EE6320 Homework 2: Due Monday 15/03/2021

1. Figure 1 below shows the low-frequency model of a *bipolar* transistor. The base resistance and its associated noise are represented by r_b and $\overline{v^2}_{n,b}$ respectively. The base-emitter and base-collector junctions have "*shot noise*" associated with them. {Note: the power spectral density of shot noise in a *p-n* junction is *white* in nature, and is proportional to the DC current through the junction.} The base and collector mean-square noise currents are given by

$$\overline{i^2}_{n,b} = 2qI_B\Delta f \qquad \text{and}$$
$$\overline{i^2}_{n,c} = 2qI_C\Delta f$$

respectively, where q is the electronic charge. Assume that all noise sources are uncorrelated, and that the source resistance is R_s. Ignore all flicker noise sources. Assume that the bipolar transistor is configured as a common emitter amplifier in small-signal mode, with a tuned LC load with equivalent parallel resistance R at the frequency of operation. Derive an expression for the (low-frequency) noise figure. {Hint: in this case, it may be easier to use the fundamental definition of noise figure instead of working with a two-port model; also recall that $\beta = g_m r_\pi$}

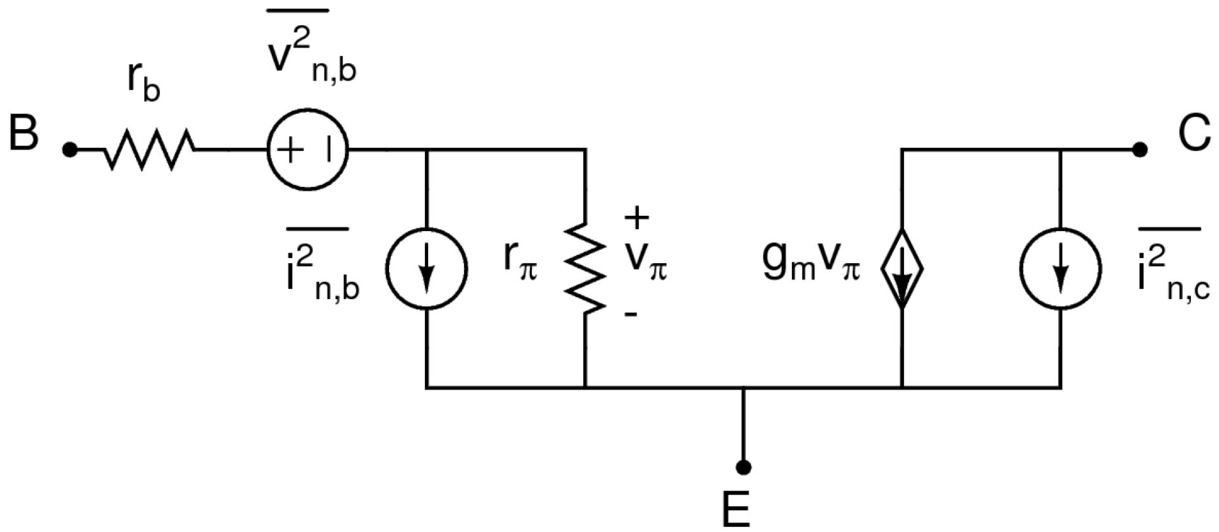

Figure 1

2. A circuit exhibits a noise figure of 3 dB. What percentage of the output noise power is due to the source resistance R_S?

3. A circuit exhibits a noise figure of 2 dB. What percentage of the output noise power is due to the source resistance R_S?

4. A circuit exhibits a noise figure of 1 dB. What percentage of the output noise power is due to the source resistance R_S?

5. For the following problems, neglect device parasitics and flicker noise. Calculate the noise figure with respect to the source resistance R_s as a function of frequency.

(a) Refer to circuit in Figure 2. Assume R_F is very large.

(b) Refer to circuit in Figure 3.

(c) Refer to circuit in Figure 4.

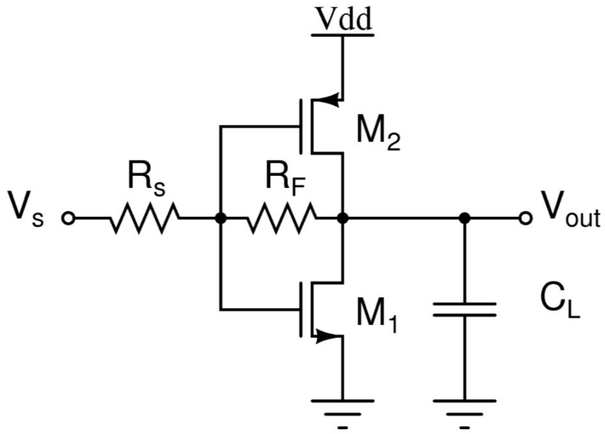

Figure 2

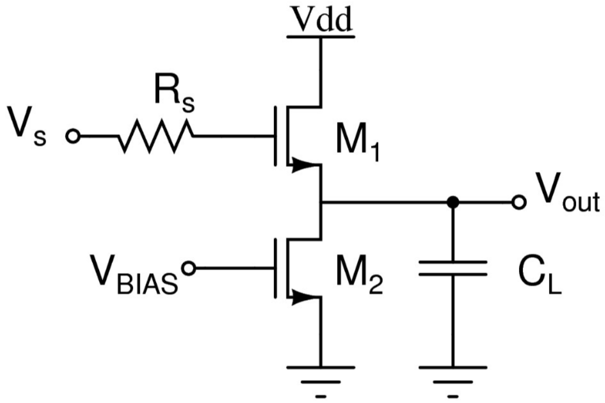

Figure 3

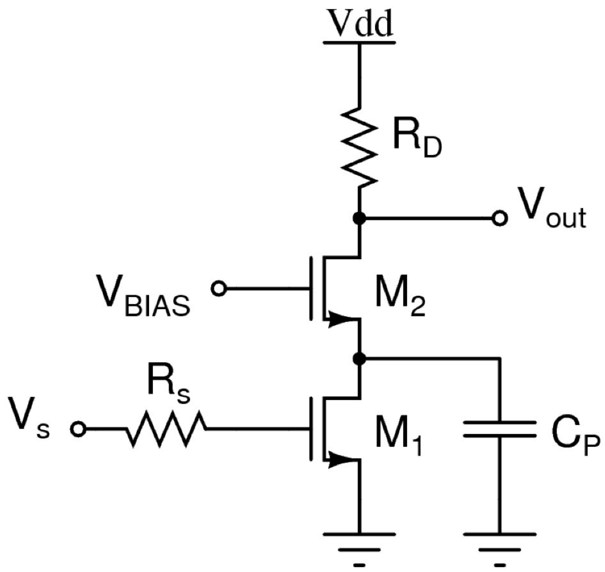

Figure 4