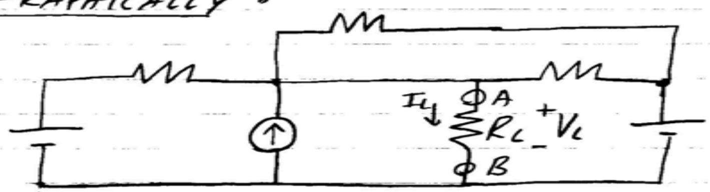
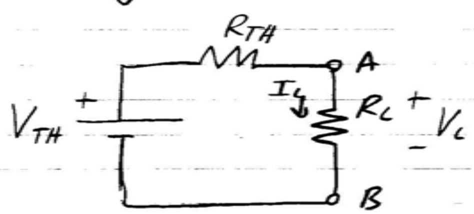
9.3 THÉVENIN'S THEOREM

ANY TWO-TERMINAL, LINEAR BILATERAL DC NETWORK CAN BE REPLACED BY AN <u>EQUIVALENT</u> <u>CIRCUIT</u> CONSISTING OF A VOLTAGE SOURCE & A SERIES RESISTOR.

<u>GRAPHICALLY</u>:



⇓ REPLACE EVERYTHING EXCEPT <u>R_L</u> WITH:



V_L & I_L THE SAME AS ABOVE

* EQUIVALENT AT TERMINALS A-B only

<u>PROCEDURE</u>:

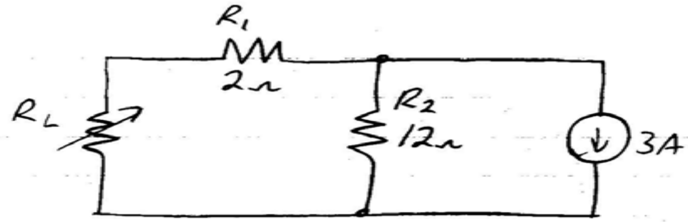
(1) REMOVE THE LOAD (OR PORTION OF THE NETWORK ACROSS WHICH THE THÉVENIN EQUIVALENT CIRCUIT IS TO BE FOUND) & MARK THE TERMINALS (A-B).

(2) FIND R_{TH}
- REPLACE VOLTAGE SOURCES W/ SHORT-CIRCUITS
- REPLACE CURRENT SOURCES W/ OPEN-CIRCUITS
- FIND $R_{TH} = R_{AB}$

(3) FIND V_{TH}
- ALL SOURCES IN CIRCUIT
- FIND O/C VOLTAGE $V_{A-B} = V_{TH}$

(4) DRAW THE THÉVENIN EQUIVALENT CIRCUIT

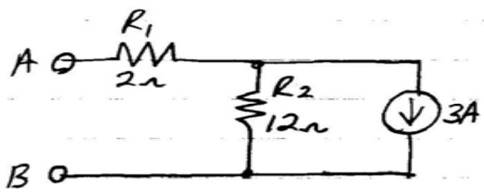
(EXAMPLE)



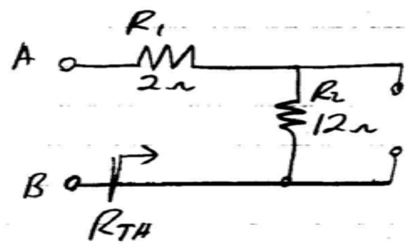
→ FIND THE THÉVENIN EQUIV. CIRCUIT AS SEEN BY R_L

→ FIND P_{R_L} FOR $R_L = 10\Omega$

(1) REMOVE R_L & MARK TERMINALS A & B:



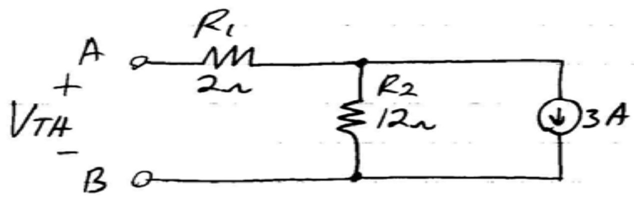
(2) FIND R_{TH} (VOLT SOURCES → S/C
CURRENT SOURCES → O/C)



$R_{TH} = R_{AB} = R_1 + R_2$

$\boxed{R_{TH} = 14\Omega}$

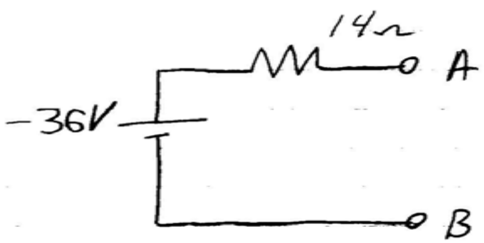
(3) FIND V_{TH} (SOURCES IN-CIRCUIT
$V_{TH} = V_{AB} = V_{o/c}$)



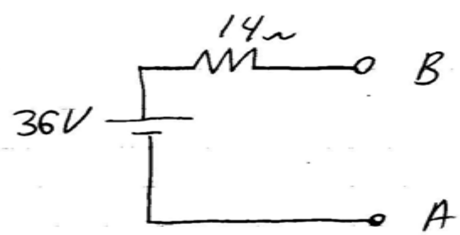
$V_{TA} = (-3A)(12\Omega)$

$\boxed{V_{TH} = -36V}$

(4) THÉVENIN EQUIVALENT CIRCUIT:

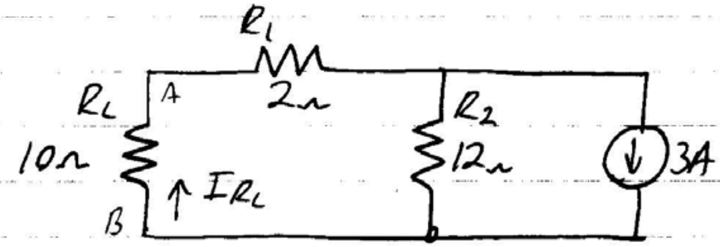


OR

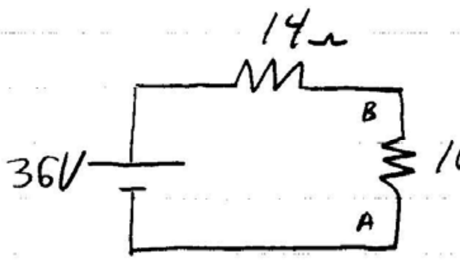


FIND P_{R_L} FOR $R_L = 10\,\Omega$:

ORIGINAL CIRCUIT



THÉVENIN EQUIVALENT



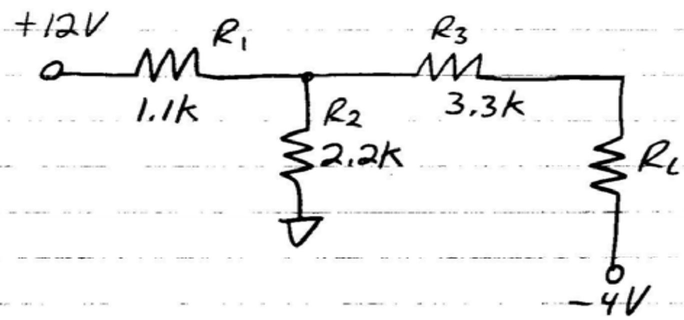
$+$ V_L $-$

$V_L = 36V\left(\frac{10}{10+14}\right) = \underline{15V}$

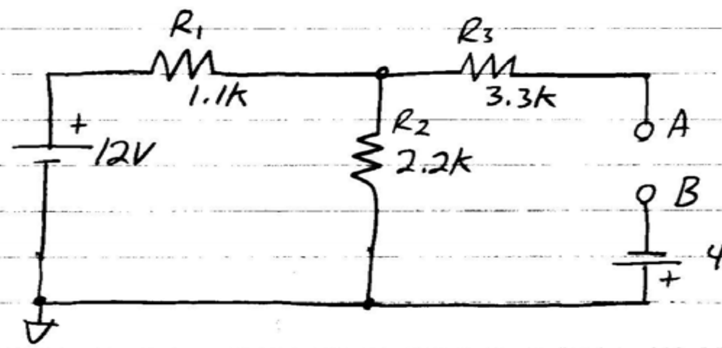
$P_{R_L} = \frac{V_L^2}{R_L} = \frac{(15)^2}{10} = \boxed{22.5\,W}$

FOR MORE COMPLICATED CIRCUITS IT WOULD BE EASIER TO ANALYZE THE THÉVENIN EQUIVALENT CIRCUIT (REPEATEDLY) INSTEAD OF THE ORIGINAL.

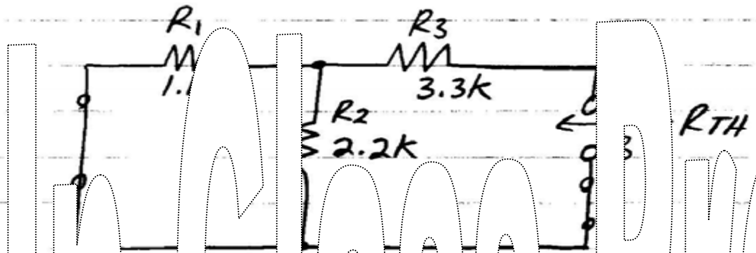
(EXAMPLE) DETERMINE THE THÉVENIN EQUIVALENT CIRCUIT AS SEEN BY R_L.



REDRAW, REMOVE R_L, LABEL A-B:



R_{TH}:



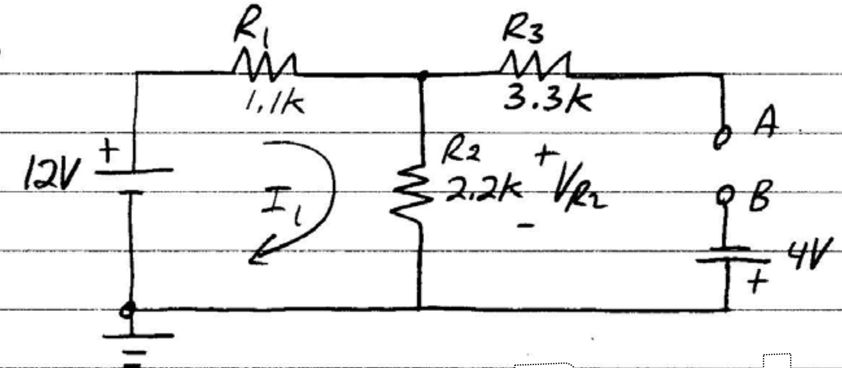
$R_{T\ldots} = [\ldots // \ldots] + \ldots$

$R_{T\ldots}\ (\ldots // \ldots.2\ldots) + 3.3k$

$\therefore R_{T\ldots}\ \ldots\ 3\ldots 3k$

In Class Problem

$\underline{V_{TH}}$:



$V_{AB} = V_{TH}$

$I_1 = \frac{[illegible]2V}{[illegible] + R_2} = \frac{[illegible]V}{[illegible]k} = [illegible].636mA$

$\therefore V_{R2} = I_1 R_2 = ([illegible].63[illegible])([illegible])$

$V_{R2} = [illegible]V$

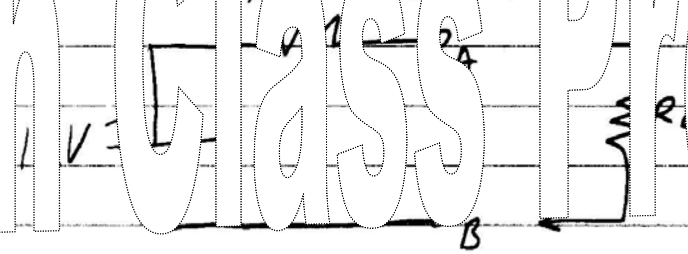
[illegible] : $+V_{[illegible]} - V_{AB} + 4 = 0$; No [illegible] THROUGH R_3

$V_{AB} = V_{[illegible]} + [illegible] = \boxed{[illegible] V \Rightarrow V_{TH}}$

[illegible]HÉVENIN EQUIV. CKT

In Class Problem

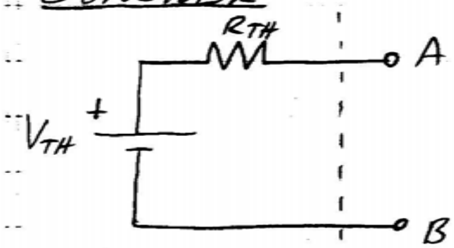
$R_{[illegible]} = [illegible].0 \, k\Omega$



9.3 THÉVENIN'S THEOREM (CONTINUED)

EXPERIMENTALLY: FIND R_{TH} & V_{TH}

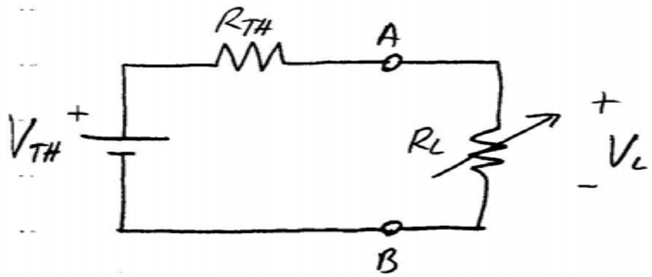
CONSIDER



ANY TWO-TERMINAL, LINEAR BILATERAL DC NETWORK

- FIND V_{TH} EXPERIMENTALLY: $\boxed{\underline{\underline{V_{AB\ o/c}}} = V_{TH}}$

- HOW ABOUT R_{TH} EXPERIMENTALLY?



$$V_L = V_{TH}\left(\frac{R_L}{R_L + R_{TH}}\right)$$

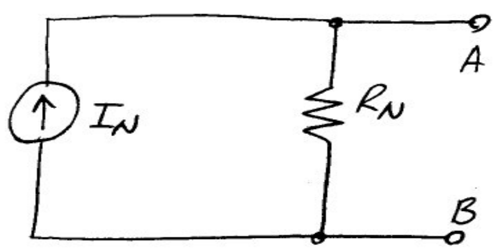
FOR $R_L = R_{TH}$: $V_L = V_{TH}\left(\frac{R_{TH}}{R_{TH} + R_{TH}}\right)$

$$\underline{\underline{V_L = \frac{V_{TH}}{2}}}$$

$\therefore$ ADJUST R_L UNTIL $V_L = \frac{1}{2} V_{TH}$, $\boxed{\underline{R_L = R_{TH}}}$

9.4 NORTON'S THEOREM

ANY TWO-TERMINAL LINEAR BILATERAL DC NETWORK CAN BE REPLACED WITH:



PROCEDURE

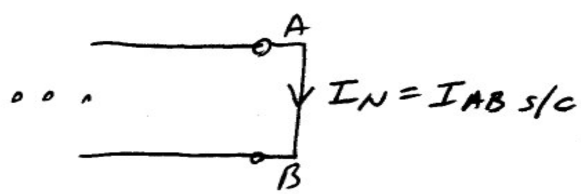
R_N: - REMOVE R_L (OR THAT PORTION OF THE NETWORK ACROSS WHICH THE NORTON EQUIVALENT CIRCUIT IS TO BE FOUND).

- MARK THE TWO TERMINALS (A-B)
- CALCULATE $R_N = R_{AB\,o/c}$ BY RELAXING ALL SOURCES & LOOKING INTO A-B

* $R_N = R_{TH}$, SOURCE CONVERSION

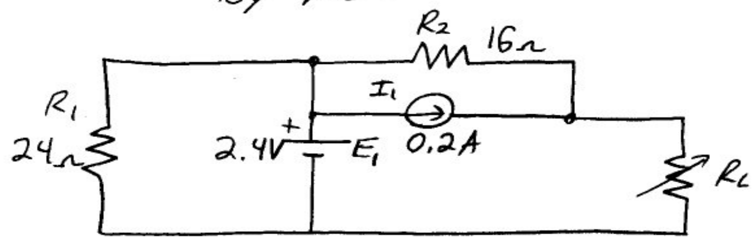
I_N: - PUT THE SOURCES BACK INTO THE CIRCUIT

- FIND $I_N = I_{AB}$:

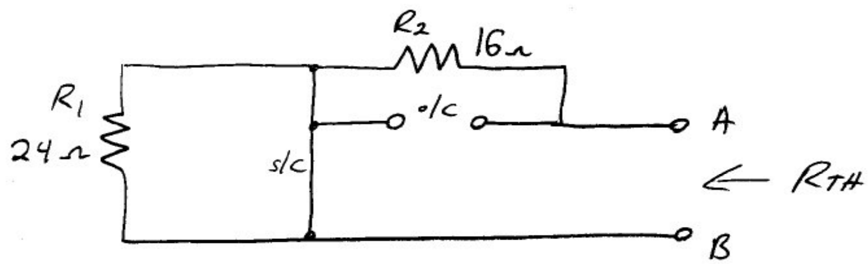


* $I_N = \dfrac{V_{TH}}{R_{TH}}$, SOURCE CONVERSION

(EXAMPLE) FIND THE NORTON EQUIVALENT AS SEEN BY R_L:

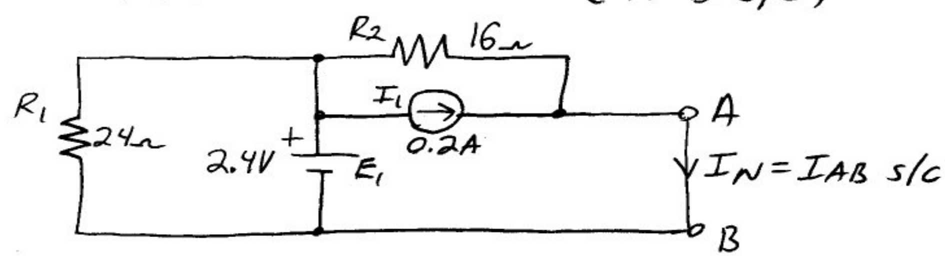


<u>$R_N = R_{TH}$</u> - RELAX SOURCES
- CALCULATE R_{AB}



$$\boxed{R_N = R_{TH} = R_2 = 16\,\Omega}$$

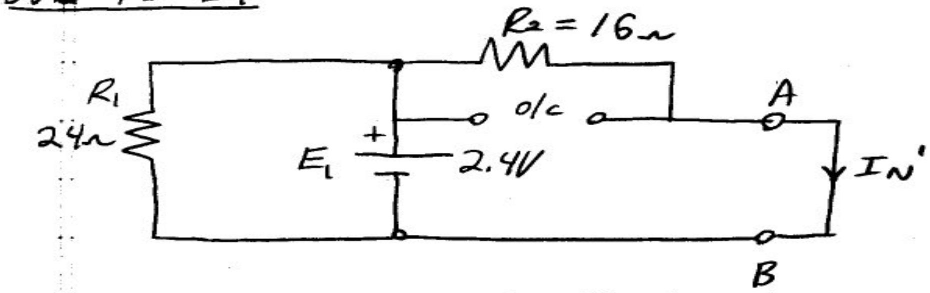
<u>I_N</u> - SOURCES IN CIRCUIT
- R_L OUT OF CIRCUIT (A-B s/c) I



SUGGESTIONS ON FINDING I_N ?

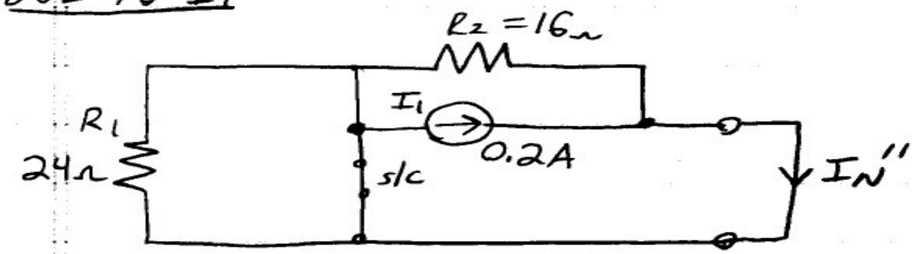
FIND I_N BY SUPERPOSITION:

DUE TO E_1



$$I_N' = E_1/R_2 = \frac{2.4V}{16\Omega} = \underline{150mA}$$

DUE TO I_1



$$I_N'' = \underline{0.2A}$$

$$\therefore \; I_N = 150mA + 200mA = \boxed{350mA}$$

EQUIVALENT CIRCUIT