All Things Digital

Amateur Radio for the 21st Century
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The Pixie 2: Part 2

21st Century Pixie 2

In 1996, a varactor controlled receive incremental tuning (RIT) crystal oscillator (VXO) circuit “Add RIT to the Pixie 2” (*QRPp*, March 1996) was added by Jeff Furman, KD6MNP (see Figure 1, next page). A varactor (varicap or variable capacitor tuning diode) is a special diode whose reversed-biased [PN] junction capacitance varies with voltage. The VXO provided several kilohertz (kHz) of frequency swing along with an automatic receive incremental tuning (RIT) audio offset of several hundred hertz (Hz) when switching between transmit and receive. Jeff also opined that perhaps 1N4001/1N4007 type power [rectifier] diodes would work (they do, but have less capacitance/pull).

More searching of the *QRPp* online PDF files found “The Pixie 2 with TiCK Sidetone and Offset” (*QRPp*, Winter 1997) by Charles Ludinsky, K1CL. He added an electronic keyer using an Embedded Research TiCK chip, plus another transistor to automatically switch an RIT fixed offset capacitor in/out of circuit, but Charles omitted varactor tuning (see Figure 2, next page). Embedded Research liked the design and sold it as a kit called the “Tixie 2”. The PCB can still be ordered from Far Circuits, and modern TiCK keyer drop-in replacements are available from various sources. Around the same time, the great QRP designer and operator Doug DeMaw, W1FB published his own version of the humble Pixie 2 with automatic 700 Hz transmit offset and a 700 Hz narrow band audio operational amplifier (op amp) filter.

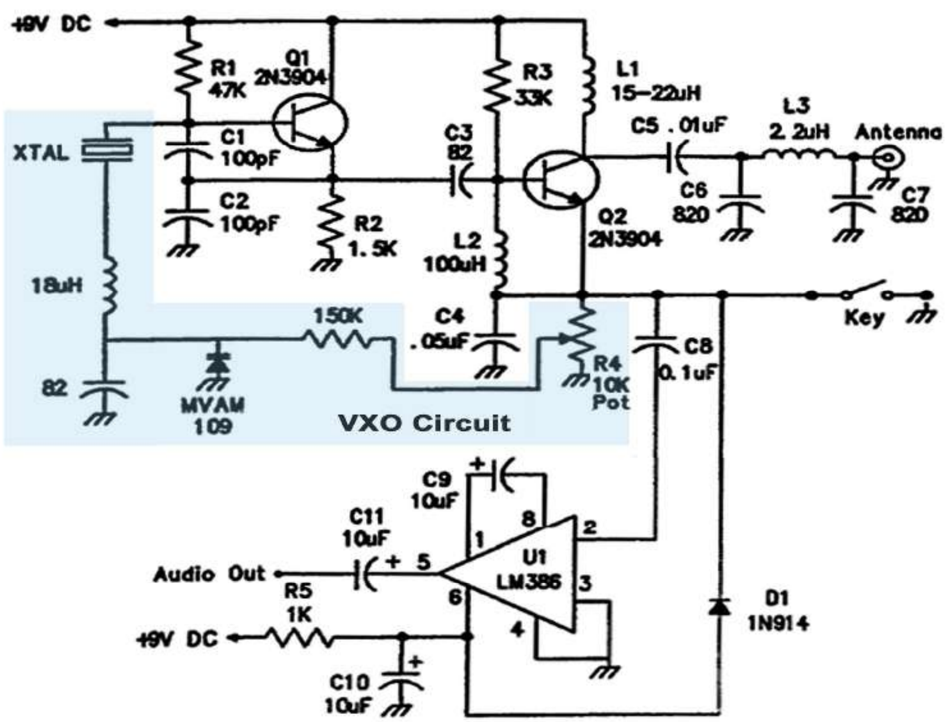

Figure 1: Pixie 2 with added VXO tuning circuitry. Credit: *QRPp*.

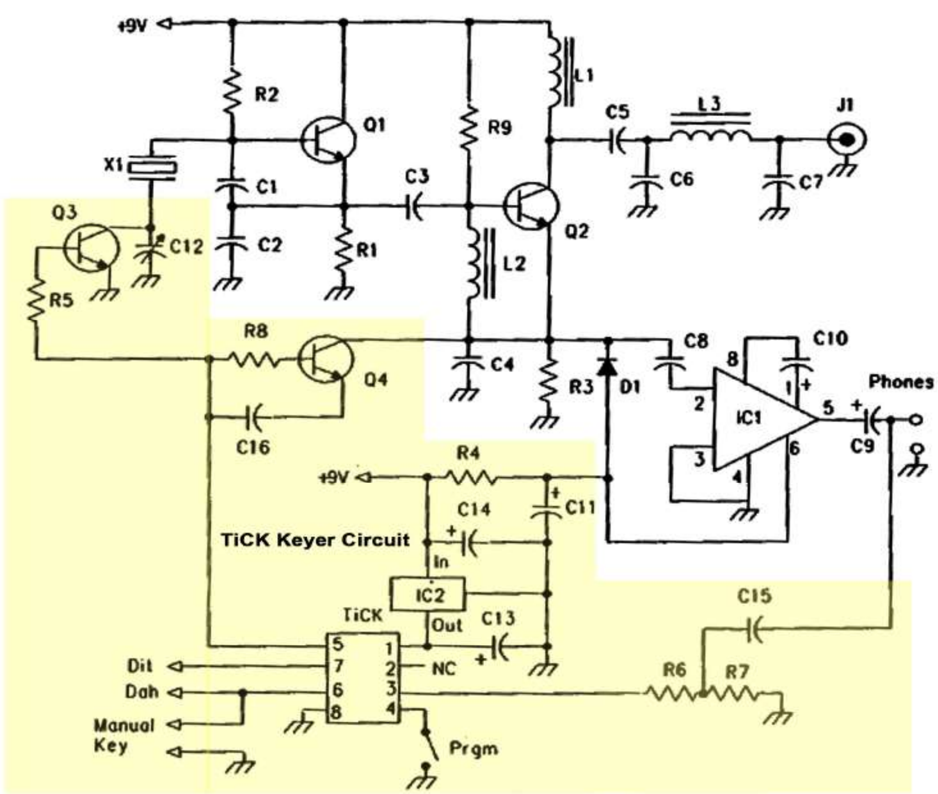

Figure 2: Tixie 2 with added TiCK keyer circuitry. Credit: *QRPp*.

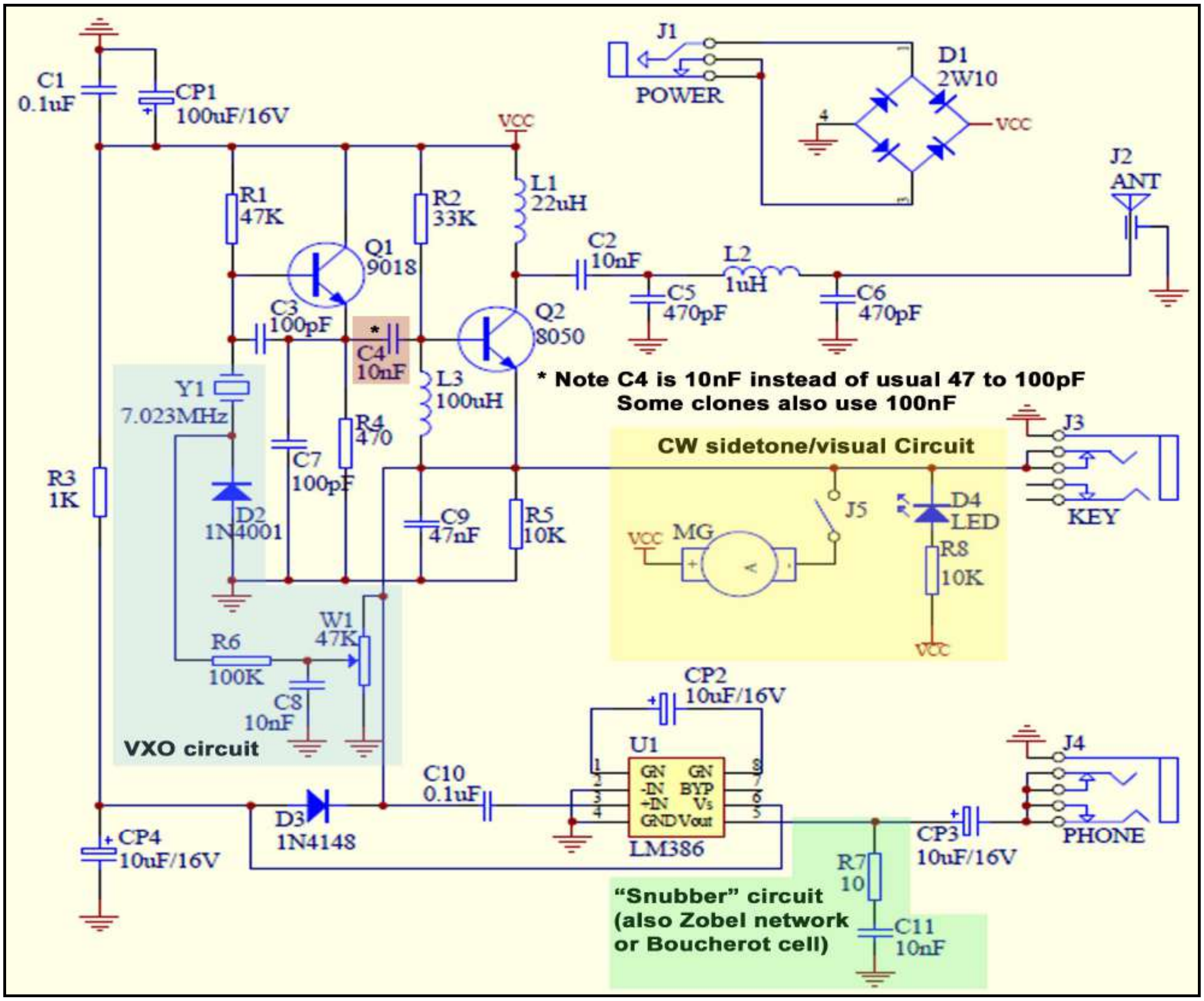

Figure 3: This seems to be the standard design used by most clones—with minor variations. But for some reason, they still don't include the [now] well-known LM386 power control diode pin 7 rerouting, and they still use the woefully inadequate Pi filter. You have to fix that. Credit: S-Pixie 2 manual.

A variation of Jeff's VXO circuit is used by many 21st century Chinese clones. Some designs have added a piezo speaker for the sidetone generator, but the audio isn't routed into your headphones. The piezo speaker is extremely loud and shrill (at least to my ears), but putting a piece of electrical tape over it fixes this nicely, and also shifts its frequency down a bit from the usual 1000 Hz signal they shriek. Some clones also add a light emitting diode (LED) to provide a visual sidetone when keying the transmitter on/off (see Figure 3).

Figure 4 is the schematic diagram of some of the modifications you can add to the S-Pixie 2 (40 m band). Figure 5 (next page) shows the modified circuit board top and bottom. Swiss machine pin female headers were added to easily swap critical components in/out for experimenting with various combinations.

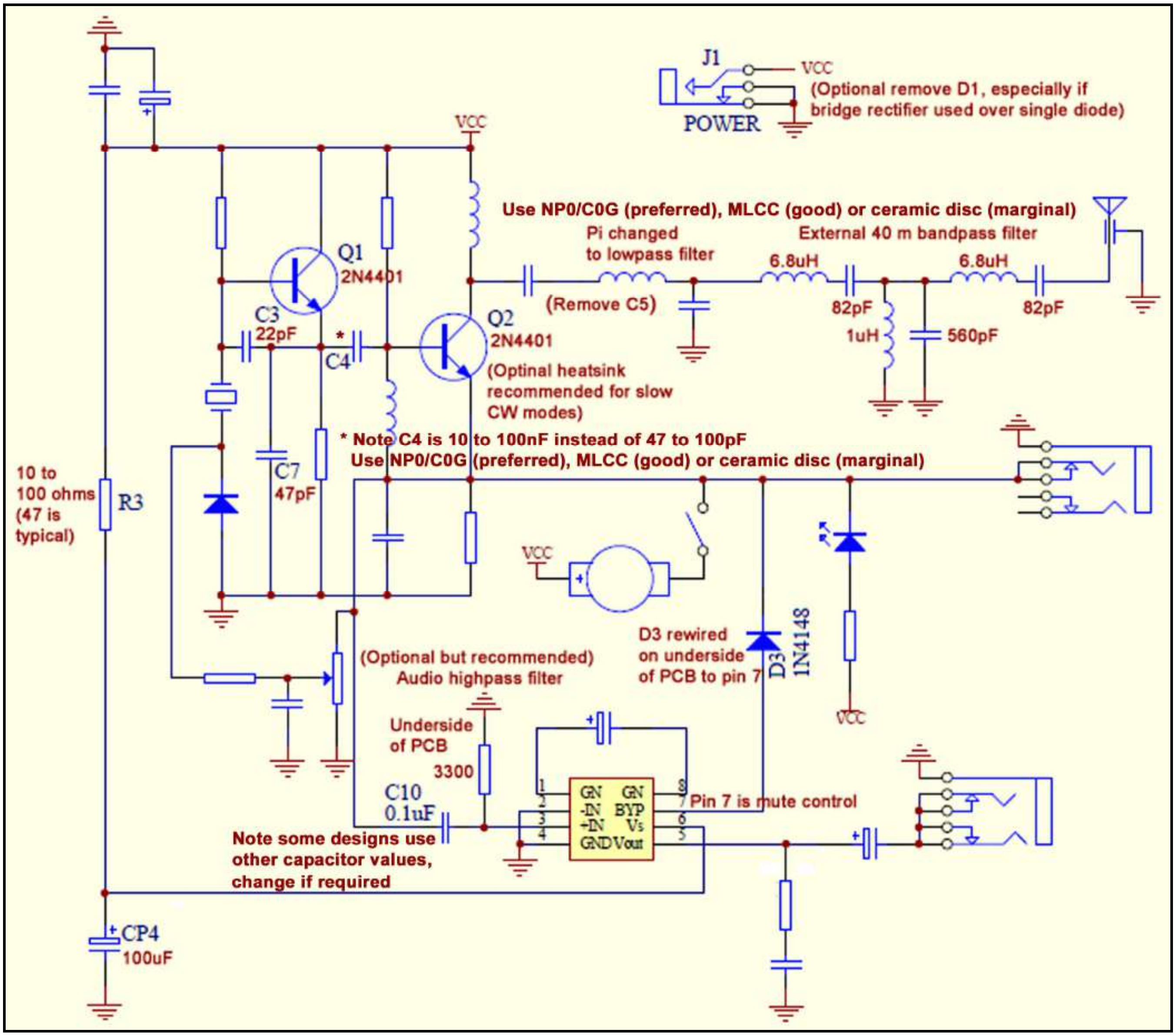

Figure 4: Various S-Pixie 2 modifications.

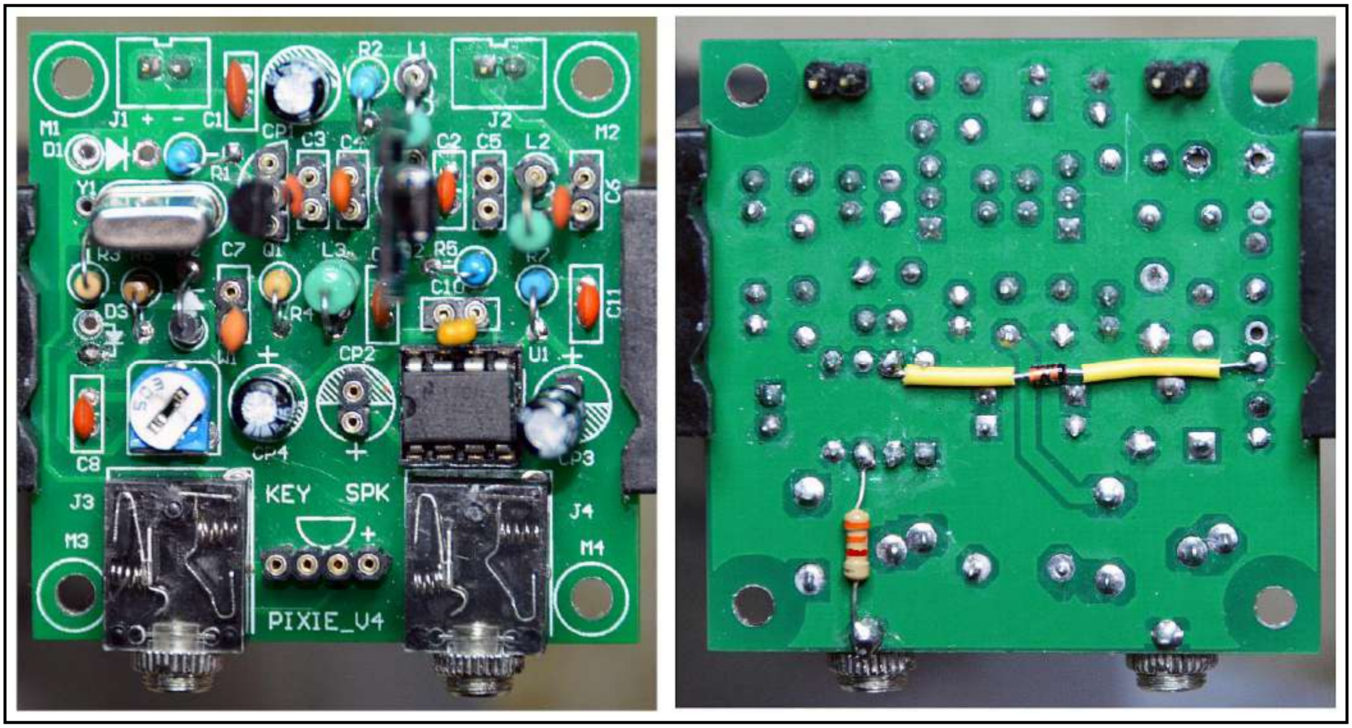

Figure 5: Modified S-PIXE 2 circuit board.

Explanations of S-Pixie 2 Clone Modifications (40 m band)

1. Reverse voltage polarity protection is provide with the Chinese clones using a power diode (or bridge rectifier), but I prefer to remove this because most kits use JST (Japan solderless terminal) connectors or polarized power jacks. We need to squeeze every milliwatt (mW) from our very low power (QRPp) transmitter, and can’t afford any extra voltage drop(s) from rectifiers at this early stage.
2. An external radio frequency (RF) bandpass filter (see Figure 6, next page) was added to improve transmit/receive performance by restricting the DC receiver’s very wide bandwidth and multi-mode demodulating capabilities (both pro and con), in reducing amplitude modulated (AM) radio broadcast band (BCB) interference (BCI), and in meeting today’s more stringent harmonic attenuation requirements, which is at least 43 dBc (decibels below the carrier).

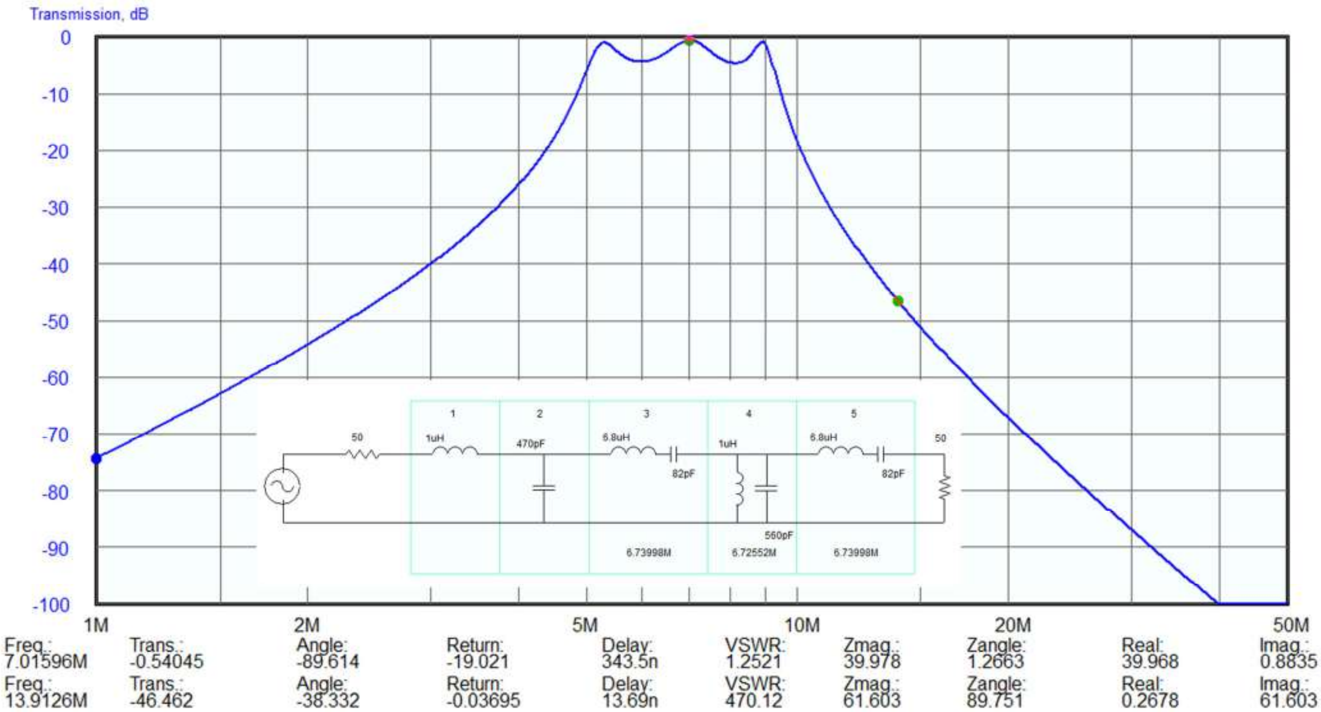

Figure 6: Chebyshev bandpass filter (40 m band). This design uses standard value moulded inductors and NP0 (negative positive zero) capacitors for more convenience albeit not as optimized using custom wound wire toroids. The Elsie model depicts passband ripple typical of Chebyshev filters along with the sharp, steep sloping sides ("skirts") typical of the type 1. Credit: ELSIE filter design program.

3. The kit's transistors are replaced with the medium power 2N4401 transistor (they just work so much better). A heat sink was also added because the power amplifier (PA) gets very hot when using extremely slow keying (QRSS) modes with very long key down transmitter duty cycles, but you can omit if only using the faster continuous wave (CW) modes with much lower duty cycles.
4. Most Chinese Pixie 2's now use an LO to PA coupling capacitor of 10 nanofarads (nF) or sometimes 100 nF, instead of the old standard of 47 to 100 picofarads (pF).This change increases RF power output by about 25%, and also improves receiver conversion gain up to about minus 6 decibels (dB). We still have signal conversion loss with the combination mixer/PA stage so we'd need to add an RF preamplifier or use a different type of product detector to get more gain.

5. Both Colpitts oscillator capacitors changed. A lot of variations on a theme here, but as a general design rule the “bottom” capacitor’s value can either be 10 percent of the oscillator transistor’s emitter resistor value (470 ohms), or have an capacitance reactance (XC) close to 450 ohms, whichever works better (either 47 or 50 pF, in this case). The “top” capacitor’s value should be about half that and 22 pF was the closest standard value available.
6. The rest of the changes are for the LM386 audio amplifier stage. A DC receiver does 100% of its signal amplification and processing at audio frequency (AF) or baseband levels, and it operates right on the knife-edge between stable amplifier and howling oscillator. We also have to deal with “microphonics” (acoustic pickup and feedback) whereby any sources of mechanical vibrations are also mixed in and amplified.
    a. To improve LM386 performance and stability, its power supply resistor and filter capacitor are changed to better decouple it from the power supply, and provide more current to prevent current “starvation”, which often turns it into an unintended product detector and very prone to BCI.
    b. A 3300 ohm resistor (optional) is added to create a simple audio high pass filter in combination with the LM386’s input capacitor (make sure it’s 100 nF) to attenuate low frequency noise below 500 Hz.
    c. The control diode, normally used to cut power from the chip during key down (another source of current starvation) is rewired to pin 7. Pin 7 can do three separate things: provide a third [fixed low gain] audio input, add more power supply bypass and increased amplifier stability, or mute the audio output but keep the chip powered on (Sverre Holm, LA3ZA, 2003).

Ten DC Transceiver Operating Tips

1. Avoid any weekend. A lot of “big guns” running power and contests. You don’t have great dynamic range (ability to deal with weak and strong signals at the same time), or decent selectivity (ability to pick out specific signals from the crowd). The 30 m band could be used to avoid some of these problems.
2. “Make them come to you.” Pick a spot and call “CQ”. Add “/QRP” as necessary.

3. All DC receivers have sideband ambiguity. Let's say your LO is tuned to 7040 kHz; if a station is transmitting on 7040.8 kHz, you will hear the product detector's audio difference of 800 Hz in your headphones, but if another station is also transmitting on 7039.2 kHz you also hear the same 800 Hz audio difference! Without strong opposite sideband suppression it's always best to tune DOWN the band so you hit the higher sideband signal first.
4. Because of the total lack of receiver selectivity, it's really a good idea to add an ancillary audio signal processor (analog or digital); the listening difference is like night and day (see Figure 7).

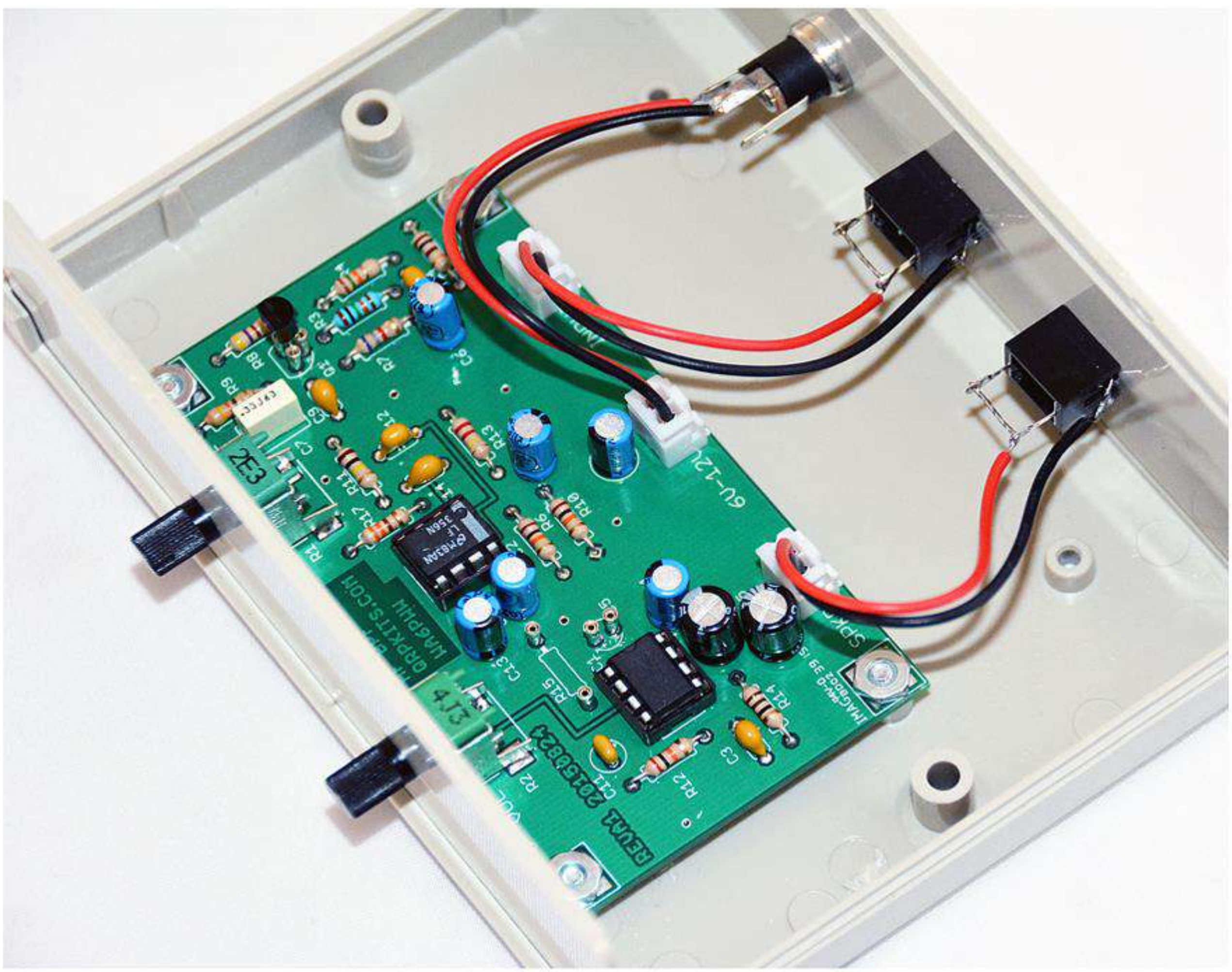

Figure 7: Variable audio bandpass filter and amplifier kit by QRP Kits (Pacific Antennas). A low noise audio preamplifier feeds a low noise bandpass filter (500 Hz) with a variable audio peaking filter (APF). This provides the badly needed receiver selectivity and also reduces signal noise. An audio amplifier boosts the processed signal along with a volume control (you supply case/connectors). The Pixie 2's product detector should be rerouted directly into this device bypassing its onboard LM386.

5. The solar cycle is heading towards a very deep and perhaps prolonged minimum by 2020 taking the propagation south with it, so be very happy if you can work someone in the next province or state over. In other words, don't expect long distance (DX) "miracles"!
6. A fully-charged and appropriate type 9 to 12 VDC battery pack is required to ensure oscillator/transmitter stability, and/or power any ancillary devices. Some kind of visual/audible voltage monitoring/regulating device is a good thing to use.
7. Let the transceiver warm up to electronic thermal equilibrium before using it (at least 30 minutes). The oscillator needs time to stabilize without drifting too much in frequency.
8. The varactor tuned VXO is non-linear (unequal tuning intervals). I.E. tuning up the band, frequency may start out changing slowly by 10 Hz intervals, then suddenly jump to 200 Hz by the tuning potentiometer's midpoint, and quickly shoot up at 500 Hz with another a slight turn (and vice versa tuning back down).
9. Don't set the VXO's tuning potentiometer to its low/high extremes (hard against either stop). You don't want to operate the oscillator too far below/above the crystal's stated frequency because it becomes less and less stable and more prone to transmitter "chirp".
10. The LO is always on, so a very weak RF signal leaks out into the local reception area. If you try to use a linear or switching power supply, the LO is picked up by the AC line cord, modulated by the 60 Hz line voltage, dutifully detected by any diodes or transistors inside the power supply, superimposed on the output voltage and rides back in on the interconnecting power leads. This mixes in with the receiver's product detected audio signals and heard as hum. And back and forth the cycle goes.

Additional Information and Ideas

A great source of inexpensive crystals and/or specific band pack collections is KC9ON.com, but you can easily convert a Pixie 2 to use a direct digital synthesis (DDS) variable frequency oscillator (VFO), as described in the book "Arduino Projects for Amateur Radio" (Purdum and Kidder, 2015). Coupling it to an Arduino or PICAXE µ-controller can take it to another level.

Once you do this, you can then transceive almost every carrier based data mode using free processing software available for µ-controllers, smartphones, and/or laptop/desktop computers. There're some really cool, amazing, useful and fun things you can do with the Pixie 2 because its design isn't immutable or written in stone so your imagination makes all possibilities possible. Build a few for propagation and/or telemetry radio beacons; receive and stream signals to the Internet of Things (IoT), or to any of the various Amateur Radio web digital data mode web servers

My Final

And just when you thought something so simple and sublime couldn't possibly become even more so, there's a 21st century redesign (Cripe, 2017). Because it's a huge departure from the original, and fixes some of the Pixie 2's inherent faults, I've decided to write about it as a separate article and not as a part 3 continuation.—73