1. Two resistors $R_1$ and $R_2$ are connected in parallel. The two resistors are in thermal equilibrium.

(a) Suppose that only $R_1$ generates thermal noise and $R_2$ is noiseless, show that the average thermal noise power delivered by $R_1$ to $R_2$ in the band $\Delta f$ is given by

$$P_{12} = \frac{4kTR_1R_2\Delta f}{(R_1 + R_2)^2}$$

(b) Suppose that only $R_2$ generates thermal noise and $R_1$ is noiseless, show that the average thermal noise power $P_{21}$ delivered by $R_2$ to $R_1$ in the band $\Delta f$ is given by the same expression obtained above.

(c) Note that $P_{12} = P_{21}$. If the two answers were not the same, could the two resistors be in thermal equilibrium? How would the temperatures of the individual resistors vary with time if $P_{12} > P_{21}$?

2. Calculate the thermal spot noise voltage in $V/\sqrt{\text{Hz}}$ at the standard temperature across the terminals of the circuit $[v_{rms} = 8.72 \text{nV}/\sqrt{\text{Hz}}]$.

![Circuit Diagram]

3. Calculate the spot noise voltage at the output of the circuit at the frequency $f = 1.5 \text{ kHz}$. Assume $T = T_0 = 290\text{ K}$. $[9.83 \text{nV}/\sqrt{\text{Hz}}]$.

![Circuit Diagram]

4. A $1\text{ M}\Omega$ resistor has a dc voltage across it of $4\text{ V}$. At the frequency $f = 100\text{ Hz}$, the spot noise voltage across the resistor is $v_n/\sqrt{\Delta f} = 400\text{ nV}/\sqrt{\text{Hz}}$.

(a) Show the flicker noise coefficient is $K_f = 9 \times 10^{-13}$.

(b) Show that the noise index is $NI = 3.17\text{ dB}$.

(c) The mean-square short-circuit noise current generated by the resistor is given by

$$i_n^2 = \frac{4kT\Delta f}{R} + \frac{K_f I_{DC}^2 \Delta f}{f}$$

Show that the flicker noise corner frequency is $f_{flk} = 900\text{ Hz}$.  

5. A 100 mH lossy inductor has a measured impedance magnitude of 8 kΩ at the frequency \( f = 10 \text{ kHz} \). Show that the open-circuit thermal spot noise voltage generated by the inductor at 10 kHz is \( v_t / \sqrt{\Delta f} = 8.9 \text{nV/Hz} \). Note that \(|Z|^2 = R^2 + (\omega L)^2\) for the inductor.

6. If the diode generates only shot noise and the resistor generates only thermal noise, solve for the rms noise output voltage over the band from 1 kHz to 3.5 kHz. The diode is modeled as a shot noise current source in parallel with a small-signal resistance given by \( r_d = \eta V_T / I_D \), where \( \eta \) is the emission coefficient or ideality factor and \( I_D \) is the dc current in the diode. Assume \( \eta = 2 \) and \( V_T = 25 \text{ mV} \). \( v_{rms} = 23.9 \text{nV} \)