Experiment No.4 **Date:05/10/2021**

Circuit Analysis with Dependent Sources

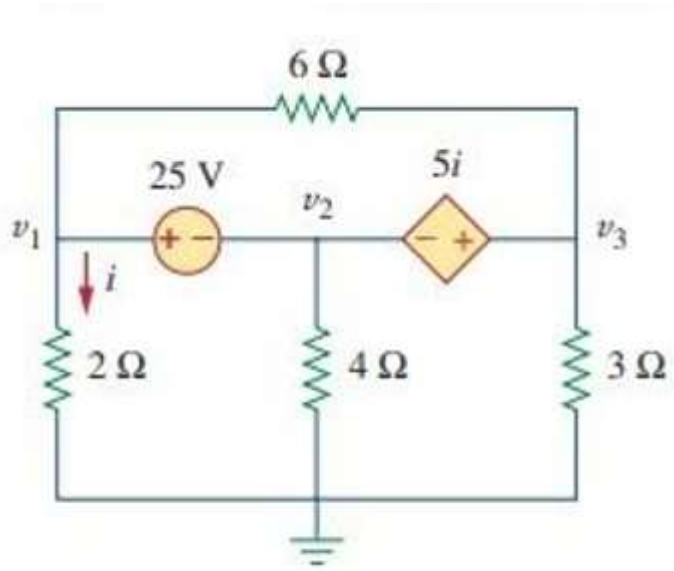
Objectives:

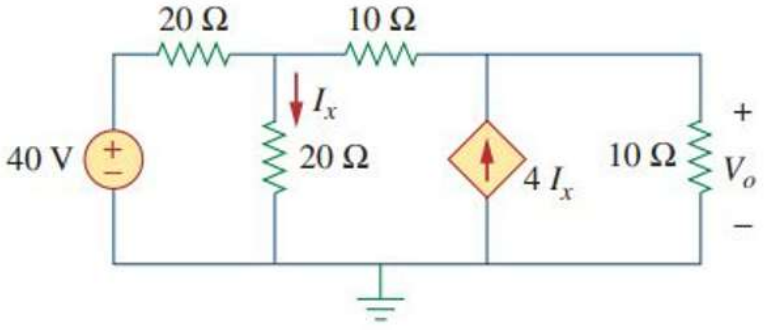
1. To model dependent voltage sources and current sources in LTSpice
2. To find the nodal voltages and branch currents

Simulation Tool:

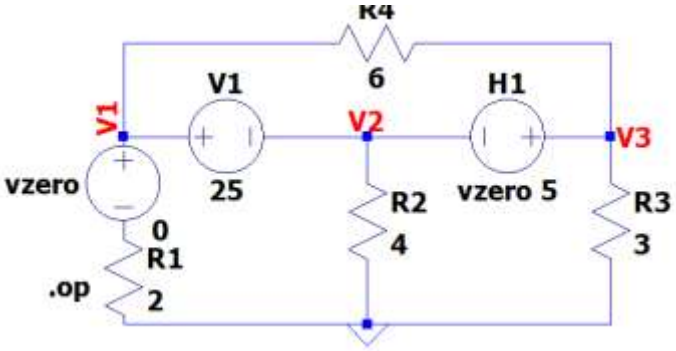
LTSpice – dc operating point analysis and transient analysis.

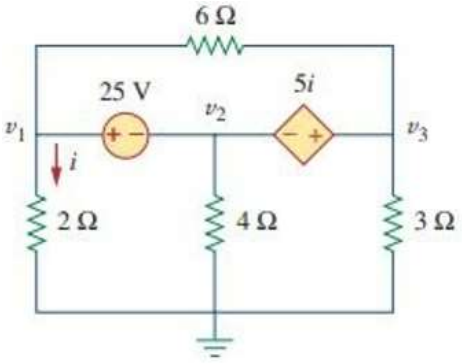
Circuits:

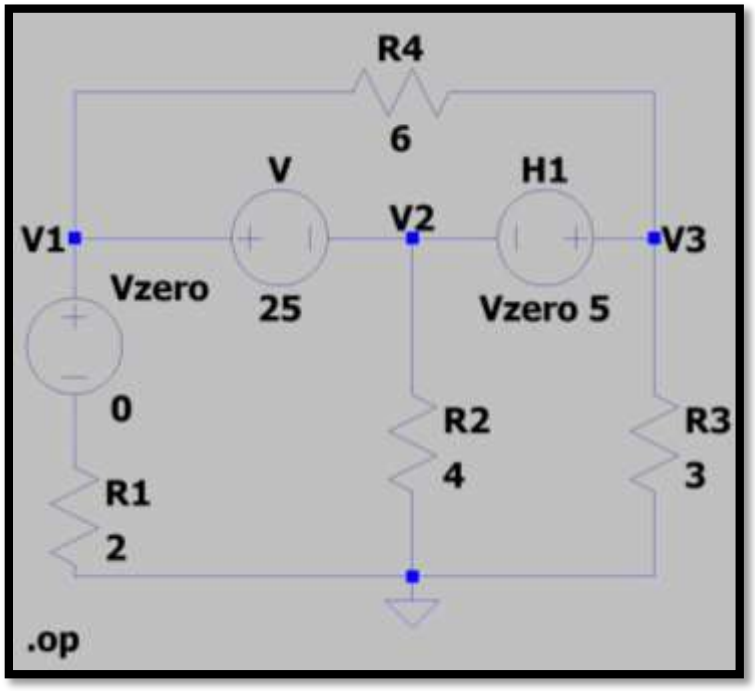




Current Dependent Voltage Source



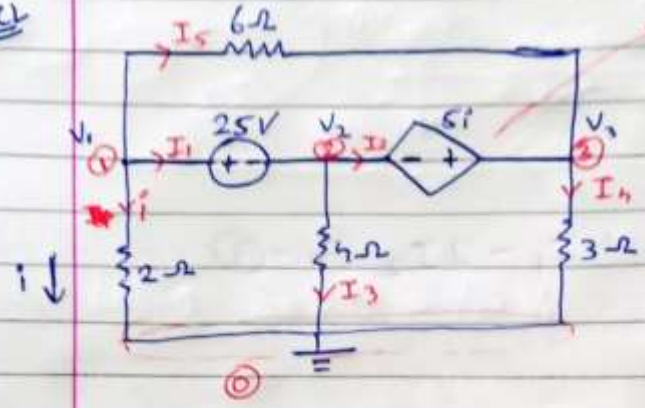





```
        --- Operating Point ---

V(n001):        7.6087          voltage
V(v2):          -17.3913        voltage
V(v3):          1.63043         voltage
V(v1):          7.6087          voltage
I(H1):          0.452899        device_current
I(R4):          -0.996377       device_current
I(R3):          0.543478        device_current
I(R2):          -4.34783        device_current
I(R1):          3.80435         device_current
I(Vzero):       3.80435         device_current
I(V):           -4.80072        device_current
```

KCL



→ Current controlled Voltage source

Find V_1, V_2, V_3 and i

→ KCL at node ①: $\Sigma I_{entering} = \Sigma I_{leaving}$

$\Rightarrow 0 = i + I_1 + I_5$

$\Rightarrow I_1 = -i - I_5 \quad -①$

→ KCL at node ②: $\Sigma I_{entering} = \Sigma I_{leaving}$

$I_1 = I_2 + I_3 \quad -②$

→ Compare ① and ②,

$-i - I_5 = I_2 + I_3$

$\Rightarrow I_2 = -i - I_5 - I_3 \quad -③$

→ KCL at node ③: $\Sigma I_{entering} = \Sigma I_{leaving}$

$I_2 + I_5 = I_4$

$\Rightarrow I_2 = I_4 - I_5 \quad -④$

→ Compare ③ and ④

$-i - I_5 - I_3 = I_4 - I_5$

$\Rightarrow i + I_3 + I_4 = 0$

$\Rightarrow \frac{V_1}{2} + \frac{V_2}{4} + \frac{V_3}{3} = 0$

$\Rightarrow \boxed{6V_1 + 3V_2 + 4V_3 = 0} \quad -⑤$

$V_{12} = \boxed{V_1 - V_2 = 25V}$ — (6)

$V_{32} = 5i = V_3 - V_2$

$\Rightarrow V_3 - V_2 = \frac{5V_1}{2}$

$\Rightarrow \boxed{2V_3 - 2V_2 - 5V_1 = 0}$ — (7)

From (6)

$V_2 = -25 + V_1$

Substituting V_2 in (5) and (7)

$9V_1 + 4V_3 = 75$; $2V_3 - 7V_1 = -50$

$4V_3 + 9V_1 = 75$

$(-)\ 4V_3 \pm 14V_1 = \pm 100$

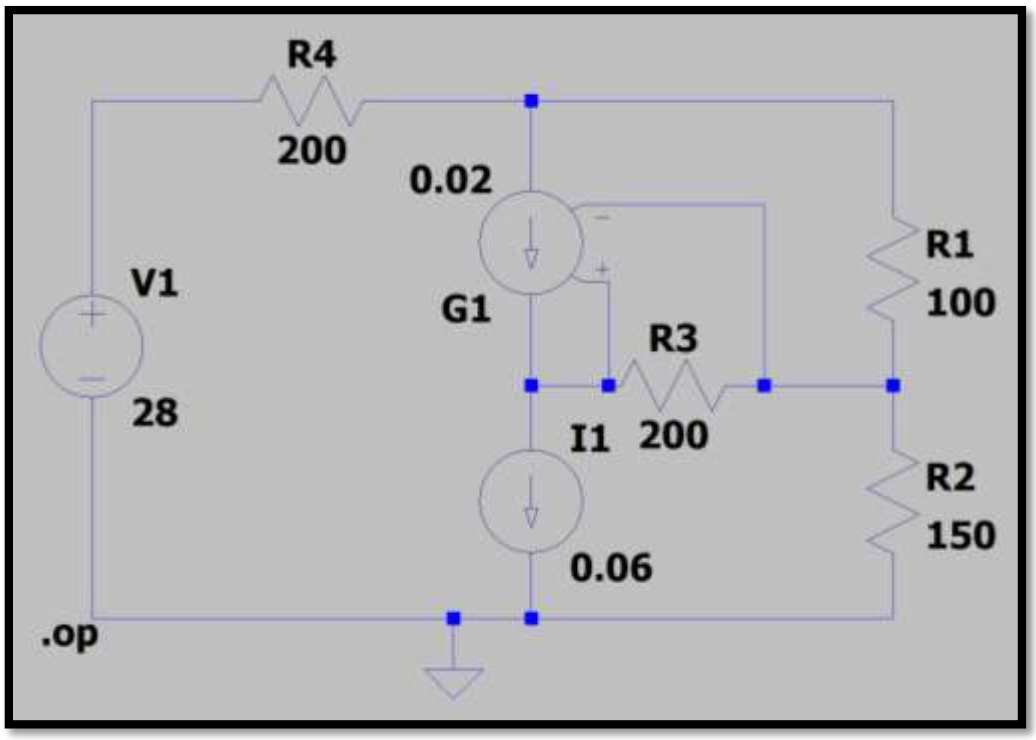
$23V_1 = 175$

$\Rightarrow \boxed{V_1 = 7.60V}$ $\Rightarrow \boxed{V_2 = -17.39}$

$\Rightarrow \boxed{V_3 = 1.63V}$ $\Rightarrow \boxed{i = 19.02A}$

Voltage Dependent Current Source

1) Class work question

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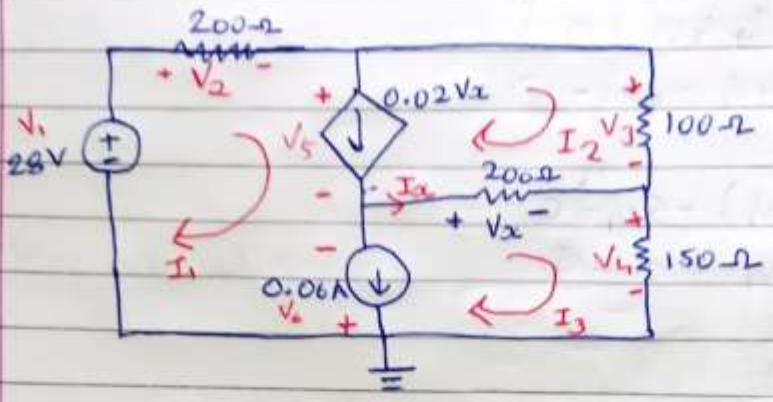
        --- Operating Point ---

V(n001):        28              voltage
V(n002):        8               voltage
V(n003):        6               voltage
V(n004):        10              voltage
I(I1):          0.06            device_current
I(R4):          0.1             device_current
I(R3):          0.02            device_current
I(R2):          0.04            device_current
I(R1):          0.02            device_current
I(G1):          0.08            device_current
I(V1):          -0.1            device_current
```

KVL



KVL in loop ①: $28 + V_6 = V_2 + V_5$ — ①

KVL in loop ②: $V_5 + V_x = V_3$

$\Rightarrow V_5 = V_3 - V_x$ — ②

KVL in loop ③: $0 = V_6 + V_x + V_4$ — ③

$\Rightarrow V_6 = -V_x - V_4$ — ③

Substituting ② and ③ in ①

$28 - V_x - V_4 = V_2 + V_3 - V_x$

$\Rightarrow V_2 + V_3 + V_4 = 28$

$\Rightarrow \boxed{200I_1 + 100I_2 + 150I_3 = 28}$ — ④

$I_1 - I_2 = 0.02 V_x$ $\quad V_x = I_x \, 200$

$\Rightarrow I_1 - I_2 = 0.02(200)(I_3 - I_2)$ $\quad I_x = I_3 - I_2$

$\Rightarrow I_1 - I_2 = 4I_3 - 4I_2$

$\Rightarrow \boxed{I_1 + 3I_2 - 4I_3 = 0} \quad -(5)$

$\boxed{I_1 - I_3 = 0.06} \quad -(6)$

$\Rightarrow 100 I_1 = 6 + 100 I_3$

OR $I_1 = \frac{6}{100} + I_3$

Substituting Value of I_1 in (5) and (6)

$\Rightarrow 100 I_2 + 350 I_3 = 16$

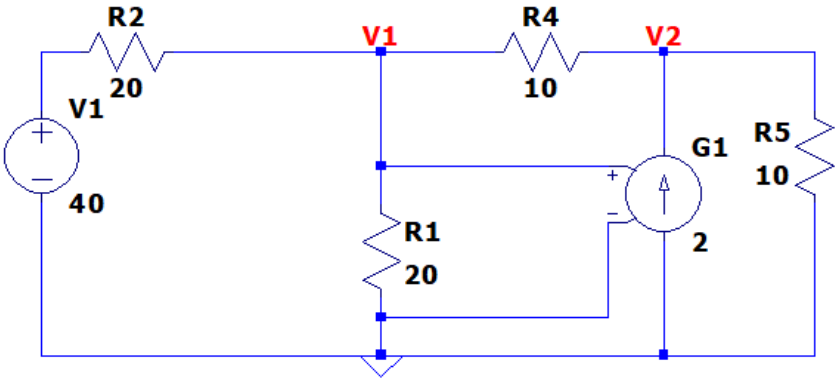
$\ominus \; 100 I_2 \overset{(4)}{-} 100 I_3 = \overset{(2)}{2}$

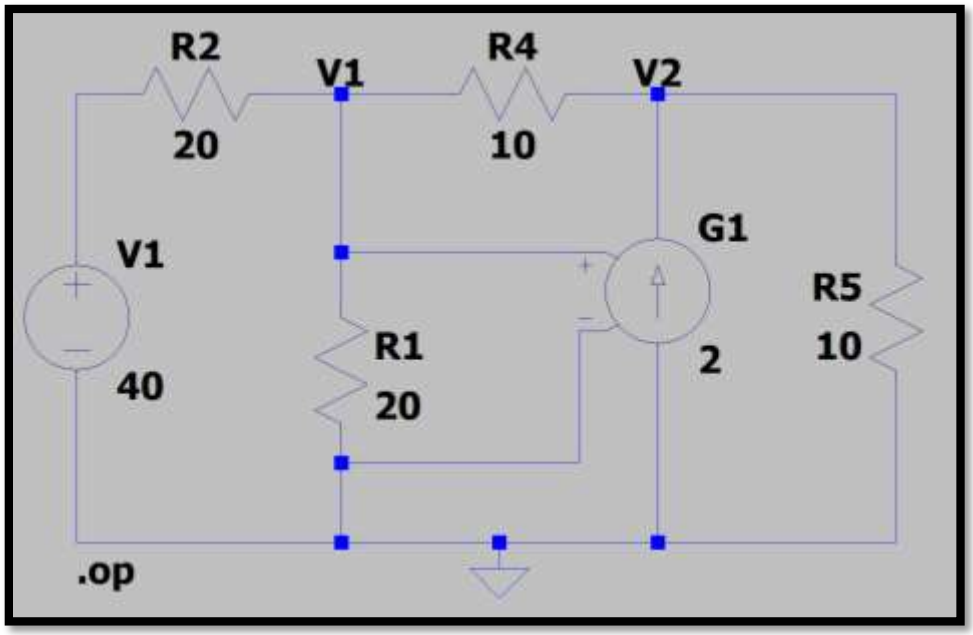
$450 I_3 = 18$

$\Rightarrow \boxed{I_3 = 0.04A}$ $\quad \Rightarrow \boxed{I_2 = 0.02A}$

$\Rightarrow \boxed{I_1 = 0.1A}$ $\quad \Rightarrow \boxed{V_x = 4V}$

2) Practical file question

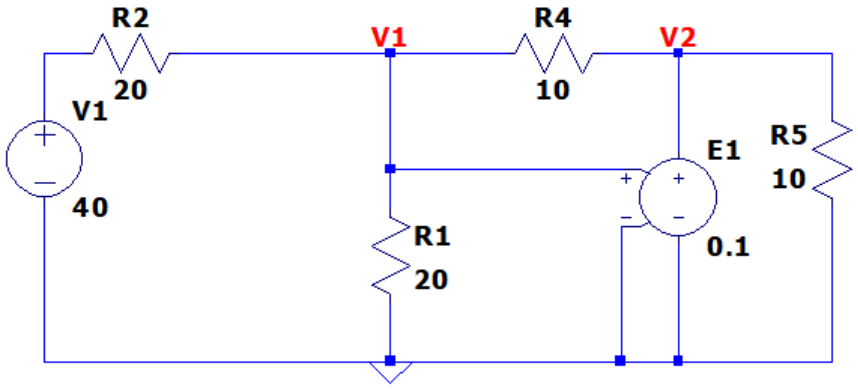


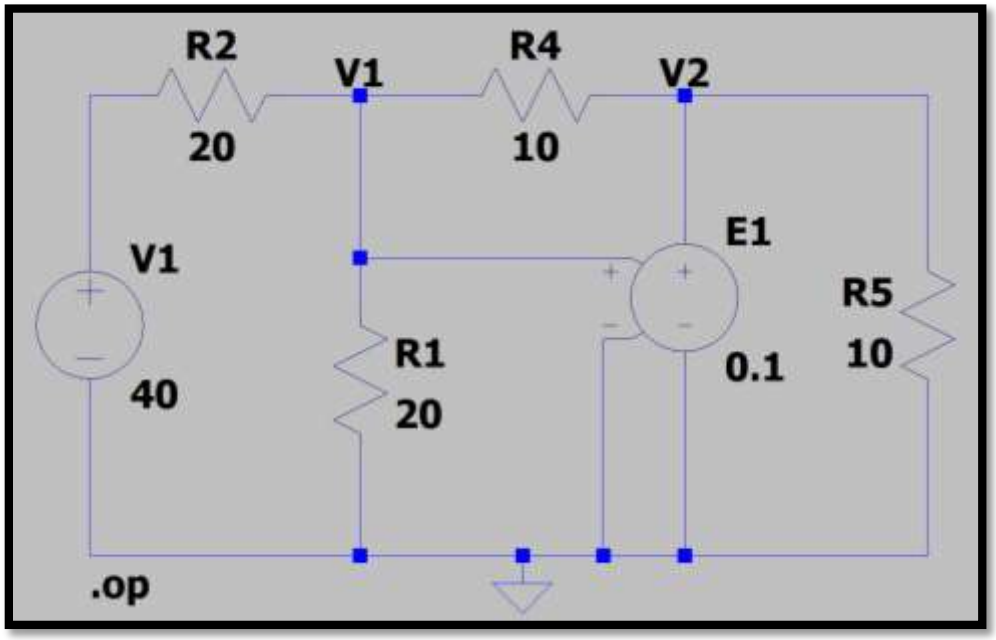



```
        --- Operating Point ---

V(v1):          -2.35294        voltage
V(n001):        40              voltage
V(v2):          -24.7059        voltage
I(R5):          2.47059         device_current
I(R4):          2.23529         device_current
I(R2):          2.11765         device_current
I(R1):          -0.117647       device_current
I(G1):          -4.70588        device_current
I(V1):          -2.11765        device_current
```

Voltage Dependent Voltage Source



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        --- Operating Point ---

V(v1):          10.5263         voltage
V(n001):        40              voltage
V(v2):          1.05263         voltage
I(R5):          -0.105263       device_current
I(R4):          0.947368        device_current
I(R2):          1.47368         device_current
I(R1):          0.526316        device_current
I(E1):          0.842105        device_current
I(V1):          -1.47368        device_current
```
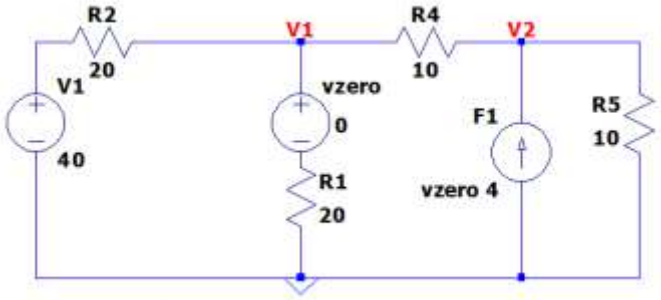
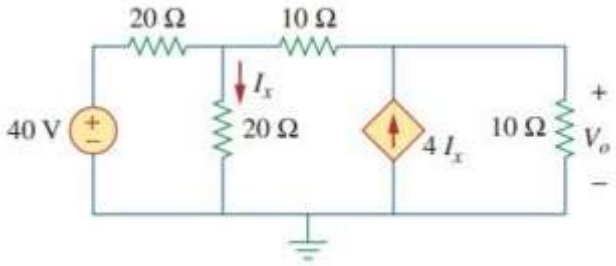
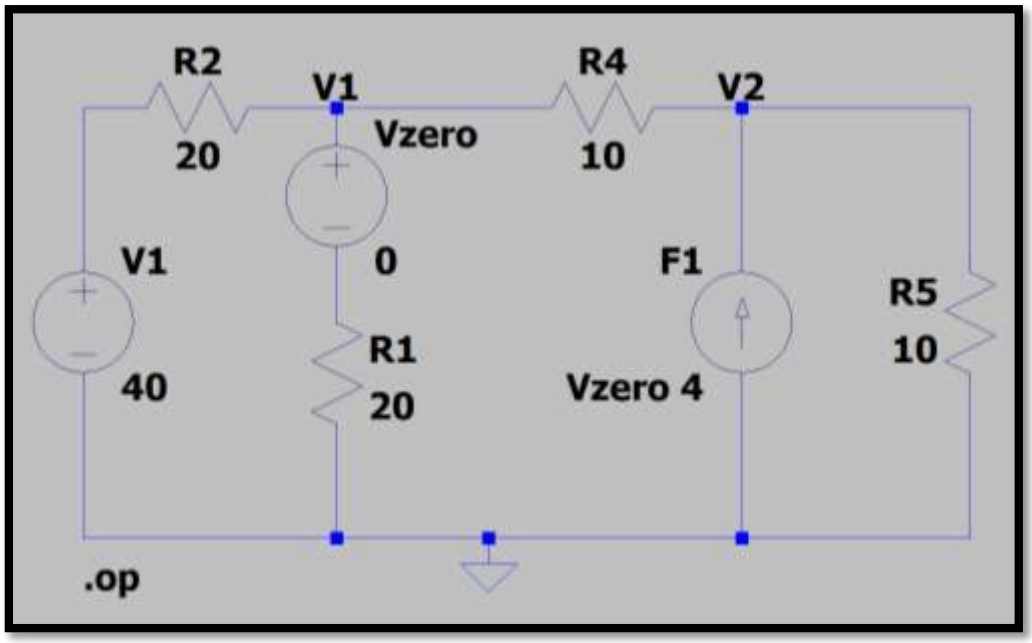

Current Dependent Current Source

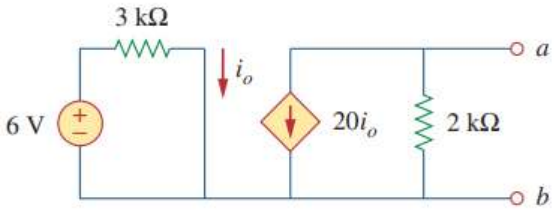


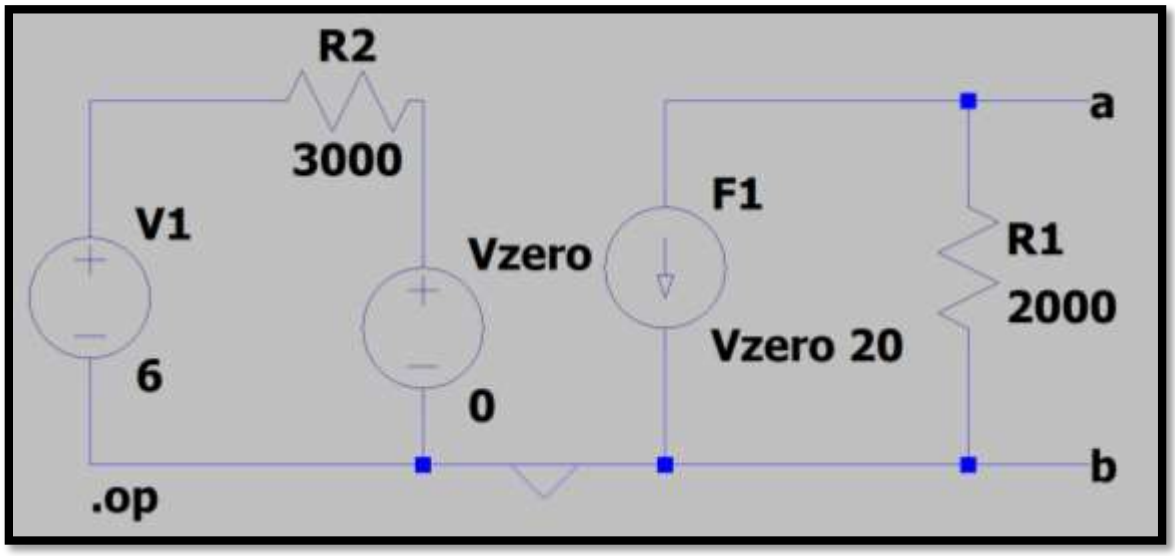




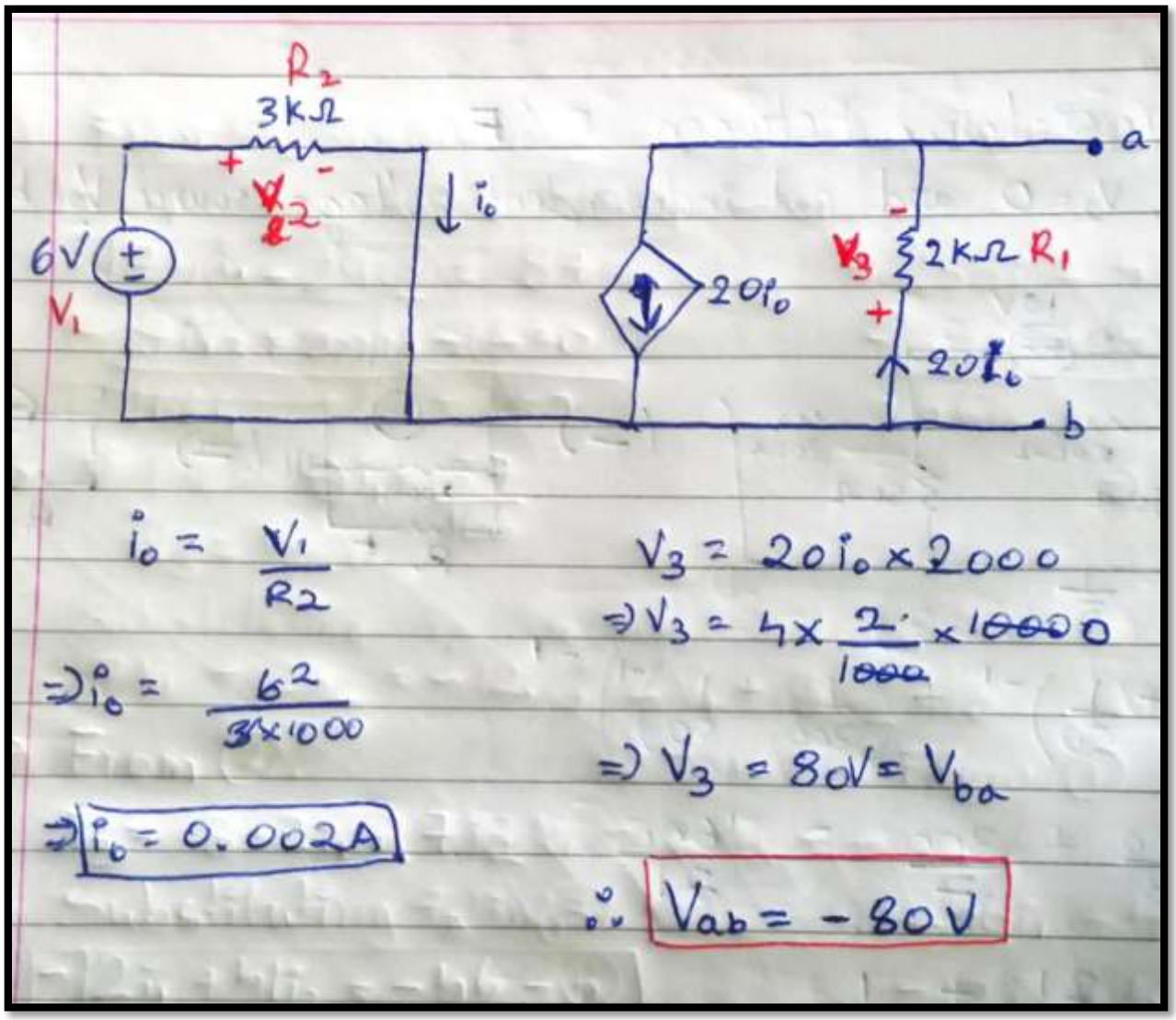

```
        --- Operating Point ---

V(n002):        40              voltage
V(n001):        40              voltage
V(v1):          40              voltage
V(v2):          60              voltage
I(F1):          8               device_current
I(R5):          -6              device_current
I(R4):          -2              device_current
I(R2):          -3.55271e-016   device_current
I(R1):          2               device_current
I(Vzero):       2               device_current
I(V1):          4.44089e-016    device_current
```

Do it Yourself: Find io and voltage across the terminals a-b






```
        --- Operating Point ---

V(n001):        6               voltage
V(a):           -80             voltage
V(n002):        0               voltage
I(F1):          0.04            device_current
I(R2):          -0.002          device_current
I(R1):          -0.04           device_current
I(Vzero):       0.002           device_current
I(V1):          -0.002          device_current
```



$$i_o = \frac{V_1}{R_2}$$

$$\Rightarrow i_o = \frac{6^2}{3 \times 1000}$$

$$\Rightarrow \boxed{i_o = 0.002A}$$

$$V_3 = 20 i_o \times 2000$$

$$\Rightarrow V_3 = 4 \times \frac{2}{1000} \times 10000$$

$$\Rightarrow V_3 = 80V = V_{ba}$$

$$\therefore \boxed{V_{ab} = -80V}$$