Problem with W1GHZ Simple and Cheap 1296 & 902 MHz Transverter PC Boards and 1152 MHz LO boards

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Tony, G4CIZ, recently found a problem my 1296 MHz transverter boards. The transverter had low gain at 1296 MHz. With the help of Brian, G4NNS, he found that the printed hairpin filter was tuned too low in frequency, so that it had excess loss at 1296 MHz. Removing approximately 2 mm from the open end of each hairpin resonator moved the center frequency up near 1296 MHz. Subsequent investigation found a similar problem with the 902 MHz transverter PCB.

What caused this problem

Printed circuit boards are made of epoxy resin filled with sheets of woven fiberglass for stiffness. The dielectric constant, typically 4.1 to 4.5, depends on the ratio of epoxy to fiberglass; each fabricator has their own recipe, so it usually doesn't vary a lot from a given vendor. But there are no guarantees – any testing of dielectric constant would be at 1 MHz, which has only a weak correlation to the effective dielectric constant around 1 GHz.

My original boards were made by ExpressPCB. They provide three quick prototypes at reasonable cost, but have a setup charge for larger quantities, so large quantity orders are needed to make the cost per board reasonable. The demand for my boards is very modest, so I use a vendor that provides modest quantities at modest cost, making them affordable for hams.

My best estimate for the effective dielectric constant from ExpressPCB is about 4.2, based on matching measured center frequency of printed hairpin filters to simulation with Serenade software. When I switched to a new vendor, the filter performance was similar. In 2018, I decided to cover the hairpin filters with soldermask to protect them from handling and soldering; previously, the metal traces were unprotected . This moved the center frequency down by about 20 MHz, putting 1296 MHz near the edge of the passband.

After Tony alerted me to the problem, I measured a current PC board filter as well as the earlier test boards. The center frequency had indeed shifted, as shown in Figure 1. I found the same shift with 902 MHz transverter boards. From this data and Tony's experiment, I shortened the hairpin resonators by 0.075 inches at each end and ordered new PC boards. Filter performance of these boards are shown as 2024e in Figure 1, with a center frequency of 1315 MHz. That is slightly high, but it looks like hams will only be using the top end of the band, and it improves LO rejection.

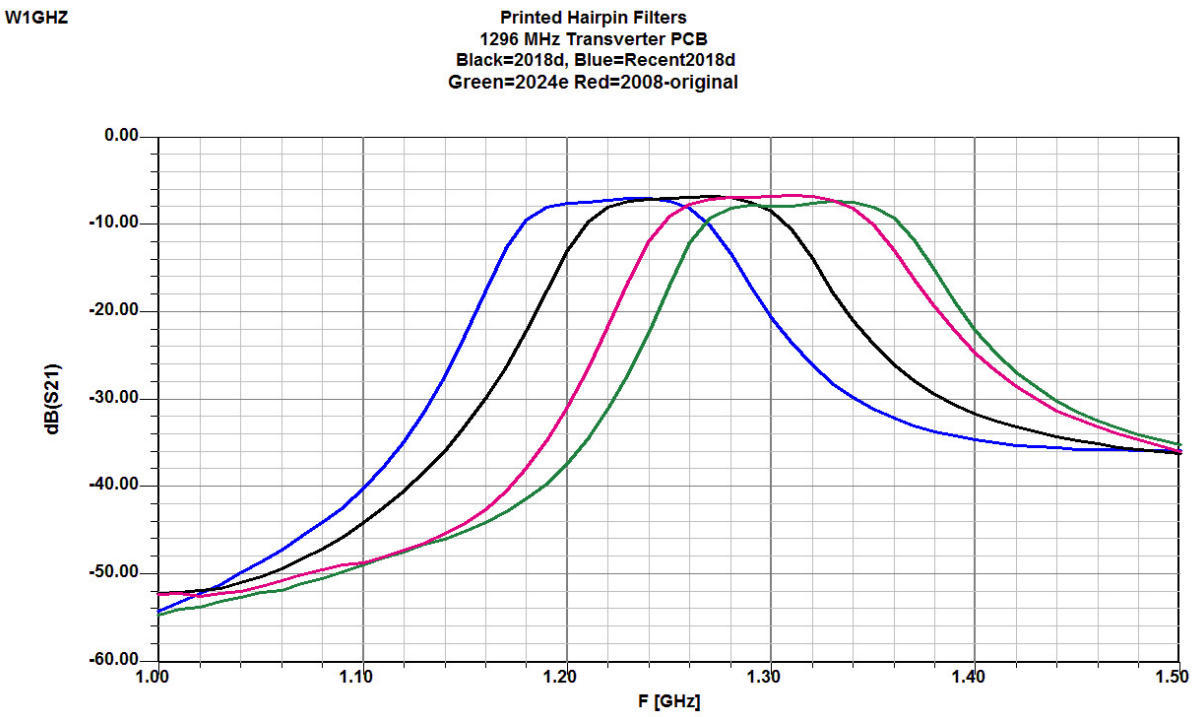


Figure 1 – Measured response of 1296 MHz printed hairpin filters

902 MHz Transverter

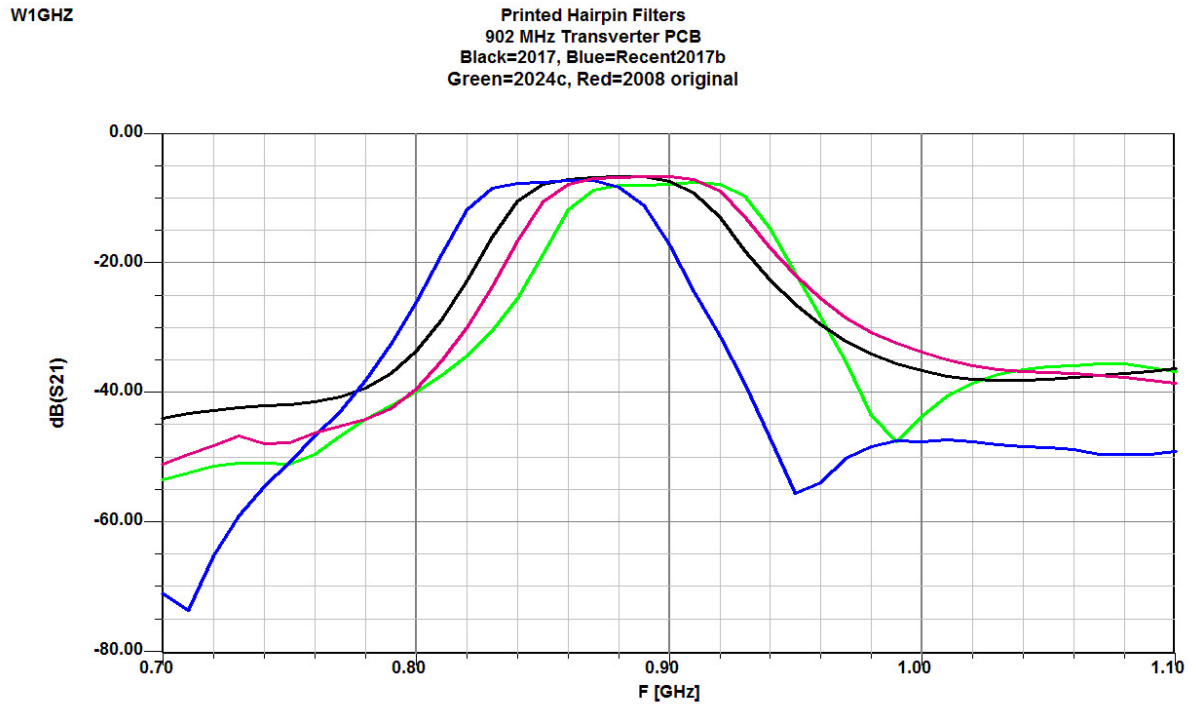
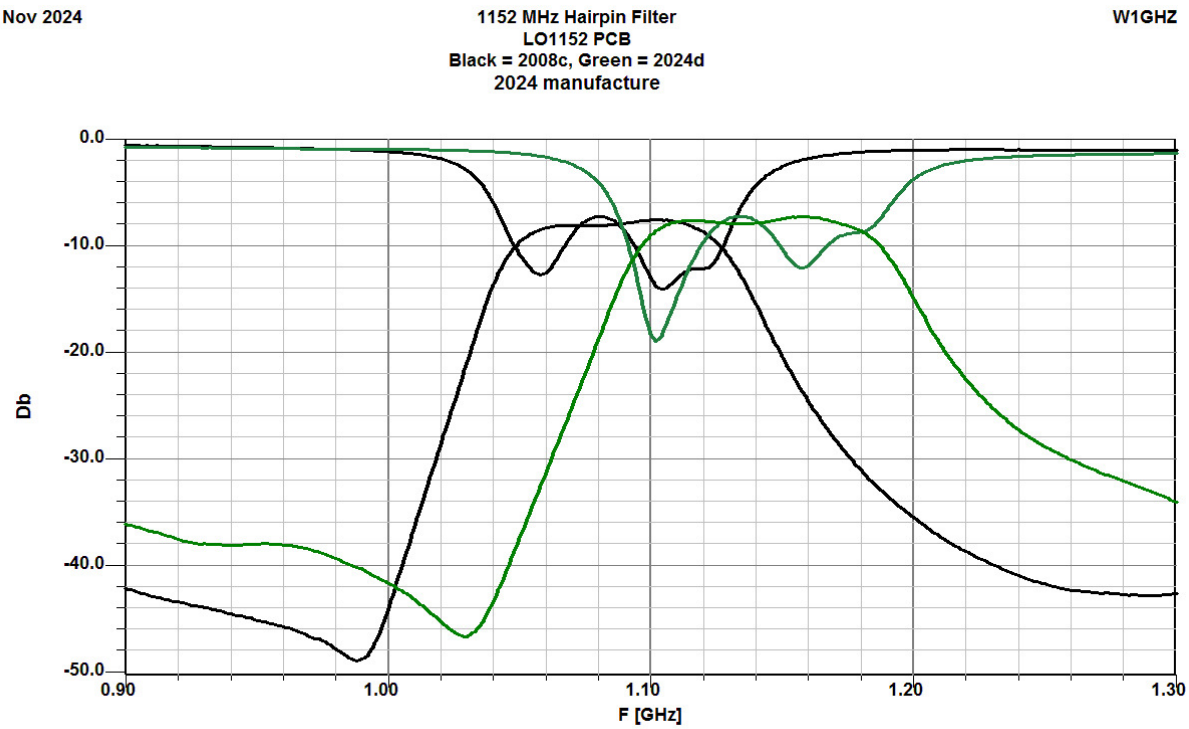


Figure 2 – Measured response of 902 MHz printed hairpin filters

The 902 MHz transverter also uses hairpin filters printed on the PC board, so I measured these also. The recent ones are also centered low in frequency, at about 850 MHz, resulting in excess loss at 902 MHz. I shortened the hairpin resonators by 0.075 inches at each end and ordered new PC boards. The new 2024c boards are centered at 901.5 MHz and cover the whole 902-928 MHz band. Measurement data is shown in Figure 2.

1152 MHz LO

Finally, the Local Oscillator boards for 1152 MHz and 720 MHz use printed hairpin filters. The 720 MHz board uses a 3-hairpin filter, which is still centered at 720 MHz on a very recent batch. But the 1152 MHz board uses a 4-hairpin filter like the 1296 and 902 MHz board, which has also shifted in frequency as shown in Figure 3. I shortened these hairpins by 0.075 inches at each end and ordered new boards. The new 2024d boards are centered at 1142 MHz and easily include include 1152 MHz in the passband.



What next?

Since I haven't tested every lot, any 1296 MHz transverter board in the past four years is suspect. Therefore, I will replace any board labelled 2018d on request with a 2024e board. If you have already built a transverter using one, performance might be improved by simply trimming 2 mm from the open end of each hairpin resonator.

For 902 MHz, I will replace any board labelled 2017 on request with a 2024c board. Existing boards may be trimmed also.

For the 1152 MHz LO, I will replace any board labelled 2008c on request with a 2024d board. Very old boards are probably fine, and existing boards may be trimmed.

Transverter PC boards for other frequencies do not have a problem, since they use pipe-cap filters that are individually tuned and do not rely on the PC board dielectric.

If you have any use for the filters centered at 850 or 1224 MHz, they are available while they last for cost of postage.