Receiver construction using 50 ohm modules (gain blocks)

Part 3: 23cm version

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7. The 23cm version

The beauty of the Gainblock principle is that you can continue to use existing assemblies from previous projects that may still be in the "drawer". This is, for example, the basic version of the LNA used (see [6]) for the range of 1 to 2GHz with over 20dB gain and a noise figure NF of 0.3 to 0.4dB. This amplifier can be used directly and it only remains to develop a new a bandpass filter for the range of 1240 to 1300MHz.

Fig 29 shows the circuit diagram of the LNA with an additional 4.7µF SMD ceramic capacitor to decouple the supply voltage. This prevents signals from sneaking out of the device and secretly entering the system somewhere (see chapter 6 in part 2).

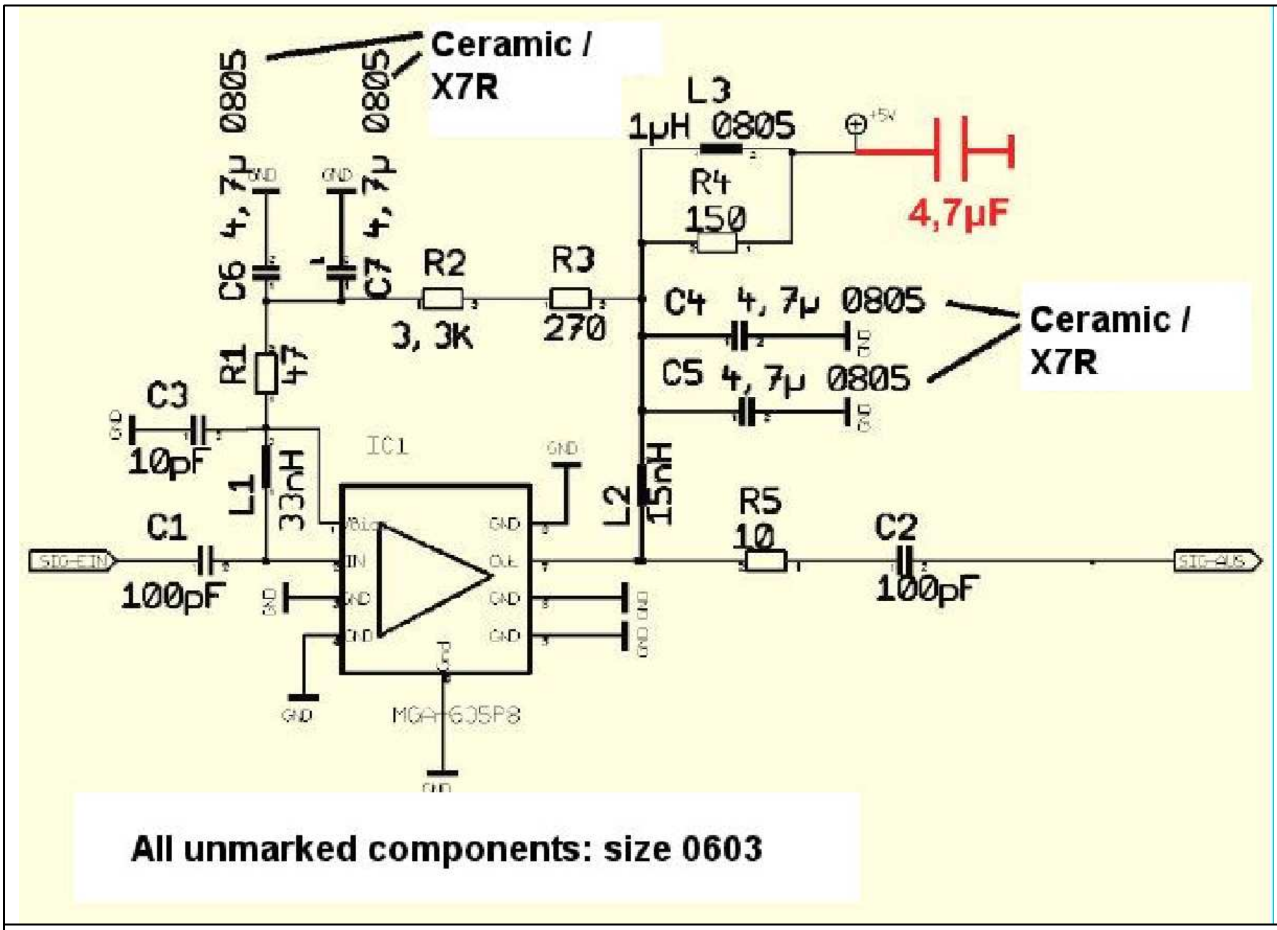

Fig 29: This is the LNA circuit for 1270MHz. Tricks are needed to prevent unwanted strong FM radio stations finding their way over the supply line to the output.

7.1. The 1270MHz bandpass and its "siblings"

As so often in life, the whole thing starts completely harmlessly: You design a microstrip bandpass filter using the inexpensive yet good material ROGERS "RO4003" or its non-flammable brother "RO4350" However, there was suddenly a problem because with the very low dielectric constant of about 3.5, the calculated mechanical length is almost 160mm. But the maximum length of the milled aluminium housings in stock is 130mm. Luckily, I remembered that at some time I had purchased an A4 sized piece of ROGERS RT6010 at a Ham Radio flea market. Newly purchased this Teflon material is incredibly expensive, but a one-man PCB company had stopped using this type and cleared the warehouse, so was probably the residual price after depreciation. That was the salvation: this stuff has a dielectric constant of 10.8 and therefore reduces the dimensions significantly (by a factor of 10.8 / 3.5). The losses are lower compared to RO4003 and so a new design was carried out. The result is shown in **Fig 30,** four conductor pairs were needed for the required filter function:

a Because the interconnection of adjoining line pairs are of unequal in width, "microstrip-step models" must be used in between them.

b All open ends of individual line sections must be terminated with the "Open End Extension Model".

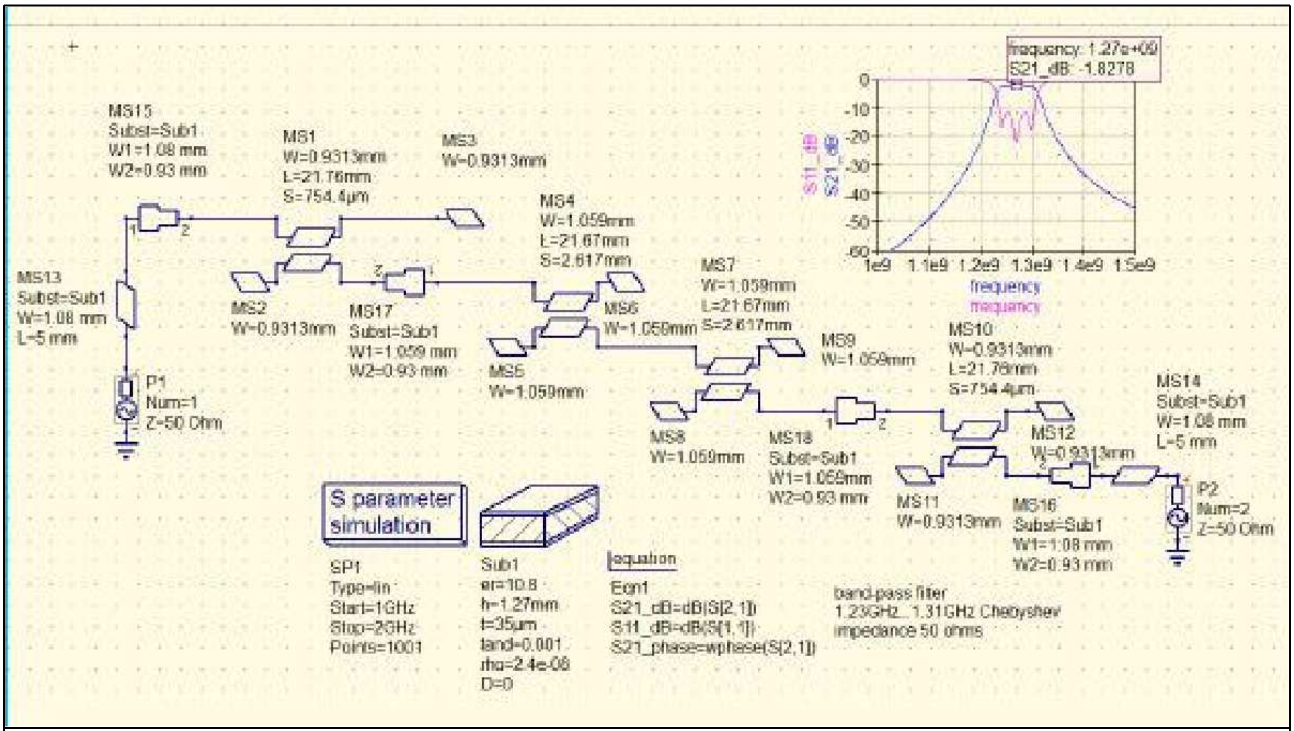

Fig 30: Thanks to the good filter calculator from qucsstudio (and the additional simulation diagram), the design of the 1270MHz bandpass filter is just hard work, but no problem (see text)

This will move the filter curve and shift the centre frequency. It will still take some time to optimise the line lengths until the desired bandwidth, centre frequency and input match are correct.

Teflon material requires completely different techniques for the pre-treatment and etching. Once again, this was a task for the etching plant in Munich (www.aetzwerk.de) who had always been cooperative and competent in the past. But this time it was not without critical remarks (In Bavarian

- "Granteln") because a smaller clamping device for the A4 sheet had to be improvised. The etching baths usually hold half a meter wide boards. **Fig 31** shows what was produced. In addition to the 23cm bandpass filter it also contains another version for 1420MHz ("hydrogen frequency") with a higher filter degree and a 13cm version The 13cm version will be used later fitted in a smaller screened housing 50mm long.

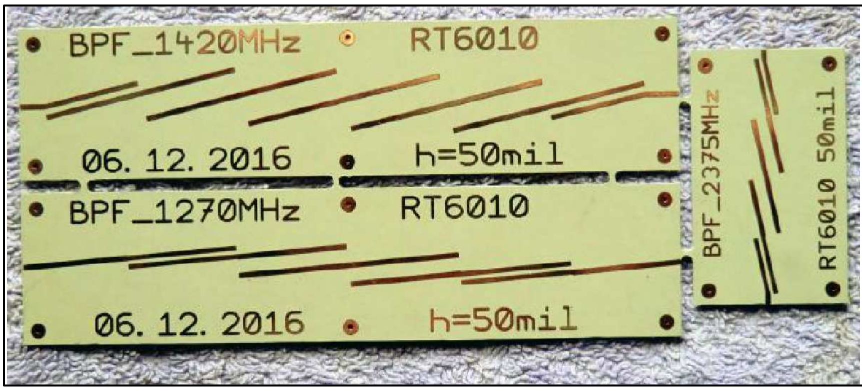

Fig 31: This is the "benefit" of professional board production (here Teflon material). Because of the high material and preparation costs you try to produce as many circuits as possible.

Unfortunately, during etching of the circuit board some of the surface around the edge was lost because of the improvised clamping device so there was only room for two sets of filters on the A4 sheet.

After the etching the board was silver plated and fitted in the aluminium housing (**Fig 32**), the measured values are of interest. A pleasingly low transmission loss (minimum value = 2dB) is shown in **Fig 33,** but unfortunately also a filter curve that is shifted upwards by 9MHz. This deviation can

Fig 32: Honestly - if you have this sight in front of you, you're glad: First, because of the pleasing data and because the module can finally be used and all the work and effort of the preparation is behind you.

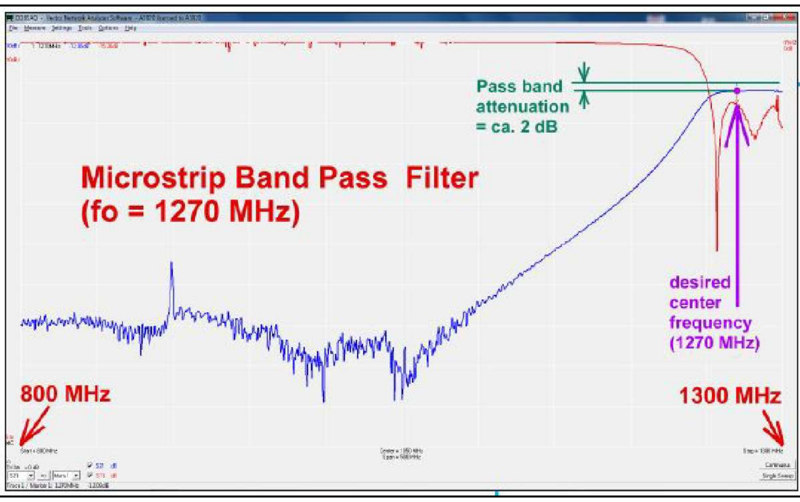

Fig 33: That's the reward: a transmission loss of just 2dB at f=1270MHz is a real dream value; unfortunately, the centre frequency is too high by 9MHz.

easily be remedied by another design, if you simply extend all line lengths by a factor of 1279:1270.

But to do this, two things would be necessary: First, an expensive Teflon board and secondly a lot of money again for board production.

Fig 34 shows the distant selectivity with the unavoidable periodic dips in the stopband attenuation as the frequency increases. The damping material glued on the inside of the lid (see **Fig 32**) prevents housing resonances that cause additional annoyance with resonance behaviour from 4GHz. But that's the way it is with this type of filter ...

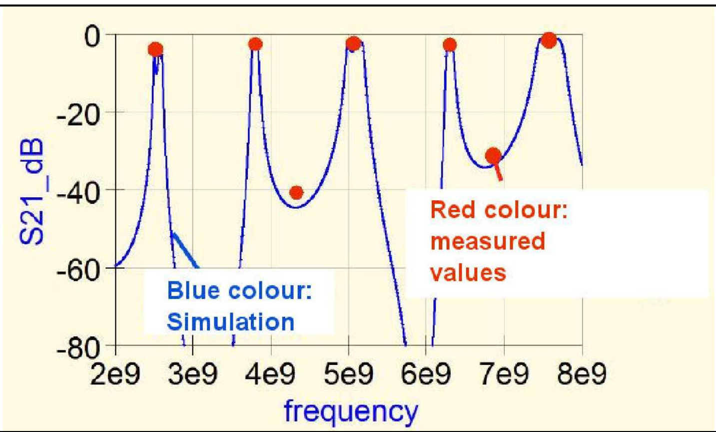

Fig 34: Behaviour in the stop area is the same as the textbook.

Otherwise: Full match of simulation and finished product in the first run!

7.2. Comparison of the DVB-T-Sticks

We already talked about using the "RTL SDR.COM" stick in Chapter 4 (In part 2). Interestingly, and for comparison with this stick some of the cheap sky blue stick version offered everywhere on Ebay from China were ordered. These are also advertised with the R820T2 tuner chip (**Fig 35**). For a total of 20 Euros (with free delivery) you get not only three sticks but also three remote controls, 3 small CDs and three telescopic antennas with magnetic bases and MCX connector on the antenna cable.

Fig 35: The two sticks examined shown for comparison have almost identical dimensions.

Such a blue stick was immediately opened and its input examined under a microscope with 12 times magnification. There is an SMD protection diode is in parallel with the input socket, followed by a DC isolation capacitor. Between it and the antenna input on the tuner chip there is a tiny nanohenry

SMD inductor.

This of course calls for S11 measurements, the result in the range of 100MHz and 1300MHz is shown in **Fig 36.** I wonder if I could have done it so well! And a comparison with the RTL-SDR.COM-Stick (see **Fig 17** in part 2) clearly goes in favour of the blue DVD-T-Stick ....

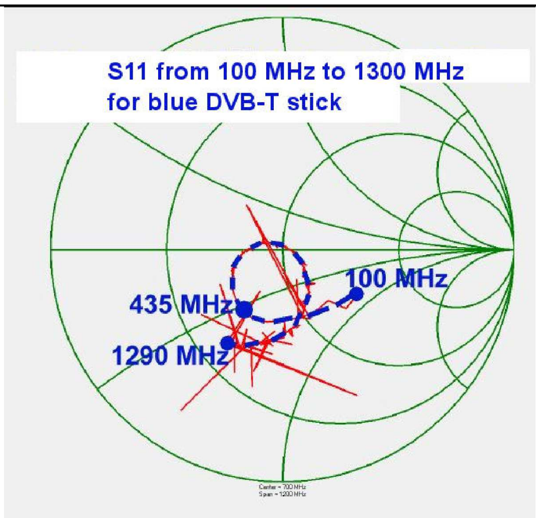

Fig 36: The S11 curve from 50MHz to 1300MHz of the blue stick in the its original condition is amazing and pleasing.

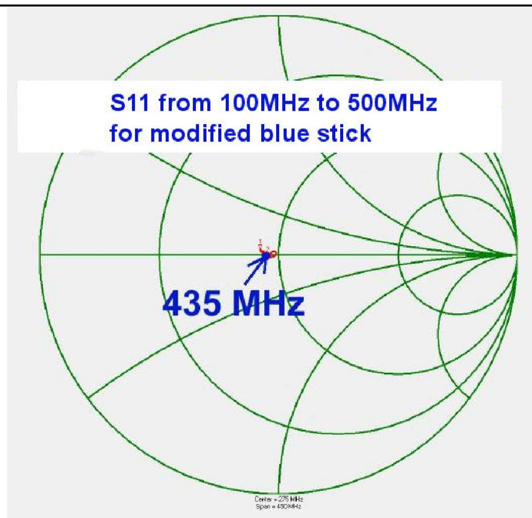

Fig 37: With a simple change at the input of the blue stick you can create ideal S11 ratios up to 500MHz.

... but there are possibilities for improvements as shown in **Fig 37.** Here, an attempt was made to optimise the S11 curve of the blue stick in the range up to 500MHz and thus to create improved conditions for 70cm reception. For this purpose the protection diode on the antenna input was removed and replaced by a series circuit of 100Ω and 39nH. With the new integrated 100Ω parallel resistor in the chip input this gives close to the ideal case of 50Ω as antenna input resistance at 500MHz (But from 800 to 900MHz the reflection is unfortunately worse than without conversion).

The question: "is an immediate change to this blue stick necessary?" After closer examination this was answered with "no". In this version with no input to the stick there are repeated spectral lines that are certainly related to the board layout in the tuner chip plus the type of screening and decoupling. With this latest version of HDSDR you can use the keyboard shortcut <Control + N> to add extra amplitude adjustable broadband noise to cover these unwanted "blips". Usually they are below 0.22µV (-120dBm) in amplitude and thus the increased noise level is not particularly disturbing. More decisive, however, is the superior quality of the highly stable quartz oscillator (TCXO) installed in the RTL-SDR.COM. Not only the absolute accuracy of the frequency and its minimal temperature dependence are convincing, but also the significantly low sideband noise near the carrier.

Of course, if you only want to listen to music, you are well served by the "Blue Bird".

However, there was a certain restlessness and uncertainty left and the following question drilled into the subconscious:

Since the clipping indicator of HDSDR is not effective in the tuner but in the IQ decoder RTL2832. Using this it is possible to measure the frequency responses of the two sticks from 50MHz to 1700MHz and compare.

This is how it was done:

a At the lowest measuring frequency of f = 50MHz, set the signal generator voltage so that "Clip" lights up. This includes a well-defined IF level coming from the tuner chip.

b The tuner AGC is off.

c The required signal generator level for "Clipping" at this frequency is noted.

d Then, the frequency is increased in increments of 50MHz to f_{max} = 1700MHz, and at each step, the signal generator level required for "clipping" is noted again. Since the intermediate frequency generated by the tuner chip practically always has the same amplitude, one sees exactly where the gain increases (less signal generator level for "Clip" necessary) or decreases (more signal generator level for "Clip" necessary)

e Now examine in the resulting measurements for the frequency with the smallest signal generator level because that corresponds to the maximum tuner gain. This value is set to "Null" in a newly created list.

f For all other frequencies, the signal generator level is higher. The difference to the minimum value is calculated and recorded in the new list. The necessary increase in the signal generator level corresponds exactly to the decrease in the tuner gain. This gave the diagram shown in **Fig 38** and you see:

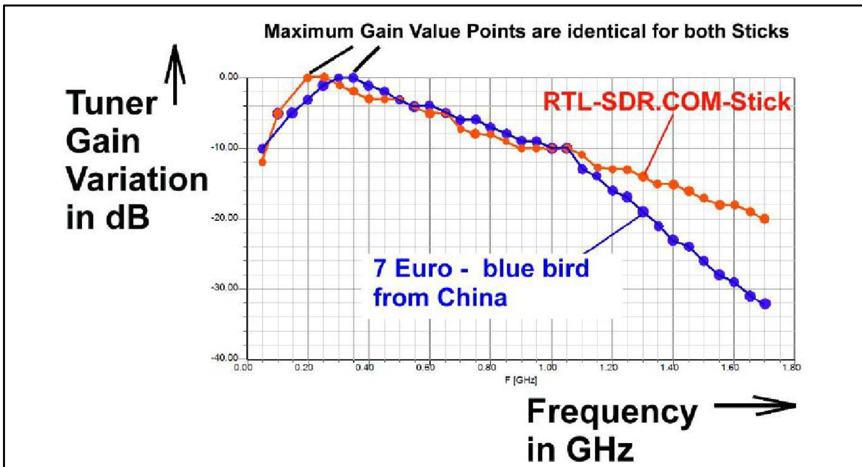

Fig 38: Unfortunately, the simpler original input circuit leads to a greater drop in the gain from 1GHz for the "blue stick" (see text).

up to 1GHz, the difference between the two sticks is not earth shattering. From there, however, the inductance in the input line of the blue stick together with the input capacitance of the tuner chip acts as a lowpass filter and the sensitivity decreases linearly up to 1.7GHz. This was solved much better on the RTL-SDR.COM-Stick.

7.3. The complete experimental setup for 23cm

We are already familiar with the setup shown in **Fig 39.** There are no unpleasant surprises when it comes to receiving power as the noise behaviour is determined by the LNA with its low and virtually frequency independent intrinsic noise figure (NF just below 0.4dB).

Since the gain of the LNA is more than 20dB, the other modules with their attenuations do not play a decisive role. So similar results to the 70cm version are to be expected if the same HDSDR settings are selected:

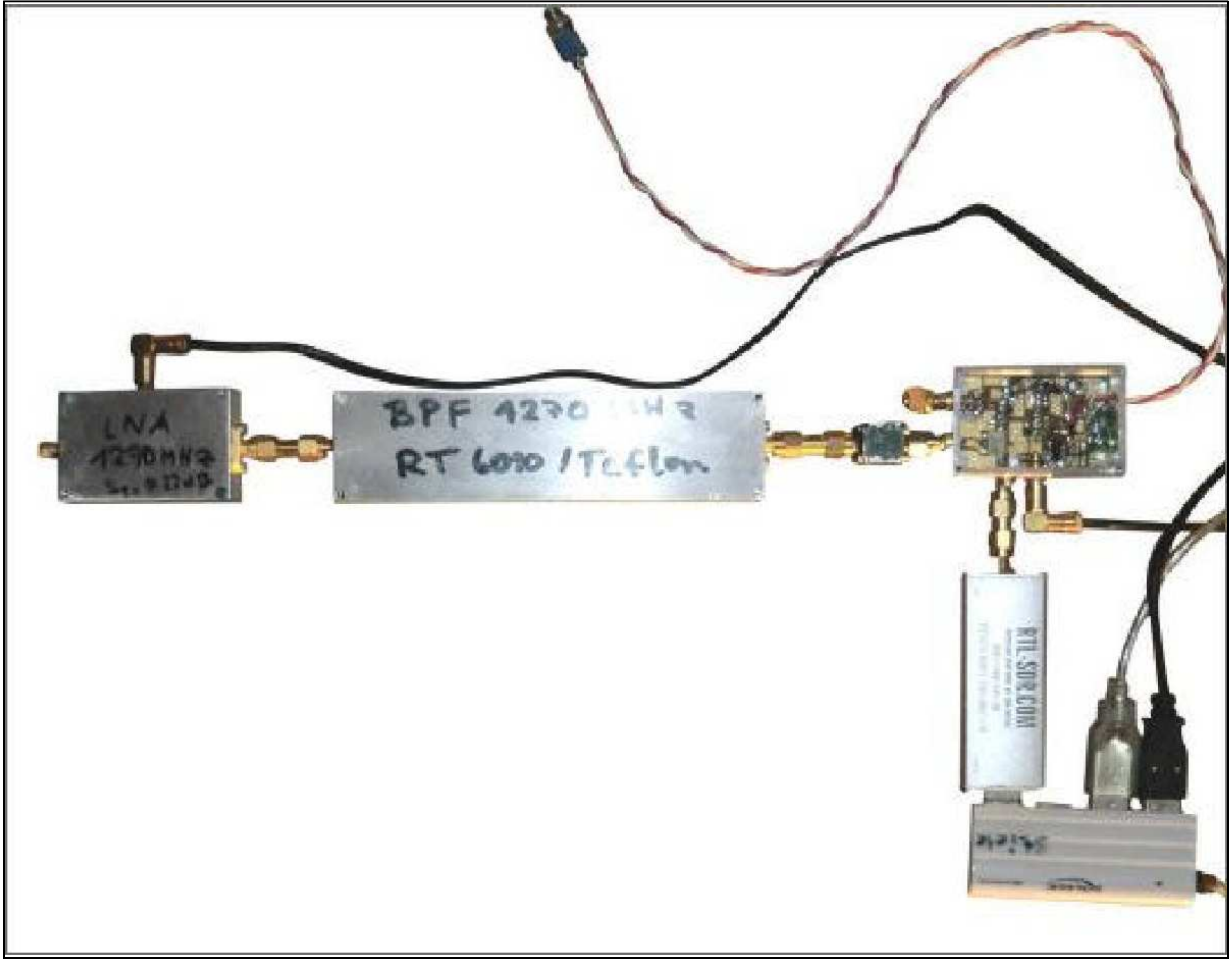

Fig 39: The modern SDR technology is somehow unbelievable: That's all you need for a good 23cm receiver!

f	=	1270MHz
AGC	=	OFF
Tuner gain = maximum	=	49.6dB
Sample frequency	=	1.152Msps
IF bandwidth	=	2050kHz
Buffer	=	64kB
Decimation	=	1
Operating mode	=	CW
RBW	=	17.6Hz

As expected, **Fig 40** shows that the assumption was correct.

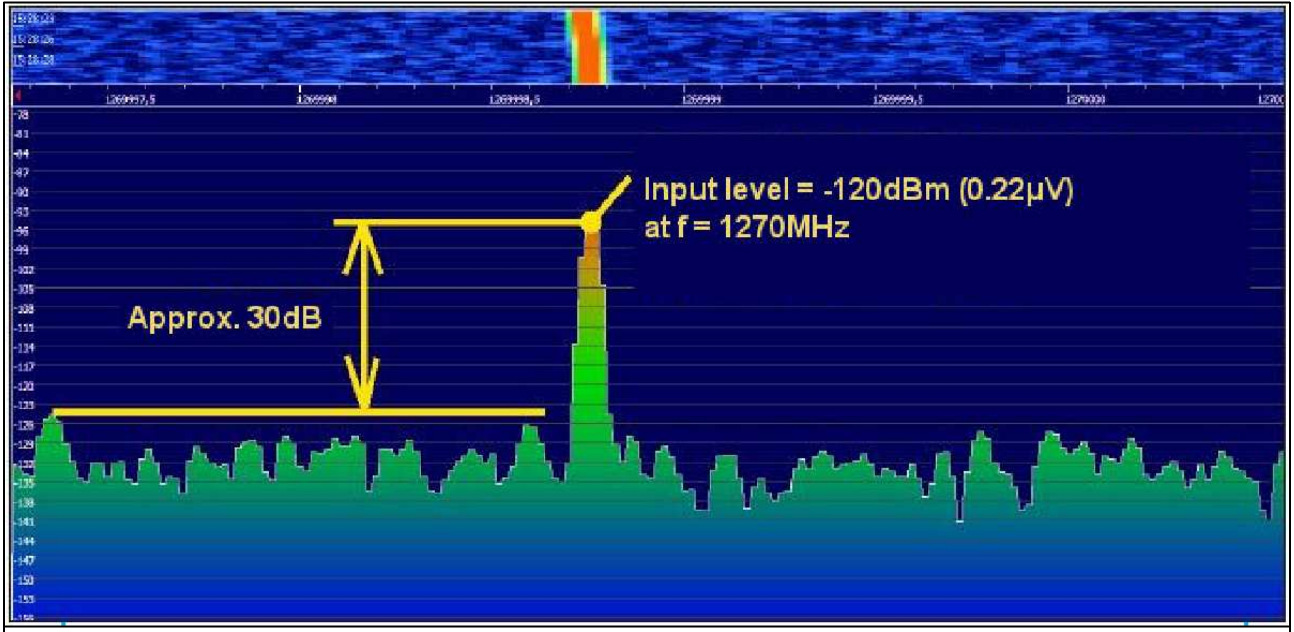

Fig 40: Again, it is accomplished, the expected input sensitivity is shown.

References:

[1] RTL-SDR.COM - Homepage

[2] On the homepage (www.gunthard kraus.de) there is a folder with the name " Frischer Wind für DVB-T-Sticks und SDRs …" and in that folder there is a list of keyboard shortcuts under "Liste mit den Tastenkombinationen (keyboard shortcut list) für die HDSDR-Version 2.76"

[3] Company TACTRON, Vetrieb, Mr. Achim Baier; Tel. +49 (0) 7308811 2026; Fax +49 (0) 7191 3540-15; Email: achim.baier@tactron.de; Web: http://www.tactron.de

[4] Receiver building with 50 ohm building groups ("Gainblocks"), Part 1, Gunthard Kraus, DG8GB; UKW Berichte 4/2016, pages 221-238. Also in English on the VHF Communications web site - www.vhfcomm.co.uk and Gunthard Kraus's web site (www.gunthard kraus.de)