RF Design - Noise

Exercise 1: What is the noise figure of a 6 dB attenuator?

$$-6\ \text{dB} = \frac{S_o}{S_i} = 10^{-\frac{6}{10}} = \frac{1}{4}$$

noise factor = 4

noise figure = 6 dB

Exercise 2: What are the minimum possible values of T_e and F?

minimum $T_e = 0$

minimum $F = \frac{T_0 + T_e}{T_0} = 1$

$F = 0$ dB

Exercise 3: The datasheet for a low-noise amplifier (LNA) specifies a noise figure of 2 dB. What is the noise temperature T_e?

$$F = 2\ \text{dB} = 10^{\frac{2}{10}} = 1.58 = \frac{T_0 + T_e}{T_0} = \frac{T_e}{T_0} + 1$$

$$\frac{T_e}{T_0} = 0.58 \qquad T_e = 290 \cdot 0.58 = 168\ \text{K}$$

Exercise 4: An LNA with a noise figure of 0.3 dB receives a signal with an SNR of 6 dB. What is the output SNR?

$$F = \frac{SNR_{in}}{SNR_{out}}$$

$$F = SNR_{in} - SNR_{out} = 0.3$$

$$SNR_{out} = SNR_{in} - 0.3$$

$$= 6 - 0.3 = 5.7$$

Exercise 5: A noise source with an ENR of 15 dB is connected to an LNA. The noise PSD at the output of the LNA is measured as -152 dBm/Hz and with the noise source on and -165.2 dBm/Hz with it off. Assuming the spectrum analyzer adds negligible noise and the "off" noise source temperature is 290K, what are T_e and F? Do not confuse mW and dBm.

165.2
162
13.2

$Y = -152 - (-165.2) = 13.2$ dB

$Y = 10^{\frac{13.2}{10}}$

$= 20.9$

$T_e = \frac{T_0 \cdot ENR}{Y-1} = \frac{290 \cdot 31.6}{20.9-1}$

$\approx \frac{290 \cdot 31.6}{20} \approx 450$ K.

$ENR = 15$ dB

$= 10^{1.5} = 31.6$

$F_{(dB)} = ENR - 10\log_{10}(Y-1)$

$= 15 - 10\log(20) = 15 - 13$

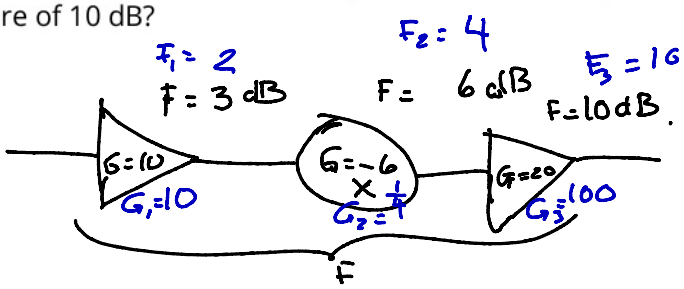
$= 2$ dB

check: $F = \frac{T_e}{T_0} + 1 = \frac{450}{290} + 1$

≈ 2.5

???

Exercise 6: A What is the system noise figure of a receiver that consists of a 10 dB amplifier with 3 dB noise figure followed by a mixer with a 6 dB loss and an IF amplifier with a 20dB gain and a noise figure of 10 dB?



$$F = 2 + \frac{4-1}{10} + \frac{10-1}{10 \cdot \frac{1}{4}}$$

$$= 2 + \frac{3}{10} + \frac{9}{2.5}$$

$$= 2 + 0.3 + 4$$

$$\approx 6.$$

$$\approx 7.8 \text{ dB}.$$

blue is linear units.

noise factor (linear)

noise figure (dB).