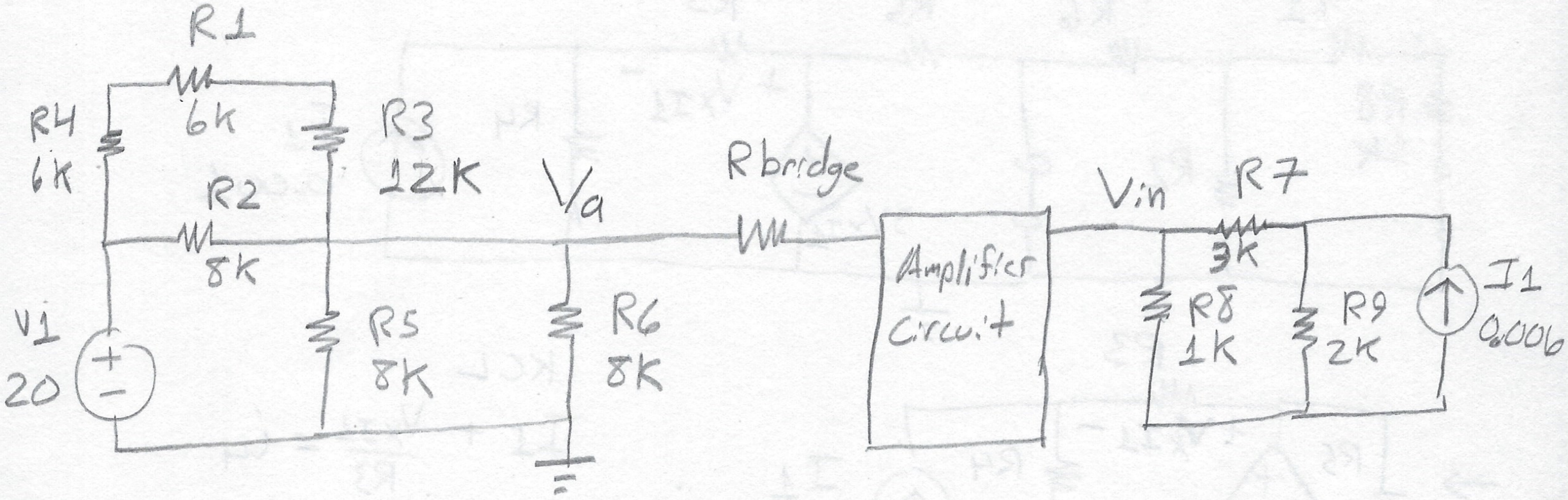
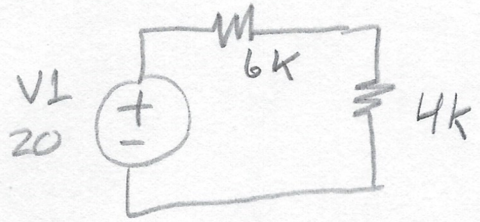
(12) 4) Bridges / Amplifiers (14 points)



In the above circuit, the current through Rbridge is zero

a) Determine the voltage at Va (5pts)



$V_a = 8V$ use voltage divider

b) Determine the voltage at Vin, which corresponds to the input to an amplifier circuit (4pts)

→ recall that the input impedance for the Amplifier circuits we know so far, OP-AMP circuits (Ideal), is $\infty\,\Omega$

we can use current divider

$$V_{in} = i_8 R8$$

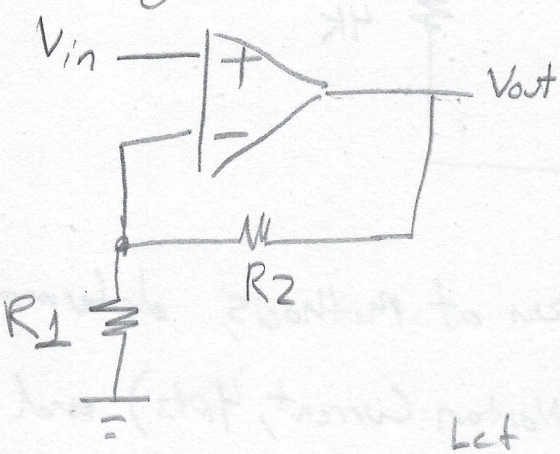
$$i_8 = \frac{R9}{R9 + (R7 + R8)} I_1 = 0.002\ A$$

$$V_{in} = 2\ V$$

c) Based on your above results, design an amplifier circuit that results in zero current through Rbridge. (5pts)

→ Output of Amplifier must be 8V for zero current through Rbridge

→ non-inverting OP Amp circuit

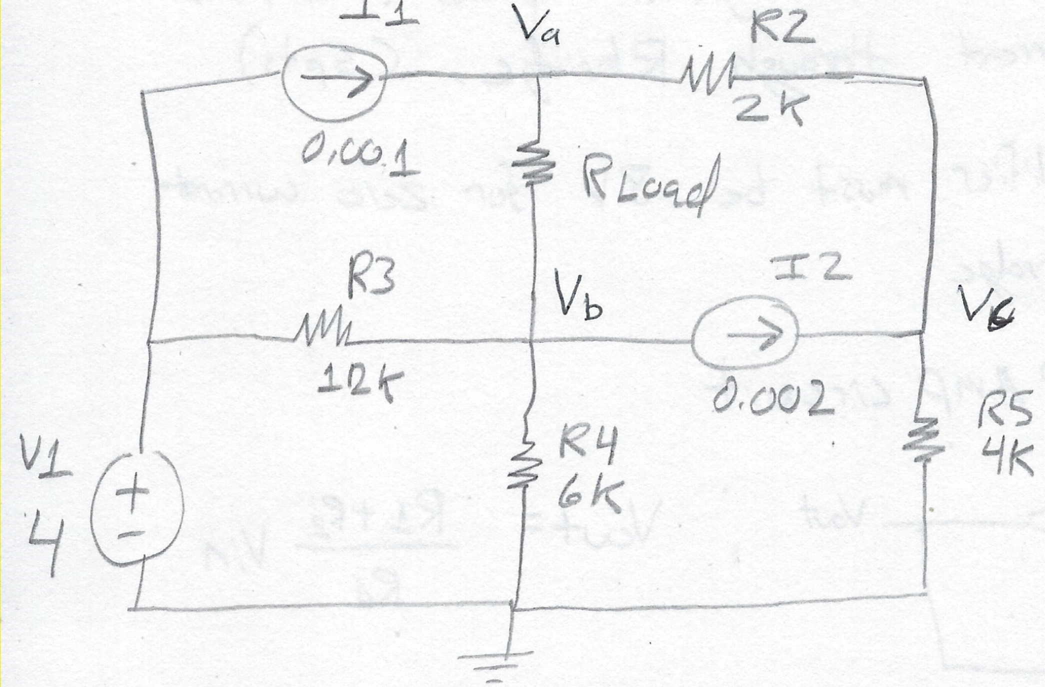


$$V_{out} = \frac{R_1 + R_2}{R_1} V_{in}$$

$$\rightarrow \frac{R_1 + R_2}{R_1} = 4$$

Let $R_1 = 1k\Omega$, $R_2 = 3k\Omega$

(14) 5) Thevenin Circuits (15 points)



a) Using any method or combination of methods, determine V_{TH} (Thevenin Voltage, 4pts), I_N (Norton Current, 4pts) and R_{TH} (Thevenin Resistance, 4pts) for the above circuit. In your solution, include any appropriate schematics

$V_{TH} = V_{oc} = V_a - V_b$ (with Load removed.)

$V_c = (I_2 + I_1)\, R5$ (KCL)

$= 12V$

$V_a - V_c = I1\,R2 = 2V \rightarrow V_a = 14V$

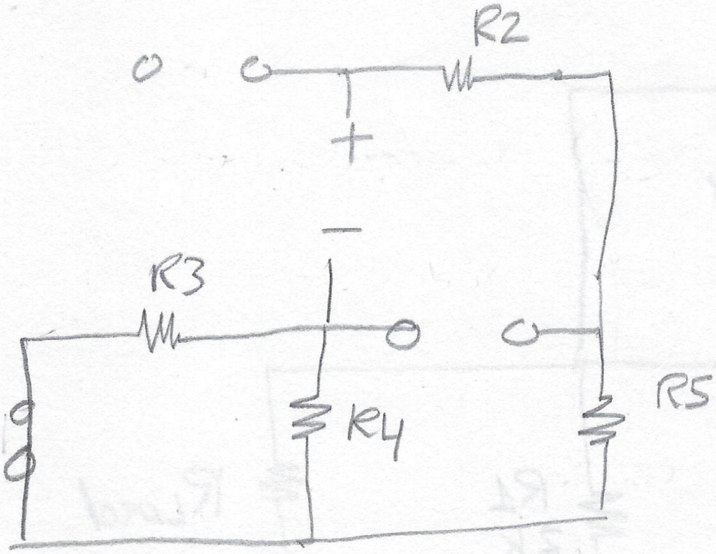
To get V_b (Node Analysis of V_b, from Inspection)

$-\left(\frac{1}{R3} + \frac{1}{R4}\right) V_b - \frac{V1}{R3} - I_2 = 0$

$V_b = -6.667\,V$

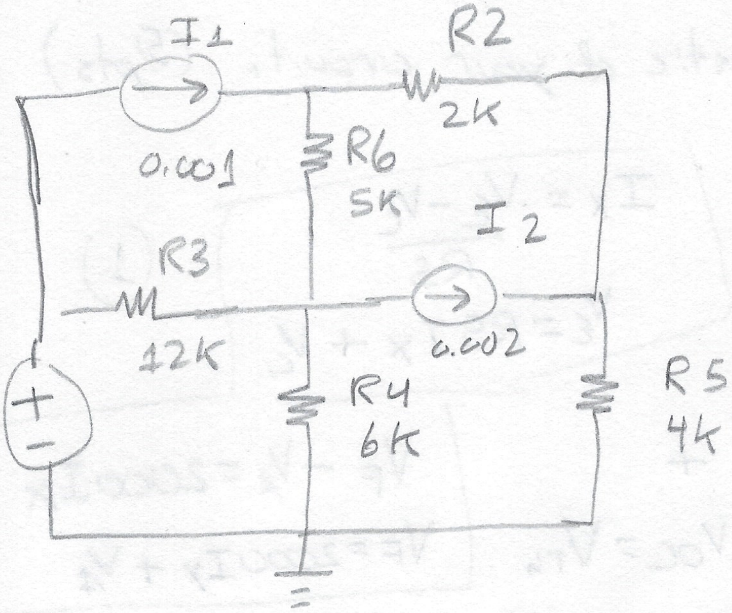
$$\boxed{V_{Th} = V_a - V_b = 12 - (-6.667) = 20.667\ V}$$

Look back method to get R_{Th}



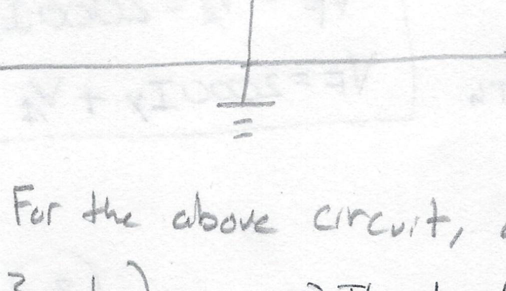
$$R_{Th} = R2 + R5 + R4 \| R3$$
$$= 10\,K\Omega$$

So $I_N = \dfrac{V_{Th}}{R_{Th}} = 2.06\ mA$



b) For the above circuit, determine the power dissipated through R6 (3 pts)

→ The trick here is that, it's still thevenin and Norton, so use thevenin



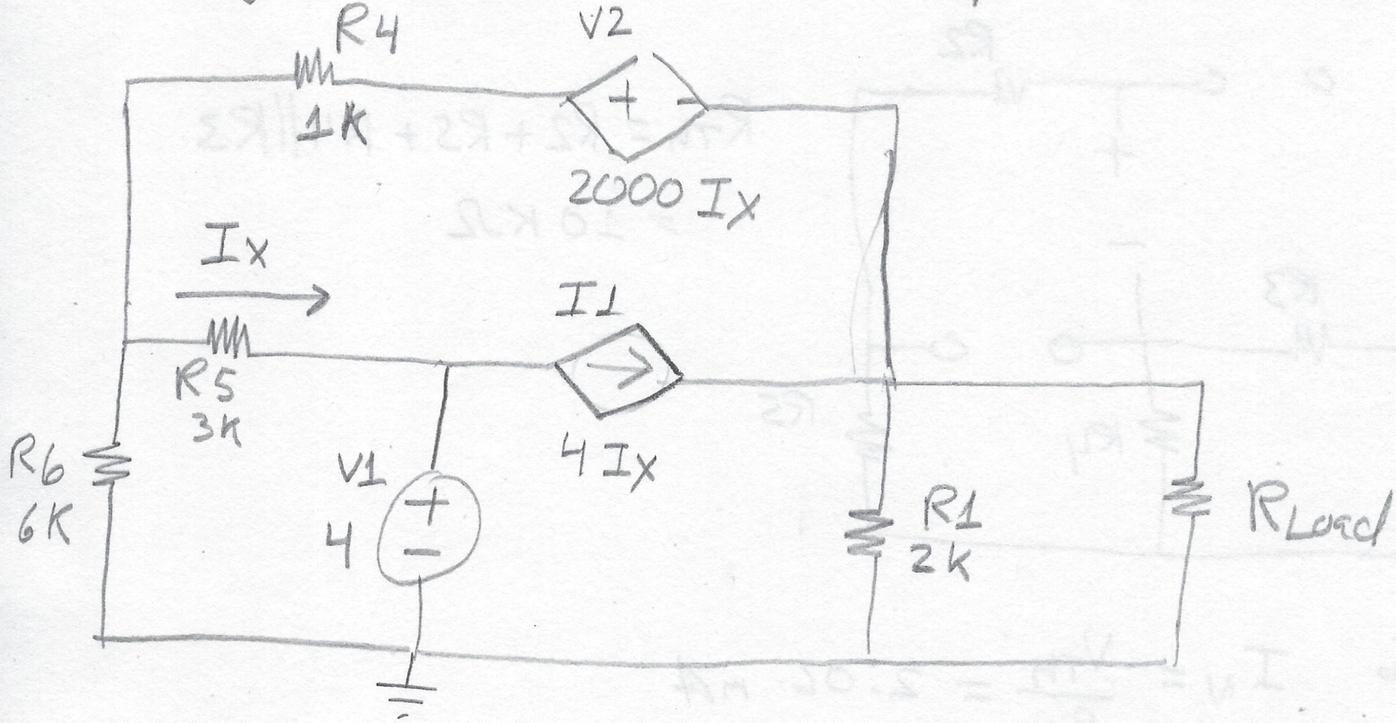
$$P = VI \qquad I = \frac{V_{Th}}{R_{Th} + R_6}$$

$$V = \frac{R6}{R_{Th} + R6} V_{Th}$$

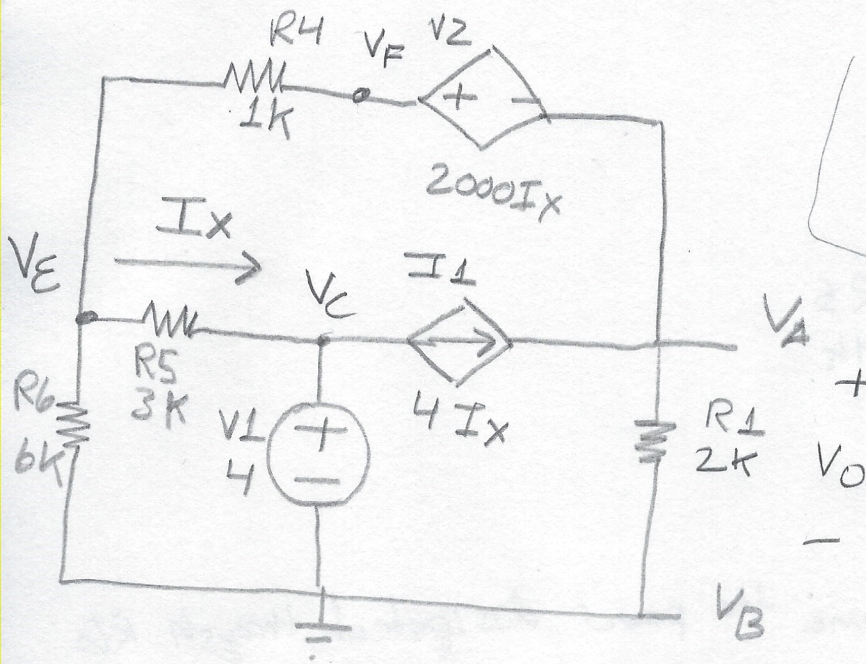
$$P = 9.49\ mW$$

16

6) Thevenin Circuits – Dependent Sources (15 points)



a) For the indicated load, use nodal analysis to determine $V_{Thevenin}$. Include a schematic of your circuit. (5 pts)



+

$V_{OC} = V_{Th}$

−

$$I_X = \frac{V_E - V_C}{R5}$$

$$V_E = R5\, I_X + V_C$$

1

$$V_F - V_A = 2000\, I_X$$

$$V_F = 2000\, I_X + V_A$$

2

$$V_E' \quad -\frac{V_E}{R6} - I_X - \frac{V_E - V_F}{R4} = 0 \longrightarrow -\left(\frac{1}{R6} + \frac{1}{R4}\right)V_E - I_X + \frac{1}{R4}2000 I_X + \frac{V_A}{R4} = 0$$

$\underline{V_A}$:

$$-\frac{V_A}{R1} + 4I_x + \frac{V_E - V_F}{R4} = 0 \rightarrow -\frac{V_A}{R1} + 4I_x + \frac{V_E}{R4} - \frac{2000I_x}{R4} - \frac{V_A}{R4} = 0$$

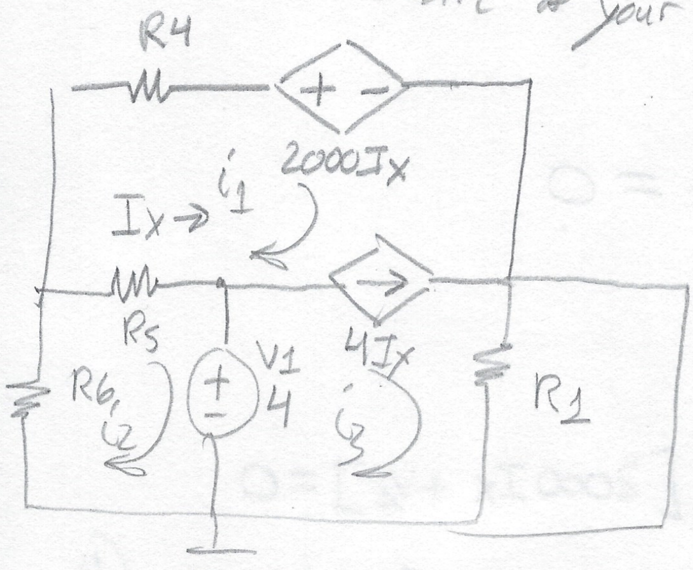
3

$$\begin{bmatrix} -\frac{1}{2}-1 & 4000-2000 & 1 \\ 1 & -1000+2000 & -\frac{7}{6} \\ 0 & -3000 & 1 \end{bmatrix} \begin{bmatrix} V_A \\ I_x \\ V_E \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 4 \end{bmatrix}$$

$V_A = 10.667$ V $\quad I_x = 0.0024$ A $\quad V_E = 11.2$ V

$V_{Th} = V_A = 10.667$ V

b) For the indicated load, use mesh analysis to determine I_{Norton}. Include a schematic of your circuit (5pts)



3 $\underline{i_2}$

$(R_6 + R_5) i_2 - R_5 i_1 + V1 = 0$

$\underline{i_1 / i_3}$ supermesh

$(R_4 + R_5) i_1 - R_5 i_2 - V_1 + 2000 I_x = 0$ 1

$4I_x = i_3 - i_1$

$I_x = i_2 - i_1$ 2

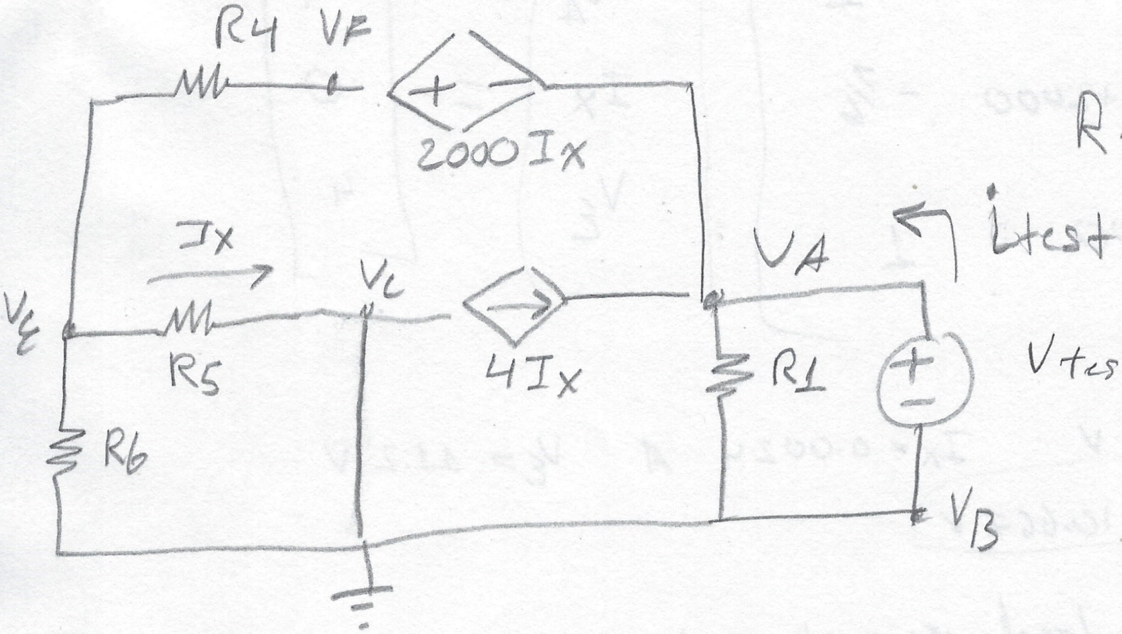
$i_3 = i_N = -5.333$ mA

$i_1 = 0.002133$

$i_2 = 0.00026667$

$I_x = -0.0018667$

c) Use the test voltage method to determine $R_{Thevenin}$. You may use any analysis technique for the circuit. You can use the relationship between V_{TH}, I_N and R_{TH} to check your answer, But your R_{TH} result must be based on the test voltage circuit. Include a Schematic of your circuit. (5pts)



$$R_{Th} = \frac{V_{test}}{I_{test}} = \frac{V_{AB}}{I_{AB}}$$

$V_{test} = 1V$.

$V_B = 0 = V_C \quad V_A = 1\,V \quad V_F = 2000 I_X + V_A$

<u>VA</u> (Node analysis)

$$4I_X - \frac{V_A}{R_1} + \frac{V_\varepsilon - V_F}{R_4} + i_{test} = 0$$

<u>V_ε</u>

$$-\frac{V_\varepsilon - V_F}{R_4} - I_X - \frac{V_\varepsilon}{R_6} = 0$$

$$\rightarrow -\left(\frac{1}{R_4} + \frac{1}{R_6}\right)V_\varepsilon - I_X + \frac{1}{R_4}\left[2000 I_X + V_A\right] = 0$$

$$\rightarrow -(7/6)V_\varepsilon - R4 I_X + 2000 I_X + V_A = 0 \quad (1)$$

$$\frac{V_\varepsilon}{R_5} = I_X \rightarrow V_\varepsilon - R5 I_X = 0 \quad (2)$$

$$\rightarrow V_\varepsilon = 1.2V \quad I_X = 0.0004\ A$$

$$V_F = 1.8V = 2000 I_x + V_A$$

$$-i_{test} = 4(I_x) - \frac{1}{R_1} + \frac{1.2-1.8}{R_4}$$

$$= 0.0005\,A$$

$$\boxed{R_{Th} = \frac{V_{test}}{I_{test}} = \frac{1}{-0.0005} = -2000\,\Omega}$$