EE334 Homework: Noise

Problems:

- Do the problems on the attached pages (pages 2-4).

Additional Problems (Instructor Option):

- Any as assigned by instructor

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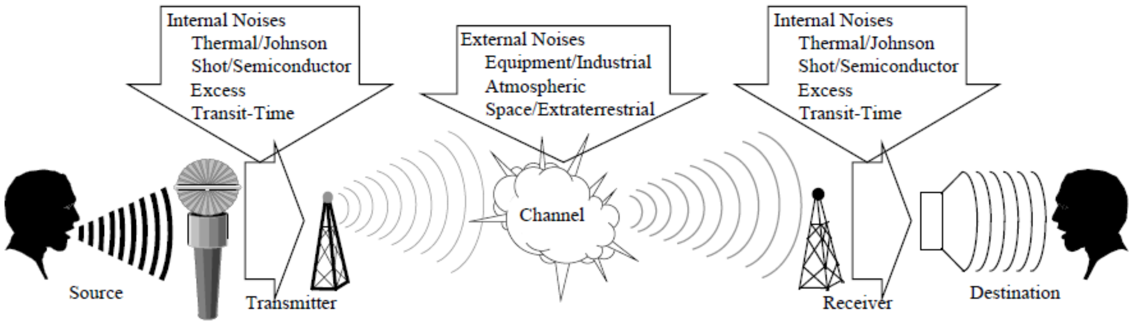
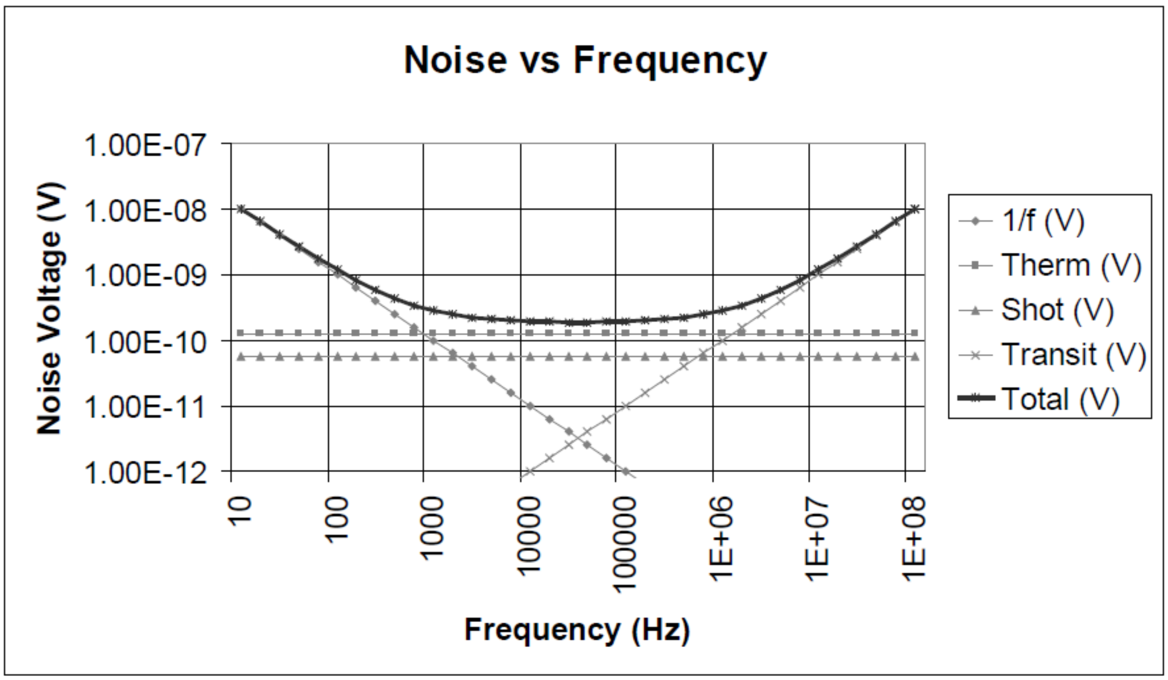
#1 – Describe (in detail) the internal sources of noise for a communications system. Discuss over what frequencies the different types of noise dominate and describe what can be done to minimize their effects.



There are four common sources of internal noise source: Thermal, Shot, Excess, and Transit-time. Internal noise can be minimized through judicious use of temperature, bandwidth, resistance, bias current, and frequency. Choice of operating frequency is crucial.



External sources are many and varied, but include noise caused by machines or by the electrical device itself (e.g., rotation of a generator or motor, a poorly shielded transformer, etc.) , lightening, sunspots, galactic background radiation, jamming, another signal over-lapping into the desired signal, etc., etc. It can be random or predictable, terrestrial or extra-terrestrial, man-made or natural, etc. We minimize its effect through various methods such as electromagnetic shielding, filtering, robust circuit design, or simply avoiding a problem area (like avoiding the Van Allen radiation belt for a space satellite).

#2 – An AM receiver has a 100 Ohm input resistance and operates at 25 degrees C. The receiver bandwidth is 10 kHz. The signal input power to the receiver is 12.4 fW.

a.) Find the open circuit noise voltage.
b.) Find the noise power.
c.) Calculate the SNR_{input} as a ratio and in dB.

a)

$$V_n = \sqrt{4k_B TBR} = \sqrt{(4)\left(1.381x10^{-23}\, {}^{J}/_{K}\right)\left((273.15+25)K\right)(10{,}000\ Hz)(100\Omega)} = \boxed{128\ nV}$$

b)

$$P_n = k_B TB = \left(1.381x10^{-23}\, {}^{J}/_{K}\right)\left((273.15+25)K\right)(10{,}000\ Hz) = \boxed{41.2x10^{-18}W}$$

$$= 41.2\ aW = 0.041\ fW$$

c)

$$SNR_{in} = \left(\frac{P_{in,signal}}{P_{in,noise}}\right) = \left(\frac{12.4\ fW}{0.041\ fW}\right) \cong \boxed{301 \cong 24.8\ dB}$$

#3 - The SNR at the input to a two stage amplifier is 200 and the SNR at the output of the first stage amplifier is 100. The power gain of the first amplifier stage is 120, the gain of the second amplifier stage is 100, and the noise ratio of the 2^{nd} amplifier is 4.

a.) Calculate the noise ratio and noise figure of the first stage amplifier.

b.) Calculate the total Gain, NR, NF, and output SNR of the composite two stage amplifier.

a)

$$NR_1 = \left(\frac{SNR1_{input}}{SNR1_{output}}\right) = \left(\frac{200}{100}\right) = \boxed{2} \rightarrow NF_1 = 10\log(2) = \boxed{3\ dB}$$

b)

$$A_T = (120)(100) = 12{,}000 = 10\log(12000) = \boxed{40.8\ dB}$$

$$NR_T = NR_1 + \frac{(NR_2 - 1)}{A_1} = 2 + \frac{(4-1)}{120} = 2 + \frac{3}{120} = \boxed{2.025}$$

$$NF_T = 10\log(2.025) = \boxed{3.06\ dB}$$

$$SNR_{output} = \frac{SNR_{input}}{NR_T} = \frac{200}{2.025} = \boxed{98.8 = 20\ dB}$$

$$Take\ note!$$

$$NF_T \neq NF_1 + NF_2$$

$$NR_T \neq NR_1 \times NR_2$$