DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2002 (2 hours)

EEE 103 ANALOGUE CIRCUITS
EEE 176 ANALOGUE CIRCUITS AND DEVICES
EEE 121 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 waveshape of the output voltage, V_O, for the circuit of figure 1. Label the voltage and time scales as appropriate. ***{3}***

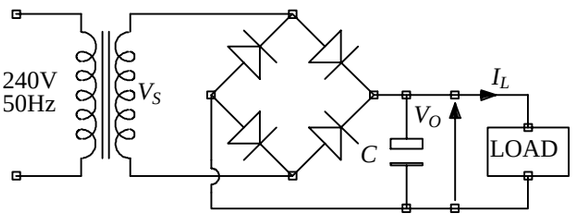


Figure 1

(ii) Using a suitable model, estimate the minimum value of C that can be used to give a ripple voltage of less than 0.75V peak to peak for I_L = 1.5A. You should state any assumptions or approximations that you use. ***{5}***

(iii) If a nominal V_O of 40V is required suggest a suitable value for V_S and define the biggest reverse bias that will appear across the diodes. ***{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 80mA 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? ***{3}***

(vi) If the zener diode has a slope resistance of 6Ω, estimate the ripple voltage at the output of the 15V supply assuming a peak to peak ripple of 0.75V on the 40V supply. ***{3}***

(vii) What power rating must the zener diode have to survive in this application? ***{2}***

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}***

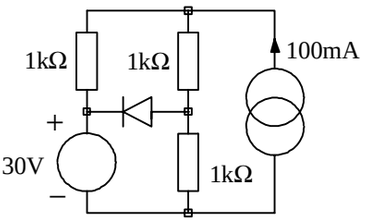


Figure 2a

(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 are the maximum and minimum voltages reached by V_O? Calculate the time for which $V_O < -1$V. ***{7}***

(ii) An R_2 of 47kΩ 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}***

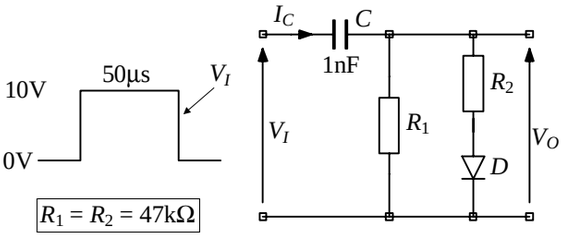


Figure 2b

3 The transistor in figure 3 has a static current gain, h_{FE}, of 100 and an incremental current gain, β, of 400.

(i) Define h_{FE} and β in terms of the appropriate transistor currents. ***{2}***

(ii) What is the purpose of R_E, C_1 and C_2? ***{4}***

(iii) Choose values of R_L, R_E, R_1 and R_2 such that $V_E \approx 4$V, $V_C \approx 12$V and $I_C \approx 2$mA. State clearly any assumptions or approximations you used to help you make your choices ***{6}***

(iv) Assuming that C_1 and C_2 have a negligible impedance at signal frequencies, draw a small-signal equivalent circuit of figure 3. ***{4}***

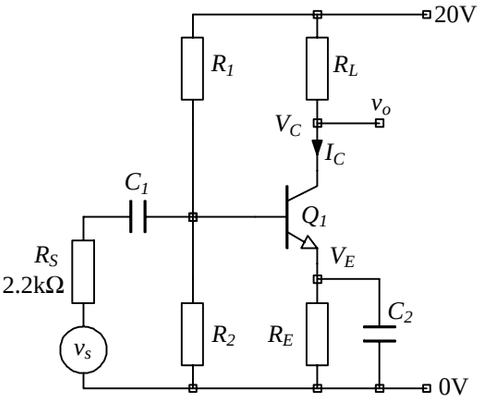


Figure 3

(v) Using the equivalent circuit of part **(iv)**, estimate the small-signal voltage gain, v_o/v_s, of your amplifier design. ***{4}***

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

4 **(a)** **(i)** Write down the gain v_o/v_i that you would expect from the circuit of figure 4a if $A \Rightarrow \infty$. ***{2}***

(ii) Derive an expression for the gain v_o/v_i of figure 4a which includes the effects of A. ***{6}***

(iii) Write down the input resistance of the circuit if $A \Rightarrow \infty$. Eplain briefly how the circuit input resistance will change if A is steadily reduced from its notional ideal value of infinity. ***{3}***

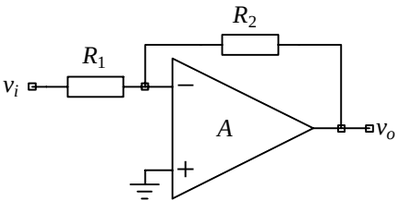


Figure 4a

(b) In the circuit of figure 4b, V_1 is the sum of a sinusoidal signal and a dc offset and is of the form $V_1 = 5 + 4\sin \omega t$ V. V_2 is a dc voltage designed to remove the dc component of the amplified V_1 from the output signal. If the resistors R_1, R_2, R_3 and R_4 each have a value of 1kΩ,

(i) What value of R_F is required to give an ac component of output signal of $10\sin \omega t$ V? ***{5}***

(ii) What value of V_2 is needed to give a dc component of output signal of 0V? ***{4}***

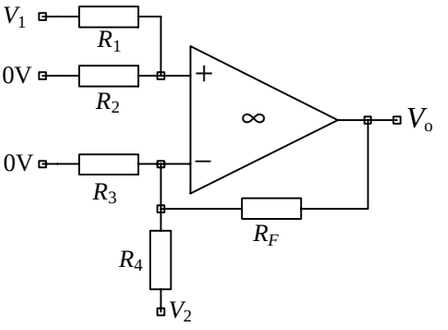


Figure 4b

4RCT/DAS

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