

Physics 198, Spring Semester 1999
Introduction to Radiation Detectors and Electronics

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Problem Set 11: Due on Tuesday, 20-Apr-99 at begin of lecture.

Discussion on Wednesday, 21-Apr-99 at 12 – 1 PM in 347 LeConte.

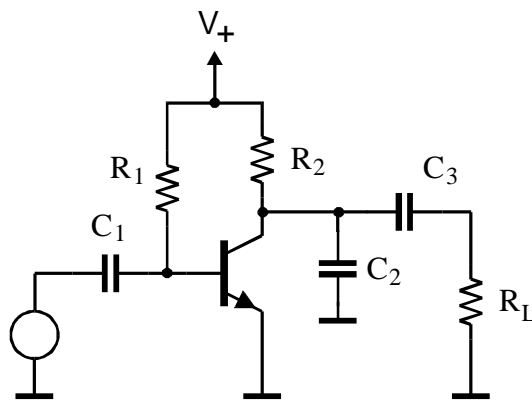
Office hours: Mondays, 3 – 4 PM in 420 LeConte

1. Consider a spectroscopy system whose resolution is determined by electronic noise.
 - a) Find a quiet place and clearly recite 100 times “Noise contributions add in quadrature.”
 - b) The current noise contribution is 120 eV and the voltage noise contribution is 160 eV. What is the total noise?
 - c) After cooling the detector the current noise is 10 eV and the voltage noise remains unchanged at 160 eV. What is the total noise?

2. If the overall resolution of a system is determined by the convolution of multiple Gaussian distributions, the individual resolutions add in quadrature.

In a time-of-flight system the start detector has a time resolution of 100 ps and the stop detector has 50 ps resolution. What is the overall time resolution?

3. Calculate the properties of a simple transistor amplifier. A small-signal silicon transistor is used with a current gain of 100 with an Early voltage >100 V. The supply voltage $V_+ = 12$ V.



- a) The transistor is to operate at a collector current of 5 mA. What is the required value of the base bias resistor R_1 ? (Assume $V_{BE} = 0.6$ V)

- b) What value of the collector resistor R_2 is required to obtain 6 V at the collector?
- c) The output of the amplifier is measured using a high-impedance probe, so the load resistor $R_L = 1 \text{ M}\Omega$. If the coupling capacitances C_1 and C_3 are sufficiently large to be irrelevant at the measurement frequency (and neglecting C_2), what is the voltage gain for a sinusoidal input?
- d) What is the small signal input resistance measured at the base of the transistor?
- e) The lower cut-off frequency of the amplifier is to be 160 kHz. What is the required value of C_1 ? Assume that the signal source has zero source resistance.
- e) The capacitance to ground at the output of the amplifier C_2 is 133 pF. What is the upper cutoff frequency?
- f) If the signal source provides a step impulse, what is the pulse shape at the output? (Assume that C_3 is sufficiently large to be negligible.)