Name Master

ECE 241 Winter 2008
Test #1

Time allowed: 1 hour 50 minutes; calculator permitted.

Closed book; one-side 8½x11in "crib-sheet" permitted; (turn in the crib sheet with the test paper.)

Answer questions on these pages. If you need more space, use the back of the page.

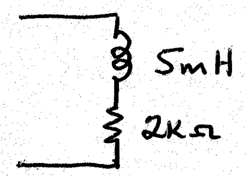
Answer all TEN questions, which are equally weighted at 10% each.

In all your answers, state all approximations clearly, and explain each step succinctly.

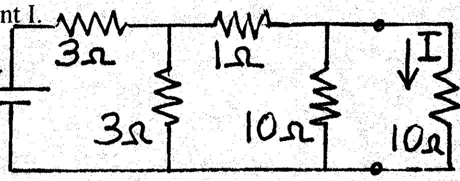
1 [AP 1.5] Laboratory tests on a coil show that:
A change in current from +10mA to -10mA over 50µs results in an average voltage of 2V
A steady current of 10mA requires a power input of 0.2W.
Devise a linear circuit model to represent the coil.

$$2V = L\frac{\Delta I}{\Delta T} = L\frac{20\times10^{-3}}{50\times10^{-6}} \quad \therefore L = \frac{2\times50\times10^{-6}}{20\times10^{-3}} = 5mH$$

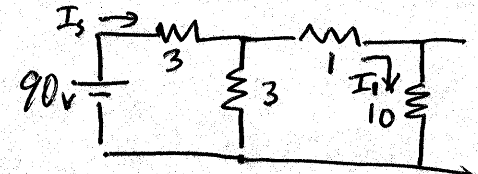
$$P = I^2R = (10^{-2})^2R = 0.2 \quad \therefore R = .2\times10^4 = 2k\Omega$$



2. [P 2.16] Find the Thevenin equivalent of the source in order to calculate current I.



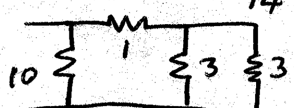
No dependent sources, Find V_{oc} & R_T

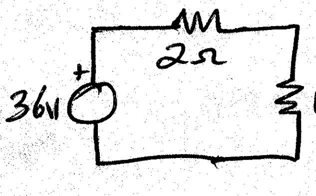


$$V_{oc} = 10\Omega . I_1 = 10\frac{3}{3+11}I_s = \frac{30}{14}\frac{90}{3+3//11}$$

$$= \frac{30}{14}\frac{90}{3+\frac{33}{14}} = \frac{30\times90}{42+33} = \frac{30\times90}{75} = 36V$$

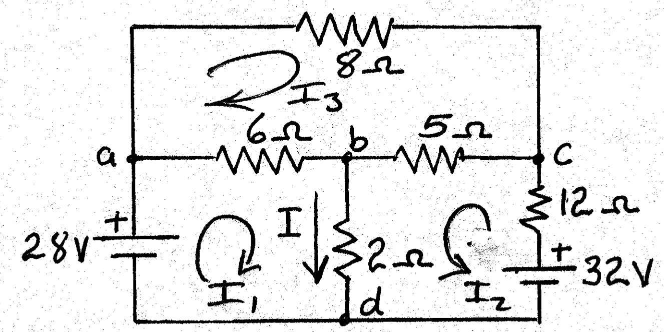
$3//11 = \frac{33}{14}\Omega$

$R_T \rightarrow$  $= 10//2\frac{1}{2} = \frac{25}{12.5} = 2\Omega$



$\therefore I = \frac{36V}{12\Omega}$

I = 3A



3. [P2.12(b)] Use the mesh (loop) current method to find I in the figure above.

$$28 = 6(I_1 - I_3) + 2(I_1 + I_2) \qquad 8I_1 + 2I_2 - 6I_3 = 28$$
$$32 = 12I_2 + 5(I_2 + I_3) + 2(I_1 + I_2) \qquad 2I_1 + 19I_2 + 5I_3 = 32$$
$$8I_3 = 6(I_1 - I_3) - 5(I_2 + I_3) \qquad 6I_1 - 5I_2 - 19I_3 = 0$$

$$\left.\begin{array}{l} 8I_1 + 76I_2 + 20I_3 = 128 \\ 8I_1 + 2I_2 - 6I_3 = 28 \end{array}\right\} . \; 74I_2 + 26I_3 = 100 \rightarrow 1258I_2 + 442I_3 = 1700$$

$$\left.\begin{array}{l} 6I_1 + 57I_2 + 15I_3 = 96 \\ 6I_1 - 5I_2 - 19I_3 = 0 \end{array}\right\} \; 62I_2 + 34I_3 = 96 \rightarrow 806I_2 + 442I_3 = 1248$$

$$\therefore 452I_2 = 452, \; I_2 = 1A$$

$$\therefore I_3 = \frac{96 - 62}{34} = 1A \qquad \& \; I_1 = \frac{5I_2 + 19I_3}{6} = 4A$$

$$\therefore I = I_1 + I_2 = 5A$$

I = 5A

4. [P2.12(c)] Use the node voltage method to find I in the figure above.

$$\frac{28 - V_b}{6} = \frac{V_b}{2} + \frac{V_b - V_c}{5} \rightarrow 140 - 5V_b = 15V_b + 6V_b - 6V_c$$
$$140 = 26V_b - 6V_c$$

$$\frac{32 - V_c}{12} = \frac{V_c - V_b}{5} + \frac{V_c - 28}{8} \rightarrow 320 - 10V_c = 24V_c - 24V_b + 15V_c - 420$$
$$740 = -24V_b + 49V_c$$

ie. $$\left.\begin{array}{l} 6860 = 1274V_b - 294V_c \\ 4440 = -144V_b + 294V_c \end{array}\right\} \rightarrow 11300 = 1130V_b$$

$$\therefore V_b = 10v$$
$$\& \; I = \frac{V_b}{2\Omega} = 5A$$

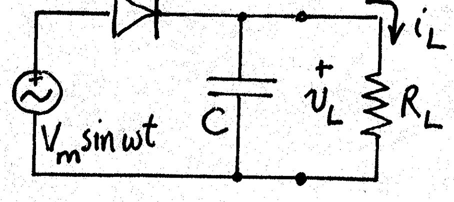
I = 5A

5. [3.30] For V_m=20V at 60Hz, R_L=10kΩ, C=100μF, find:

(a) The DC load current I_L in R_L

(b) The ripple voltage V_r in v_L.

State assumptions clearly.



Assume ideal diode

Assume ripple small, so $I_L \approx V_m/R_L = 20v/10k\Omega = 2mA$

$$V_r = V_{DC}\frac{T}{R_L C} = 20v\,\frac{1/60}{10^4 \times 10^{-4}} = 1/3\,v$$

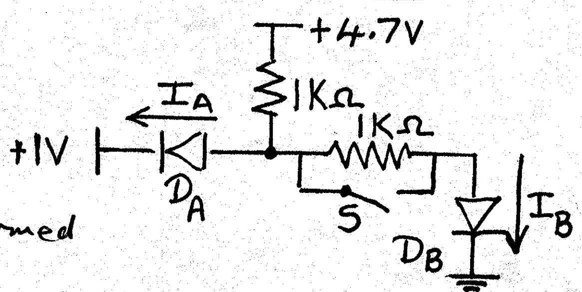
(a) I_L = 2mA (b) V_r = 0.33V

6. [11.28] Estimate I_A and I_B for:

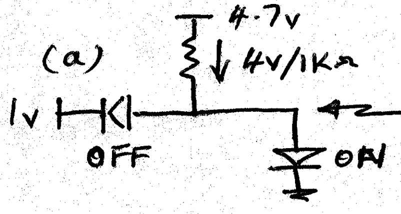
(a) Switch S closed and (b) Switch S open

Indicate clearly whether the diodes are ON or OFF

Assume V_{ON}=0.7V

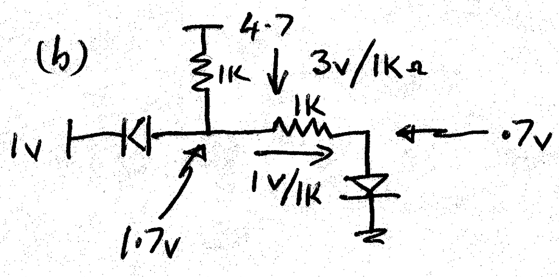


(a)



← 0.7v ∴ D_A off confirmed

(b)



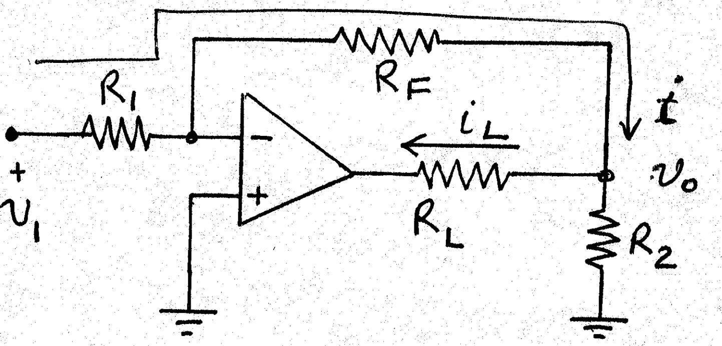
(a) D_A is ON OFF D_B is ON OFF

I_A = 0 I_B = 4mA

(b) D_A is ON OFF D_B is ON OFF

I_A = 2mA I_B = 1mA

7. [P16.16] Derive an expression for i_L in terms of the quantities shown on the figure, and show that it is independent of R_L.



Assume ideal op amp

$\therefore$ no input current

$v^- - v^+ = 0$

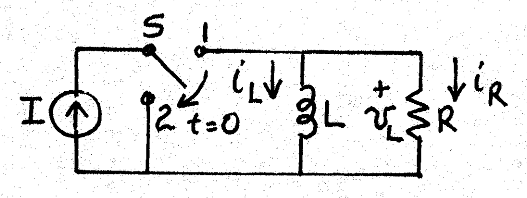
$$\therefore i = \frac{v_1}{R_1} = \frac{0 - v_o}{R_F} = i_L + \frac{v_o}{R_2}$$

$$\therefore i_L = -\frac{v_o}{R_F} - \frac{v_o}{R_2} = -v_o\left(\frac{1}{R_F} + \frac{1}{R_2}\right) = \left(\frac{1}{R_F} + \frac{1}{R_2}\right)\frac{R_F}{R_1} v_1$$

$$= \frac{1}{R_1}\left(1 + \frac{R_F}{R_2}\right)v_1$$

8. [P4.3] Switch S has been in position 1 for a long time.

(a) What is $v_L(0)$, $i_R(0)$, $i_L(0)$?



$v_L(0) =$ 0 V $i_R(0) =$ 0 A $i_L(0) =$ I

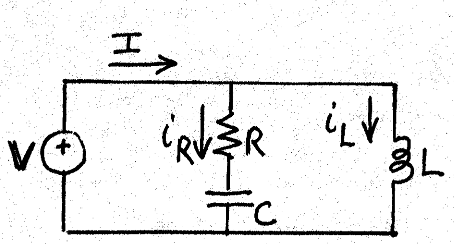
(b) Switch S moves to position 2 at t=0$^+$. Now what are $i_L(0^+)$, $i_R(0^+)$, $v_L(0^+)$, and di_L/dt at t=0$^+$?

$i_L(0^+) =$ I $i_R(0^+) =$ −I $v_L(0^+) =$ −IR di_L/dt (at t=0$^+$) = $\frac{1}{L}(-IR) = -I\frac{R}{L}$

(c) Write an equation for $v(t)$ for t>0. $v_L(t) = -IR\, e^{-t/(L/R)}$

(c) Write an equation for $i_L(t)$ for t>0. $i_L(t) = I\, e^{-t/(L/R)}$

9. [5.17] **V** = V$\underline{/\ 0°}$, R=2Ω, L=0.3H, i_R=10√2. cos(10*t*+45°).
(a) Draw a phasor diagram showing:
$\mathbf{I}_R$, $\mathbf{V}_R$, $\mathbf{V}_C$, and $\mathbf{V}_L$ (= **V**)
(b) Hence determine *v*(*t*).



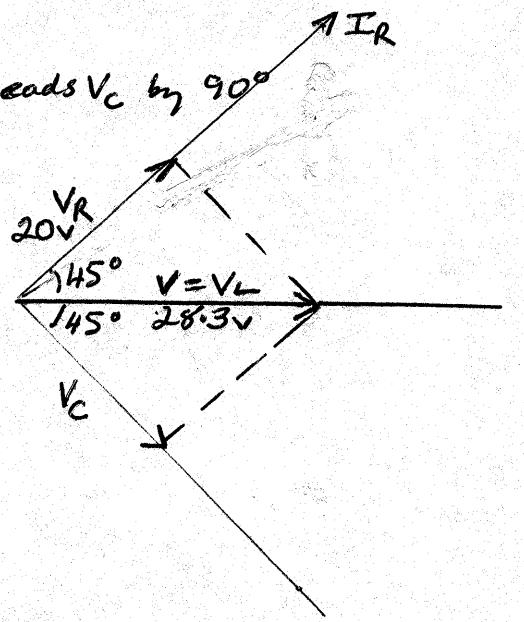
$\bar{I}_R = 10 \angle 45°$ A

$\bar{V}_R = 20 \angle 45°$ V

$\bar{V}_C = ?\ \angle -45°$ since $I_C = I_R$ leads V_C by 90°

$\hat{V} = \hat{V}_R + \hat{V}_C$

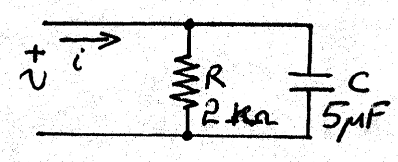
$\hat{V}_L = \hat{V}$



$|V_L| = 20\sqrt{2}$

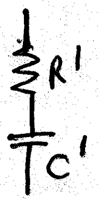
v(*t*).= $40 \cos 10t$

10.[5.20] Determine the two components of a <u>series</u> circuit with the same terminal admittance at ω = 1000rad/s as the circuit shown.



$Y = \frac{1}{R} + j\omega C = \frac{1}{R}(1 + j\omega RC)$

$Z = \frac{R}{1 + j\omega C}$



$Z' = R' + \frac{1}{j\omega C'} = \frac{1 + j\omega R'C'}{j\omega C'}$

For these to be equal

$Z = Z' = \frac{R}{1 + j\omega RC} = \frac{1 + j\omega R'C'}{j\omega C'}$

$j\omega RC' = 1 - \omega^2 RCR'C' + j\omega(RC + R'C')$

$\therefore\ \omega^2 RCR'C' = 1$

& $RC' = RC + R'C'$

$= RC + \frac{1}{\omega^2 RC}$

$\therefore C' = C + \frac{1}{\omega^2 R^2 C} = C\left(1 + \left(\frac{1}{\omega RC}\right)^2\right)$

$\omega RC = 10^3 \times 2 \times 10^3 \times 5 \times 10^{-6}$

$= 10$

∴ From results below

$C' = 5\mu F(1 + (1/10)^2)$

$= 5.05\mu F$

$R' = \frac{2k\Omega}{1 + (10)^2} = \frac{2k\Omega}{101}$

$= 19.8\Omega$

$R' = \frac{1}{\omega^2 RC}\frac{1}{C'} = \frac{1}{C}\ \frac{1/\omega^2 RC}{1 + (1/\omega RC)^2}$

$= \frac{R}{1 + (\omega RC)^2}$