Pipe Coupler Filters for 1296MHz

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As part of a project to use a Pluto SDR on the microwave bands, I've been experimenting with pipe cap filters. When researching the topic, I read Paul Wade's paper "Pipe Cap Filters Revisited"[1], where he stated:

> Pipe-caps for larger diameter pipe are not significantly taller than the one-inch variety. Thus, they cannot accommodate much longer screws, so will not operate much lower in frequency.

When I was at the hardware store purchasing pipe caps, I came across a 1" pipe coupler which is longer than the pipe caps. I thought: is this long enough to tune down to 1296 if I enclose it myself? I bought one to experiment with.

Prototype

To make a top for the coupler, I soldered a #10-32 brass nut to a piece of PCB material. I made a base using a board with UT-141 sticking through the board and soldered to it. I copied the probe spacing of .7" from a W1GHZ transverter board for 2304MHz. I clamped the prototype together in a vise, and measured it with a NanoVNAv2 (v2 operates to 4.4GHz). The results were encouraging so I investigated the best probe length experimentally. I found that 1" and 0.8" probe lengths worked best. A plot of a single filter with 1" probes is shown below.

Construction

I had a W1GHZ 2304/3456 transverter board (2016 version) on hand. This board was designed to use two filters for the LO chain, one common filter for RX and TX and a second filter for TX. I had no need for the LO chain, so I use the four filters as two independent chains. This is also what Paul's latest design does. Since the frequency is much lower than the board is designed for, I used 22nH inductors in place of the dropping resistors.

I constructed the top the same way as the prototype. When soldering the coupler and lid assembly to the transverter PCB, I held the nut with a screw to keep it from falling off.

One of the filters, has a much higher attenuation and worse return loss than the others, so I decide not to use it. I've resisted the temptation to un-solder it to find out what the problem is.

References

[1] Pipe-Cap Filters Revisited Paul Wade W1GHZ ©2008 from www.w1ghz.org

VNA View

Calibration   S parameters   View   Device   Debug

Impedance	Admittance	Series Admittance	Parallel Impedance	Series Equivalent	Parallel Equivalent
53.87	0.0184	0.0186	54.43	53.87 Ω	54.43 Ω
- j5.53	+ j0.0019	- j0.1809	‖ j530.37	22.20 pF	231.46 fF

mag(S21)   mag(S11)

Calibration

Calibration type:
SOLT (T/R)   ?

Measure...
Short
Open
Load
Thru

Clear Measurements
Clear
Apply

Current calibration:
SOLT (T/R)

30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0

30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0

1100.0   1144.4   1188.9   1233.3   1277.8   1322.2   1366.7   1411.1   1455.6   1500.0

×	2	1500.00 MHz	-20.2 dB	0.9 dB
×	1	1100.00 MHz	-28.6 dB	0.3 dB
+	0	1296.49 MHz	-0.1 dB	-23.8 dB