DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2003 (2 hours)

EEE 103 ANALOGUE CIRCUITS
EEE 121Z ANALOGUE CIRCUITS FOR AEROSPACE

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 waveshapes you would expect to observe for V_S, V_O and I_C in the circuit of figure 1a. Why is this type of power supply unattracive from the electricity supply industry's point of view? ***{5}***

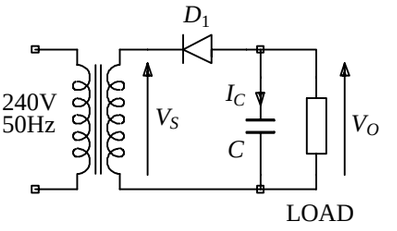


Figure 1a

(ii) Using a suitable model, estimate the minimum value of C that can be used to give a ripple voltage of less than 0.5V peak to peak for I_L = 0.1A. You should state any assumptions or approximations that you use. ***{4}***

A second diode and capacitor, D_2 and C_2 are added to the circuit as shown in figure 1b such that $C_1 = C_2$. Both outputs are loaded by 100mA as shown so the ripple on both outputs will be 0.5Vpeak to peak.

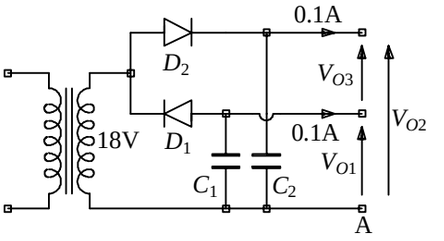


Figure 1b

(iii) On the same axes, sketch the waveforms you would expect to find at V_{O1}, V_{O2} and V_{O3}. Label your sketches with times and amplitudes, taking care to maintain the correct time registration between the diagrams. ***{5}***

A supply of 9V with respect to node A is to be derived from the supply of figure 1b by using a simple zener diode regulator circuit consisting of a resistor and zener diode attached to V_{O2}. The load for this second supply may draw a current anywhere in the range 5mA to 20mA and the current through the zener diode must never fall below 5mA.

(vi) What is the maximum value of resistor that can be used in the zener diode regulator circuit if the voltage at V_{O2} is assumed constant at its average value? ***{3}?***

(v) If r_Z is 5Ω, estimate the ripple voltage on the 9V supply. Assume that the ripple voltage on V_{O2} is 0.5V peak to peak. ***{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}***

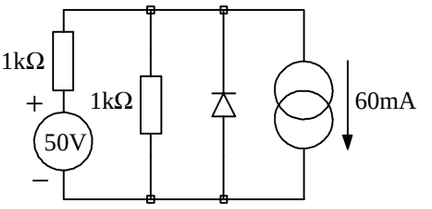


Figure 2a

(b) (i) In figure 2b R_2 is initially an open circuit so the circuit effectively consists of R_1 and C only. Sketch the response of the circuit to the input pulse shown. What is the voltage reached by V_O at the end of the input pulse? Calculate the time for which $V_O >$ 5V. ***{7}***

(ii) An R_2 of 1kΩ is included in the circuit. 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 the V_O and I_C sketches. You may assume that D is ideal - ie it has a forward voltage drop of 0V. ***{6}***

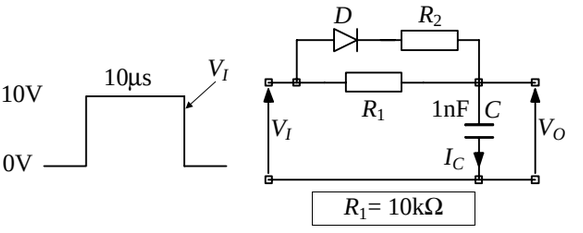


Figure 2b

3 The transistor in figure 3 has a static current gain, h_{FE}, somewhere in the range 50 to 500 and an incremental current gain, β, of 600. The base emitter voltage, V_{BE} is 0.7V.

(i) Work out the maximum and minimum values of I_C and V_C that would be expected due to the spread in h_{FE} and use your result to explain why this bias arrangement is not very effective. ***{6}***

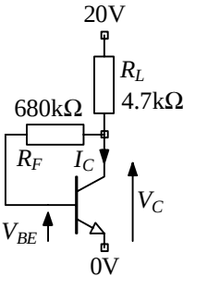


Figure 3a

The bias circuit of figure 3a can be improved considerably by the addition of an extra resistor and some modification to resistor values as shown in figure 3b. For the circuit of figure 3b,

(ii) Calculate the dc conditions I_C and V_C, and the small signal parameters, g_m and r_{be}. Make assumptions that are appropriate for a well designed circuit ***{5}***

(iii) Draw the small signal equivalent circuit. ***{4}***

(iv) Using your equivalent circuit of part **(iii)**, estimate the voltage gain v_o/v_s for the special case of $R_S = 0$. ***{5}***

Assume that a p-n junction has a forward voltage drop of 0.7V and that kT/e = 0.026V.

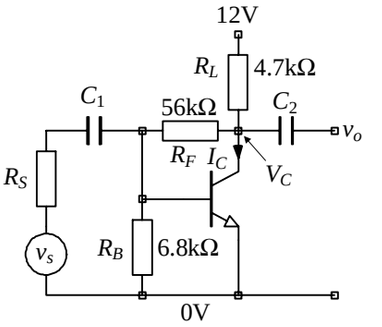


Figure 3b

4 **(a)** Draw a circuit diagram to show how an op-amp and two resistors can be connected to form a practically useful non-inverting amplifier circuit. Write down the gain of the circuit in terms of the resistors you have used. State what approximation has to be valid in order for your gain expression to be accurate and explain briefly how it simplifies the process of defining the relationship for gain. ***{8}***

(b) **(i)** Find the voltage gain v_o/v_i of the circuit of figure 4a. ***{4}***

(ii) Can you suggest a circuit using only two resistors around the op-amp that will achieve the same gain? ***{2}***

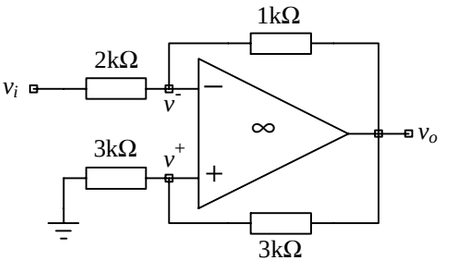


Figure 4a

(c) The output voltage, v_o, of the circuit of figure 4b will be of the form $v_o = a + b\sin\omega t$. Find a and b. ***{6}***

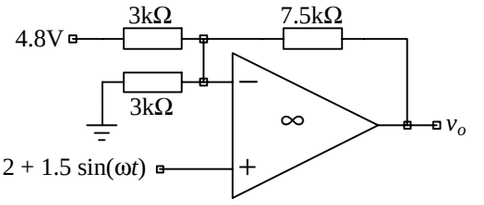


Figure 4b

4RCT/DAS

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