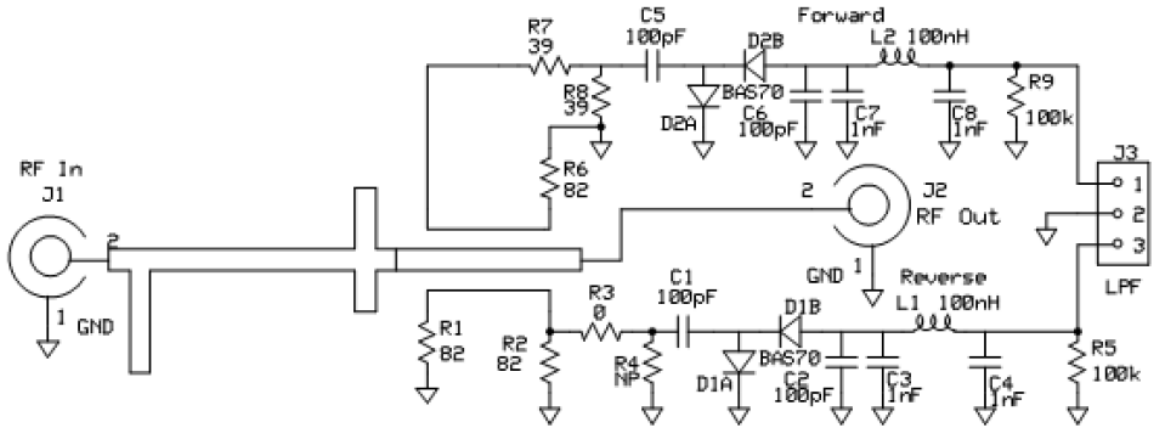
1296 MHz Lowpassfilter with harmonic notches and integrated reflectometer

Matthias , DD1US, February 2nd 2020, rev 1.1

Hello,

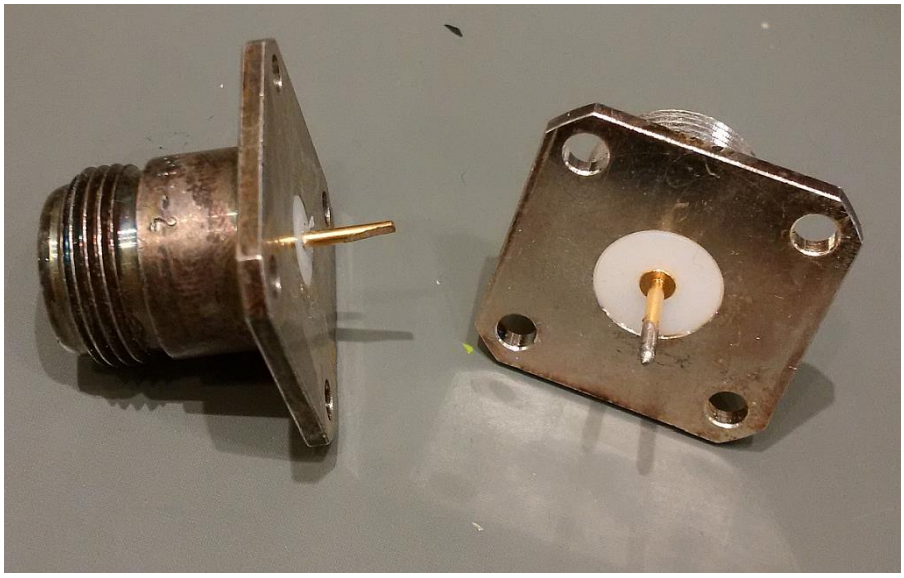
I am presently building a high-power amplifier for the 23cm band and needed a low pass filter to suppress the harmonics. Browsing the internet, I found a very nice design from John G3XYD which is not a simple low-pass filter but it includes notches for the harmonics and a reflectometer based on an integrated directional coupler and detectors. When contacting John, he kindly offered me to sell me a kit. You can find his description here: https://www.qsl.net/g3xdy/QRO%2023cm%20Harmonic%20Filter%20and%20Reflectometer.htm

To understand the overall concept, I will show only the schematic but I will not repeat, what John has already documented very well at his website. I rather want to focus on my experiences when building such a unit.

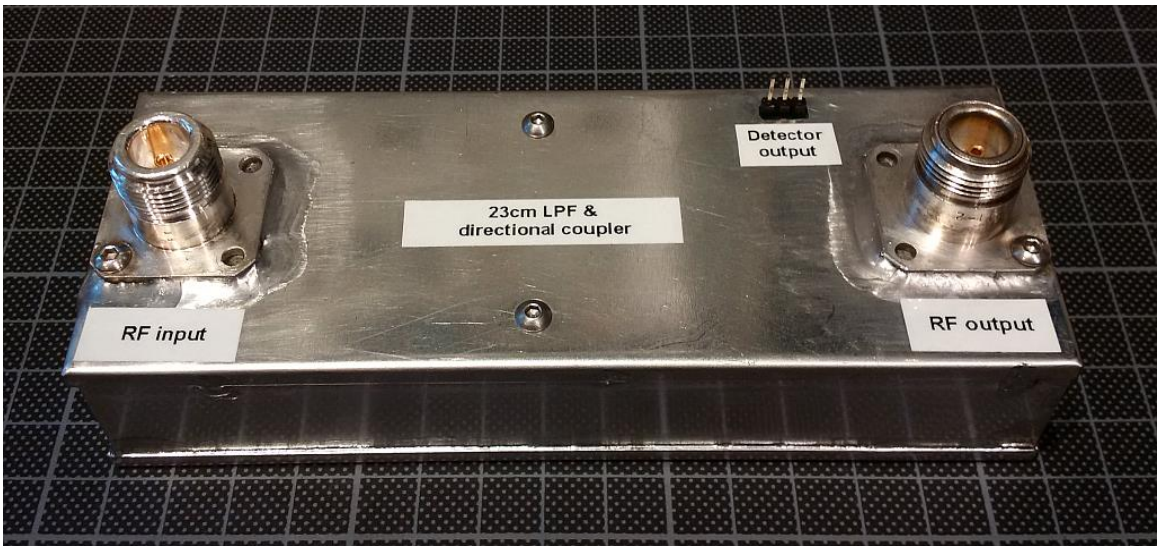


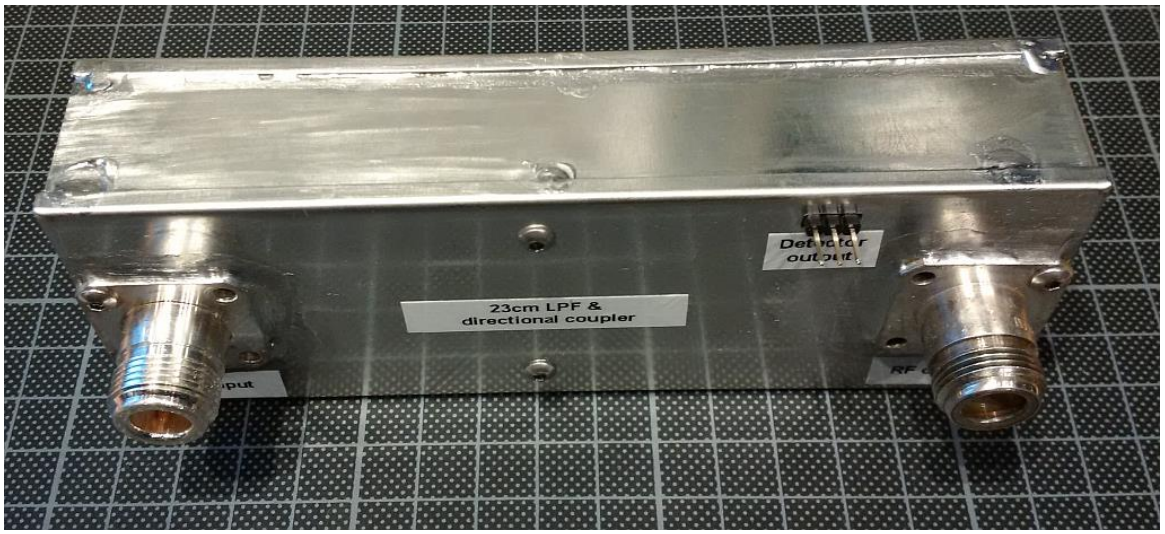
I followed closely John's description. Fortunately, I found two suitable N-jacks in my drawers. It is important that the jacks have a flat flange and that they are of high quality as they will need to handle high power.

Here is a picture of the N-jacks which I used:

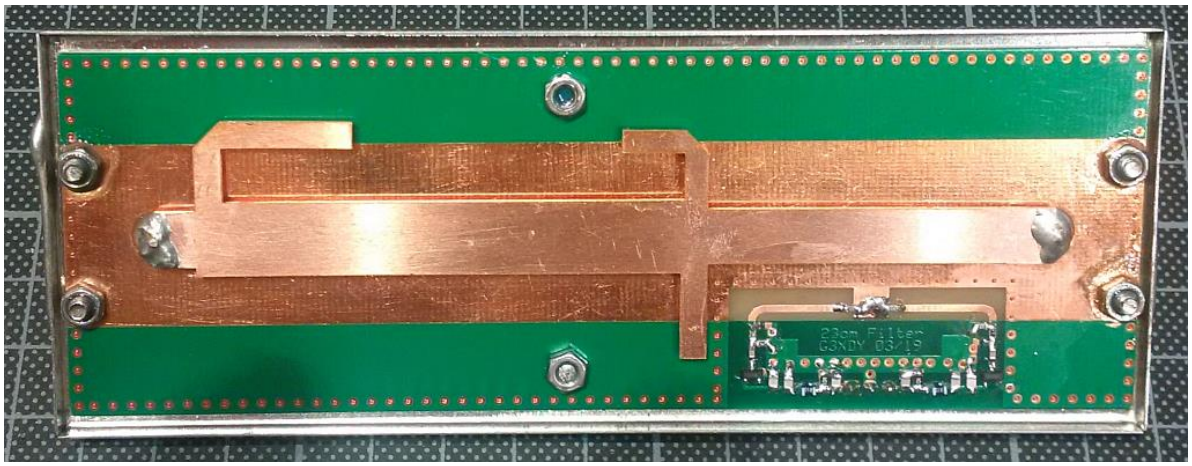


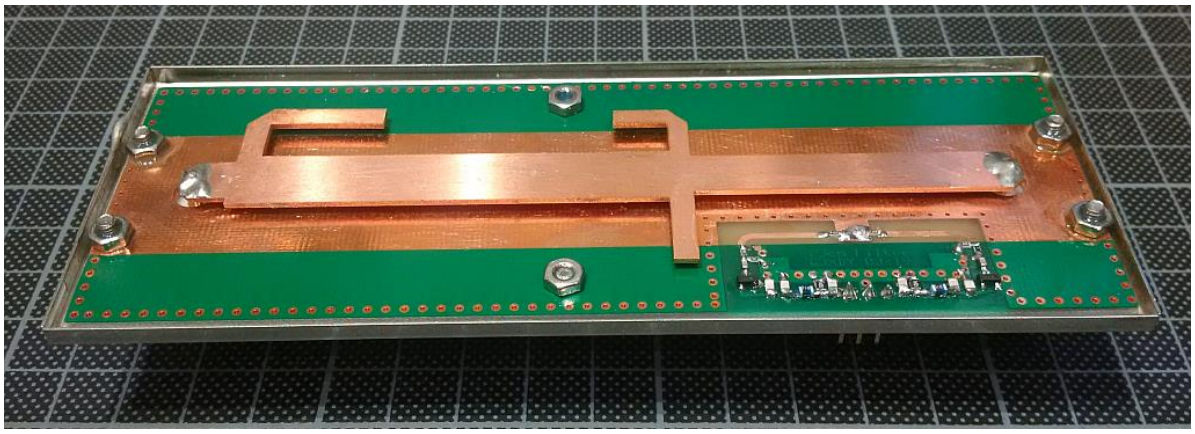
Here are some pictures of the finished unit housed as John proposed in a tin-plated cabinet with the dimensions 55x148x30mm. I decided to solder the silver- plated N-jacks to the box lid to ensure good grounding and improved mechanical stability.

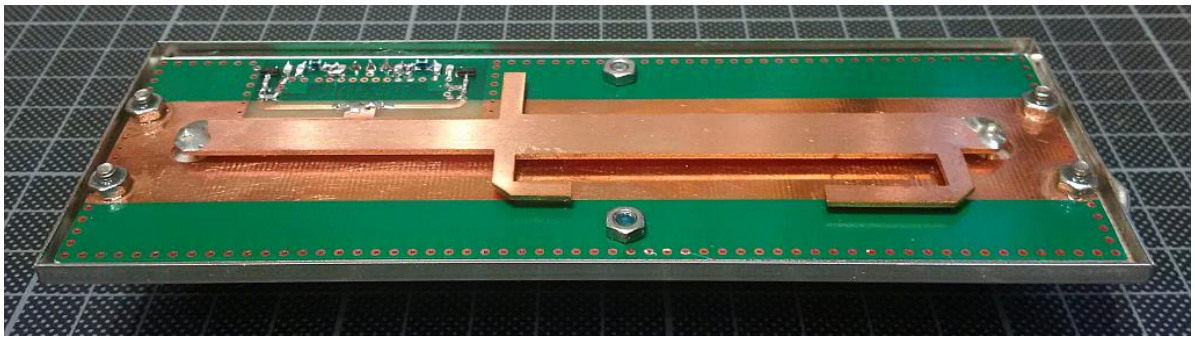




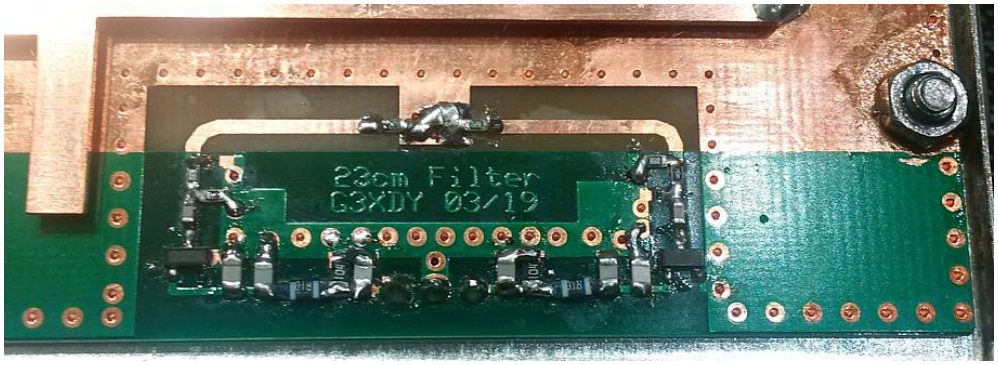
Here are some pictures of the internal construction. The key component is the transmission line with the quarter wave stub for the harmonic at 2592 MHz and two open stubs for 3876 MHz and 5184 MHz. John G3XDY delivers an excellent quality of this unit cut from a copper bar.





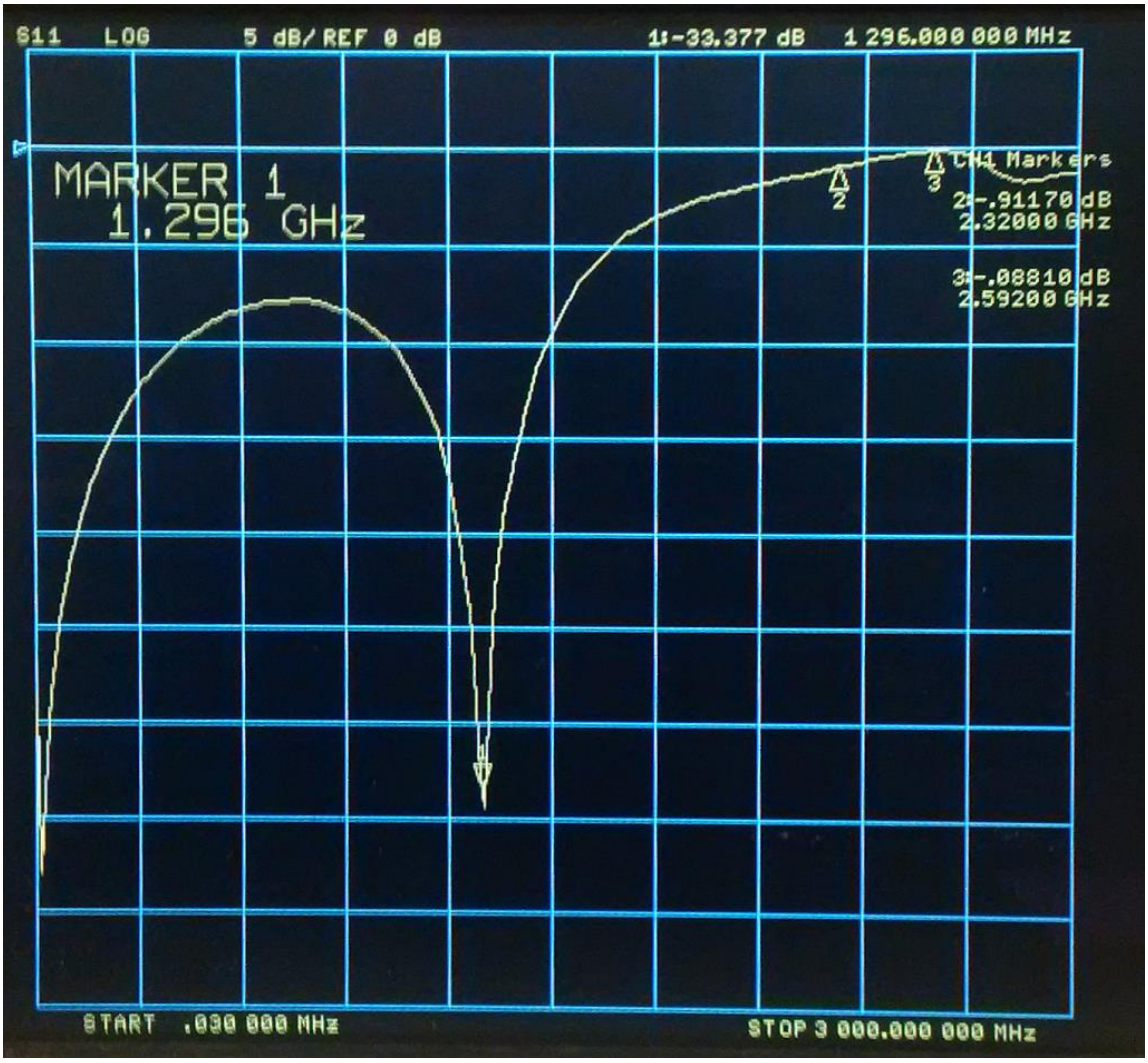


Here is a closer look at the reflectometer comprised of the directional coupler, 2 double diode detectors Infineon BAS70-04 and some passive components:



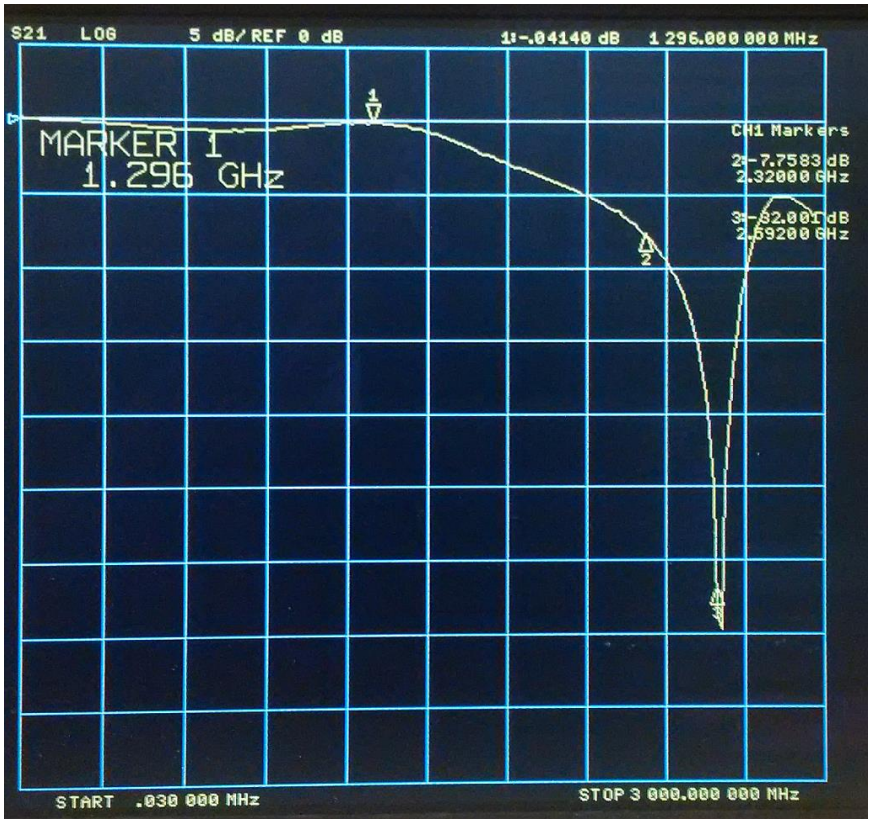
I am fortunate to have access to a VNA up to 3GHz and a spectrum analyzer with tracking generator up to 7 GHz. As John suggested I first tuned the transmission line for minimum insertion loss and maximum return loss using the VNA by bending the transmission line slightly towards the copper plated ground-plane. Also tuning the open stubs following his recommendations works perfectly well. Here are my final results:

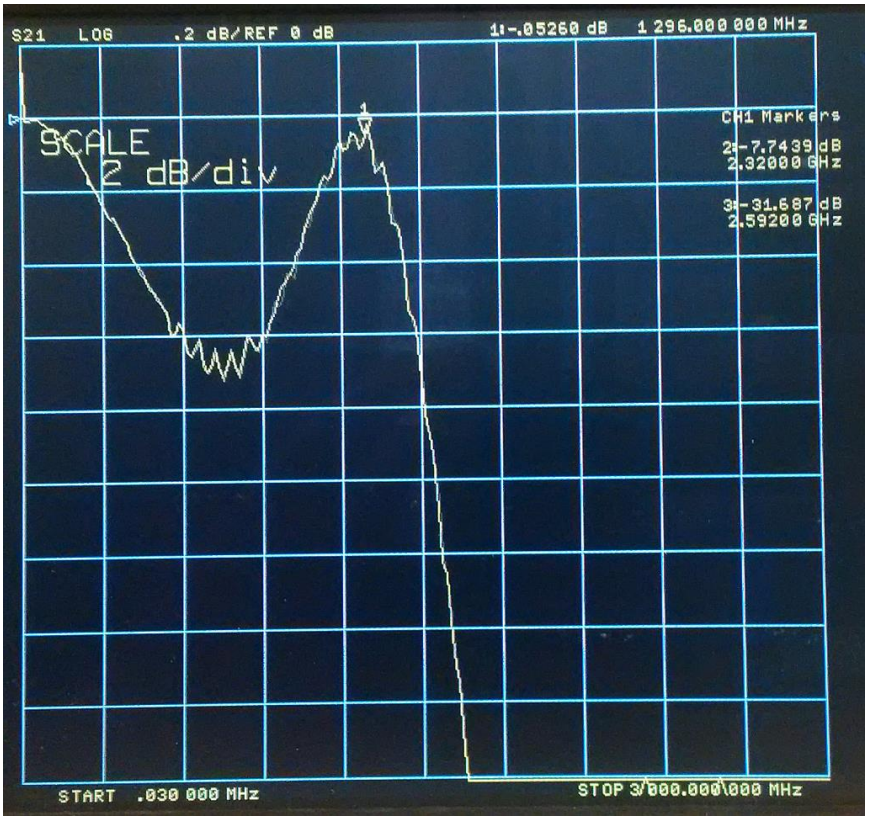
S11 input matching (hor. axis 300MHz/div, vert. axis 5dB/div):



The input return loss at 1296 MHz is 33dB which corresponds to a VSWR of 1:1.04. This means only 0.04% of the input power at 1296 MHz gets reflected. This is exceeding the target return loss of 25dB given by John G3XDY.

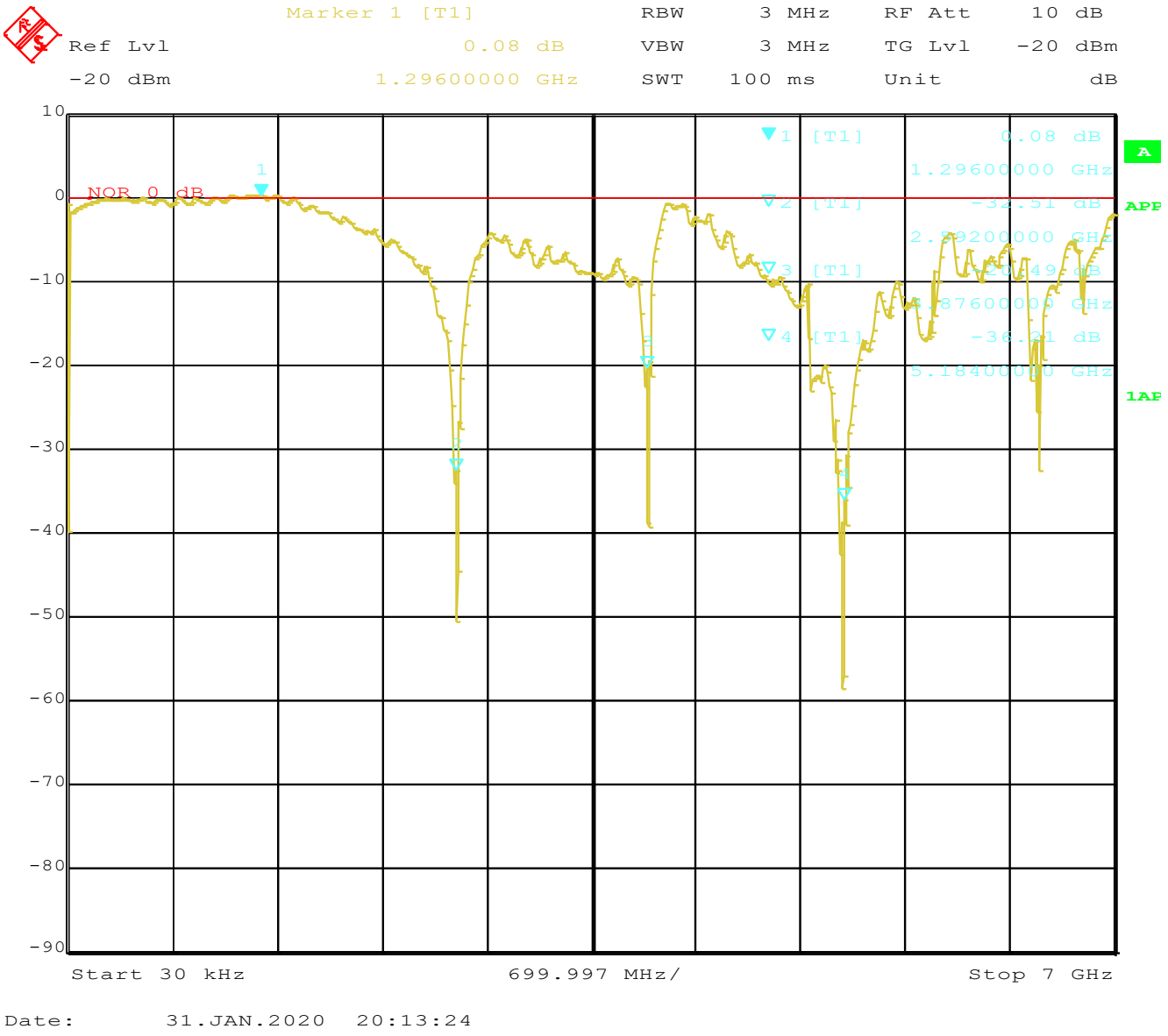
S21 insertion loss (hor. axis 300MHz/div, vert. axis 5dB/div first plot respectively 0.2dB/div second plot):



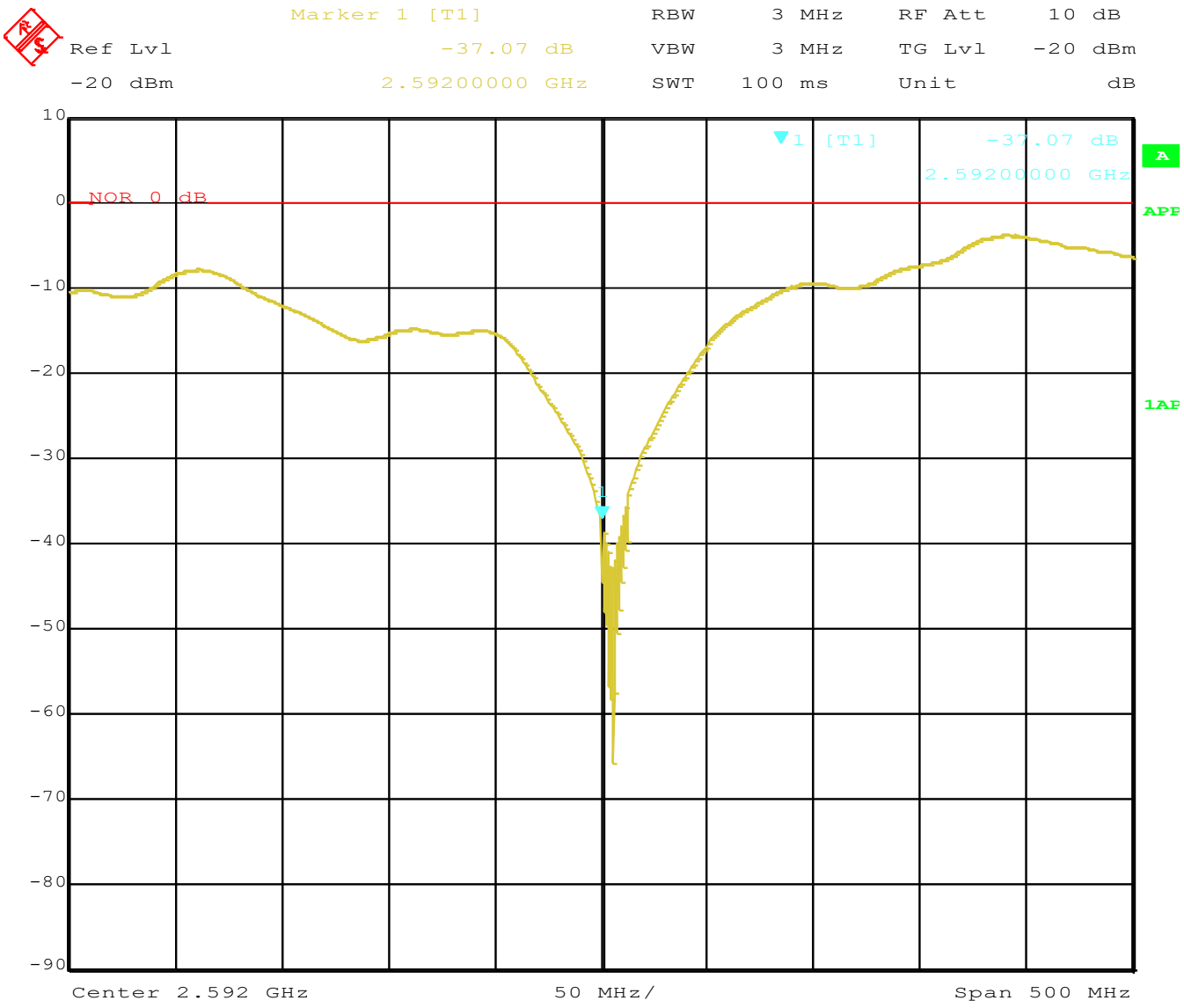


The insertion loss at 1296 MHz is approximately 0.05dB and thus amazing low. This is perfect especially for using the filter at high power levels. You can see also the function of the first notch at 2592 MHz: the 2nd harmonic is suppressed by 32dB.

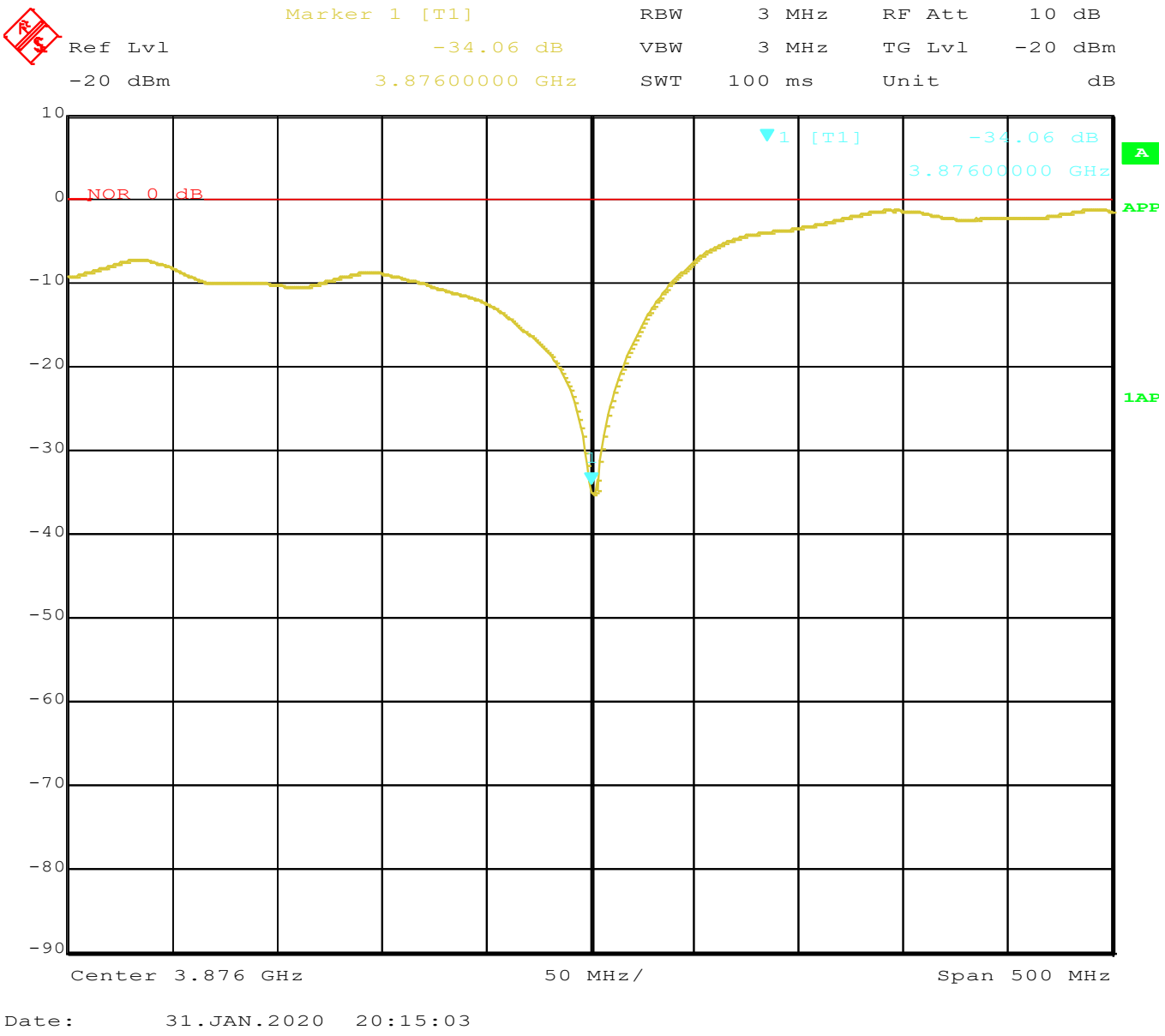
As my VNA can only be used up to 3 GHz I used my spectrum analyzer with tracking generator to measure also the suppression of the higher harmonics. First please find the insertion loss over the full frequency range up to 7 GHz (hor. axis 700MHz/div, vert. axis 10dB/div):



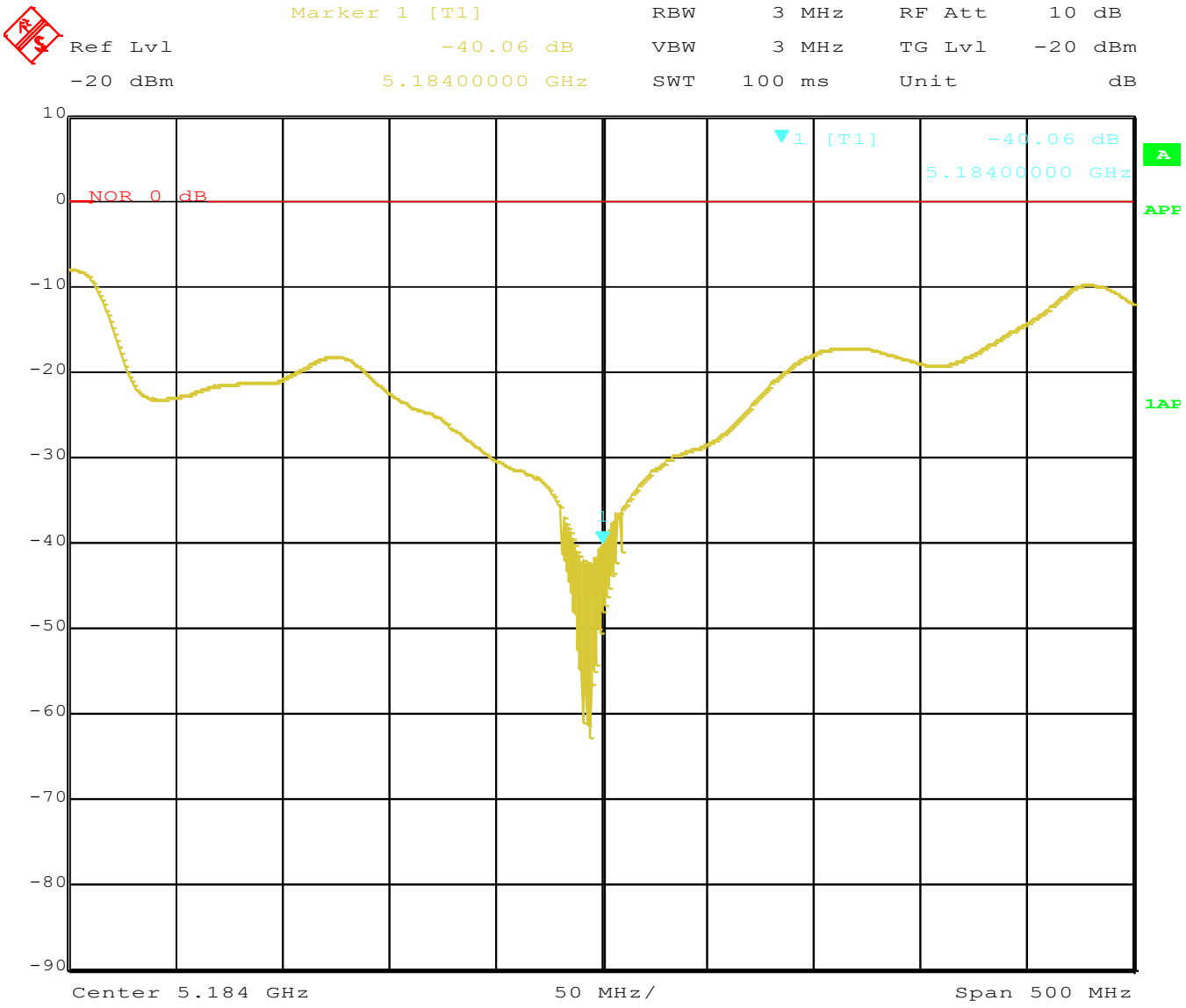
Please note that the measured depth of the notches is not precise due to the wide frequency span. Therefore, please find the measured insertion loss zoomed to the 2nd, 3rd and 4th harmonics in the next 3 diagrams. The scaling of the horizonal axis is 50MHz/div. and of the vertical axis it is 10dB/div.



The measurement with the spectrum analyzer with integrated tracking generator shows an insertion loss at the 2nd harmonic at 2592 MHz of 37dB. The notch is very narrow and deep which is a result of the very high quality factor of the quarter wave stub for the 2nd harmonic at 2592 MHz

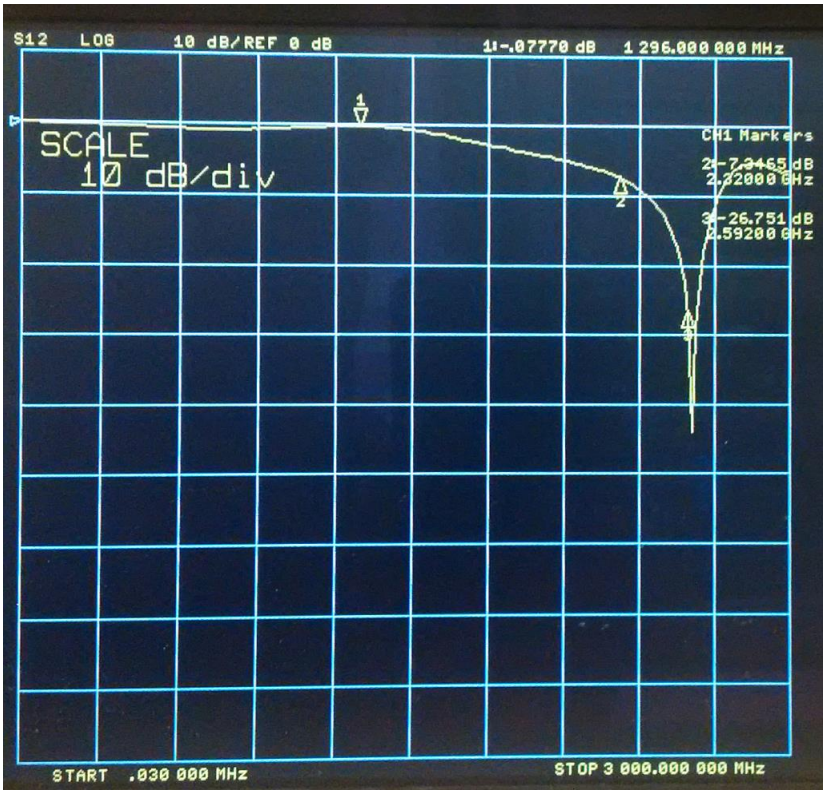


The measurement with the spectrum analyzer with integrated tracking generator shows an insertion loss at the 3rd harmonic at 3876 MHz of 34dB.



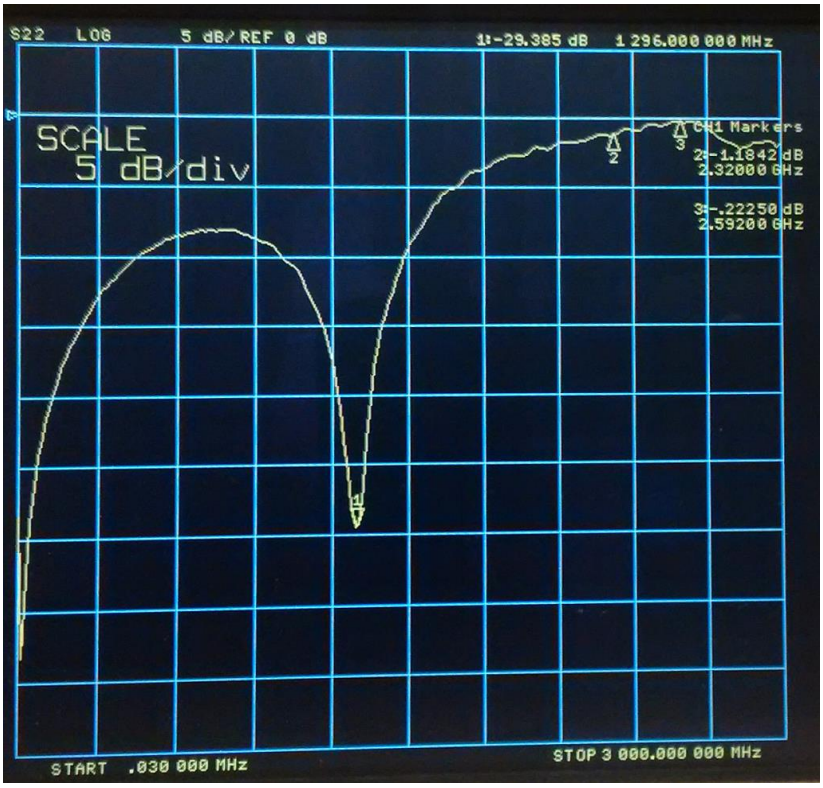
The measurement with the spectrum analyzer with integrated tracking generator shows an insertion loss at the 4th harmonic at 5184 MHz of 40dB.

S12 insertion loss (hor. axis 300MHz/div, vert. axis 10dB/div):



As to be expected the filter is symmetric, thus S12 is basically identical to S21.

S22 output matching (hor. axis 300MHz/div, vert. axis 5dB/div):



The output return loss at 1296 MHz is 29dB which corresponds to a VSWR of 1:1.07 or a reflection coefficient of 0.11%.

I have not yet calibrated the integrated reflectometer as my available output power is presently to low.

I would like to thank John G3XDY for developing and publishing this excellent harmonic filter with integrated reflectometer. Special thanks to him for his friendly support when I built my unit. The results are truly excellent and I was quite astonished how reproduceable his design is.

I always appreciate feedback. Many thanks in advance.

Best regards

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