**RF SYSTEMS**
**Written Test of July 6th, 2016**

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| **Surname & Name** |
| **Identification Number** |
| **Signature** |

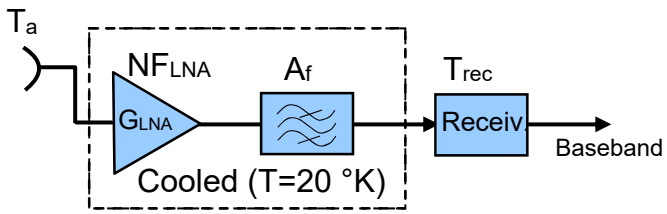
Exercise 1

Consider a spacecraft for deep-space exploration in orbit around Jupiter. It is equipped with a digital transmitter operating at 12 GHz (transmitted power $P_T$=20 W). The antenna of the vehicle is a 5m dish with aperture efficiency $e_a$=0.6 and efficiency $\eta$=0.8. The receiving station on the Earth has a 70m dish antenna with $e_a$=0.65 and $\eta$=0.9; the receiver exhibits a overall system noise temperature of $T_{sys}$=25 °K.
Imposing the maximum BER at the receiver output equal to $10^{-3}$, the required $E_b/N_0$ ration must be 4.75 (6.77 dB).

1) Evaluate the gain of both antennas and the half-power beamwidth $\theta_{3dB}$ of the Earth station antenna
2) Evaluate the maximum data rate R of the link assuming the path length r=$0.78.10^9$ Km and the additional link attenuation La=5 dB (due to atmospheric losses).
3) If there is an error in the antenna pointing equal to $\theta_{3dB}/2$, what is the resulting degraded BER for the same data rate previously evaluated? Assume:

$$BER = \frac{1}{2} erfc\left(\sqrt{x}\right) \cong -0.0012541x^3 + 0.016458x^2 - 0.073553x + 0.11351 \quad (x = E_b/N_0)$$

Exercise 2

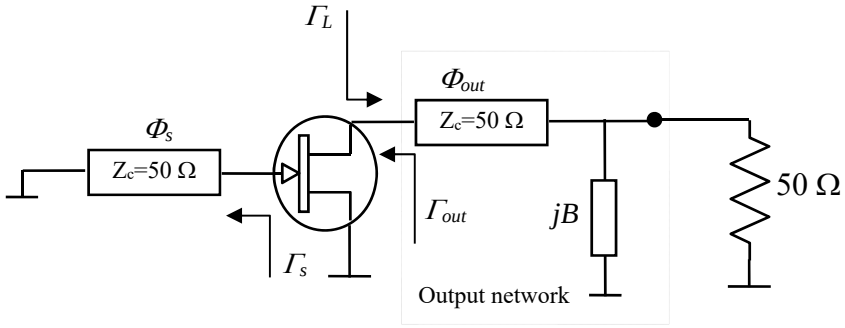



$T_a$=10°K
$NF_{LNA}$= ?
$G_{LNA}$=20 dB
$A_f$=0.5 dB
$T_{rec}$= 100 °K

The scheme in the above figure represents the front-end of the Earth Station receiver of exercise 1 (note that the low noise amplifier and the filter are cooled at 20°K). Assuming the parameters above reported and the imposed system temperature $T_{sys}$=25 °K, evaluate the required value of the LNA noise figure. If the system SNR must be 10 dB, what is the maximum system bandwidth?

Exercise 3

We want design the oscillator in the following figure, operating at 5 GHz:




The scattering parameters of the transistor are given by:

$S_{11}$= 0.844∠-62.3°, $S_{21}$=5.273∠121.7°, $S_{12}$=0.069∠42.7°, $S_{22}$=0.521∠-52.6°

a) Select a value for $\Gamma_s$ and evaluate the electrical length $\Phi_s$ of the first line. (Hint: set $|\Gamma_{out}|$=1.2 and select the $\Gamma_s$ which determines the minimum value of $\Phi_s$)

b) Design the output network, once the required value of $\Gamma_L$ has been computed