

# ECE 110 Spring 2018 Test II

Note Title

I (1)  $v = L \frac{di}{dt}$        $v = iR$        $i = C \frac{dv}{dt}$

(2)  $\frac{1}{2} Li^2$        $\frac{1}{2} Cv^2$

(3) voltage across ... current through

(4)  $3 \sin(17t + 17^\circ) \rightarrow 3 \cos(17t - 72^\circ)$   
 $3 \angle -72^\circ + 2 \angle -41^\circ = 4.83 \angle -59.7^\circ$   
 $4.83 \cos(17t - 59.7^\circ)$

(5)  $Z = R + jX$   
 impedance      resistance      reactance

$Y = G + jB$   
 admittance      conductance      susceptance

(6) $\omega$	$V$ (V)	$I$ (mA)	$Z$ ( $\Omega$ )
10	$10 \angle 0^\circ$	$3.84 \angle 54.8^\circ$	$2604 \angle -54.8^\circ = 1501 - j2128$
20	$10 \angle 0^\circ$	$5.44 \angle 35.4^\circ$	$1838 \angle -35.4^\circ = 1498 - j1064$

Since R does not really change, series; since  $X < 0$ , capacitor

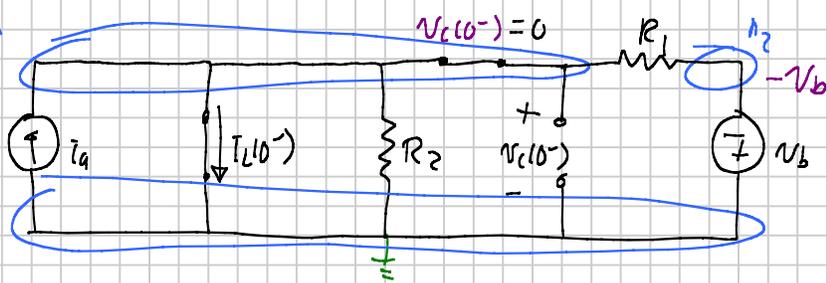
$R + \frac{1}{j\omega C}$

$R = 1500 \Omega$        $C = \frac{1}{\omega X} = 47 \mu F$

(can check w/ either  $Z$ )

$\mathbb{R}$

$t=0^-$



$v_C(0^-) = 0$ ; shorted by inductor

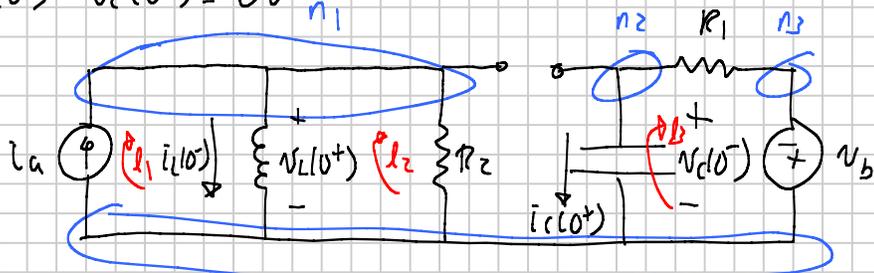
$$\text{KCL, } n_1: -i_a + i_L(0^-) + \frac{0}{R_2} + \frac{0 + v_b}{R_1} = 0$$

$$i_L(0^-) = i_a - \frac{v_b}{R_1} = 5 \text{ mA}$$

(1)  $i_L(0^+) = i_L(0^-) = 5 \text{ mA}$

(3)  $v_C(0^+) = v_C(0^-) = 0 \text{ V}$

$t=0^+$



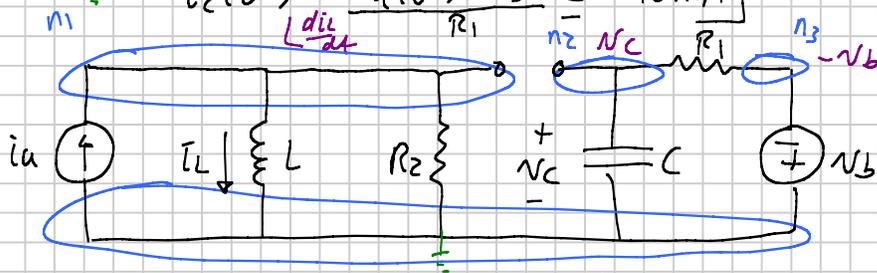
(2)  $\text{KCL, } n_1: -i_a + i_L(0^+) + \frac{v_L(0^+)}{R_2} = 0$

$$v_L(0^+) = R_2(i_a - i_L(0^+)) = 40 \text{ V}$$

(4)  $\text{KVL, } l_3: -v_C(0^+) - R_1 i_C(0^+) - v_b = 0$

$$i_C(0^+) = \frac{-v_C(0^+) - v_b}{R_1} = -10 \text{ mA}$$

$t > 0$



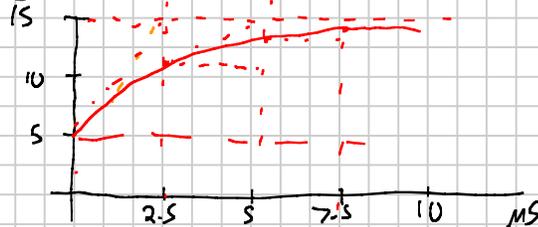
(5)  $\text{KCL, } n_1: -i_a + i_L + \frac{L}{R_2} \frac{di_L}{dt} = 0$

$$\frac{L}{R_2} \frac{di_L}{dt} + i_L = i_a$$

$$i_L(0^-) = 2 \text{ mA} \quad i_L(\infty) = i_a = 15 \text{ mA} \quad \tau = \frac{L}{R} = 2.5 \text{ ms}$$

$$i_L(t) = i_L(\infty) + (i_L(0^-) - i_L(\infty)) e^{-t/\tau}$$

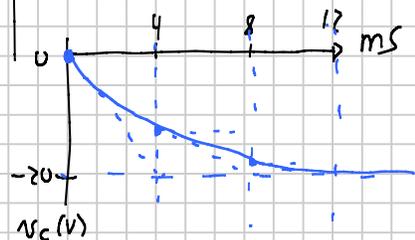
$$i_L(\text{mA}) = (15 - 10 e^{-t/2.5 \cdot 10^{-3}}) \text{ mA}$$



(6)  $\text{KCL, } n_2: C \frac{dv_C}{dt} + \frac{v_C + v_b}{R_1} = 0$

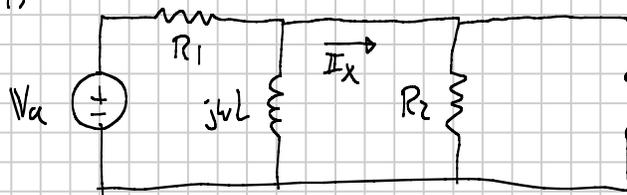
$$R_1 C \frac{dv_C}{dt} + v_C = -v_b$$

$$v_C(0^-) = 0 \quad v_C(\infty) = -v_b = -20 \text{ V} \quad \tau = R_1 C = 4 \text{ ms}$$



II

(1)

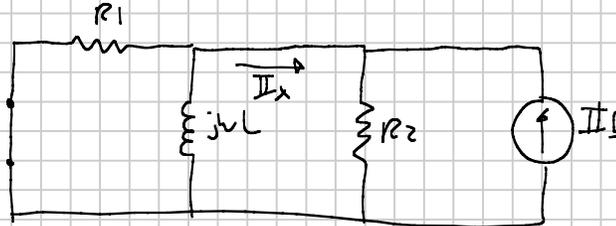


$$Z_{LR2} = \frac{j\omega L R_2}{j\omega L + R_2}$$

$$V_{R2} = \frac{V_a Z_{LR2}}{R_1 + Z_{LR2}} = V_a \frac{j\omega L R_2}{R_1 + \frac{j\omega L R_2}{j\omega L + R_2}} = \frac{V_a j\omega L R_2}{j\omega L R_1 + j\omega L R_2 + R_1 R_2}$$

$$I_x = \frac{V_{R2}}{R_2} = \frac{V_a j\omega L}{j\omega L (R_1 + R_2) + R_1 R_2} \quad H_a = \frac{I_x}{V_a} = \frac{j\omega L}{j\omega L (R_1 + R_2) + R_1 R_2}$$

(2)



$$Z_{LR1} = \frac{j\omega L R_1}{j\omega L + R_1}$$

$$I_x = \frac{-I_b R_2}{R_2 + Z_{LR1}} = \frac{-I_b R_2}{R_2 + \frac{j\omega L R_1}{j\omega L + R_1}} = \frac{-I_b (R_2 (j\omega L + R_1))}{j\omega L (R_1 + R_2) + R_1 R_2}$$

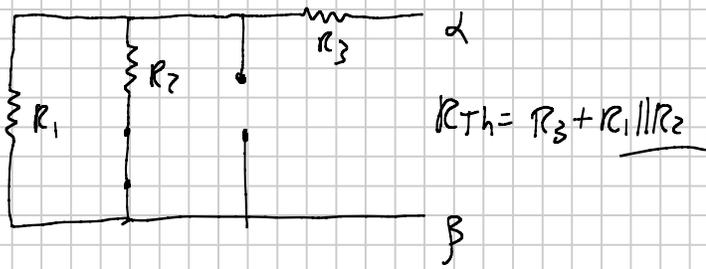
$$H_b = \frac{I_x}{I_b} = \frac{-R_2 (j\omega L + R_1)}{j\omega L (R_1 + R_2) + R_1 R_2}$$

$$(3) \quad [H_a] = \frac{A}{V} = \mathcal{U} \quad [H_b] = \frac{A}{A} = 1$$

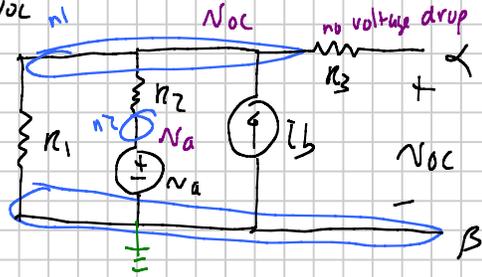
(4)	$\omega$	$V_a$	$I_b$	$H_a$	$H_b$	$I_x = V_a H_a + I_b H_b$
	0	6	$5 \cdot 10^{-3}$	0	-1	$-5 \cdot 10^{-3}$
	500	$4 \angle 0^\circ$	$2 \cdot 10^{-3} \angle 0^\circ$	$6.25 \cdot 10^{-6} \angle 88^\circ$	$1 \angle 178.6^\circ$	$2 \cdot 10^{-3} \angle 177.8^\circ$
	$10^5$	$8 \angle 0^\circ$	0	$1.97 \cdot 10^{-4} \angle 9.1^\circ$	NR	$1.58 \cdot 10^{-3} \angle 9.09^\circ$

$$i_x(t) = -5 + 2 \cos(500t + 177.8^\circ) + 1.58 \cos(10^5 t + 9.09^\circ) \text{ mA}$$

IV) Since only independent sources, turn them off to get  $R_{Th}$

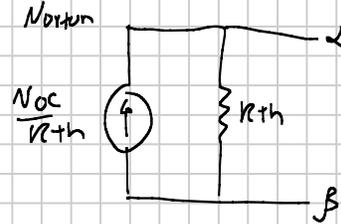
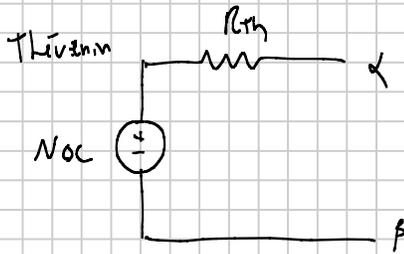


Find  $V_T = V_{OC}$



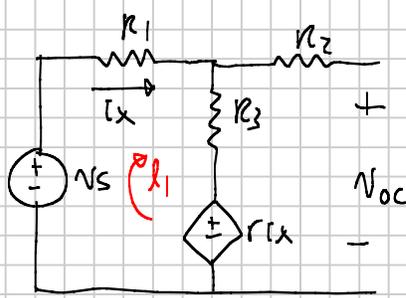
$$KCL(m): \frac{V_{OC}}{R_1} + \frac{V_{OC} - V_a}{R_2} - I_b = 0$$

$$V_{OC} = \frac{V_a}{\frac{1}{R_1} + \frac{1}{R_2}} + I_b = \frac{V_a R_1 + I_b R_1 R_2}{R_1 + R_2}$$



(3)  $R_L = R_{Th}, \quad P_{max} = \frac{V_{OC}^2}{4R_{Th}}$

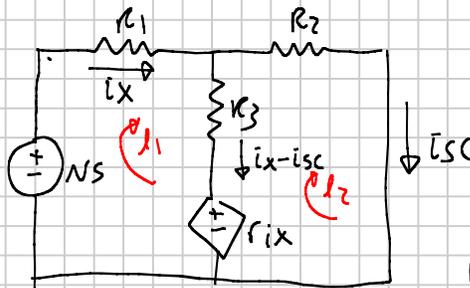
(5)



$$\text{KVL, } l_1: -V_s + R_1 i_x + R_3 i_x + r i_x = 0$$

$$i_x = \frac{V_s}{R_1 + R_3 + r}$$

$$V_{oc} = r i_x + R_3 i_x = \frac{V_s (R_3 + r)}{R_1 + R_3 + r}$$



$$\text{KVL, } s l_2: -V_s + R_1 i_x + R_2 i_{sc} = 0$$

$$i_x = \frac{V_s - R_2 i_{sc}}{R_1}$$

$$\text{KVL, } l_2: -r i_x - R_3 (i_x - i_{sc}) + R_2 i_{sc} = 0$$

$$(-r - R_3) \left( \frac{V_s - R_2 i_{sc}}{R_1} \right) + (R_2 + R_3) i_{sc} = 0$$

$$\left( \frac{r R_2}{R_1} + \frac{R_2 R_3}{R_1} + R_2 + R_3 \right) i_{sc} = \frac{(r + R_3) V_s}{R_1}$$

$$I_{sc} = \frac{(r + R_3) V_s}{R_1 R_2 + R_1 R_3 + R_2 R_3 + R_2 r}$$

$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{V_s (R_3 + r)}{R_1 + R_3 + r} \cdot \frac{R_1 R_2 + R_1 R_3 + R_2 R_3 + R_2 r}{(R_3 + r) V_s} = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3 + R_2 r}{R_1 + R_3 + r}$$

note: if  $r=0$ ,  $R_{th}$  should be  $R_2 + (R_1 \parallel R_3) = \frac{R_1 R_2 + R_1 R_3 + R_2 R_3}{R_1 + R_3}$  ✓

