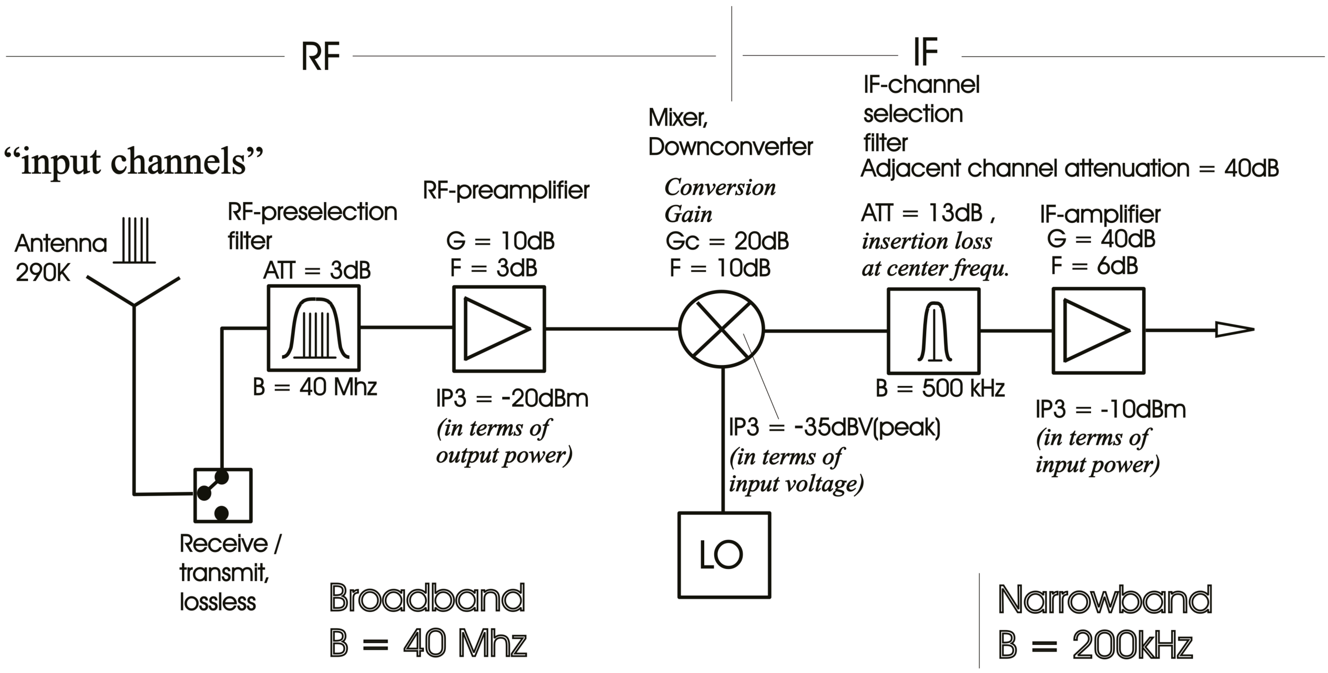
Exercise 6, Deadline: Mon, Dec 14th, 10:00

Problem. 6.1 VU RF Techniques 2015/2016 **15-dec-2015**

Heterodyne receiver, equidistant channel spacing:

the antenna „looks“ into an urban area, 50 ohm system, antenna and all stages of the chain matched.

We pick out three channels for further discussion: channel 10 shall be the desired channel (active channel, “Nutzkanal”). Two interferers are in channel 11 (adjacent channel), and in channel 12 respectively, each of the interferers has -56dBm at the antenna output.



a) Antenna signal input power in channel 10 is 1 pW: calculate the **SNR at the IF-amplifier output**.

b) Calculate the over all noise figure $\mathbf{NF_{TOTAL}}$ of the complete receiver chain. What are the “additional” noise figures $\mathbf{NF_{ADD}}$ from stage to stage (all in dB)?

c) Calculate the interferer power levels at the IF amplifier output, if the LO is tuned to select channel 10 (the desired channel). *See textbook 2015, page 125, Fig. 4.24: adjacent channel attenuation down from "0dB", general insertion loss for all channels indicated separately*.

d) Draw the double-log sketches of $\boldsymbol{\log P_{out}}$ *versus* $\boldsymbol{\log P_{in}}$ for the preamplifier, for the mixer, and for the IF-amplifier. Draw the traces of 1st order and 3rd order products powers, and mark the 3rd order Intercept Points ***IP3***. Calculate the total $\boldsymbol{IP3_{TOT}}$ and indicate it in the sketch.

e) Draw a **sketch of the power level diagram** of the receiver chain for noise, signal, interferers, and intermodulation products, all powers in dBm.

Remark: for the calculation of absolute noise powers consider the bandwidth reduction !!!
Absolute noise power = (noise power density) x (filter bandwidth)

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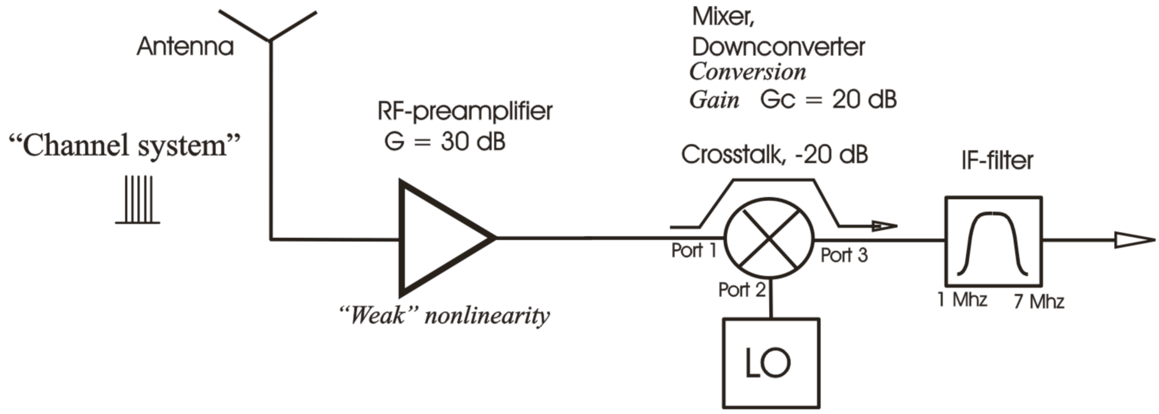
Problem. 6.2 VU RF Techniques 2015/2016 **15-dec-2015**

Heterodyne Receiver, **2^{nd} order and 3^{rd} order nonlinearity" !!!!**
The following frequencies in a channel system are active at **-30dBm** each:
f1 = **1850**MHz, f2 = **1853**MHz, f3 = **1854**MHz, f4 = **1859**MHz, f5 = **1862**MHz .

RF-preamplifier, GAIN = 30dB , **2nd AND 3rd order nonlinearities!!**
3rd order nonlinearities: dual beat intermodulation distance **$IM_{3rd\ order,\ dual\ beat}$** = 40dB at –30dBm signal input.
2nd order nonlinearities: **IP_2** = (0dBm/+30dBm).

Mixer, ideal multiplier producing difference (absolute value of the differences!), and sum frequencies, NO intermodulation, Conversion Gain = 20dB, cross talk from port 1 to port 3, $|S31|$ = -20dB, all ports DC-2GHz.

IF-filter*:* Pass Band: lower limit (**1,0 MHz**) to upper limit (**7,0 MHz), i.e.** total bandwidth: **6 MHz**



a) RF-preamplifier output: draw the power spectrum (power versus frequency) of ocurring 3^{rd} order (i.e. intermodulation) products, that can be observed in the frequency range from 1838 MHz to 1874 MHz).

b) RF-preamplifier output: calculate the distance between the power of 2^{nd} order combination products and the power of the desired 1^{st} order (i.e. signal) power for the given signal input power.

b) Some of the 2^{nd} order products from the RF-preamplifier propagate to the mixer output without frequency conversion, but simply **via cross talk** across the mixer ports 1 and 3, and may fit into the IF-filter passband. At the mixer output port: give a frequency example, how many dB are the levels of those 2^{nd} order products below the levels of 3^{rd} order (i.e. intermodulation) products?