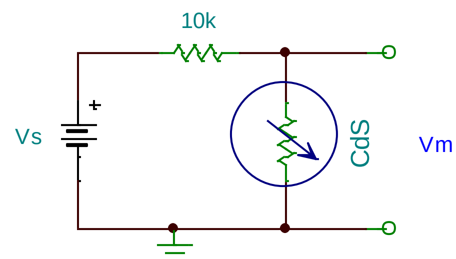
Chem 721-Instrumental Analysis

Fall 2024

PS#1 - Introduction to electronics

Part I. The voltage divider. One of the simplest visible light detection circuits is made with a voltage divider that has cadmium sulfide photoresistor as one of the resistors. A photoresistor is a semiconductor where the resistance of the material decreases as the light intensity increases. For CdS there is an inverse linear relationship between the resistance as the intensity of light striking the detector. A CdS detector that has a resistance range of 1 kOhm to 100 kOhm is used in the following detection circuit. The supply voltage is +5 V.



1) Using Spyder, create a script to plot the output voltage over the 1 k to 100 k range of the detector resistance.

2) Is the circuit response more sensitive at higher or lower light intensities? Explain.

3) Is the circuit response more linear at higher or lower light intensities? Explain.

4) How does changing the value of R1 (the 10 k resistor) affect the linearity and the sensitivity of the response.

5) Consider the case where only a small amount of light hitting the CdS so its resistance is 95 kΩ

   a) What would a voltmeter with an internal resistance of 1 MΩ measure for a voltage at V_m? Calculate the relative error in this measurement.

   b) What internal resistance would be required for a voltmeter to measure V_m with a relative error of less than 0.1%. Do our lab voltmeters, Rin= 10 MOhm, meet this requirement?

Part II. RC filters. Bode plots are often used to display the frequency response of electronic filter circuits. A Bode plot is a plot of the voltage gain in dB (20 log(V_{out}/V_{in}) vs log of frequency. Bode plots can also show the phase relationship between the input and output signals by plotting the relative phase vs log f. The simplest, but still useful, AC filters include a single resistor capacitor combination in either the low pass or high pass configuration.

1. Create scripts to generate Bode plots (both magnitude and phase) for high and low pass filters given R and C values as inputs. Run your scripts for the following combinations of R and C.

   47 K; 0.2 µF   1 K; 0.1 µF

   a) Which filter would you use to pass only the DC component of a 100 Hz signal?

   b) Which filter would you use to block 60 Hz power line noise in a detection circuit where the signal is at 10 kHz?

2. Add to your scripts the ability to plot the time response of the output voltage, if the input voltage is stepped from 0 to 1 V. Run your scripts for the same combinations of R and C as before.

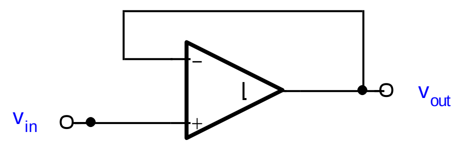
   a) Determine the rise time of the 1 K; 0.1 µF low pass filter. The rise time is the time it takes for the output to go from 10% to 90% of the limiting value.

   b) From the rise time, calculate the bandwidth of the 1 K; 0.1 µF low pass filter. Compare this bandwidth to the 3dB point on your Bode plot. What is the phase shift at the 3dB point?

$$BW = \frac{0.35}{T_r}$$

Part III. Operational Amplifiers. A 100 mV p-p sine wave at 1.5 kHz is the input to the following operational amplifier circuits. Using Spyder, plot the expected output signal for each circuit. Include the input signal on the same axes for easy comparison.

1)



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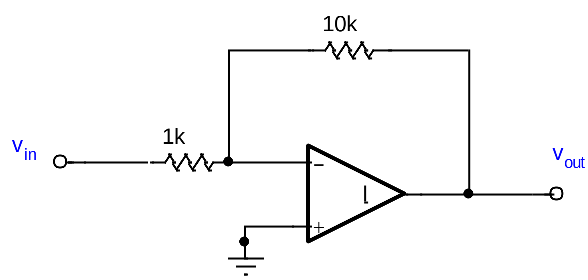

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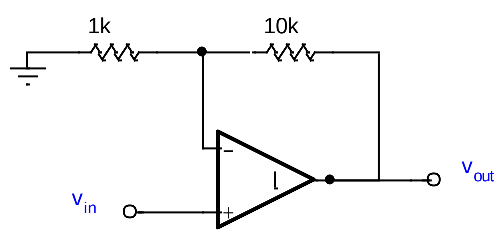

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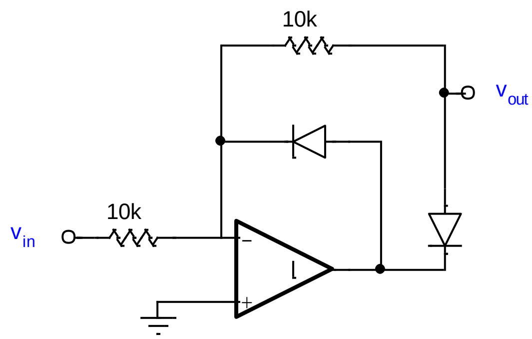

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