Op amp Problems

Monday, July 7, 2025 12:10 AM

■ Question 1 *[CO2] [7.5 marks]*

(a) **[2.5 marks] Show** the alternative representation (i.e. line representation/diagram) of the circuit in *Figure-1*.

(b) **[1 mark] State** the values of i^+ and i^- of the circuit shown in *Figure-1*.

(c) **[1.5 marks] Analyze** the circuit in an alternative representation from part-(a), and **calculate** V_X.

(d) **[2.5 marks] Analyze** the circuit in an alternative representation from part-(a) & the waveform of V_{in} in *Figure-2*, and **draw** the waveform of the output voltage on *Figure-2*. **Label** the graph properly.

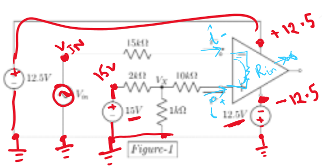


Figure-1

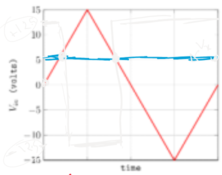
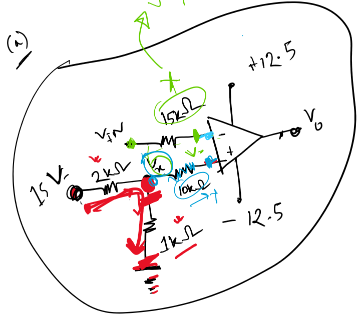


Figure-2

$i_- = i_+ = 0$

(a)



(c) $V_x - 0 = \frac{1}{1+2} \times 15 = 5V$

V_x

$V_0 = A(V_+ - V_-)$

$V_- = V_{IN}$

$V_+ = V_x$

$V_x > V_{IN} \rightarrow +12.5$

$V_+ > V_- \rightarrow +12.5$

$V_+ < V_- \rightarrow -12.5$

$V_x < V_{IN}$

(d)

(c)

■ Question 3 *[CO2] [7.5 marks]*

(a) **[2 marks] Analyze** the circuit in *Figure-5*, and **determine** the expression of the function, f where x, y and z are the input of the circuit.

(b) **[4 marks] Analyze** the circuit in *Figure-6*, and **calculate** I_{D1}, I_{D2}, & V_O using the method of assumed states. You must **validate** your assumptions. Here, $V_{D0} = 0.7V$.

(c) **[1.5 marks] Draw** the Voltage Transfer Characteristics (VTC) of a non-inverting amplifier with Gain = 1.5, $V^+_{Sat} = 8V$, and $V^-_{Sat} = -8V$. **Label** the graph properly.

$V_0 = -\frac{1}{RC}\int v_i \, dt$

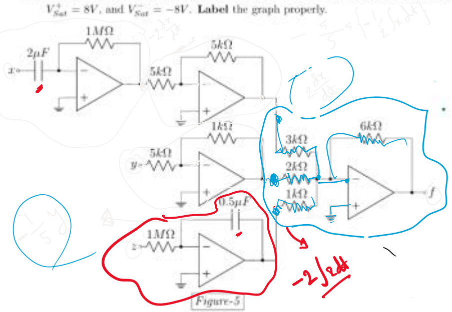


Figure-5

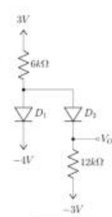


Figure-6

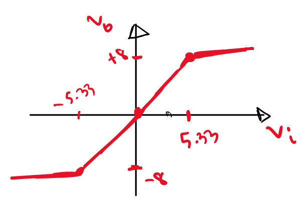
Adder,

$V_0 = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$

$= -6\left(\frac{2\frac{dx}{dt}}{3} + \frac{-\frac{y}{5}}{2} + \frac{-2\int z\,dt}{1}\right)$

(c)

Gain = 1.5



non-inv

$V_0 = \left(1 + \frac{R_2}{R_1}\right)V_i$

$V_{sat+} = +8$

$V_{sat-} = -8\,V$

$1 + \frac{R_2}{R_1} = 1.5$

$\frac{R_2}{R_1} = \frac{1}{2}$

$[R_2 = 1k\Omega, R_1 = 2k\Omega]$

$V_0 = 1.5\,V_i$

$V_0 = 0 \rightarrow V_i = 0$

$V_0 = 8 \rightarrow 8 = 1.5 V_i \Rightarrow V_i = \frac{8}{1.5} = \frac{16}{3} = 5.33$

$V_0 = -8 \rightarrow -8 = 1.5 V_i \Rightarrow V_i = \frac{8}{-1.5} = -\frac{16}{3} = -5.33$

■ Question 4 *[CO1] [5 marks]*

(a) **[1 mark] State** the relation between the input and output voltages of an ideal op-amp.

(b) **[2 marks]** What is a linear amplifier? **Explain** the reason for the saturation of the output voltage of an amplifier briefly.

$V_0 \propto V_i$

V_-, V_+, V_0

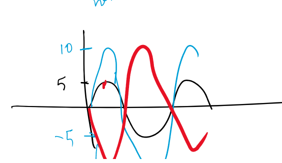
$V_0 = A(V_+ - V_-)$

■ Question 5 *[CO3] [5 marks]*

(a) **[3 marks] Analyze** the graph in *Figure-7*, and **design** a circuit that implements the relationship between the voltage waveforms, $V_{input} = 5sin(t)$ and V_{output}. **Assume** any value if necessary.

(b) **[2 marks] Design** the circuits with the boolean inputs A, B, C, D using Ideal Diodes to implement the following boolean logic functions:
(i) f = A.B.C+D (ii) f = (A+B+C).D

non-inv



$\cos\theta = \sin(90+\theta)$

$-\sin\theta = \cos(90+\theta)$

the voltage waveforms, $V_{input} = 5sin(t)$ and V_{output}. **Assume** any value if necessary.

(b) **[2 marks] Design** the circuits with the boolean inputs A, B, C, D using Ideal Diodes to implement the following boolean logic functions:
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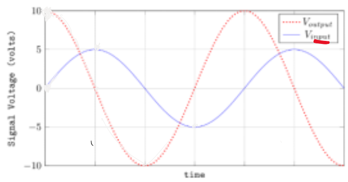


Figure-7

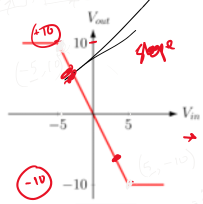
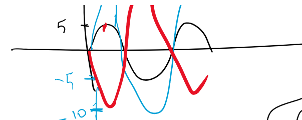
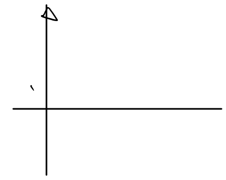


Figure-8



$\cos\theta = \sin(90+\theta)$
$-\sin\theta = \cos(90+\theta)$

$\int \sin = -\cos$
$\int \cos = \sin$
$\frac{d}{dt}\sin = \cos$
$\frac{d}{dt}\cos = -\sin$



■ Question 6 *[CO3] [5 marks]*

(a) **[2 marks] Analyze** the graph in *Figure-8*, and **design** a circuit that implements the relationship between V_{in} and V_{out}. **Assume** any value if necessary.

$V_{in}\uparrow$ $V_{out}\downarrow$ (inv)

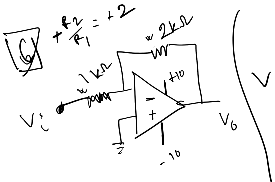
(b) **[3 marks] Design** a device to implement the following function, f where x, y, and z are the input of the device. **Assume** any value if necessary.

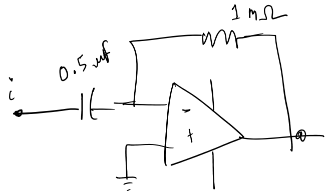
$$f = 5\int (x+y)dt - 3\frac{d}{dt}(z)$$

$\int 5\sin t = -5\cos t$

$\boxed{V_o = 10\cos t}$

(a) $+\frac{R_2}{R_1} = +2$





$V_o = -\frac{1}{RC}\int v_i\,dt$

-2 $\quad -5\cos t$

$\frac{1}{RC} = 2$

$\Rightarrow RC = \frac{1}{2}$

(b)

$f = \boxed{5\int (x+y)\,dt}\ \boxed{-3\frac{dz}{dt}}$

$\int$ $\quad d$

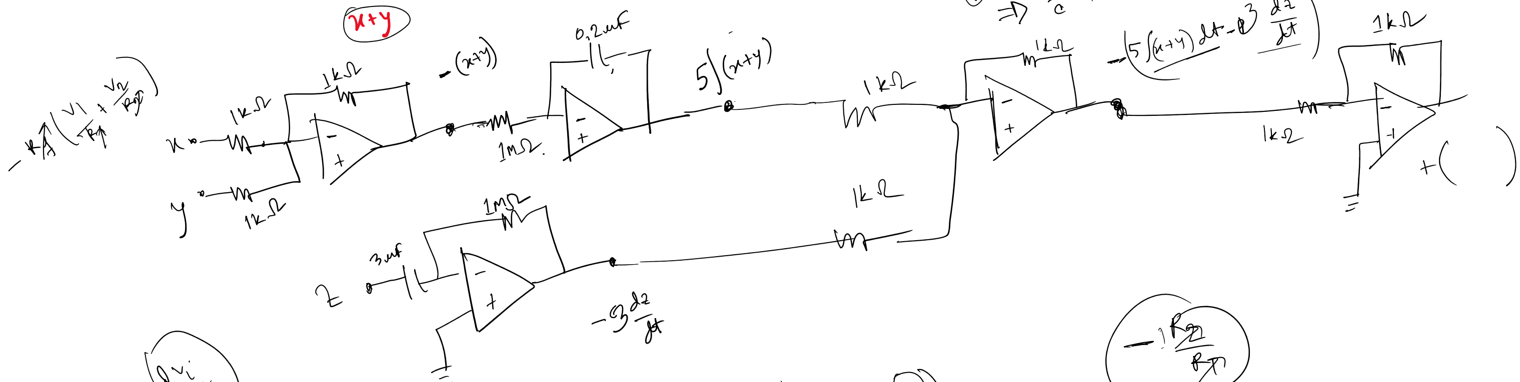
$x+y$

$V_o = -\frac{1}{RC}\int v_i\,dt$

$\frac{1}{RC} = 5$

$\Rightarrow \frac{1}{C} = 5 \Rightarrow C = \frac{1}{5} = 0.2$

$-R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right)$



$-\frac{R_2}{R_1}$

$-RC\frac{dV_i}{dt}$

-3

$RC = 3$

$-R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right)$

■ Question 7 *[CO3] [5 marks]*

Open

(a) **[4 marks]** The Voltage Transfer Characteristics (VTC) of an ideal NOT gate can be represented by the graph in *Figure-9*. **Analyze** the graph in *Figure-9*, and **design** a circuit using an op-amp comparator that can work as an ideal NOT gate. **Assume** any value if necessary.

(b) **[1 mark] Design** a circuits with the boolean inputs A, B using Ideal Diodes to implement the boolean logic function, f = $\overline{A.B} + A.B$

$V_o = A(V_+ - V_-)$

$\Rightarrow 0 = A(V_+ - V_-)$

$V_+ - V_- = 0$

$\Rightarrow V_+ = V_-$

3V $\quad V_{in}$

3V

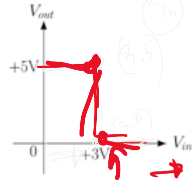
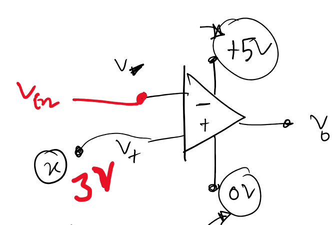


Figure-9



$x > V_{in} \rightarrow +5$

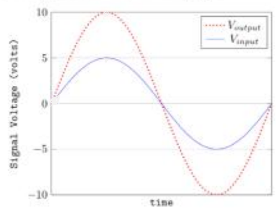
$x > V_{in} \rightarrow +5$
$x < V_{in} \rightarrow 0$

$3V$

Summer 24

■ **Question 1 of 5** *[CO1, CO2, CO3]* *[10 marks]*

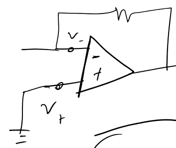
Michael Scott wants to make a phone call to his assistant, Dwight Schrute, but the outdated phone system keeps failing as the signal is too weak by the time it reaches Dwight. Dwight plans on designing a device to help Michael make the call. The device will take the weak signal as input and give a strong signal at its output without changing the waveshape and polarity of the signal as shown in the following figure.



(a) [**1 mark**] What is a virtual ground? **Explain** briefly.

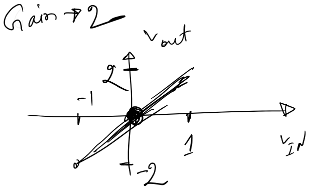
(b) [**2 marks**] **Analyze** the figure above and **draw** the VTC graph of the device in the graph given below. **Label** the graph properly.

(a)



$V_- = V_+$

(b) Gain → 2



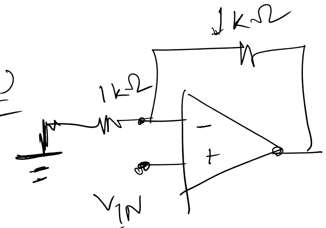
Slope = 2

Gain = 2

$\frac{\Delta y}{\Delta x} = 2$

$\Delta y = \Delta x \times 2$

(c)



$\left(1 + \frac{R_2}{R_1}\right) = 2$

$\frac{R_2}{R_1} = 1$

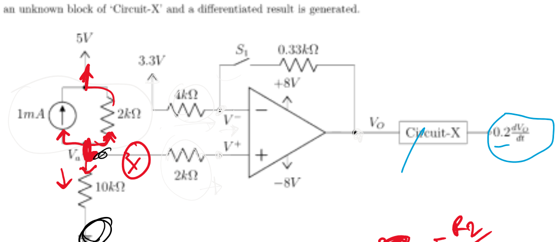
(d) [**4 marks**] Dwight calculates his yearly sales using the following function. **Design** a device to help Dwight implement the function, f where x, y, and z will be the inputs of the device.

$$f = \boxed{-3\frac{dz}{dt}} + \boxed{6x} + \boxed{9\int(y)dt}$$

+

■ **Question 3 of 5** *[CO1, CO2, CO3]* *[10 marks]*

The circuit diagram has a switch S_1 which is shown to be 'open' in the figure. The output V_O is passed through an unknown block of 'Circuit-X' and a differentiated result is generated.



$-\frac{R_2}{R_1}$

(a) [**1 mark**] **State** the equation of gain of an inverting amplifier.

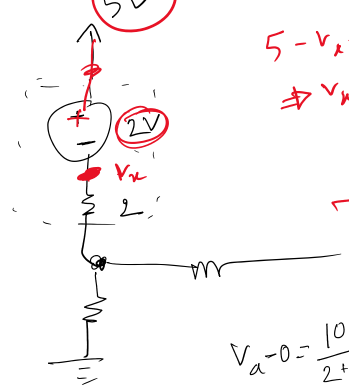
(b) [**3 marks**] **Calculate** the values of V_a and $V+$.

(c) [**2 marks**] **Determine** V_O when the switch S_1 is closed.

(d) [**2 marks**] **Determine** V_O when the switch S_1 is open.

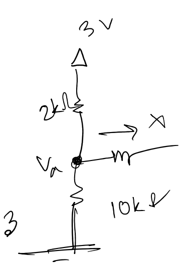
(e) [**2 marks**] **Design** the 'Circuit-X'. **Assume** any value if necessary.

$$1 + \frac{V_a - 5}{2} + \frac{V_a - 0}{10} = 0$$



$5 - V_x = 2$

$\Rightarrow V_x = 3V$

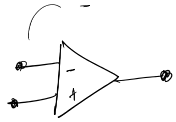


$V_a - 0 = \frac{10}{2+10} \times 3$

$= 2.5$

(d)

Open Loop



$A(V_+ - V_-)$

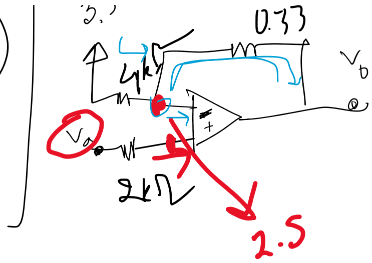
$V_0 = -8V$

Open loop

$V_o = A(V_+ - V_-)$

$V_+ \to 2.5V$ $\quad$ $V_- \to 3.3V$ $\quad$ (-)

$V_o = -8V$



$= 2.5$

$$\frac{3.3-2.5}{4} = \frac{2.5-V_o}{0.33}$$

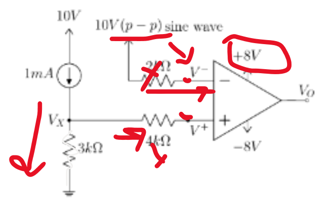


Figure-1

(a) [**5 marks**] **Analyze** the circuit in *Figure-1*, and **calculate** the value of V_X. Now, **draw** the waveform of V_O, and **label** the graph properly.

$V_x - 0 = 1\times 3 = 3V$