The University Of Sheffield.

Data Provided: useful definitions and equations at end of paper (after Q4)

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2010 - 2011 (2 hours)

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 The circuit of figure 1a is the power supply circuit for a 100W valve guitar amplifier.

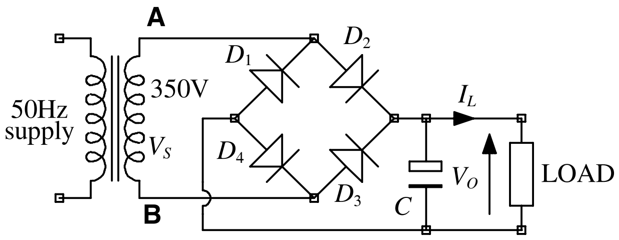

Figure 1a

(i) What is the common name given to this form of full wave rectifier? {*1*}

(ii) Which diodes will conduct at the peak of the half cycle that makes node **B** positive with respect to node **A**? {*2*}

(iii) What is the largest reverse voltage that each of D_1 to D_4 have to withstand? {*3*}

(iv) For the conditions $C = 68\ \mu$F and I_L at full power output (100 W) = 350 mA, estimate

(a) The dc component of V_O .

(b) The peak to peak ripple component of V_O .

State any assumptions or approximations used in arriving at your answers. {*5*}

The zener diode regulator circuit of figure 1b is to be used to derive a 200 V supply from figure 1a for the input and driver stages of the amplifier which between them draw a constant current of 5 mA.

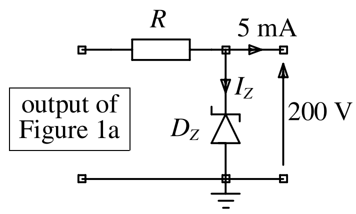

Figure 1b

(v) If I_Z must always be > 1 mA, find the largest value of R that can be used in figure 1b? {*3*}

(vi) What ripple voltage would you expect to measure at the output of the regulator if $r_Z = 25\ \Omega$ and the amplifier is operating under the conditions of part **(iv)**? {*2*}

(vii) What is the power dissipation in R and D_Z under normal operating conditions? {*4*}

State any assumptions or approximations used in arriving at your answers to **(v)**, **(vi)** and **(vii)**.

2 **(a)** **(i)** For the circuit of figure 2a, find the value of I that will put the diode on the point of conduction. (ie, $V_D = 0.7$ V and $I_D = 0$) {*2*}

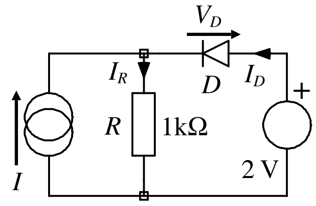

Figure 2a

(ii) Find I_D and V_D for $I = +5$ mA and $I = -5$ mA. {*4*}

(iii) With the help of the results of parts **2 (a) (i)** and **(ii)** or by other means, sketch a graph of I_D as a function of I for $I = +5$ mA to $I = -5$ mA. Label all the main features of your graph. {*4*}

(b) The diodes used in figure 2b have a forward voltage drop of zero.

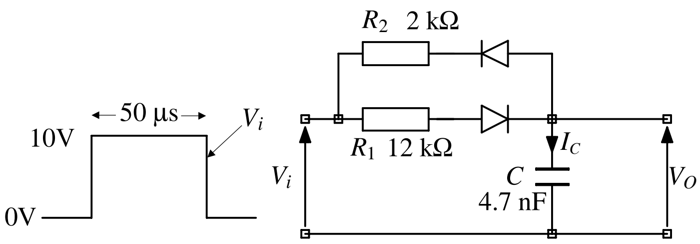

Figure 2b

(i) For the circuit of figure 2b sketch the V_O you would expect to observe in response to the input shown. Calculate the voltage reached by V_O at the end of the pulse and label rising and falling time constants. {*4*}

(ii) Sketch the form of I_C that you would expect to measure and calculate the positive and negative peak values of I_C. {*3*}

(iii) An 18 kΩ resistor is now placed in parallel with C. Calculate the new value of V_O reached at the end of the input pulse. {*3*}

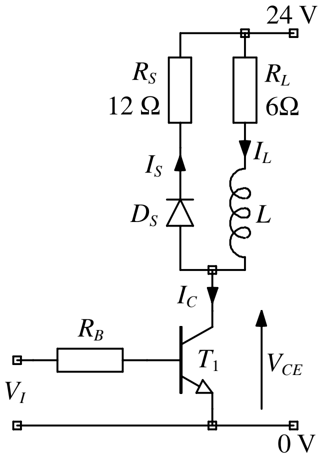

Figure 3a

3 **(a)** Figure 3a shows a BJT switching circuit. The switch is controlled by V_I which is 10 V for an "on" drive and 0 V for an "off" drive. The "off" state I_C is approximately zero, $V_{CE(ON)}$ is 0.2 V and the "on" state V_{BE} is 0.7 V.

(i) What are the "on" state values of I_C, I_L and I_S? {*2*}

(ii) What is the "on" state power dissipation in the BJT? {*2*}

(iii) If h_{FE} for the BJT is 30, find a suitable value of R_B. {*3*}

(iv) What are the values of I_C, I_L and I_S immediately after switch off? {*3*}

(v) What is the value of V_{CE} immediately after switch off? {*2*}

(b) **(i)** Work out suitable component values for the circuit of figure 3b in order to achieve $I_C = 1$ mA, $V_E = 4$ V and $V_C = 14$ V. Assume that $V_{BE} = 0.7$V and that $h_{FE} = \beta = 200$ for T_1. {*5*}

(ii) Redraw the circuit to include the coupling and decoupling capacitors that would be necessary to achieve a high voltage gain. {*3*}

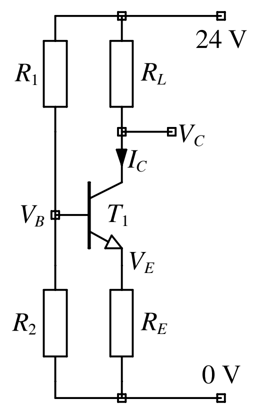

Figure 3b

4 **(a)** In the amplifier circuit of figure 4a, V_1 is a voltage source and V_O is the resulting output voltage.

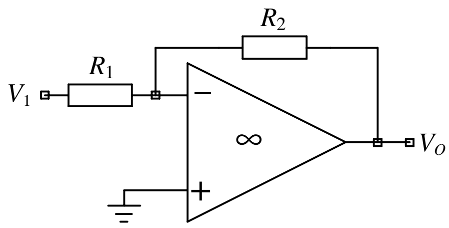

Figure 4a

(i) Which of the terms "inverting", "non-inverting", "buffer" and "subtractor" correctly describe the circuit of figure 1? **{*1*}**

(ii) Write down the gain, V_O/V_1 of the amplifier and suggest resistor values that would be suitable to achieve a gain magnitude of 10 using a typical op-amp. **{*4*}**

(iii) By redrawing the circuit and labelling it appropriately, identify the virtual earth (or virtual ground) node in the circuit and explain briefly how the virtual earth is created and maintained. **{*4*}**

(iv) What is the input resistance of the circuit? You should briefly justify your answer. **{*2*}**

(b) The circuit of figure 4b is required to take an input signal of $V_1 =$ 1.5 sin ωt and condition it such that at V_O it is of the form $V_O = 2.5 + 2.5 \sin \omega t$

If V_2 is a dc voltage and $V_3 = 0$ V, find values of R_F and V_2 that will give the required output. **{*9*}**

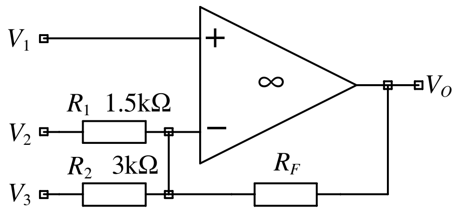

Figure 4b

4RCT/DAS
END OF PAPER

You may find some of the following relationships and definitions useful:

$$g_m = \frac{eI_C}{kT} \qquad r_{be} = \frac{\beta}{g_m} \qquad h_{FE} = \frac{I_C}{I_B} \qquad \beta = \frac{\Delta I_C}{\Delta I_B} = \frac{i_c}{i_b} \qquad \tau = RC$$

$$I = C\frac{dV}{dt} \qquad \omega = 2\pi f \qquad V(t) = (V_{START} - V_{FINISH})\exp\left(\frac{-t}{\tau}\right) + V_{FINISH}$$

$$V_{AVE} = \frac{V_P}{\pi} \text{ for a half wave rectified sinusoid} \qquad V_{rms} = \frac{V_P}{\sqrt{2}} \text{ for a sinusoid}$$

$$v_o = A_v\,(v^+ - v^-) \qquad \frac{kT}{e} = 0.026\text{V} \qquad V = IR$$

unit multipliers: p = $\times 10^{-12}$, n = $\times 10^{-9}$, μ = $\times 10^{-6}$, m = $\times 10^{-3}$, k = $\times 10^{3}$, M = $\times 10^{6}$ G = $\times 10^{9}$

All the symbols have their usual meanings