Frequency Doubler 3,2 – 6,4 GHz to 6,2 – 12,8 GHz based on HMC204MS

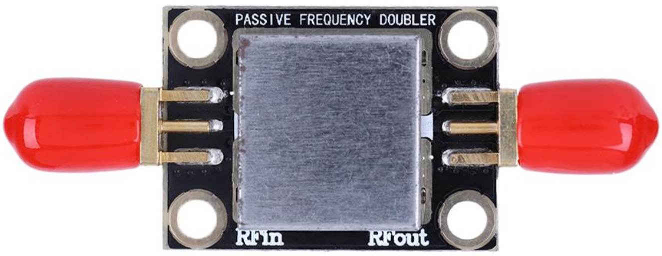
Matthias, DD1US, January 4th 2018, Rev 3.0

Hello,

as I just finished refurbishing a R&S SMIQ06 signal generator, which covers the frequency range up to 6.4 GHz, I wanted to extend my measurement setup now to cover also the 3cm ham radio band / KU-band up to 12 GHz. As Es'Hail-2 will now hopefully soon gets activated I needed to modify some KU-Band LNBs.

Recently, PCBs with the Hittite HMC204MS passive frequency doubler became available for very low cost on Ebay. Thus, I decided to build a frequency doubler based on such a board in order to be able to generate signals also in the frequency range 6,4 – 12,8 GHz.

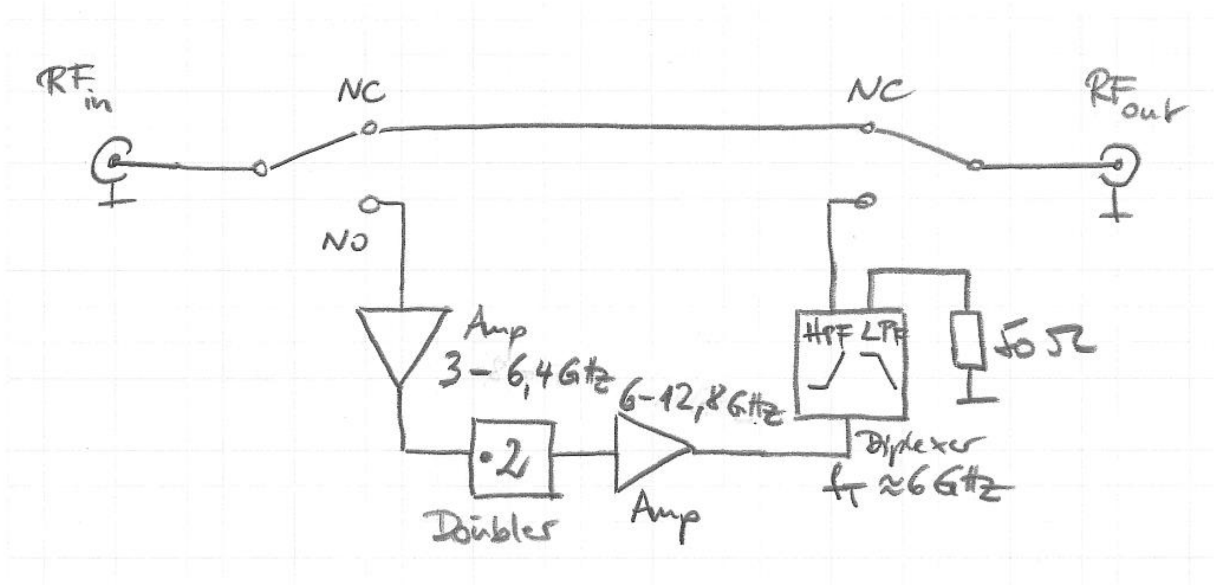
The boards are available as a PCB with a tin-plated lid for shielding or embedded in a milled aluminium encasing. Both units are using female SMA connectors for the input and output ports. Here are pictures of the 2 versions:



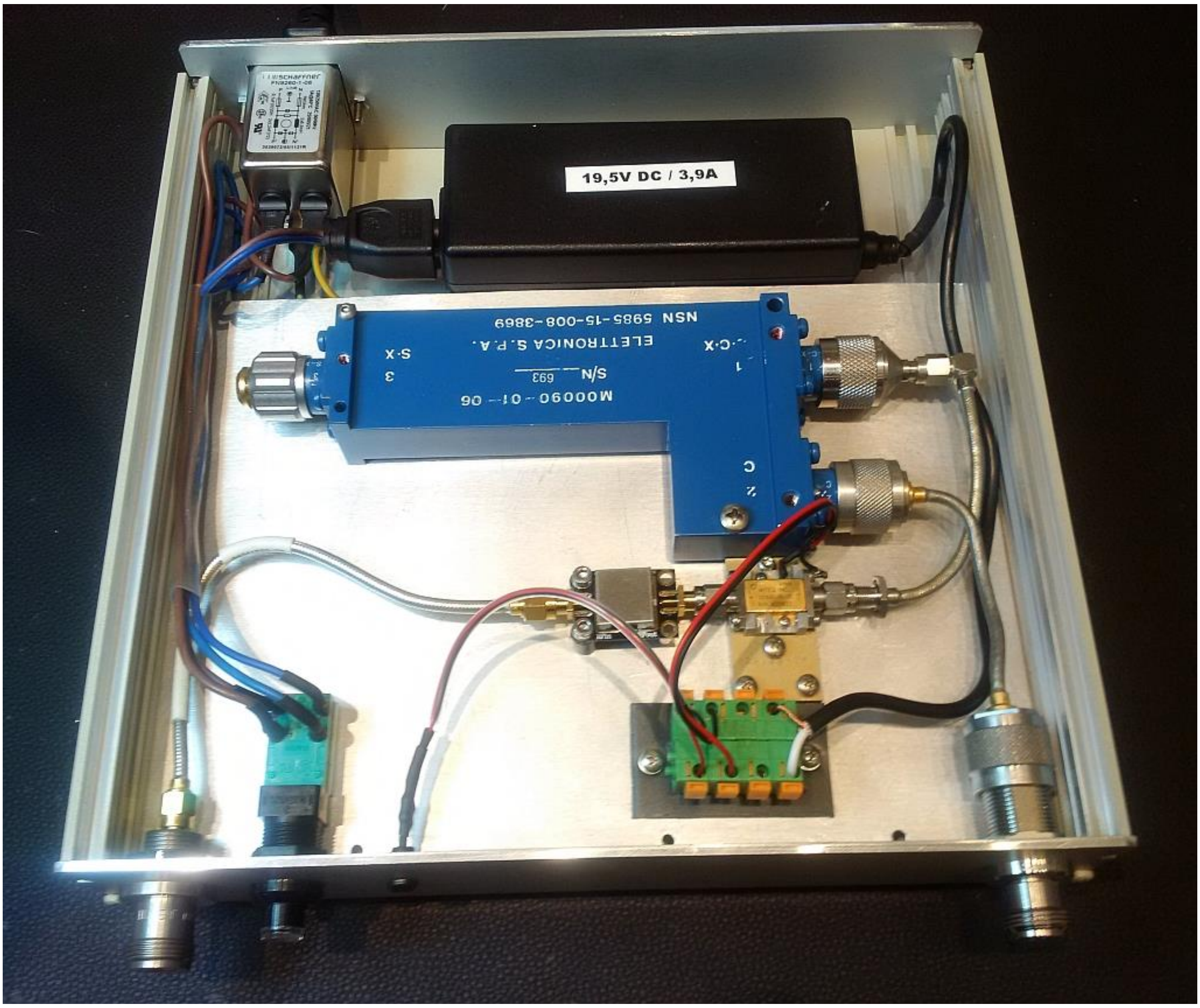
As I planned to integrate the doubler together with other components in a larger encasing I decided to go for the cheaper PCB with the simple lid for shielding. Hindsight I should have decided for the version in the milled aluminium casing as the PCB board is very thin and fragile.

The HMC204MS (from Hittite, which is now part of Analog Devices Inc.) is a passive frequency doubler for an input frequency range of 4-8 GHz with a conversion loss of typically 17dB (max. 21dB). The suppression of undesired fundamental and higher order harmonics is typically 42 dB (min. 35dB) with respect to the input signal level. The optimum input power level is +15dBm.

Here is a sketch of the block diagram of my initially planned setup:



As I was lacking a suitable input amplifier I build the setup above also omitting the bypass relays, which I might add at a later stage. Here are pictures of my setup:

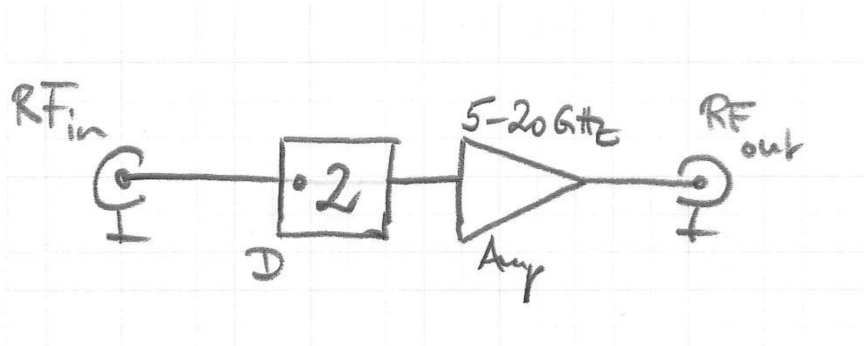



Power
DC on
Frequency Doubler

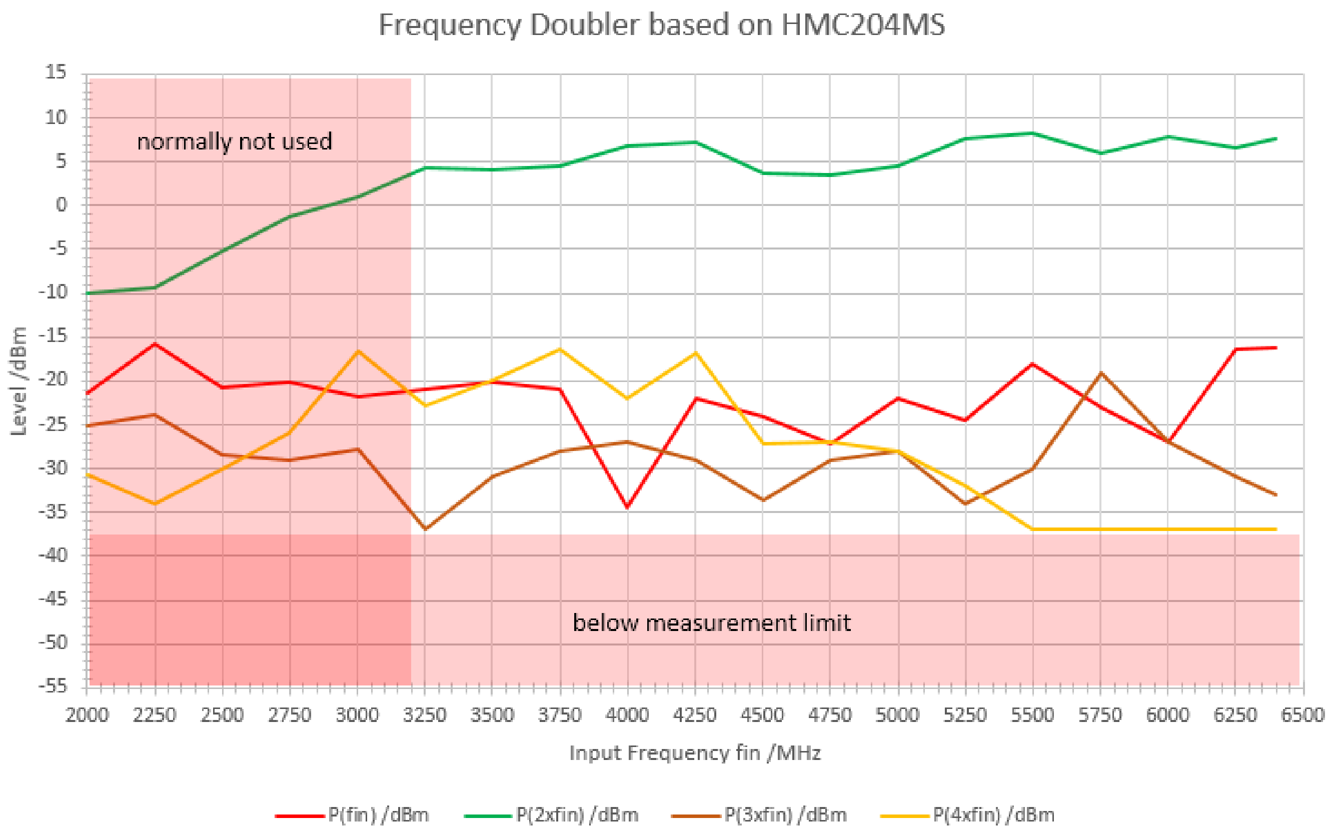

RF input
Power
DC on


RF output

Unfortunately, it turned out that the diplex filter at the output, which I wanted to use to terminate the unwanted subharmonic signal and filter out the frequency doubled signal, was not suitable. The part number is P/N M00090-01-06 and they were produced by a company in Roma/Italy called Elettronica S.p.A. Roma. You can find a detailed description of the diplexer in a separate document on my website. The high pass section of the diplexer was in fact a band pass filter which did strongly attenuate signals already at 6.5 GHz and above. Therefore, I removed this diplexer and the subsequent measurements were done only with the passive doubler and a broadband amplifier. The amplifier MITEQ 121643-10-17 is boosting the output levels by about 12-14 dB at 5 GHz and above. You can also find a description of this amplifier in a separate document on my website.



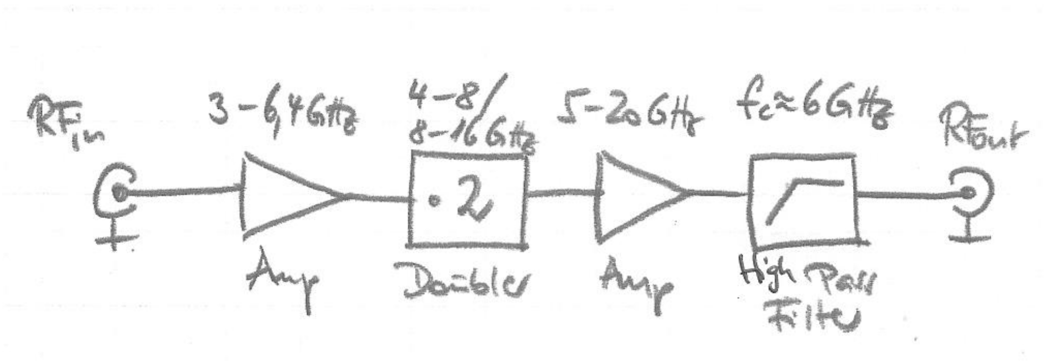
Here is a diagram of the measured output signals:



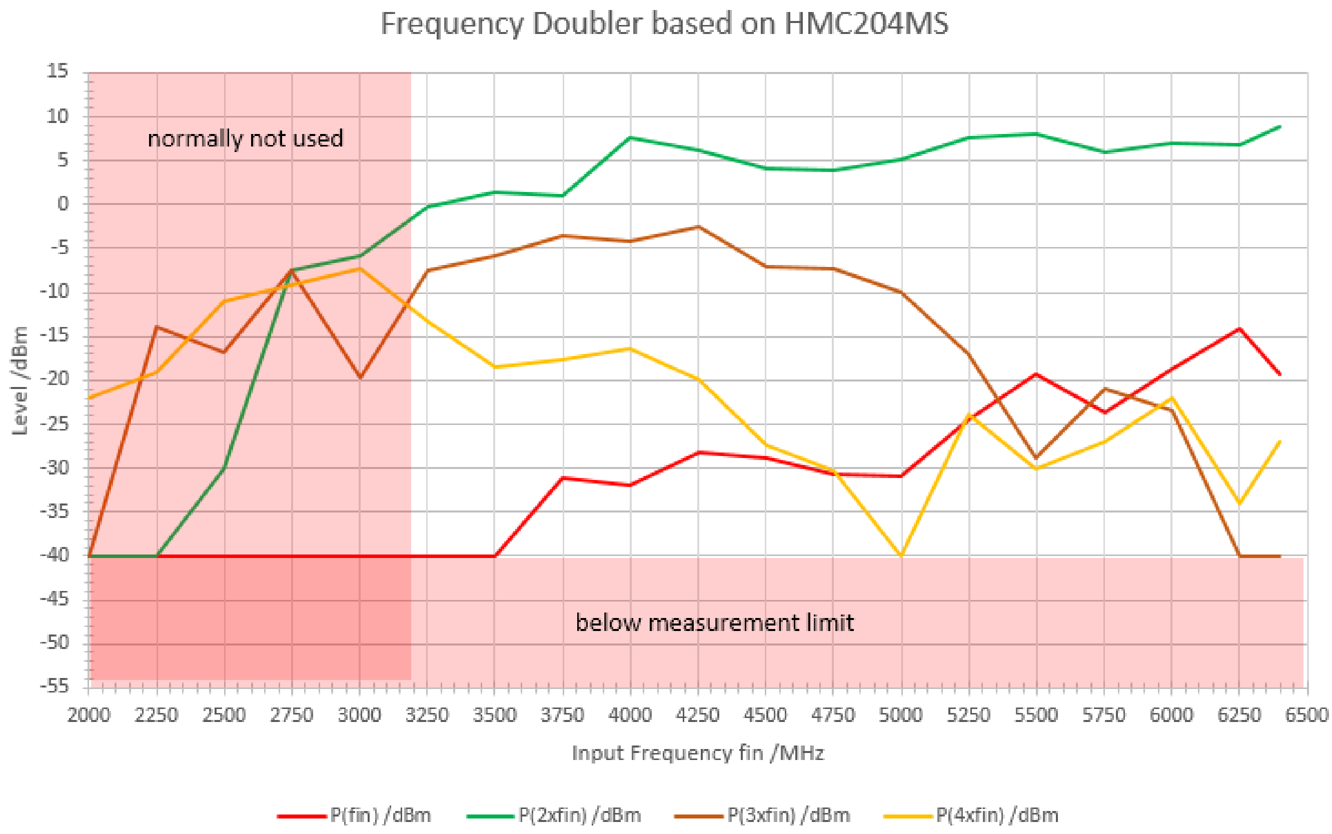
The green curve P(2xfin) shows the output level of the wanted output signal (at twice the input frequency) as a function of the input frequency. Please note that I did not calibrate for the losses of the coaxial cable between the output of the unit and the input of the spectrum analyser which I used for the measurements. Thus, the real output level will be a bit higher, I estimate 0.5 dB at the lower frequencies (4 GHz) and 2dB at the higher frequencies (13 GHz). The red curve P(fin) shows the residual input signal of the doubler measured at the output port. The input level was always set to +16 dBm (minus the losses of the coaxial cable between the signal generator and input of the doubler which I did not calibrate out). The brown and the yellow curves show the corresponding output signals at 3x and 4x of the input frequency. The measurement limit was about -37dBm.

The measurement results are in line with the datasheet parameters of the HMC204MS.

In the next step I inserted an amplifier before the doubler in order to reduce the needed input power to -20dBm. I also added a high pass filter after the second amplifier to reduce the level of the subharmonic signal. Descriptions of the high-gain amplifier MITEQ AMF-5S-040080-12-13P and the 5.5 GHz high-pass filter HPF5500 are available in separate documents on my website.

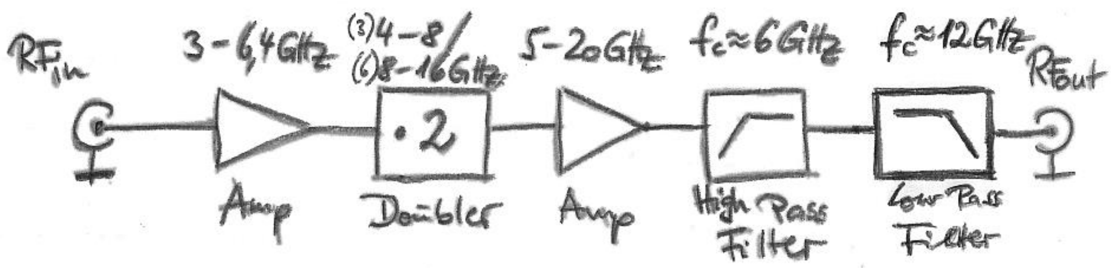


Here is a diagram of the measured output signals:

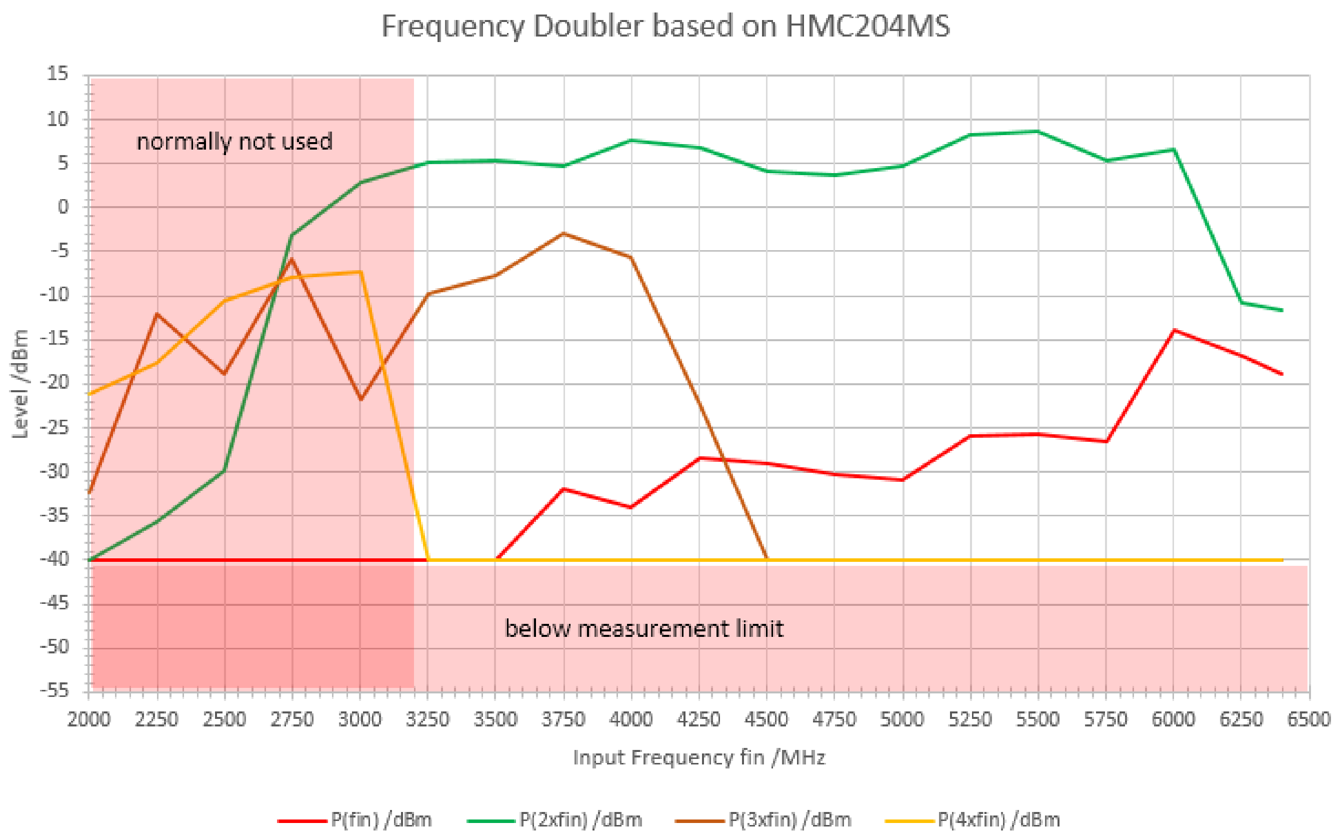


The input signal with the frequency fin is suppressed nicely by the high-pass filter in the range up to 5 GHz. However, the 3rd harmonic 3xfin increased significantly probably due to the first amplifier with a P1dB=13dBm driven into compression. Even the 4th harmonic 4xfin increased in some areas.

Thus, next I added a 12GHz low-pass filter between the 5.5 GHz high-pass filter and the RF-output port. The lowpass filter is from Bendix. The part number is no longer readable. It features a very flat passband and a cut-off frequency of slightly above 12 GHz. The attenuation at 13.5 GHz is 40dB.

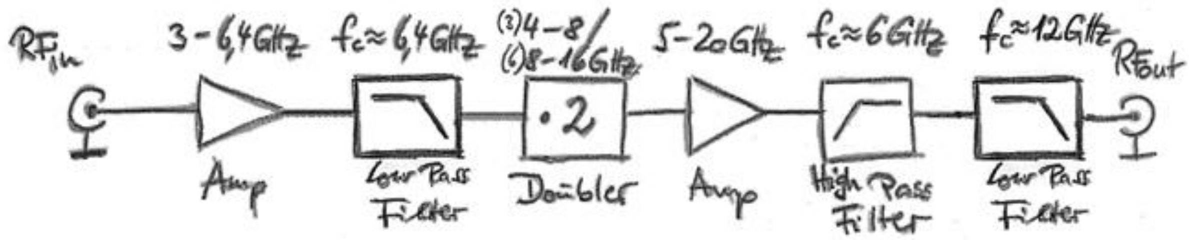


Here is a diagram of the measured output signals:

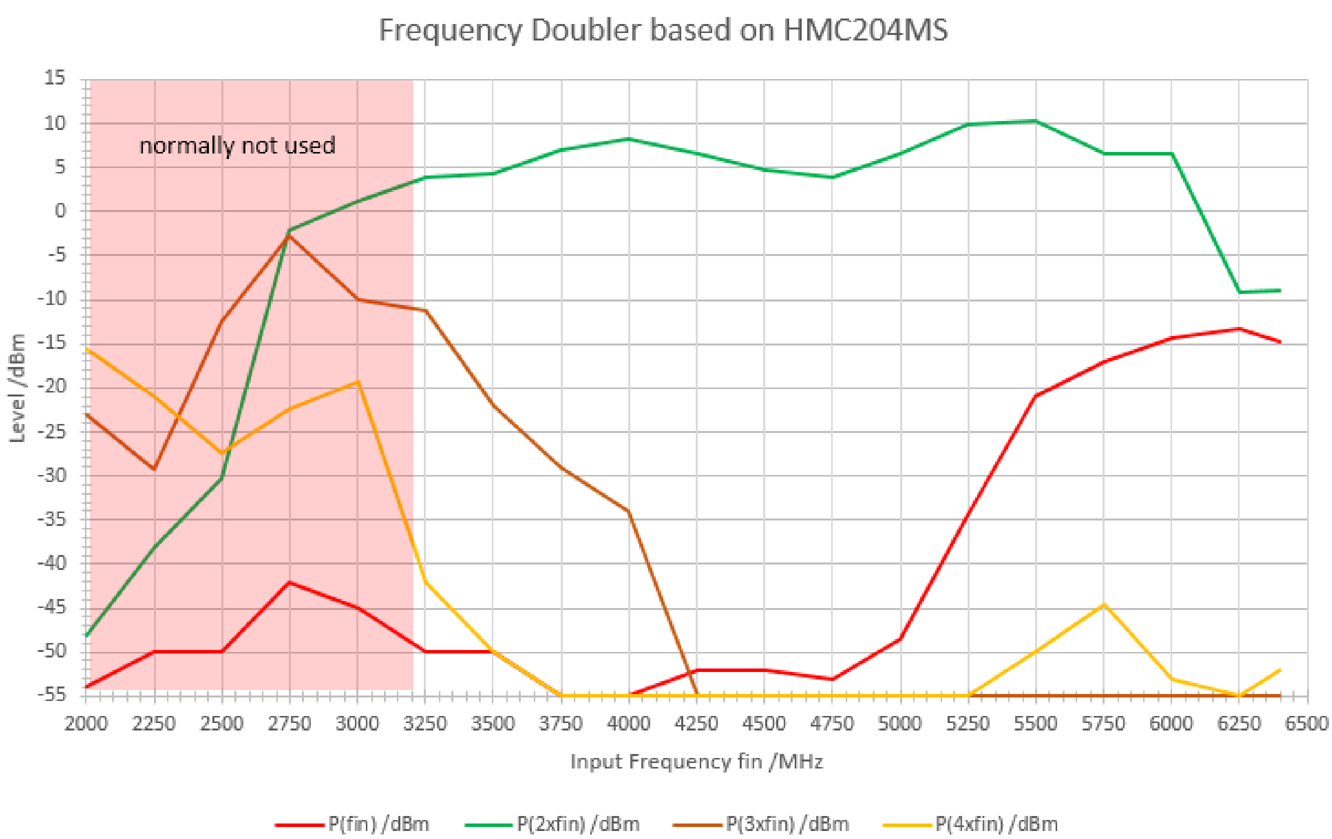


As can be seen the filter improved the output level of the unwanted harmonics 3xfin and 4xfin above 12 GHz effectively. The compromise here is that also the wanted signal at 2xfin is attenuated above 12 GHz.

Still, I was not completely happy because the 3rd harmonic (3xfin) in the frequency range fin = 2000 … 4500 MHz was quite high. After some search I found a low-pass filter from HP Agilent 9135-0040 which were supposedly used in HP test equipment such as 8671B, 8672B, 8672A, 8673D and 8970B. Its cut-off frequency is specified to be 6.2 GHz. I measured the 3dB cut-off frequency to be 6.5 GHz which fitted well for my system. I inserted this low-pass filter between the input amplifier and the frequency doubler.

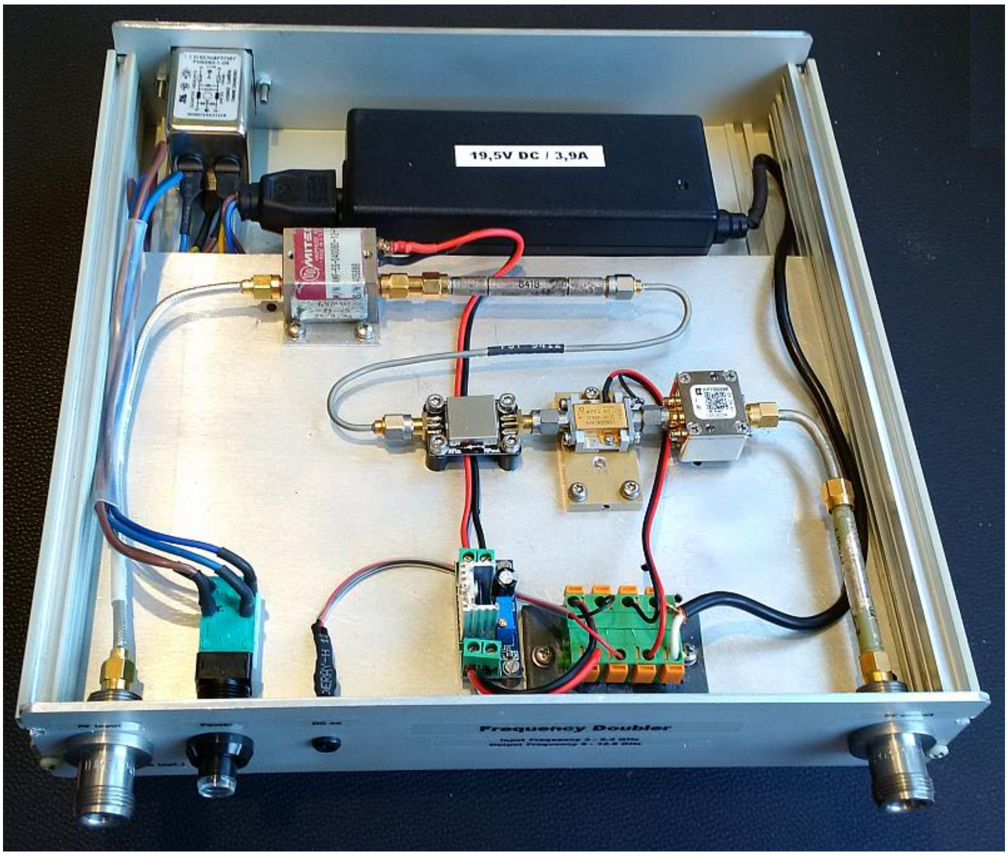


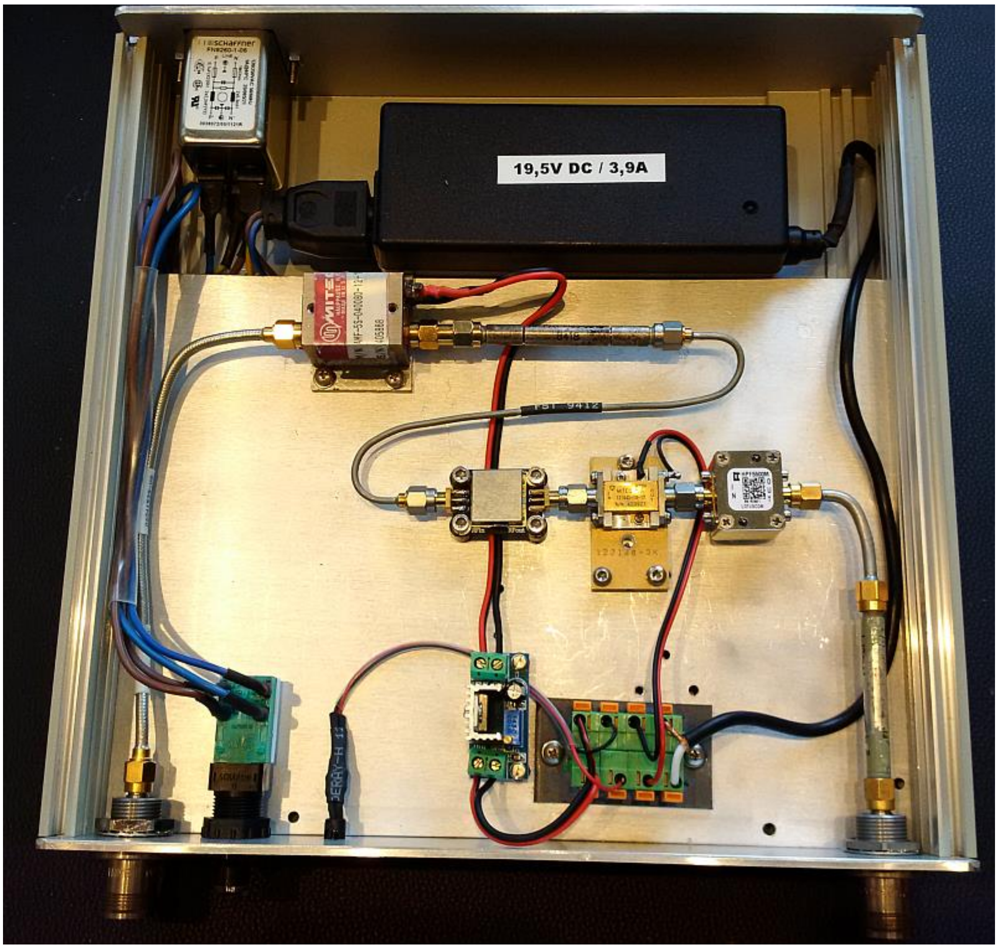
Here is a diagram of the measured output signals:

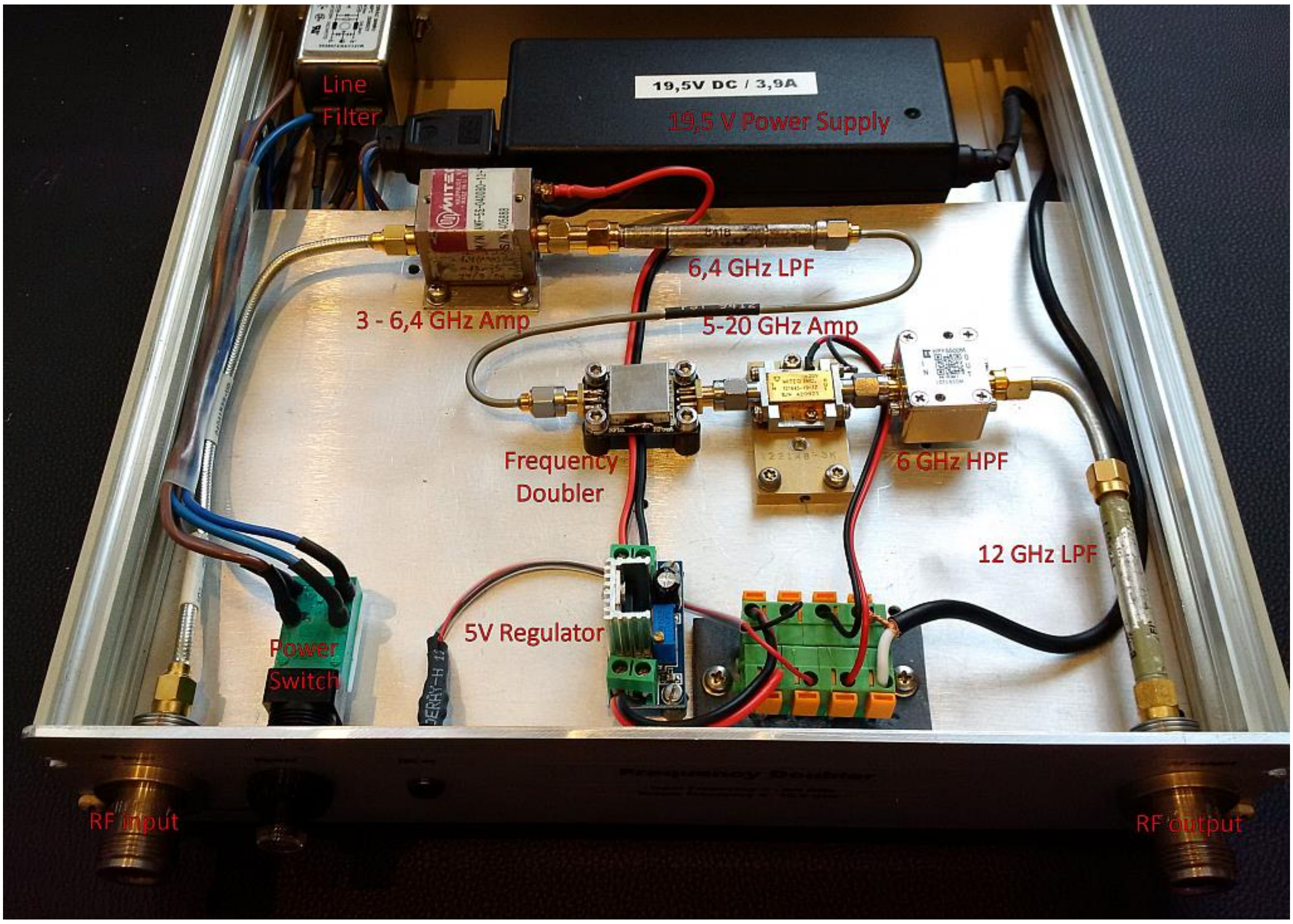


The unwanted the 3rd harmonic (3xfin) is improved nicely in the frequency range fin = 3250 … 4500 MHz. Whether it also improved in the range 4500 MHz to 6400 MHz is unclear as the previous measurement was limited to -40dBm. Anyway, with the improved measurement range down to -55dBm it can be guaranteed that the 3rd harmonic is -55dBm or below at 4250 MHz and above.

Here are some pictures of the final setup:







I have not yet decided whether I will add relays as I had originally envisioned in order to be able to bypass the frequency doubler when not needed.

Anyhow, I have now a frequency doubler covering the range fin = 3.2 … 6.4 GHz respectively fout = 6.4 … 12.8 GHz with quite good performance. The needed input level is approx. -20dBm and the output level between 6.4 and 12 GHz is +4 … +10 dBm rolling off to -9dBm at 12.8 GHz.

I am always interested in feedback. Please send it to the Email address given below.

Best regards

Matthias

Email: dd1us@amsat.org Homepage: www.dd1us.de