2 Meter Miniverter – a tiny transceiver

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Last fall I acquired a used 10-meter mobile rig, an HTX-100, with the hope of using it as an IF radio for microwave transverters. Since most transverters have an IF output of 144 MHz or higher, an intermediate transverter was needed. It would have to be small enough to fit inside the radio, inexpensive, and have adequate performance for microwave operation.

Down East Microwave offers small transverters for 144 and 432 MHz for this application. Some time ago, I tried to fit the 432 MHz version into another HTX-100, but it didn't quite fit, so I ended up trading the whole mess for something else.

The problem with the DEMI transverter is that it had the same LO oscillator and multiplier circuit as their big high-performance transverter, and the LO took up most of the space. For 144 MHz, a smaller oscillator circuit might be possible — at a flea market, I found some canned computer oscillators for 115 MHz, perfect for a 29 MHz output. The oscillators have the same footprint as a 14 pin DIP IC.

Printed Circuit Board

I was ready to build a dead-bug transverter on a bit of perf board when heard about an outfit called ExpressPCB. They offer a "MiniBoard Service" — three boards made overnight for $59 — and they provide free software. With a PC board, I could make this transverter more robust, and make it possible to duplicate.

I looked at the web page (www.expresspcb.com) to see what was really offered. The boards are quality construction, double-sided with plated-thru holes, but the catch is that they have to be exactly one size: 2.5 by 3.8 inches. However, you can put as many copies of a circuit as you can fit on each board. If the transverter were small enough, I could fit more than one on a board.

I sketched out a basic transverter: oscillator, mixer, filter, and a couple of MMIC amplifiers. Then I downloaded the free software and starting seeing how it would fit. The software included footprints for surface-mount resistors and capacitors, which seemed like a good way to keep things small. However, footprints for RF stuff, like Toko helical filters, are not included, so I had to learn how to make them — basically placing the required hole sizes and locations, then "grouping" them together. (Note: the finished hole size after plating is 5 to 7 mils smaller than the drill size shown in the software.) Then the whole pattern can be added to other boards using cut-and-paste.

After I had all the components drawn on the screen, I printed out the pattern and stuck the components into the paper to make sure the footprints were correct. Then I started wiring the circuit together on the bottom of the board (green color), leaving the top for a nice ground plane. After some squeezing, it was clear that I couldn't fit more than two

transverters on each board, but I did have a little extra space for a small relay, so I added one plus a PTT circuit. All the wiring fit on the bottom except for one short crossover on the top surface; then I covered the top (red color) with copper for a ground plane, except for clearance holes for component pins.

The final step was to copy the whole circuit to the other half of the board, so that each board has the pattern for two complete transverters, requiring just a snip to separate.

Circuit

The final circuit is shown in the schematic diagram, Figure 1. All the components are available from Down East Microwave and Digikey, my preferred sources for small quantities. The board layout is shown in Figure 2, and Figure 3 is a photo of a couple of finished units. The layout diagram only identifies locations for the larger components, but the circuit is simple enough to trace out from the schematic. Besides, no self-respecting VHFer ever builds something without improving it somehow!

Although the layout only shows surface-mount components, the photo clearly shows two ¼ watt resistors with wire leads. The explanation is simple: the resistor dissipates nearly 200 milliwatts, and my board layout only had room for a 1/16 watt (0603) resistor. *Oops!* The improved layout in Figure 2 has two parallel resistors in a larger size at R6 to handle the power, so the next version can be all surface-mount on the bottom.

Performance

The transverter provides about 5 dB gain in each direction, just enough to cover any stray losses between a microwave transverter and the IF radio. Maximum drive on transmit should be less than 0 dBm; the output power is then about right to drive the microwave mixer. Receive noise figure with a MAR6 MMIC should be in the 3 dB range, more than adequate with a decent microwave front end. The helical filter does a decent job, with LO and image down 30 dB or so, but not good enough to transmit on 2 meters — another filter would be needed before the power amps.

Oscillator

The oscillator operates at the LO frequency, so there are no extra birdies from frequency multiplication. However, this limits our choice of IF frequency unless we are buying huge quantities. I was fortunate to find some 115 MHz oscillators — they turned out to be ECL oscillators, requiring –5 Volts, so I had to install them backwards and insulate the case with some tape.

There are some other possible oscillators in the Digikey catalog. One choice would be 120 MHz, resulting in a 24 MHz IF; any HF radio made in the last 15 years includes the 12 meter band. Another possibility is a programmable oscillator: Digikey carries one made by Epson. I got a couple programmed to 116 MHz, for a 28 MHz IF. On the spectrum analyzer, phase noise is not as good as the fundamental crystal oscillators. By

ear, there is a definite increase in noise, enough to hamper weak-signal operation — these oscillators are probably only good for FM operation. I also tried a programmable oscillator from another manufacturer; the phase noise was even worse.

How to get your own PC board

You can get your own PC board by ordering it from ExpressPCB. First you download their software from www.expresspcb.com, then download the miniverter file at www.w1ghz.cx/miniverter.zip. Install the software on your PC and use it to open the minivert.pcb file. If you don't wish to make any changes, pull down "Layout" on the tool bar and select "Order boards via the Internet," and you'll have them in a few days. But I'm sure you'll want to make some improvement, so feel free to modify the layout.

The minimum order quantity is 3 boards for $59, which can make six transverters since I put two patterns on each board, so you might want to share an order. Another alternative would be to replace one of the transverter patterns with something else, so that you get two different circuits on each board — just make sure it fits in the same space. Any change from the fixed board size requires a much different price schedule.

Even if you don't want to make a miniverter, you might want to look at the layout and try modifying it to get a feel for the PCB software. Perhaps you will be inspired to come up with another design.

Summary

The Miniverter is not going to be a kit, at least until we find a good source for oscillators. But that wasn't my intent in writing this; the idea was to illustrate what you can accomplish with a simple and inexpensive source for PC boards. I've made enough PC boards with icky chemicals in my basement that I can assure you that using a mouse is a much better way.

So think about that idea for a small project that you never got around to building, and do something about it. Then share the files with the rest of us to copy and improve.