How to control the quality of IMD3 Test Systems

Example: Down you see the IFSS-curve of a direct sampling SDR. At an input level of 2x-22dBm the IFSS-curve goes down to -130dBm and the DR3 (IMD3-distance) is -22dBm - (-130dBm) = 108dB. This means, if your Test System is not able to produce an IMD3-free dynamic range of at least 110dB you will never be able to measure this "sweet spot" and your measurement at this point will be wrong.

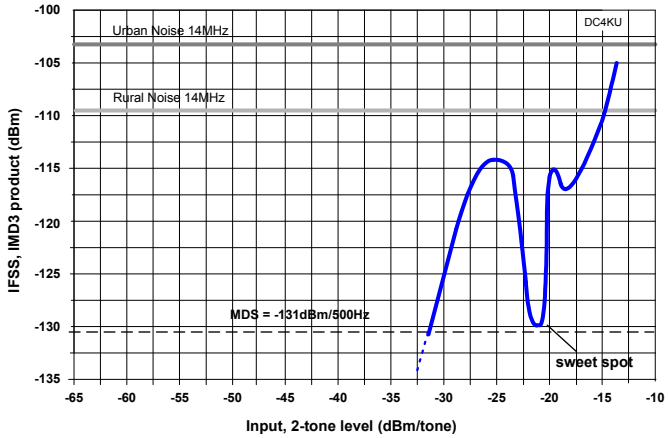
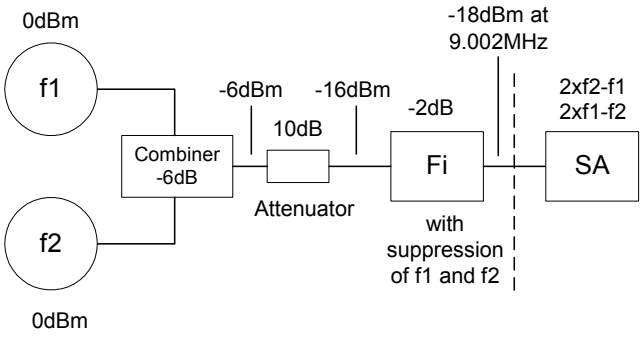


Fig 1: IFSS-curve of a direct sampling SDR with a deep sweet spot

How to control the IMD3-free dynamic range of my 2-tone station?

To control it with help of a standard Spectrum Analyzer is impossible. The Analyzer itself would need an IMD3-free dynamic range of >110dB. Do you have such one? Therefore you need a very good quartz-filter, I use a one from KVG which has a very high IP3. The filter suppresses the 2-tone signal but lets the IMD3-product pass through.



KVG-Filter 9.002MHz, B=2.2kHz

Fig 2: Setup to measure the IMD3 of a 2-tone generator/equipment

You have to set f1 and f2 in that way, that only 2f1-f2 or 2f2-f1 can pass the filter, everything else is suppressed by at least 80dB. One have to be careful, that the filter does not produce itself IMD3. The professional KVG Filter I use was only one that fits. Additional an attenuation of 10dB between combiner and filter-input is necessary as well.

1.) DR3-measurement without a Filter, standard measurement

Generators level: 2x-0dBm

Combiner output level: 2x-6dBm (Wheatstone-Bridge)

f1=9.012MHz, f2=9.022MHz, Delta f = 10kHz

IM3-Products appears at 2xf1-f2 and 2xf2-f1, at 9.002MHz and 9.032MHz

Result: DR3 = -6dBm - (-67dBm) = 61dB

Just 61dB?? Is that the IMD3-free range of my 2-tone generator?? Not more?

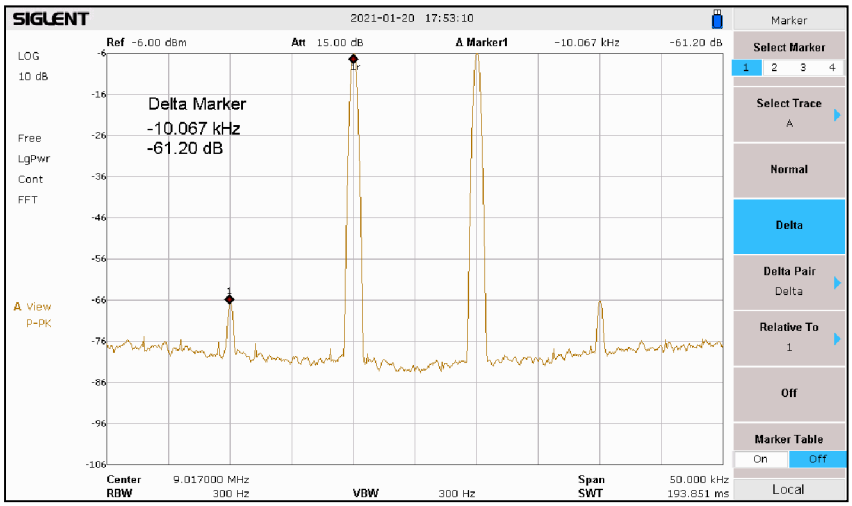


Fig 3: Standard IMD3 measurement with a SA, without filter

2.) DR3-measurement with Filter

The following measurement is the same like before, but now with 9.002MHz filter and 10dB attenuation (Fig. 2).

Result: Beside the noise there is nothing to see! Where are the signals?

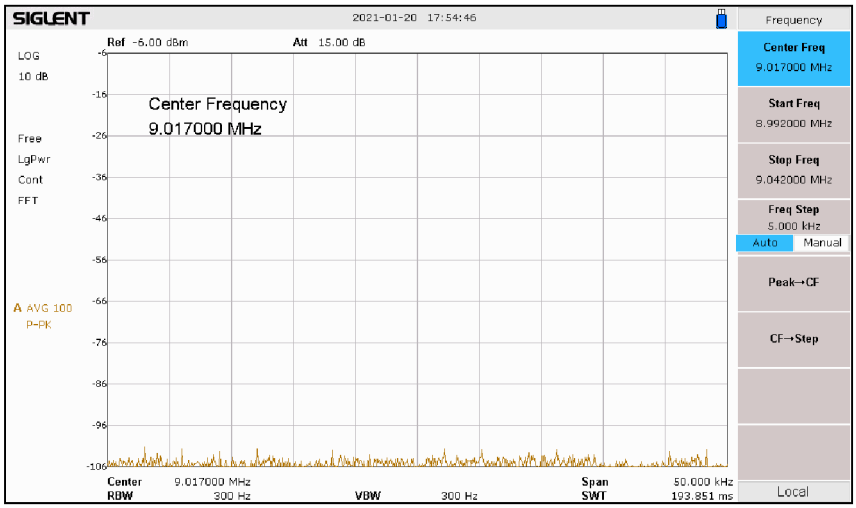


Fig. 4: Same measurement, but with the 9.002MHz filter

Now I activate the SA preamplifier (+20dB) and increase the reference level up to -50dBm. I can do so because the two big signals are suppressed by the filter and analyzer cannot be overdriven!

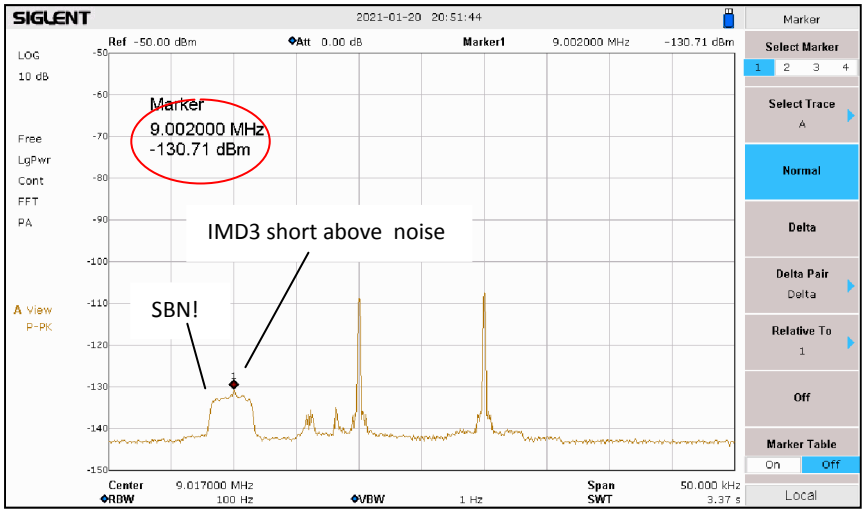


Fig. 5: Result with preamplifier On and Ref. Level on -50dBm

Now I can indicate the resulting IMD3-product at -131dBm - 3dB (noise) = -134dBm

Result: DR3 = Pin - IMD3 = -18dBm - (-134dBm) = -116dB
with Pin = -6dBm (combiner output) -10dB (Attenuator) -2dB (Filter) = 18dB

This means: At level of Pi = 2x-18dBm the self produced IMD3 from my 2-tone generator is at 2x-134dBm which results in an IMD3-free dynamic range of 116dB.
Now I can start with my IMD3-measurements on radios up to a DR3 of 116dB and can be sure that my measurements are correct.

3.) Sideband-Noise
Another strong problem can appear by the sideband noise from the two generators, especially when working with a small distance of only 2kHz (with 20kHz there mostly no problem). You have to know the level of the SBN of your generators in 2kHz distance. If the SBN is too high, the IMD3 products are covered by the noise of your generators and the measurement results are wrong. If that happens, the RMDR determine the dynamic range. Therefore I use normally quartz-oscillators at 14.1 and 7.1 MHz with a SBN of -164dBm/Hz in 2kHz distance. If the radio itself produces too much SBN, we have the same problem.

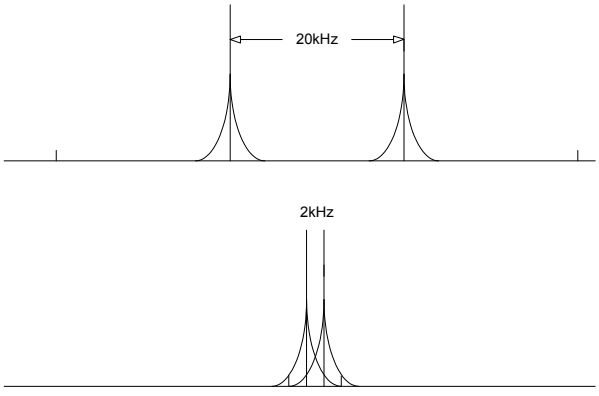


Fig. 6: At a distance of 2 KHz the IMD3 products are covered by the SBN

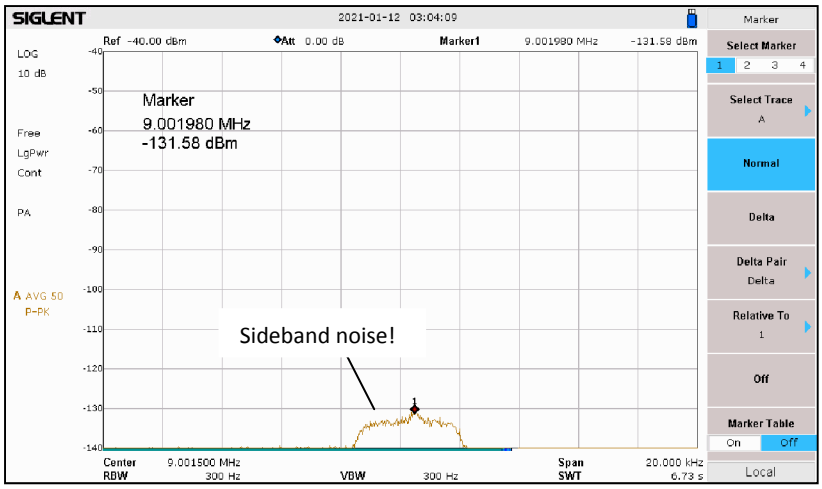


Fig 7: Generator sideband noise starts to limit the IMD3-produkt

In Fig. 7 you can see the sideband noise of my generators. In this measurement I took the signals from my Sigland SDG6022X 2-Tone Generator. As you can see, the SBN of the generators is recognizable short below the CW-Signal. The SBN from the SDG6022X quite good, but for this measurement nearly too high! Therefore: Low SBN is very important to test the IMD3 of modern radios in a correct way. If the SBN covers the CW-Signal, the results are wrong.

The main points

Quartz-Filter: The used filter itself must not generate IMD3. Its IP3 should be at least +40dBm. Therefore I use a professional filter from KVG. When I tried it with other filters, I did not get valid results.

SBN: The SBN of both generators has extreme low. Especially when measuring in only 2 kHz distance. If not, the SBN of your generators will limit the measuring rang. If that happens, the RMDR will be responsible for the dynamic range but not the IMD3. The same happens, if the SBN of your tested radio is too high.

2nd Harmonic suppression: It's important that the 2nd harmonic produced by your generators is very low. You have to control that. To measure the harmonics with a standard spectrum analyzer is impossible. The analyzer will show a distance of perhaps 60...65dB, but that's the harmonic produced by your analyzer and hopeful not the value of your generator! You need again a Filter which suppresses the oscillator signal by at least for 40dB. After that you can measure a true harmonic distance up to 100dB. The harmonic distance of your 2-tone generators should be at least 80dB.

Well, I'm shure you have controlled already all these points before you have started your IMD3-measuremts on analog- and digital radios!

Further information you can find in my book "Spektrumanalysator - Theorie und Praxis" from 1990
https://www.amazon.de/Theorie-Praxis-Spektrumanalyse-Werner-Schnorrenberg/dp/3834332216

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