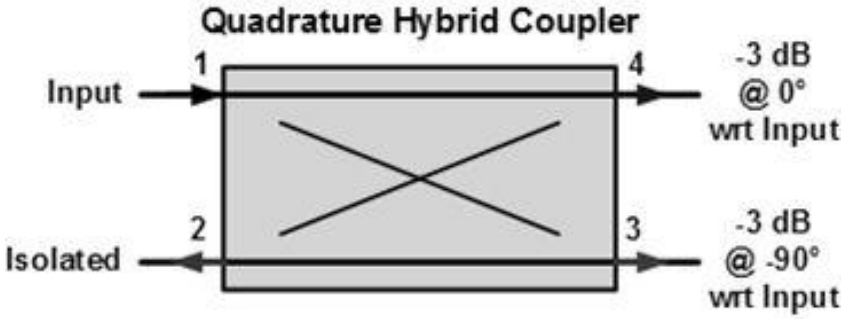
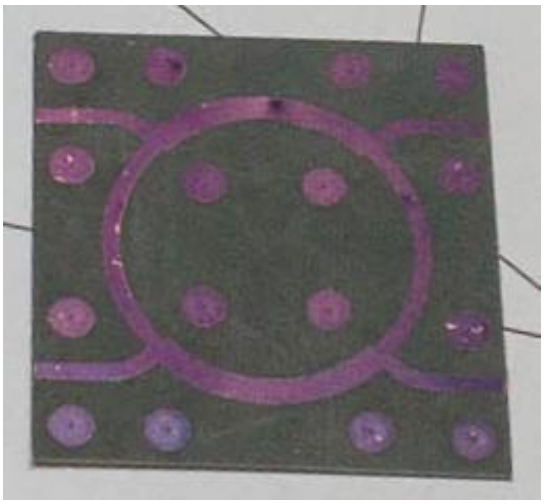
S-band 90 degree hybrid coupler

Matthias DD1US February 5th2020

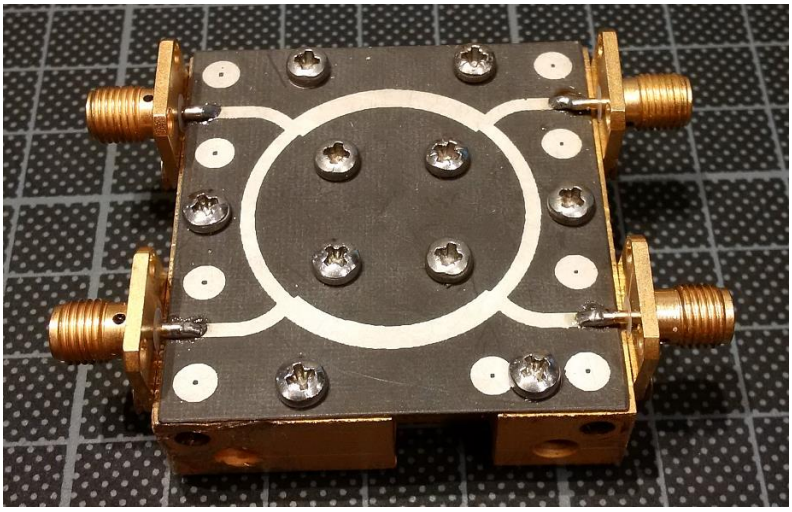
90 degree hybrid couplers are very useful for various RF applications.

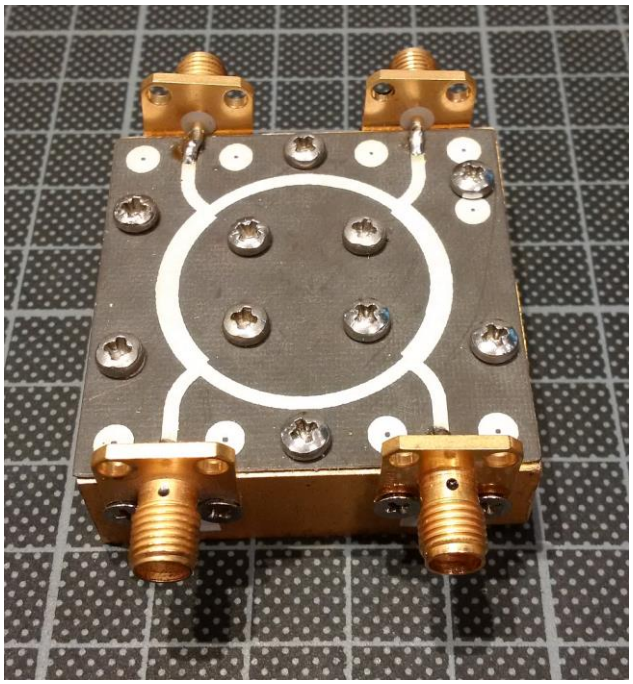


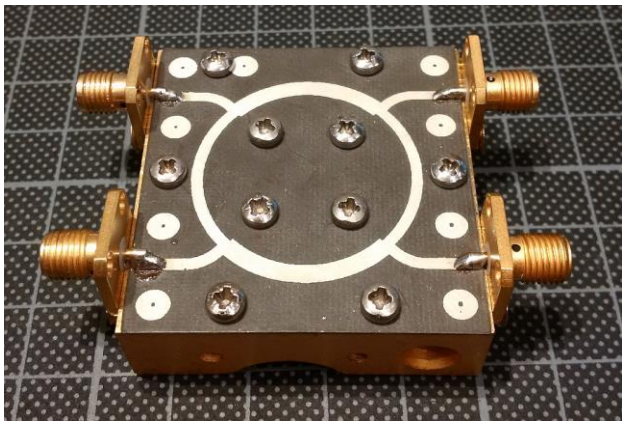
Sometime last year I got a PCB with an etched branch-line coupler from DD1IA. He had bought it from PE1RKI but never tested it himself. The coupler should work at 2.4 GHz and handle up to 2 times 100W input power as a combiner.

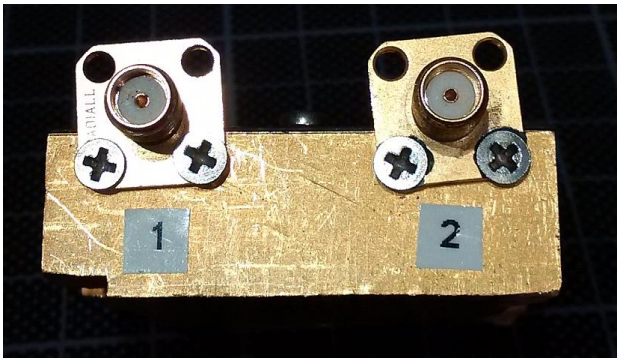


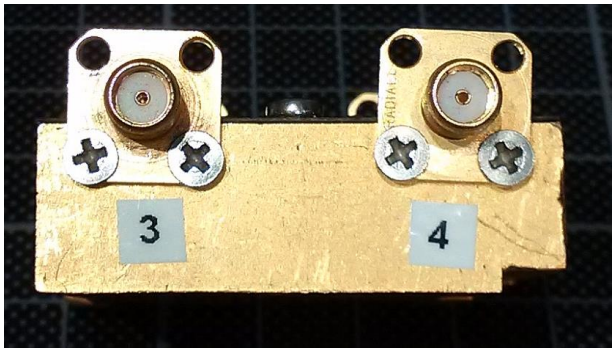
I cleaned the Teflon PCB and silver plated it. Then I mounted it on a surplus brass plate (which is gold plated which makes it look like 😉) in order to be able to test it.



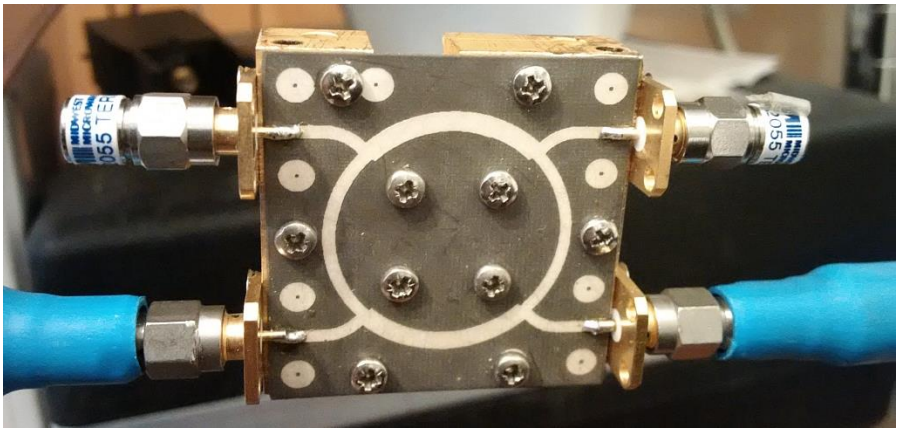


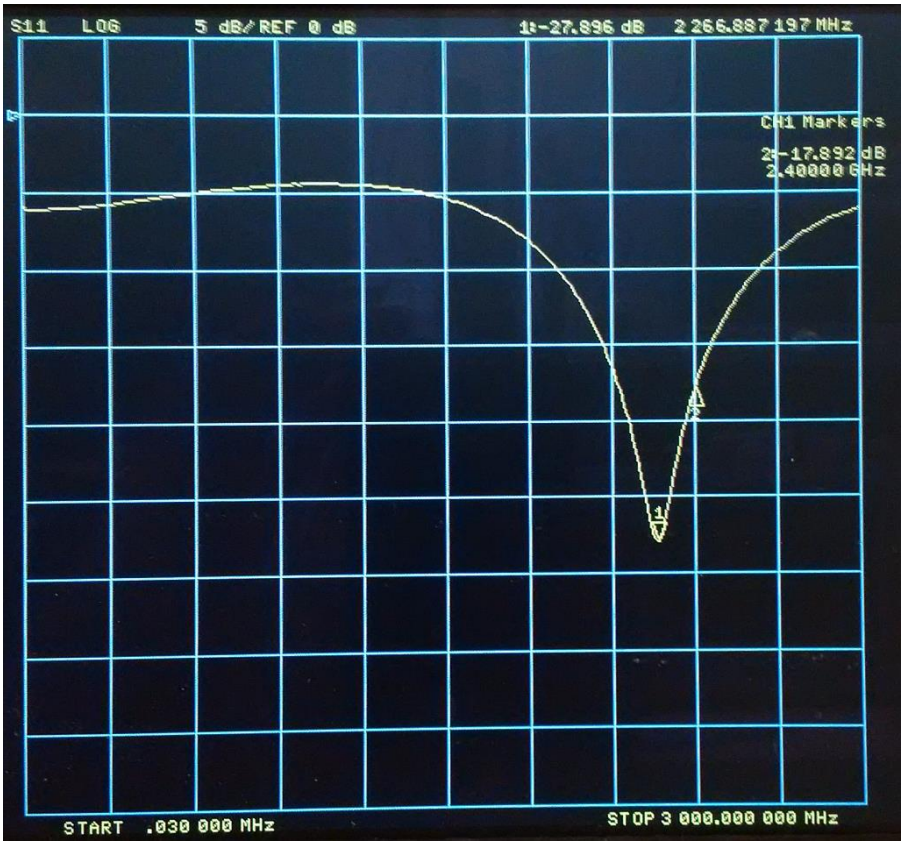



1
2

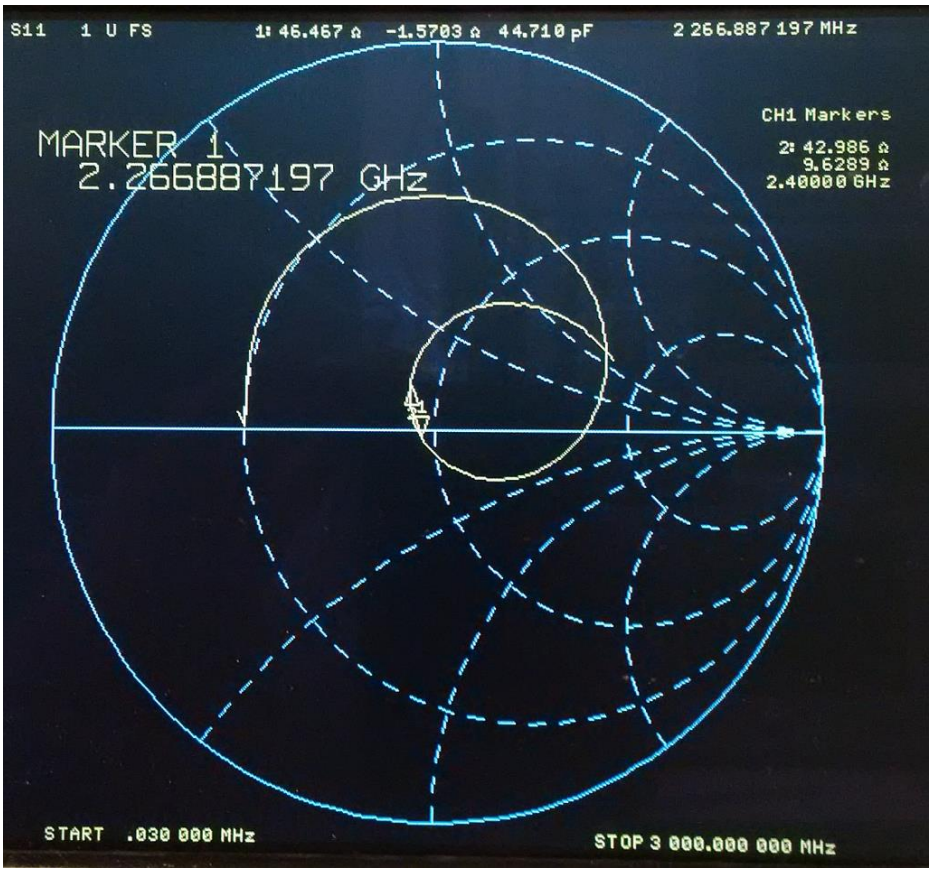

3
4

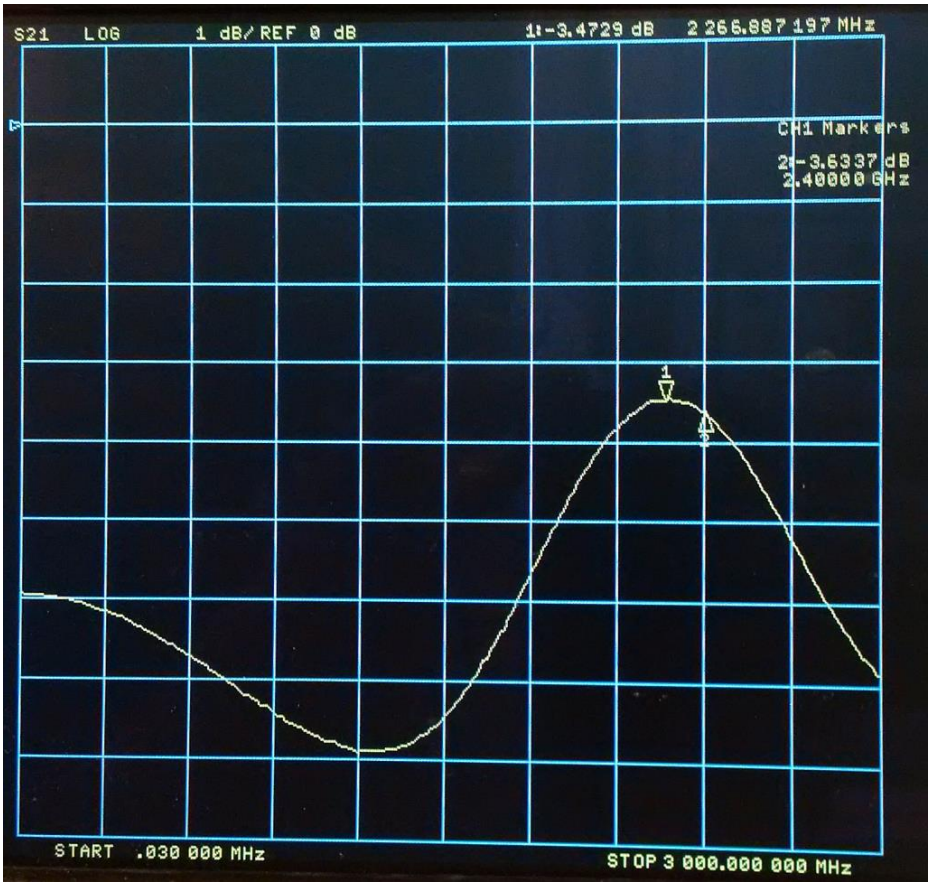
I started with measuring the characteristic from port 2 to port 3.



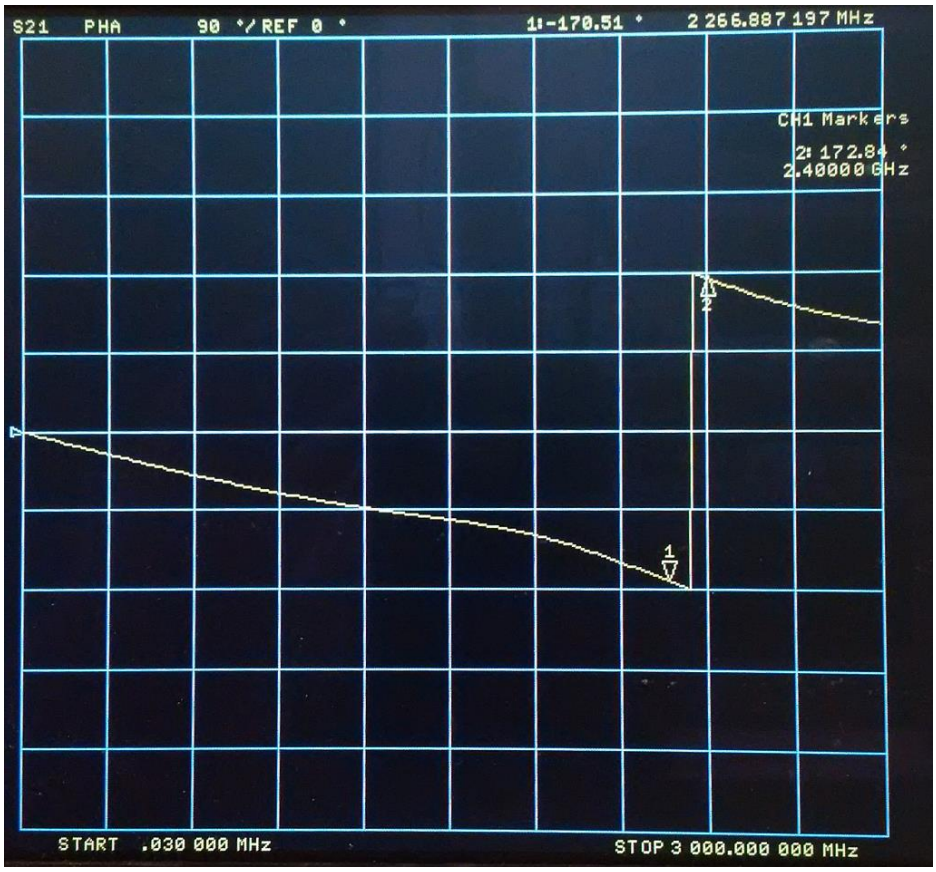


The quadrature coupler is rather narrowband and shows a clear resonance frequency at 2267 MHz. Input return loss S11 is -28dB. At 2400MHz the return loss S11 is only -18dB.

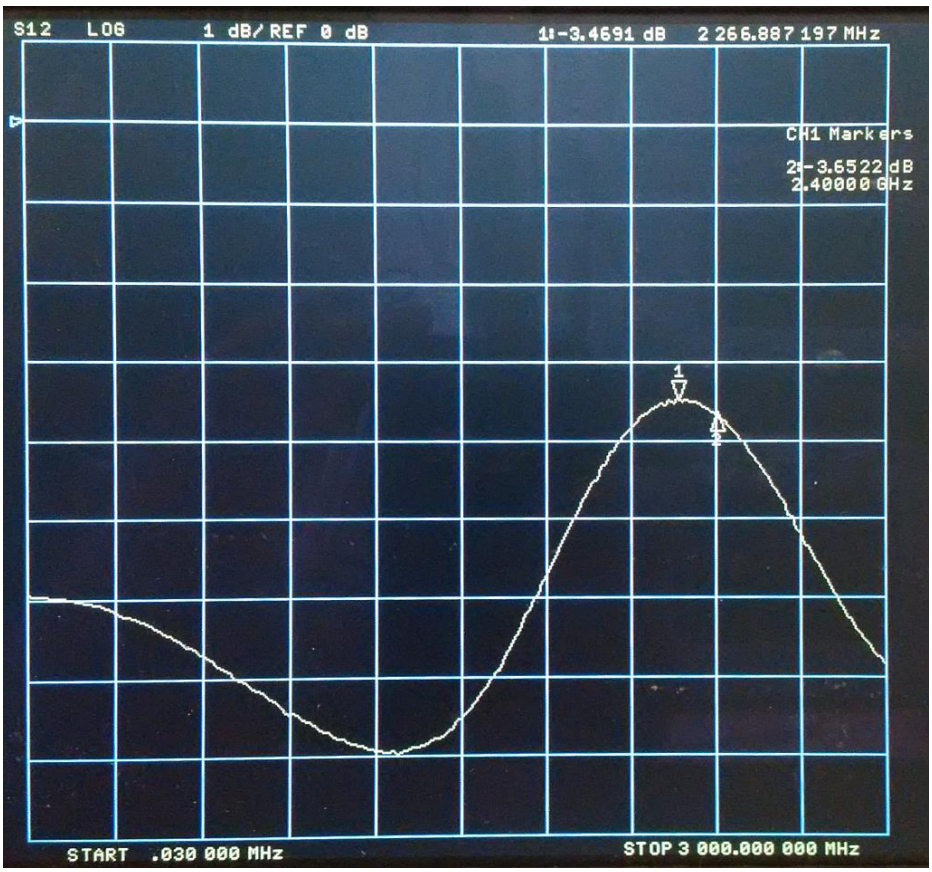




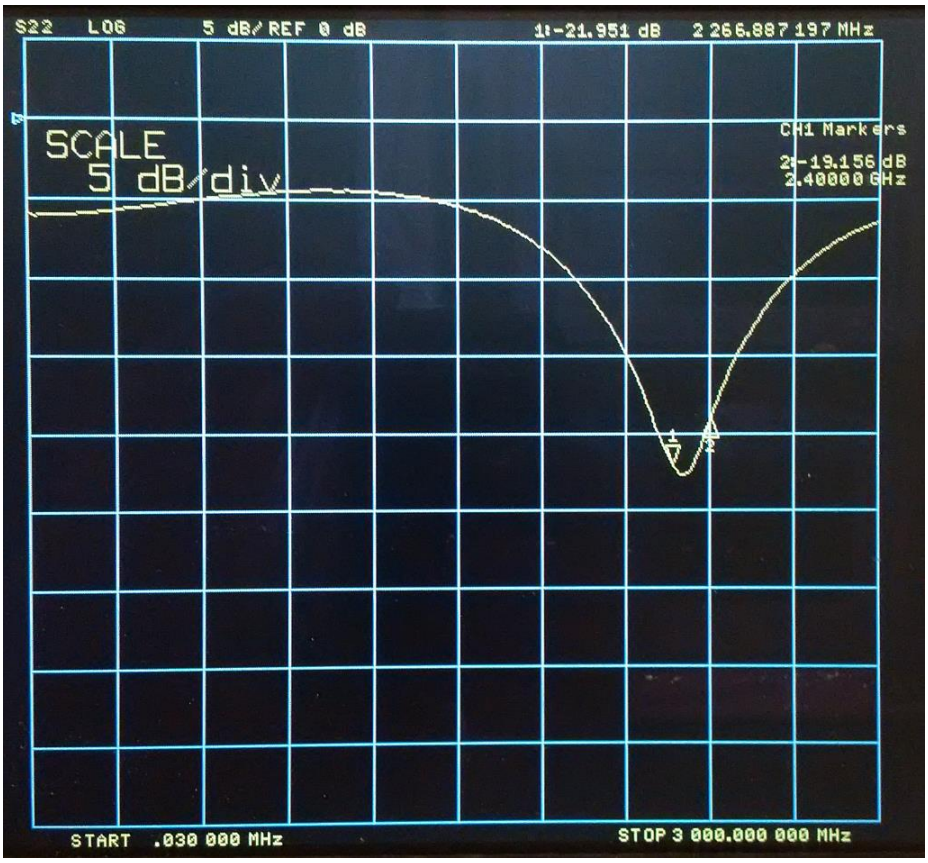
S21 log mag at 2267 MHz is -3.47dB. S21 log mag at 2400 MHz is -3.64dB.



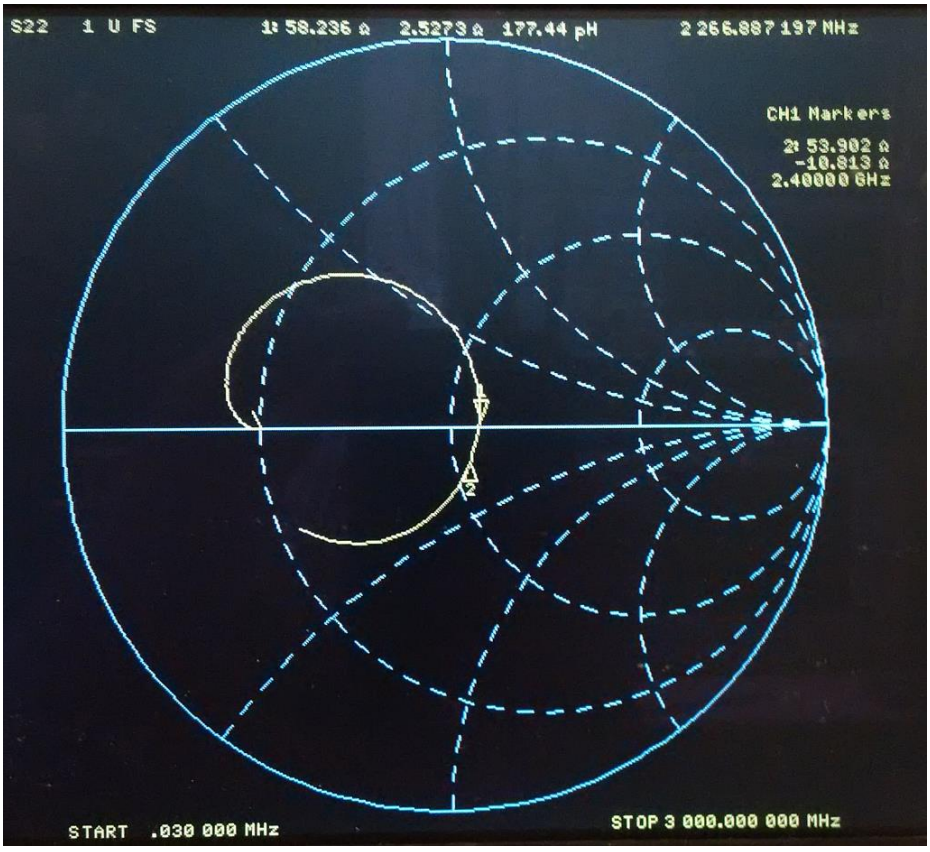
S21 phase at 2267 MHz is 170.51 degree, at 2400 MHz it is 172.84 degree.



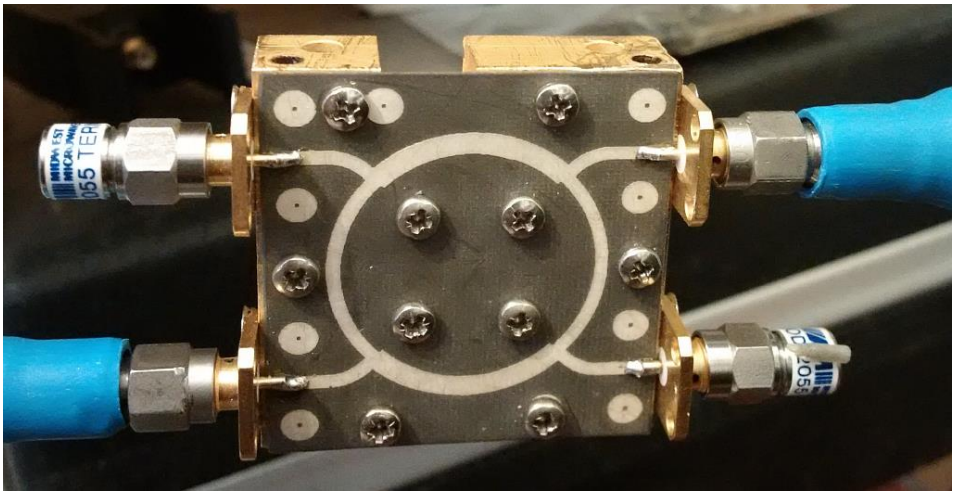
As to be expected S12 log mag is basically the same as S21.

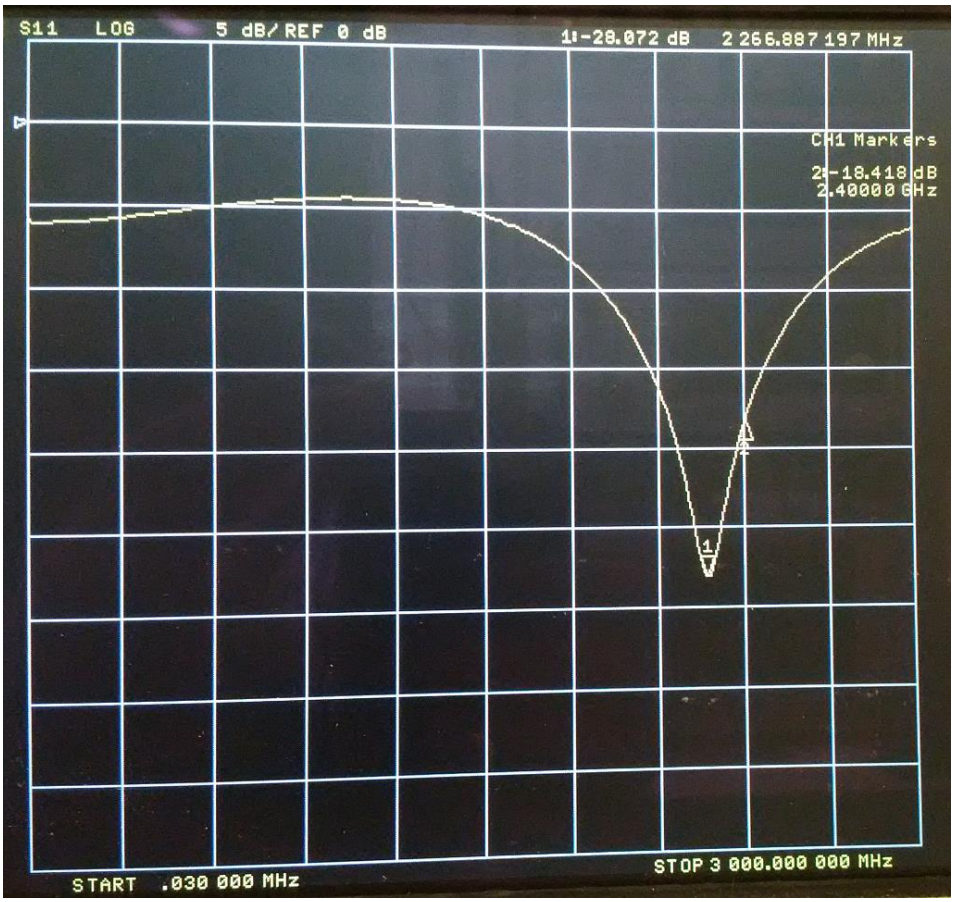


S22 log mag at 2267 MHz is -22dB. S22 log mag at 2400 MHz is -19dB.

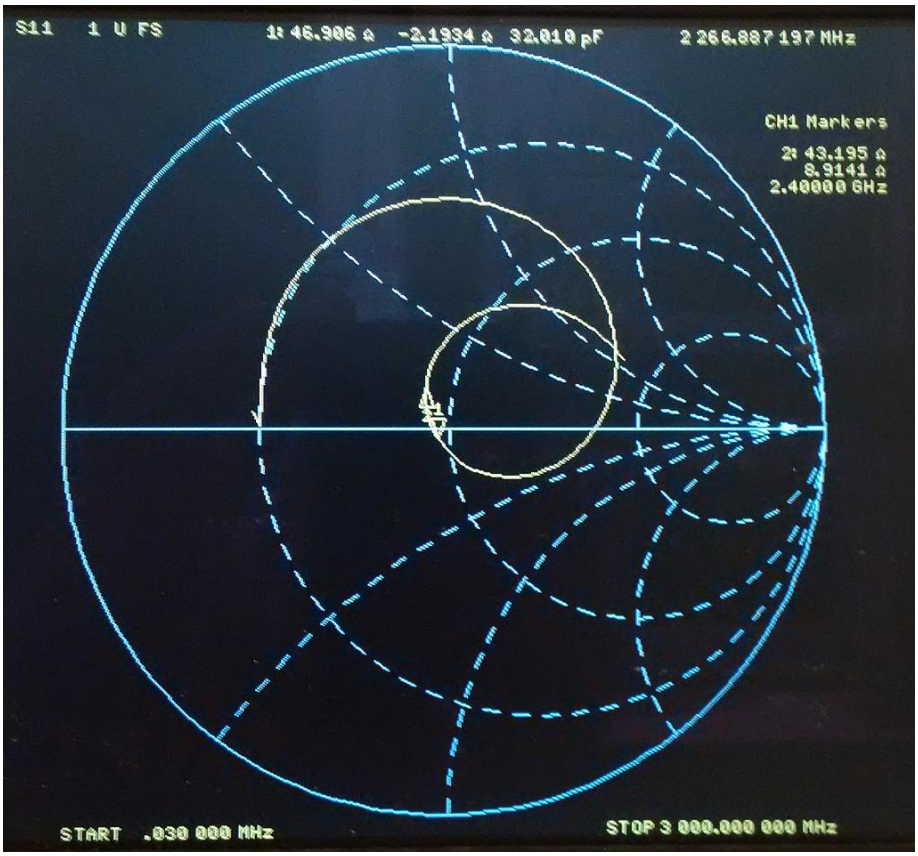


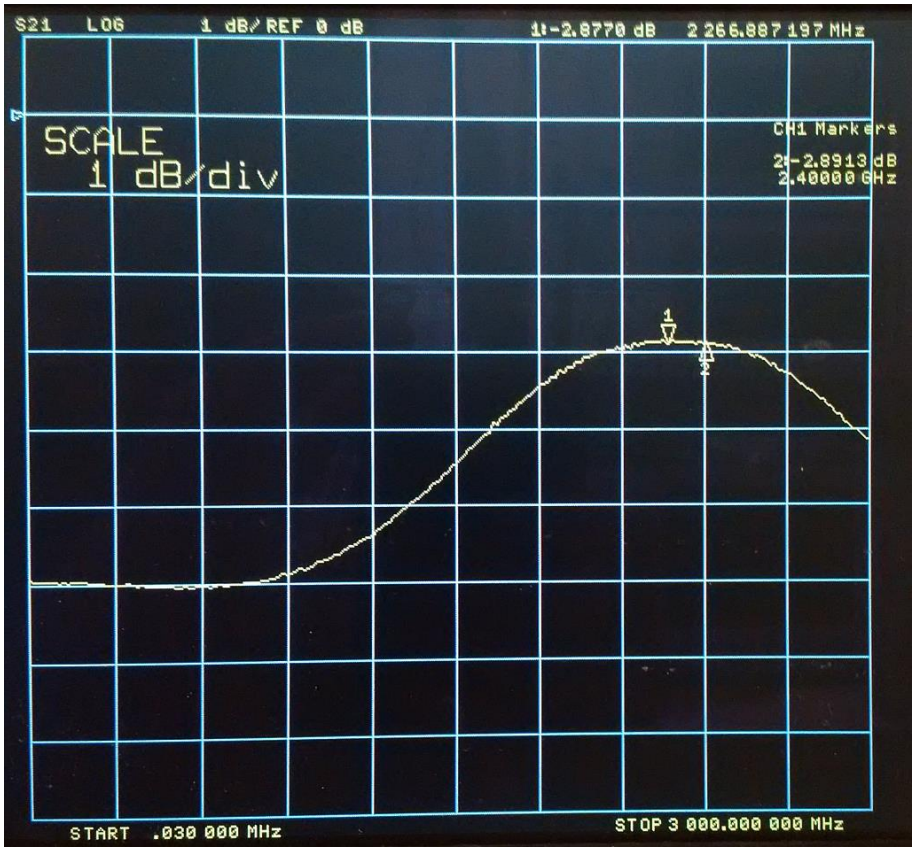
Next I measured the characteristic from port 2 to port 4:



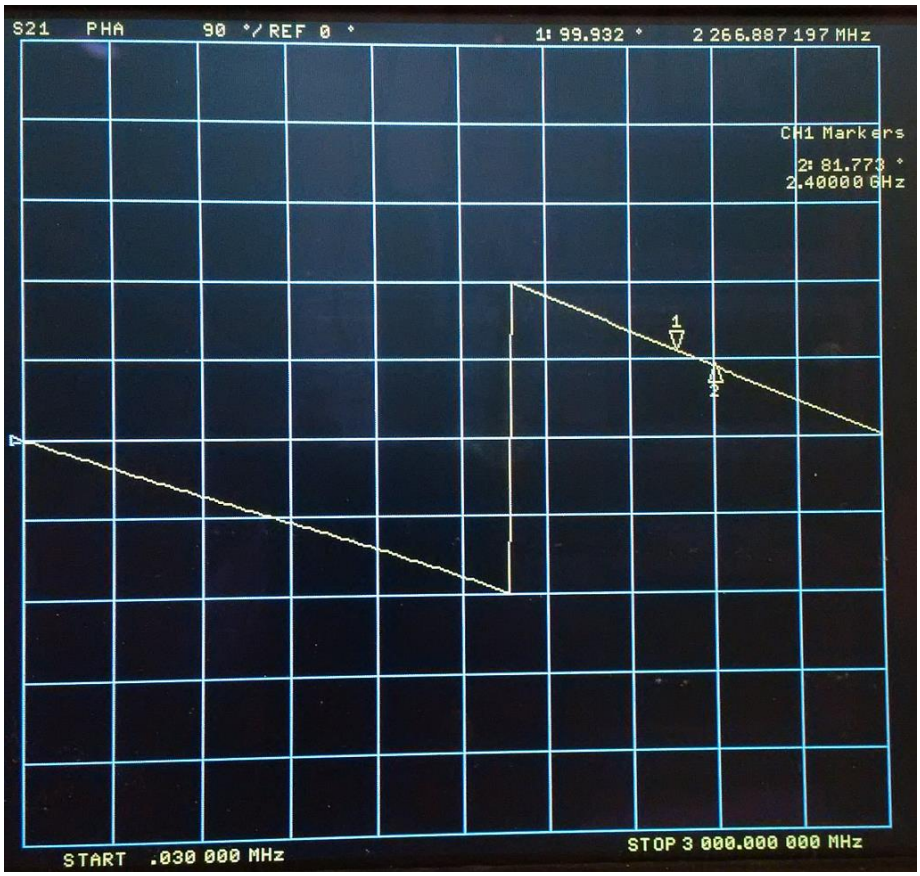


Input return loss S11 at 2267 MHz is -28dB.
At 2400MHz the return loss S11 is only -18dB.

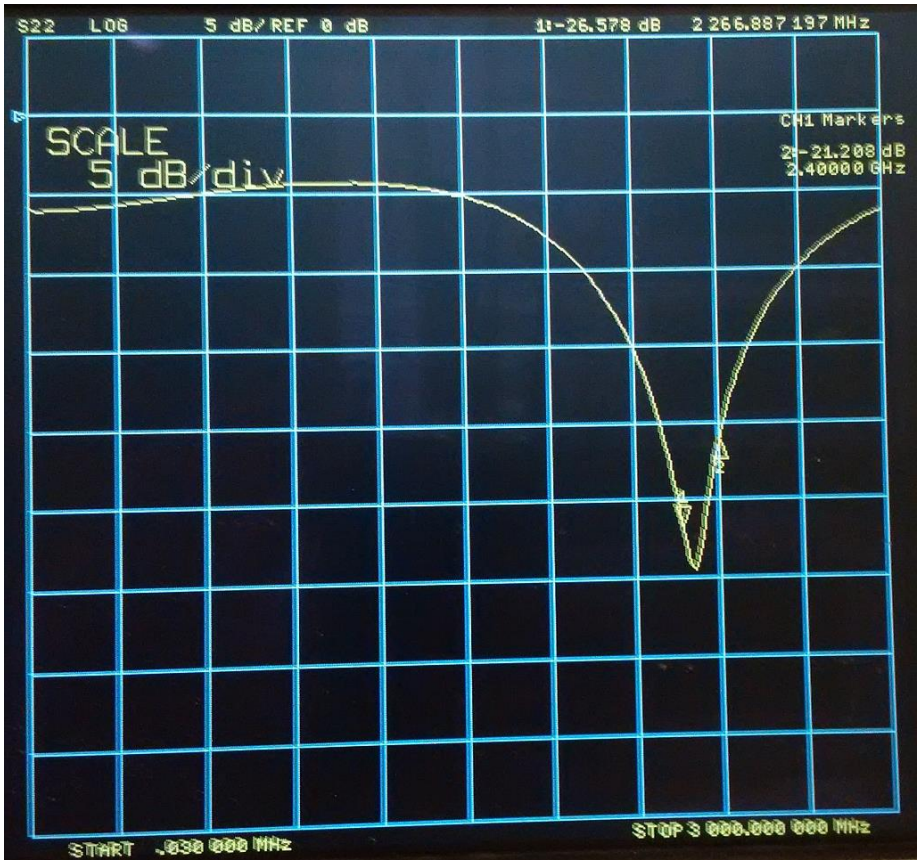




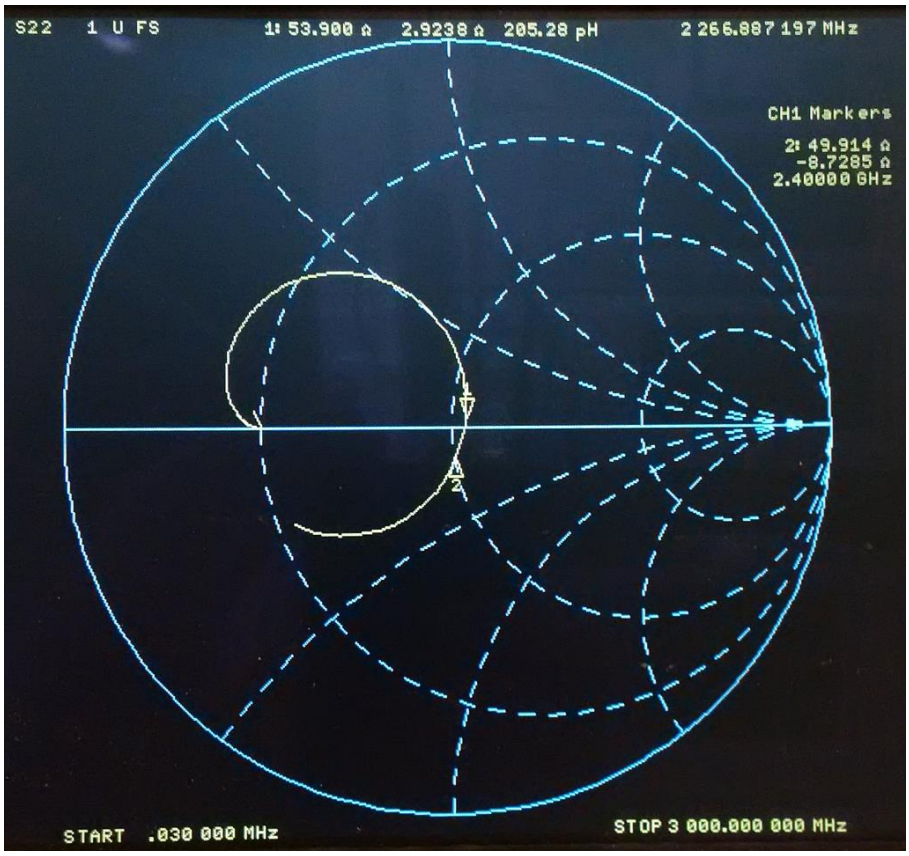
S21 log mag at 2267 MHz is -2.88dB. S21 log mag at 2400 MHz is -2.89dB.



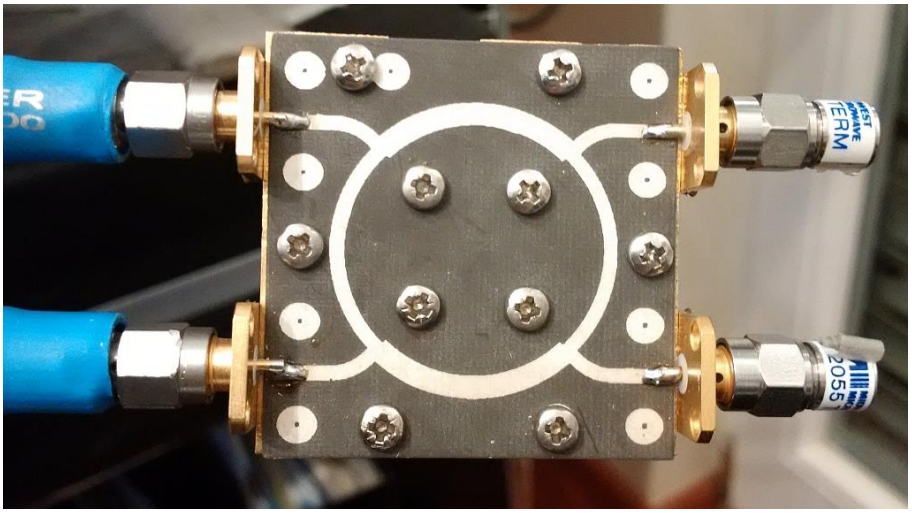
S21 phase at 2267 MHz is 99.93 degree, at 2400 MHz it is 81.77 degree.

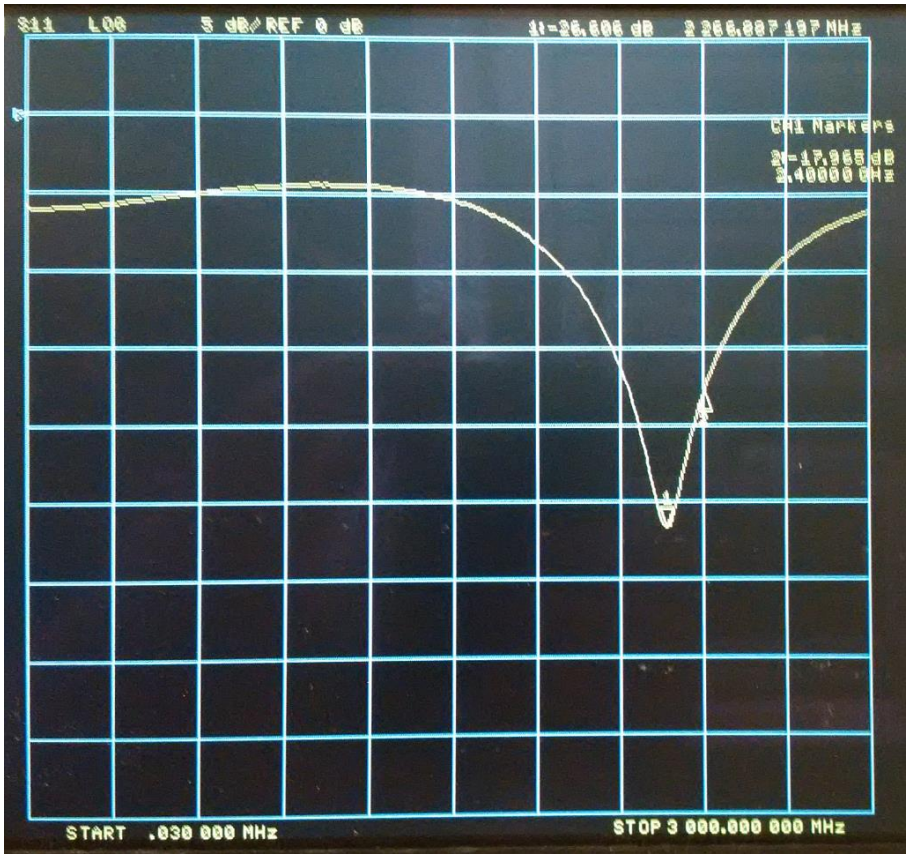


S22 log mag at 2267 MHz is -27dB. S22 log mag at 2400 MHz is -21dB.

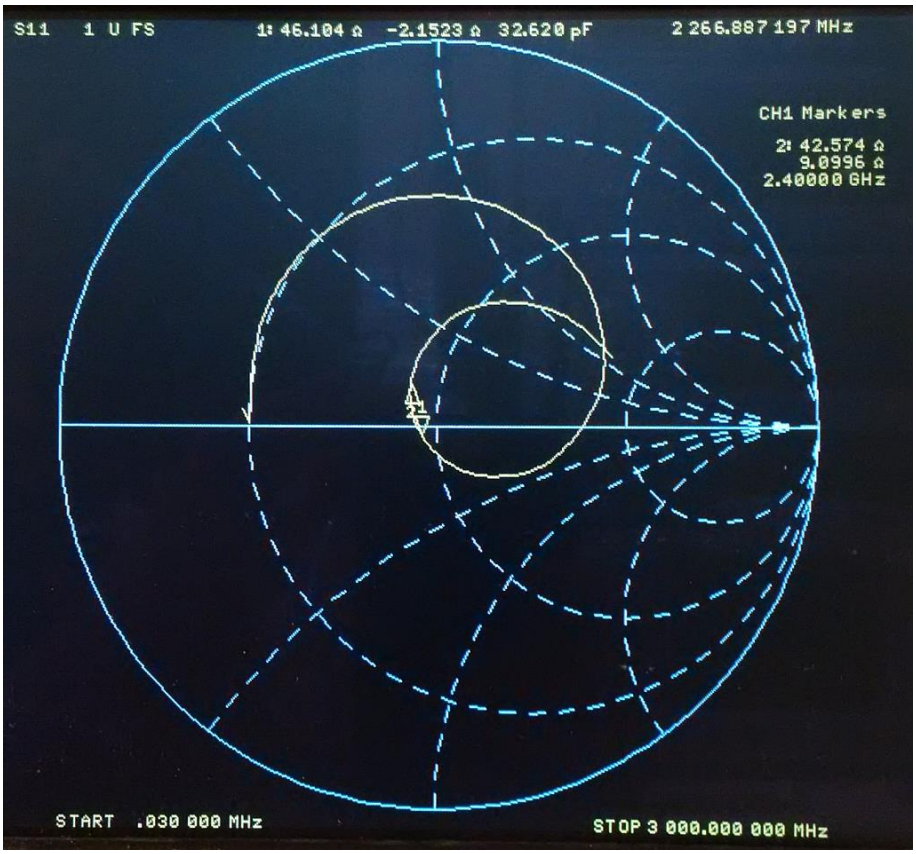

S22 1 U FS
1: 53.900 Ω 2.9238 Ω 205.28 pH
2 266.887 197 MHz
CH1 Markers
2: 49.914 Ω
-8.7285 Ω
2.40000 GHz
START .030 000 MHz
STOP 3 000.000 000 MHz

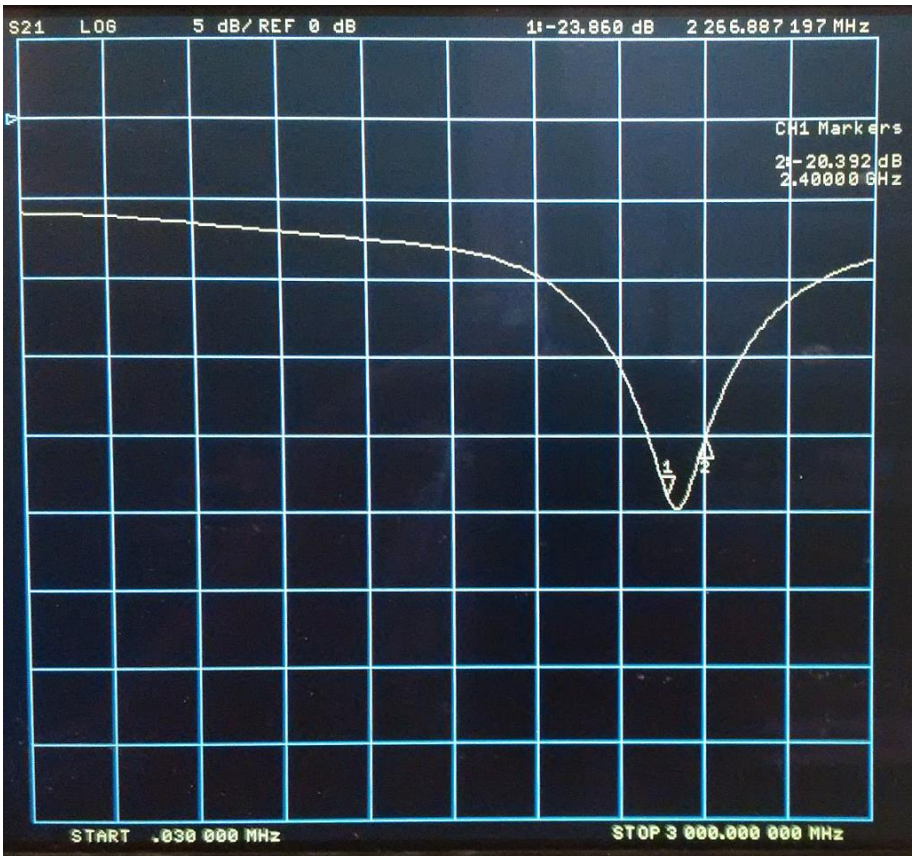
Finally, I measured the characteristic from port 2 to port 1:



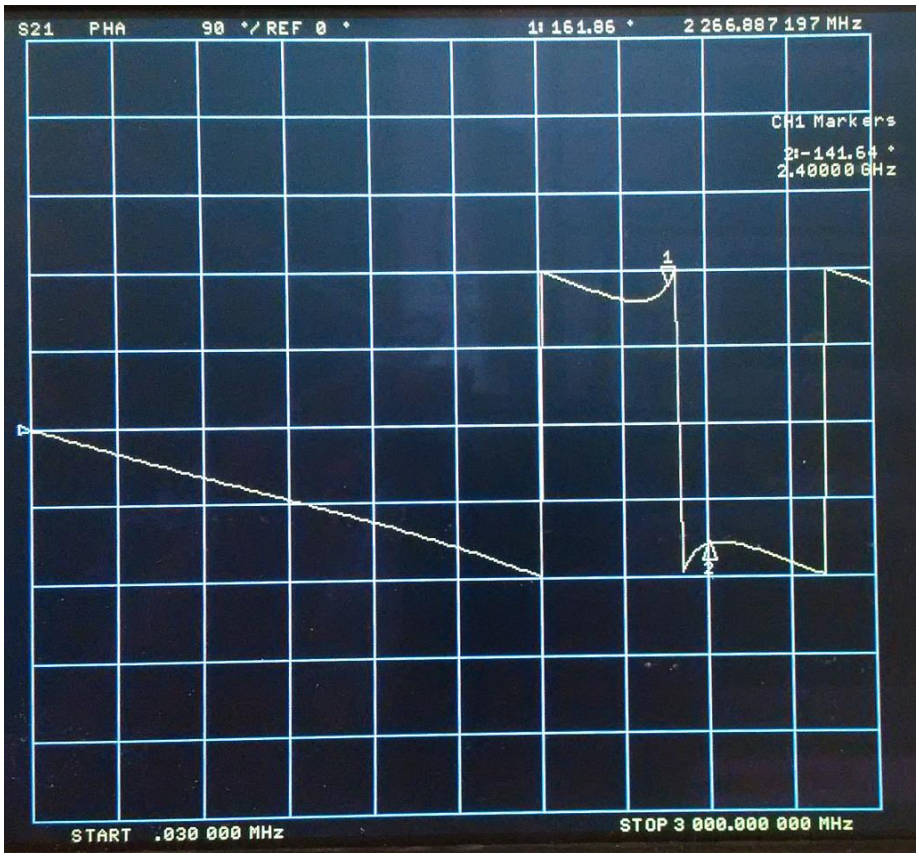


Input return loss S11 at 2267 MHz is -26dB.
At 2400MHz the return loss S11 is only -18dB.

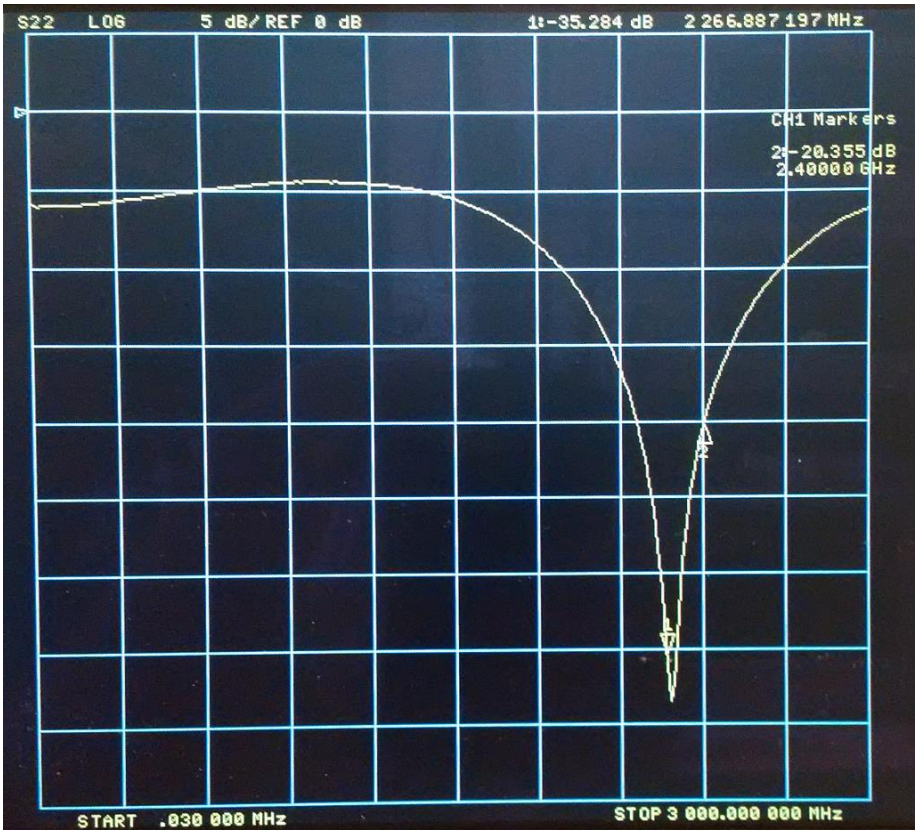




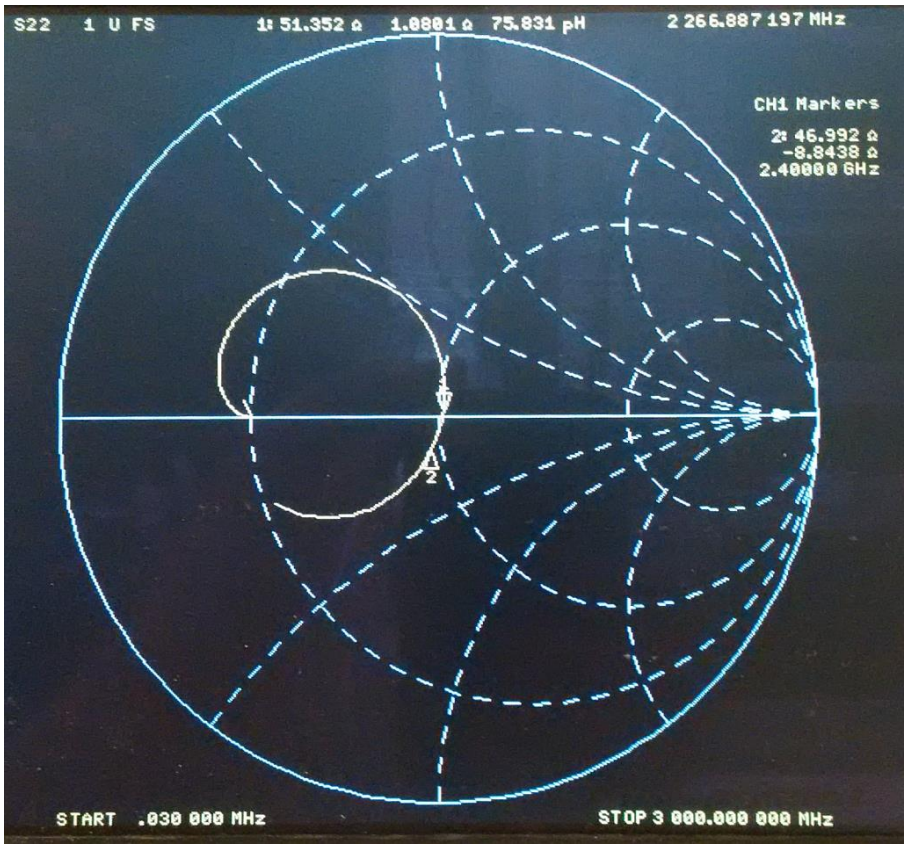
S21 log mag at 2267 MHz is -23.9dB. S21 log mag at 2400 MHz is -20.4dB.



S21 phase at 2267 MHz is 161.9 degree, at 2400 MHz it is -141.6 degree.



S22 log mag at 2267 MHz is -35dB. S22 log mag at 2400 MHz is -20dB.



This is the summary of the parameters of the hybrid coupler measured at 2267 MHz:

Amplitude imbalance	0.60 dB
Phase imbalance	0.44 degree
Avg. insertion loss	0.18 dB (in addition to the 3dB)
Isolation	23.9 dB

In summary here are the parameters of the hybrid coupler measured at 2400 MHz:

Amplitude imbalance	0.75 dB
Phase imbalance	15.39 degree
Avg. insertion loss	0.27 dB (in addition to the 3dB)
Isolation	20.4 dB

The measurement results show, that the coupler is centred at 2267 MHz and the performance at 2400 MHz is strongly degraded. In my opinion the phase imbalance of more than 15 degree will prohibit using it at 2.4 GHz.

If you have questions or comments please send them to the Email address given below.

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