The K8IQY 4017 Transverter

Summary

This article covers the design and construction of a CW transverter for 17 meters. It uses a 40-meter transceiver as the source for basic receive and transmit functions. As configured, it will put out 3 ½-watts of r.f. when driven with 2-watts. More output power is available with higher drive. Solid state T/R switching is incorporated for transmit and receive, so no external T/R switching is needed.

Two versions of the receive converter were designed and built. The first, which uses an active NE602 mixer, is easier to build, but is more susceptible to overload by very strong signals. The second version uses a commercial diode double balanced mixer (MiniCircuits LMX-113) that provides much better strong signal performance, but is a bit more complicated to build.

The transmit strip uses another LMX-113 DBM, along with a transistor line-up comprised of a 2N2222, 2N5109, and a 2SC1945 final. Two additional 2N2222s and a 2N2907 device are employed for local oscillator and r.f. detector/switch functions.

Multiple "on-air" contacts have confirmed the unit functions quite well, and is an inexpensive way to provide 17-meter coverage for those who don't have this capability.

Acknowledgements

Good writers always have good proofreaders. Mine is my wife, Kathy, KB8IMP. Although she doesn't understand most of what I do, she is excellent with the English language, and a careful reader. Her skills helped make this article a reality. Paul Harden, NA5N, who has illustrated two previous works, did the wonderful illustrations. His art talent is legendary, and I am truly in awe of his ability. Once again, his illustrations add great breadth to my design, building, and writing efforts. Last on this list is George Heron, N2APB. George took a keen interest in the project after my posting to QRP-L. I'm most appreciative of his support and willingness to commit a significant number of QRP Homebrewer pages to my latest project. I hope he wasn't disappointed with the result.

Background

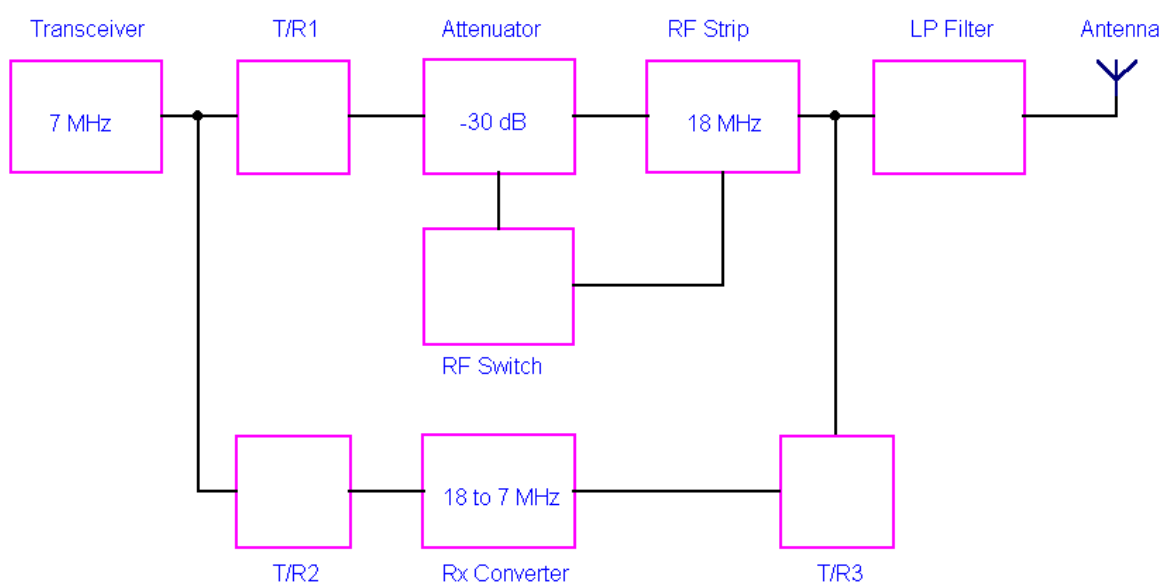
As is often the case with many of my projects, this transverter wasn't the ultimate goal of a recent design and building effort. The project that was being worked on was the design of a two-band, (40 and 17 meters) SSB/CW transceiver that could be used for bicycle mobile. A pair of Mizuho SSB transceivers is currently used on the bike, along with a homebrew 10-watt linear amplifier. I've thought about replacing those two transceivers with a single unit. The other driving force behind this effort was having a small number of commercially made 9 MHz, SSB crystal filters in my stock of goodies that really needed to be put to some good use.

Several schemes for implementing the two band SSB rig have been sketched out, and the most promising one was a basic crystal filter SSB rig, with the second band being implemented using a transverter approach. This method makes use of the primary band rig for all signal generation on the transmit side, and receive functions on the receive side, for the first band. The second band is then implemented via a receiving converter. In this case, one that receives signals on 17 meters, and down converts them to 40 meters where they can be tuned and detected by the base frequency transceiver. In addition, an r.f. strip is required for the second band. The excitation for this r.f. strip comes from the 40-meter transceiver. A suitable low-level output from this rig is mixed with a local oscillator to generate a driving signal on 17 meters. Once this is done, it is quite straightforward to do the appropriate filtering and amplification to generate a transmit signal on the second band. This is the scheme planned for the two-band bicycle mobile rig.

It was after the 17 meter NE602 receive converter was completed, and a "candidate" 17-meter r.f. strip was bread boarded, that the idea surfaced to marry these two units together, and construct a standalone 40 meter to 17-meter transverter. To make this work requires a deviation from what was just described, by virtue of the transmit strip being driven by the normal output of the 40 meter transceiver. In this case, we are dealing with an output of 2 to 5 watts, thus an attenuator must be used between the output of the 40-meter rig and the input to the 17-meter r.f. strip, or else the input of the 17-meter transmit strip gets burned out from excessive input power. Some changes are also required in the way the transmit/receive switching is accomplished, and the handling of the high level and low-level signals. These details will be discussed later in the appropriate sections.

Technical Overview

Let's start the technical discussion by first looking at a block diagram of the transverter, as shown in figure 1.



(Fig. 1)

The transverter normally receives signals that come into the antenna. They are routed through the transmit low pass filter (LP Filter), where signals below 18.5 MHz are passed intact, and those above this frequency are attenuated, the amount being dependent on how much above 18.5 MHz they are. Passed signals are then routed through an r.f. controlled transmit/receive switch T/R3. T/R3 will pass signals when no r.f. is being transmitted. Coming out of T/R3, signals are then down converted from 17 meters to 40 meters by the receive converter (Rx Converter), and routed through a second r.f. controlled transmit/receive switch T/R2. T/R2 also passes signals when no r.f. is being transmitted. Signals are then routed to the input of the 40-meter transceiver, and can be heard. During receive, r.f. controlled transmit/receive switch one (T/R1) appears as an open circuit.

On the transmit side, signals from the 40-meter transceiver are routed through yet another r.f. controlled transmit/receive switch, T/R1. The main purpose of this switch is to decouple the 40-meter transceiver from the attenuator during receive. If that didn't happen, the received signals would be severely degraded from attenuator loading of the receive converter output. When the transmit signal passes through the attenuator, it is reduced in level by a factor of 1000, or –30 dB. A 5-watt input is therefore reduced down to 5 milliwatts. Another way of looking at this is using dBm values. Five watts is +37 dBm, and the transmit mixer used requires a drive level of +7 dBm, so the attenuator supplies a loss of 30 dB. Midway through the attenuator, some of the transmit signal is tapped off to drive the r.f. controlled switch (RF Switch) that supplies bias to the early transmit strip stages. That will be discussed in detail later. Within the r.f. strip (RF Strip) the incoming 40-meter signal is up converted to 17 meters and amplified. The power output is related to the amount of drive available. At 2 watts of drive, 3 ½ watts of output power were measured on the prototype. The transmit signal is then sent on through the low pass filter (LP Filter) to reduce out-of-band harmonics and other spurious signals, and is available on the antenna connector. During transmit, the r.f. controlled switches at either end of the receive converter protect its input and output from the high-level drive and r.f. strip output signals.

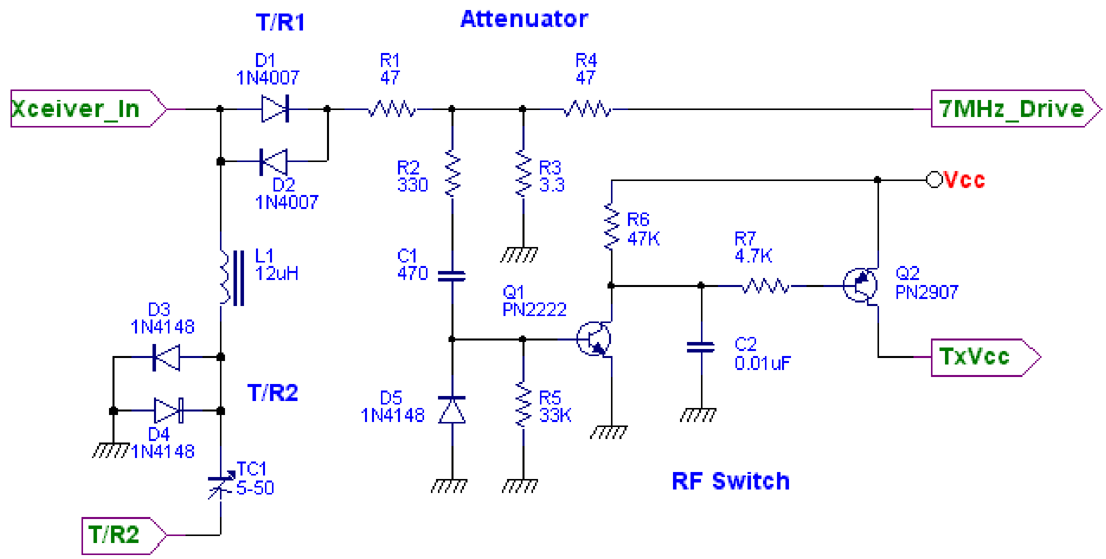
Before delving into the details of the transverter, a comment or two is appropriate regarding the rationale for partitioning the design, and the resulting schematic diagrams. There are two issues here. The first is an attempt to put the common elements on one schematic, so that they don't have to be repeated on other schematics. The second issue is the very practical limitations of the schematic capture program, and how much information can be reasonably placed on an "A" size drawing. Keeping to that size makes publishing the information easier, regardless of whether it is in a magazine, or on a web page.

Design Details – TR1/TR2/Attenuator/RF Sensed Switch

Let's begin the detailed technical discussion by looking at the simplest part of the transverter shown in figure 2. This part of the circuitry represents a collection of common elements that would be required, regardless of the receive converter design, or the design of the transmit strip.

We start with T/R1, which is a back-to-back pair of 1N4007 diodes. They are being used as PIN diodes; diodes that change their conductivity based on the amount of r.f. voltage applied across their terminals. When the r.f. voltage is very low, as it is during receive, their terminal resistance is very high. When 2 to 5 watts of r.f. is applied as it is during transmit, their terminal resistance is very low. This pair of devices then effectively isolates the receive converter from the attenuator, which would severely load down its output if they weren't there.

The next element is the attenuator. It is comprised of R1, R3, and R4 and provides 30 dB of attenuation. Since most of the power to be dissipated in the attenuator is handled by R1, it has to be a high wattage resistor. The unit selected is a low inductance thick film resistor packaged in a TO-220 case, ideal for mounting on the PC board substrate. It is rated for 35 watts if properly heat sunk. R3 is a 3 watt, low inductance metal film resistor, and R4 is a ¼ watt common carbon or metal film resistor. With 2 watts driving the attenuator, no appreciable temperature rise occurs, even under extended "key down" conditions.



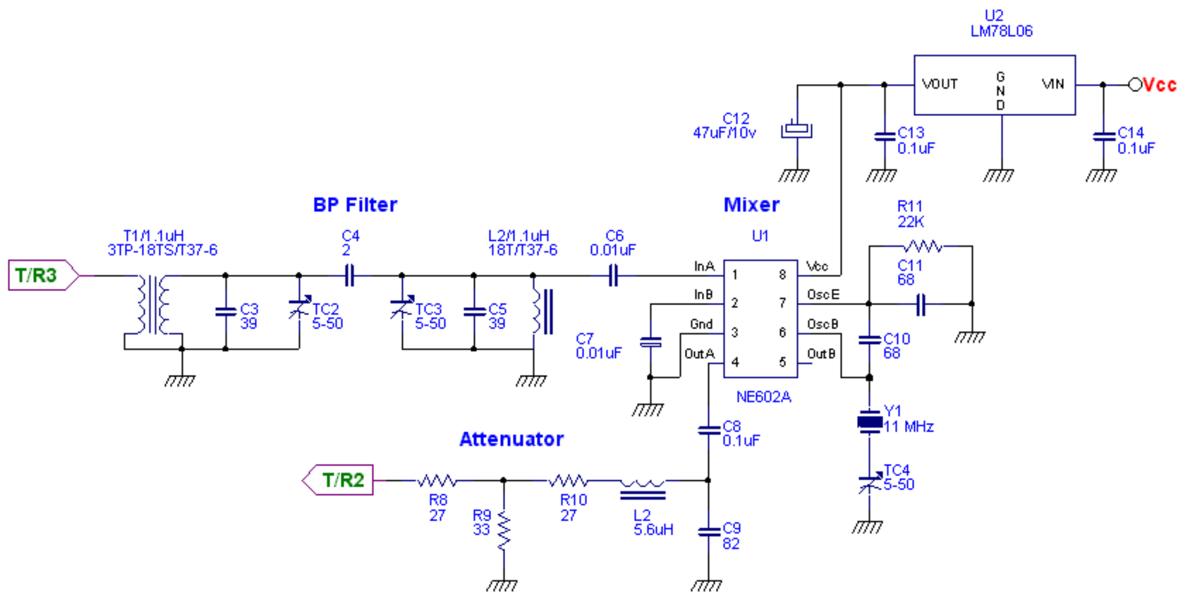
(Fig. 2)

Some of the incoming r.f. is sampled by R2, C1, and D5. They comprise a simple r.f. probe, rectifying the incoming signal, and supplying a positive signal to the base of Q1. The values were chosen to lightly load the attenuator so that its impedance isn't changed from 50 ohms or its attenuation compromised. The rectified signal causes Q1 to conduct, which in turn causes Q2 to conduct. With Q2 conducting, TxVcc voltage is applied to the first two amplifier stages in the r.f. strip during transmit. This voltage level is about 0.2 volts below the Vcc or supply voltage.

The remaining element on this schematic is T/R2. It is comprised of inductor L1, diodes D3 and D4, and trimmer capacitor TC1. L1 and TC1 can be tuned to series resonance at 7 MHz. This series tuned circuit appears as a very low impedance in series with the output of the receive converter during receive. During transmit, however, the two diodes conduct because of the applied r.f., shorting the center of the inductor-capacitor pair to ground. This keeps the incoming r.f. from burning out the output of the receive converter. In addition, shorting the center point makes the opposite ends of these elements appear as a high reactance (approximately 535 ohms) so that the 40-meter transceiver output isn't loaded.

Design Details – Receive Converter Version 1
Two receive converter designs were built. Figure 3 shows the first version, based on an NE602 active mixer.

Input to the receive converter connects to T/R3 on the Transmit Strip schematic. Signals are fed to a lightly coupled two-resonator band pass filter using the 3-turn link that is part of transformer T1. The turns ratio was chosen to load the input side of the filter with 1800 ohms. Input resistance of the NE602, which is 1500 ohms, supplies the loading on the output.



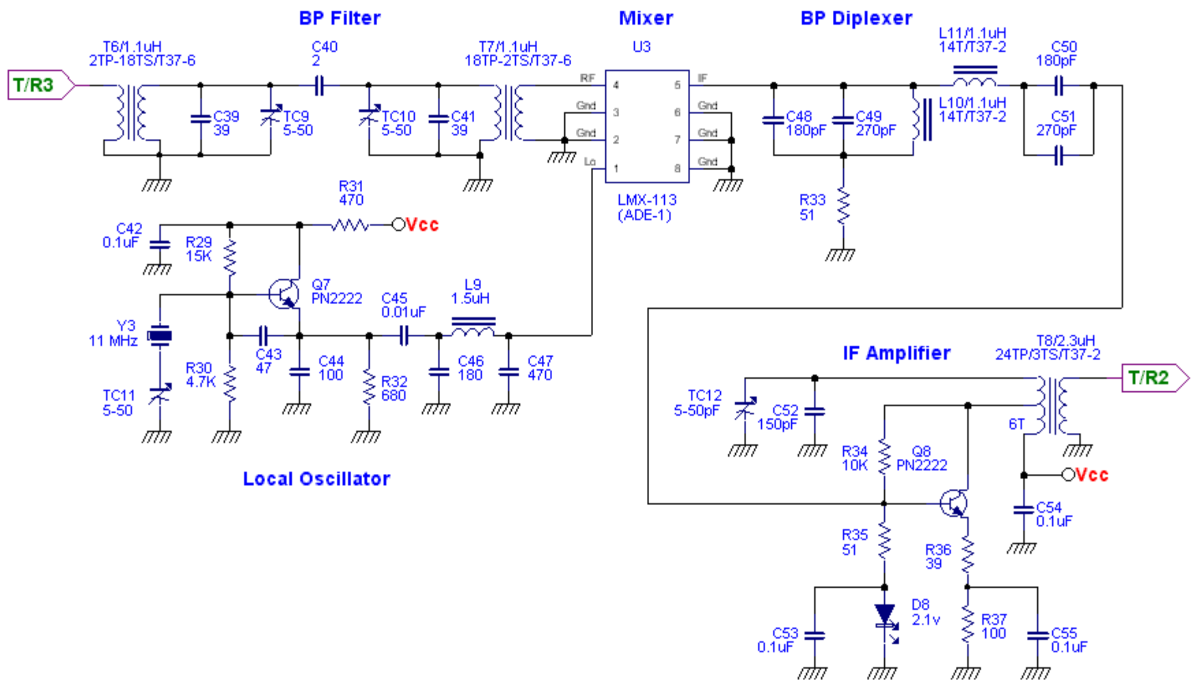
(Fig. 3)

The local oscillator implemented on the NE602 includes R11, C11, C10, Y1, and TC4. Trimmer capacitor TC4 was included to allow adjusting the 11.000 MHz crystal to its design frequency. The desired output signal at nominally 7 MHz (18.068 – 11.000 = 7.068 MHz for example) comes out of the NE602 on pin 4, along with numerous other mixing products. These signals are passed to the connected 40-meter transceiver through T/R2 shown in figure 2. Capacitor C9, and inductor L2 comprise an impedance matching network for the desired 7 MHz output signal, changing the impedance from 1500 ohms down to 50 ohms. Resistors R8, R9, and R10 provide 10 dB of attenuation, to prevent overdriving the input of the 40-meter transceiver. These parts could be eliminated if your 40-meter rig suffers from low receive sensitivity. Rounding out this design is a three terminal regulator U2, along with filter capacitors C12, C13, and C14. Some type of regulator is required to drop the supply voltage down to the six-volt level used by the NE602. A Zener diode and appropriate dropping resistor could also be used here.

While this converter is easier to build than the second version due to the lower parts count, it does not perform quite as well. The main problem with this design is the sensitivity to front-end overload when strong signals are present. In general, signals above –40 dBm, begin to cause spurious outputs from the mixer, which worsen as the signal level is raised. That's because this mixer was not designed to handle signals above this level. Overloading the front-end causes many non-17-meter signals to show up in the output where they are be heard on the 40-meter transceiver. That being said however, the basic design is more than adequate for constructing a simple receive converter for almost any segment of the hf spectrum, or for any ham band in which one might have an interest. A handful of parts and a few hours work will yield a very useable receive converter.

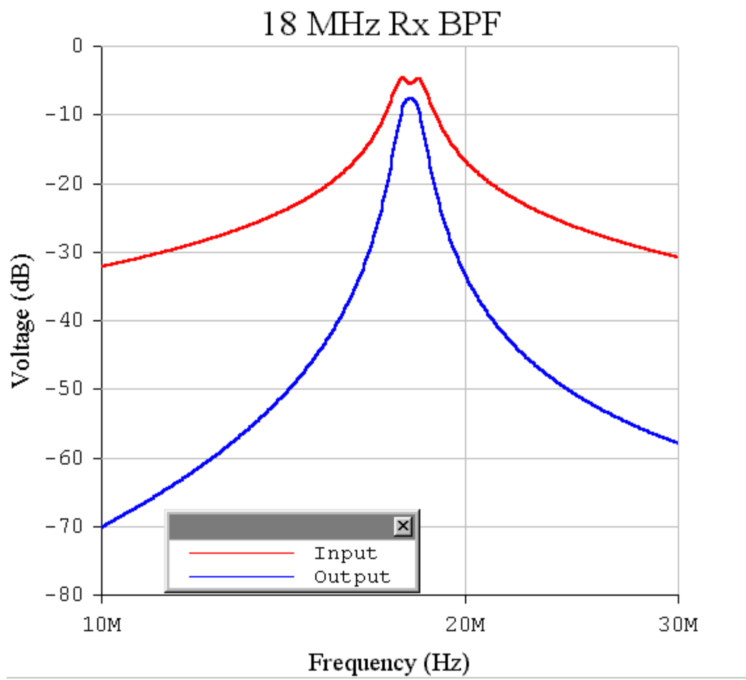
Design Details – Receive Converter Version 2

The second receive converter design employs a MiniCircuits LMX-113 passive diode double balanced mixer (DBM), and is shown in figure 4.



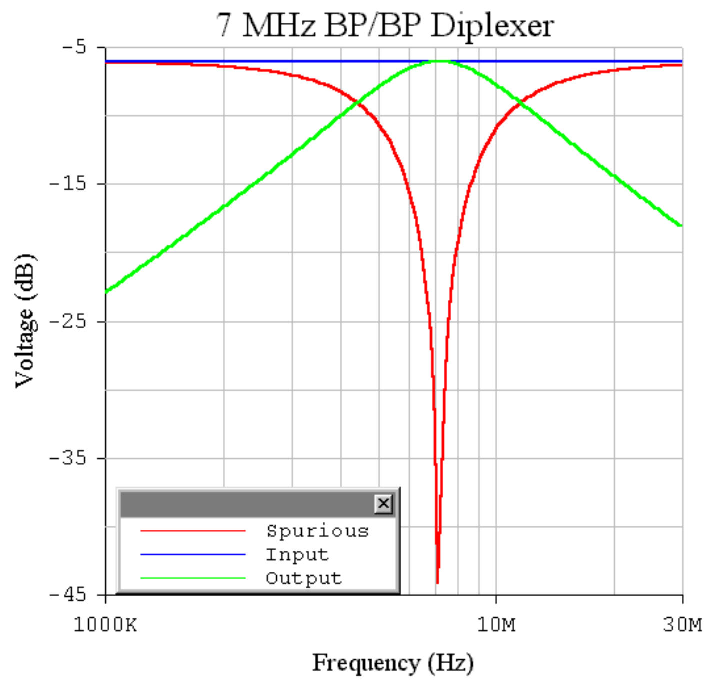
(Fig. 4)

This converter uses an input band pass filter modified from the first version for narrower bandwidth. The second inductor also becomes another transformer, T7, with a 2-turn secondary for matching the input impedance of the mixer RF port. Figure 5 shows a frequency response plot of this filter created with Electronics Workbench.



(Fig. 5)

Mixer, U1 could be replaced with any +7 dBm unit. The MiniCircuits ADE-1 device is recommended as a low cost alternative to the LMX-113 part that was used. Any other commercial or home brewed level 7 mixer could also be used. The LMX-113 parts were available, so were utilized. Local oscillator drive for the mixer is provided by Q7 and its components, which are configured as a Colpitts oscillator. Trimmer capacitor TC11 is included to adjust the crystal frequency to exactly 11.000 MHz, as was done in the version 1 design. Capacitors C46, C47 and inductor L9 comprise a low pass filter/impedance matching network to provide a 50 ohm termination to the mixer LO port, and reduce harmonic power in the drive signal. Power into the mixer's LO port is + 7 dBm as specified by the manufacturer. The IF port of the mixer drives a band pass – band pass diplexer consisting of capacitors C48, C49, C50, C51, inductors L10 and L11, and resistor R33. Signals above and below 7 MHz are terminated into the 51-ohm resistor, while those at 7 MHz are passed to the input of the i.f. amplifier (IF Amplifier). Figure 6 shows a frequency response plot of the diplexer, again produced with Electronics Workbench. Notice the constant input impedance (50 ohms) and the peak in the output at 7 MHz, the mixer product of interest.

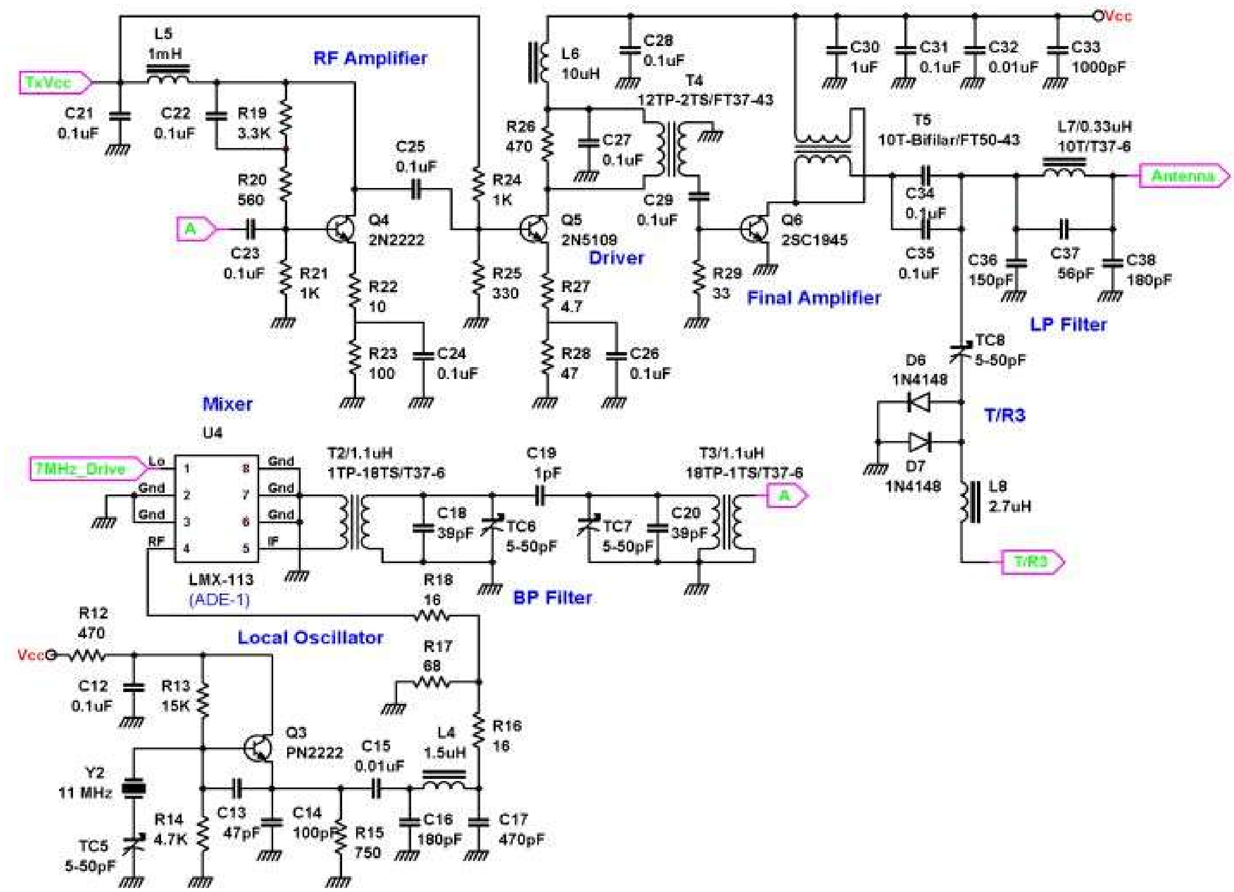


(Fig. 6)

Output from the mixer is amplified by the i.f. amplifier comprised of Q8 and its components. This amplifier has some interesting design details. On the input, two are worth discussing. The first is the constant base bias arrangement afforded by the light emitting diode, D8. Most common low current (1 – 2 milliamp) light emitting diodes (LED) have a forward voltage drop of around 1.8 to 2.1 volts, depending on the LED color. They can be used as low voltage Zener diode equivalents. In this design, resistor R34 (10 K) supplies approximately 1 milliamp of current through the LED, to bias the base to approximately 2.1 volts. This bias level is maintained over a wide Vcc range. The second feature is setting the input impedance of the amplifier to 50 ohms, essentially independent of frequency, by using resistor R35, which is part of the bias string but is grounded for ac currents at its lower end. This arrangement sacrifices some input power, but keeps a constant 50-ohm impedance on the output of the mixer – diplexer combination. Optimal mixer performance is achieved in this manner. On the output side, a tapped primary transformer, T8, is used to better match the collector impedance of Q8, while still providing a high Q tuned circuit. Output is taken from the 3-turn secondary winding. This configuration is very stable, and provides over 10 dB of power gain.

<u>Design Details – Transmit Strip</u>

The transmit strip is the most complicated part of the transverter. Its design is shown in figure 7.



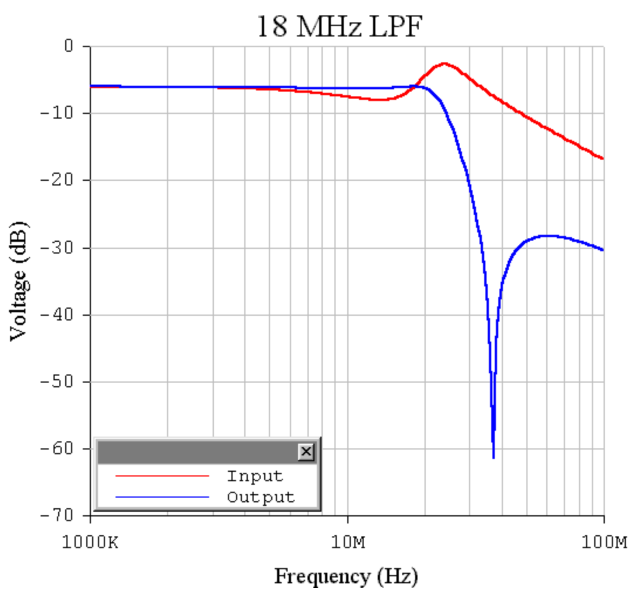
(Fig. 7)

A +7 dBm, 7 MHz drive signal comes into the transmit strip (RF Strip) to the LO port of another LMX-113 mixer. Remember, this signal is from the output of the –30 dB attenuator shown earlier. As suggested before, an ADE-1 or similar mixer could be substituted for the LMX-113 device. An 11 MHz r.f. signal is provided by Q3 and its components. This signal is filtered and impedance matched by C16, C17 and L4, just as was done in the version 2 receive converter. In addition, it is also attenuated by 6 dB by resistors R16, R17, and R18, so that the RF port of the mixer isn't overdriven. Output from the mixer is filtered by a band pass filter, even narrower in bandwidth than the one used in the version 2 receive converter input. Output from the filter contains mainly 18 MHz r.f., but there are some low level spurious products also. However, these are at least 55 dB below the carrier (dBc), more than adequate to meet FCC requirements for 5 watt and under transmitters.

The filtered signal is coupled to the base of transistor Q4, a venerable 2N2222A. This stage is configured as a class A, broadband amplifier, with an input impedance of 50 ohms, and an output impedance of 200 ohms. This design employs negative feedback in both the collector and emitter circuits for stability. It has gain in excess of 10 dB. The next stage is also a class A, broadband amplifier, using a huskier 2N5109 device. This stage also employs some negative feedback in the emitter for stability, and has gain in excess of 10 dB. Collector transformer T4, provides the required impedance step down (36:1) to drive the low base impedance of the final.

The required turns ratio was found experimentally. Note the TxVcc voltage discussed earlier is applied to the base bias and collector circuitry of Q4, and to the base bias circuitry of Q5. This was done to keep the current draw during receive to a minimum, as the quiescent current in Q4 is 10 milliamps, and in Q5, over 50 milliamps.

The final amplifier transistor, Q6 is a 2SC1945 device. It was chosen because of power handling capability, its TO-220 packaging, and the fact that the case tab is also the emitter, so it can be bolted to a heat sink without using a mica insulator kit. This is the same transistor employed by Mizuho in their 10 watt SSB/CW linear amplifier for use with their 2-watt handheld SSB/CW rigs. Transformer T5 in the collector of Q6 provides a 1:4 impedance step up to the output filter. The output filter is a traditional three element half-wave design for 50 ohms, but has been modified to include an additional 56-pF capacitor, C37, across inductor L7 to tune it for resonance at 36.175 MHz. This places a deep notch in the frequency response at the second harmonic of the output, which helps meet FCC requirements. Figure 8 shows a frequency response plot of this filter arrangement.



(Fig. 8)

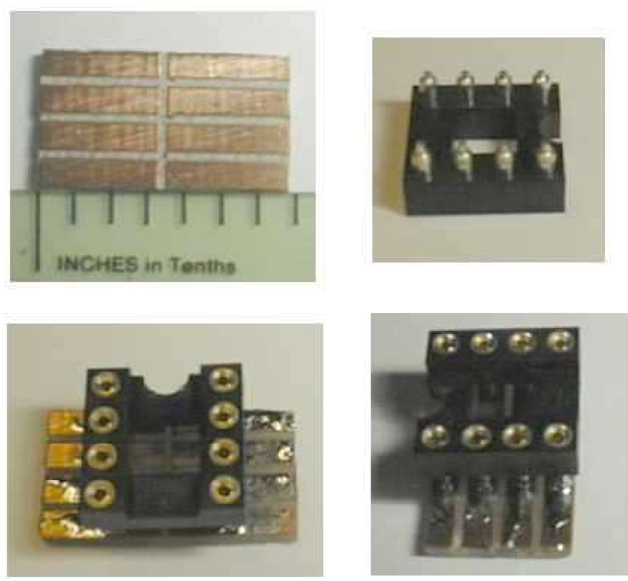
Note that capacitor C36, 150 pF, does not match C37, 180 pF, in value. It is because the remainder of the capacitance needed for C36 is contained in trimmer capacitor TC8. This trimmer, diodes D6 and D7, and inductor L8 comprise the remaining r.f. switched transmit/receive switch, T/R3. It protects the input of the receive converter when the transverter is transmitting. Outgoing r.f. causes D6 and D7 to conduct, shorting the mid-point of TC8 and L8 to ground. The capacitance of TC8 then becomes the remaining capacitance needed for the output low pass filter.

This r.f. strip is quite robust. It has been run in a “key down” condition for several minutes with only a slight rise in temperature above ambient. When we get to the construction details, you’ll see the heat sinks employed to handle the power dissipation of the transmit strip transistors. In addition to being robust, it is also very stable. No indications of instability have been noted either while the unit was undergoing tests, or using it "on air". Since the basic design is also broadband, it could be probably be used on any ham band, up through 10 meters without any changes, except for the output low pass filter. That would have to be frequency scaled for the appropriate band.

Construction Overview

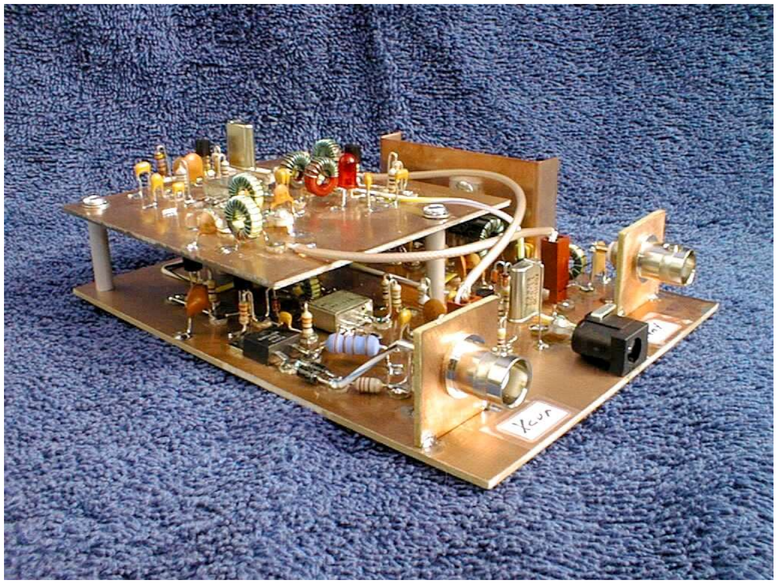
As most folks know by now, building equipment using Manhattan-style construction is my preference, especially if the equipment is going to be used at hf or vhf frequencies. The "everything over copper" approach of this method provides superior stability. In addition, the method facilitates ease of tracking down problems or making changes because of the parts organization and pad termination approach. Those who have seen my work know that round pads have an advantage in some situations, while rectangular pads work better in others, and either can be used exclusively. On this project, 5/32 inch round pads were used exclusively, except for mounting the IC socket.

This project builds on the techniques that have been employed in other equipment. However, instead of using an array of single pads for mounting the IC socket for the NE602, as small PC board fabricated from some scrap PC board material was utilized. This new method is much quicker than laying an array of 8 pads, used previously. Figure 9 shows some details of the pad and the socket.



(Fig. 9)

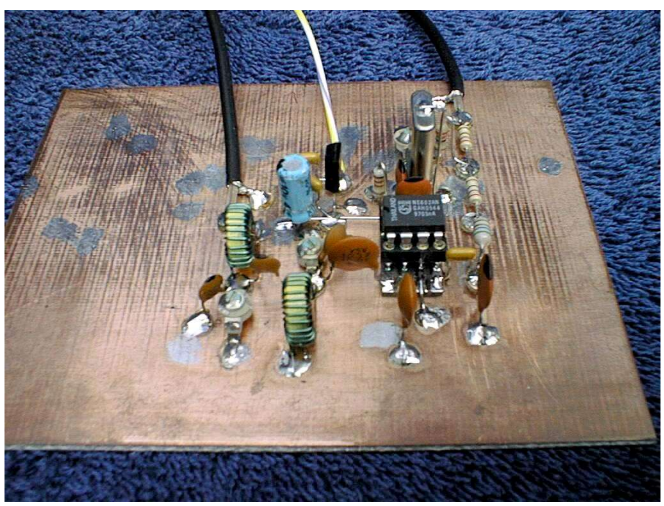
The finished transverter ended up as a two-story affair, akin to the original 2N2/40. This improves the packaging by keeping the overall footprint smaller. This is a picture (figure 10) of the final assembly. The receive converter was mounted on standoffs above the "main" board, and short runs of RG-174 coax were used for input and output connections. No additional packaging is envisioned since there is a certain “Object de Art” quality about the transverter that should be displayed.



(Fig. 10)

Construction Detail – Receive Converter Version 1

Figure 11 is a photo of the version 1 receive converter, the one using the NE602 IC.

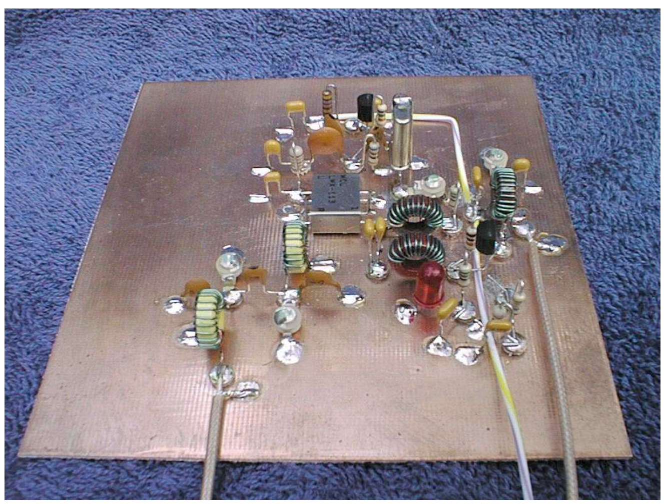


(Fig. 11)

In the foreground are for the input band pass filter elements. To the right of that is the NE602, with the socket soldered to the miniature 8 pad PC board shown earlier. The output impedance matching and attenuator elements are the objects in a line seen to the right of the NE602. Moving to the center - top of the picture is the 78L06 regulator and its filter capacitors. Above the NE602 is the 11 MHz crystal, and behind it, trimmer capacitor TC4. This layout is about optimal in terms of board space required, and results in the output being removed from the input as far as is practical. The overall footprint of this version of the receive converter would be approximately 2 X 2 ½ inches, if excess PC board material were remove. Notice the several soldered areas where no components exist. Those represents rearranging and revising the construction for a more optimal layout, and is a part of Manhattan-style construction when entirely new designs are built, at least when I'm doing it.

Construction Detail – Receive Converter Version 2
The next photo (figure 12) shows the second receive converter construction, this time with the LMX-113 double balanced mixer.

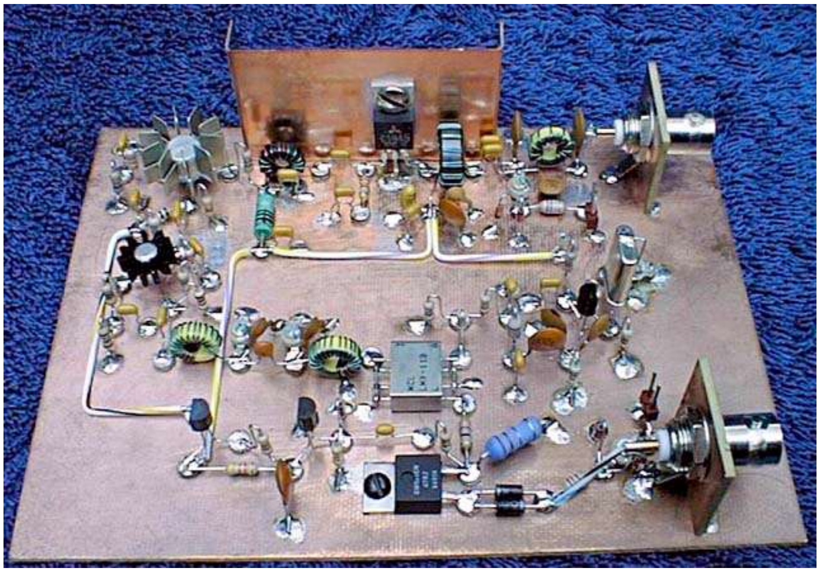
The input filter, band pass elements are shown in the left foreground of this photo. Behind them is the LMX-113 mixer, the object in the rectangular metal can. At the top of this photo are the components that comprise the local oscillator, with the 11 MHz crystal clearly visible. In the right foreground are the two inductors that are part of the band pass/band pass diplexer. To the right of those is i.f. amplifier transistor Q8 and its components. Note the red LED in the foreground; that's D8. Transformer T8 is the toroid core with the green wire to the right and rear of Q8. The overall footprint of this version of the receive converter is 3 ¼ X 3 ½ inches, quite a bit larger than the previously version. This photo was taken before removing excess PC board material.



(Fig. 12)

Construction Detail – TR1/TR2/Attn/RFSwitch/Transmit Strip
This board contains all of the parts that are "common", and the actual r.f. strip components. That layout is shown in this photo, figure 13. It is 4 X 5 ½ inches in size.

Starting in the right foreground is the input BNC connector. This is where the 40-meter transceiver is connected. Above that is a small two-pin connector which is the T/R2 output going to the receive converter. Between those two connectors are the components for T/R2. Moving to the left are diodes D1 and D2, which form T/R1. Those diodes are connected to resistor R1, the 47 ohm, 35-watt unit (TO-220 case) that is the input leg of the 30 dB attenuator. It is screwed down to the copper substrate to aid in heat dissipation.



(Fig. 13)

The blue resistor above and to the right of that is resistor R3, the 3-watt unit forming the center leg of the attenuator. The remaining attenuator resistor, R4 is soldered between the R1/R3 pad, and the LO port of the LMX-113 mixer.

On the R1/R3 pad is also resistor R2, which steals a bit of signal for driving the r.f. sensed switch, which provides the TxVcc voltage. The remaining elements of that circuitry are just above and to the left of R1. The leftmost wire leaving the last transistor of the pair carries TxVcc to the first two r.f. amplifier stages.

To the left and centered between the two BNC connectors are the components for the local oscillator which provides the approximate 0 dBm, 11 MHz carrier to drive the mixer's RF port. On the opposite side of the mixer (left) are the components that make up the 18 MHz, coupled resonator band pass filter. Transformers T2 and T3 are the two visible, yellow toroids wound with green wire.

Moving to the left side of this layout toward the left background are Q4, the 2N2222A transistor and Q5, the larger 2N5109 transistor. Note that both transistors use a multi-finned heat sink. These are very important for keeping the transistors cool during extended "key down" periods. The wiring for TxVcc is also clearly visible.

The prominent feature in the background, and extending across part of the rear of the substrate is the heat sink for the 2SC1945 final. This heat sink is 2 ½ inches long, by 1 ¼ inches high, and the mounting tabs are 3/8 inches wide. It was fabricated from 0.025 inch sheet copper, purchased at the local hobby store, and is soldered directly to the copper surface of the PC board substrate.

Thin flashing copper might also be suitable. The attachment method is shown in Figure 14 detail.

(Fig. 14)

The 2SC1945 is screwed to this heat sink, after covering the TO-220 case tab with a thin layer of silicone grease to aid heat transfer. To the left of the final transistor is transformer T4, and to the right, transformer T5. These two transformers are purposely mounted at right angles to each other to minimize any chance for coupling, which would contribute to instability.

Remaining components to the right of the final are the low pass filter capacitors C36, C37, C38, and inductor L7. Capacitor C37, is mounted so its surface is parallel with the substrate, and is clearly visible. Also within this group of components are those that form the remaining r.f. sensed transmit/receive switch, T/R3, which protects the input of the receive converter. That connection is the other small two-pin connector just below the output BNC connector. The output BNC connector is where the 17 meter antenna is connected during "on air" operation.

As was shown in figure 10, the second receive converter was mounted to the larger "main" board with 7/8 inch high standoffs. One was placed at the left-front corner, and the other at approximately 1 inch forward of the right-rear corner. The receive converter connecting cables were made from RG-178 miniature coax, and terminated in matching 2-pin connectors. The power connection pin and socket were taken from a machined pin IC socket.

Tune up

One of the neat things about this project is how easy it is to tune everything up and put the transverter on the air. If the receive converter you've decided to use and the r.f. strip/common board are both built correctly, tune up should follow this scheme. First, connect your 40-meter transceiver to the transceiver connector, and a suitable 17 meter antenna to the antenna connector. Power up the 40 meter transceiver and listen to the background noise level. Now power up the transverter. The background noise level on your 40-meter transceiver should come up enough that you can hear the change. It's not much, but should be detectable by ear. Alternately peak each of the receive converter input trimmers on the background noise; TC2 and TC3 if you built the NE602 version, or TC9 and TC10 if you built the DBM version. Then tune around until you find a CW signal and repeak these trimmers for the loudest signal. If you have a signal generator, connect it to the antenna lead, set it to 18.080 MHz and a 50 micro volt level.

Tune around with the 40 meter transceiver until you find the signal. It should be near 7.080, and very loud. Alternately peak the receive converter input trimmers.

After tuning the receive converter, connect the output of the transverter to a dummy load through a SWR/power meter. Set your 40 meter transceiver to 7.080 MHz and key it up. As you watch the power output meter, alternately peak trimmers TC6 and TC7 for maximum output. With those adjustments done, you should be getting 3 ½ watts out with 2 watts of drive. With 5 watts of drive, the output will probably be at least 5 watts.

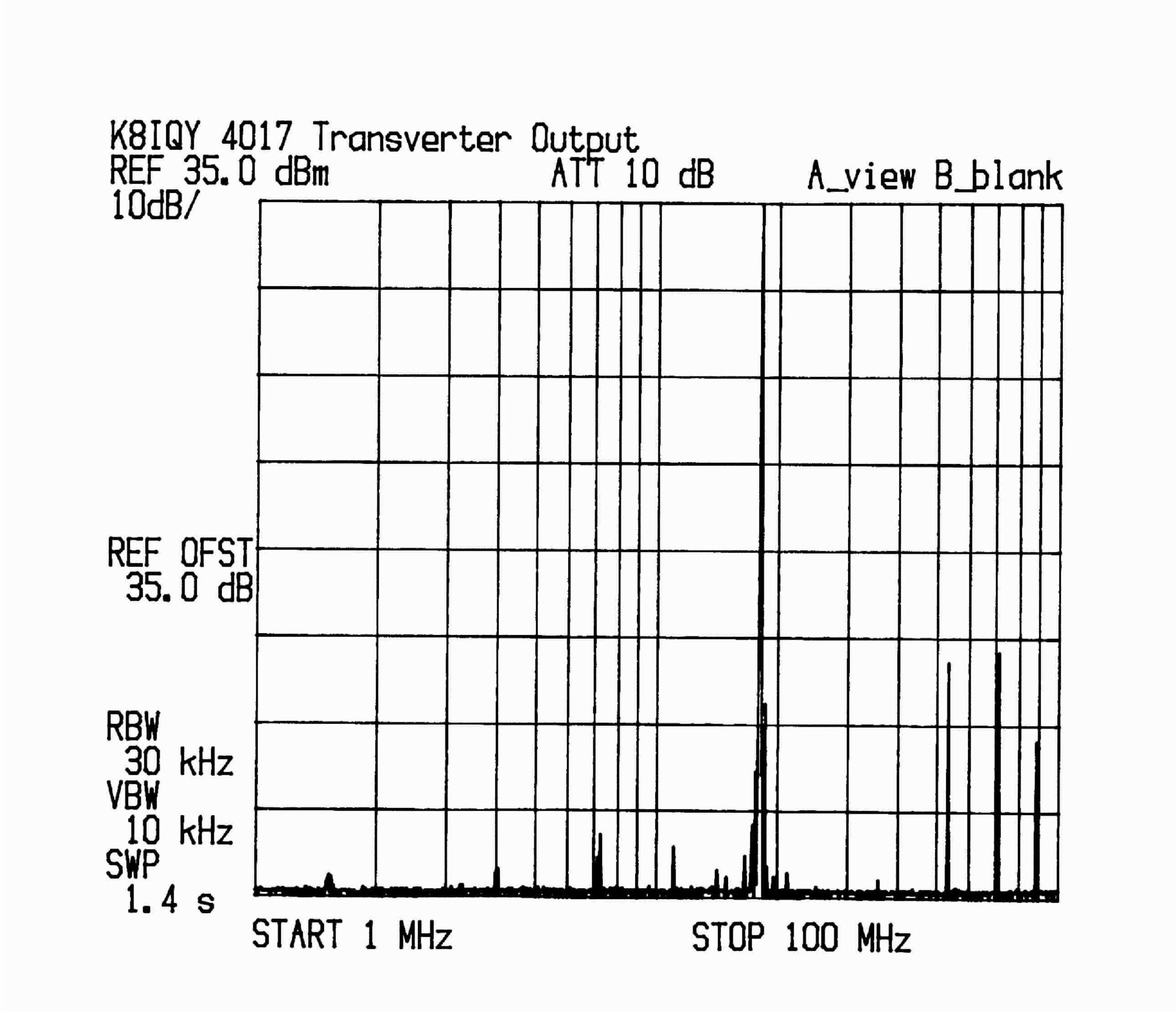
The next adjustments set the receive and transmit 11 MHz crystal oscillators to 11.000 MHz, so that the transverter tracks your 40 meter transceiver. These adjustments require a counter, and if one of those isn't available, a second receiver, which can receive 11 MHz, can be used. If you built the NE602 receive converter, connect the counter probe (10X low capacitance preferred) to the junction of C10 and C11. Adjust trimmer TC4 until the counter reads 11.000 MHz. If using a receiver, place it in the LSB mode, set it to 11.000 MHz, and adjust trimmer TC4 until the tone goes below an audible level or "zero beat". The procedure for the DBM based receive converter is essentially the same, only this time the counter is connected to the junction of L9 and C47, or to the LO port of the DBM. Adjust trimmer TC11 until the counter reads 11.000 MHz. If using a receiver, follow the procedure already described for the NE602 receive converter.

The transmit 11 MHz oscillator is much like the receive converters. A counter is attached to the junction of R16 and R17, and trimmer TC5 is adjusted until the counter reads 11.000 MHz. The above procedure using a receiver can also be used for the transmit local oscillator.

Note that the receive converter oscillator and transmit oscillator run all of the time. One can take advantage of this fact and listen for the two oscillators in a receiver, and adjust either the receive or transmit trimmer until the two signals are at the same frequency. This method will assure the receiver converter and transmit r.f. strip are aligned relative to each other, but they both could be off several KHz from the transceivers dial calibration. If that doesn't cause a problem, this method is by far the simplest.

Performance

Overall, the performance of this transverter is very good, considering that it can be built in a few days. Most important to putting a rig on the air is knowing its spectral purity. First, it must meet FCC requirements, and second, it should have a fair amount of stability, so that it can be relied upon to consistently have good spectral purity. Figure 15 is a spectral plot of the transverter running at 3.5 watts output into a dummy load. It was being driven with my 2N2/40 rig (Winter 1998 QRPp) set at 2 watts.



(Fig. 15)

This plot shows the output spectrum from 1 MHz to 100 MHz on a log scale; 10 MHz is at the center of the X-axis. Y-axis scaling is 10 dB per major division, for 80 dB total. The largest peak is the transverter output (18.08 MHz) at 3.5 watts, so all of the smaller peaks are measured with respect to this peak, and reported as minus values below this reference level. If you look to the right of the main peak between the 30 and 40 MHz lines, there is a very small peak of about –78 dBc. This is the second harmonic. Its amplitude is lower than the third harmonic because of the trap that was used in the output filter discussed earlier. The next higher peak is the third harmonic, and it is down about –53 dBc, well below the –35 dBc required by FCC regulations. The remaining two peaks to the right are respectively the fourth and fifth harmonics.

A second spectral plot, figure 16, shows the details near the main peak.

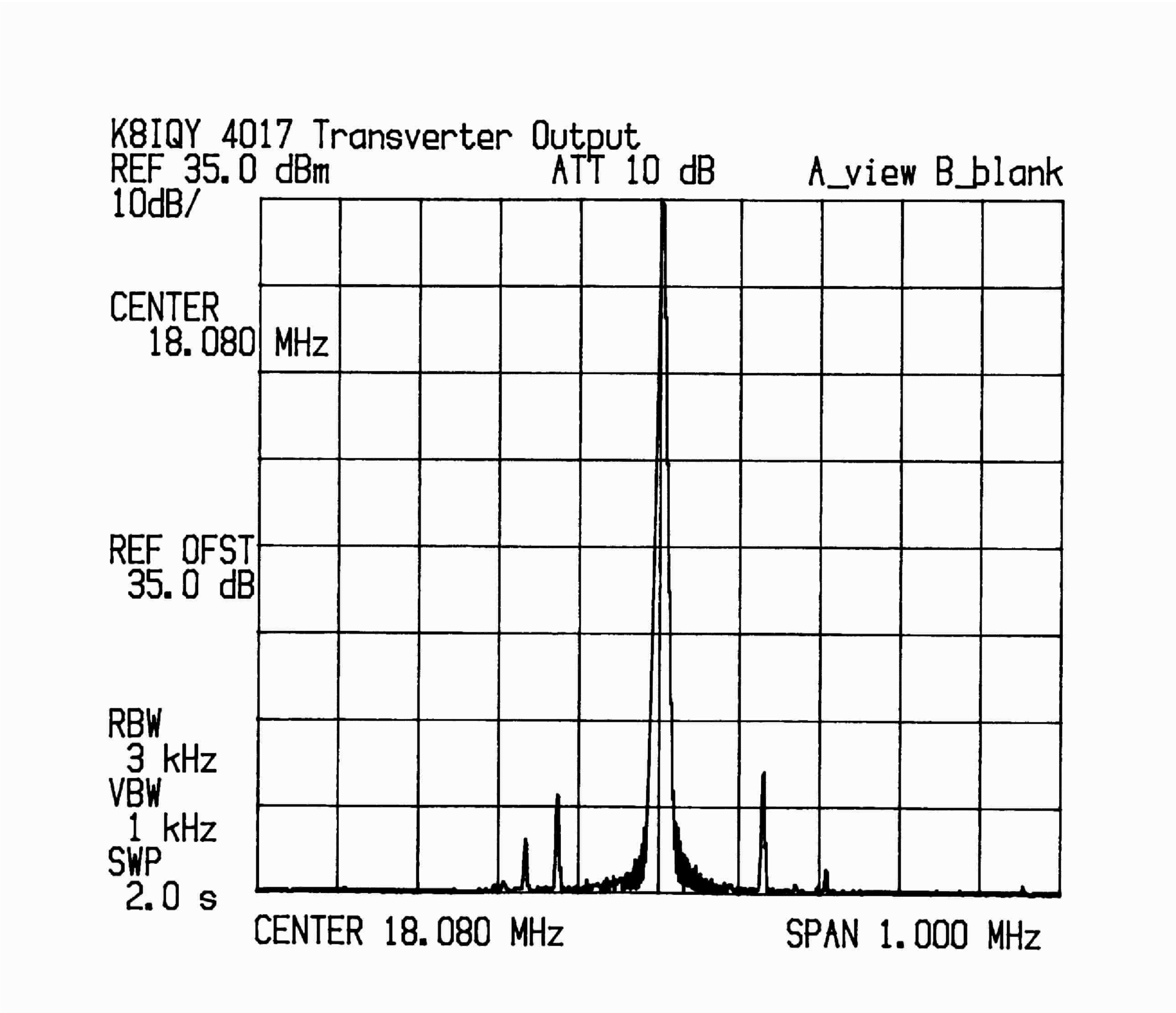


Fig. 16

These are all of the "close in" mixer products, most of which are effectively filtered out by the narrow band pass filter on the IF port of the transmit mixer. All of them are more than 65 decibels (-65 dBc) below the reference carrier.

As a means for comparison, several performance measures for each receive converter were obtained and tabulated.

Parameter	**Rx Conv. V1 (NE-602)**	**Rx Conv. V2 (DBM)**
MDS	-127 dBm	-128 dBm
Rx noise contribution	0 dB	1.5 dB
Image rejection	25 dB	Too high to measure
IF rejection	78 dB	76 dB
Input linearity	-30 dBm	-15 dBm

Input compression level	-25 dBm	-10 dBm
Current consumption	5.8 milliamps	18.2 milliamps

Normally, the receive converter stays powered during transmit. However, with the receive converter shut off, the current draw is 550 milliamps at a power output of 3 ½ watts. Using this current value and a supply voltage of 13.8 volts, the total power input to the transmit section is 7.6 watts. With a power output of 3.5 watts, the overall efficiency is 46 percent.

Overall, either receive converter is more than adequate for general usage. The MDS measurements are a bit suspect, as these numbers are close to that of the 2N2/40 which was used as the receiver for these tests. For environments with higher ambient r.f. levels, the DBM receive converter has a leg up. It will handle much higher receive input signal levels without overloading or going into compression. It also has much higher signal rejection at the i.f. frequency than the NE-602 based converter.

On air performance has been most gratifying. Many DX and state side stations have been worked and none have reported any stability or keying problems.

Final Comments

I hope you have enjoyed reading this article and will consider building the transverter presented, or build one for another band. If you do, I'd like to hear about your experiences, and maybe you will take pen-in-hand and write your own article, so that we all may learn.

Technical comments and alternate ideas are always welcome. That's how I learn to do things better or differently. I can be contacted by snail mail at:

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