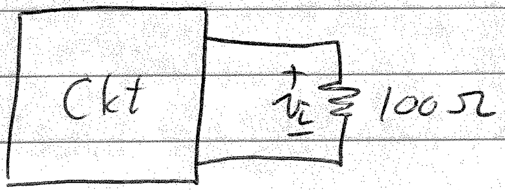
2014 - HW4 Solutions

1. 3-43

Linear ckt w/2 sources drives a 100Ω load R. Source 1 delivers 1W to load when Source 2 is off. Source 2 delivers 4W to load when Source 1 is off. Find power delivered to load when both sources are on.



Src 1 on : $P_{L_1} = 1W = \frac{v_{L1}^2}{100\Omega}$

$$100 = v_{L1}^2$$

$$\underline{v_{L1} = 10V}$$

Src 2 on : $P_{L_2} = 4W = \frac{v_{L2}^2}{100\Omega}$

$$400 = v_{L2}^2$$

$$\underline{v_{L2} = 20V}$$

Both sources on → $v_L = v_{L1} + v_{L2} = 10V + 20V$

$$v_L = 30V$$

$$P_L = \frac{v_L^2}{100\Omega} = \frac{900}{100} = \underline{\underline{9W}}$$

2. 3-44 Linear ckt driven by $v_s = 10V$ + $i_s = 10mA$.

v_s on + i_s off → $v_{o1} = 2V$

Both on → $v_o = 1V$

Find v_o' when $v_s = 20V$ and $i_s = -20mA$

Solution: Find K's in

$$v_o = K_1 v_s + K_2 i_s$$

$$v_o = v_{o1} + v_{o2}, \quad v_{o1} = 2V,$$

$$v_{o2} = v_o - v_{o1} = 1V - 2V = \underline{\underline{-1V}}$$

So $K_1 = \frac{v_{o1}}{v_s} = \frac{2V}{10V} = 0.2$

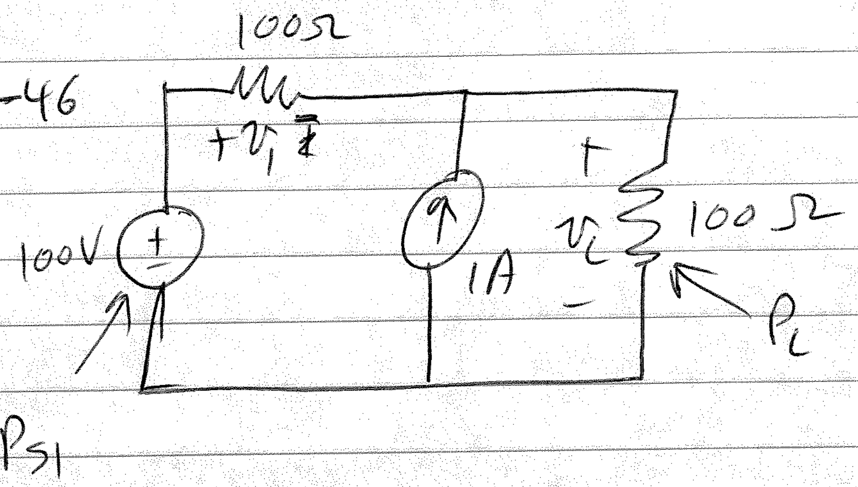
$$K_2 = \frac{v_{o2}}{i_s} = \frac{-1V}{10mA} = -0.1k = -100(\Omega)$$

So $v_o' = K_1(20V) + K_2(-20mA)$

$= (0.2)(20V) + (-100\,\Omega)(-20mA)$

$= 4V + 2V = \boxed{6V = v_o'}$

3. 3-46



Current src off, V src delivers 25 W to load R. How much power does it deliver to the load when both sources are on? Explain.

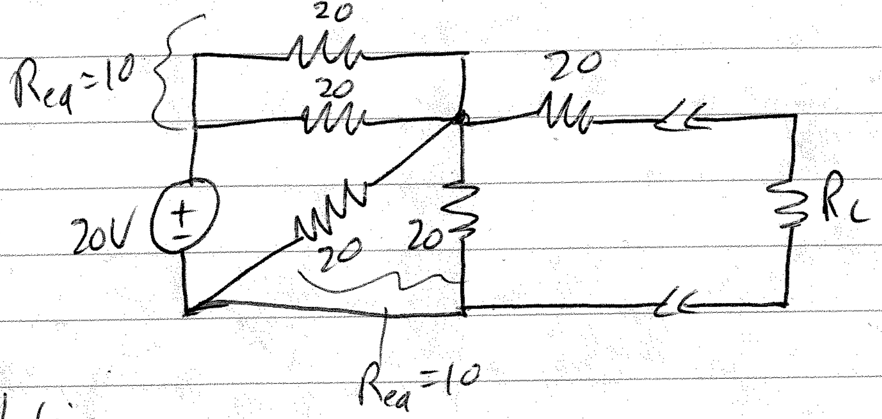
Solution: With Vsrc off and Isrc on, current divides through the resistors equally, so $v_L' = 100\Omega(1/2A) = 50V$, and $-50V$ across the other, $v_1' = -50V$

With Vsrc on and I src off, the voltages divides across both resistors, $v_1'' = 50V$, $v_L'' = 50V$.

With both sources on, $v_L = v_L' + v_L'' = 50V + 50V = 100V$ and $v_1 = v_1' + v_1'' = -50V + 50V = \underline{\underline{0V}}$

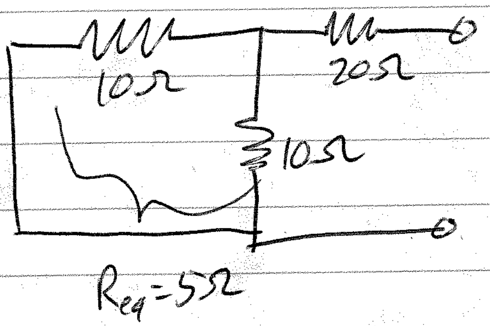
Turning on both sources simply drives all the current from the I src though the load, and no current goes thru the V src, so it delivers no power to the load.

4 3-51 Find Thev. equiv. seen by R_L, find v_L when $R_L = 5\Omega$, 10Ω, and 20Ω.



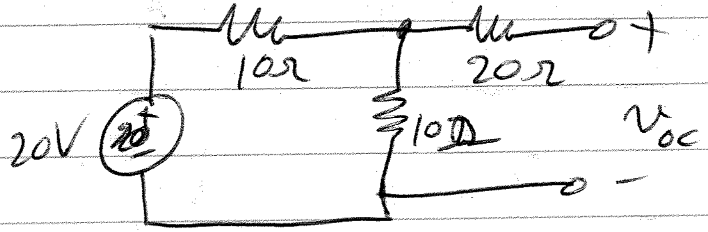
Solution

Turn V src off for "lookback" method:



$$R_s = 20\Omega + 5\Omega = 25\Omega$$

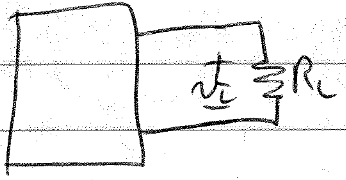
Turn source on to get V_{oc}:



$$v_{oc} = \frac{10}{10+10} 20 = 10V$$

R_L	v_L
5Ω	$\frac{5}{30}(10V) = \frac{5}{3}V$
10Ω	$\frac{10}{35}(10V) = \frac{20}{7}V$
20Ω	$\frac{20}{45}(10V) = \frac{40}{9}V$

5 3-53 - Linear ckt, lot v_o measured for different R_L's, determine V_{oc} + R_s.



R_L	~~v_L~~ i_L	v_L
10kΩ	91 μA →	910 mV
1kΩ	5 mA ←	5V should be 124 mV

Solution: Use Voltages + Voltage Division.

$$910\,mV = \frac{10k\Omega}{10k\Omega + R_s} V_s \quad \text{and} \quad 5V = \frac{1k\Omega}{1k\Omega + R_s} V_s$$

Solve for $V_s + R_s$:

$$(5V)(1k\Omega) + 5V(R_s) = 1k\Omega$$

$$5V + 5V\left(\frac{R_s}{1k}\right) = V_s$$

$$.91V = \frac{10k}{10k + R_s}\left[5V + 5V\left(\frac{R_s}{1k}\right)\right]$$

$$9.1k + .91R_s = 50k + 50k\left(\frac{R_s}{1k}\right)$$

$$= 50k + 50R_s$$

With correction, $.91V = \frac{10k\Omega}{10k\Omega + R_s}\left[0.124V + 0.124V\left(\frac{R_s}{1k\Omega}\right)\right]$

~~9,1kΩV~~

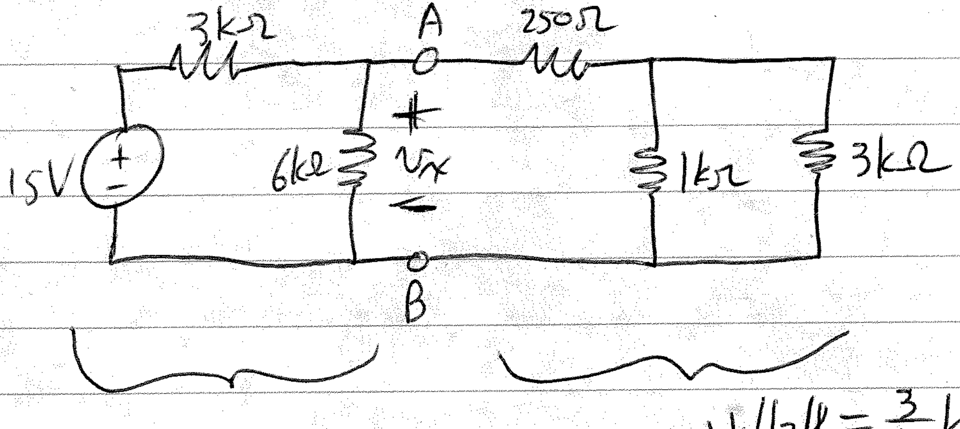
$$9,1\,k\Omega V + 0.91V R_s = 1.24\,k\Omega V + 1.24V R_s$$

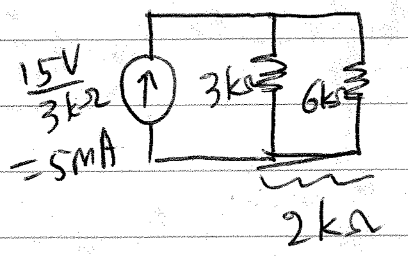
$$7.86\,k\Omega \cancel{V} = 0.33\cancel{V} R_s$$

$$R_s = \frac{7.86\,k\Omega}{0.33} = \underline{23.58\,k\Omega}$$

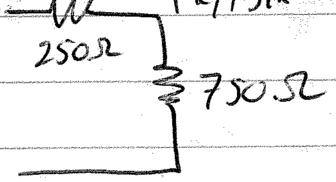
$$V_s = 0.124V + 0.124V\left(\frac{23.58\,k\Omega}{1k\Omega}\right) = 3.05V$$

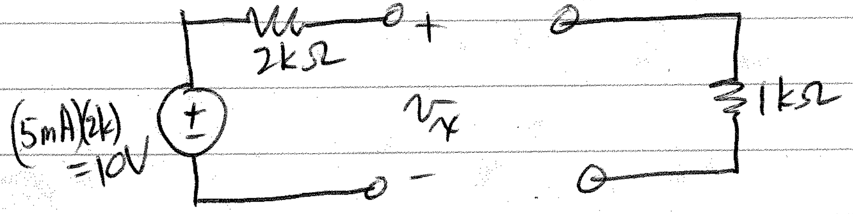
6 3-56 Use Thevenin Eq.'s to right and left of terminals A+B to find v_x:





$1k // 3k = \frac{3}{4} k\Omega = 750\Omega$



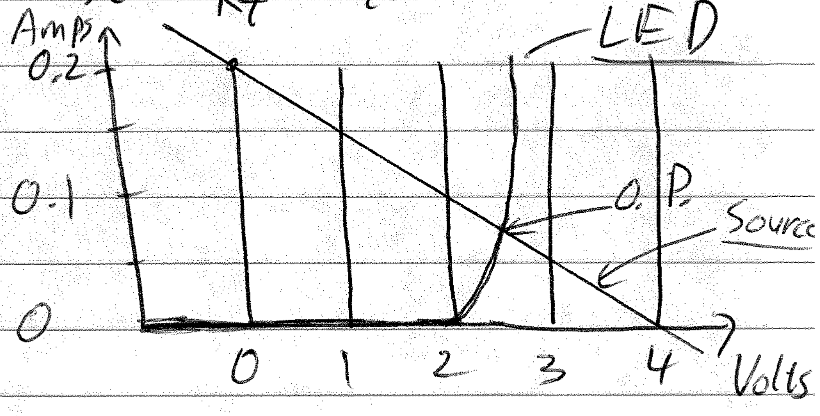


$$v_x = \frac{1k\Omega}{1k\Omega + 2k\Omega}(10V) = \frac{1}{3}(10V) = \underline{3.33\,V}$$

7) Blue LED across a 2 terminal Thév source, $v_{oc} = 4V$, $R_T = 20\Omega$. IV characteristic plotted in text. Use graphical method to determine Voltage across + current thru LED.

Solution: Find $i_{SC} = \frac{V_{oc}}{R_T} = \frac{4V}{20\Omega} = 0.2A$

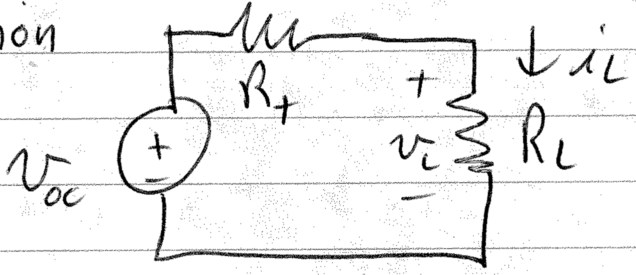
From text:



So $v_L = 2.5V$
$i_L = 0.075A$

8.) 3-73. 5kΩ R across a 2 terminal device, a current of 15 mA is delivered. When a second 5kΩ R is connected in parallel with first, a total of 20 mA is delivered. Find max power available from src.

Solution



$$R_L = 5k\Omega,\ i_L = 15mA \Rightarrow \underline{v_L = 75V}$$

$$R_L = 2.5k\Omega(5k//5k),\ i_L = 20mA = \underline{v_L = 50V}$$

Use Voltage Division:

$$75V = \frac{5k\Omega}{R_s + 5k\Omega}V_{oc} \quad + \quad 50V = \frac{2.5k\Omega}{R_s + 2.5k\Omega}V_{oc}$$

$$75VR_s + 375k\Omega V = 5k\Omega v_{oc}$$

$$\frac{75VR_s + 375k\Omega V}{5k\Omega} = v_{oc}$$

$$\frac{75VR_s}{5k\Omega} + 75V = v_{oc} \longrightarrow 50V = \frac{2.5k\Omega}{R_s + 2.5k\Omega}\left(\frac{75VR_s}{5k\Omega} + 75\right.$$

$$50VR_s + 125k\Omega V = \frac{187.5k\Omega V}{5k\Omega}R_s + 187.5k\Omega$$

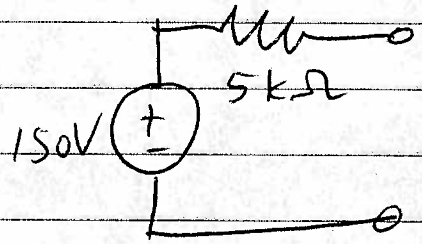
$$(50V - 37.5V)R_s = (187.5 - 125)k\Omega V$$

$$12.5VR_s = 62.5k\Omega V$$

$$R_s = \frac{62.5}{12.5} k\Omega = \underline{5 k\Omega}$$

$$v_{oc} = 75V + \frac{75V}{5k\Omega}(5k\Omega) = 75V + 75V = \underline{150V}$$

So



is the Thev. Equivalent

Max power available:

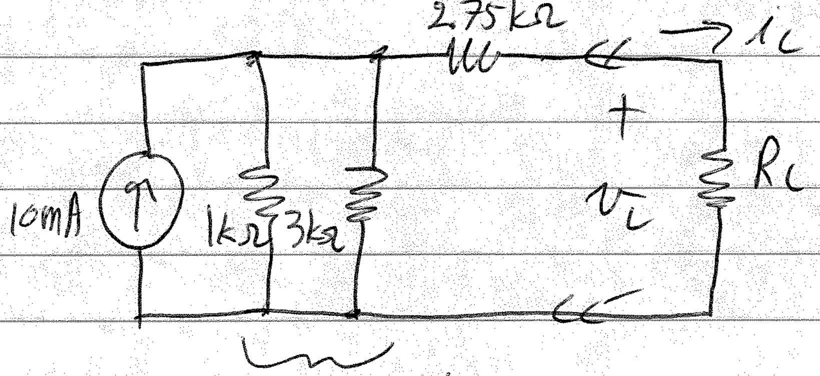
$$P_{L\,max} = \frac{\left(\frac{150V}{2}\right)^2}{5k\Omega} = \frac{(75V)^2}{5k\Omega} = \underline{\underline{\underline{1.125 W}}}$$

9 3-75. For ckt below, find values of R_L that result in

a) Max voltage. What is it?

b) Max current. What is it?

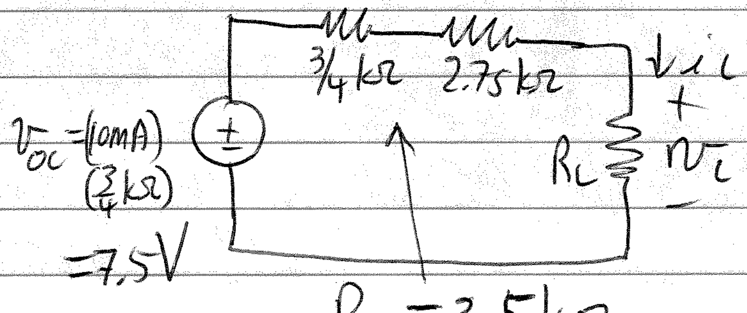
c) Max power. What is it?



$R_1 = 1k\Omega // 3k\Omega$

$= \frac{3k^2\Omega^2}{4k\Omega}$

$\underline{R_1 = \frac{3}{4}k\Omega}$



$v_{oc} = (10mA)(\frac{3}{4}k\Omega)$

$= 7.5V$

$R_T = 3.5k\Omega$

a) $V_{max} = \underline{7.5\,V}$ for $\underline{R_L = \infty}$.

b) $i_{max} = \frac{7.5V}{3.5k\Omega} = \underline{2.14\,mA}$ for $\underline{R_L = 0}$.

c) $P_{max} = \frac{(3.75V)^2}{3.5k\Omega} = \underline{4.02\,mW}$ for $\underline{R_L = 3.5k\Omega}$

10 3-77 – Practical Src delivers 50 mA to a 300 Ω load and 12V to a 120 Ω load. Find max power available from source.

$$R_L = 300\,\Omega, \quad v_L = (300\,\Omega)(50\,mA) = \underline{\underline{15\,V}}$$

$$R_L = 120\,\Omega, \quad \underline{\underline{v_L = 12\,V}}$$

Voltage Div. ① $15\,V = \frac{300\,\Omega}{R_S + 300\,\Omega} v_{oc}$

② $12\,V = \frac{120\,\Omega}{R_S + 120\,\Omega} v_{oc}$

Take ratio: $\frac{15V}{12V} = \frac{5}{4} = \frac{\frac{300}{R_S+300}\cancel{v_{oc}}}{\frac{120}{R_S+120}\cancel{v_{oc}}}$

$$\frac{5}{4} = \frac{R_S+120}{120} \cdot \frac{300}{R_S+300} = \frac{R_S+120}{R_S+300}\left(\frac{5}{2}\right)$$

$$\left(\frac{2}{5}\right)\left(\frac{5}{4}\right) = \frac{1}{2} = \frac{R_S+120}{R_S+300}$$

$$R_S + 300 = 2R_S + 240$$

$$300 - 240 = (2-1)R_S = R_S$$

$$\underline{60\,\Omega = R_S}$$

Substitute: $15\,V = \frac{300\,\Omega}{60\,\Omega + 300\,\Omega} v_{oc}$

$$= \frac{30\cancel{0}}{36\cancel{0}} v_{oc} = \frac{5}{6} v_{oc}$$

$$\frac{90V}{5} = \underline{18\,V = v_{oc}}$$

$$P_{max} = \frac{\left(\frac{v_{oc}}{2}\right)^2}{R_S} = \frac{(9V)^2}{60\,\Omega} = \frac{81}{60}W = \frac{27}{20}W = \underline{\underline{1.35\,W}}$$