Microwaves
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1 Mixing Frequencies

The input signal to a mixer is at 0.1 GHz, the LO is at 1 GHz. Calculate all positive and real frequencies of order 3 for LO and order 2 for RF! And identify the technical importance of selected frequencies!

Lösung:

The solution is (all frequencies in GHz)

LO	IN	f_{mix}	LO	IN	f_{mix}	LO	IN	f_{mix}	LO	IN	f_{mix}	LO	IN	f_{mix}
-3	-2	3.2	-3	-1	3.1	-3	0	3	-3	1	2.9	-3	2	2.8
-2	-2	3.2	-2	-1	2.1	-2	0	2	-2	1	1.9	-2	2	1.8
-1	-2	1.2	-1	-1	1.1	-1	0	1	-1	1	0.9	-1	2	0.8
0	-2	0.2	0	-1	0.1	0	0	0	0	1	0.1	0	2	0.2
1	-2	0.8	1	-1	0.9	1	0	1	1	1	1.1	1	2	1.2
2	-2	1.8	2	-1	1.9	2	0	2	2	1	2.1	2	2	2.2
3	-2	2.8	3	-1	2.9	3	0	3	3	1	3.1	3	2	3.2

The technical importance (just examples) is

Upconversion	1	1	1.1	Upconv. (image)	1	-1	0.9
Downconversion	-1	1	0.9	Downconv. (image)	1	-1	0.9

2 Intercept-Mixer

The input signal to a mixer is at 1.1 GHz and at 1.15 GHz, the LO is at 1 GHz. Calculate all positive and real frequencies of order -1 (downconversion) for LO and maximum combined order 3 for RF! And identify the most disturbing and wanted signals frequencies!

Lösung:

The solution is (all frequencies in GHz)

LO	IN1	IN2	f_{mix}	LO	IN1	IN2	f_{mix}	LO	IN1	IN2	f_{mix}
-1	-2	-1	4.35	-1	-2	0	3.2	-1	-2	1	2.05
-1	-1	-2	4.4	-1	-1	-1	3.25	-1	-1	0	2.1
-1	-1	1	0.95	-1	-1	2	0.2				
-1	0	-2	3.3	-1	0	-1	2.15	-1	0	0	1
-1	0	1	0.15	-1	0	2	1.3				
-1	1	-2	2.2	-1	1	-1	1.05	-1	1	0	0.1
-1	1	1	1.25	-1	1	2	2.4	-1	2	-1	0.05
-1	2	0	1.2	-1	2	1	2.35				

The wanted signals are of order $(-1, 1, 0)$, $f = 0.1\,\text{GHz}$ and $(-1, 0, 1)$, $f = 0.15\,\text{GHz}$.
Most disturbing are the ones closest to these: $(-1, -1, 2)$, $f = 0.2\,\text{GHz}$ and $(-1, 2, -1)$, $f = 0.05\,\text{GHz}$. These are the intermodulation products of this order of the input signal.

3 Mixer Conversion

The input signal to a mixer is of RF-power -20 dBm, at 12 GHz, and -40 dBm, at the image frequency.
The LO-power is of 17 dBm, 10 GHz. The mixer is straight downconversion. At output we find measure

Frequency/GHz	Power/dBm	Comment
2	-27	
2	-60	RF off
10	-13	
12	-50	

Caluclate the relevant performance measures of the mixer! and comment on what to so in order to improve certain parameters!
Lösung:
The performances are

Parameter	value/dB	Frequency/GHz	Improvement
Conversion	-7	2	Different design
LO-Isolation	30	10	Rat-Race, Balanced, Filter
RF-Isolation	30	12	Rat-Race, Balanced, Filter
Image Suppression	20	2	Balanced, Filter

4 Mixer Noise

A mixer has the following measured parameters Conversion $c = -7\,\text{dB}$, input noise 2.00 dB above thermal noise at 290 K with bandwidth of 1 MHz. Output noise in double sideband configuration is $N_{out,DSB} = -112.01\,\text{dBm}$. Converion for LSB and USB are the same, noise performance as well.
Calculate the DSB-Noisefigure, SSB-noise-figure and the filtered DSB-noise figure!
Lösung:

In linear scale the intermediate values are:
$c|_{lin} = 0.20$ for the conversion $N_{in}|_{lin} = 6.31e-012\,\text{W}$ for the input power $N_{mix}|_{lin} = 3.15e-011\,\text{W}$ for the output noise power projected at the input.
The DSB-Noise-figure is $F_{DSB} = 1 + \frac{N_{mix}}{N_{in}} = 6.00 = 7.78\,\text{dB}$
The pure SSB-Noise Figure is then twice that $F_{SSB} = 2 + 2 * \frac{N_{mix}}{N_{in}} = 12.00 = 10.79\,\text{dB}$
And filtered we get the filtered SSB-Noise Figure $F'_{SSB} = 1 + 2 * \frac{N_{mix}}{N_{in}} = 11.00 = 10.41\,\text{dB}$