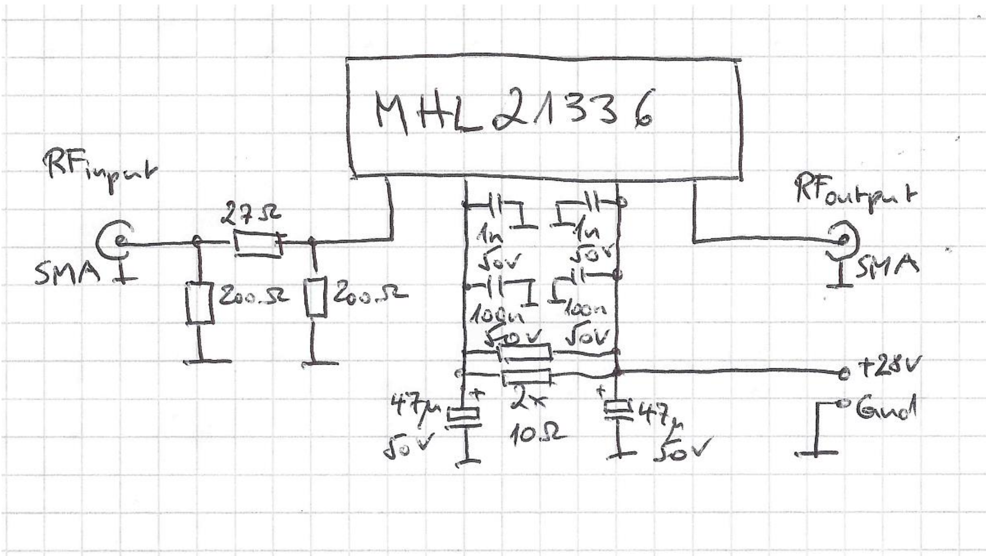
2.4 GHz 1.3W medium power amplifier MHL21336

Matthias, DD1US, Updated March 21st 2020, rev 1.4

In my setup for QO-100 I was missing a medium power amplifier to drive the planned DATV power amplifier. A friend from the NL, Remco PA3FYM, recommended to use the PA module MHL21336. As such modules are very cheap (approx..7€ including shipping from China) I decided to give it a try.

This PA is supposed to give a saturated output power of 3W at a supply voltage of 28V.

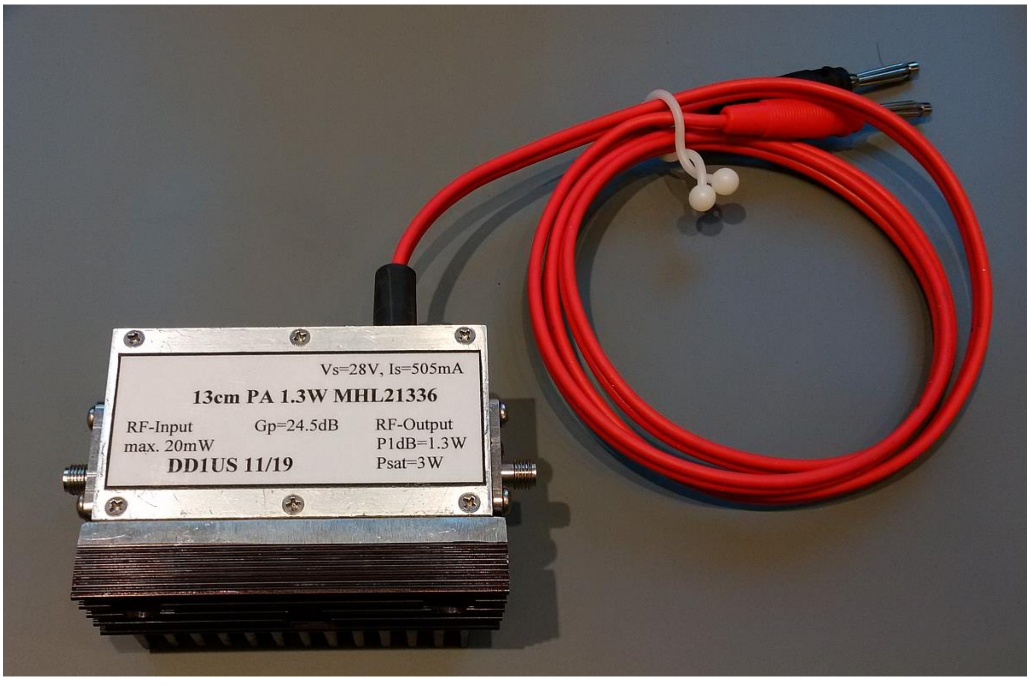
Here is the schematic of this PA:

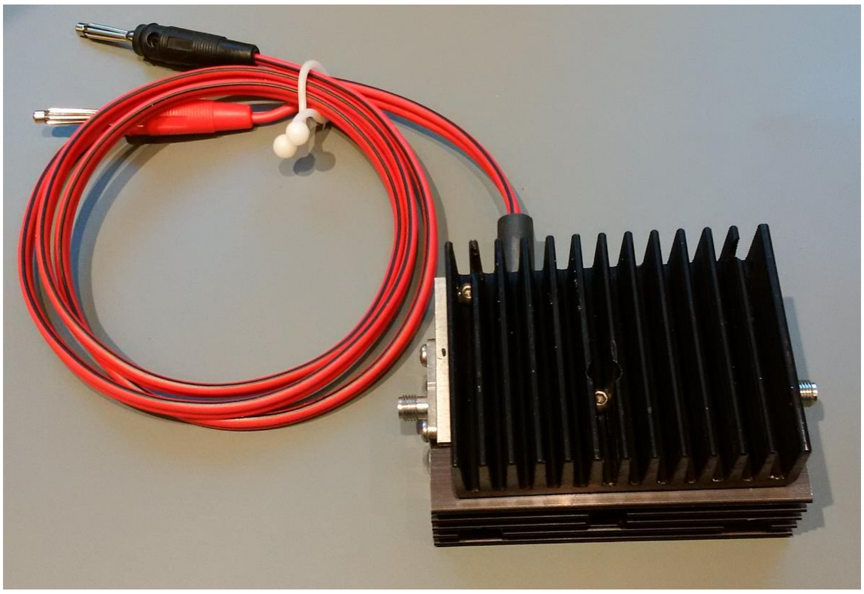


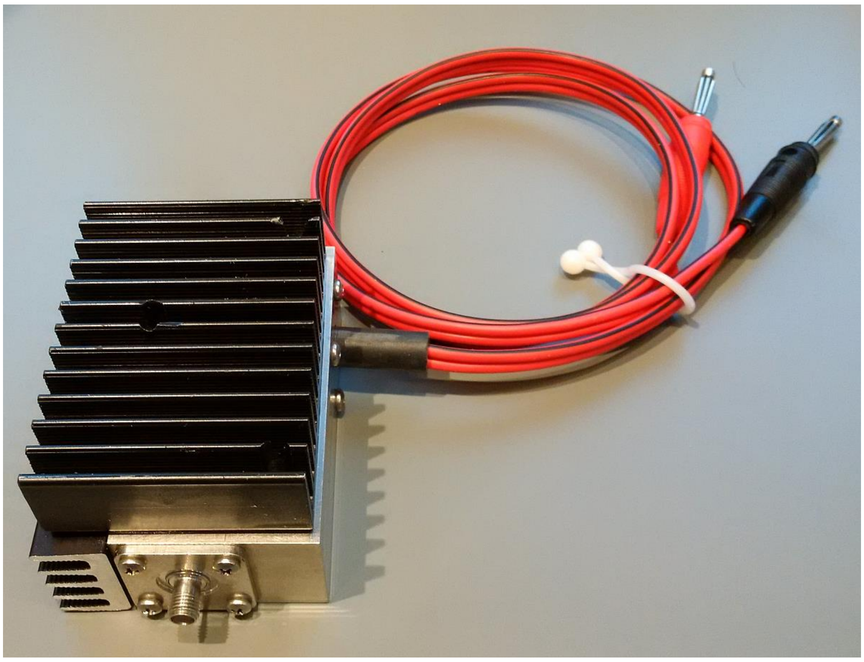
I added a 4.4dB attenator at the input of the PA in order to improve the input matching. The two 10 Ohms resistors are connected in parallel and thus the current to the first stage / supply input pin can be measured.

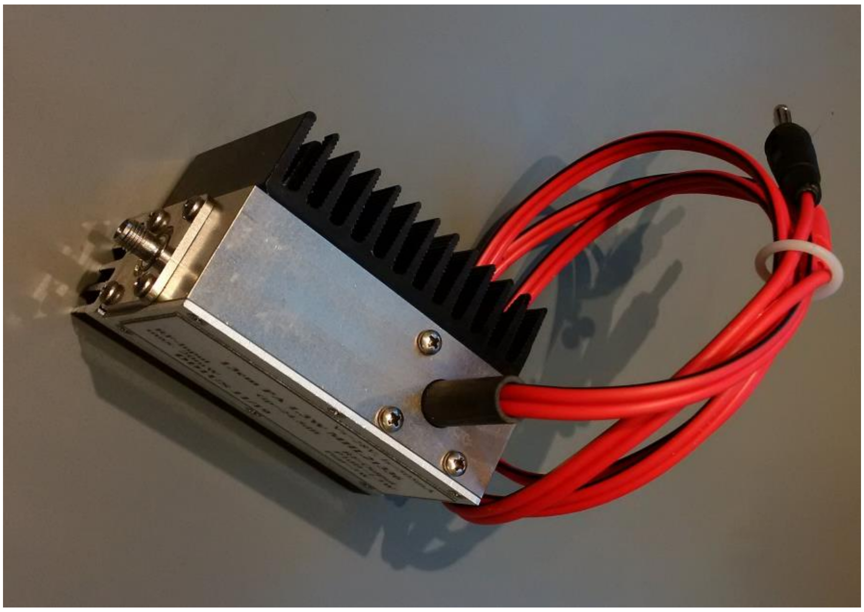
All components including a suitable encasing and old heat sinks were already in my drawers and thus I built this very simple medium power amplifier for less than 10€.

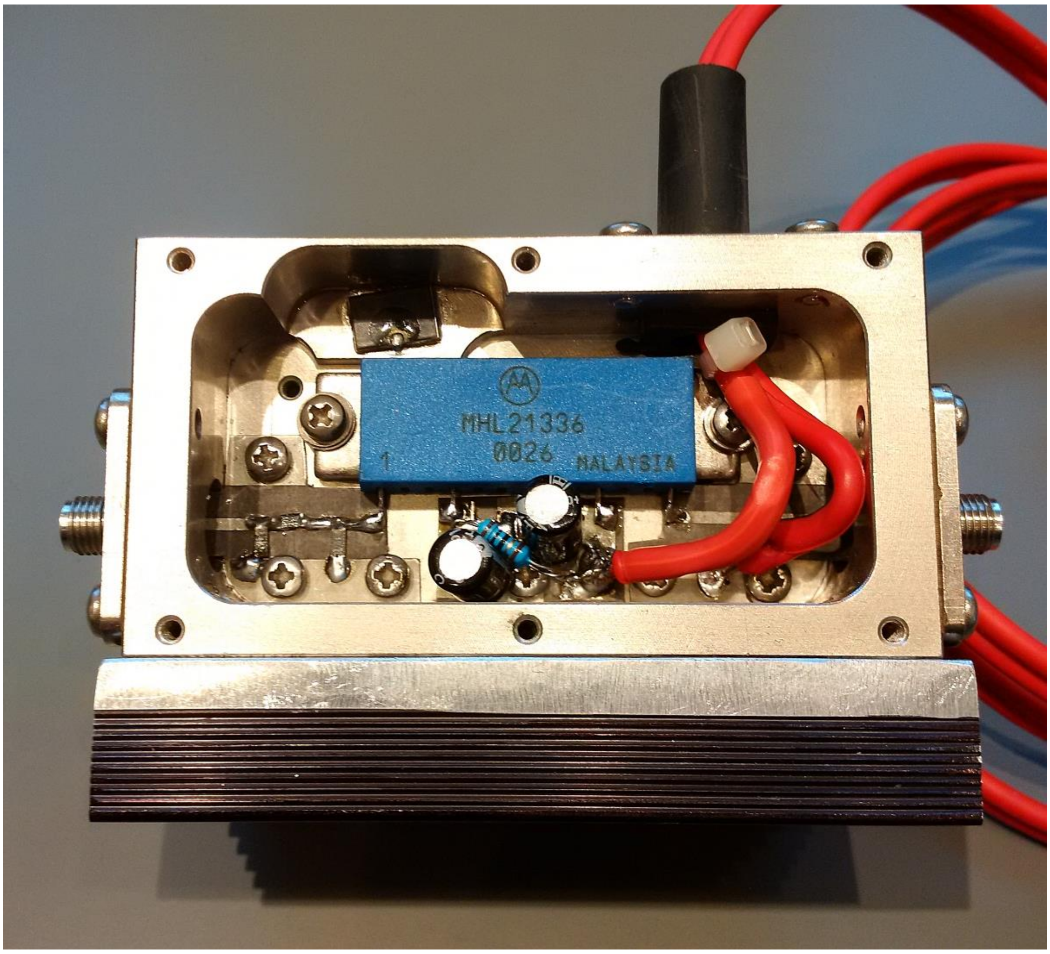
Here are some pictures of my finished unit:



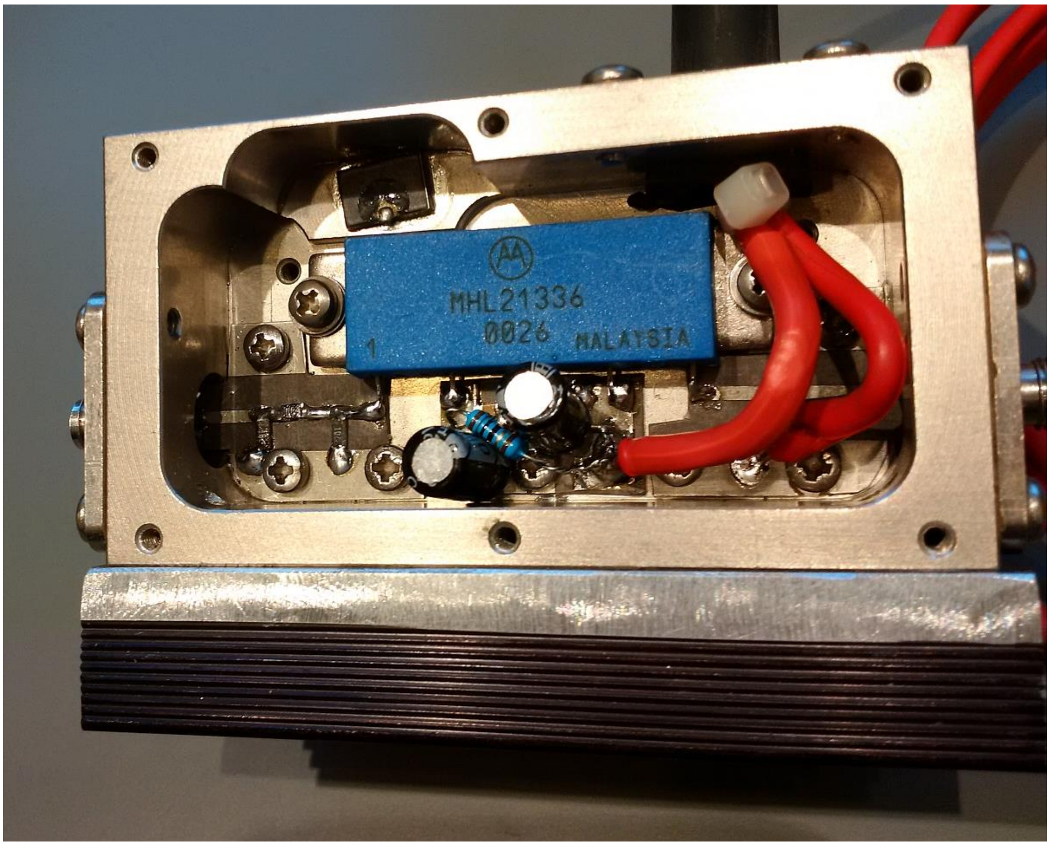


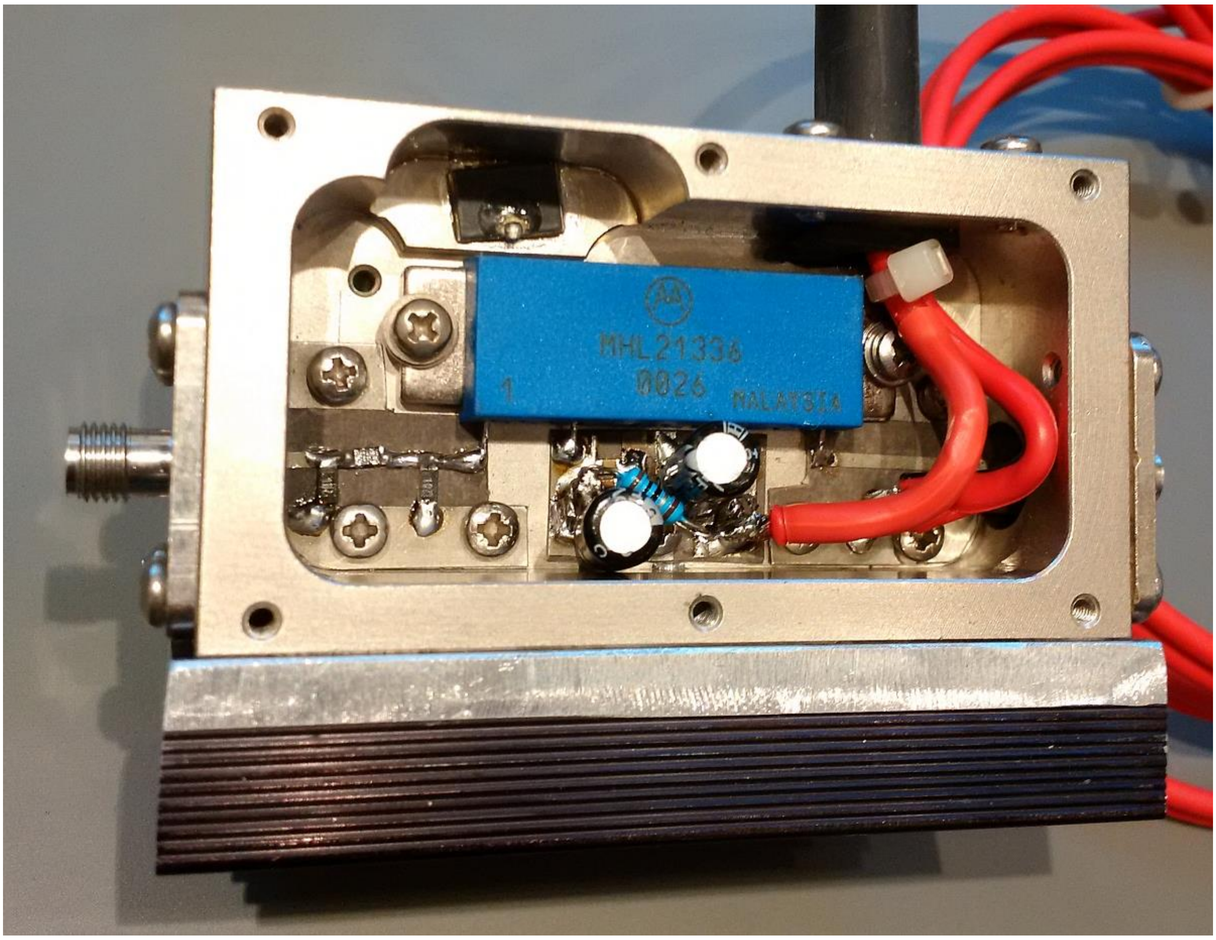






I used an old RT-duroid PCB and cut out suitable pieces for input, output and biasing

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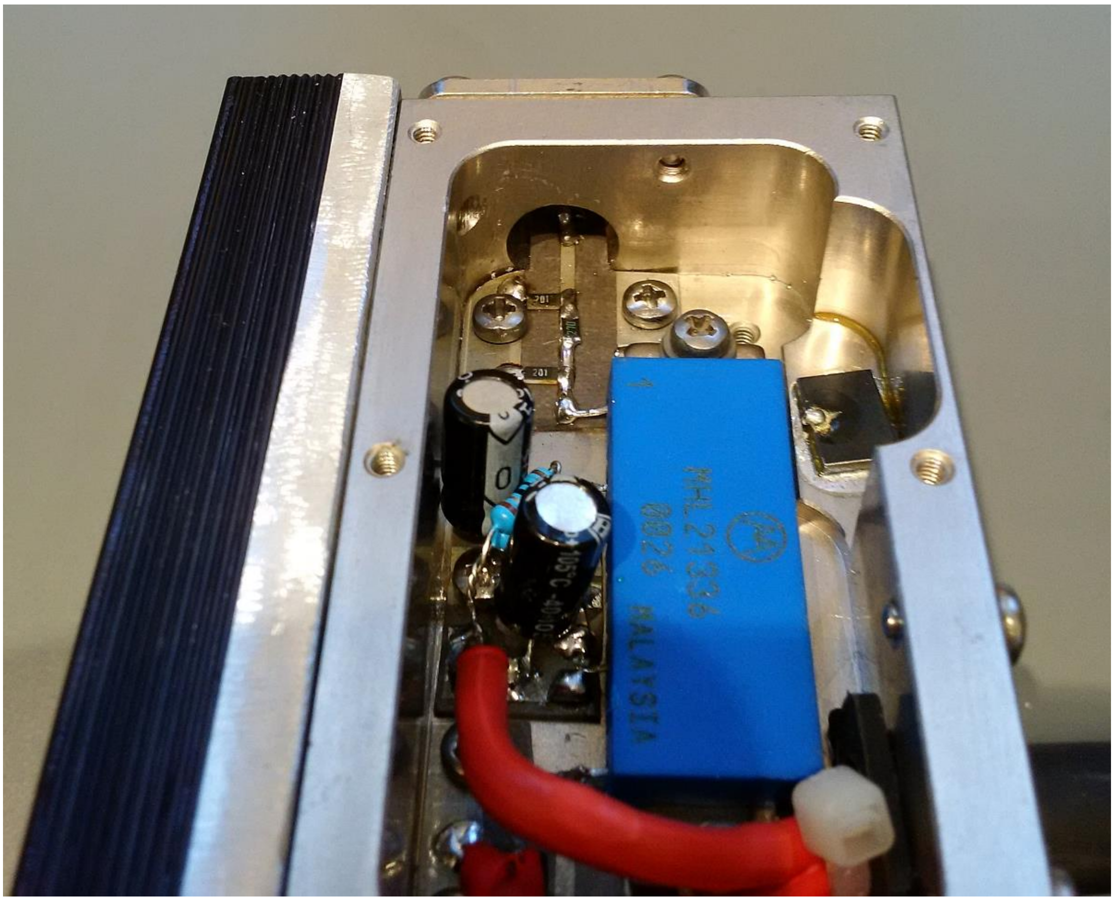
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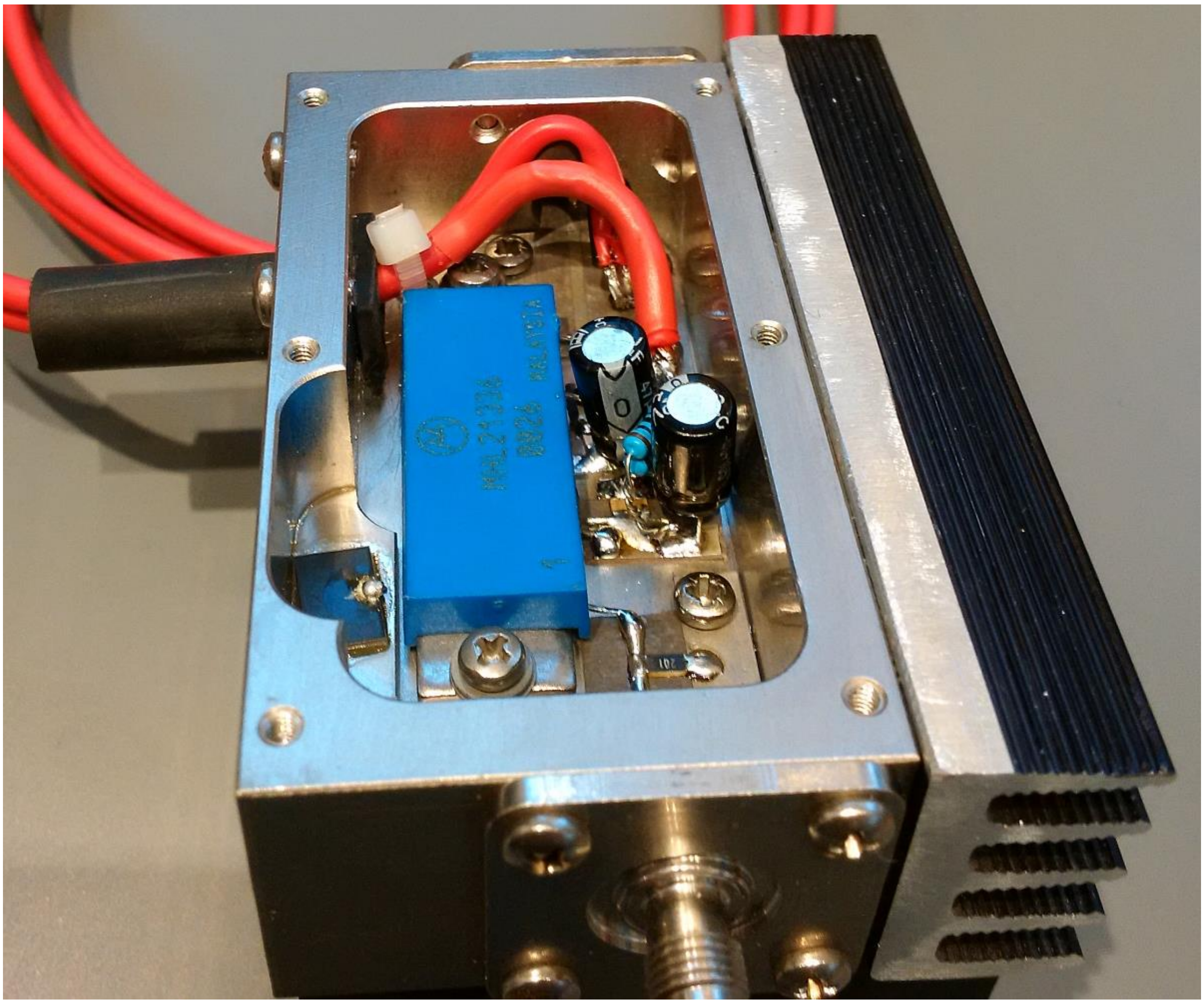
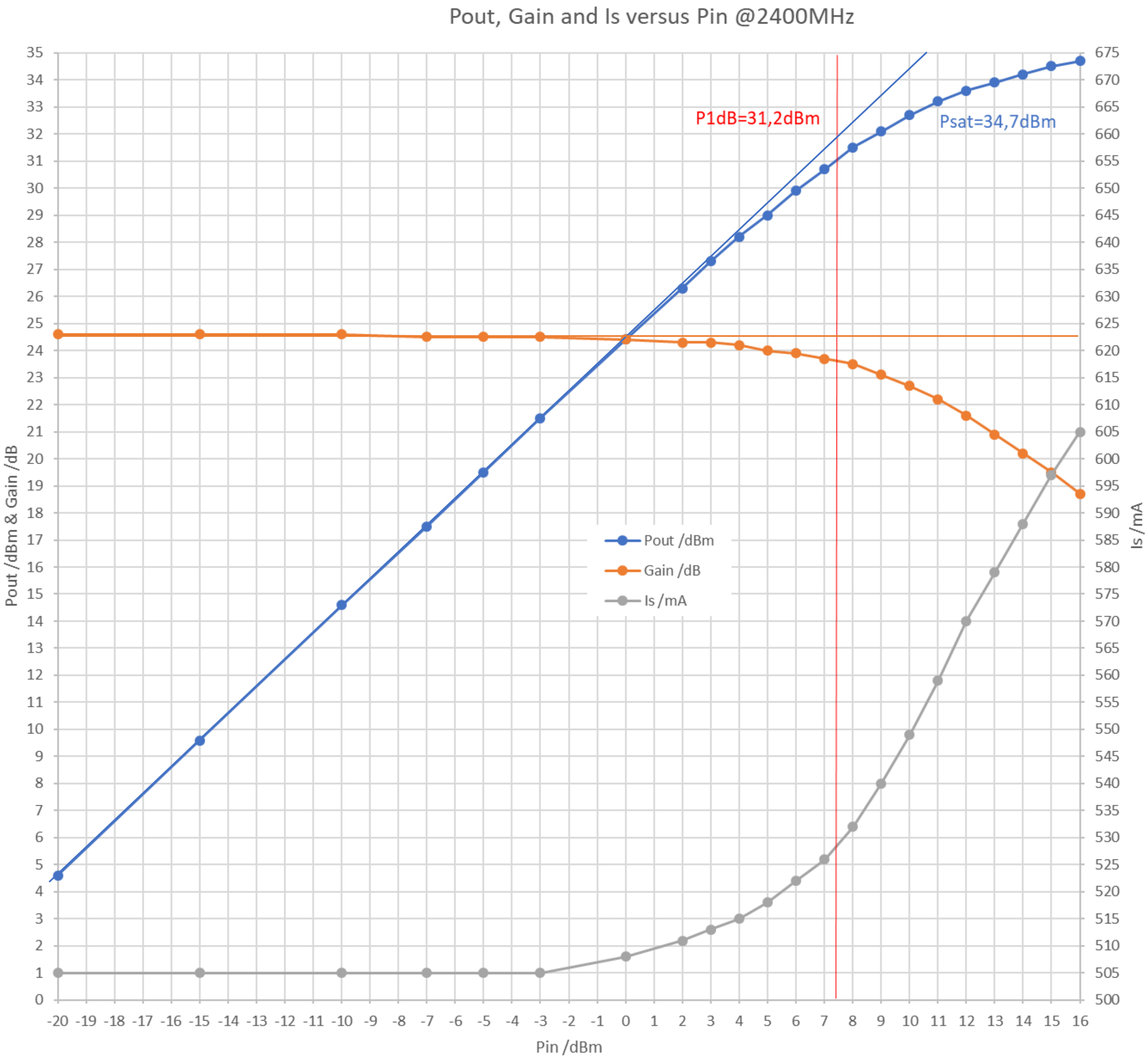


The power resistor on the left in the encasing is a remnant of the previous use of the milled aluminum encasing

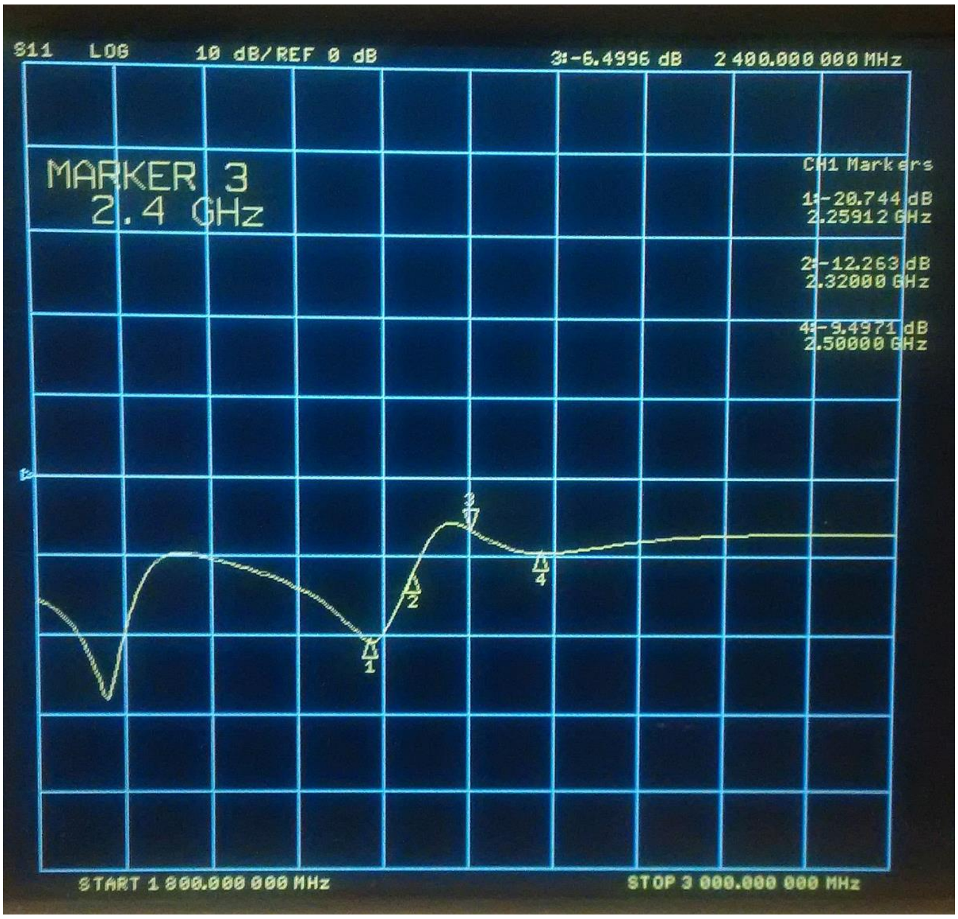
I measured the output power as a function of the drive level. I operated the PA at a supply voltage of 28V. The quiescent current is 505mA.

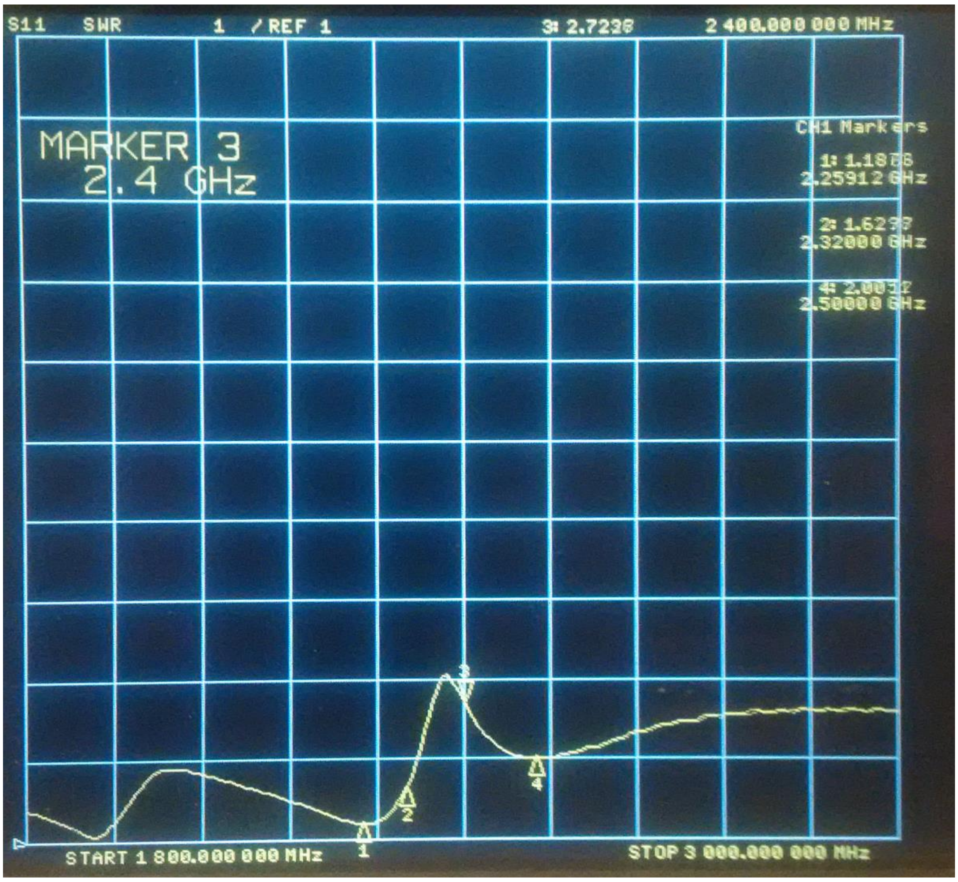


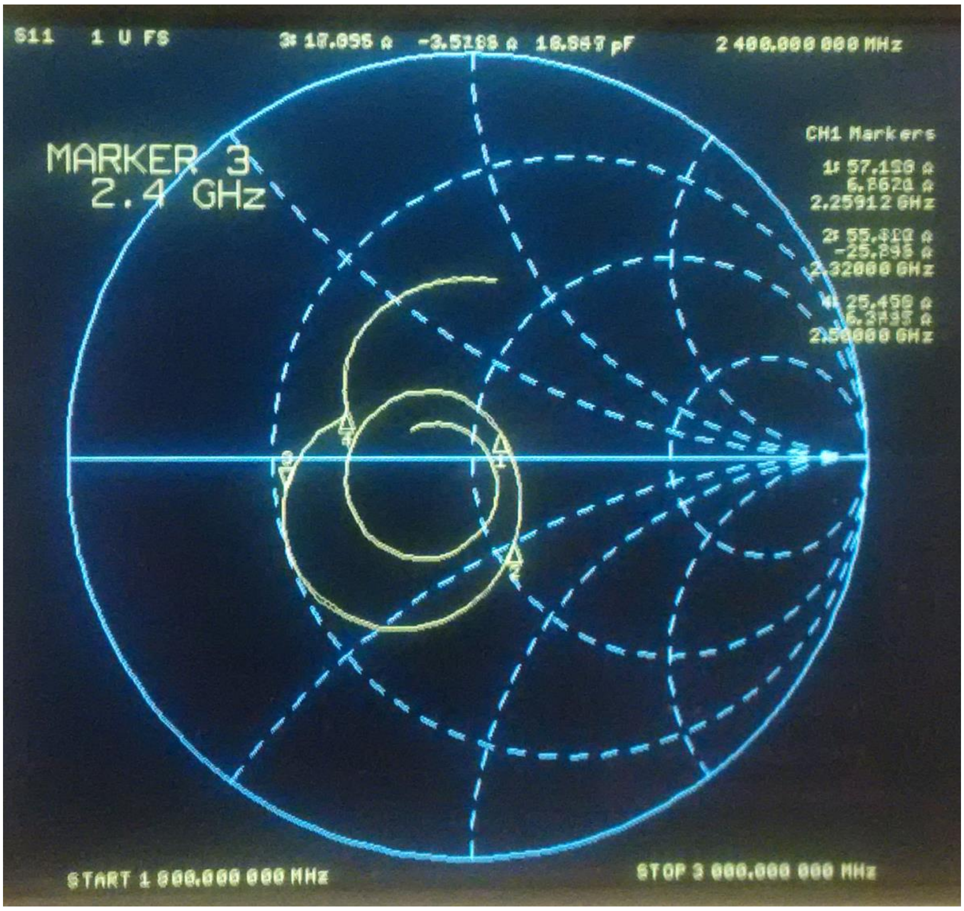
The small signal gain is 24.5dB, the P1dB is +31.2dBm=1.3W with a drain efficiency of 11%. The saturated output power is +34.7dBm=3W at a current consumption of 600mA and a drain efficiency of 20%.

The measurements were done, after running the PA for some time (it was warm). I noticed that the output power is up to 1dB higher when it is cold.

Next, I measured the input matching of the amplifier. I was expecting to see a return loss in excess of 10dB as the input attenuator should help to improve it. Here are the measurement results.


S11 LOG 10 dB/REF 0 dB
3:-6.4996 dB 2 400.000 000 MHz
MARKER 3
2.4 GHz
CH1 Markers
1:-20.744 dB
2.25912 GHz
2:-12.263 dB
2.32000 GHz
4:-9.4971 dB
2.50000 GHz
START 1 800.000 000 MHz
STOP 3 000.000 000 MHz


S11 SWR 1 / REF 1
3: 2.7238
2 400.000 000 MHz
MARKER 3
2.4 GHz
CH1 Markers
2.25912 GHz
2.32000 GHz
2.50000 GHz
START 1 800.000 000 MHz
STOP 3 000.000 000 MHz

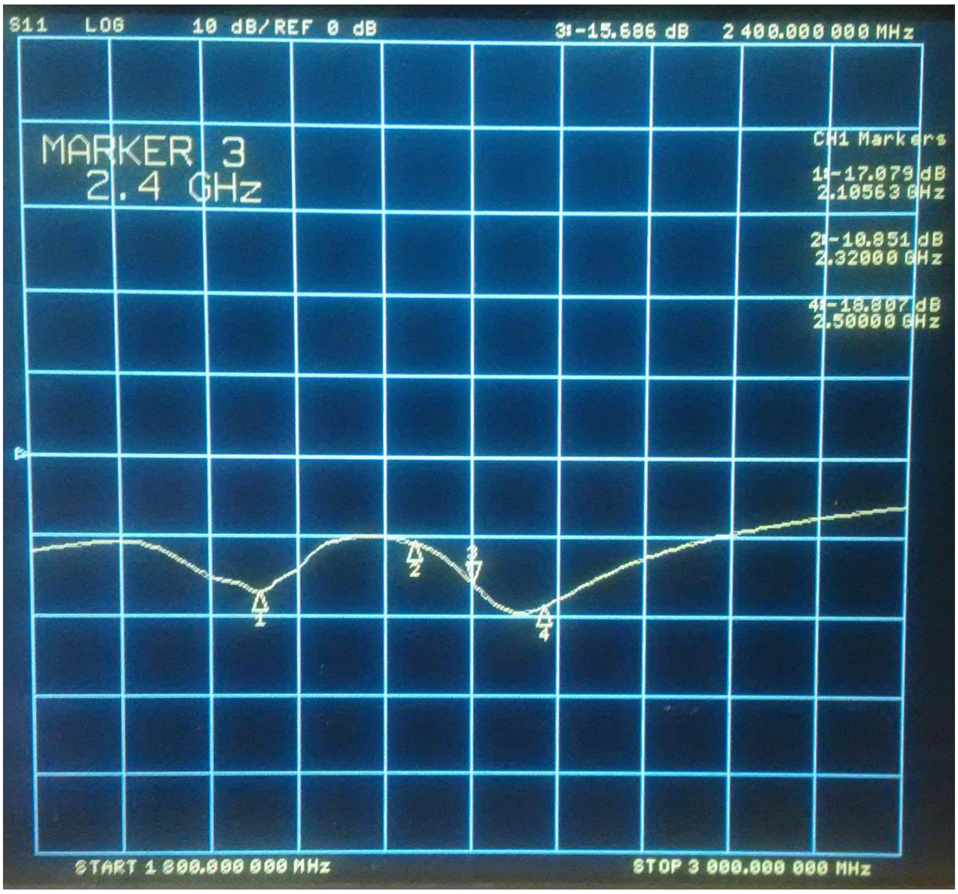


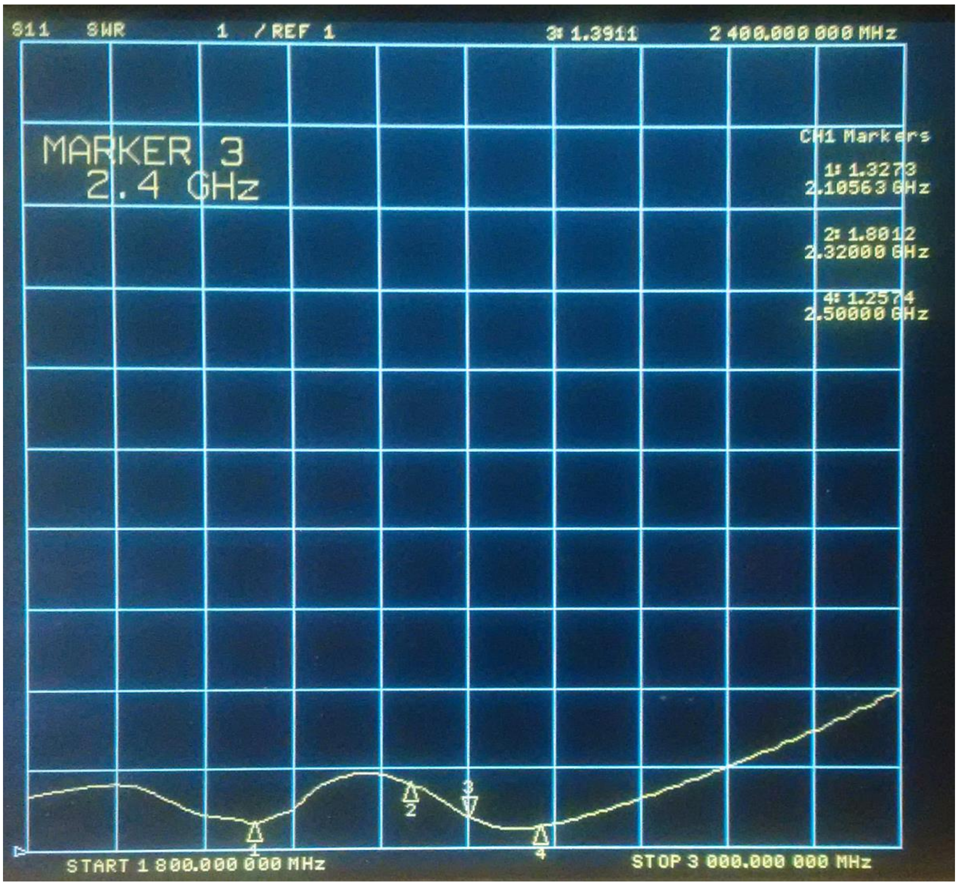
Frankly speaking I was a bit shocked about the poor return loss at the input of the amplifier. It was only 6.5dB respectively a VSWR of 1:2.7.

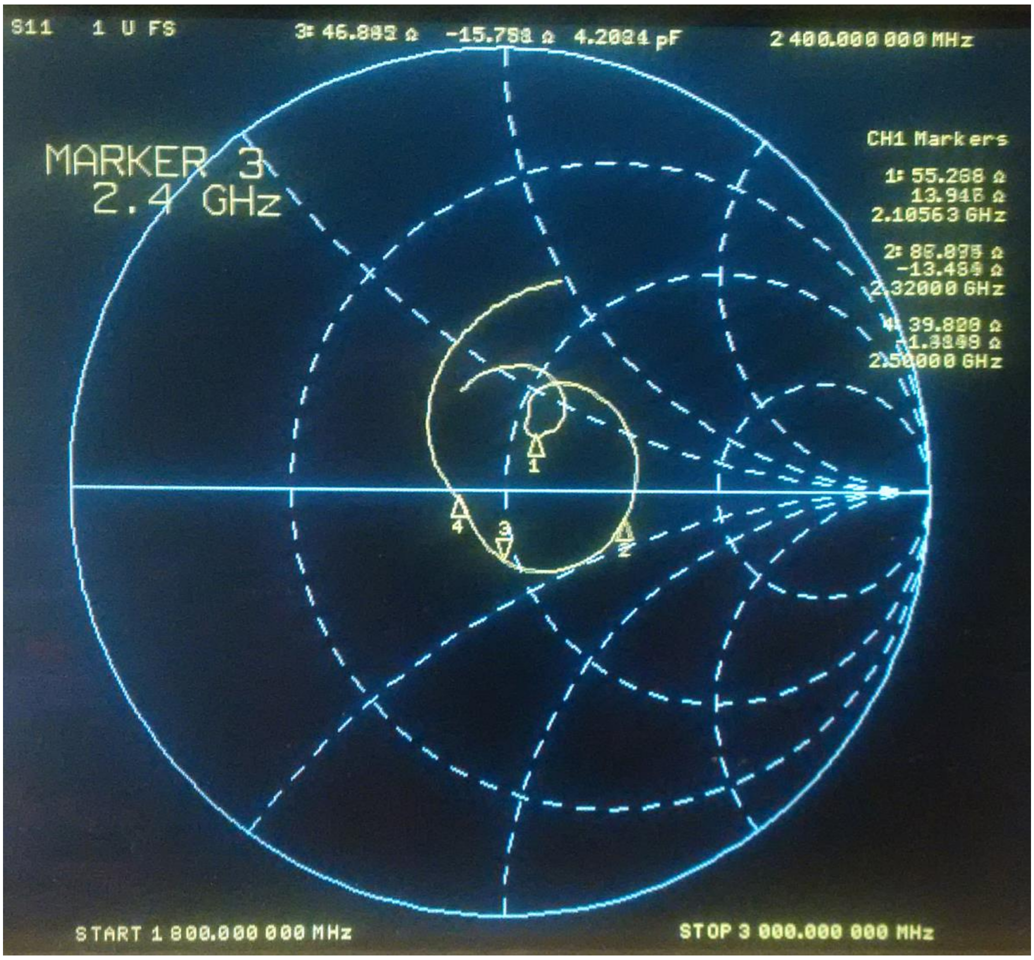
As I was afraid that this might create problems in real applications e.g. when a filter is inserted in front of the amplifier, I decided to optimize the input matching.

After some steps I ended up with the following input circuit: just 2 resistors 82 Ohm and 560 Ohm in parallel. The 82 Ohm resistor is placed closer to the input coaxial connector, the 560 Ohm resistor closer to the input of the amplifier module. No series resistor was used. Here is a picture of this input circuit:

Here are the corresponding measurement results:

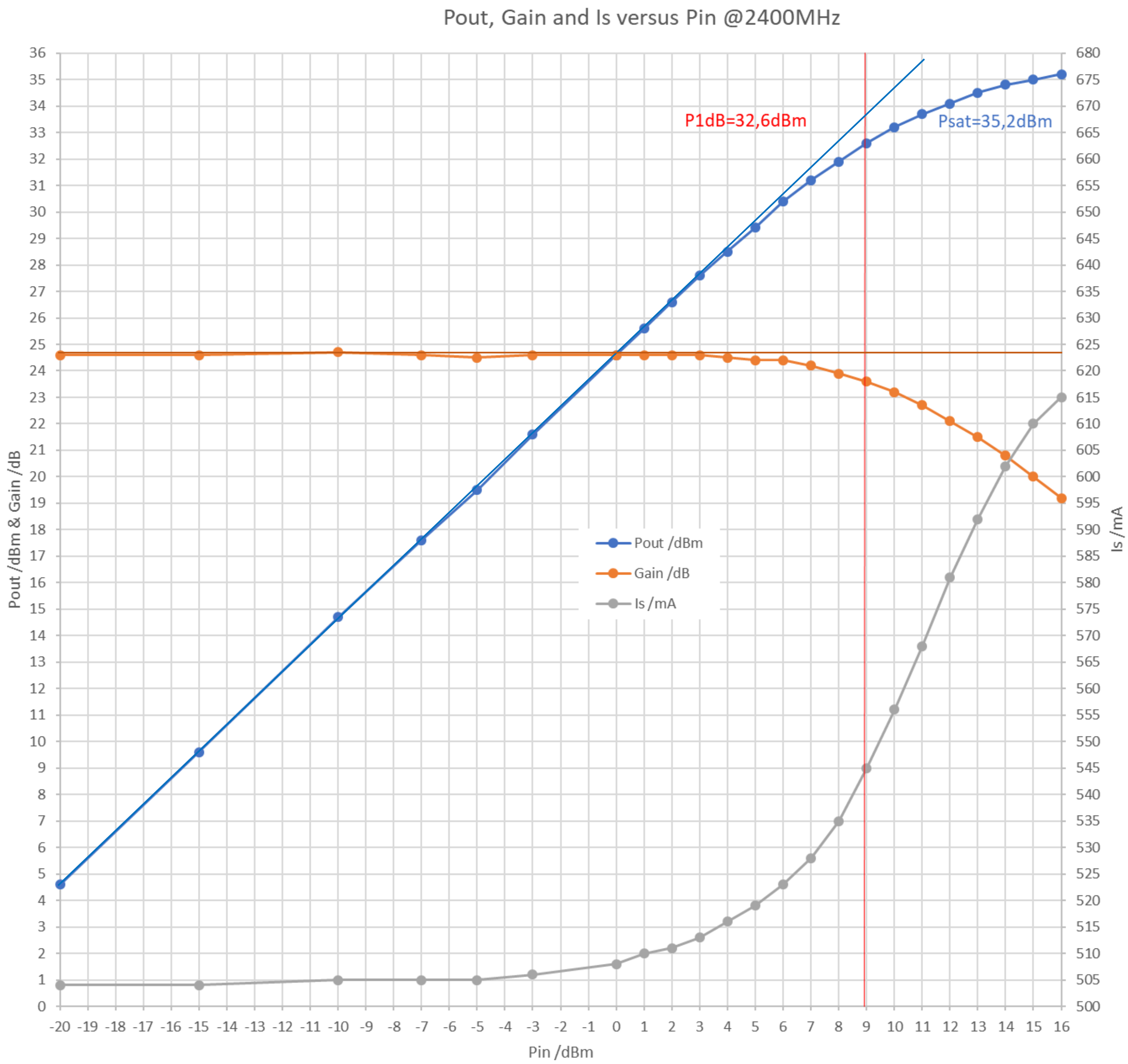






The return loss is now 15.5dB respectively the VSWR 1:1.4. I am sure this could have been further improved but I felt it is certainly good enough for my applications.

Of course, I double checked the output power as a function of the drive level. As before I operated the PA at a supply voltage of 28V and a quiescent current of 505mA. It turns out that the results are very similar as before.



The small signal gain is 24.5dB, the P1dB is +32.6dBm=1.8W with a drain efficiency of 14%. The saturated output power is +35.2dBm=3.3W at a current consumption of 615mA and a drain efficiency of 22%. The improved P1dB and Psat might also be due to a lower temperature of the amplifier during these measurements.

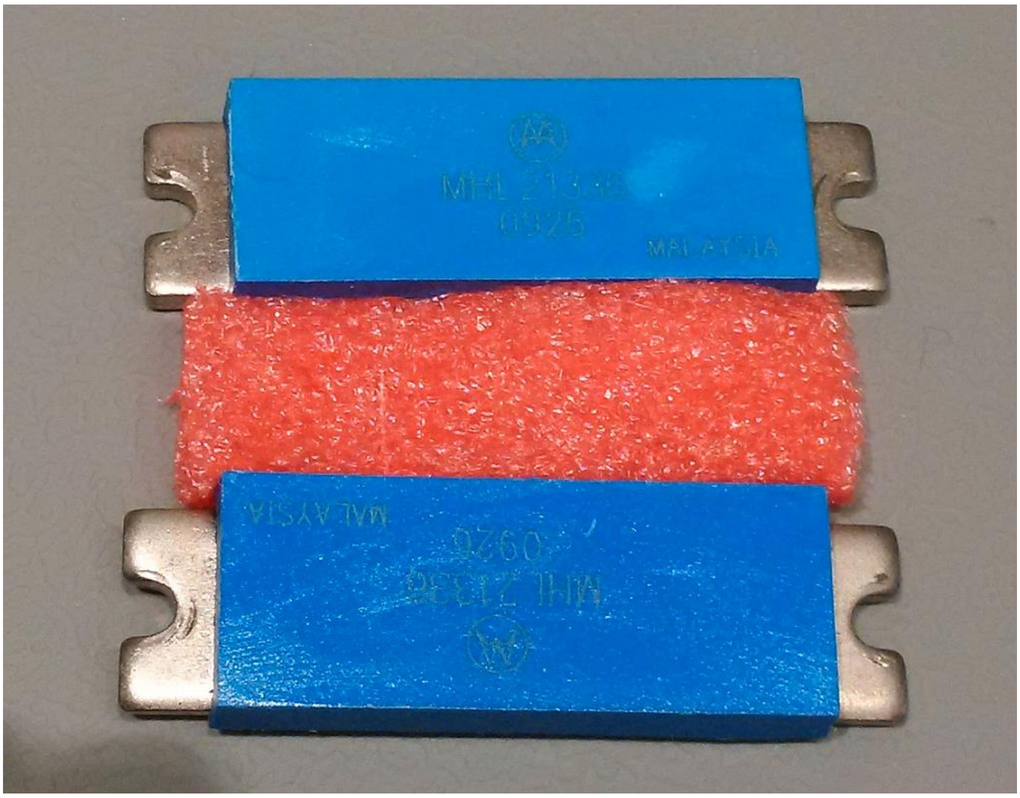
In summary the PA is working as expected. One caveat is the fact, that the PA is always running with a quiescent current of 500mA and thus the power consumption is 14W even without driving the PA at high power output. Thus, a suitable cooling is needed.

In January 2020 I decided to build some more amplifiers based on the MHL21336 devices.

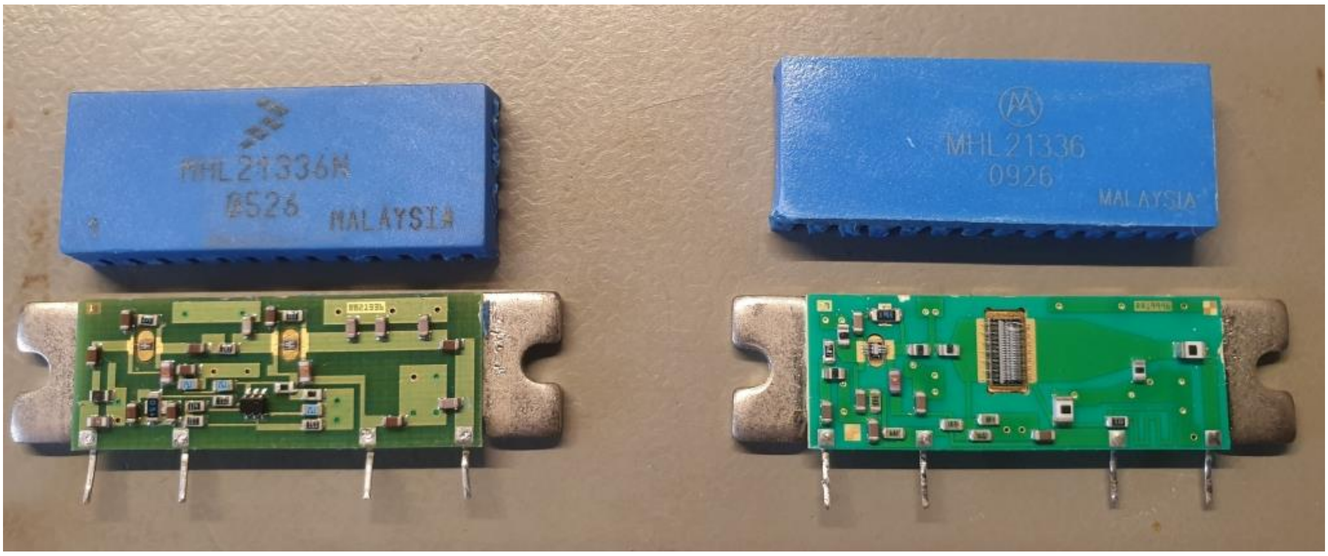
However, when starting to test the additional PAs their quiescent current was way too high. Only when reducing the base currents Vbias1 at Pin 2 to about 7.2V, I was able to get to a reasonable quiescent current of about 500mA.

Apparently that this second module is not a MHL21336 but a counterfeit.

Also, the marking on the blue lids looked different at the fake devices!

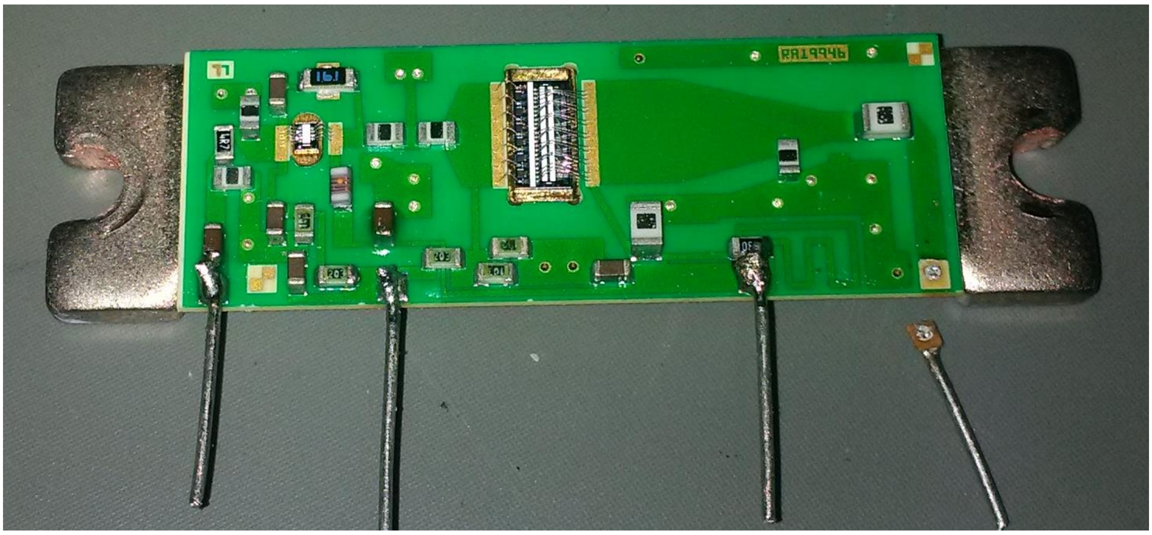


Below is a picture of the original MHL21336 device on the left and the fake device on the right.

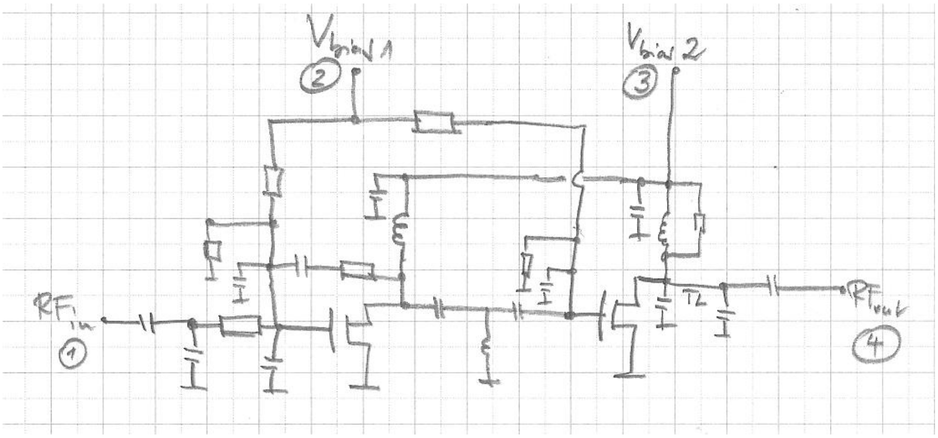


Many thanks to Wolfgang DC2TH for the picture.

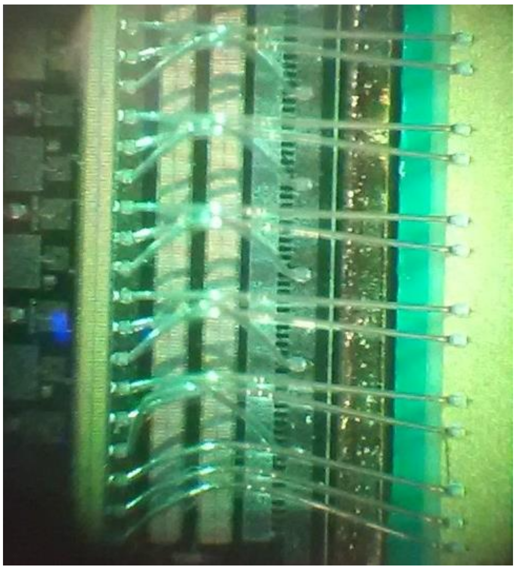
One of my fake MHL21336 devices was slightly damaged and I had to repair it. Here is a picture of my fake amplifier with the blue plastic lid removed. You can see the output pin was broken but easy to repair.



It is apparently a 2-stage design, one can see 2 semiconductor dies bonded on the substrate. The substrate is marked with RA1994b. Here is a sketch of the schematic:



Here is a more detailed view of the final stage.



As the transistor of the final stage in the fake device has a much bigger die size compared to the original module, I suspect that the fake modules are in reality MHPA21010 or a MHPA19010N or a MHPA18010N modules. Heiner DD0KP had kindly sent me links to their datasheets. These devices are 25W WCDMA modules for 2100 MHZ respectively 10W CDMA modules for 1900 and 1800 MHz. Another reason why I believe those modules are the basis for the counterfeit modules is the fact, that their Vdd1=Vbias specification matches my measurements very well.

I am always grateful to get feedback and will be happy to answer questions.

Please direct them to the Email address which you will find below.

Best regards

Matthias DD1US

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