

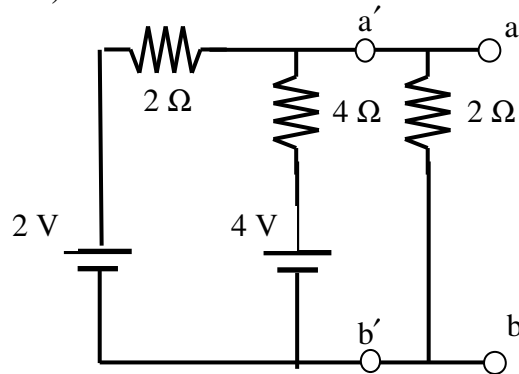
PHYS-COIS 2250H – Electronics

Midterm: Monday Feb 9, 2015

Allowed: 1 hour, 50 mins. Calculator.

Answer all four questions. Each question is worth equal marks. Show your working!

1a) Derive and draw the Thevenin equivalent of the circuit below, to the left of terminals a' - b' (i.e. assuming the 2 Ω resistor is absent).



b) Using your result from part (a) determine the Thevenin equivalent of the circuit between terminals a-b, (i.e. with the 2 Ω resistor present).

2. An ac dimmer switch operates on a sinusoidal input voltage by providing zero volts output for the first  $\Delta t$  seconds of each peak or trough of the input signal, and then after this time sending to its output the remainder of the input signal's peak or trough. Thus, for a sine wave input of period  $T$ , the output voltage,  $V_o(t)$ , takes the following form:

$$\begin{aligned} nT \leq t \leq nT + \Delta t & \quad V_o(t) = 0 \\ nT + \Delta t \leq t \leq (n+1/2)T & \quad V_o(t) = V_{\max} \sin\left(\frac{2\pi}{T}t\right) \end{aligned}$$

where  $n$  takes an integer value (i.e. 0,1,2,...) for a peak, and a half-odd-integer value (i.e. 1/2, 3/2, 5/2, ... ) for a trough.

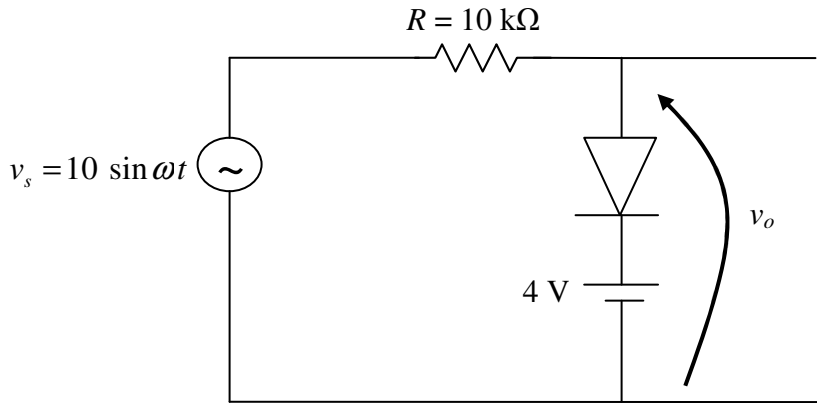
a) Sketch the form of  $V_o(t)$  [you do not need to understand how dimmer switches work for this]

b) Find the rms value of the output voltage as a function of  $\Delta t$ , i.e.  $V_{o,rms}(\Delta t)$ . Verify that it goes to  $V_{\max} / \sqrt{2}$  as  $\Delta t \rightarrow 0$  and to zero as  $\Delta t \rightarrow T/2$  [note the following identity:  $\sin^2 x = \frac{1}{2}(1 - \cos(2x))$ ]

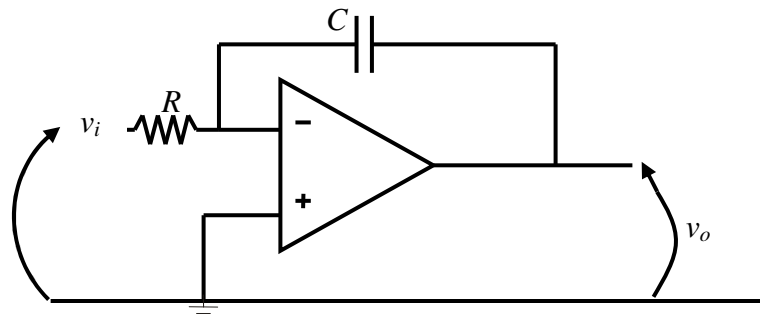
c) By examining the value of  $V_{rms}$  at  $\Delta t/T = 0, 0.125, 0.25, 0.375,$  and  $0.5$ , sketch  $V_{rms}$  as a function of  $\Delta t$ .

3a) Use an energy-level diagram to explain the operation of a p-n junction diode.

b) Sketch the form, on two graphs above each other, of both the input voltage  $v_s$  and output voltage  $v_o$  as a function of time in the circuit below. You may assume the diode is ideal. Briefly explain your reasoning. Include a numerical scale for the voltage.



c) By assuming the usual op-amp approximations for negative feedback, find the output voltage below in terms of the circuit parameters given.



4. An npn transistor with common emitter collector characteristics shown is set up in the *common emitter configuration*, with a supply voltage of  $V_{cc} = 10\text{ V}$ , and a load resistance,  $R_L = 1.25\text{ k}\Omega$ .

a) Draw the circuit described here.

b) From the characteristics shown, determine an approximate value of  $\beta$  for this transistor.

c) For these values of  $V_{cc}$  and  $R_L$ , determine the range of base current required for this circuit to act as an effective *transistor switch* between an ON and an OFF state and explain your reasoning.

