EE6240 Homework 2: Due Wednesday 14/09/2011

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.

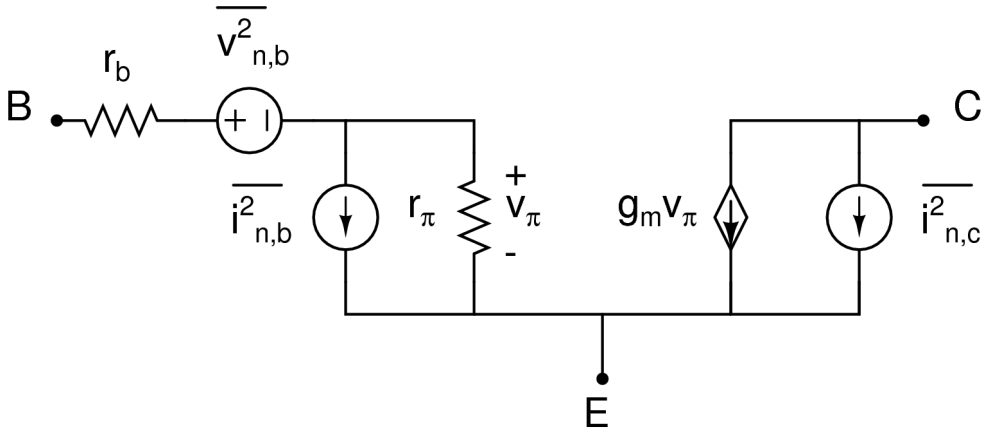

Figure 1

a) 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 $\beta = g_m r_\pi$}

b) Based on the above result, derive expressions for F_{min} and R_{opt}.

2. Show that the noise bandwidth of a critically-damped second-order low-pass filter is about 1.22 times the -3dB bandwidth.