1. An amplifier has a voltage gain of 300 and an input resistance of 5 kΩ. A white noise source with an output resistance $R_s = 2$ kΩ is connected to the amplifier input. With the source voltage zeroed, the rms amplifier noise output voltage is 0.470 mV. With the rms spot noise output voltage of the source set to $v_s = 0.1 \mu V/\sqrt{Hz}$, the rms amplifier output voltage is 4.82 mV. Solve for the noise factor and the noise figure of the amplifier.

$$v_{n/1}^2 = \left(\frac{AR_i}{R_S + R_i}\right)^2 4kT R_S B_n \times F$$

$$v_{n/2}^2 = \left(\frac{AR_i}{R_S + R_i}\right)^2 (S_v B_n + 4kT R_S B_n \times F)$$

Take ratios and solve for $F$.

$$F = \frac{S_v}{\frac{v_{n/2}^2}{v_{n/1}^2} - 1} = \frac{(0.1 \times 10^{-6})^2}{(4.82 \times 10^{-3})^2 - 1} \times 1.6 \times 10^{-20} \times 2000$$

$$NF = 10 \log(F) = 4.77$$

2. An amplifier has $v_n = 3 \mu V/\sqrt{Hz}$, $i_n = 6 \mu A/\sqrt{Hz}$, and $\rho = 0.15$. The amplifier is driven from a voltage source with an output resistance $R_s = 1$ kΩ. Assume the noise bandwidth $B_n = 1$ Hz.

(a) Calculate the noise factor $F$ and noise figure $NF$.

$$F = \frac{4kT R_S + v_n^2 + 2v_n i_n R_S \rho + i_n^2 R_S^2}{4kT R_S} = 4.15 \quad NF = 10 \log(F) = 6.18$$

(b) Calculate the optimum source resistance $R_{so}$.

$$R_{so} = \frac{v_n}{i_n} = 500 \Omega$$

(c) A resistor is added in parallel with the amplifier input to make the source resistance seen by the amplifier equal to $R_{so}$. What is the required value of the resistor?

$$R_p = \frac{R_S R_{so}}{R_S - R_{so}} = 1000 \Omega$$

(d) What are the new noise factor and noise factor?

$$V_{i(oc)} = \frac{R_p}{R_S + R_p} V_s + V_{iso} + V_n + I_n R_{so} = \frac{R_p}{R_S + R_p} \left[ V_s + \frac{R_S + R_p}{R_p} (V_{iso} + V_n + I_n R_{so}) \right]$$

$$V_{ni} = \frac{R_S + R_p}{R_p} (V_{iso} + V_n + I_n R_{so})$$

$$F = \frac{\left(\frac{R_S + R_p}{R_p}\right)^2 (4kT R_{so} + v_n^2 + 2v_n i_n R_{so} \rho + i_n^2 R_{so}^2)}{4kT R_S} = 7.18 \quad NF = 10 \log(F) = 8.56$$
3. The figure shows the ac signal circuit of a common-base amplifier. The BJT has the parameters \( \beta = 150 \), \( r_x = 50 \, \Omega \), and \( r_0 = \infty \). It is given that \( R_s = 50 \, \Omega \) and \( R_C = 30 \, k\Omega \).

(a) If flicker noise is neglected, calculate the optimum bias current \( I_{C(opt)} \) and the rms equivalent noise voltage in series with \( V_s \) for the band \( 0 \, \text{Hz} \leq f \leq 50 \, \text{kHz} \).

\[
I_{C(opt)} = \frac{V_T}{R_s + r_x} \frac{\beta}{\sqrt{1 + \beta}} = 3.05 \, mA
\]

\[
v_{ni} = 4kT (R_s + r_x) \beta \frac{\sqrt{1 + \beta}}{\sqrt{1 + \beta} - 1} = 8.71 \times 10^{-14} \, V^2 \quad v_{ni} = 2.95 \times 10^{-7} \, V
\]

(b) What is the noise factor and noise figure for the band \( 0 \, \text{Hz} \leq f \leq 50 \, \text{kHz} \)?

\[
F = \frac{v_{ni}^2}{4kTR_sB_n} = 2.18 \quad NF = 10 \log(F) = 3.38
\]

(c) What is the rms noise voltage at the amplifier output for the band \( 0 \, \text{Hz} \leq f \leq 50 \, \text{kHz} \)?

\[
A_v = \frac{v_o}{v_s} = \left( -\frac{1}{r_C + R_s} \right) + 510 \quad v_{no} = A_v v_{ni} = 0.150 \, mV
\]