

ELEC 2507 Mock Midterm

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General Disclaimer:

Users of this document should know this is for education purposes only and is not an alternative to an actual evaluation in ELEC 2507 - nor is it an exact representation of what the examination will look like. This document is for practice only and we are in no way claiming that this is what the evaluation will look like. If there are findings of any mistakes or general inquiries of the solutions please contact president@desoc.ca.

1 Questions

1.1 Question 1

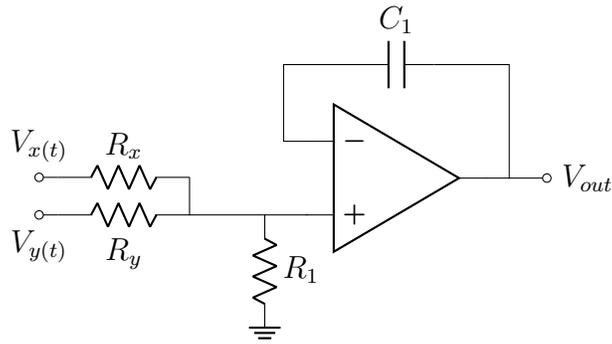


Figure 1: Question 1 Circuit

Find the gain V_{out} of the above circuit (Fig. 1).

1.2 Question 2

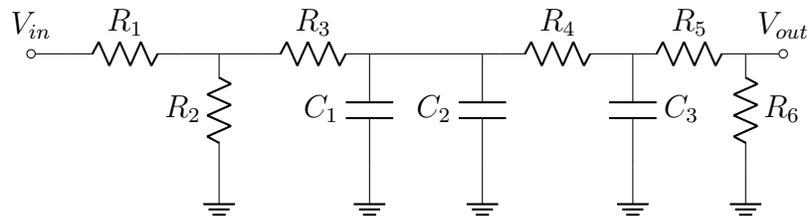


Figure 2: Question 2 Circuit

- Find the low frequency gain of the circuit
- Find all the high frequency poles of the circuit
- Draw a magnitude and phase response of the poles assuming that none of the poles are equal, and their frequencies will follow an ascending order.
- Determine the transfer function of the circuit in standard form.

1.3 Question 3

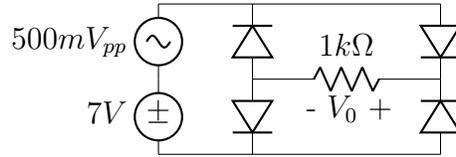


Figure 3: Question 3 Circuit

- Draw the transfer function curve of the circuit
- Find the peak-to-peak voltage of the output voltage.

Assume a voltage drop across diodes is $0.7V$ and that the $V_t = 25mV$

2 Answers

2.1 Question 1

Using Superposition

Recall $i_{in} = 0$

Just $V_x(t)$:

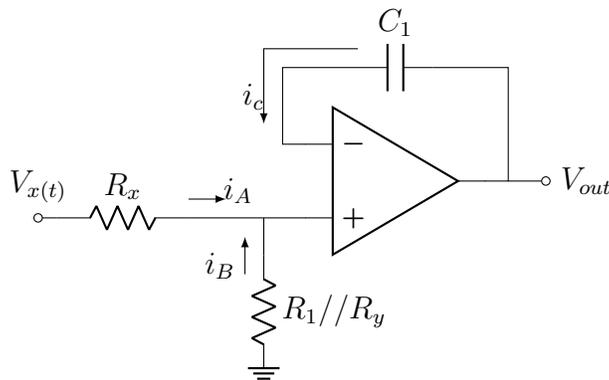


Figure 4: Question 1 $V_x(t)$

$$\begin{aligned}
 i_A + i_B &= 0 \\
 \frac{V_x - V_+}{R_x} + \frac{0 - V_+}{R_1 // R_y} &= 0
 \end{aligned}$$

$$\begin{aligned}
 \frac{V_x}{R_x} - \frac{V_+}{R_x} - \frac{V_+}{R_1 // R_y} &= 0 \\
 \frac{V_x}{R_x} &= \frac{V_+}{R_x} + \frac{V_+}{R_1 // R_y} \\
 \frac{V_x}{R_x} &= V_+ \left(\frac{1}{R_x} + \frac{1}{R_1 // R_y} \right) \\
 V_x &= V_+ \left(1 + \frac{R_x}{R_1 // R_y} \right) \\
 V_+ &= V_x \frac{R_1 // R_y}{R_1 // R_y + R_x} \\
 \frac{V_+}{V_x} &= \frac{R_1}{R_1 // R_y + R_x} \\
 V_A &= V_x \frac{R_1}{R_1 // R_y + R_x}
 \end{aligned}
 \tag{1}$$

$$\begin{aligned}
 \frac{V_{out} - V_+}{Z_{c1}} &= 0 \\
 \frac{V_{out}}{Z_{c1}} &= \frac{V_+}{Z_{c1}} \\
 V_{out} &= V_+
 \end{aligned}$$

Just $V_y(y)$:

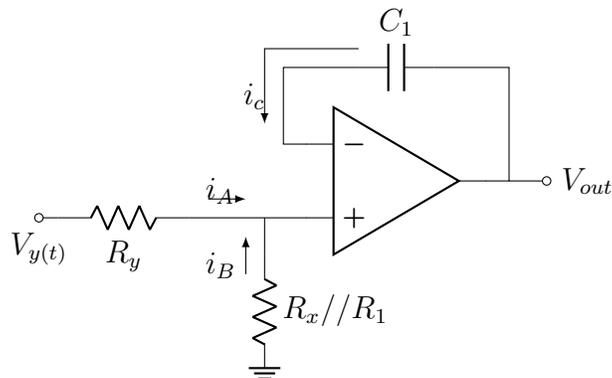


Figure 5: Question 1 $V_y(t)$

$$\begin{aligned}
\frac{V_+}{V_{y(t)}} &= \frac{R_1 // R_x}{R_y + R_1 // R_x} \\
V_- &= V_+ \\
\frac{V_{out} - V_+}{Z_{c_1}} &= 0 \\
V_{out} &= V_+ \\
\frac{V_{out}}{V_+} \cdot \frac{V_+}{V_y} &= \frac{R_1 // R_x}{R_y + R_1 // R_x} \\
V_B &= V_y \frac{R_1 // R_x}{R_y + R_1 // R_x}
\end{aligned} \tag{2}$$

Combined:

$$\begin{aligned}
V_{out} &= V_A + V_B \\
&= V_x \frac{R_y // R_1}{R_y // R_1 + R_x} + V_y \frac{R_1 // R_x}{R_1 // R_x + R_y}
\end{aligned} \tag{3}$$

2.2 Question 2

a) Find the low frequency gain of the circuit

Using Fig. 6a as a DC/low frequency circuit ignores capacitors.

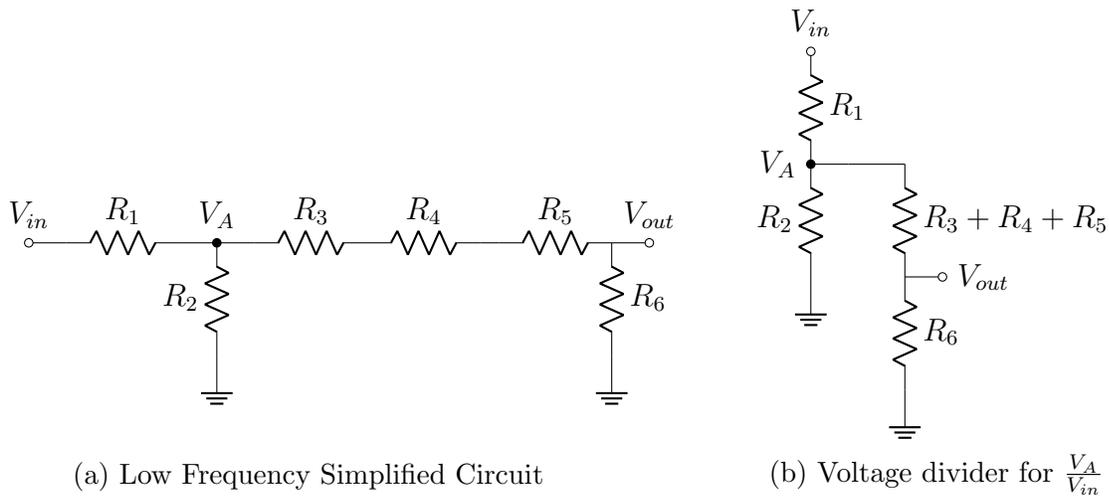


Figure 6: Question 2(a)

$$\begin{aligned}
 \frac{V_{out}}{V_{in}} &= \frac{V_A}{V_{in}} \times \frac{V_{out}}{V_A} \\
 \frac{V_A}{V_{in}} &= \frac{R_2 \parallel (R_3 + R_4 + R_5 + R_6)}{R_1 + R_2 \parallel (R_3 + R_4 + R_5 + R_6)} \text{ see Fig. 6b} \\
 \frac{V_{out}}{V_A} &= \frac{R_6}{R_3 + R_4 + R_5 + R_6} \text{ see Fig. 6b} \\
 V_{out} &= V_A \frac{R_6}{R_3 + R_4 + R_5 + R_6} \\
 &= V_{in} \frac{R_2 \parallel (R_3 + R_4 + R_5)}{R_1 + R_2 \parallel (R_3 + R_4 + R_5)} \cdot \frac{R_6}{R_3 + R_4 + R_5 + R_6}
 \end{aligned} \tag{4}$$

b) Find all the high frequency poles of the circuit

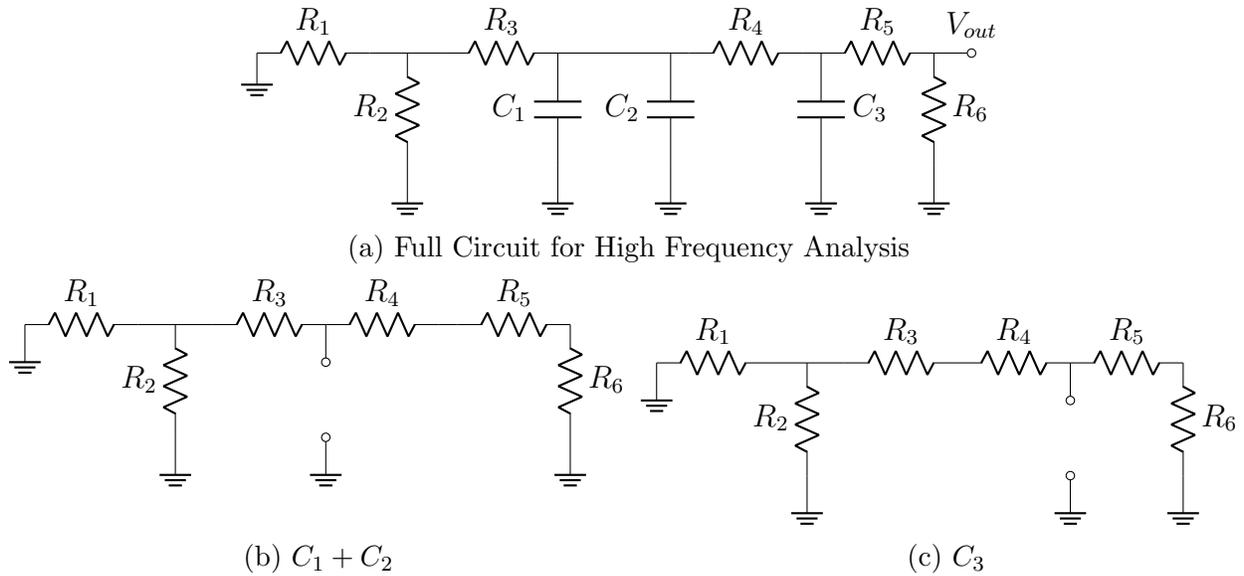


Figure 7: Question 2(b)

Parallel capacitors ($C_1 + C_2$) (see Fig. 7b):

$$R_{eq} = ((R_1 \parallel R_2) + R_3) \parallel (R_4 + R_5 + R_6)$$

$$\omega_{p1} = \frac{1}{R_{eq}(C_1 + C_2)} \quad (5)$$

3rd capacitor (C_3) (see Fig. 7c):

$$R_{eq} = ((R_1 \parallel R_2) + R_3 + R_4) \parallel (R_5 + R_6)$$

$$\omega_{p2} = \frac{1}{R_{eq}C_3} \quad (6)$$

c) Draw a magnitude and phase response of the poles assuming that none of the poles are equal, and their frequencies will follow an ascending order.

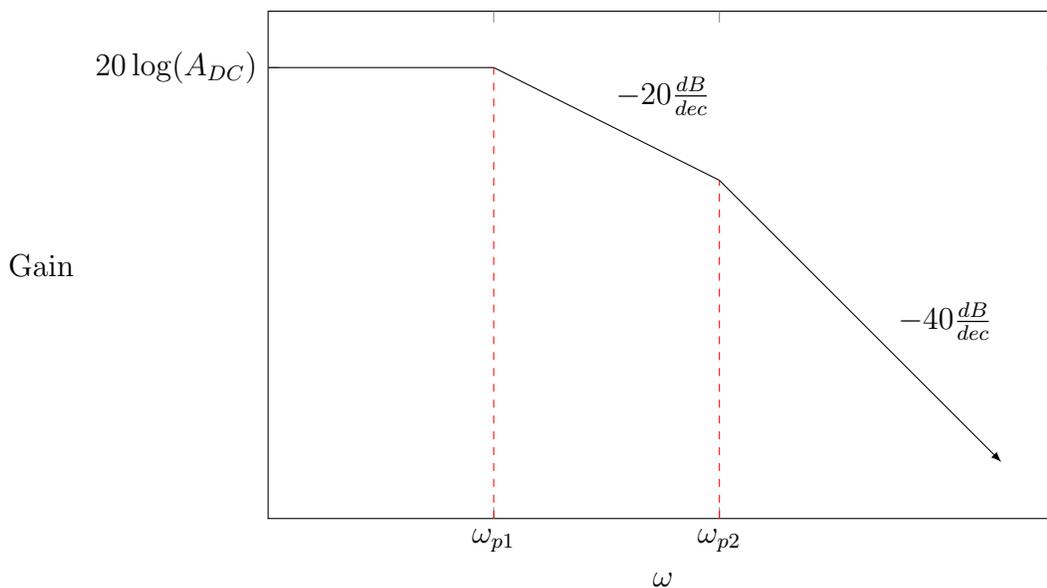


Figure 8: Bode Gain Plot

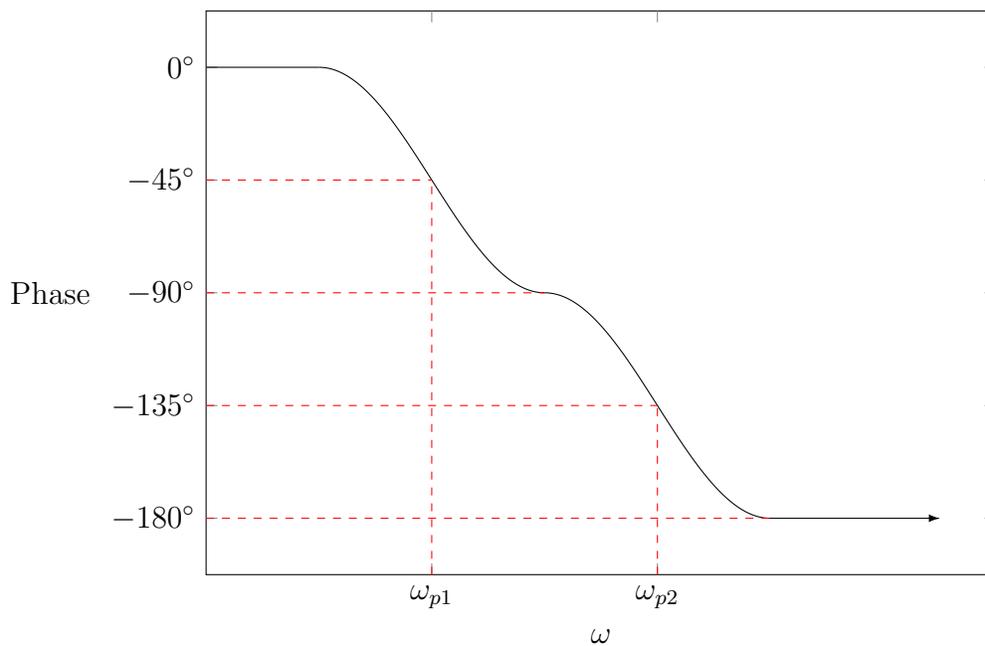


Figure 9: Bode Phase Plot

d) Determine the transfer function of the circuit in standard form.

$$\begin{aligned} H(s) &= \frac{A_{DC}}{\left(1 + \frac{s}{\omega_{p1}}\right) \left(1 + \frac{s}{\omega_{p2}}\right)} \\ &= \frac{\frac{V_A}{V_{in}} \times \frac{V_{out}}{V_A}}{\left(1 + s(R_{eqA}(C_1 + C_2))\right) \left(1 + s(R_{eqB}C_3)\right)} \end{aligned} \quad (7)$$

2.3 Question 3

a) Draw the transfer function curve of the circuit

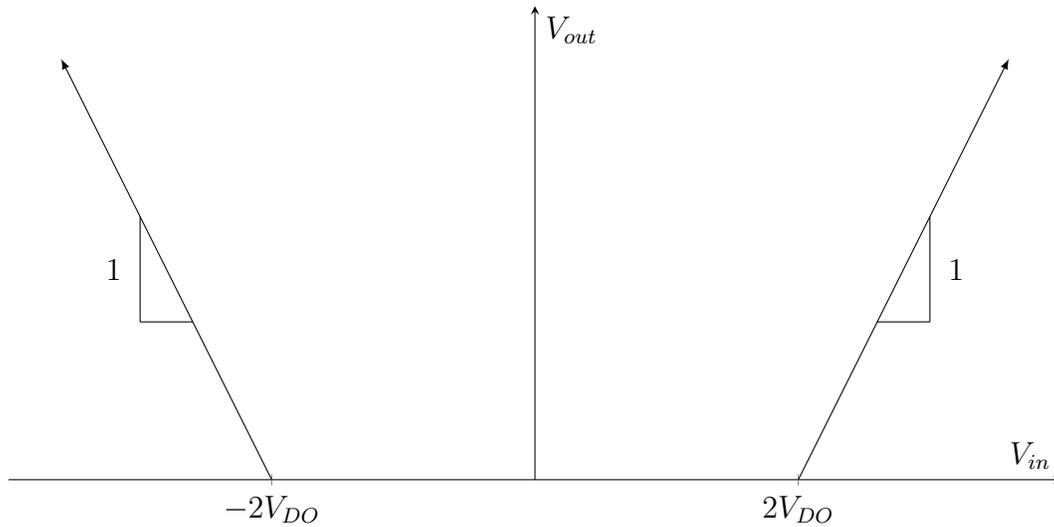
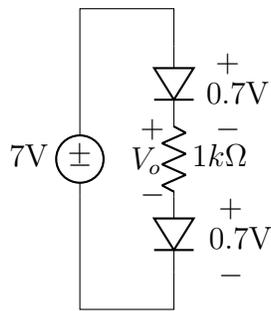


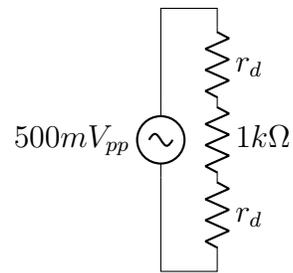
Figure 10: V_{out}/V_{in}

Disclaimer: graph is approximate

b) Find the peak-to-peak voltage of the output voltage.



(a) DC Component



(b) AC Component

Figure 11: Question 3(b)

DC Component:

$$\begin{aligned}V_o &= 7V - 0.7V - 0.7V \\ &= 5.6V \\ I_D &= \frac{5.6V}{1k\Omega} \\ &= 5.6mA\end{aligned}\tag{8}$$

AC Component:

On one positive/negative function

$$\begin{aligned}r_d &= \frac{V_t}{I_D} = \frac{25mV}{5.6mA} \\ &= 4.46\Omega \\ V_{AC} &= 500mV_{pp} \frac{1k\Omega}{1k\Omega + 4.46\Omega + 4.46\Omega} \\ &= 0.4955V \\ &= 496mV_{pp}\end{aligned}\tag{9}$$