DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2001 (2 hours)

EEE 103 ANALOGUE CIRCUITS
EEE 121 ANALOGUE CIRCUITS FOR AEROSPACE
EEE 176 ANALOGUE CIRCUITS AND DEVICES
EEE 171Z ANALOGUE AND DIGITAL CIRCUITS

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 The input to the transformer of figure 1 is a 50Hz sinusoid and the secondary voltage is as shown.

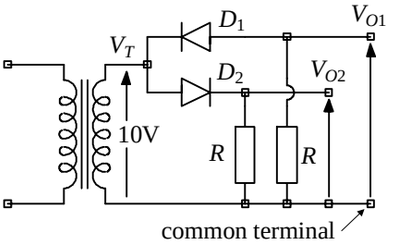


Figure 1

(i) Sketch the waveforms you would expect to see at V_T, V_{O1} and V_{O2}. Label times and amplitudes and take care to ensure the correct relative timings of your sketched waveforms. State any assumptions you have made about the diodes in the circuit. ***{6}***

(ii) What are the average values of the three waveforms of part **(i)**? ***{4}***

The resistors, R, are removed from figure 1 and replaced by loads that draw a constant current of 100mA from V_{O1} and V_{O2}. These loads, however, require a supply with a ripple voltage no larger than 1V peak to peak, so smoothing capacitors must be added between each output line and the common terminal.

(iii) Estimate a suitable value of smoothing capacitor for the V_{O1} and V_{O2} outputs. ***{3}***

If the loads between each output and the common line are replaced by a single load drawing a constant 100mA connected between V_{O1} and V_{O2}, and the smoothing capacitors are left as calculated in part **(iii)**;

(iv) What voltage would appear across the load and which of V_{O1} and V_{O2} would be its positive end? ***{2}***

(v) What would be the peak to peak magnitude and the frequency of the ripple voltage across the load? You should briefly justify your answer. ***{5}***

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. ***{6}***

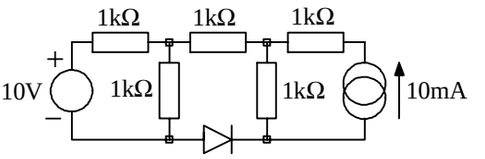


Figure 2a

(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 maximum voltage reached by V_O? Calculate the time for which $V_O > 5$V. ***{6}***

(ii) An R_2 of 15kΩ 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. ***{8}***

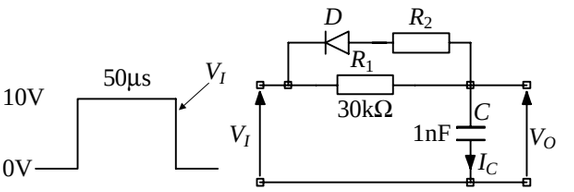


Figure 2b

3 The transistor T_1 in the amplifier circuit of figure 3 has a small signal current gain of 500 and a forward biassed base - emitter voltage drop of 0.7V.

(i) What is the purpose of C_1, C_2 and C_3? ***{3}***

(ii) Redraw the circuit of figure 3 to include only the transistor and the components that control the transistor's bias conditions. ***{3}***

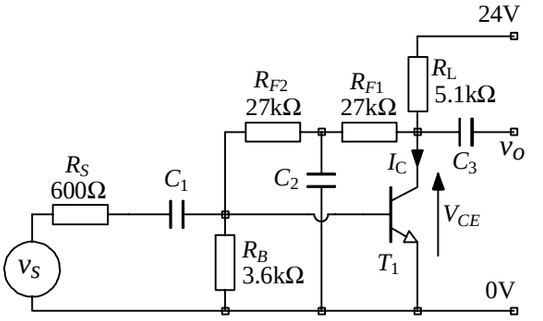


Figure 3

(iii) Calculate the dc conditions I_C and V_{CE} and the small signal parameters g_m and r_{be}. ***{5}***

(iv) Draw a small signal equivalent circuit of the circuit of figure 3, assuming that C_1, C_2, and C_3 have negligible impedances at all signal frequencies. ***{5}***

(v) Using your small signal circuit, find the small signal voltage gain, v_o/v_s, of the amplifier. ***{4}***

You may assume that $kT/e = 0.026$V.

4 (a) (i) Draw diagrams of a conventional inverting and non-inverting operational amplifier based amplifier circuits indicating on the diagrams which is which. Write down their gains in terms of the resistors used and state any assumptions implicit in the gain expressions. ***{6}***

(ii) What is the difference between conventional inverting and non-inverting operational amplifier based circuits from the point of view of the signal source? Why does this difference exist? ***{4}***

(b) The circuit of figure 4 is a signal conditioning circuit for monitoring the charge state of a battery with a nominal terminal voltage, V_B, of 36V. Under some conditions the voltage may reach 42V while under others it may fall to 28V. The conditioning circuit is required to convert the range 28V to 42V into a 0V to 5V range that can be input to the micro-controller that monitors the battery charge state.

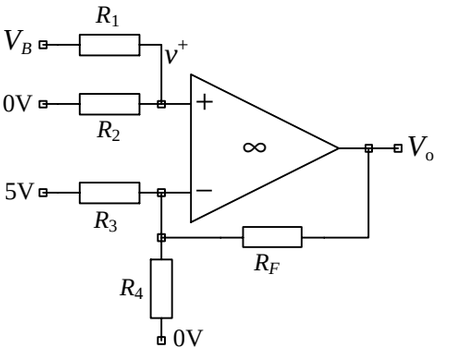


Figure 4

(i) If the maximum allowed input voltage to either input of the operational amplifier is 4V, what is the minimum ratio of R_1/R_2 that can be used and what is the resulting range of v^+? ***{4}***

(ii) Find the ratios R_F/R_3 and R_F/R_4 which will convert the voltage range appearing at v^+ into the required 0V - 5V range at the output. ***{6}***

4RCT/RCW

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