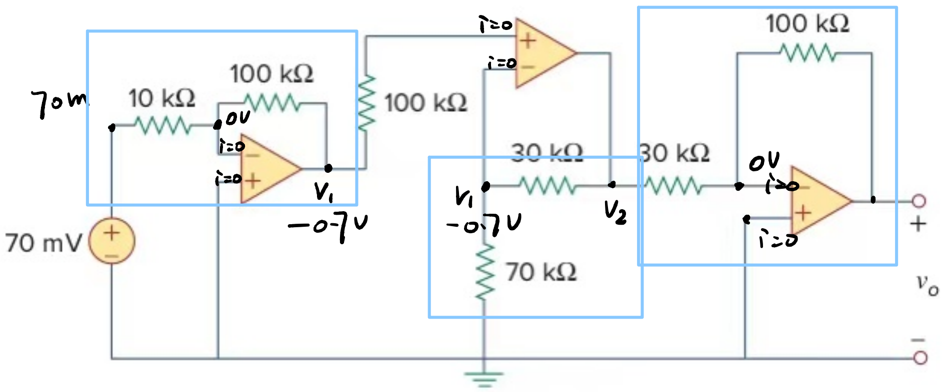
VE215 2022Fall Assignment 3

Due Date: 23:59, October 30th, 2022

Exercise 3.1 (30%)
Find v_o in the following op amp circuit.



Assume V_1, V_2

KCL: $\dfrac{0-70mV}{10k\Omega}+\dfrac{0-V_1}{100k\Omega}=0 \Rightarrow V_1=-700mV=-0.7V$ 10'

KCL: $\dfrac{V_1-V_2}{30k\Omega}+\dfrac{V_1-0}{70k\Omega}=0 \Rightarrow V_2=-1V$ 10'

KCL: $\dfrac{0-V_2}{30k\Omega}+\dfrac{0-V_o}{100k\Omega}=0 \Rightarrow V_o=\dfrac{10}{3}V.$ 10'

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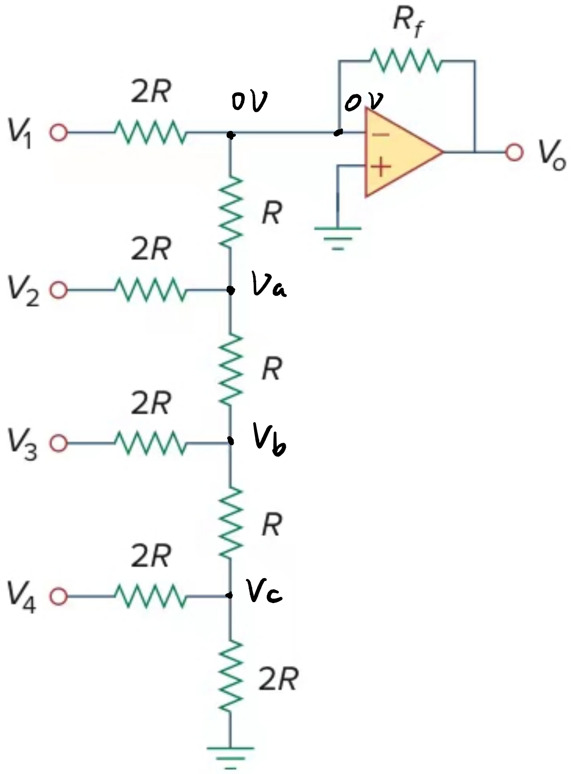
Exercise 3.2 (30%)

A four-bit $R-2R$ ladder digital-to-analog converter is shown below.

(a) (~~15~~ 20%) Show that the output voltage is given by

$$-V_o = R_f\left(\frac{V_1}{2R}+\frac{V_2}{4R}+\frac{V_3}{8R}+\frac{V_4}{16R}\right)$$

(b) (~~15~~ 10%) if $R_f = 12k\Omega$ and $R = 10k\Omega$, find $|V_o|$ for $[V_1V_2V_3V_4]$=[1001] and $[V_1V_2V_3V_4]$=[1010].



(20')

(a) $\dfrac{0-V_1}{2R}+\dfrac{0-V_o}{R_f}+\dfrac{0-V_a}{R}=0 \Rightarrow V_o=\dfrac{R_f}{2R}(-V_1-2V_a)$ 4'

$\dfrac{V_a-V_2}{2R}+\dfrac{V_a-0}{R}+\dfrac{V_a-V_b}{R}=0 \Rightarrow V_a=\dfrac{1}{5}(V_2+2V_b)$ 4'

$\dfrac{V_b-V_3}{2R}+\dfrac{V_b-V_a}{R}+\dfrac{V_b-V_c}{R}=0 \Rightarrow V_b=\dfrac{1}{5}(2V_a+2V_c+V_3)$ 4'

$\dfrac{V_c-V_4}{2R}+\dfrac{V_c-V_b}{R}+\dfrac{V_c-0}{2R}=0 \Rightarrow V_c=\dfrac{1}{2}V_b+\dfrac{1}{4}V_4$ 4'

Hence $V_b=\dfrac{1}{5}(2V_a+V_b+\dfrac{1}{2}V_4+V_3) \Rightarrow V_b=\dfrac{1}{2}V_a+\dfrac{1}{4}V_3+\dfrac{1}{8}V_4$

$V_a=\dfrac{1}{5}(V_2+V_a+\dfrac{1}{2}V_3+\dfrac{1}{4}V_4) \Rightarrow V_a=\dfrac{1}{4}V_2+\dfrac{1}{8}V_3+\dfrac{1}{16}V_4$

$V_o=\dfrac{R_f}{2R}(-V_1-\dfrac{1}{2}V_2-\dfrac{1}{4}V_3-\dfrac{1}{8}V_4) \Rightarrow -V_o=R_f\left(\dfrac{V_1}{2R}+\dfrac{V_2}{4R}+\dfrac{V_3}{8R}+\dfrac{V_4}{16R}\right)$ 4'

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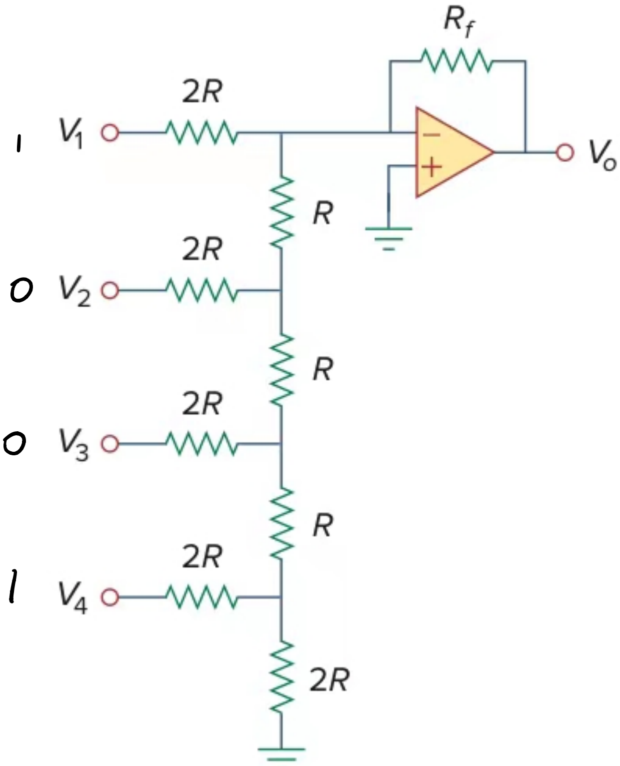
Exercise 3.2 (30%)
A four-bit $R-2R$ ladder digital-to-analog converter is shown below.
(a) (15%) Show that the output voltage is given by

$$-V_o = R_f\left(\frac{V_1}{2R}+\frac{V_2}{4R}+\frac{V_3}{8R}+\frac{V_4}{16R}\right)$$

(b) (15%) if $R_f = 12k\Omega$ and $R = 10k\Omega$, find $|V_o|$ for $[V_1V_2V_3V_4]$=[1001] and $[V_1V_2V_3V_4]$=[1010].



(b) $[V_1 V_2 V_3 V_4] = [1001]$

$$|V_o| = \frac{12k\Omega}{10k\Omega} \times \left(\frac{1}{2}+\frac{0}{4}+\frac{0}{8}+\frac{1}{16}\right) = \frac{27}{40}\,V$$ 5'

$[V_1 V_2 V_3 V_4] = [1010]$

$$|V_o| = \frac{12k\Omega}{10k\Omega} \times \left(\frac{1}{2}+\frac{0}{4}+\frac{1}{8}+\frac{0}{16}\right) = \frac{3}{4}\,V$$ 5'

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Exercise 3.3 (20%)
The voltage across a 50-mH inductor is given by

$$v(t) = [5e^{-2t} + 2t + 4]V$$

for $t > 0$.
Determine the current $i(t)$ through the inductor. Assume that $i(0) = 0$A.

$$L\frac{di}{dt} = [5e^{-2t} + 2t + 4]V \qquad 5'$$

$$i(0) = 0A$$

$$\frac{di}{dt} = 20[5e^{-2t} + 2t + 4]$$

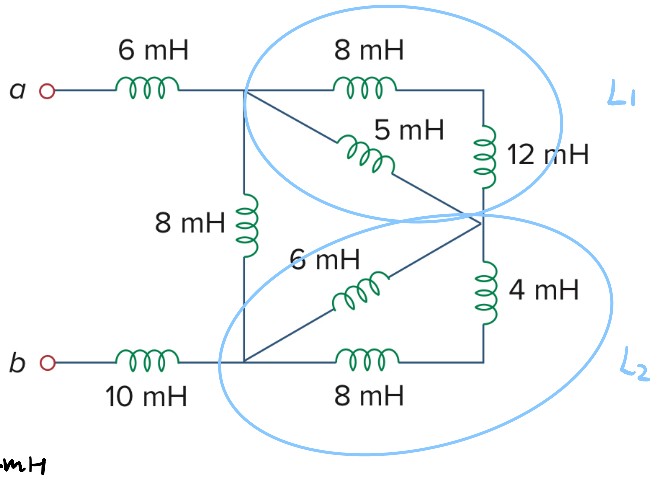
$$i(t) - \underset{0}{\underset{\parallel}{i(0)}} = \int_0^t 100e^{-2k}\,dk + \int_0^t 40k\,dk + \int_0^t 80\,dk \qquad 5'$$

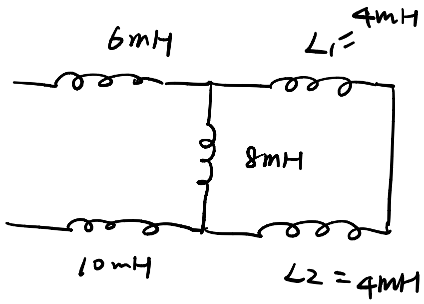
$$\Rightarrow i(t) = [-50e^{-2t} + 50 + 20t^2 + 80t]A$$

$$= [-50e^{-2t} + 20t^2 + 80t + 50]A \qquad 10'$$

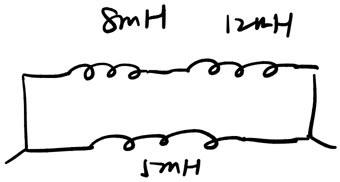
Exercise 3.4 (20%)

Find L_{eq} at the terminals of the following circuit.





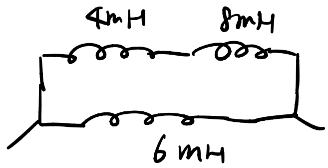
L1:



$L_1 = [(8+12) \| 5]$ mH

$\Rightarrow L_1 = 4$mH 5'

L2:



$L_2 = [(4+8) \| 6]$ mH

$= 4$mH 5'

$L_{eq} = 6\text{mH} + [(4+4) \| 8]\text{mH} + 10\text{mH}$ 5'

$= (6+4+10)\text{mH} = 20$ mH 5'

答案对即可给满分.