EE101 Lecture #4 Jan 17, 2018

Quiz #1 today 3:30 – 3:45 p.m.

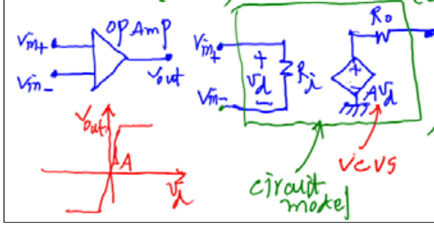
Text adopted (official) register by Friday

<connect>
http://connect.mheducation.com/class/s-kang-winter2018-mwf240

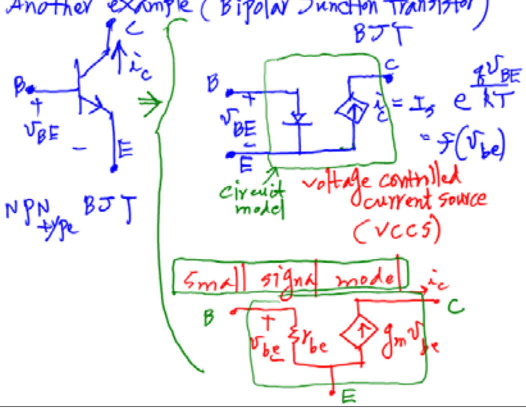
Dependent Sources

dependent voltage source
- voltage controlled (VCVS)
- current controlled (CCVS)

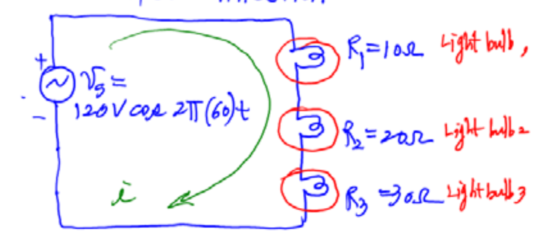
dependent current source
- voltage controlled (VCCS)
- current controlled (CCCS)



Another example (Bipolar Junction Transistor) BJT



Series connection



Loop (Mesh) current $i = ?$

By Ohm's Law $i = \dfrac{v_S}{R_1+R_2+R_3} = \dfrac{120\cos 120\pi t}{60}$

$= 2\cos 120\pi t\ [A]$

Average power in Light Bulb 1

$$P_1 = \frac{1}{T}\int_0^T v_1(t)\, i(t)\, dt$$

$$= \frac{1}{T}\int_0^T R\, i^2(t)\, dt$$

$v_1 = R_1 i$

$$= \frac{10}{T}\int_0^T \left[2\cos 120\pi t\right]^2 dt$$

$$= \frac{10\times 4}{T}\int_0^T \cos^2 120\pi t\, dt$$

$$= \frac{40}{T}\int_0^T \frac{1}{2}\left(1+\cos 2(120\pi t)\right) dt$$

$\cos^2\theta = \frac{1}{2}(1+\cos 2\theta)$

$$= \frac{40}{T}\left[\frac{1}{2}T + \underbrace{\frac{1}{2}\int_0^T \cos 2(120\pi t)\, dt}_{=0}\right]$$

$= 20\,W$

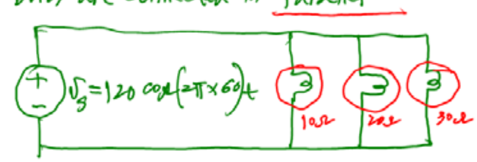
For Light Bulb 2 ($R_2 = 20\Omega$)

$P_2 = \frac{20}{10}[20W] = 40\,W$

$P_3 = \frac{30}{10}[20W] = 60\,W$

Total wattage $P_1 + P_2 + P_3 = \boxed{120\,W}$

If bulbs are connected in Parallel



Avg Power in bulb 1

$$P_1 = \frac{1}{T}\int_0^T v_s(t)\, i_1(t)\, dt = \frac{1}{T}\int_0^T \frac{v_s^2(t)}{R_1}\, dt$$

$$= \frac{1}{10\ T}\int_0^T [120 \cos 120\pi t]^2\, dt$$

$$= \frac{14400}{10T}\left[\frac{1}{2}\int_0^T (1 + \cos 240\pi t)\, dt\right]$$

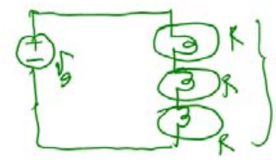
$$= \frac{144}{T}\left[\frac{1}{2}T + \underbrace{\frac{1}{2}\int_0^T \cos 240\pi t\, dt}_{=0}\right]$$

$$= 72\ W$$

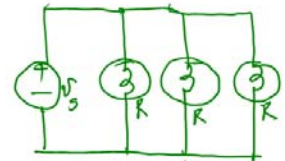
$$P_2 = 72\ W\left(\frac{10}{20}\right) = 36\ W \quad \left(P(t) = \frac{v_s^2(t)}{R}\right)$$

$$P_3 = 72W\left(\frac{10}{30}\right) = 24W$$

$$P_1 + P_2 + P_3 = 72 + 36 + 24 = \boxed{132\ W}$$



$R_T = 3R \quad P(t) = \frac{v_s^2(t)}{3R}$



$P(t) = \frac{v_s^2(t)}{R} \times 3$

9 time more wattage!

(Light Bulb at home are connected this way)

But if too many in parallel, then overload (shut off)

Chapter 2

Resistance

$$R[\Omega] = \rho \frac{l}{A}$$

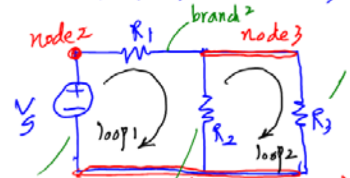
length [m]

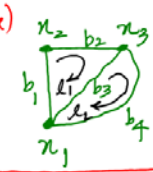
resistivity $[\Omega \cdot m]$

cross-sectional area $[m^2]$

Material	$\rho[\Omega \cdot m]$	Type
copper	1.72×10^{-8}	conductor
silicon	6.4×10^{2}	semiconductor
glass	10^{12}	insulator

Nodes, Branches, Loops



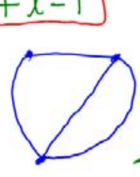


Let n = number of nodes
b = " branches
l = " independent loops

$\boxed{b = n + l - 1}$

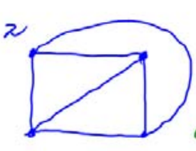
$\boxed{b = n + l - 1}$

Example 1



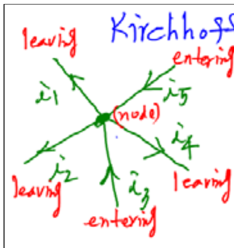
$n = 3$
$b = 4$
$l = 2$
$4 = 3 + 2 - 1$ (v)

Example 2



$n = 4$
$b = 6$
$l = 3$
$6 = 4 + 3 - 1$ (v)

Kirchhoff's Current Law (KCL)



$$\boxed{\sum_{k=1}^{B} i_{k(\text{leaving node})} = 0}$$

$$= -\sum_{k=1}^{B} i_{k(\text{entering})} = 0$$

$$= \boxed{\sum_{k=1}^{B} i_{k(\text{entering})} = 0}$$

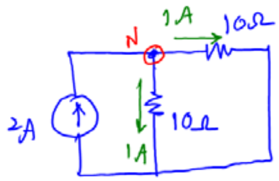
$i_1 + i_2 - i_3 + i_4 - i_5 = 0$, $(\Rightarrow \underbrace{i_1 + i_2 + i_4}_{\text{leaving}} = \underbrace{i_3 + i_5}_{\text{entering}})$

or $-i_1 - i_2 + i_3 - i_4 + i_5 = 0$

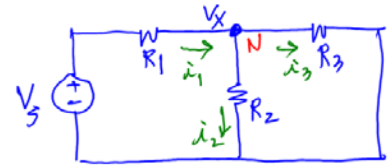
Another way of saying KCL is

$$\boxed{\sum i_k(\text{leaving}) = \sum i_k(\text{entering})}$$

Example



At N, by KCL
$-2+1+1=0$
or $+2-1-1=0$
or $2=1+1$ (v)

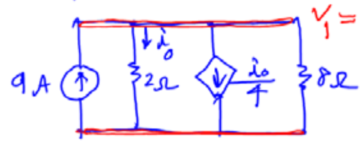


Applying KCL at node N,
current entering node N, $i_1 = \frac{V_s - V_x}{R_1}$
currents leaving node N,
$i_2 = \frac{V_x}{R_2}$, $i_3 = \frac{V_x}{R_3}$

$\Rightarrow \frac{V_s - V_x}{R_1} = \frac{V_x}{R_2} + \frac{V_x}{R_3}$ V_x = unknown

solve for V_x, then i_1, i_2, i_3 ⊠

Example Practice Prob. 2.7



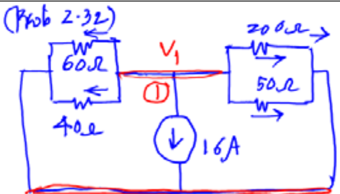
KCL $9 = i_o + \frac{i_o}{4} + \frac{V_1}{8}$ ($V_1 = 2i_o$)

$= i_o\left(1 + \frac{1}{4} + \frac{1}{4}\right)$

$i_o = \frac{9}{1.5} = 6[A]$

$V_1 = 2 i_o = 2[\Omega]\, 6[A] = 12[V]$

(Prob 2.32)



KCL at node 1

KCL $\sum i_k$ leaving $= 0$

$16 + \left(\frac{V_1}{200} + \frac{V_1}{50}\right) + \left(\frac{V_1}{60} + \frac{V_1}{40}\right) = 0$

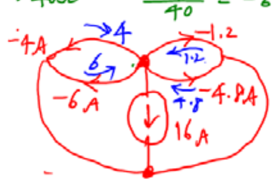
$16 + V_1\left(\frac{1}{200} + \frac{1}{50} + \frac{1}{60} + \frac{1}{40}\right) = 0$

$V_1 = -16 / \left(\frac{1}{200} + \frac{1}{50} + \frac{1}{60} + \frac{1}{40}\right)$, $= \frac{3+12+10+15}{600}$

$= -16/(40/600) = \boxed{-240V}$

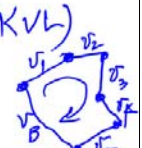
$i_{200\Omega} = -\frac{240}{200} = -1.2A$
$i_{50\Omega} = -\frac{240}{50} = -4.8A$
$i_{60\Omega} = -\frac{240}{60} = -4A$
$i_{40\Omega} = -\frac{240}{40} = -6A$

$\Big\}\ \sum i_k = -16A$



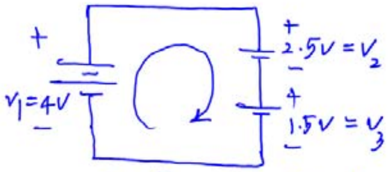
Kirchhoff's Voltage Law (KVL)

$$\boxed{\sum_k^{B\,(\text{in a loop})} v_k\,(\text{voltage drop}) = 0}$$



$$= \sum_k^{B} \left(-v_k(\text{voltage drop})\right) = 0$$

$$= \boxed{\sum_k^{B\,(\text{in a loop})} v_k\,(\text{voltage rise}) = 0}$$



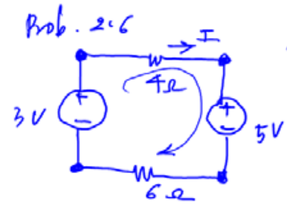
$\sum V_k = 0$ (KVL)

$-V_1 + V_2 + V_3 = 0$ $\quad V_1 = V_2 + V_3$

rise drop drop

$-4 + 2.5 + 1.5 = 0$ ✓

Prob. 2.6



$n = 4$
$b = 4$
$l = 1$

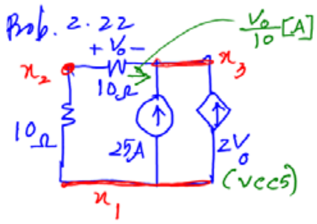
$b = n + l - 1$
$4 = 4 + 1 - 1$ ✓

KVL $\quad -3 + 4I + 5 + 6I = 0$

$2 + 10I = 0 \Rightarrow I = -\frac{2}{10}$
$= -0.2$ [A]

0.2A current flows in opposite (−) direction

Prob. 2.22



KCL at n_3 (sum of current entering = 0)

$\frac{V_0}{10} + 25 + 2V_0 = 0$

$2.1V_0 + 25 = 0 \Rightarrow V_0 = -\frac{25}{2.1} = -11.8$ V

V_0 polarity is reversed
+11.8 V in opposite direction