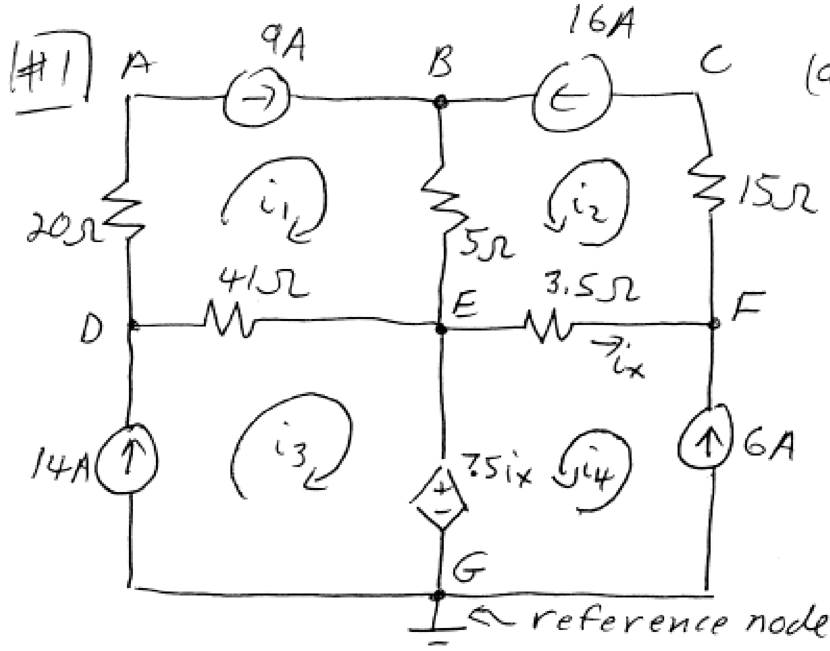
#1



(a) We are looking for voltages, but many currents sources are given ∴ use the Mesh method.

We are given all the mesh currents!

$i_1 = 9A$
$i_2 = 16A$
$i_3 = 14A$
$i_4 = 6A$

Now, add or subtract mesh currents to obtain branch currents and use the definition of voltage, ie potential difference, to find node voltages, e.g. $V_A = V_{AG} = V_{AD} + V_{DE} + V_{EG}$ or $V_A = V_{AD} + V_{DG}$.

Step 1: $i_x = i_2 - i_4 = 10A \Rightarrow V_E = V_{EG} = 7.5 i_x = 75V$

Step 2: $V_D = V_{DE} + V_{EG} = V_{DE} + V_E = (i_3 - i_1) \times 41\Omega + V_E$
$= V_{DG}$ $\qquad = 5 \times 41\ V + 75V = 280V$

Step 3: $V_A = V_{AD} + V_{DG} = -i_1 \times 20\Omega + V_{DG} = -9 \times 20 + 280 = \underline{\underline{100V}}$

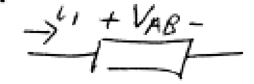
Step 4: $V_B = V_{BE} + V_{EG} = (i_1 + i_2) \times 5\Omega + V_{DG} = 25 \times 5 + 75 = \underline{\underline{200V}}$

Also, for practice: $V_F = (i_4 - i_2) \times 3.5 + V_E = -10 \times 3.5 + 75 = 40V$
$V_C = -i_2 \times 15 + V_F = -16 \times 15 + 40 = -200V$

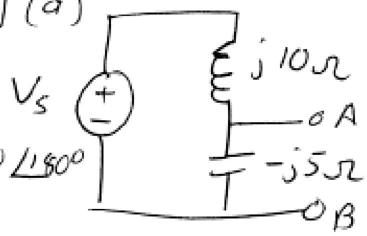
In summary, we have found all node voltages relative to the ground node, G: $V_A = 100V$, $V_B = 200V$, $V_C = -200V$, $V_D = 280V$
$V_E = 75V$, $V_F = 40V$.

(b) $V_{BA} = V_B - V_A = 200 - 100 = 100V$ } since i_1 <u>leaves</u> the positive
$V_{BA} \times i_1 = 100 \times 9 = 900W$ } node of V_{BA}, power is generated.

or: $P_{Active} = V_{BA} \times i_1$ [active notation ]
$= 900W > 0$ ∴ generated.

or: $P_{passive} = V_{AB} \times i_1$ [passive notation ]
$= -100V \times 9A = -900W < 0$ ∴ generated.

#2 (a)



$V_T = V_{AB}$ open circuit

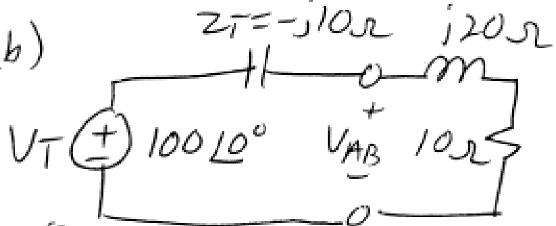
$$= \frac{-j5}{j10 - j5} \times (-100V) \quad \Leftarrow 100\angle 180^\circ$$

↖ voltage division factor

$$= -\tfrac{1}{2} \times -100V = \underline{\underline{100\angle 0^\circ\ V}}$$

Now let $V_S = 0 \Rightarrow Z_T = -j5 \,//\, j10 = \frac{-j5 \times j10}{j5} = \frac{50}{j5} = \underline{\underline{-j10\Omega}}$

(b)



step ①

$$V_{AB} = 100V \times \frac{10 + j20}{10 + j20 - j10} = 100 \times \frac{10 + j20}{10 + j10} \quad (*)$$

$$= 100 \times \frac{\sqrt{5}}{\sqrt{2}} \angle 63^\circ - \angle 45^\circ$$

$\leftarrow \tan^{-1}\frac{20}{10}$ $\quad \leftarrow \tan^{-1}\frac{10}{10}$

$\nwarrow \frac{|10+j20|}{|10+j10|} = \frac{|1+j2|}{|1+j1|} = \frac{\sqrt{1^2+2^2}}{\sqrt{1^2+1^2}}$

$$= \underline{\underline{158\angle 18^\circ\ V}}$$

$\Rightarrow \boxed{V_{AB}(t) = 158\cos(\omega t + 18^\circ)\ V \text{ where } \omega = 2\pi 60 = 377\ \text{rad/s}}$

step ②

$$I_O = \frac{V_T}{-j10 + j20 + 10} \quad \text{or} \quad \frac{V_{AB}}{10 + j20} \leftarrow \text{use } (*)$$

$$= \frac{100}{10 + j10}$$

$$= \underline{\underline{\frac{10}{\sqrt{2}} \angle -45^\circ\ A}}$$

$\Rightarrow \boxed{I_O(t) = 7.07\cos(\omega t - 45^\circ)\ A, \ \omega = 377\ \text{rad/s}}$

$$P_{out} = \frac{|V_{AB}|}{\sqrt{2}} \times \frac{|I_o|}{\sqrt{2}} \cos(\theta_{V_{AB}} - \theta_{I_o})$$

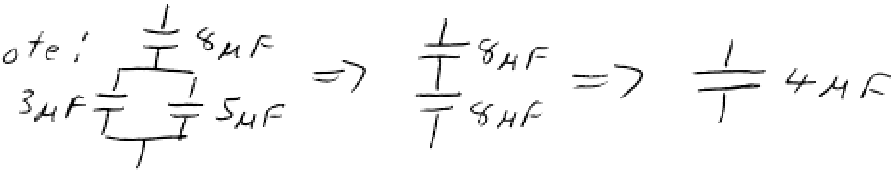
$$= \frac{158}{\sqrt{2}} \times 5 \cos 63^\circ$$

$$= \underline{\underline{250W}}$$

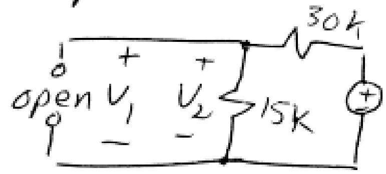
or $P_{out} = I_{O\,rms}^2 \times R = 5^2 \times 10 = \underline{\underline{250W}}$

$P_{L\,avg} = 0$ since an inductor does not dissipate energy.

#3 First note:



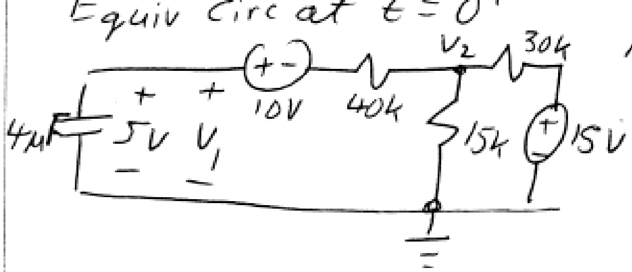
Equiv Circuit at $t=0^-$



$$\underline{V_1(0^-)} = \frac{15k}{15k+30k} \times 15V = \boxed{5V}$$

$$\underline{V_2(0^-)} = V_1(0^-) = \boxed{5V}$$

Equiv Circ at $t=0^+$



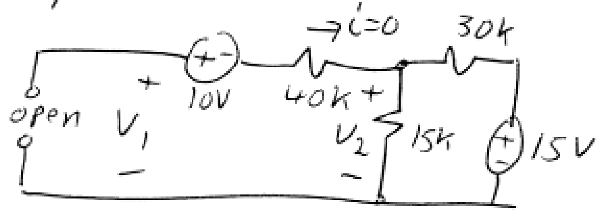
Note: $V_{cap}(0^+) = V_{cap}(0^-) \Rightarrow \underline{V_1(0^+)} = \boxed{5V}$

Find $V_2(0^+)$. Let's use Node Method

$$\frac{V_2 - (5V - 10V)}{40k} + \frac{V_2}{15k} + \frac{V_2 - 15V}{30k} = 0$$

$$\Rightarrow \underline{V_2(0^+)} = \boxed{3V}$$

Equiv Circ at $t=\infty$



$$\underline{V_2(\infty)} = \frac{15k}{45k} \times 15V = \boxed{5V}$$

$$\underline{V_1(\infty)} = V_2(\infty) + i \times 40k + 10V = \boxed{15V}$$

Equiv Circ at $t>0$ with sources set to zero:

The resistance "seen" by the capacitor is

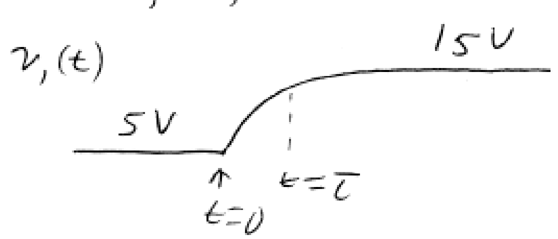
$$R_{eq} = 40k + 15k // 30k$$
$$= 40k + 10k = 50k\Omega$$

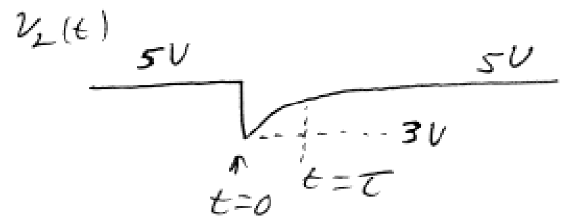
$$\therefore \tau = R_{eq} C_{eq} = 50k \times 4\mu = \underline{200\,ms}$$

For graphs note $V(0^-)$, $V(0^+)$, $V(\infty)$

V_1: 5V, 5V, 15V

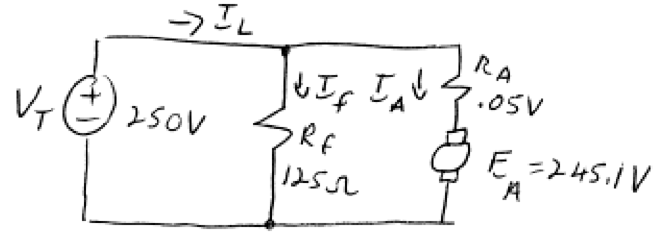
V_2: 5V, 3V, 5V





$\boxed{\#4}$ (a) DC Steady State Model

Note: $V_{inductor} = 0$



$n_{rat} = 4500\,rpm \Rightarrow \omega_{rat} = 2\pi \times \frac{4500}{60}$
$= 471.24\,\frac{rad}{s}$

$P_{out} = P_{motor} = 30HP = 30HP \times 746\frac{W}{HP}$
$= 22380W$

(a) cont'd

$I_f = \frac{250V}{125\Omega} = 2A$

$I_A = \frac{250V - 245.1V}{.05\Omega} = 98A$

$\therefore I_L = I_f + I_A = \underline{\underline{100A}}$

$P = T\omega \Rightarrow T_{out} = \frac{P_{out}}{\omega} = \frac{22380W}{471.24\frac{rad}{s}}$
$= \underline{\underline{47.49Nm}}$

Field loss $= I_f^2 R_f = \underline{\underline{500W}}$

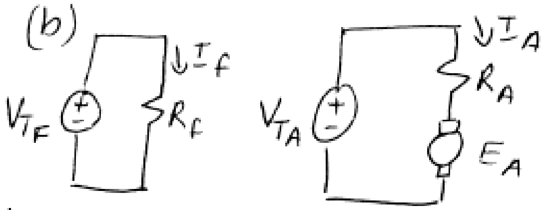
Arm loss $= I_A^2 R_A = \underline{\underline{480.2W}}$

$E_A I_A = P_{out} + P_{fric}$

$\therefore P_{fric} = E_A I_A - P_{out}$
$= 245.1 \times 98 - 22380 = \underline{\underline{1640W}}$

$\eta = \frac{P_{out}}{P_{in}} = \frac{22380}{250 \times 100} = 89.52\%$

(b)



$V_{TF} = 250V$ $\qquad V_{TA} = ?$

I_f still 2A $\therefore k\phi$ same as in part (a)

$\left.\begin{array}{l}\therefore E_A \propto n \Rightarrow E_A = \frac{1500rpm}{4500rpm} \times 245.1V \\ = 81.7V\end{array}\right\} *$

Since $T_{out} = const$

$\Rightarrow P_{out} = \frac{1500}{4500} P_{rated} = \frac{1}{3} \times 10HP = 7460W$

But $E_A I_A = P_{out} + \cancel{P_{fric}}$ → given ≈ 0

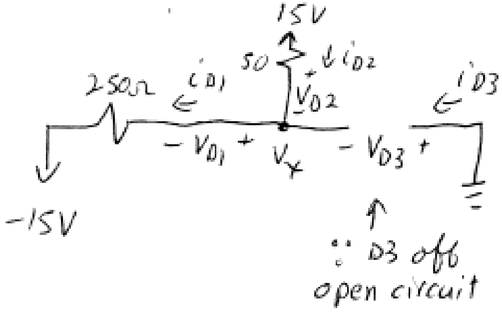
$87.1 \times I_A = 7460W \Rightarrow I_A = \cancel{4.6A}\ 91.3A$

$\therefore V_{TA} = E_A + I_A R_A = 81.7V + 91.3 \times 0.05$
$= 81.7V + 4.6V$
$= \underline{\underline{86.3V}}$

$*$ Alternative way: From (a) $E_A = k\phi\omega \Rightarrow k\phi = \frac{E_A}{\omega} = \frac{245.1}{471.24} = 0.5201$

$\therefore$ For (b) $E_A = k\phi \times \omega = 0.5201 \times 2\pi \left(\frac{1500}{60}\right) = 81.7V$

#5 By the method of assumed states (ie trial and error) we determine that we have D1 on, D2 on, D3 off:



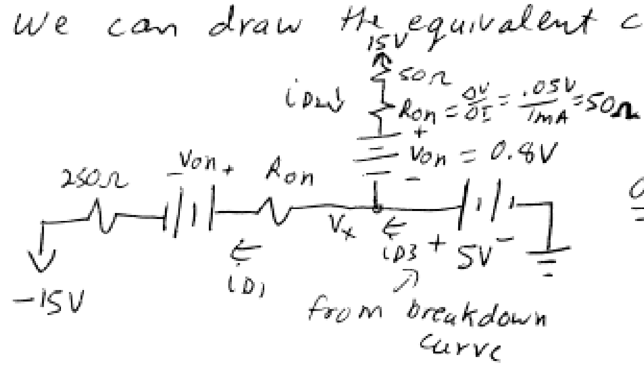
$i_{D3} = 0$

let $i = i_{D1} = i_{D2} = \frac{V_{total}}{R_{total}} = \frac{30V}{300\Omega} = 100\,mA$

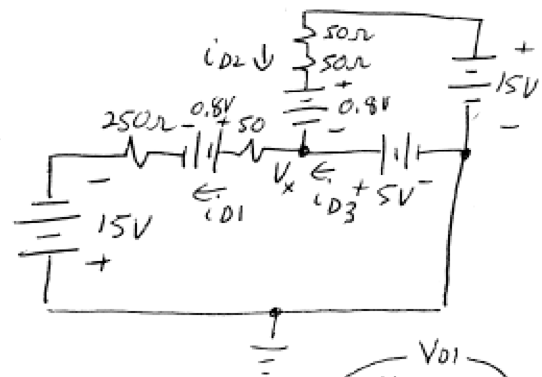
$V_{D1} = V_{D2} = 0$

$V_x = -15V + i \times 250 = 10V \Rightarrow V_{D3} = -10V$

(b) Now assume D1 on, D2 on, D3 in breakdown:
We can draw the equivalent circuit many ways. Here are 2 ways:



or



Using either of these circuits:

$i_{D1} = \frac{15V + V_x - V_{on}}{250 + R_{on}} = \frac{15 + 5 - .8}{300} = 64\,mA$

$i_{D2} = \frac{-V_{on} - 5V + 15V}{50 + R_{on}} = \frac{-.8 - 5 + 15}{100} = 92\,mA$

By KCL

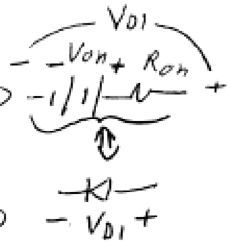
$i_{D3} = i_{D1} - i_{D2}$

$= 64mA - 92mA$

$= -28\,mA$

Note: $1mA = 0.001A = 10^{-3}A$

Noting on diode $\Leftrightarrow$



$V_{D1} = V_{on} + i_{D1} R_{on}$

$= 0.8V + 0.064 \times 50$

$= 0.8 + 3.2\ V$

$= 4.0V$

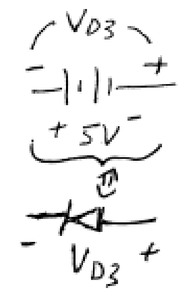
$V_{D2} = V_{on} + i_{D2} R_{on}$

$= 0.8V + 0.092 \times 50$

$= 0.8 + 4.6V$

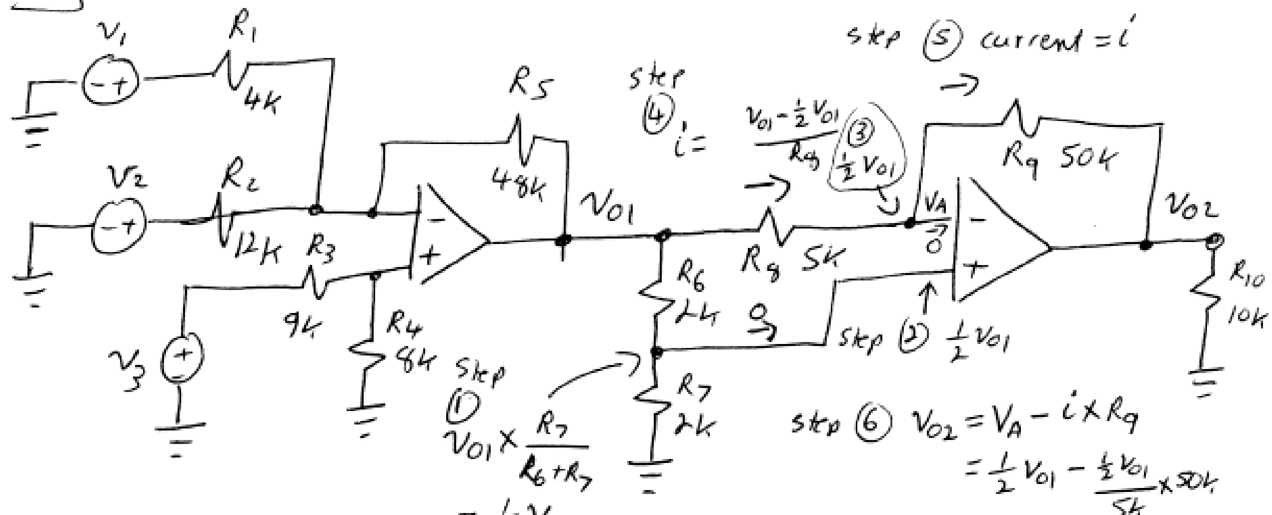
$= 5.4V$

Noting breakdown diode:



$\therefore V_{D3} = -5V$

#6 (a)



step ⑥ $v_{02} = V_A - i \times R_9$

$= \frac{1}{2}v_{01} - \frac{\frac{1}{2}v_{01}}{5k} \times 50k$

$= -4.5\, v_{01}$

step ⑦ $v_{02}/v_{01} = \underline{\underline{-4.5}}$

(b) Use superposition with sources v_1, v_2, v_3.

$v_2 = 0,\ v_3 = 0 \Rightarrow \frac{v_{01}}{v_1} = -\frac{R_5}{R_1} = -\frac{48k}{4k} = -12$

$v_1 = 0,\ v_3 = 0 \Rightarrow \frac{v_{01}}{v_2} = -\frac{R_5}{R_2} = -\frac{48}{12} = -4$

$v_1 = 0,\ v_2 = 0 \Rightarrow \frac{v_{01}}{v_3} = \frac{R_4}{R_3 + R_4} \times \left(1 + \frac{R_5}{R_1 // R_2}\right) = \frac{8}{17} \times \left(1 + \frac{48}{3}\right) = 8$

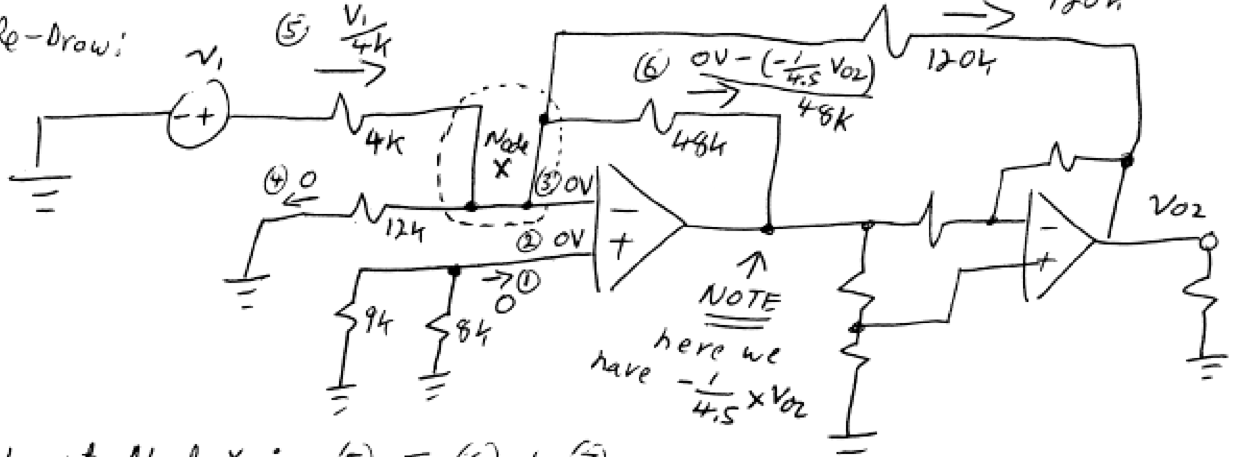
$\therefore\ v_{02}/v_1 = -12 \times (-4.5) = 54$

$v_{02}/v_2 = -4 \times (-4.5) = 18$

$\frac{v_{02}}{v_3} = 8 \times (-4.5) = -36$

$\therefore\ v_{02}(t) = 54\, v_1(t) + 18\, v_2(t) - 36\, v_3(t)$ //

(c) Re-Draw:



KCL at Node X : ⑤ = ⑥ + ⑦

$$\frac{v_1}{4k} = \frac{1}{48k} \times \frac{1}{4.5} v_{02} - \frac{v_{02}}{120k}$$

$$\frac{v_1}{4k} = v_{02}\left(\frac{1}{216k} - \frac{1}{120k}\right) = -\frac{v_{02}}{270k}$$

$$\Rightarrow \frac{v_{02}}{v_1} = -\frac{270}{4} = \underline{\underline{-67.5}}$$

Note: Parts (a), (b) & (c) could also have been solved with Node Analysis.

May 2005 - EPN