ENEE 2301

Final Exam

Solutions

جامعة بيرزيت

BIRZEIT UNIVERSITY

Electrical & Computer Engineering Department

ENEE2301-Network Analysis 1

Final Exam-January 19th, 2016

Instructors: M. Jubeh , N. Ismail & Khader Mohammad

Student Name: **ID:** **Section:**

Notes and Instructions:

- **Read each question carefully before starting your solution and answer in the assigned space.**
- **Write neatly and clearly and leave only one answer for each question.**
- **Use of cell Phones is categorically prohibited so please make sure to turn them off.**
- **Percentage (%) of total mark is given for each question. Budget your time accordingly.**
- **The results of this exam will be evaluated according to ABET "a" and "e" student outcomes and the questions are designed for that.**

Part One:

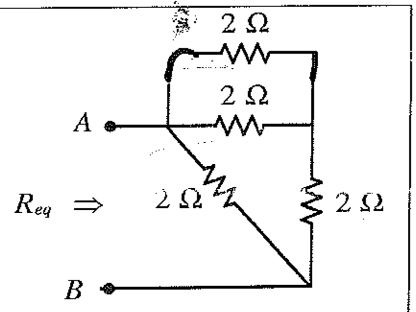
Problem1. (15 points) ***To assess "a" student outcome***

Choose the correct Answer:

1. The equivalent resistance R_{eq} between the two terminals A and B is

(I) 2 Ω (II) 2.8 Ω (III) 1 Ω (IV) 2.5 Ω

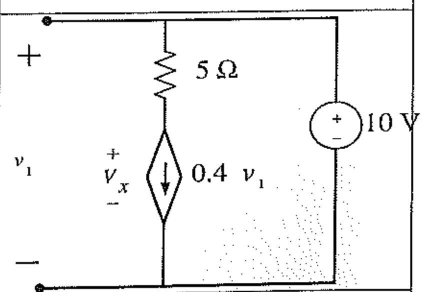
(V) 1.2 Ω (VI) 3 Ω (VII) 1.5 Ω (VIII) 3.3 Ω



2. In the circuit shown below, the value of V_x is

(I) 10 V (II) −10 V (III) 4 V (IV) −4 V

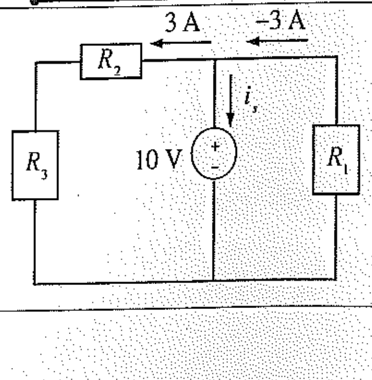
(V) −6 V (VI) 0 V (VII) 6 V (VIII) 5 V



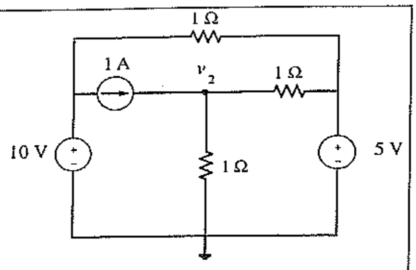
3. In the circuit shown below, the value of i_s and the power absorb by R_1 are

(I) 6A, −30W (II) −6A, −30W (III) 6A, 30W (IV) −6A, 30W

(V) 3A, −30W (VI) −6A, −60W (VII) −3A, 60W (VIII) 3A, 60W



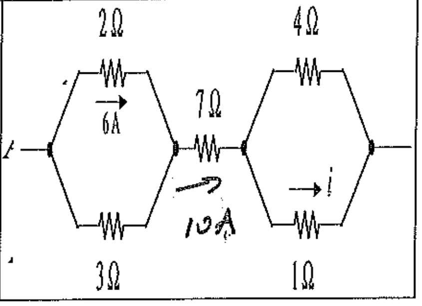
4. In the circuit shown below, the value of V_2 is :



(I) 2 V (II) -2 V (III) -5 V (IV) 5 V

(V) -3 V (VI) 3 V (VII) 0.5 V (VIII) -0.5 V

5. In the circuit shown below, the value of i is



(I) $\frac{24}{5}$ A (II) $-\frac{6}{5}$ A (III) $\frac{6}{5}$ A (IV) 2

(V) $-\frac{24}{5}$ A (VI) -8 A (VII) 8 A (VIII) -2

Problem2. (10 points) *To assess "a" student outcome*
For the circuit of Fig.(2) , determine Vx using Superposition.

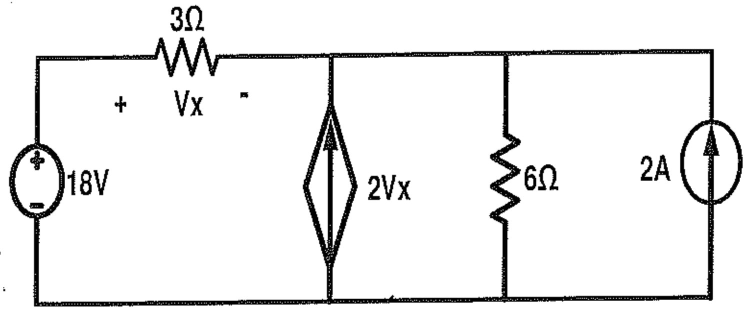
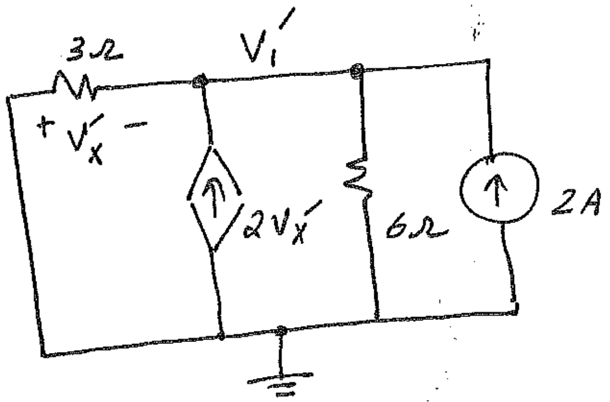


Fig.(2)

1) Kill 18 V source

Nodal



$2V_x' + 2 = V_1'\left(\frac{1}{6}+\frac{1}{3}\right)$

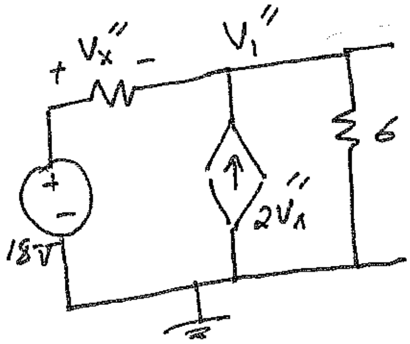
$V_x' = -V_1'$

$\therefore\ -2V_1' + 2 = V_1' \cdot \frac{3}{6}$

$-2.5\,V_1' = -2 \Rightarrow V_1' = 0.8\ V$

$\boxed{\therefore\ V_x' = -0.8\ V}$

2) Kill 2A source



$2V_x'' = V_1''\left(\frac{1}{6}+\frac{1}{3}\right) - 18V \times \frac{1}{3}$

$V_x'' = 18 - V_1''$

$2(18 - V_1'') = \frac{1}{2}V_1'' - 6$

$36 + 6 = 2.5\,V_1''$

$\therefore\ V_1'' = \frac{42}{2.5} = 16.8\ V$

$\boxed{V_x'' = 18 - 16.8 = 1.2\ V}$

3) $V_x = V_x' + V_x'' = -0.8 + 1.2 = 0.4\ V$

Problem3: (10 points) *To assess "a" student outcome*

For the circuit of Fig.(3) , find power dissipated in the 0.2375 Ω resistor.

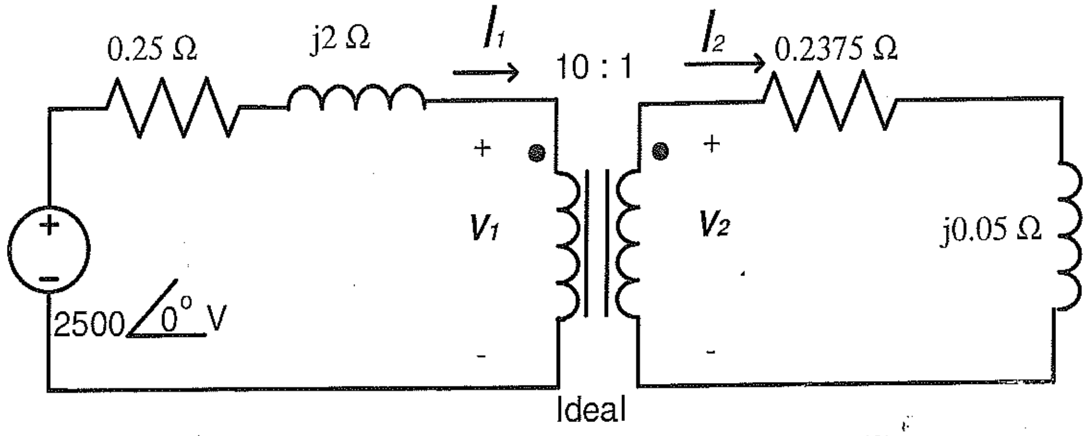


Fig.(3)

$2500\angle 0^\circ = (0.25+j2)I_1 + V_1$

$V_1 = 10\,V_2$

$V_2 = I_2\,(0.2375+j0.05)$

$V_1 = 10 \cdot I_2\,(0.2375+j0.05)$

$V_1 = 10 \cdot 10\, I_1\,(0.2375+j0.05)$ ... (1)

$V_1 = 2500\angle 0 - (0.25+j2)I_1$ ... (2)

equalizing (1) & (2)

$100\, I_1 (0.2375+j0.05) = 2500\angle 0 - (0.25+j2)I_1$

$((23.75+0.25)+j7)I_1 = 2500\angle 0^\circ$

$I_1 = \dfrac{2500\angle 0}{24+j7} = \dfrac{2500\angle 0^\circ}{25\angle 16.26^\circ} = 100\angle -16.26^\circ$

$I_2 = 10 I_1 = 1000\angle -16.26^\circ$

$P_{0.2375\Omega} = |I_{rms}|^2 \cdot R = \left(\dfrac{1000}{\sqrt{2}}\right)^2 \times R = 118.75$ Watt

Problem4. (15 points) *To assess "e" student outcome*

The following three loads are connected in parallel to a 240Vrms 60 Hz Ac generator:

Load #1 has P_1= 600KW and has a pf_1=0.8 lagging.

Load #2 has P_2= 400KW and has a $|S_2|$ = 500KVA and has a lagging power factor.

Load #3 has Q_3= -207KVARs and has a pf_3 = 0 leading.

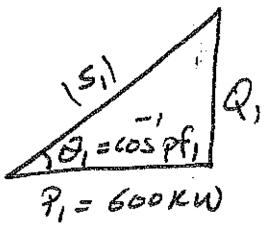
a) Determine the total apparent power of the three loads.

b) Determine the power factor of the combined load.

c) Determine the value of capacitance or inductance that will need to be added in order to make the overall pf = 1.0, assuming that the voltage across the load is to be kept at 240Vrms (with ω=377rad/sec)

Solution

load 1



$\theta_1 = \cos^{-1} pf_1 = \cos^{-1} 0.8 = 36.87°$

$|S_1| = P_{a1} = \frac{P_1}{pf_1} = \frac{600}{0.8} = 750 KVA$

$Q_1 = |S_1| \sin 36.87° = 450\ KVAR$

load 2

$P_2 = 400 KW$

$|S_2| = P_{a2} = 500 KVA$

$Q_2 = |S_2| \sin 36.87° = 300 KVAR$

load 3

$P_3 = 0$

$Q_3 = -207\ KVAR$

$|S_3| = 207\ KVA$

$S_T = (P_1+P_2+P_3) + j(Q_1+Q_2+Q_3) = (1000 + j\,543)\ KVA$

1) $|S_T| = P_{aT} = \sqrt{1000^2 + 543^2} = 1138\ KVA$

$\theta_T = \tan^{-1}\left(\frac{543}{1000}\right) = 28.5°$

2) $pf_T = \cos\theta_T = 0.878$ lagging

3) $Q_c = -\omega C V_{rms}^2 = -543\ KVAR$

$\therefore C = \frac{543\ KVAR}{377 \times 240^2} \cong 25\ mf$

ENEE2301-Network Analysis 1
Final Exam-January 19th, 2016
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Part Two:

Problem5. (15 points) *To assess "e" student outcome*
The switch in Fig.(5) has been in position (a) for a long time .
At t = 0 , it moves to position (b).
Calculate ix(t) for all t > 0 .

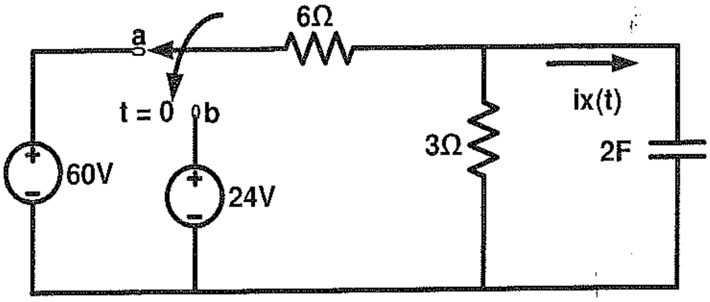
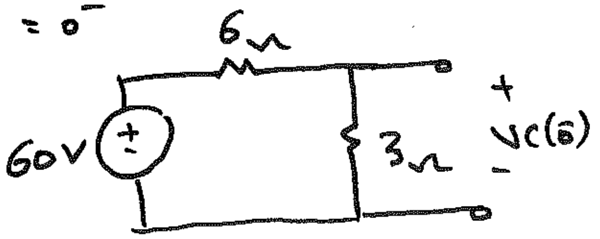


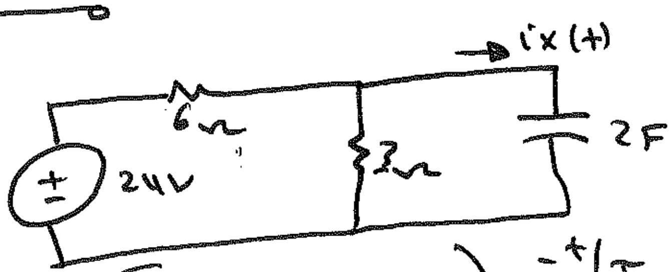
Fig.(5)

At $t = 0^-$



$\therefore V_C(0^-) = \frac{3}{3+6} \cdot 60 = 20\,V$

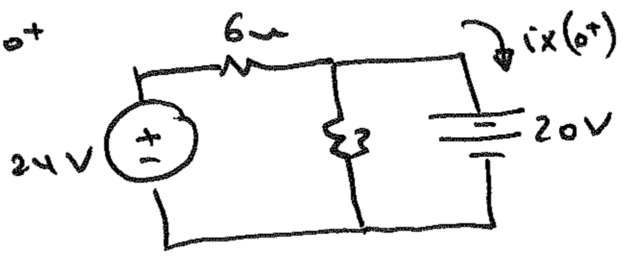
for $t > 0$



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

$i_x(\infty) = 0$

at $t = 0^+$



$i_x(0^+) = \frac{24-20}{6} - \frac{20}{3}$

$i_x(0^+) = -6\,A$

$\tau = R_{TH}\,C \quad ; \quad R_{TH} = 6\Omega \| 3\Omega = 2\Omega \rightarrow \tau = 4\,s$

$\therefore \; i_x(t) = -6\,e^{-t/4}\,A \quad \text{for } t > 0$

Problem 6. (10 points) *To assess "a" student outcome*

After being open for a long time , the switch in the circuit of Fig.(6) is closed at t = 0.

a) Find $v_C(0^-)$ and $i_L(0^-)$.
b) Find the differential equation describing $i_L(t)$, for t > 0.
c) Find the characteristic equation of the circuit of Fig.(6) .
d) Find $\frac{di_L(0^+)}{dt}$

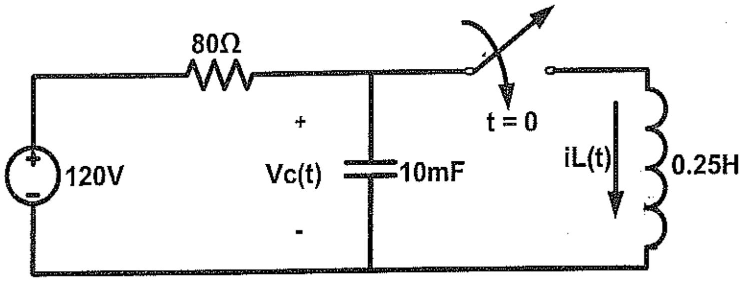
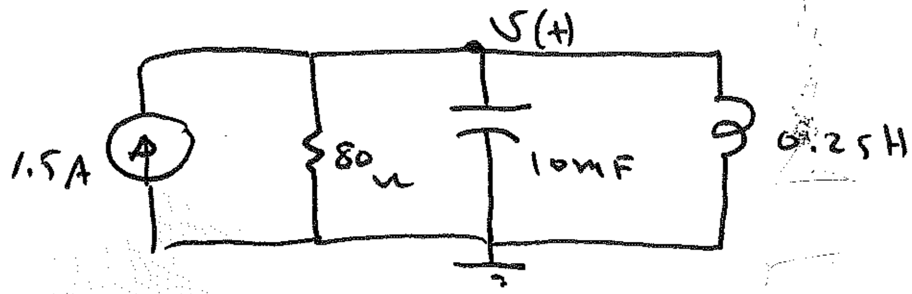


Fig.(6)

a) $V_c(0^-) = 120V$, $i_L(0^-) = 0$

b) for $t > 0$



KCL ,

$$1.5 = \frac{v(t)}{80} + 10\times10^{-3}\frac{dv(t)}{dt} + i_L(t)$$

$$v(t) = L\frac{di(t)}{dt} = 0.25\frac{di(t)}{dt}$$

$$\therefore \quad 1.5 = 2.5\times10^{-3}\frac{d^2 i(t)}{dt^2} + 3.125\times10^{-3}\frac{di(t)}{dt} + i(t)$$

c) $$0 = s^2 + 1.25s + 400$$

d) $$V_c(0^+) = V_L(0^+) = L\frac{di(0^+)}{dt}$$

$$\therefore \quad \frac{di(0^+)}{dt} = \frac{V_c(0^+)}{L} = 480$$

ENEE2301-Network Analysis 1
Final Exam-January 19th, 2016
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Part Three:

Problem7: (12 points) *To assess "a" student outcome*

For the circuit of Fig.(7) , use the thevenin's equivalent circuit to find voltage Vo

(note that the two inductors have a mutual inductance between them)

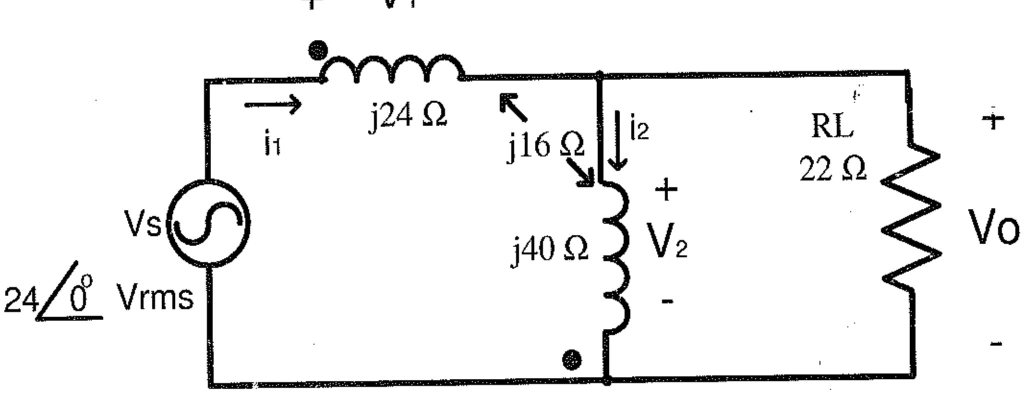


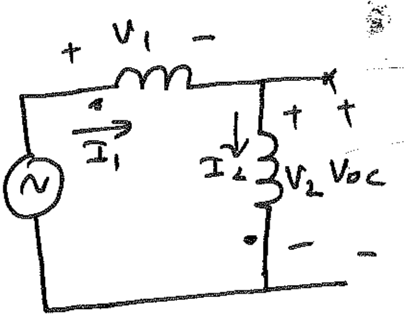
Fig.(7)

$V_{oc} = V_{th} = V_2$

$\bar{I}_1 = \bar{I}_2 = \bar{I}$

$V_1 = j24 I_1 - j16 I_2 = j8I$

$V_2 = -j16 I_1 + j40 I_2 = j24I$



also $24\angle 0° = V_1 + V_2 = j8I + j24I$

$\therefore I = \frac{24}{j32} = -j0.75$ Arms

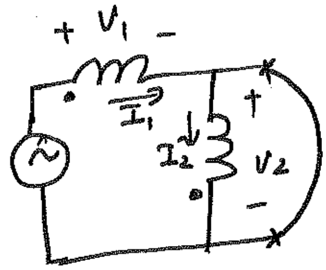
$V_{oc} = V_2 = (j24)\cdot(-j\frac{3}{4}) = 18\angle 0°$ Vrms

Isc : $V_2 = 0 = -j16 I_1 + j40 I_2$

$I_1 \neq I_2$

$\therefore j16 I_1 = j40 I_2$

$\boxed{I_1 = 2.5 I_2}$ ... (1)



$V_s = j24 I_1 - j16 I_2$

$= j24(2.5 I_2) - j16 I_2$

$V_s = j60 I_2 - j16 I_2 \Rightarrow I_2 = \frac{24}{j44} = -j\frac{6}{11}$

$I_{sc} = I_1 - I_2 = (2.5 - 1) I_2 = 1.5 I_2 = 1.5(-j\frac{6}{11}) = -j0.818$ Arms

$\therefore Z_{th} = \frac{V_{oc}}{I_{sc}} = \frac{18\angle 0°}{0.818\angle -90} = 22\angle 90°\ \Omega = j22\ \Omega$; $V_o = \frac{R_L}{R_L + Z_{th}} \cdot V_{th} = \frac{22}{22 + j22} \cdot 18 = 12.73\angle -45°$ V

Problem8: (13 points) ***To assess "a" student outcome***

For the following balanced three phase system shown in Fig.(8), the source is Δ – connected positive sequence and the load consists of parallel Δ-Y loads, given:

$$\vec{V}_{AB} = 380 \angle 30^0 \ V;\ Z_T = (0.1)\Omega; Z_Y = (-j1)\Omega; Z_\Delta = (6 + j9)\Omega$$

1) Calculate the phase currents of the delta connected load: $\vec{I}_{AB\Delta}, \vec{I}_{BC\Delta}, \vec{I}_{CA\Delta}$

2)Calculate the phase currents of the Y - connected load: $\vec{I}_{AN}, \vec{I}_{BN}, \vec{I}_{CN}$

3)Calculate the magnitude of the line current I_{aA}

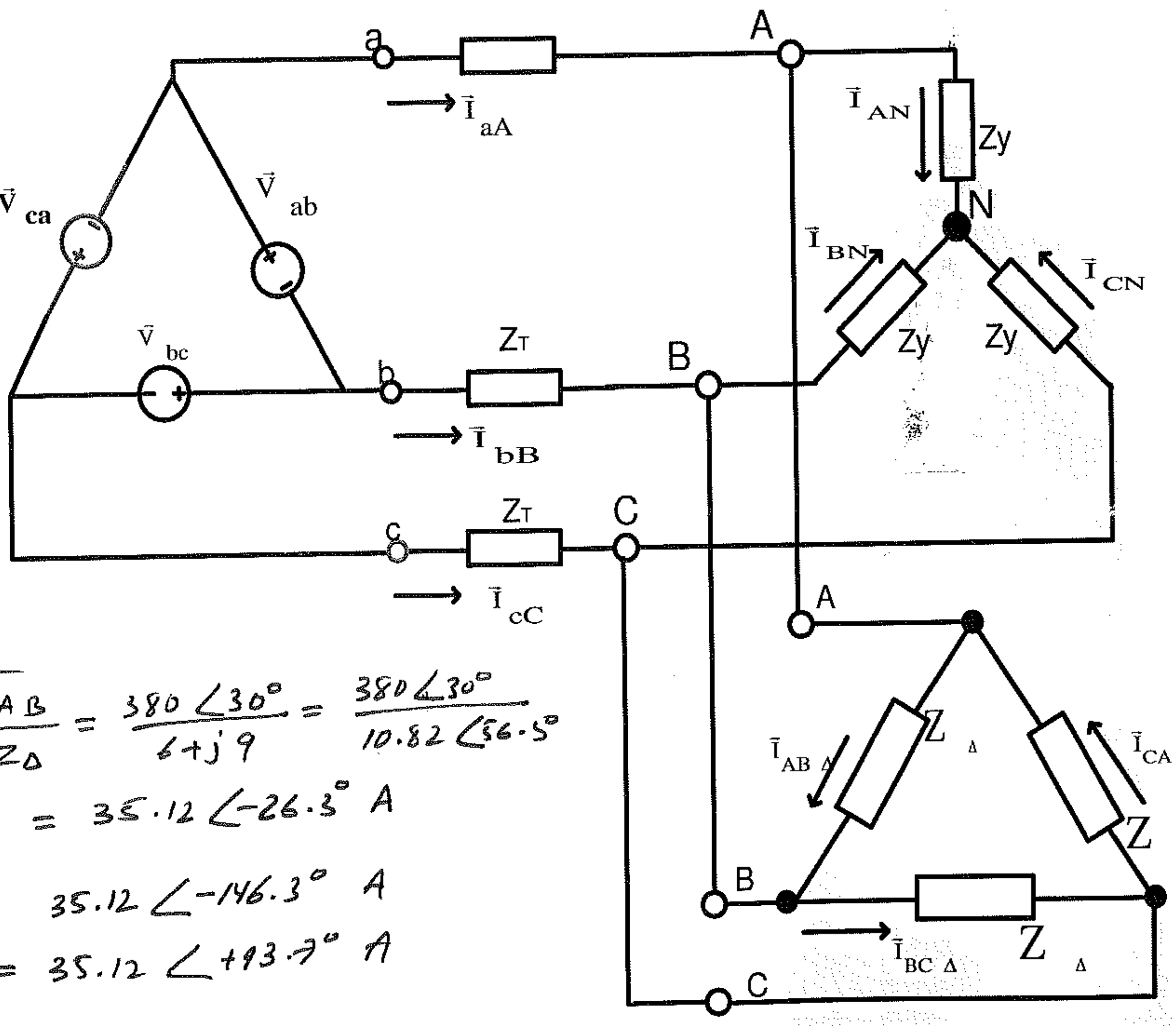


Fig.(8)

1) Δ load

$$\bar{I}_{AB\Delta} = \frac{\bar{V}_{AB}}{\bar{Z}_\Delta} = \frac{380 \angle 30^\circ}{6 + j9} = \frac{380 \angle 30^\circ}{10.82 \angle 56.5^\circ}$$

$$= 35.12 \angle -26.3^\circ \ A$$

$$\bar{I}_{BC} = 35.12 \angle -146.3^\circ \ A$$

$$\bar{I}_{CA} = 35.12 \angle +93.7^\circ \ A$$

2) Y-load

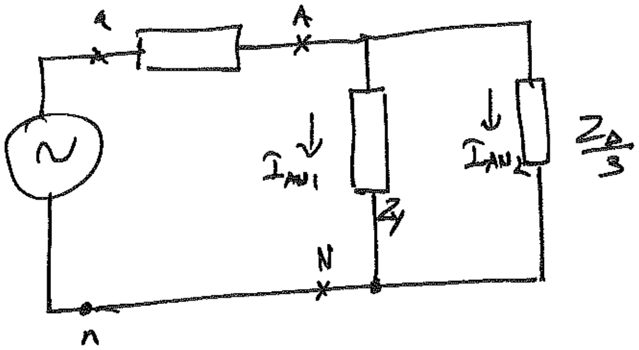
$$\bar{I}_{AN} = \frac{\bar{V}_{AN}}{\bar{Z}_Y} ;$$

$$\bar{V}_{AN} = \frac{\bar{V}_{AB}}{\sqrt{3} \angle 30^\circ} = \frac{380 \angle 30^\circ}{\sqrt{3} \angle 30^\circ} = 219.4 \angle 0^\circ \ V$$

$$\bar{I}_{AN} = \frac{219 \angle 0^\circ}{-j1} = \frac{219 \angle 0^\circ}{1 \angle -90^\circ} = 219.4 \angle 90^\circ \ A \ , \bar{I}_{BN} = 219.4 \angle -30^\circ A$$

$$\bar{I}_{CN} = 219.4 \angle 210^\circ A$$

3) To find I_{aA}, we construct single-phase equivalent circuit



$I_{aA} = I_{AN1} + I_{AN2}$

$I_{AN1} = 219.4\angle 90^\circ$ (calculated earlier)

$$I_{AN2} = \frac{\bar{V}_{AN}}{\frac{Z_\Delta}{3}} = \frac{219.4\angle 0^\circ}{\frac{6+j9}{3}} = \frac{219.4\angle 0^\circ}{2+j3} = \frac{219.4\angle 0^\circ}{3.606\angle 56.3^\circ} = 60.84\angle -56.3^\circ \text{ A}$$

$$I_{aA} = 219.4\angle 90^\circ + 60.84\angle -56.3^\circ$$
$$= j219.4 + 36.504 - j48.67 = 36.504 + j170.73$$
$$= 174.58\angle 77.93^\circ$$

OR

$$I_{aA} = \frac{\bar{V}_{AN}}{Z_Y // \frac{Z_\Delta}{3}} = \frac{219.4\angle 0^\circ}{-j1 // 2+j3} = \frac{219\angle 0^\circ}{1.275\angle -78.7^\circ}$$
$$= 172.1\angle 78.7^\circ$$

where

$$-j // (2+j3) = \frac{-j(2+j3)}{-j+(2+j3)} = \frac{3-j2}{2+j2} = \frac{3.605\angle -33.7^\circ}{2.83\angle 45}$$
$$= 1.275\angle -78.7^\circ$$

GOOD LUCK

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