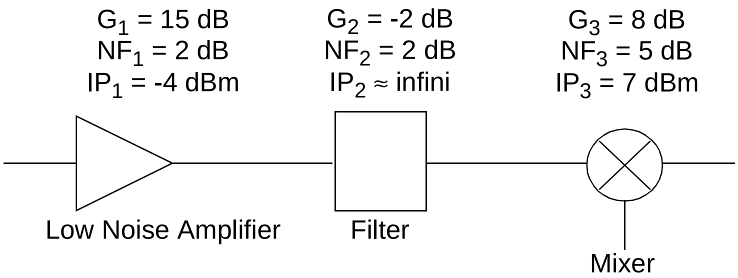
Wireless Technologies & Applications

Tutorial on RF systems issues

Problem 1: Noise factor, sensitivity & transmission range

The input stage of a radio receiver is depicted below::

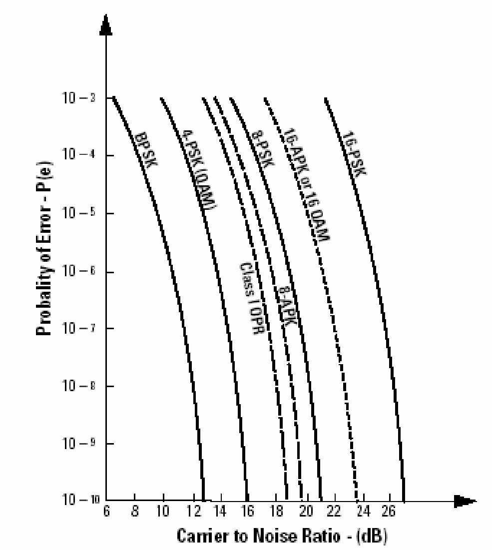


The receiver bandwidth is 1MHz.
The link operates at 2,45GHz.

1 - Calculate the noise factor for the whole chain (configuration 1 above).

In order to suppress possible out-of-band signals (interferers) that can cause saturation of the low-noise amplifier, it was decided to put the filter before the LNA (configuration 2).

Calculate, for this new configuration, the noise factor of the chain.



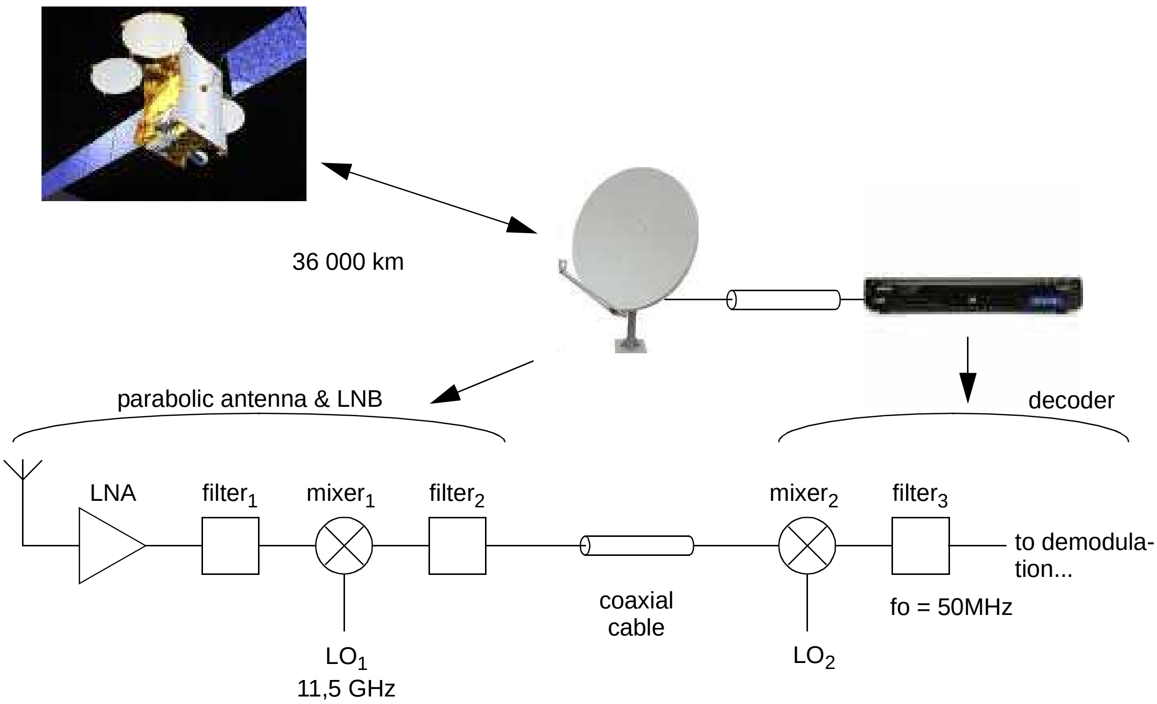
3 - The transmission chain implements BPSK modulation for which it is required that the error probability remains below 10^{-8}.

Calculate the receiver's sensitivity for both configurations (give the result in dBm and W).

4 - The transmitter provides its antenna with a power of 0 dBm. Let's assume a 0 dB antenna gain for both transmission and reception. Calculate the theoretical transmission distance for both configuration.

Problem 2: Satellite TV receiver

The ASTRA satellite located in a geostationary orbit at 36000km broadcasts TV programs. Receiving these programs is possible owing to a satellite dish comprising a parabolic reflector that concentrates radio waves on a Low Noise Block (LNB) located at the focal point of the reflector. The LNB realises a first frequency change. Then, a coaxial cable (10m long in our example) routes the received signal to the decoder which realises the second frequency change as well as demodulation and some other functions.



The data for the different blocks are given hereafter:

- satellite: Pe (transmit power) = 160 W
  Ge (antenna gain)= 30 dB

- antenna & LNB:
  antenna: Gr = 33 dB
  LNA: G = 10 dB, NF = 1 dB
  $filter_1$: G = -3 dB, NF = 3 dB
  $mixer_1$: G = 10 dB, NF = 2 dB
  $filter_2$: G = -3 dB, NF = 3 dB

- Coaxial cable of type 17vatc, with a signal attenuation of 17dB per 100m at 1GHz

-decoder:
  $mixer_2$: G = 10 dB, NF = 4 dB
  $filter_3$: G = -3 dB, NF = 3 dB

The antenna aims at the sky for which a temperature of 50K is assumed.

- transmit frequency: 12,45 to 12,75 GHz (In practice, the frequency range is larger but this makes the problem simpler).

- channels: they are 20 MHz wide, the centre frequency spacing is 20 MHz (these values are somewhat different in practice)

1 - Give the characteristics (centre frequency, bandwidth) of filters 1 and 2 as well as the required frequency range for local oscillator LO2.

2- Give, in W and dBm, the signal power at the LNA input.

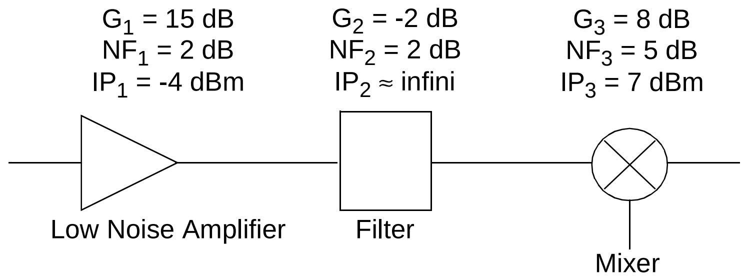
3 - Calculate the equivalent input-refered noise power . Calculate the corresponding SNR.

4 - Calculate the SNR at the output of filter 3.

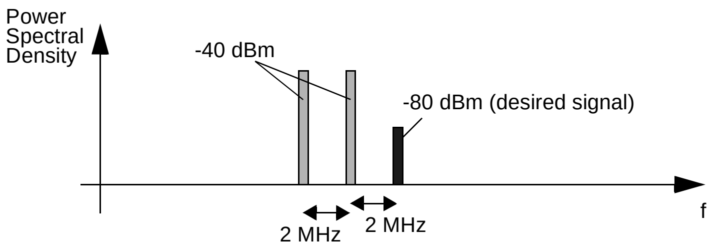
5 - How many programs can be received?

Problem 3: Intermodulation

A receiver input stage is depicted below:



At its input are superimposed:
- The desired signal (-80 dBm)
- Two interferers located in adjacent channels (-40 dBm).



1 - Calculate the IP3 of the whole chain in the configuration depicted above.

2- For the two interferers, calculate the difference in dB that exists at the receiver's output between fundamental and third-order intermodulation products (Hint: what is the slope for fundamental, for third-order intermodulation products? A graphical representation similar to the one on slide 22 may help).

3- Infer from the previous result the SNR for the desired signal.

4- Same questions if the interferers power is increased to -35 dBm.