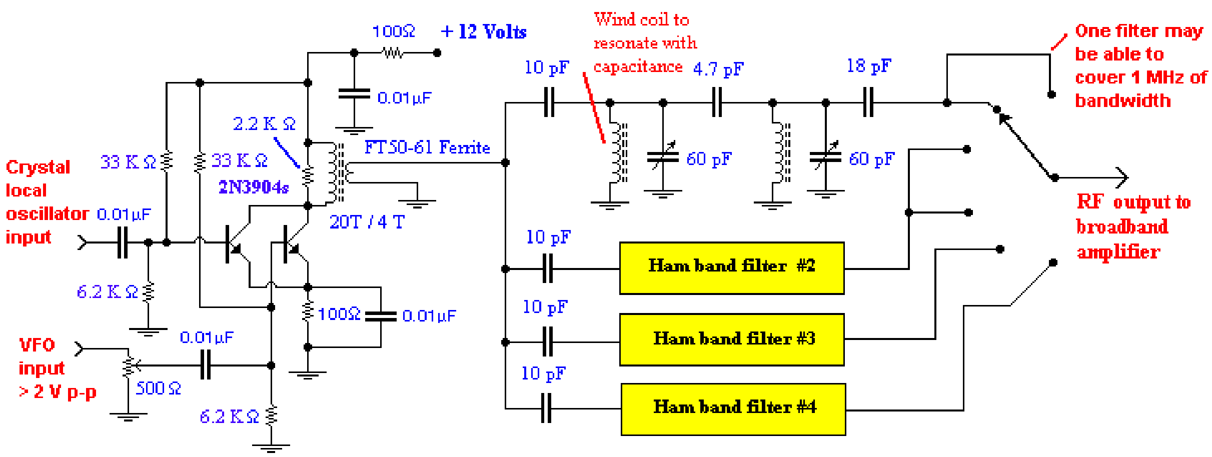
Be sure to minimize the capacitances between the oscillator emitter and ground.  All those crystals connected to the emitter will be affected by the extra capacitance.  This will tend to pull each crystal frequency away from its nominal value.  Too much capacitance and it may not oscillate at all.  This part of the circuitry would work best with a single-sided circuit board to minimize capacitance to ground.




MULTI - CRYSTAL OSCILLATOR

The multi-crystal oscillator covers a wide range so the oscillator could not be tuned and had to be broadband.  Therefore the oscillator frequency is entirely controlled by the crystal frequency.  Obviously the particular crystal must oscillate spontaneously on the labeled frequency and not a lower, primary frequency.  And because the oscillator stage isn't resonant, its signal output is tiny, tenths of a volt.  Consequently, I had to pass the oscillator signal through a broadband amplifier to make it large enough, about 2 volts p-p, to be sent to the mixer to be mixed with the 5 MHz VFO.

After the mixer each VFO signal must be filtered to select the desired frequency component.  My 6 position rotary switch has a second section that allowed me to switch in a filter for each frequency.  I found that just two tuned filters could cover the whole 10 meter band. I didn't need 4 separate filters after all.




**MULTIPLE FREQUENCY MIXER**

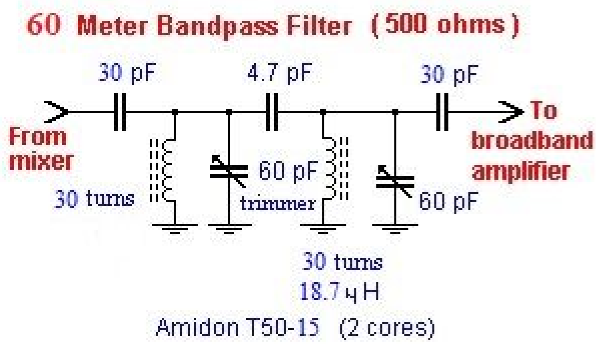
The tuned filters are high impedance and connected to the mixer with 10 pF capacitors. Because all the filters are connected to a low impedance transformer winding, the mixer can drive all of them at once. As shown the total load is only 40 pF. The rotary switch on the right then picks out the desired filter output. Another broadband amplifier amplifies the filter output before it goes to the SSB QRP driver where it is combined with the 9 MHz SSB signal. By the way, I tried to use the switching-by-grounded-diode trick to switch filters but that idea worked poorly. For 10 meters this VFO converter generates VFO signals from 19 to 21 MHz.

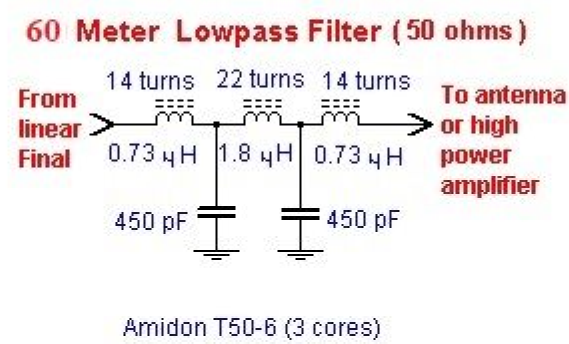
My 10 meter SSB doesn't work properly above 29 MHz because my QRP mixer filter isn't broadband enough. I guess I need two high impedance tuned filters. As of the winter of 2012, 10 meters is occasionally open and I have succeeded in talking to several stations. Victory! On the other hand, I have yet to hear a 10 meter SSB station higher than 28.5 MHz. So for me, the higher sections of the band don't seem to be worth worrying about.

I asked one of my 10 meter sideband contacts to give me a critical appraisal of my signal quality. He told me I probably needed a better microphone. Giggle. I have noticed that SSB stations spend hours discussing the relative merits of various commercial microphones. I suspect those non-homebrew guys know so little about their magnificent sideband transmitters, that they focus on the microphones. We sideband homebrewers are thrilled to have anyone understand our speech at all. Since he understood what I asked, he had already told me most of what I wanted to know.

### Getting on 60 meters

Perhaps you will have better luck making use of this band than I did. Below are the 60 meter filters I used:




I combined my 40 meter SSB driver with the 60 meter SSB driver. You'll notice that I used the same output low pass filter for both bands. A single DPDT switch allows me to switch between 40 and 60 meters. In all the other double band drivers, two DPDT switches were needed.

**Getting on 60 meters SSB - don't bother!**

Before the 60 meter (5 MHz) SSB frequency became available to American hams on July 4th 2003, I thought it would be fun to get on the air before commercial gear became available for this new frontier. I naively thought that homebrewers would own the band for at least a little while. Unfortunately 60 meters is not a "band." It's just 5 discrete frequency "channels" which are usually occupied by someone else. My sad story about trying to be a pioneer on 60 meters is told in Chapter 17B.

**Checking out the QRP module**

You will have to experiment with how to listen to your sideband signal at a signal level that simulates what it would sound like if you were receiving it off the air. I run my QRP into a 50 ohm dummy load. Then I disconnect my receiver from the antenna and leave the antenna coax from the receiver lying on the bench a few feet from the sideband generator. If that's not strong enough, I clip a test lead to the transmitter ground, then clip the other end to the center conductor of the receiver antenna coax connector.

I start by feeding a 9 MHz sinewave (CW) signal into my QRP board and then tune the filters to produce the largest, stable sinewave output into the dummy load. I monitor the frequency with a counter to be sure the VFO is controlling the frequency properly over the entire ham band. I adjust the VFO input level to produce the maximum output signal. However I just use the minimum 5 MHz VFO level that achieves this. When you are *NOT* talking, excess VFO will tend to induce signals on unwanted frequencies. I increase the DC bias to the output transistor until that transistor draws about 20 milliamperes DC more than it does with the bias set to minimum.

After the CW mode is working properly, I switch to SSB and use an audio signal injected into the "test input" of the SSB generator. I use speech from a talk radio station as supplied by a little Walkman radio. If you're lucky, the speech should sound pretty good in your ham receiver. If it doesn't, decrease the drive to the last two stages of the QRP using the 500 ohm pot. You may also need to reduce the number of secondary turns on the transformer feeding the output transistor. For example, instead of 3 turns, 2 turns or even one turn may be optimum for your particular QRP board. I found that overdriving stages was a common cause of poor audio.

## Getting 5 watts out of your QRP

Suppose you have been struggling to get your QRP working right and you notice that, the longer you work on it, the less power it produces. Check the voltage across the decoupling resistors. You may have pushed too much current through them. Maybe your 10 ohm resistor has been baked and has become an 84 ohm resistor, just like one of mine did. They don't have to look black and swollen to be damaged. In theory 1/2 watt resistors should be big enough, but I managed to damage two of them. Use 1 watt resistors in those locations and you can be sure this won't happen to you.

## Driving a QRO linear amplifier

A QRP sideband transmitter is just fine for communication around town. One or two watts are plenty for talking a few miles. But unless you have a great antenna and good conditions, you won't talk to many stations with just a few watts. For distant stations a linear amplifier will be a big improvement. Building a 50 watt linear is explained in Chapter 12. A big linear amplifier will bring out any difficulties you have with RF feedback and insufficient power supply decoupling. RF from my antenna coupler feeds back to my Walkman radio and (usually) makes that speech source impractical for testing. To test the transmitter at high power, I listen to the receiver with headphones and the receiver antenna input shorted. I turn the receiver volume way, ***way*** down. Don't deafen yourself! When you speak into the microphone, your voice should sound clear, as though you were talking on a public address system. It should not sound rough and gravelly.

Watch the output waveform across the dummy load with your scope. The waveform should look just like it did coming out of the 9 MHz generator. You will probably find that speech sounds terrible before you have everything adjusted. Speech may just be distorted to bursting, sputtering sounds.

## Beware of ampere meters in series with the power supply

An ammeter in series with your +12 volt power source may not be such a good idea. This didn't dawn on me until I was testing the 200 watt power supply described in Chapter 8. When the supply delivered 15 amperes to the transmitter, the ammeter had 0.25 volts across it. This meant that the 12 volt supply was bouncing up and down 0.25 volts just from the ammeter alone. Needless to say, this added to the RC supply voltage decoupling challenge. The 200 watt regulated supply described in Chapter 8 solved the ammeter problem by placing the DC ammeter inside the feedback loop. When the DC current varies, the regulator compensates and maintains constant output voltage.

## Adjusting DC bias to the final

You'll must adjust the DC bias to the final (50 watt) linear amplifier transistors for optimum speech quality. As you increase the bias current, watch the DC current drawn by the entire transmitter. It should not be more than about 2 amperes when you are not talking. As you talk, the current should jump up to 6 to 12 amperes, depending on the drive levels, the band you're on, etc. As always, the higher the frequency, the more difficult it will be to obtain clear speech. ***DC bias for the high power amplifier that is adequate for one band, may not be enough for another.*** Learning this little pearl of wisdom cost me days of frustration.

If the speech still sounds bad, RF chokes and RC decoupling filters for power leads to each module can help the problem. Also, filter the DC power line entering the transmitter chassis and the remote "mute" line going to the receiver. If troubles persist, filter all the wires entering your transmitter. Sometimes a clamp-on ferrite filter block around power leads or cables can be helpful.

**Finally, SSB works best with a good antenna**

A high gain, beam antenna is highly desirable. As you listen to the other SSB stations, you'll find that most strong signals come from Yagi or "beam" antennas. Directional antennas improve the signal by reflecting most of the RF energy toward the guy you are talking to. Think of beam antennas as being comparable to the mirror reflector in a flashlight. The mirror concentrates the energy in only one direction. The HF ham versions of Yagis resemble huge rooftop VHF TV antennas.

**Tuning in SSB signals on your receiver**

I suppose every receiver design is different, but here are my tactics for receiving other peoples' sideband: Using the receivers described in Chapter 13, I first set the crystal filter switch to ***a single crystal filter***. Multiple crystal filters are too narrow to receive 3 KHz wide speech. Next I ***lower the IF gain to zero or nearly zero***. Excess receiver sensitivity makes it difficult to receive SSB. Commercial SSB transceivers usually have attenuator knobs for this purpose.

***The secret to receiving SSB is to use the attenuator.*** The receivers in Chapter 13 have the 80 meter preselector tuning control which works well as an attenuator. For example, if the 80 meter preselector frequency setting for maximum signal strength is, say 3.9 MHz, mistune the preselector tuning to 3.5 or 3.6 MHz and suddenly the fellow's voice quality becomes high fidelity. The background static goes away and suddenly the voice is clear. You will be amazed how easy it is to tune a strong SSB signal when the signal input is attenuated. The reason this works is that each amplifier stage must be class A, with no clipping or distortion. In other words, the audio sinewave must fit perfectly within the voltage range of each stage, too much or too little sinewave voltage distorts the audio.

After that I ***set the BFO frequency to zero offset***. That is, I tune the BFO to the center of the IF bandpass. That way, when I want to zero beat my transmitter on another fellows signal, I can sweep my VFO until it zero-beats the center of the IF. When I do this, the whistle tone disappears and there is no audible sound. When I tune in an upper sideband (USB) SSB signal I usually start on the low frequency side of his signal. I creep up carefully until the BFO pitch overtone drops to zero. This is a situation where a high-ratio vernier reduction gear on your receiver main tuning is vital. When it reaches zero beat, the speech should become intelligible. This is when you should adjust your attenuator.

**CW operation using the SSB modules**

I equipped each SSB module with a CW keyer transistor just like the CW modules described earlier. As with the CW modules, before you go on the air, load a 50 ohm dummy load with your transmitter and listen to your signal with an independent receiver. With no antenna connected to the receiver, or perhaps even with the receiver antenna input shorted, your own CW signal should sound as though it came from a 1,000 miles away. Doing this I found that my SSB transmitter used for CW is particularly sensitive to antenna loading.

For example, on 12 meters the CW had a strong chirp sound, as in "ur RST is 599C." Not wanting to hear more "C" complaints about my signal, I unplugged the 10/12 meter output filter on the linear amplifier described in Chapter 12 and replaced it with a "blank filter." That's simply a piece of RG-58U coax connecting the output transformer with the output. I could do this because I was already using the a TV interference low pass filter which attenuates signals above 10 meters. This TVI filter is described in Chapter 9. When I used the blank filter, the antenna tuning changed, but the chirp vanished. Another cause of chirp is the power supply voltage drop when keying 100 watts or more. Taking out the external ampere meter in the supply line was a big improvement.

**In conclusion**

My first real sideband contact was with W9WFE, a fellow about a thousand miles away. When I explained to him that my rig was homebrew, he said, “Well, it certainly sounds like sideband to me. It seems to work!” Sweet success.

My sideband transmitters are still in the experimental category. You will find that it takes a great deal of tweaking and fussing to get SSB tuned so it sounds good and doesn’t radiate on unplanned frequencies. You won’t believe how many diseases your SSB transmitter will create for you to conquer! Sideband is not a project for impatient people.

Also, sideband with a "low power" 50 watt transmitter and a dipole 15 feet off the ground does not generate a competitive signal. On 20 meters I find that nearly any station can hear me and most will respond. Unfortunately, I am barely audible to them and real chit-chat isn't practical. In frustration I sometimes find myself shouting into the microphone which distorts the audio and makes me even harder to understand. However, above 20 meters a low power station like mine becomes increasingly more effective and I can often lean back and "rag chew" with the fellows. It also works well for local contacts on 40 or 80 meters. Sadly, the 15, 12 and 10 meter phone bands have rarely been open in recent years. In contrast to SSB, 20 meter CW with the same power level and antenna is quite competitive and I have rarely felt like a "peanut whistle."

Shortly after I got my sideband working, I tried to arrange a schedule with Doug, KD6DCO, in California. We failed to make contact. In that weak moment I thought I should stop messing with homemade junk and buy a modern transceiver. No, wait. If I want to communicate with Doug, all I have to do is write him an e-mail or call him on the phone. I have the Internet and long distance calls are cheap. If I insist on using radio, I could even talk with him by cellphone. No, it was back to the drawing board for me.

And after some major redesign, my next schedule with Doug was successful, but my signal was pretty weak out in California. That’s OK. I have to keep reminding myself that, so long as my station falls short of what is technically possible, my hobby continues. Woe to me if I ever finish. Long live homebrew!!

20. Chapter 15B, Harris