Improvement of receiver SNR as a function of the image rejection

Matthias, DD1US, June 2nd 2022

When using a downconverter, which is not only receiving the intended signal but also converts the image signal down, the received signal is degraded: the noise level and thus the noise figure of the receiver is increased by 3dB respectively the signal to noise ratio SNR is decreased by 3dB.

This is only true when there is white noise at the image frequency with the same level as the noise at the wanted frequency. If the noise level at the image frequency is higher or there are other signals / interference at the image frequency the signal quality will decrease further.

Therefore, filters are inserted in front of double sideband mixers DSB or single sideband SSB (image rejection mixers) are commonly used in such downconverting stages.

Considering only white noise at the image frequency the increase of the receiver's noise figure is:

$NF_{add} = 10 \times \log_{10} (1 + 1 / 10^{(IRR/10)})$

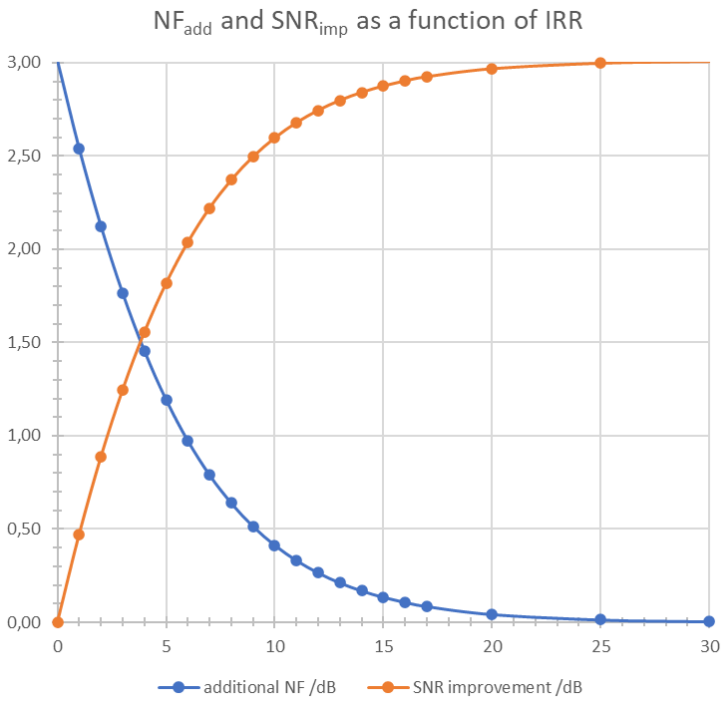
NF_{add} = additional noise figure in dB of the receiver due to noise on the image frequency

IRR = image rejection ratio of the downconverter in dB

The image rejection of the receiver improves the signal to noise ratio correspondingly:

$SNR_{imp} = 3{,}01 – NF_{add} = 3{,}01 – 10 \times \log_{10} (1 + 1 / 10^{(IRR/10)})$

SNR_{imp} = SNR improvement in dB due to image rejection



Here is a corresponding table:

Image Rejection Ratio IRR /dB	additional noise figure NF_{add} /dB	SNR improvement SNR_{imp} /dB
0	3,01	0,00
1	2,54	0,47
2	2,12	0,89
3	1,76	1,25
4	1,46	1,55
5	1,19	1,82
6	0,97	2,04
7	0,79	2,22
8	0,64	2,37
9	0,51	2,50
10	0,41	2,60
11	0,33	2,68
12	0,27	2,74
13	0,21	2,80
14	0,17	2,84
15	0,14	2,88
16	0,11	2,90
17	0,09	2,92
20	0,04	2,97
25	0,01	3,00
30	0,00	3,01

As can be seen image rejection values of more than 16dB will improve the SNR by less than 0,1dB. The maximum possible SNR improvement by image rejection is 3,01dB.

As mentioned above this is only true for white noise. Higher image rejection values certainly make sense to suppress unwanted signals at the image frequency.

If there are questions or comments, please send them to the Email address given below.

Kind regards

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