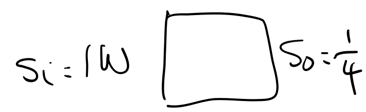
RF Design - Noise

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

$$F = S_i / S_o = 4 \ (+6\,dB).$$

$$10^{\frac{6}{10}} = \frac{1}{4}$$

$$\frac{W}{Hz} \cdot Hz \Rightarrow W$$



$$dBm - dBHz + dBHz \rightarrow dBm.$$

$$\text{"}dBm/Hz\text{"} = dBHz$$

$$B(dBHz) = 10\log(B(Hz))$$

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

$$T_e\ (min) = 0\,K$$

$$F\ (min) = 1 + \frac{T_e}{T_0} = 1 \quad (0\,dB)$$

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

$$F = 2\,dB = 10^{\frac{2}{10}} = 1.58$$

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

$$T_e = (F-1)T_0$$

$$= (1.58-1)T_0$$

$$= 0.58 \cdot 290 = 170\,K$$

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?

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

$$SNR_{out} = SNR_{in} \cdot F$$
$$= SNR_{in}(dB) - F(dB)$$
$$= 6 - 0.3 = 5.7\ dB$$

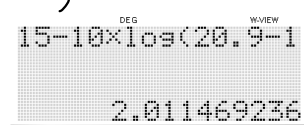
Exercise 5: A noise source with an ENR of 15 dB is connected to an LNA. The noise PSD at the output of the LNA is measured as −152 dBm/Hz and with the noise source on and −165.2 dBm/Hz with it off. Assuming the spectrum analyzer adds negligible noise and the "off" noise source temperature is 0 K, what are T_e and F? Do not confuse mW and dBm.

−152.0 dBm/Hz
−165.2 dBm/Hz

$Y = 13.2\ dB$
$= 20.9$

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

$F_{dB} = 15 - 10\log(20.9 - 1)$
$= 2.01\ dB$
$= 1.59$



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

$T_e = T_0(F - 1) = 290(0.59)$
$= 171\ K$

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_1	F_2	F_3	
$F =$	3	6	10	(dB)
$=$	2	4	10	(linear)

	G_1	G_2	G_3	
$G =$	10	−6	20	(dB)
	10	$\frac{1}{4}$	100	(linear)

$$F = 2 + \frac{4-1}{10} + \frac{10-1}{10 \cdot \frac{1}{4}} = 2 + 0.3 + 3.6 = 5.9$$

$$= 3.9 \text{ dB}$$