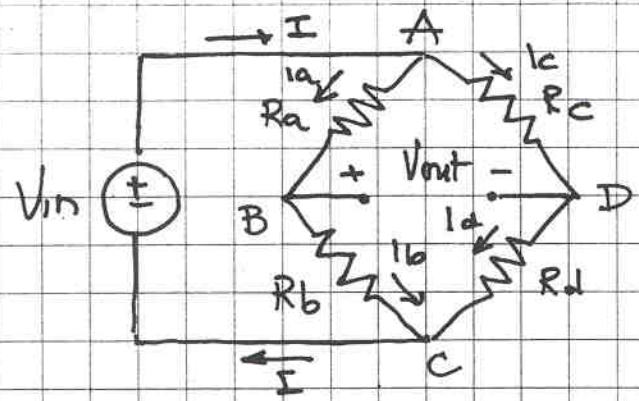
(1)



KCL: $I = I_a + I_c \quad ; \quad I_a = I_b \; ; \; I_c = I_d$

KVL: $V_{out} + R_a I_a - R_c I_c = 0 \Rightarrow V_{out} = R_c I_c - R_a I_a$

$V_{out} - R_b I_b + R_d I_d = 0 \Rightarrow V_{out} = R_b I_b - R_d I_d$

$V_{out} = 0$,

Hence: $R_c I_c = R_a I_a$

$R_b I_b = R_d I_d$

Since $I_c = I_d$

$I_a = I_b$

We have: $R_c \cdot I_d = R_a \cdot I_b \Rightarrow \frac{R_c}{R_a} = \frac{I_b}{I_d}$

$R_b \cdot I_b = R_d \cdot I_d \quad \frac{R_d}{R_b} = \frac{I_b}{I_d}$

and $\frac{R_c}{R_a} = \frac{R_d}{R_b}$ or $R_b R_c = R_a R_d$

if the bridge is balanced.

Gren Geffs: $\frac{R_a}{R_b} = \frac{R_c}{R_d}$

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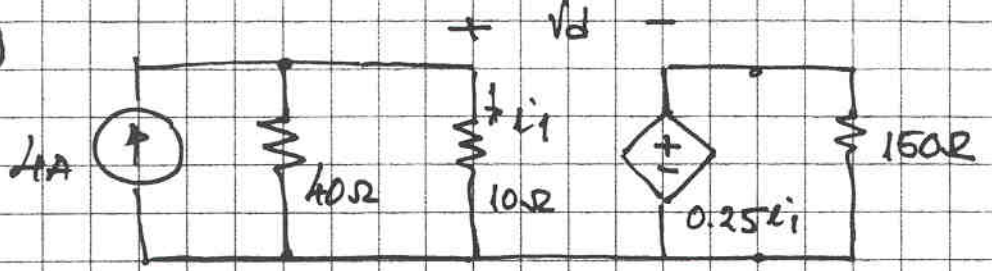
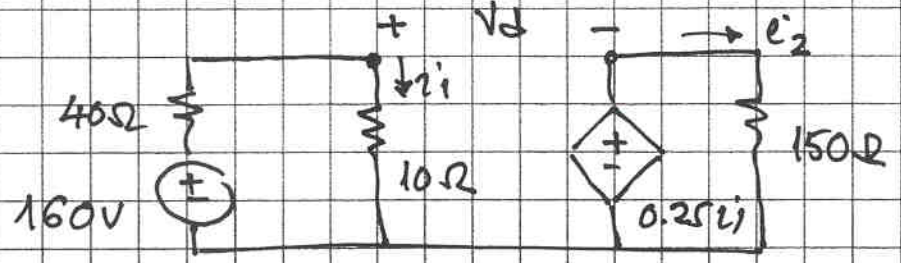
(2)





$$i_1 = \frac{160}{40+10}\ A$$

$$i_1 = \frac{16}{5}\ A\ ;\quad i_1 = 3.2\ A$$

$$i_2 = \frac{0.25 i_1}{150}\ ;\ i_2 = \frac{0.25 \times 3.2}{150}\ \rightarrow\ ;\ i_2 = \frac{16}{3}\ mA$$

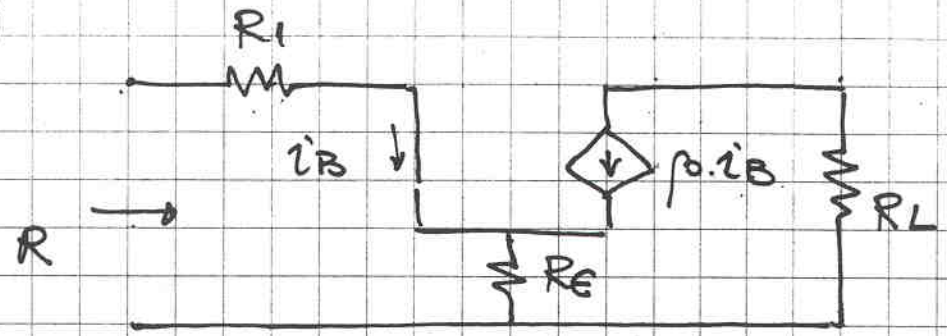
KVL: $V_d - 10 i_2 + 0.25 i_2 = 0$

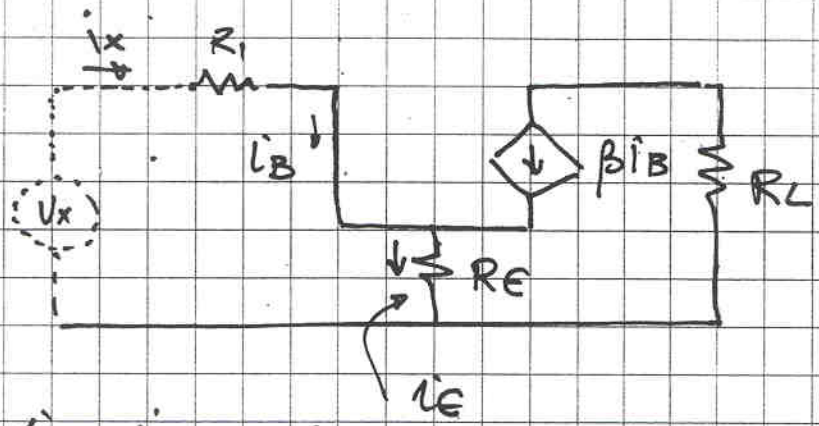
$$V_d = 9.75 i_1$$

$$V_d = 9.75 \times 3.2\ V$$

$$V_d = 31.2\ V$$

3





$i_x = i_B$

$i_E = i_B + \beta . i_B \quad ; \quad i_E = (1+\beta)\, i_B$

$V_x - R_1 \cdot i_B - R_E \cdot (1+\beta) \cdot i_B$

$V_x = (R_1 + R_E(1+\beta))\, i_B$

$\frac{V_x}{i_x} = R_1 + (1+\beta) R_E$

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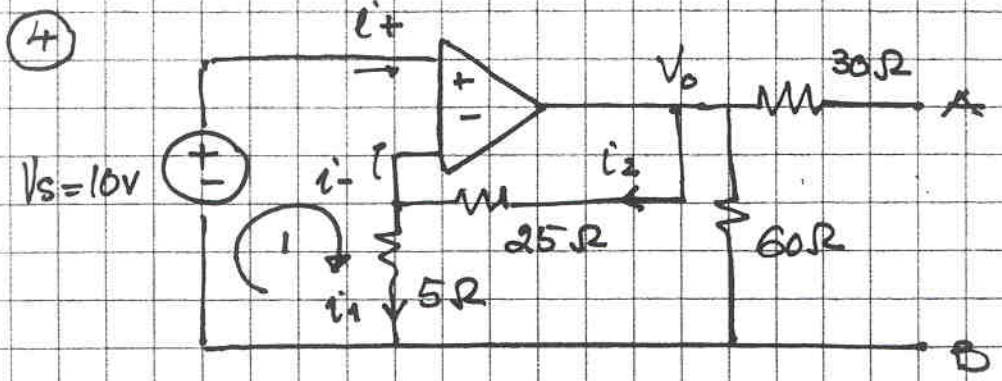
(4)



Ideal op amp

$i_+ = 0$

$i_- = 0$

$V_d := V_+ - V_- = 0$; $r_d = 0$

4 (a) thevenen voltage:

KVL : Loop #1

$V_s - V_d - 5 \cdot i_1 = 0$; $i_1 = 2A$

KCL: $i_1 = i_2$

$i_2 = 2A$

KVL: $V_o = 25 \cdot i_2 + 5 \cdot i_1$

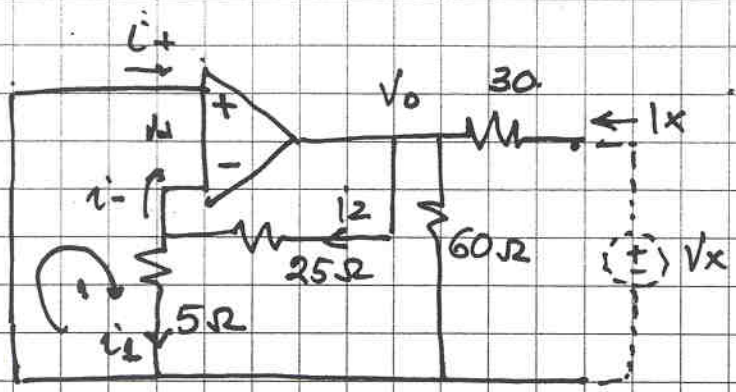
$V_o = 60V$

V_{AB} (when AB open circuited) $= V_{th}$

$V_{th} = 30 \times 0 + V_o$; $V_{th} = 60V$

4 (b) Thevenin resistance:

Independent voltage source short-circuited:



$$R_{th} = \frac{V_x}{I_x}$$

KVL: $0 + V_d + 5 \cdot i_1 = 0 \Rightarrow i_1 = 0$

KCL: $i_- = 0$, $i_1 = 0 \Rightarrow i_2 = 0$

KVL (or Ohm's Law) $V_o = 25 \cdot i_2 + 5 \cdot i_1$

$V_o = 0$

KVL: $V_x - 30 \cdot I_x - V_o = 0$

$V_x = 30 I_x$

$\frac{V_x}{I_x} = 30$

$R_{th} = 30\Omega$

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