DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2005 (2 hours)

EEE 103 ANALOGUE CIRCUITS 1

Answer **THREE** questions. Solutions will be considered in the order in which they are presented in the answer book and **no marks will be awarded for an attempt at a fourth question.** Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1 **(i)** Sketch the waveshape of the output voltage, V_O, for the circuit of figure 1 assuming that the load draws a constant current, I_L. Label your sketch with amplitudes and times expressed in terms consistent with the labels in figure 1. ***{4}***

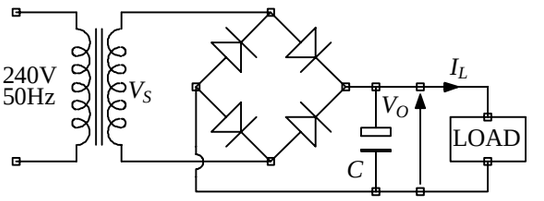


Figure 1

(ii) Using a suitable model, estimate a value of C that will give a ripple voltage of less than 1V peak to peak at a load current of 150mA. Make sure that you state any assumptions or approximations that you use. ***{5}***

(iii) What value of V_S would be appropriate for a nominal d.c. output voltage of 40V? ***{2}***

A second supply of 15V is to be derived from the 40V supply above by using a simple zener diode regulator circuit consisting of a resistor and zener diode. The load for this second supply may draw a current anywhere in the range 5mA to 25mA and the zener diode must be biased such that the current through it never falls below 5mA.

(iv) Draw a circuit diagram to show how the resistor and zener diode could be added to figure 1 to realise the 15V supply. ***{2}***

(v) What is the maximum value of resistor that can be used in the zener diode regulator circuit if the main supply output voltage is assumed constant at 40V? ***{4}***

(vi) If the zener diode has a slope resistance of 6Ω, estimate the ripple voltage at the output of the 15V supply. ***{3}***

2 **(a)** The diode in figure 2a has a forward voltage drop of 0.7V. Determine whether the diode will be conducting and work out the reverse bias voltage or the forward conduction current as appropriate. ***{7}***

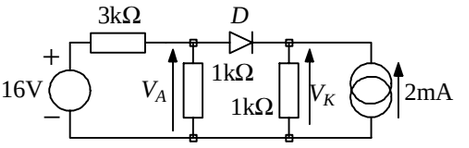


Figure 2a

(b) **(i)** The circuit of figure 2b initially consists of R_1 and C only, that is, D is initially replaced by a piece of wire and R_2 is not connected. Sketch V_O in response to the input pulse shown. If R_1 = 3kΩ and C = 2nF, what is the voltage reached by V_O at the end of the input pulse? Calculate the time for which $V_O >$ 5V. *(Remember to think carefully about what will happen to the voltages across the circuit elements at the instant of transient changes of V_I)* ***{6}***

(ii) An R_2 of 2kΩ and an ideal diode, D, are now included to give the circuit of figure 2b. Sketch V_O and I_C over a time period long enough to show all the important aspects of the circuit's response to V_I. Label any exponential shapes with their time constants and label all peak values in both sketches. Assume that D has a forward voltage drop of 0V. ***{7}***

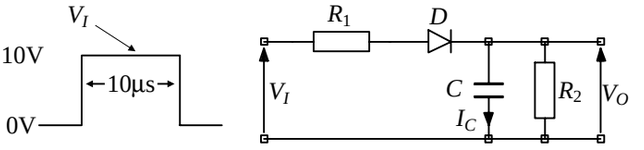


Figure 2b

3 **(i)** Redraw the circuit of figure 3 to include only the transistor and those components involved in controlling the bias conditions. ***{3}***

(ii) Calculate the d.c. conditions V_B, V_C, V_E and I_C together with the small signal parameters g_m and r_{be}. ***{6}***

(iii) Draw a small signal equivalent circuit of figure 3. ***{4}***

(iv) Work out the small signal voltage gain, v_o/v_s, of the circuit of figure 3. ***{4}***

(v) Which single component, if removed, will leave the amplifier with a gain, v_o/v_s of approximately -1? You should briefly justify your answer. ***{3}***

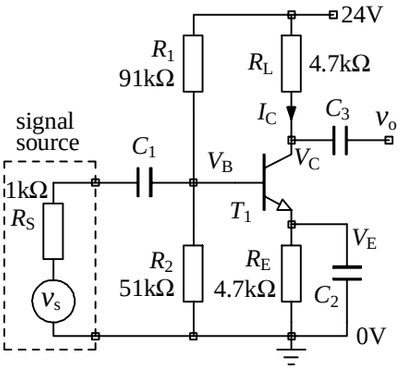


Figure 3

You should assume that a forward biassed pn junction has 0.7V across its terminals and that kT/e = 0.026V. The transistor has a small signal current gain, β, of 400. The relationships $g_m = \frac{eI_C}{kT}$ and $r_{be} = \frac{\beta}{g_m}$ may be assumed without statement but all other assumptions and approximations used in your solution must be stated and, where appropriate, justified.

4 **(a)** **(i)** Draw a circuit diagram of a practically useful operational amplifier based inverting amplifier. ***{3}***

(ii) What is meant by the term "inverting" used in part **(i)**? ***{1}***

(iii) Explain briefly what is meant by the term "virtual earth". Point out the virtual earth node in the circuit of part **(i)** and give the reason for virtual earth behaviour. ***{4}***

(iv) What relative values of resistors would you use in your circuit if a voltage gain of -10V/V was required? ***{2}***

(v) What is the input resistance of your circuit? ***{1}***

(b) The following questions relate to the circuit of figure 4 which uses an ideal operational amplifier.

(i) What is the gain v_o/v_1 if $v_2 = v_3 = 0$? ***{2}***

(ii) What is the gain v_o/v_2 if $v_1 = v_3 = 0$? **{3}**

(iii) What is the gain v_o/v_i if $v_1 = v_2 = v_i$ and $v_3 = 0$? ***{4}***

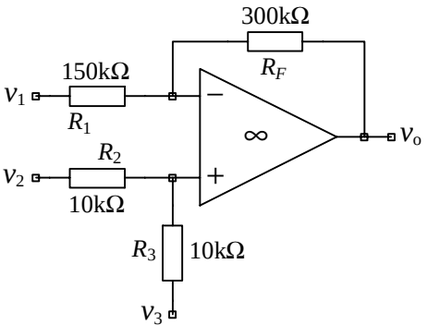


Figure 4

4RCT/DAS

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