Electrical Engineering 40/40I/41I

Midterm 2 - Fall 1995

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Problem 1 [21%]: Phasors

(a) Put a cross (X) by each of the expressions below which could be a phasor voltage:

___ $3e^{j(\omega t+\phi)}$ ___ $3\cos(\omega t+27°)$ ___ $3\sin(\omega t+\pi)$ ___ $3+j7$

___ $(3+j7)\cos(\omega t+27°)$ ___ $+3j$ $-3j$ ___ $3e^{j0.3}$ ___ $(3+j7)/(4-j10)$

(b) Write expressions for the real currents for each of the following, assuming that the frequency f=60kHz and I_0=10mA, using the convention of the text. (Angles are in radians.)

$I_0 e^{j3}$

$I_0(3+j4)$

$jI_0 e^{j\pi/2}$

(c) Convert the following real expression to the corresponding phasors:

$v(t)=4\sin(377t)mV$

$v(t)=12\cos(377t-\pi/2)mV$

$v(t)=\left(\sqrt{\frac{1}{2}}\right)\sin(377t-\pi/4)mV$

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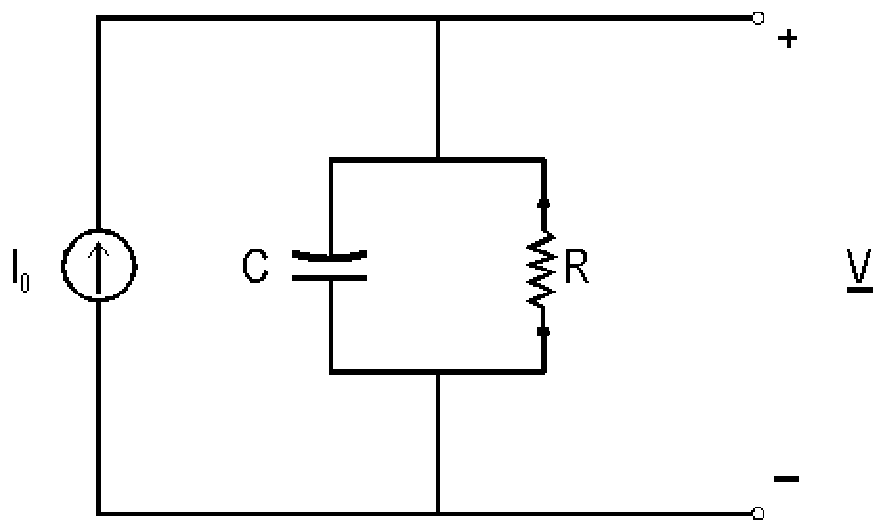
Problem 2 [21%]: Circuit Elements

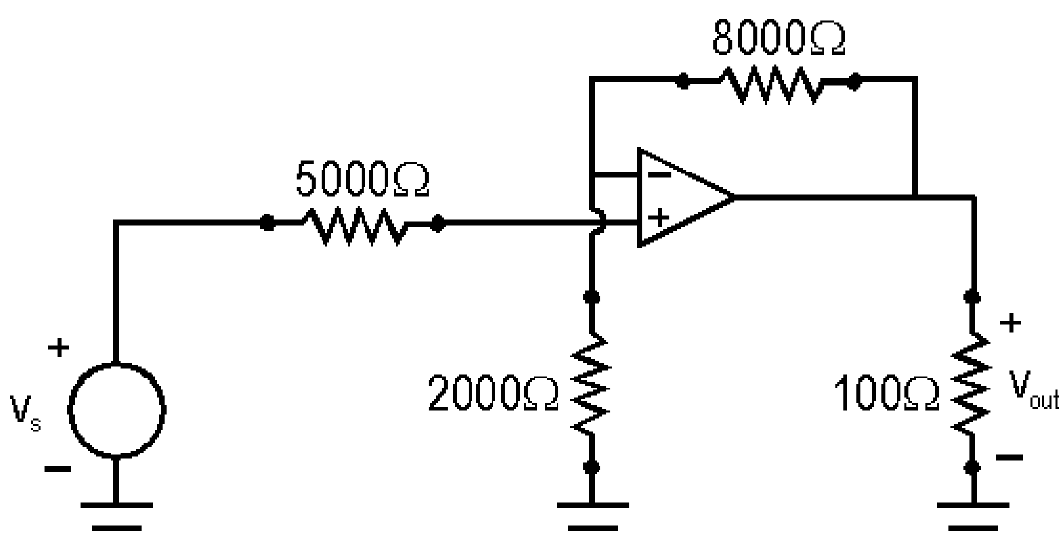
(a) [3%] List two passive circuit elements that store energy:

(b) [9%] Suppose that in a portion of the circuit for an electronic door opener you need an impedance having a 10-ohm real part and a 30-ohm negative reactive part at a frequency of 60kHz. Show two circuits that provide this.

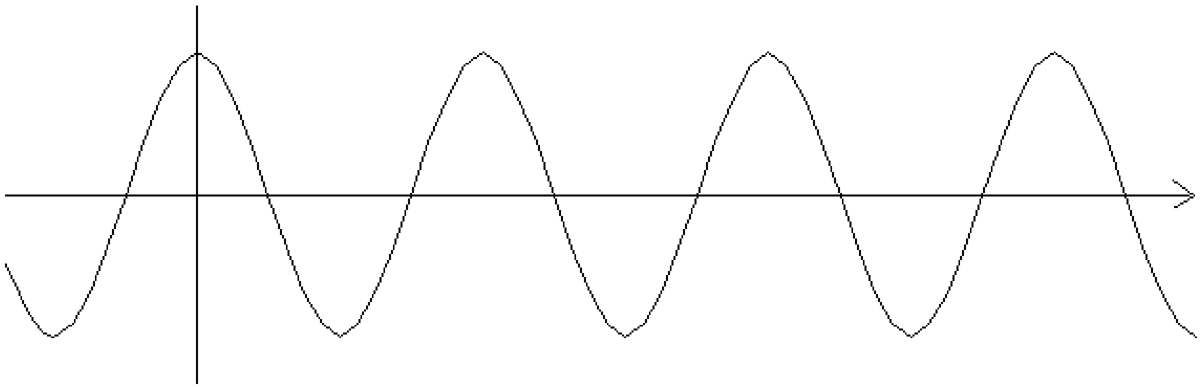
(c) [9%] In this circuit I_0 is a sinusoidal ideal current source with amplitude 1mA, C=1μF, R=1000Ω, f=60Hz. Find the amplitude of the sinusoid V.



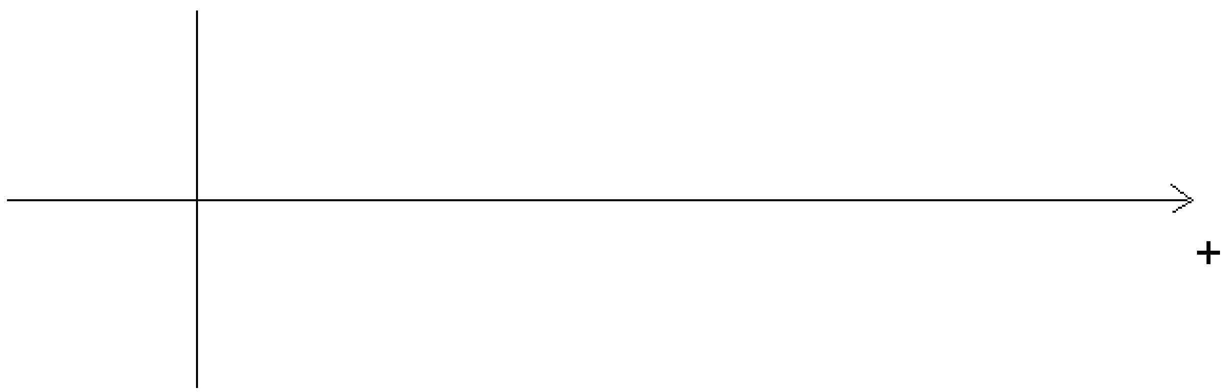
Problem 3 [18%]: Op-Amps



The voltage $v_s(t)$ is an endless sinusoid with frequency 1MHz and amplitude 2V, as shown here:



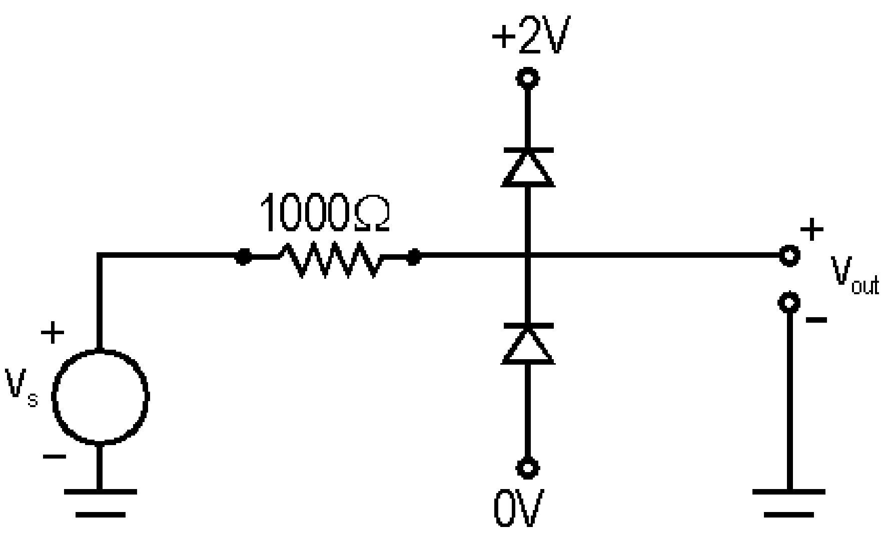
(a) Assume the op-amp is completely ideal and its power-supply voltages are &#177 15V. Sketch v_{out} showing vertical scale and maximum values.



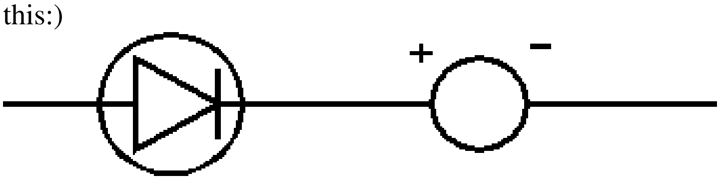
(b) Same question as (a), except the op-amp has maximum output current of 50mA. Show the vertical scale and maximum values.

(c) Same question as (a); op-amp is completely ideal except that it has a finite gain-bandwidth product of 1E6 1/s. Show the amplitude scale and maximum values.

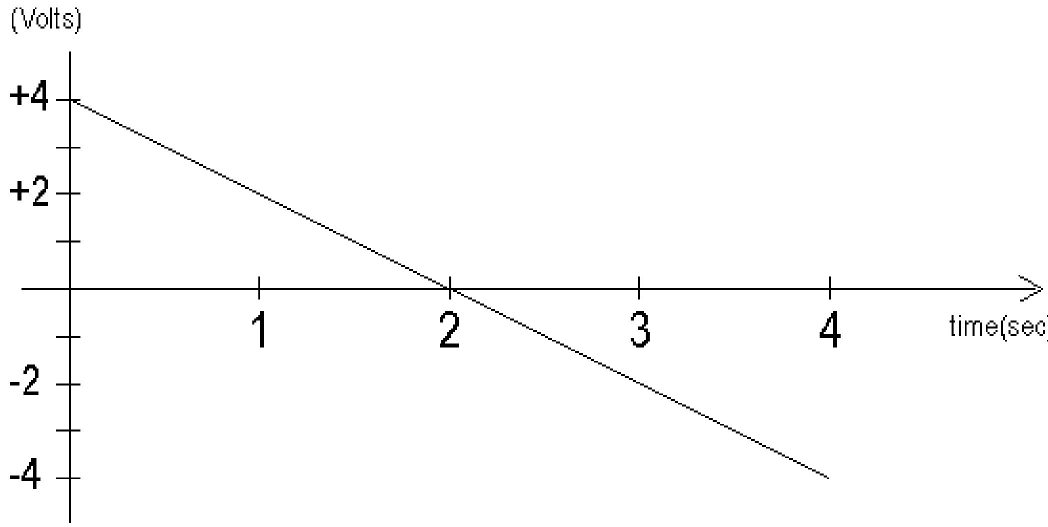
Problem 4 [20%]: Diodes



In the above circuit, the diodes are to be represented by the large signal diode model, (the one that looks like this:)

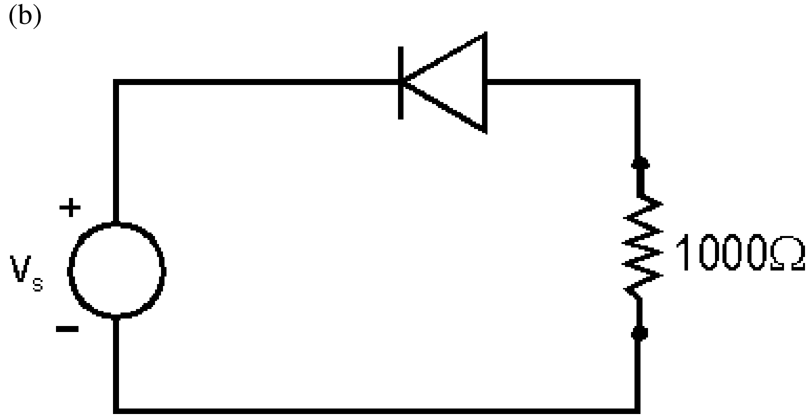


(a) Suppose $v_s(t)$ is



Graph $v_{out}(t)$ clearly on the same set of axes.

(b)



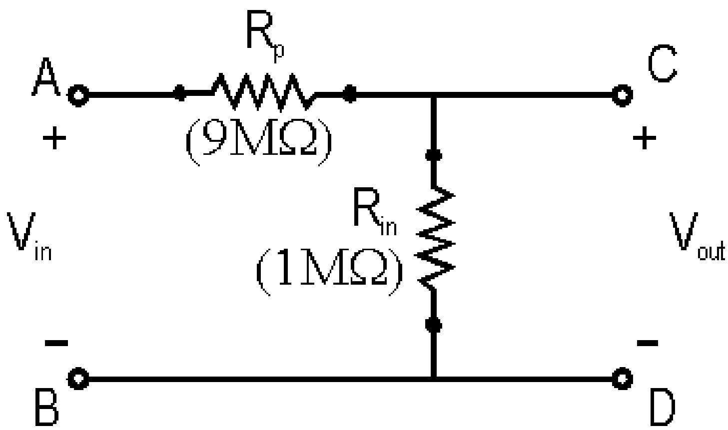
v_s and the diode are the same as in part (a). Find the time-averaged power dissipated in the diode, averaged over the 4-second period.

Problem 5 [20%]: RC Circuits and Bode Plots

This problem relates to a probe often used with oscilloscopes to prevent them from adverseley affecting circuits whose voltages they measure.

(a) The basic idea of the probe is shown here: The ideal oscilloscope would be connected at terminals C-D and the probe would be connected to the circuit under test at A-B. (Resistor R_p represents an actual resistor built into the probe, and resistor R_{in} represents the input resistance of the oscilliscope.)

Sketch the Bode plot in dB of $|v_{out}/v_{in}|$ for this circuit. Indicate slopes and break frequencies (if any).



$$\left|\frac{v_{out}}{v_{in}}\right|(dB)$$

(b) Sketch the Bode plot for another circuit in which

$$\left|\frac{v_{out}}{v_{in}}\right| = \frac{10^6 + 100\omega^2}{\omega\sqrt{\omega^4 + 10^{12}}}$$

Indicate slopes and break frequencies (if any).

$$\left|\frac{v_{out}}{v_{in}}\right|(dB)$$

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