Physics 116C Spring 2007: Assignment 7 Problems

5/23/2007

1. Two metal film resistors $R_1$ and $R_2$ are connected in series. They are at the same temperature, $T$. The Johnson noise rms voltage is measured by an instrument with bandwidth $B$.

(a) Show that the rms noise voltage across the resistors in series is equal to that of a single resistor $R = R_1 + R_2$.

(b) Would you expect an excess contribution from other kinds of noise besides Johnson noise if carbon-composition resistors were substituted for the metal film resistors? Explain briefly.

2. In the figure below, the x’s in the circles represent ground connections. The signal source $V_1$ is referenced to a different ground than the instrumentation amplifier connection (as with our circuit test board relative to the DAQ connection box). The two grounds are connected through an external ground bus (shown as a dashed line). Briefly explain the problem with the referenced single-ended (RSE) configuration, how it could produce unwanted interference and why the nonreferenced connection (NRSE) is better.

![Diagram](image-url)
3. The figure above shows a BJT in a common emitter circuit biased such that $I_C = 1.0$ mA. $I_C$ displays full shot noise (electrons can be considered independent of each other in flowing from the emitter across the base into the collector). There are other noise sources in the circuit but we will consider only $R_C$ Johnson noise and $I_C$ shot noise here. Recall that for shot noise, $I_{\text{noise}}(\text{rms}) = (2qI_{\text{DC}}B)^{1/2}$ where $q = 1.60 \times 10^{-19}$ C. Assume $T = 300$ K.

(a) Find the rms noise due to the resistor Johnson noise (for the 20 kHz bandwidth).

(b) i. Find the rms shot noise current (for the 20 kHz bandwidth)
   ii. Find the rms noise voltage at the output due to this noise current.

(c) Find the total noise voltage at the output within the 20 kHz bandwidth. Which noise source is dominant?

4. A long 75 $\Omega$ transmission line is connected to a pulse generator and is terminated at the far end by a 50 $\Omega$ resistor. The voltage on the cable is initially zero. A wave in the form of a 1 V boxcar function 20 ns wide is input and reaches the improperly terminated end.

(a) Find the amplitude and polarity of the reflected wave.

(b) Find the voltage across the 50 $\Omega$ resistor during the pulse.