EE 567

Homework 9 Solution

Problem 1. A receiver front end has a noise figure of 8 dB and a gain of 60 dB and a bandwidth of 12 MHz. The input signal power is 10^{-11} W. The antenna temperature is 175 K. Find $T_e,\ T_s,\ N_{out},\ SNR_{in}$ and SNR_{out}. You may use $T_0 = 290$ K and Boltzmann's constant equals 1.38×10^{-23} J/K.

Solution:

$$\begin{aligned} T_e &= (F-1)T_0 = (10^{0.8}-1)T_0 = 1540 \text{ K} \\ T_s &= T_e + T_a = 1540 + 175 = 1715 \text{ K} \\ N_{in} &= kT_aB_n = 2.90 * 10^{-14} \text{ W} \\ N_{out} &= kT_sB_nG = 2.84 * 10^{-7} \text{ W} \\ SNR_{in} &= \frac{S_{in}}{N_{in}} = 344.8 = 25.38 \text{ dB} \\ SNR_{out} &= \frac{S_{in}G}{N_{out}} = 35.21 = 15.47 \text{ dB} \end{aligned}$$

Problem 2. Using the same design as Problem 1 an additional amplifier is inserted in the system before the one described in Problem 1 (a preamplifier) so that now the antenna feeds energy to two networks in cascade. The preamp has a noise figure of 3 dB and a gain of 12 dB and a bandwidth of 10 MHz. Find $T_s,\ F_{out},\ N_{out}$ and SNR_{out}, where F_{out} is the overall or composite F. Indicate how much this design improved SNR_{out} relative to the design in Problem 1.

Solution:

$$\begin{aligned} F_{out} &= F_1 + \frac{F_2 - 1}{G_1} = 10^{0.3} + \frac{10^{0.8}-1}{10^{1.2}} = 2.33 = 3.67 \text{ dB} \\ T_e &= (F_{out}-1)T_0 = 385.7 \text{ K} \\ T_s &= T_e + T_a = 560.7 \text{ K} \\ N_{out} &= kT_sB_nG_1G_2 = 1.47 * 10^{-6} \text{ W} \\ SNR_{out} &= \frac{S_{in}G_1G_2}{N_{out}} = 107.8 = 20.32 \text{ dB} \end{aligned}$$

Thus the SNR improvement is 20.32-15.47=4.85 dB.