“Half-Pint” QRP transceiver

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For a long time I had wanted to build my own rig. I gave it a try sometime around 1988 when I was in college. I built a 2 transistor crystal-controlled CW transmitter for 80 meters. I had recently received my novice ticket, and my CW skills were so poor that using this rig seemed to be nearly impossible for me. The little transmitter was put on the shelf and I went on to do other things. I worked SSB on 10 meters for a while, then after passing my Technician exam I spent a lot of time on VHF.

In 2014, after having been QRT for 10 years, I was thinking about that little transmitter. Now, being older and more patient, I decided to give it another try. First order of business was to re-learn the code. I didn't want to build a rig I couldn't use again!

While researching ideas for my new homebrew rig I came across the design of the Pixie II. The Pixie was a popular and very simple transceiver designed by David Joseph WA6BOY, and Doug Hendricks, KI6DS[1]. It had a 2 transistor transmitter and a direct conversion receiver. The audio gain of the receiver was from an LM-386 audio amplifier chip, and the power amplifier of the transmitter was also the receiver mixer. I bought a kit for a Pixie and gave it a try.

The Pixie is very simple – perhaps too simple. It has a fixed frequency, no tuning. It also has no filtering at all. You end up listening to a 30-40 KHz chunk of the band at once centered on your crystal frequency. The LM-386 was configured to provide high gain, about 46 dB, and could become unstable. Many people had built the Pixie and there were numerous articles on-line on how to improve it.

Doug DeMaw, W1FB[2], published an improvement using an active audio filter build from an op-amp. However, I felt that once an op-amp was added, it was no longer a simple design. Rick Andersen, KE3IJ[3], had a version with filtering built entirely from discrete transistors. This was very interesting to me, and I wondered if I could perhaps design a similar one.

I decided I wanted a Pixie like design with an audio strip build from discrete transistors that had a gain of about 46 dB and a bandwidth of 500 Hz or so, and could directly drive headphones. I also wanted it to be easy to build. I thought that if I could minimize the number of different components that I could make it easier to build. In particular I thought that if I could reduce the number of different resistor values used that it would make it easier to build – perhaps I could use some of those resistor packs with several identical resistors in it.

So I set about designing the audio strip. What I came up with had 43 dB gain, center frequency of about 800 Hz, and a 3 dB bandwith of about 500 Hz. All amplifiers are Class A, so there is no crossover distortion. They are baised at ½ Vcc to give the most dynamic range and flexibility on power supply voltage. It uses just 5 NPN transistors and can directly drive headphones.

My first atttempt at building a transceiver is shown in Figure 1. Transistor Q1 is the local oscillator, its shown with a variable capacitor for receive tuning and a switch would plug in at CONN1 to short it out for transmit. When I actually built this, I instead used 2 variable capacitors selectable by a switch. I would tune one for zero beat and the other at an offset to maximize the received signal through the audio filter.

The audio strip is comprised of Q3-Q7. Q3 and Q5 form the filtering stages. Q4 is a buffer between the filtering stages to provide load isolation. Q6 and Q7 are the headphone drivers.

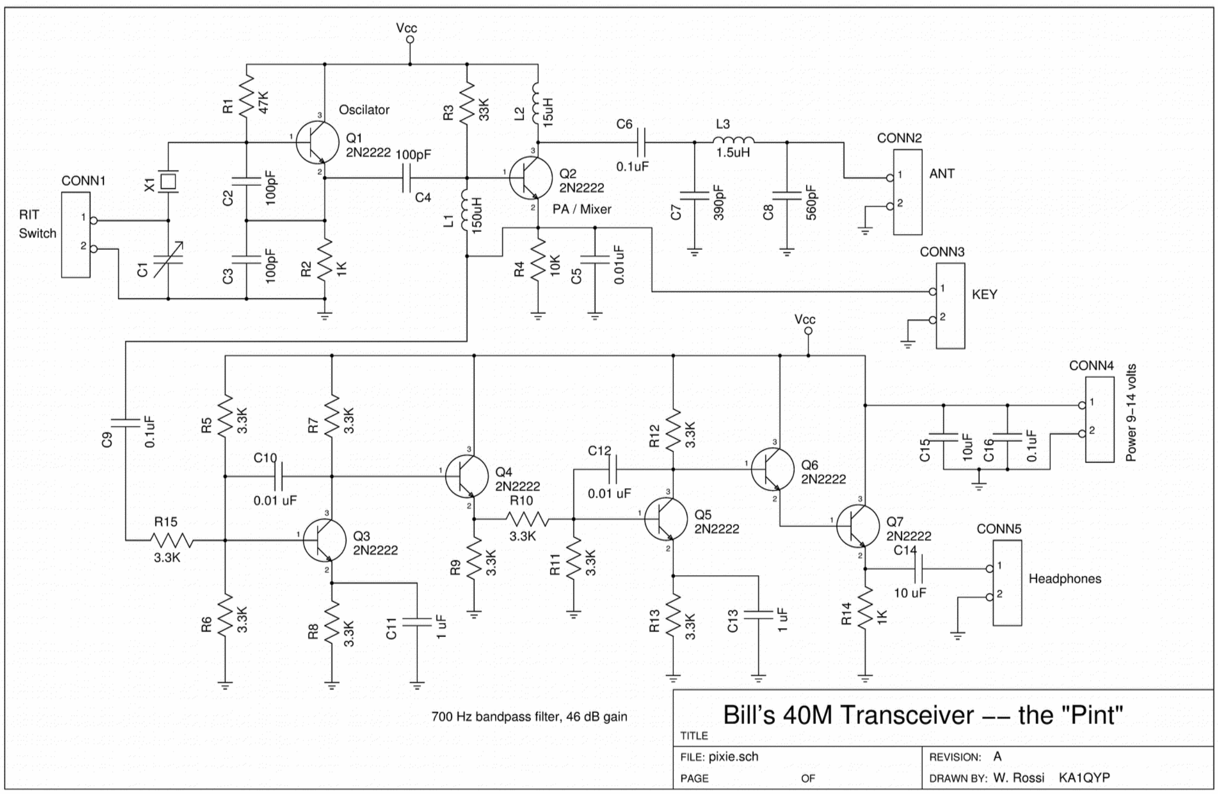

Figure 1

Almost all of the resistors in the audio strip are 3.3K, except for R14. This makes assembly easier. Capacitors C10-C13 determine the center frequency of the filter; they should be 1% ceramic if possible. In particular, avoid aluminum electrolytic types due to their poor tolerance.

Transistor Q2 performs two functions. It is the power amplifier for the transmitter when the key is down, and the receiver mixer when the key is up. The mixing action occurs because Q2 turns on briefly at the peak of each cycle to keep C5 charged. While Q2 is in cutoff, R4 discharges C5. The duty-cycle here in receive is on the order of 5% . During transmit, the emitter of Q2 is grounded and it acts as a Class C amplifier. On 40 meters I was able to get about 1 W of power output.

I named this first version the “Pint”, but both Rex Harper, W1REX, and my wife thought it would be better called the “Half-Pint”. So “Half-Pint” it shall be!

While I was able to make several contacts with this first version, there were some issues to be resolved. The biggest problem was that there was a lot of noise in the receiver. Using Q2 as a mixer is less than ideal. A good mixer should switch on and off completely at 50% duty cycle in order to reduce intermodulation products. That clearly isn't happening with Q2, and it results in a poor signal to noise ratio in the receiver.

The rig was working with Q2 as a mixer and I liked the simplicity of doing it that way. I decided to make an optional replacement mixer module that could be added if desired.

The low-pass filter between Q2 and the antenna connector is inadequate for today's FCC rules. Back when the Pixie II was designed, there was an exemption in the rules for QRP transmitters. Rex Harper, W1REX, was kind enough to point this out to me and told me how to fix the issue. Note that all the inductors are molded chokes, so there were no coils to wind!

I also wanted to have more gain in the receiver. I liked the small size and simplicity of the design and I didn't want to complicate it by adding more amplifier stages. After reading some articles on regenerative receivers, it occurred to me that I could use the same principle on the audio strip. By adding some positive feedback, I could increase the gain of audio strip while narrowing its bandwidth at the same time. Too much feedback and the audio strip would oscillate. By adding one potentiometer I was able to increase the gain by as much as 20 dB. This gave me a gain/bandwidth control, that I called the “Q-multiplier”.

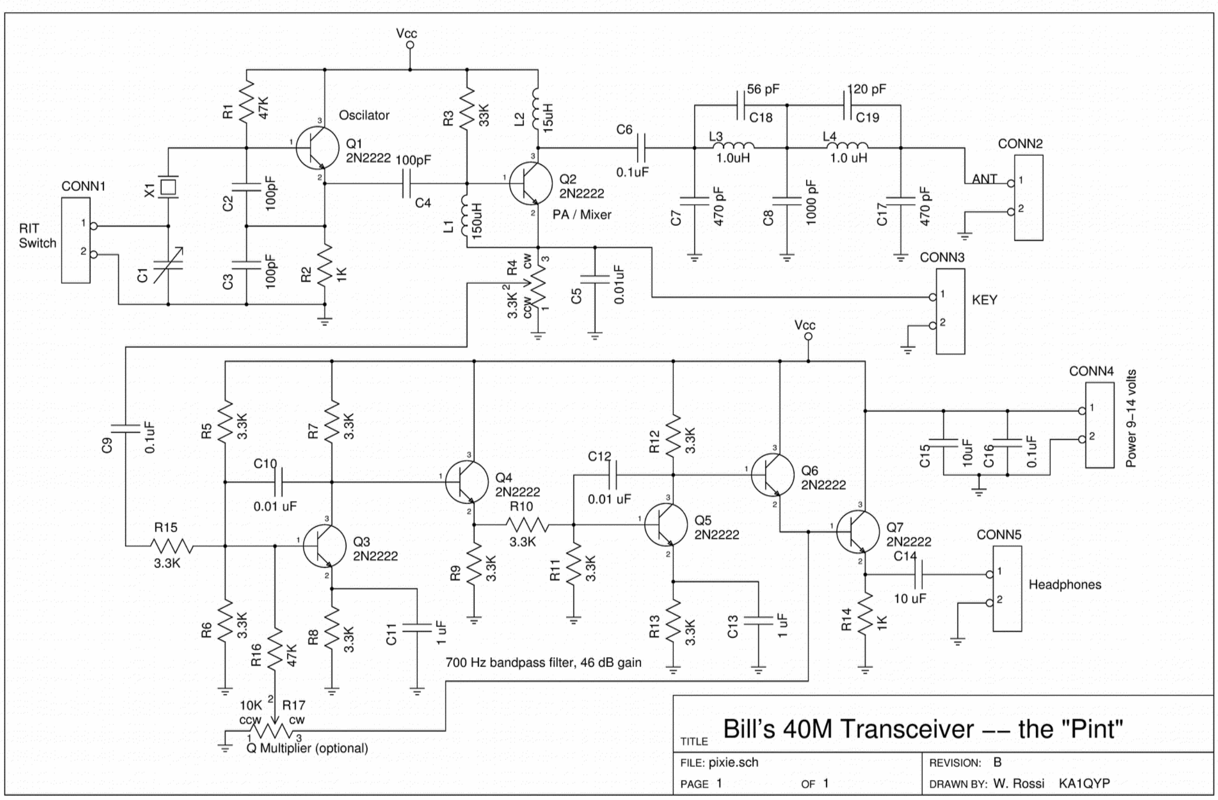

Figure 2

The second revision is shown in Figure 2. It incorporates the improved low-pass filter, and the Q-multiplier control. R4 was changed from 10K to 3.3K which improved mixing performance of Q2. Its shown as a pot in the drawing, but I just used a fixed resistor. A gain control is not really necessary.

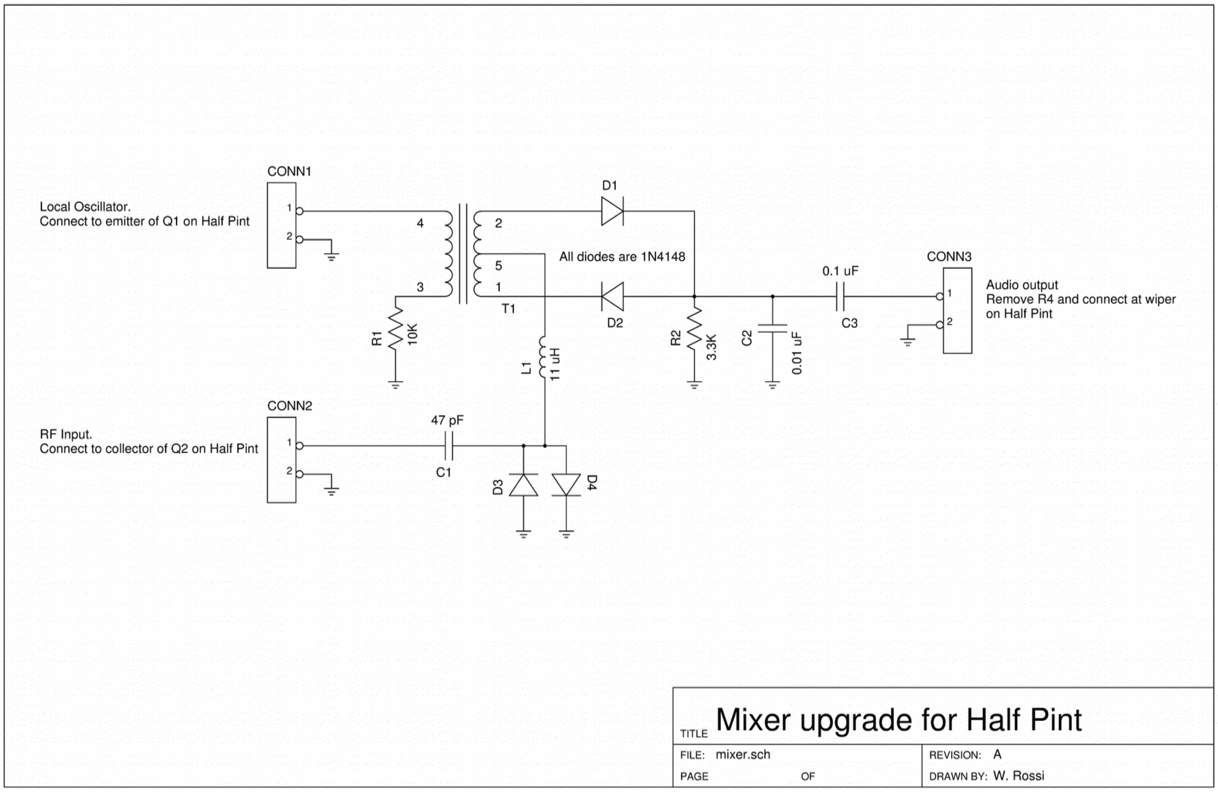

Figure 3

I made a small add-on board with a replacement mixer shown in Figure 3. This singly balanced diode mixer greatly improves the signal to noise ratio in the receiver. However, it adds complexity and reduces the receiver gain by about 8 dB. Unless you're looking for a very small package or hate winding coils, I think the advantages outweigh the disadvantages. L1 and C1 provide some front end filtering and are chosen to be resonant on 40 meters.

To increase my output power I bought an amplifier kit[4] designed by Chuck Carpenter, W5USJ, from QRPme.com. With this, I was able to boost my output on 40 meters to 8 or 9 Watts. With increased power, I was able to make more contacts.

Having independent tuning controls for transmit and receive and a T/R switch was cumbersome to operate. I decided that when I built another for 20 meters, I'd add automatic T/R switching and offset. Figure 4 shows a tuning module using a 1N4001 diode as a varactor. Potentiometer R1 is the main tuning control, and R2 is the receiver offset control. Using this tuning mechanism made operation much easier. Note that the receive frequency here is always higher than the transmit frequency, so be sure you're listening to the upper sideband before calling someone.

Building for 20 meters required changing the low-pass filter, and capacitors C2-C4 and L2. Q2 was changed to a 2N3866 for better gain at 14 MHz. The mixer module also needed L1 and C1 changed.

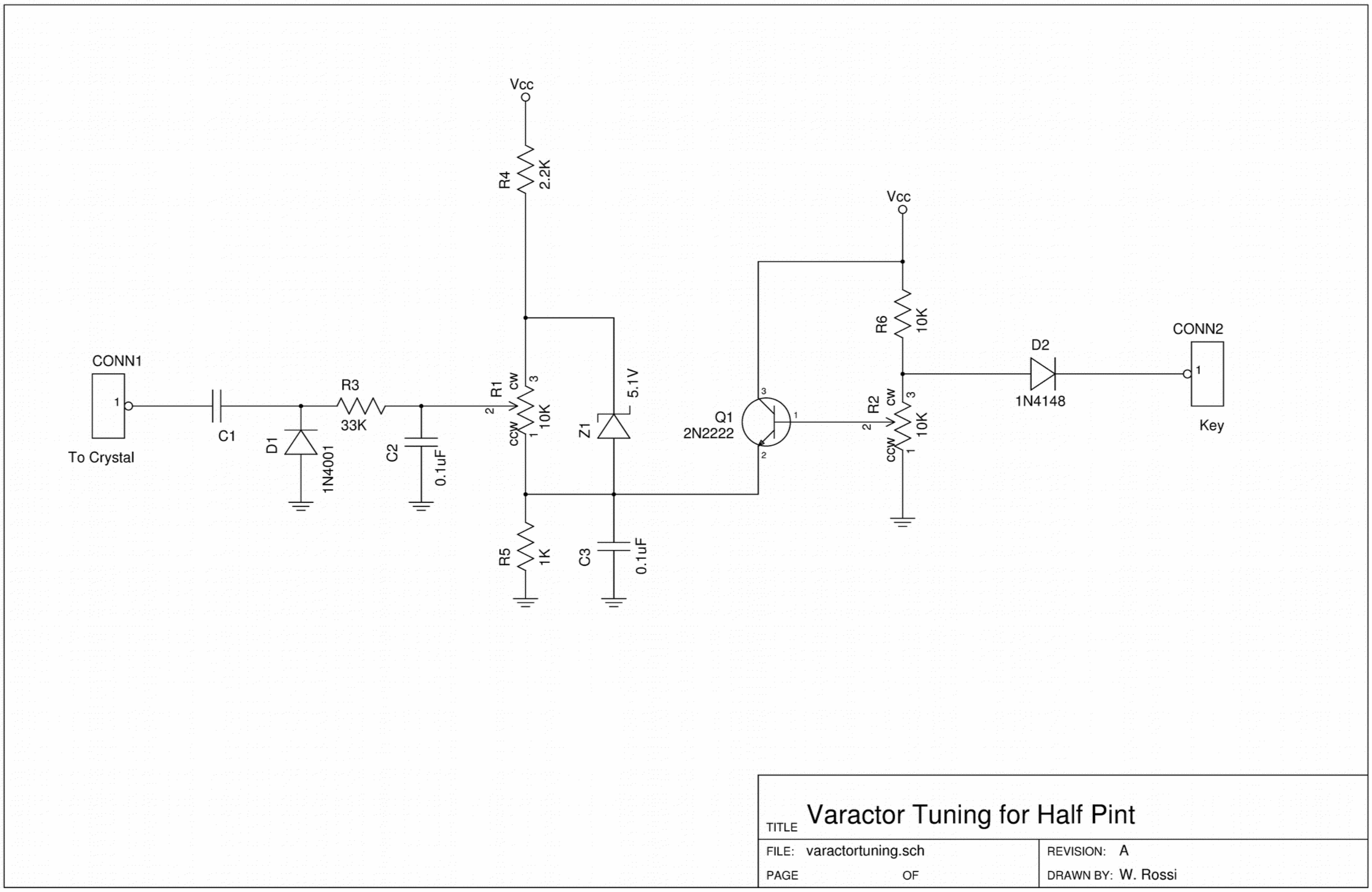

Figure 4

On my 20 meter version I put a rotary switch with 2.2 uH inductors between the crystal and the tuning module shown in Figure 4. This allowed me to add in some multiple of 2.2 uH and then I could tune about a 20 KHz portion of the band.

The power supply for this rig can be between 9 and 20 volts. The power needs to be clean as any ripple will be heard in the headphones. I generally run off of a battery for this reason.

Building this has been a lot of fun, and I hope others will be able to enjoy it as well.

Specifications

- Power supply: 9-20 volts DC
- Receive current: 35 mA @ 13.8 VDC
- Power output: up to 1 Watt on the 40 meter band with 16 VDC power supply
- Receiver sensitivity: approximately 10 uV @ 10 dB S/N
- Audio gain: 42 dB + 20dB from Q-Multiplier = 62 dB
- Receiver Selectivity: less than 500 Hz

References

1. Joeseph, Dave, "The Pixie 2: An Update", QRPp, Voume 3, June 1995, pp. 45-48
2. DeMaw, Doug, "Pixie-2 QRP Transceiver for 3.5 Mhz.", QRP-L mailing list, April 1997, <http://www.qsl.net/qrp/txr/micro80.htm>
3. Andersen, Rick, "The RixPix", Personal Website, Mar 2005, <http://www.ke3ij.com/rixpix.htm>
4. Carpenter, Chuck, "TxTopper QRP Gallon Amp by W5USJ", Personal Website, <http://w5usj.com/TxTopperQRPAmp.html>