Airspy HF+ Discovery - Test

The Airspy HF-Discovery is the successor to the Airspy HF+. The main changes are a plastic housing, smaller dimensions, and only one RF input. Due to the savings, the new, small SDR costs about € 40 less than its predecessor. In this report, the receiver should only be tested in its essential RF characteristics, such as sensitivity and large-signal behavior.

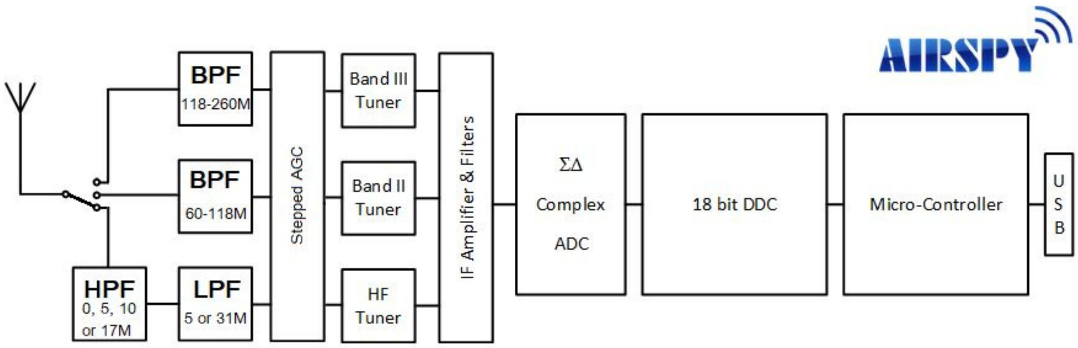


Figure 1: Block diagram of the Airspy HF + Discovery

Installation
Download the latest software version of "Windows SDR Software Package (SDR #)" from https://airspy.com/download and install it on a PC (Win 7, 8, 10). Then connect the Airspy HF + Discovery to the PC via its USB interface. The PC then automatically installs some device drivers, which takes a few seconds.

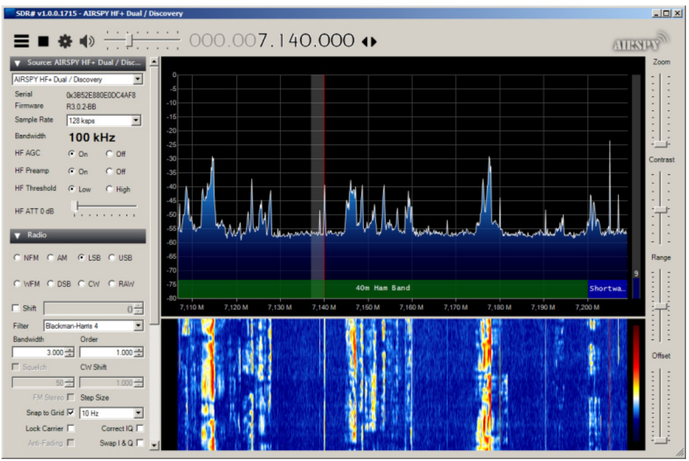


Figure 2: Screen on the PC in the 40m band

Then open the installed program "SDR #", select the AIRSPY HF + Discovery and start it **(Figure 2)**. The installation is extremely easy and fast, additional drivers do not need to be installed.

Sensitivity (MDS)

For this purpose, the input of the SDR is connected to a RF-Generator and its level (Pe) is reduced until the audio signal at the output of the SDR reaches an increase of 3dB (S + N)/N. Then the input signal corresponds to the sensitivity (the noise floor) of the receiver. **Figure 4** shows the measurement of the sensitivity at fe = 7.1MHz, it is -142dBm @ 500Hz corresponding to a noise figure (NF) of 5dB.

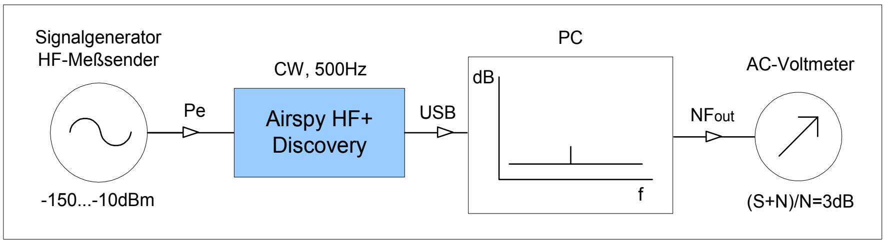


Figure 3: Test setup to determine the sensitivity

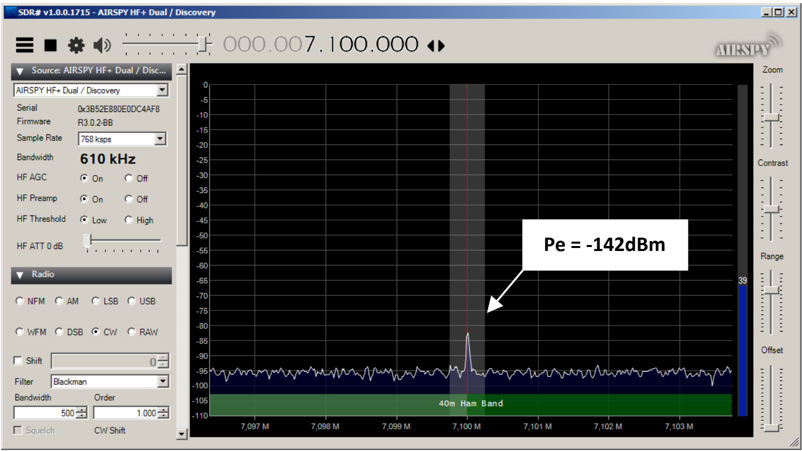


Figure 4: Signal with (S + N) / N = 3dB over noise, sensitivity (MDS) = -142dBm @ 500Hz

Frequenz	3.6MHz	7.1MHz	14.1MHz	21.3MHz	28.3MHz	145MHz
MDS	-142dBm	-142dBm	-141dBm	-141dBm	-142dBm	-143

Table 1: Sensitivity (MDS), Bandwidth (B) = 500Hz

With a noise limit of -174dBm / Hz, the noise figure (NF) is calculated to

NF = MDS - noise limit - 10logB = MDS - 147dB

Frequenz	3.6MHz	7.1MHz	14.1MHz	21.3MHz	28.3MHz	145MHz
Noise Figure	5dB	5dB	6dB	6dB	5dB	4dB

Table 2: Noise figure

When I increase the RF-input signal up to a level of -20dBm (S9 + 53dB), e.g. in order to test the AGC and then reduced the level back to -142dBm, something surprising happens: The Airspay remains on its control state, which it had at Pe = -20dBm and did not regulate back **(Picture 5, left)**. Obviously the Airspy keeps its RF-Attenuation while increasing its pre amplification. The noise floor increases by 25dB and the sensitivity goes back from -142dBm to -120dBm **(Picture 5, right)**.

Under this conditions, a -142dBm signal is no longer detectable because the noise figurer of the Airspy increases from 5dB to 27dB. In order to detect again a signal with 3dB above noise, the input level must be increased up to Pe = -120dBm. The Airspy remains in this "AGC hysteresis" until you restart the program.

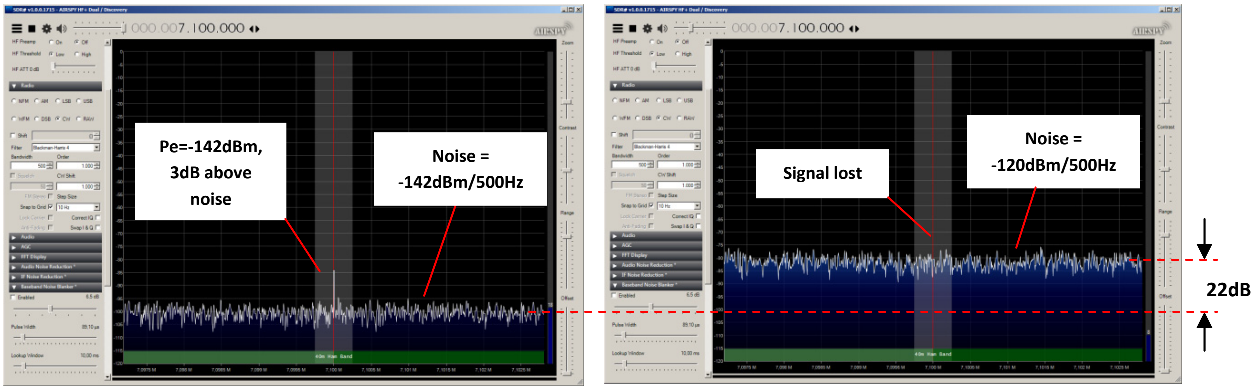


Bild 5: MDS = -142dBm/500Hz **MDS = -120dBm/500Hz**

Blocking Dynamic Range (BDR)

The blocking dynamic range of a receiver indicates how well a receiver can process small signals in addition to very large signals. The maximum BDR of a receiver is reached when an interference signal (f2) has become so large that a small signal (f1) loses amplitude by 1 dB at a distance of 2 ... 20 kHz. The level difference between the blocking signal and the sensitivity (MDS) then corresponds to the BDR.

Blocking Dynamics Range = Blocking Level - Sensitivity (MDS)

The measurement setup **(Figure 6)** is similar to an IMD3 measurement, except that the levels of the two oscillators are now very different.

Settings of the generators:
- useful signal f1 = 10.020MHz, P1 = -115dBm (rf-generator)
- Interference signal f2 = 10,000MHz, P2 = -70 ...- 10dBm (quartz oscillator signal), the interference signal must be very low noise, so that its noise sidebands do not distort the measurement result.

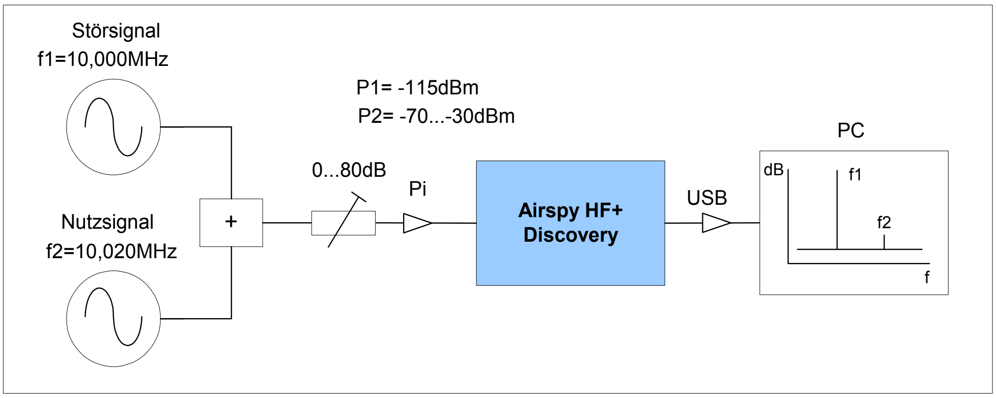


Figure 6: BDR measurement setup

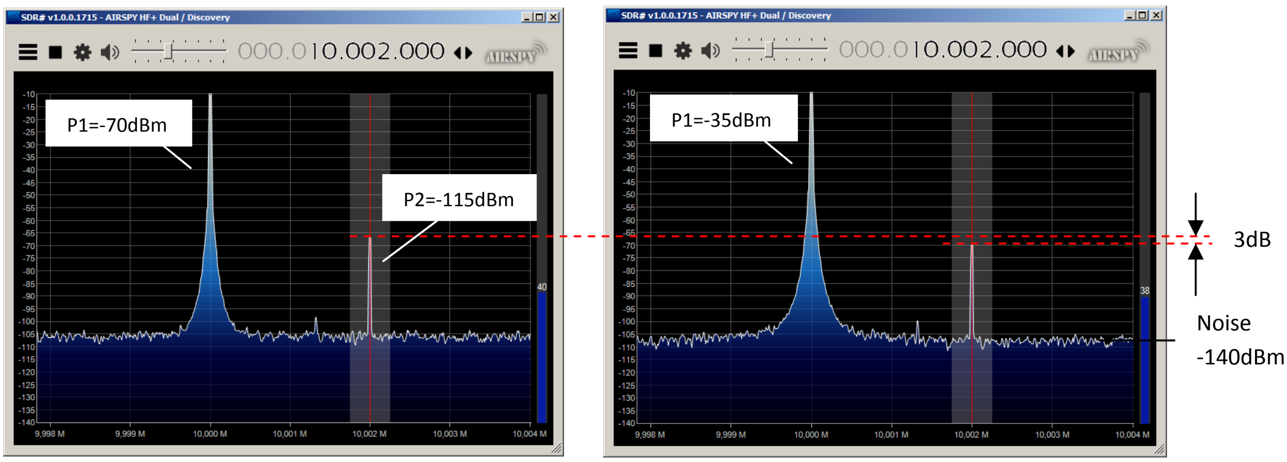


Figure 7: From a noise level of -35dBm, the useful signal gets into compression

The small signal gets into compression when large signal reaches a level of -35dBm **(Figure 7).** This results in a BDR of

BDR = - Blocking Level - MDS = -35dBm - (-142dBm) = 107dB

Note: With direct sampling SDRs, without preamp and analogue mixer in the input, no blocking occurs, a blocking-effect does not exist. Instead of "Blocking" a DDS- SDR gets in clipping (saturation) at high input signals of about Pe = -15dBm.

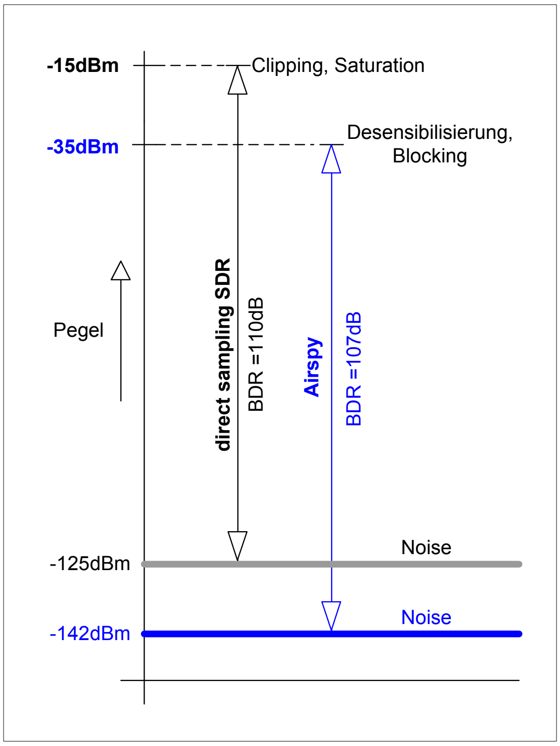


Figure 8: Comparison of typical direct sampling SDR-Receiver to Airspay HF+ Discovery

2nd-tone dynamics 3rd order (DR3)

In this test is should be checked how much the receiver can be loaded with signals until the first unwanted signals (intermodulation products) appear above the noise level. For this purpose, two RF signals (f1, f2) of the same level are fed in and enlarged until intermodulation products at 2f1-f2 and 2f2-f1 with 3dB above the noise (MDS) are produced. The measurement setup is shown in **Figure 9**.

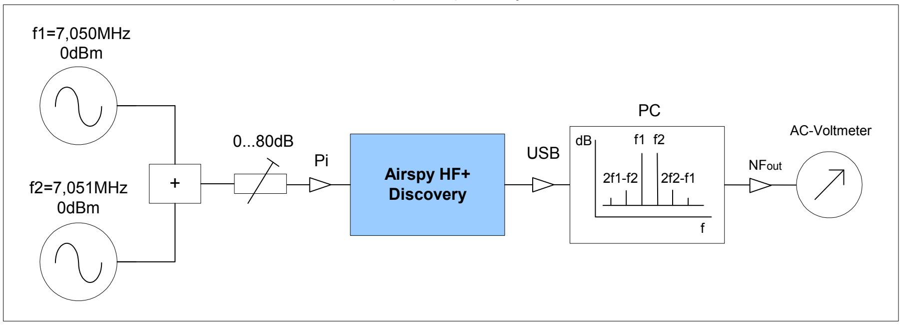


Figure 9: Setup for DR3 measurement

At an input level of Pi = 2 x -58dBm, IMD3 signals are 3dB above noise, at MDS = -142dBm.

DR3 = Pi -MDS = -58dBm - (-142dBm) = 84dB

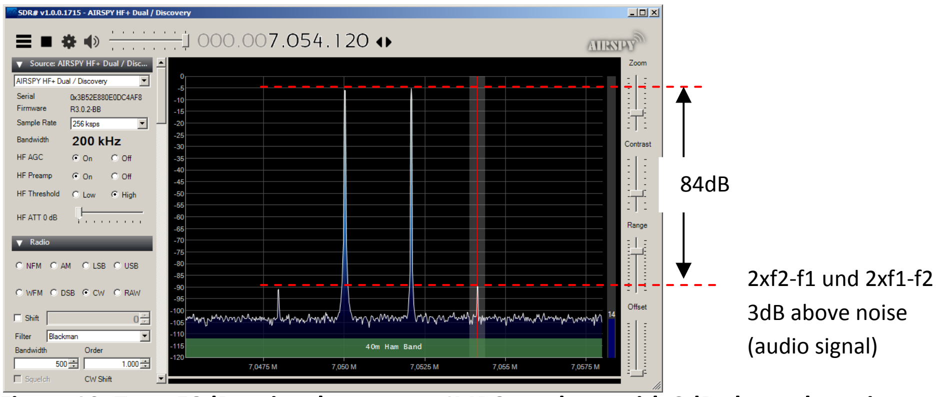


Figure 10: Two -58dBm signals generate IMD3 products with 3dB above the noise

Intermodulation of 3rd order (IMD3)

This test also two RF signals are used. Both signals are increased in their level (Pi) from 2 x -70dBm to 2 x -10dBm in 10dB increments. **Figure 11** shows the resulting IMD3 curves. The green curve shows

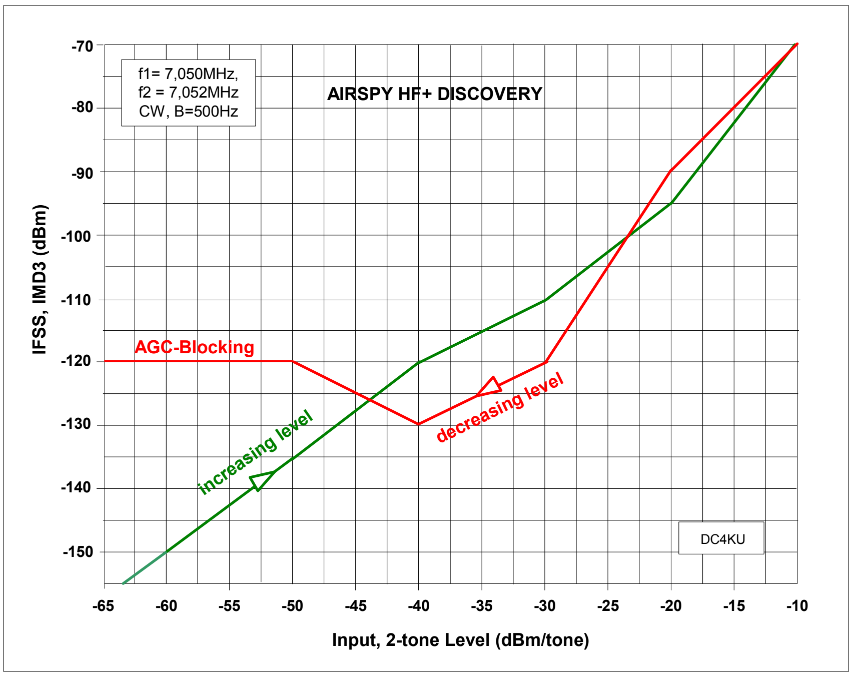


Figure 11: IMD3 distance with increasing level (green) and decreasing level (red)

the IMD3 with rising 2-tone signal, the red curve with falling 3-tone signal. Both curves should be absolute identical. Beginning from an input signal of Pe = -40dBm down to -75dBm the Airspay gets into the "AGC-blocking" (error), as already described above.

From which level does intermodulation become visible in the receiver?
To show this, I directed the 2-tone signal together with the antenna signal into the receiver's input. The ground noise level of my antenna in the 40m band raises the noise level to about -105dBm. Nevertheless, the first IMD interferers already appear with input signals of 2 x -30dBm (S9 + 43) **(Figure 12)**.

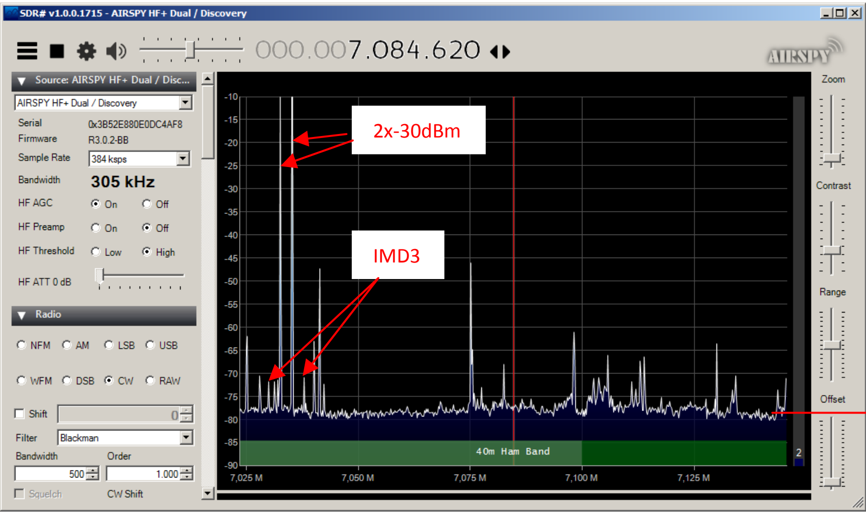
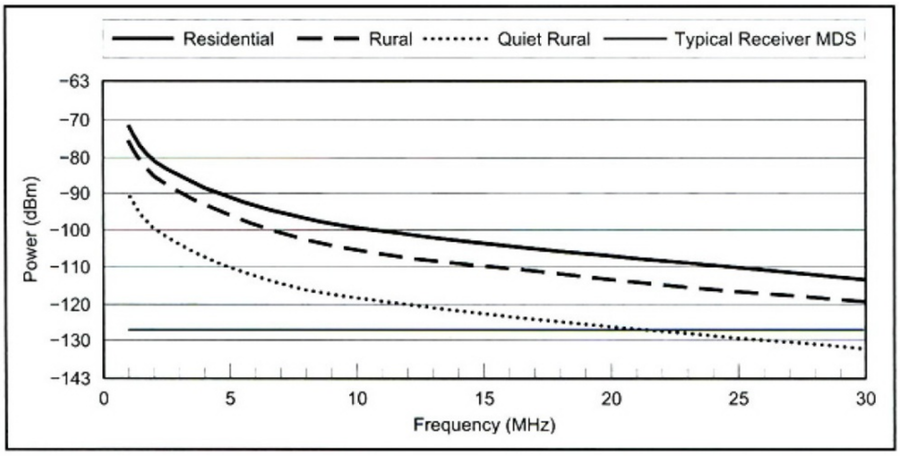


Figure 12: 2-tone signal of 2 x -30dBm together with antenna signal in the 40m band

Good receivers are designed in such a way, that regardless of the signal size the resulting IM products are always below the produced noise floor of the antenna. The IMD-Products in **Figure 12** should not audible / detectable. **Figure 13** shows the average external noise over frequency, in urban and rural areas.



Picture 13: Type. External noise in urban areas (Residential, Urban) and in rural residential areas (Rural), (Man-Made Noise in 500Hz bandwidth, from Rec. ITU-R P.372-7, Radio Noise, ARRL Handbook)

IP3 (Intercept Point 3rd Order)
An IP3 exists only for analog receivers, where the IMD3 products rise or fall three times as fast as the wanted signals. This does not apply to the Airspy, as the curves show in **Figure 11**. A calculation of

the IP3 according to the formula IP3 = ∆IMD3 / 2 would be baseless here. Would you still try to calculate the IP3 of the Airspy, you would come with signal magnification, starting from 2 x -60dBm, to an IP3 of **-15dBm** and with signal reduction, starting from 2 x -20dBm (AGC-Blocking) to an IP3 of **+ 15dBm**. This shows that the specification of an IP3 make no sense. The manufacturer specifies an IP3 of + 15dBm.

Intermodulation 2nd Order (IMD2)

In this case, the suppression of the undesired sum signals (f1 + f2) is determined. As an example I use two CW signals at 6.1MHz and 8.1MHz and measure the unwanted sum signal f1 + f2 at 14.2MHz. Also in this measurement, the level (Pi) of both signals is increased until the IMD2 signal appears with 3dB above the background noise, in this case above the receiver sensitivity of -141dBm.

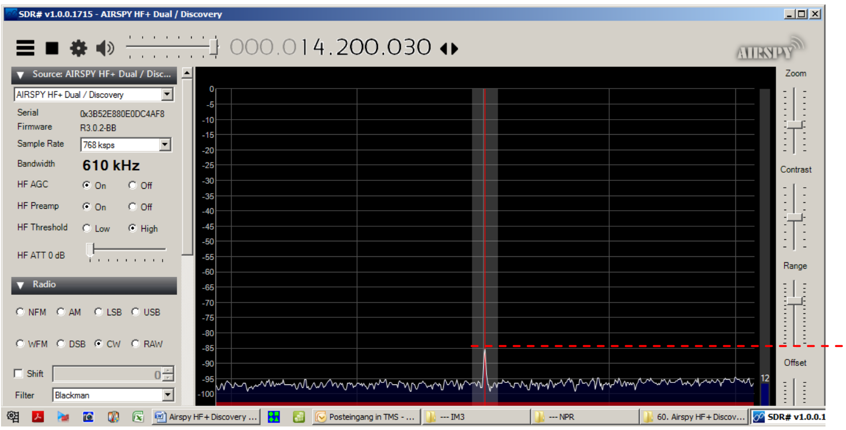


Figure 14: IMD2 product at 14.2MHz with (S+N)/2 = 3dB over noise

This was reached at Pi = 2x -50dBm. Accordingly, the IMD2-free dynamic range (DR2, Dynamic Range 2nd Order) of the receiver is

DR2 = Pi - MDS = -50dBm - (-141dBm) = 91dB

Noise Power Ratio (NPR)

An other suitable way to control the receiver large signal strength is the NPR method, which works on both, analog and digital receivers. Here, the input of the receiver is loaded with a constant white noise band signal. Only at one point the noise completely is removed by a notch filter so that at this point only background noise of the receiver remains, here at E = -142dBm. The receiver is adjusted to this frequency.
Subsequently, the noise power is increased until the receiver generates IM distortions or other interfering products, which is indicated by an increase in the background noise inside the notch filter. If the noise in the base of the filter increases by 3dB, the limit of the high signal strength of the receiver is reached. Good receivers can reach an NPR of 70...80dBc.

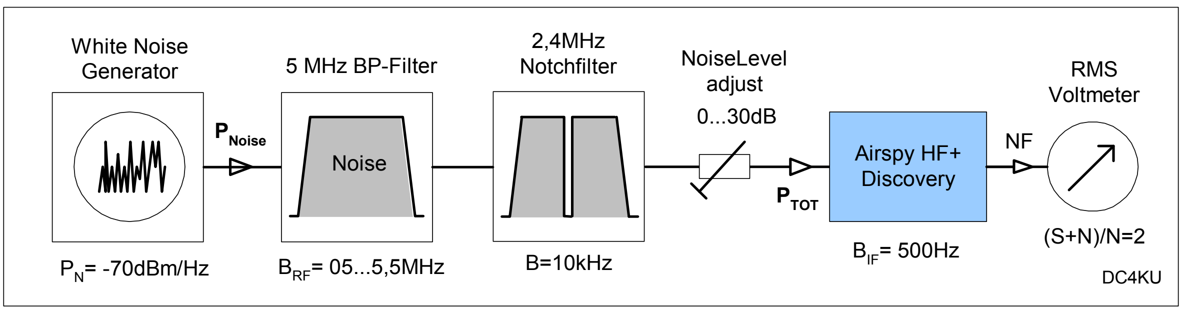
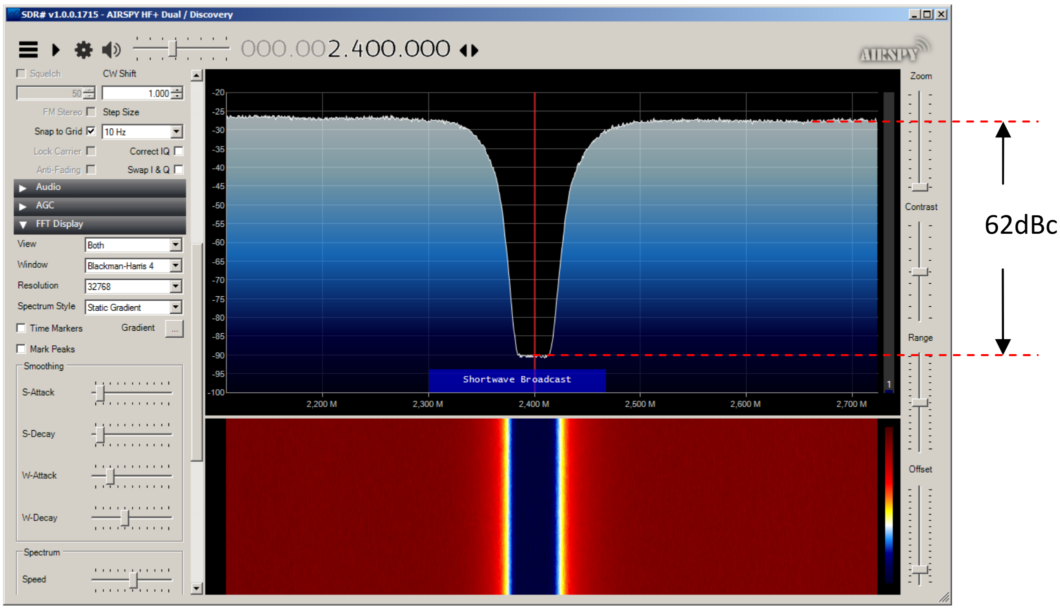


Figure 15: NPR measurement setup



Picture 16: NPR of the Airspy HF + Discovery

The determined NPR of the Airspy HF + Discovery is

NPR = 62dBc

The sideband noise (SBN) and the Reciprocal Mixing Dynamic Range (RMDR) cannot be determined due to the erroneous control behavior.

Summary

(+) For OM's who do not want to spend a lot of time experimenting on an SDR, but are looking for an uncomplicated receiver that is quick and easy to install and ready for immediate use, the HF + is an alternative. Thanks to its special "digital noise reduction" feature, Airspay HF + Discovery and Airspy HF + are said to be able to make even the smallest and most noisy signals readable, i.e. an ideal instrument for DXers. On the Internet, there are some examples of OM's with audio files of noisy signals that were only readable with the Airspy HF +. Despite some tests on different bands, I did not notice any difference between the Airspy HF + Discovery and other receivers.

(-) Unfortunately, the Airspy HF + Discovery shows the same faulty AGC hysteresis as the HF-Airspy HF +. If the SDR is operated on a powerful antenna, quite large signals may occur at the input of the SDR, so that the Airspy after that remains in its down-regulated state and small signals can no longer be detected. Since the Airspy works with an extremely high sensitivity, I would connect an external 10dB-attenuator, at least in the 80 and 40m band.

Thanks to WiMo for loaning the Airspy HF + Discovery.

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