University of Kelaniya
Faculty of Science
Bachelor of Science Honours Degree Examination
in Applied Chemistry
November/December 2022
Academic Year 2020/2021 - Semester 1

ELEC 11534 - Basic Electronics

No. of questions: Eight (08) No. of pages: Five (05) Time: 03 hours

Answer 06 (six) questions

Note: All the undefined symbols appear below have their usual meanings.

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01. (a) Briefly describe the characteristic curve of a semiconductor pn junction diode. **(05 marks)**

(b) Briefly describe the behavior of a zener diode. **(05 marks)**

(c) Figure 1 shows a zener network. (V_Z - Zener Voltage, I_{ZM} - Maximum Zener current).

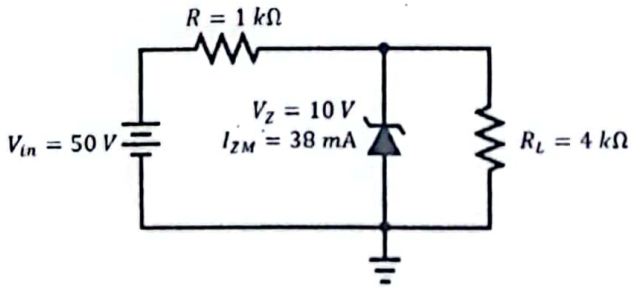

Figure 1: Zener diode network.

(i) Show that the zener diode is "ON." **(02 marks)**

(ii) Calculate

1) the voltage, V_L across R_L and the current I_L through the load resistor R_L. **(02 marks)**
2) the voltage, V_R across R and the current I_R through the resistor R. **(02 marks)**
3) the current through the zener diode, I_Z. **(02 marks)**
4) the power dissipated from the zener diode, P_Z. **(02 marks)**
5) the maximum load resistor that can be applied without damaging the zener diode ($R_{L_{max}}$). **(05 marks)**

02. Assume that you have an ideal diode.

(a) Draw the circuit diagram with input and output waveforms and briefly explain the operation of a half-wave rectifier circuit. **(08 marks)**

(b) What is the major difference between a full-wave and a half-wave rectifier? **(02 marks)**

(c) The ripple of the output waveform can be reduced using a capacitive filter at the output of a rectifier circuit. Draw the circuit diagram and the waveform of the output voltage from a half-wave rectifier with a capacitive filter with respect to time. Indicate the peak voltage V_p and the ripple voltage V_r, on the output waveform. **(05 marks)**

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(d) Figure 2 shows the input voltage and the circuit diagram of a voltage clipper circuit.

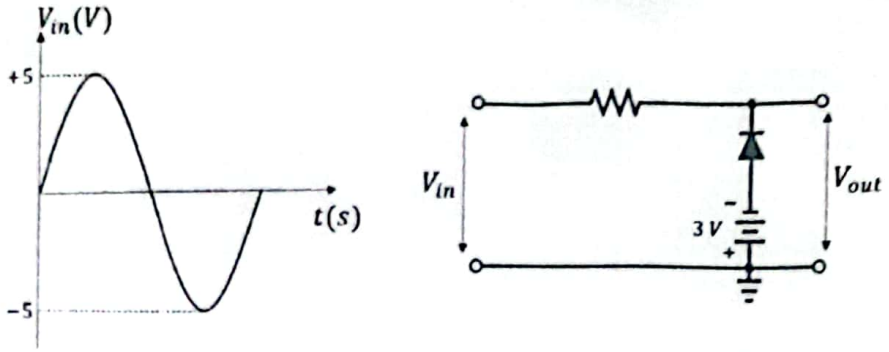

Figure 2: The input voltage and a voltage clipper circuit

Draw the output waveform and briefly explain it. Clearly indicate the voltage values on the output waveform diagram. **(10 marks)**

03. (a) What are the three main configurations of a BJT transistor? **(03 marks)**

(b) Draw the input and output characteristic curves of an npn transistor for one of the configurations. **(06 marks)**

(c) What is a transistor's operating point or Q-point? What is the importance of it? **(04 marks)**

(d) Figure 3 shows a circuit diagram of a Silicon transistor network ($V_{BE} = 0.7\ V$)

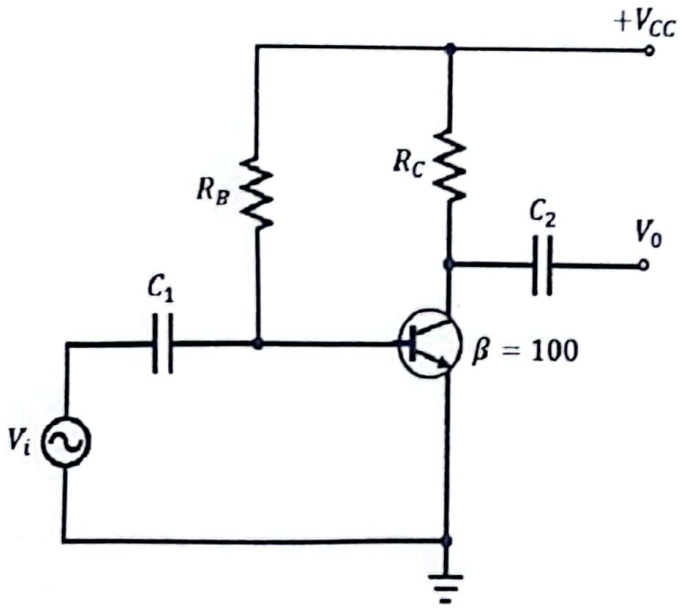

Figure 3: Fixed biased transistor network

(i) Derive expressions for I_B, I_C, and V_{CE} **(06 marks)**

(ii) If $V_{CC} = 20\ V$, find the suitable values of the resistor R_B, and R_C, to have the Q-point at $I_C = 2\ mA$ and $V_{CE} = 8\ V$. **(06 marks)**

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04. Answer the following questions using the Darlington pair shown in figure 4. The two transistors are labeled as Q_1 and Q_2.

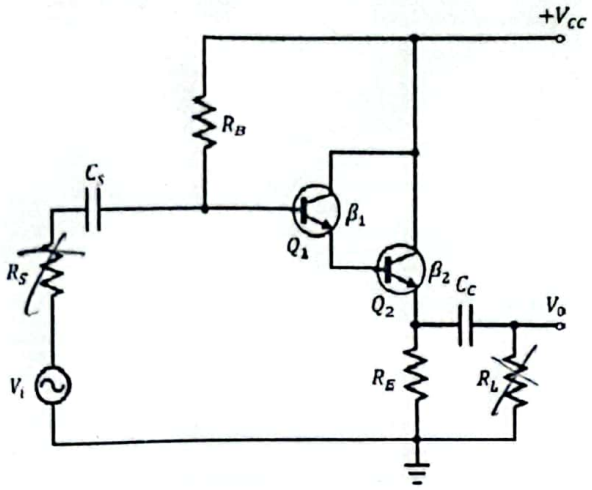

Figure 4: Circuit diagram of a Darlington amplifier

(a) What is the main purpose of a Darlington pair? **(03 marks)**

(b) Assuming that $\beta_1, \beta_2 \gg 1$ show that the total current gain is given by $\beta_D = \beta_1\beta_2$. **(08 marks)**

(c) Derive an expression for I_{B_1} (consider that $V_{BE_D} = V_{BE_1} + V_{BE_2}$). **(04 marks)**

(d) Derive expressions for V_{E_2} and V_{CE_2} as a function of I_{B_1}. **(06 marks)**

(e) Write down one advantage and a disadvantage of a Darlington pair. **(04 marks)**

05. (a) Write down the steps for an ac analysis of figure 5. Is there any component that can be discarded? Justify your answer. **(05 marks)**

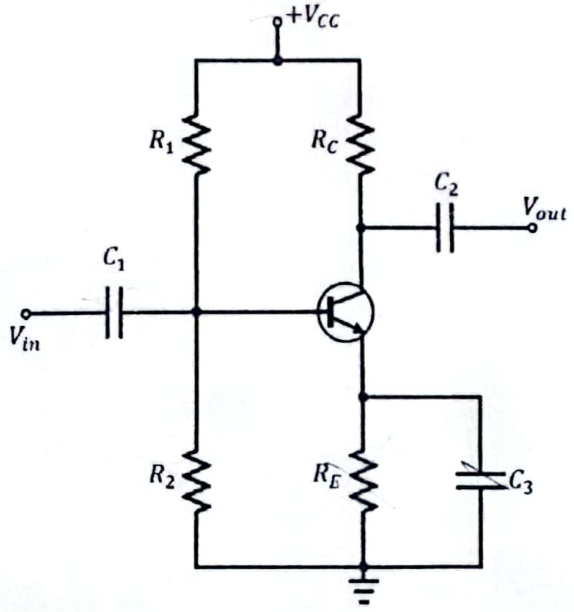

Figure 5: Circuit diagram of a voltage divider biased BJT amplifier network

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(b) Draw the r_e equivalent model for the circuit and label the components. **(05 mark**

(c) Write down the expressions for the ac input resistance Z_i and the ac output resistance Z_o. **(02 marks)**

(d) Derive an expression for the voltage gain, A_v. **(04 marks)**

(e) What is the value of the phase difference between input and output signals? Explain the reason. **(04 marks)**

(f) If $I_B = 2 \times 10^{-5}$ A, $R_C = 520\ \Omega$, $\beta = 250$, and $r_0 = \infty\ \Omega$, what will be the voltage gain? (**Hint:** $r_e = \frac{26\ mV}{I_E}$) **(05 marks)**

06. (a) What do you mean by the inverting and the non-inverting inputs of an operational amplifier (op-amp)? **(04 marks)**

(b) Draw a circuit diagram of an inverting amplifier and derive an expression for the output voltage, V_0. **(05 marks)**

(c) If the three input signals labeled as X, Y, and Z are provided, draw a circuit diagram of a summing amplifier to obtain $-(2X + Y + 3Z)$ as the output voltage. Write down the relevant input resistor values in terms of the feedback resistor, R_f. **(08 marks)**

(d) Figure 6 shows a circuit diagram of an op-amp network called an instrumentational amplifier. Show that the output voltage V_0 is given by $-\left(1 + \frac{2R}{R_G}\right)(V_2 - V_1)$. **(08 marks)**

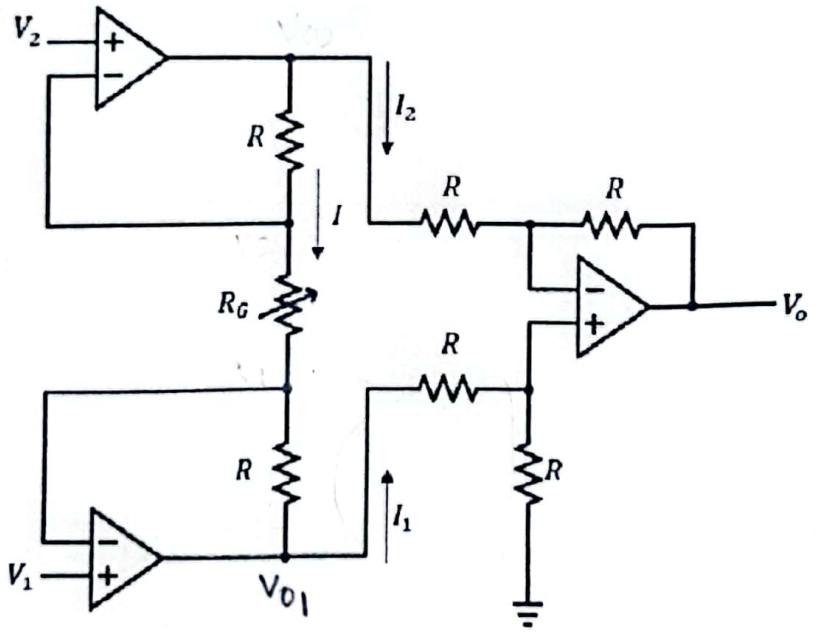

Figure 6: Circuit diagram of an Instrumentational amplifier

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07. (a) Draw the circuit diagram of a voltage buffer using an operational amplifier(op-amp). **(04 marks)**

(b) Why is a voltage buffer more suitable than a voltage divider to connect a load to the system? **(08 marks)**

(c) How can you use an op-amp as a comparator? **(07 marks)**

(d) Show any two methods that can be used to apply a reference voltage to an op-amp comparator circuit. **(06 marks)**

08. (a) Convert the following binary numbers to BCD

(i) 10011_2 **(01 marks)**

(ii) 1101010001_2 **(01 marks)**

(b) What is a Universal gate? Name one of the universal gates. NOR , NAND **(03 marks)**

(c) Write down an expression for the output X for the logic circuit diagram shown in figure 7. **(05 marks)**

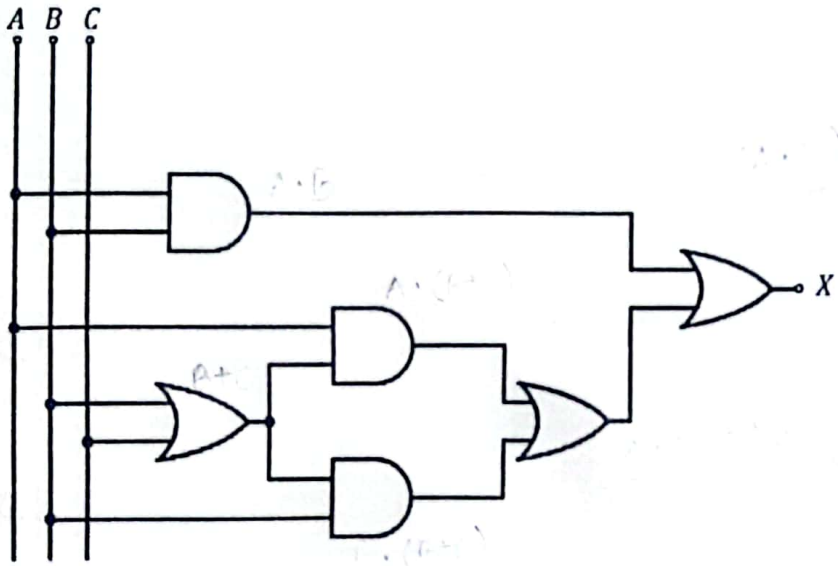

Figure 7: Circuit diagram of a Logic network

(d) Simplify the expression of X to the simplest form using the laws and the theorems of Boolean algebra. **(05 marks)**

(e) State de Morgan's theorem. **(02 marks)**

(f) Draw a logic circuit diagram for the expression in part (d) using the universal gate that you named in part (b). **(08 marks)**

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