1. A. True.

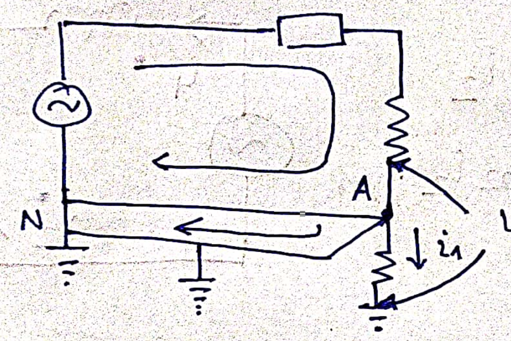
B. False.

C. There is voltage drop due to loop inductance as well.

D. Region-1.

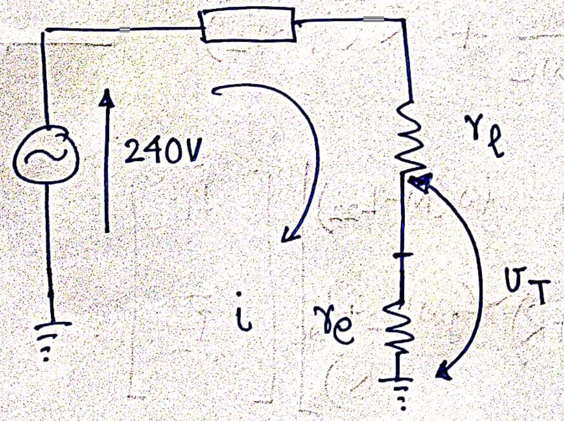
2. Subjective.

3. (a).



$i_1 = 0$. So, $v_A = v_N$. So, $v_T = v_A - v_N = 0$.

(b).



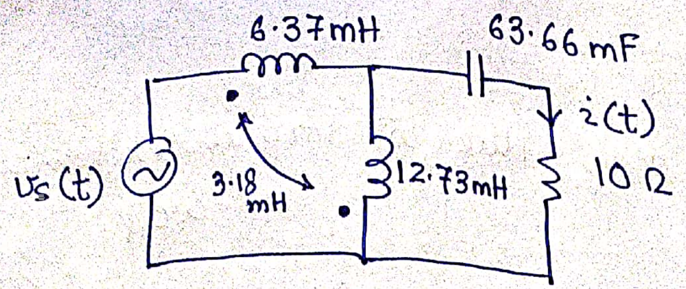
Lamp rating $= 2 \times 400W$
$= 800W$.

So, lamp resistance (r_l)
$= \frac{V^2}{P} = \frac{240^2}{800}$
$= 72\Omega$.

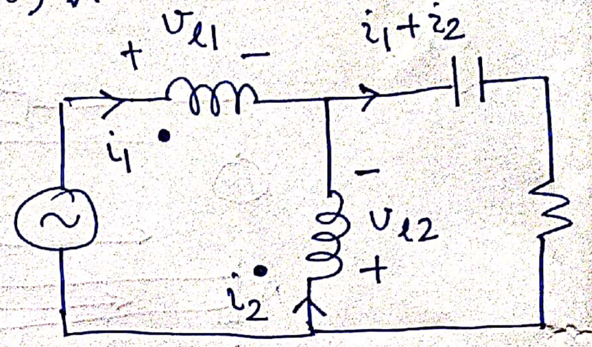
Electrode resistance $= r_e = 25\Omega$.

$\therefore v_T = 240 \times \frac{r_e}{r_e + r_l} = 240 \times \frac{25}{97} V = 61.86 V.$

4.



$v_s(t) = \sqrt{2} \times 100 \sin(2\pi \times 50t)$ V.



$v_{\ell 1} = j\omega L_{11} i_1 + j\omega M i_2$

$v_{\ell 2} = j\omega M i_1 + j\omega L_{22} i_2$

Now, $\bar{V_s} = V_{L1} - V_{L2}$

$$100\angle 0^\circ = j\omega\left[(L_{11} - M) i_1 + (M - L_{22}) i_2\right]. \quad \text{—— (1).}$$

$$-V_{L2} = (i_1 + i_2)\cdot\frac{1}{j\omega C} + R(i_1 + i_2) \quad \text{—— (2).}$$

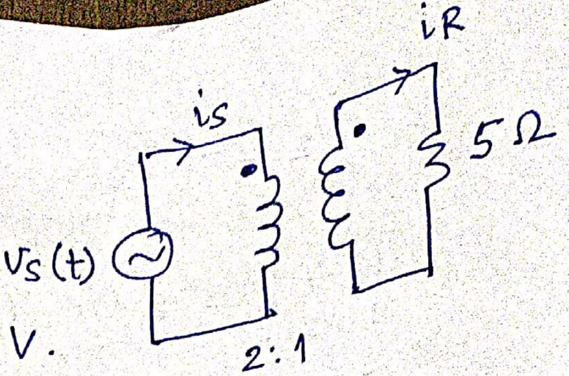
$$\begin{bmatrix} 100\angle 0 \\ 0 \end{bmatrix} = \begin{bmatrix} j\omega(L_{11} - M) & j\omega(M - L_{22}) \\ \left(j\omega M + \frac{1}{j\omega C} + R\right) & \left(j\omega L_{22} + \frac{1}{j\omega C} + R\right) \end{bmatrix} \begin{bmatrix} \bar{I_1} \\ \bar{I_2} \end{bmatrix}.$$

Solving, $\bar{I_1} = 26.48\angle -78.1^\circ$ A, $\bar{I_2} = 24.742\angle 85.77^\circ$

$\therefore \bar{I_R} = \bar{I_1} + \bar{I_2} = 7.39\angle -9.649^\circ$ A.

$$\underline{i_R(t) = \sqrt{2} \times 7.39 \sin(2\pi \times 50t - 9.649^\circ) \text{ A}}$$

5. (a) Ideal transformer:



$v_S(t) = \sqrt{2} \times 100 \sin(2\pi \times 50t + 45^0)$ V.

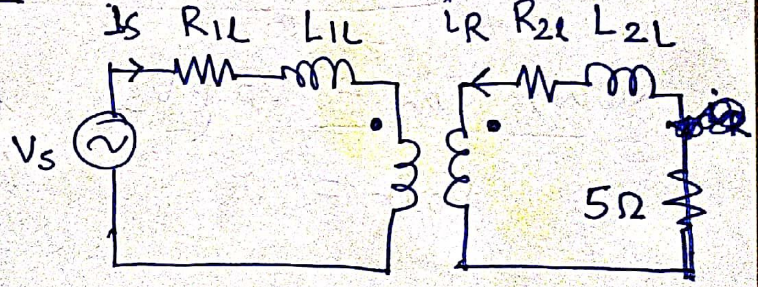
$\bar{V}_S = 100\angle 45^0$ V.

$\bar{V}_R = \bar{V}_S / 2 = 50\angle 45^0$ V.

$\bar{I}_R = \bar{V}_R / 5 = 10\angle 45^0$ A.

$\bar{I}_S = \frac{N_2}{N_1} \bar{I}_R = \frac{1}{2} \times 10\angle 45^0 = 5\angle 45^0$ A.

(b) Non-ideal transformer:



Under open-circuit condition,

$\bar{V}_S = j\omega L_{11} \bar{I}_{oc}$

$\therefore j\omega L_{11} = \frac{\bar{V}_S}{\bar{I}_{oc}} \Rightarrow L_{11} = 795.8$ mH.

$L_{11} = \frac{N_1}{N_2} M + L_{1l} \Rightarrow M = 396.3$ mH.

$L_{22} = \frac{N_2}{N_1} M + L_{2l} \Rightarrow L_{22} = 198.85$ mH.

Now, $\bar{V}_S = R_{1l} \bar{I}_S + j\omega L_{11} \bar{I}_S + j\omega M \bar{I}_R$

$0 = j\omega L_{22} \bar{I}_R + j\omega M \bar{I}_S + R \bar{I}_R$

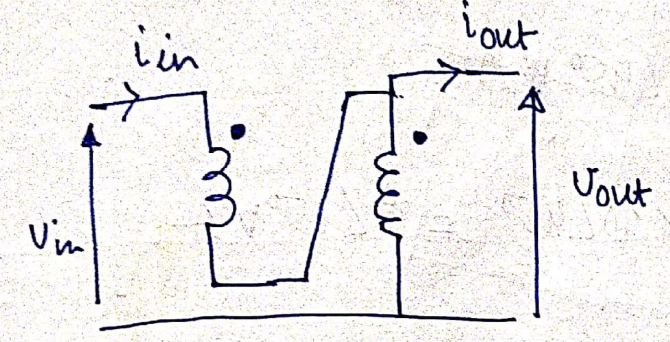
Solving, $\bar{I}_S = 4.75\angle 35.13^\circ$ A, $\bar{I}_R = 9.44\angle -140.18^\circ$ A.

$\therefore\ \bar{V}_2 = -R\bar{I}_2 = 47.2\angle 39.82^\circ A.$

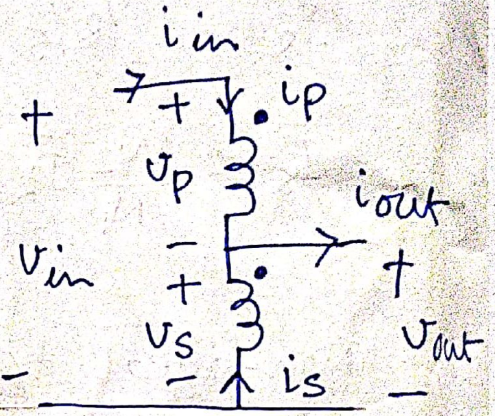
$$\left|\frac{\bar{V}_1}{\bar{V}_2}\right| = 2.118 \neq 2, \quad \left|\frac{\bar{I}_2}{\bar{I}_1}\right| = 1.987 \neq 2.$$

$Re\left[\bar{V}_1 \bar{I}_1^*\right] = 468.68\, W, \quad Re\left[\bar{V}_2 \bar{I}_2^*\right] = 446.22\, W.$

6.



100/50 V, 50 Hz, 2kVA.



Now, $v_{in} = v_p + v_s$

$v_{out} = v_s$

$$\therefore \frac{v_{out}}{v_{in}} = \frac{v_s}{v_p + v_s} = \frac{1}{1 + v_p/v_s} = \frac{1}{3}.$$

$i_{in} = i_p$ and $i_{out} = i_p + i_s$.

$$\therefore \frac{i_{in}}{i_{out}} = \frac{i_p}{i_p + i_s} = \frac{1}{1 + i_s/i_p} = \frac{1}{3}.$$ 8.

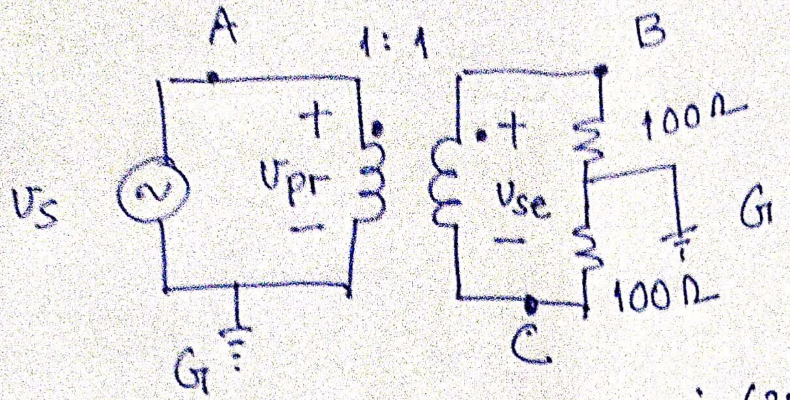
VA rated $= 2000\, VA$ $\quad V_p$ rated $= 100\, V$.

So, I_p rated $= 20\, A$.

New rating $= V_{in} \cdot i_{in} = (v_p + v_s)\, i_p = 1.5\, v_p$

$= 3\, kVA$

7.



$$v_s = \sqrt{2} \times 100 \sin(2\pi \times 50 t).$$

$$\bar{v}_{pr} = \bar{v}_s = 100 \angle 0 \text{ V}.$$

$$\bar{v}_{se} = \bar{v}_{pr} = 100 \angle 0 \text{ V}.$$

$$\therefore \bar{v}_{BC} = 100 \angle 0 \text{ V}.$$

$$\therefore \bar{v}_{BG} = \frac{100 \angle 0}{2} = 50 \angle 0 \text{ V}.$$

$$\bar{v}_{AG} = 100 \angle 0 \text{ V}.$$

$$\therefore \bar{v}_{AB} = \bar{v}_{AG} - \bar{v}_{BG} = 50 \angle 0 \text{ V}.$$

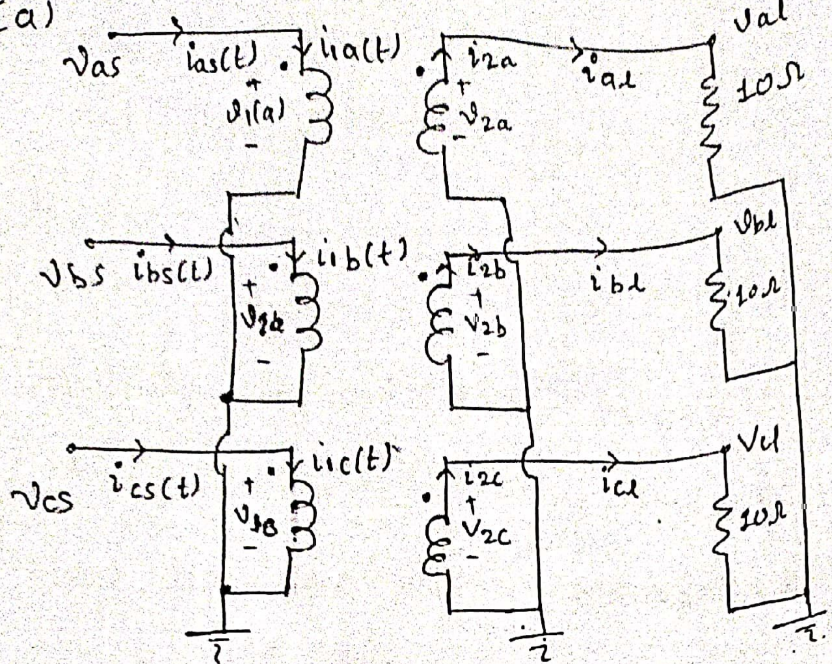
$$\therefore v_{AB}(t) = \sqrt{2} \times 50 \sin(2\pi \times 50 t) \text{ V}.$$

8. $$\frac{v_1}{N_1} = \frac{v_2}{N_2} = \frac{v_3}{N_3}.$$

$$N_1 i_1 = N_2 i_2 + N_3 i_3.$$

Problem: 9

(a)



Let the voltage across the three primary windings be v_{1a}, v_{1b}, v_{1c} and the corresponding secondary winding voltages be v_{2a}, v_{2b}, v_{2c}, respectively.

Let the current in the three primary windings be i_{1a}, i_{1b}, i_{1c} and the corresponding secondary winding currents be i_{2a}, i_{2b}, i_{2c} respectiv

Note: The current enters the dot in primary and leaves the dot in secondary.

The transformers are given to be ideal, so,

$$\frac{v_{1a}}{v_{2a}} = \frac{v_{1b}}{v_{2b}} = \frac{v_{1c}}{v_{2c}} = \frac{2}{1}$$

And assuming there is no open-circuit current, i.e $I_{oc}=0$,

we have, $$\frac{i_{1a}}{i_{2a}} = \frac{i_{1b}}{i_{2b}} = \frac{i_{1c}}{i_{2c}} = \frac{1}{2}$$

Since primary side windings are connected in star, we have,

$i_{as} = i_{1a}$, $i_{bs} = i_{1b}$, $i_{cs} = i_{1c}$.

Since neutral point is grounded, we have

$v_{as} = v_{1a}$, $v_{bs} = v_{1b}$, $v_{cs} = v_{1c}$.

Since secondary ...
grounded, we have

$i_{al} = i_{2a}$, $i_{bl} = i_{2b}$, $i_{cl} = i_{2c}$,

$v_{al} = v_{2a}$, $v_{bl} = v_{2b}$, $v_{cl} = v_{2c}$.

$$\therefore \frac{v_{al}}{v_{as}} = \frac{v_{2a}}{v_{1a}} = \frac{1}{2} \Rightarrow v_{al} = \frac{\sqrt{2} \times 50 \times \sin(2\pi \times 50t)}{2} = \sqrt{2} \cdot 25 \sin(2\pi \times 50t)$$

Similarly, v_{bl} and v_{cl} can be calculated.

$v_{bl} = \sqrt{2} \times 25 \times \sin(2\pi \times 50t - 2\pi/3)$, $v_{cl} = \sqrt{2} \times 25 \times \sin(2\pi \times 50t + 2\pi/3)$

Since the impedances are start connected with neutral grounded,

$i_{al} = v_{al}/10$, $i_{bl} = v_{bl}/10$, $i_{cl} = v_{cl}/10$.

$i_{al} = \sqrt{2} \times 2.5 \times \sin(2\pi \times 50t)$, $i_{bl} = \sqrt{2} \times 2.5 \times \sin(2\pi \times 50t - 2\pi/3)$

$i_{cl} = \sqrt{2} \times 2.5 \times \sin(2\pi \times 50t + 2\pi/3)$

$$\frac{i_{al}}{i_{as}} = \frac{i_{2a}}{i_{1a}} = \frac{2}{1} \Rightarrow i_{as} = \frac{\sqrt{2} \times 2.5 \sin(2\pi \times 50t)}{2}$$

$$= \sqrt{2} \times 1.25 \sin(2\pi \times 50t)$$

Similarly i_{bs}, i_{cs} can be calculated.

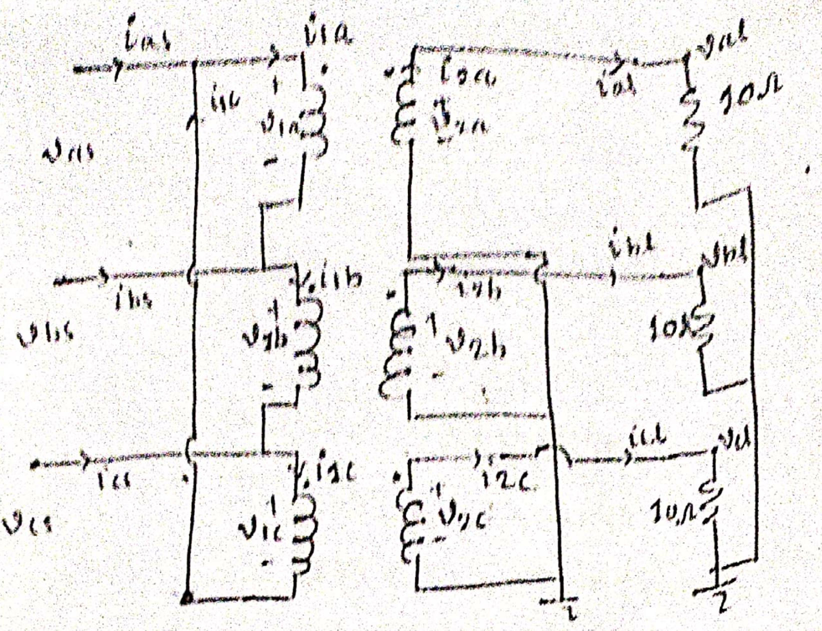
(b) configuration II is same as configuration I except primary is delta connected.

Since the secondary windings are connected in star, we have
$i_{2a} = i_{al}$, $i_{2b} = i_{bl}$, $i_{2c} = i_{cl}$

Since the secondary winding neutral and load neutral are grounded
we have $v_{2a} = v_{al}$, $v_{2b} = v_{bl}$, $v_{2c} = v_{cl}$.

$$\frac{v_{1a}}{v_{2a}} = \frac{v_{1b}}{v_{2b}} = \frac{v_{1c}}{v_{2c}} = \frac{2}{1}$$

$$\frac{i_{1a}}{i_{2a}} = \frac{i_{1b}}{i_{2b}} = \frac{i_{1c}}{i_{2c}} = \frac{1}{2}.$$



The primary windings are connected in delta, It can be seen from the circuit diagram,

$v_{1a} = v_{as} - v_{bs}$; $v_{1b} = v_{bs} - v_{cs}$; $v_{1c} = v_{cs} - v_{as}$.

$v_{1a} = \sqrt{2} * \sqrt{3} * \sin(2\pi * 50t + \pi/6) * 50$;

$v_{1b} = \sqrt{2} * \sqrt{3} * \sin(2\pi * 50t - \pi/2) * 50$;

$v_{1c} = \sqrt{2} * \sqrt{3} * \sin(2\pi * 50t + \frac{5\pi}{6}) * 50$;

$v_{2a} = \frac{1}{2} v_{1a} = \sqrt{2} * \sqrt{3} * 25 * \sin(2\pi * 50t + \pi/6)$

$\because$ $v_{al} = v_{2a}$ $\Rightarrow$ $v_{al} = \sqrt{2} * \sqrt{3} * 25 \sin(2\pi * 50t + \pi/6)$

As load is neutral connected, we can write,

$i_{al} = \frac{v_{al}}{10} = \sqrt{6} * 2.5 * \sin(2\pi * 50t + \pi/6)$

Similarly i_{bl} and i_{cl} can be calculated.

we know that , $i_{al} = i_{2a}$ and $\frac{i_{1a}}{i_{2a}} = \frac{1}{2}$

$i_{1a} = \sqrt{6} * 1.25 \sin(2\pi * 50t + \pi/6)$

$i_{1b} = \sqrt{6} * 1.25 \sin(2\pi * 50t - \pi/2)$

$i_{1c} = \sqrt{6} * 1.25 \sin(2\pi * 50t + 5\pi/6)$

looking at circuit diagram on primary side,

$i_{bs} = i_{1b} - i_{1a}$

$i_{cs} = i_{1c} - i_{1b}$

$i_{as} : i_{1a} - i_{1c}$

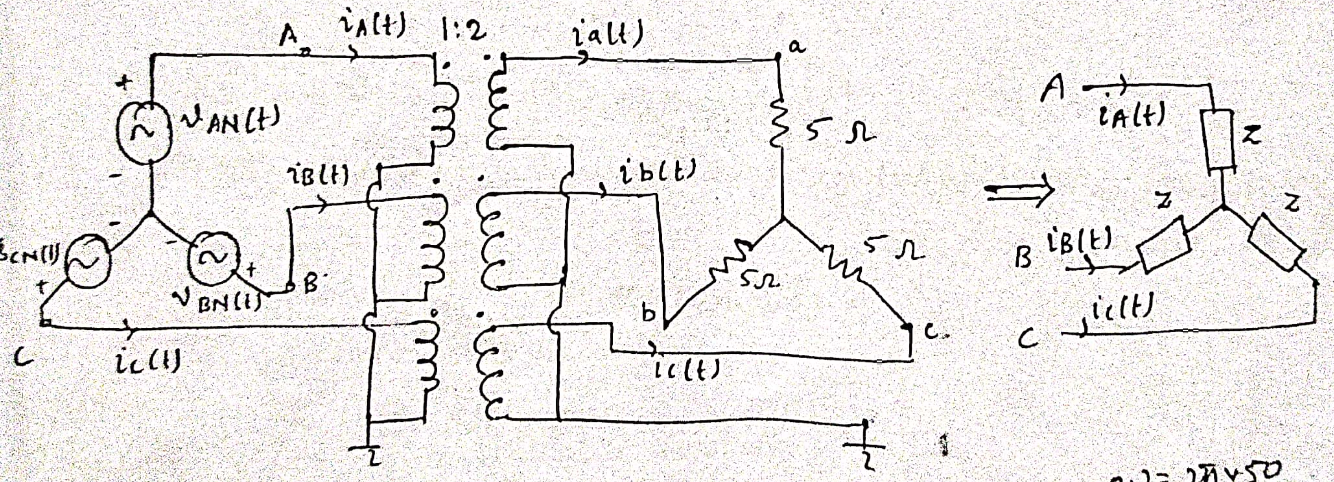
$i_{as} = \sqrt{6} * \sqrt{3} * 1.25 * \sin(2\pi * 50t + \pi/6 - \pi/6)$

$= \sqrt{2} * 3.75 * \sin(2\pi * 50t)$

$i_{bs} = \sqrt{2} * 3.75 * \sin(2\pi * 50t - 2\pi/3)$

$i_{cs} = \sqrt{2} * 3.75 * \sin(2\pi * 50t + 2\pi/3)$

Problem: 10



$w = 2\pi * 50$

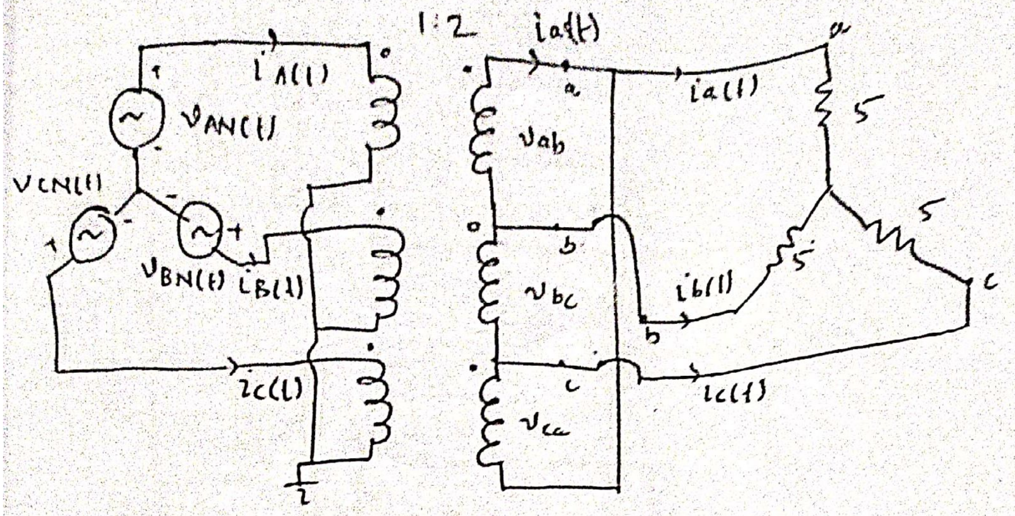
$\frac{v_{aN}}{v_{AN}} = \frac{2}{1} \Rightarrow v_{aN} = 2 * v_{AN} = \sqrt{2} * 220 * \sin(\omega t)$ V.

$i_a(t) = \frac{v_{aN}}{5} = \sqrt{2} * \frac{220}{5} * \sin(\omega t) = \sqrt{2} * 44 \sin(\omega t)$ A. $\Rightarrow i_{a rms} = 44A$

$\frac{i_a(t)}{i_A(t)} = \frac{1}{2} \Rightarrow I_A(t) = 2 * i_a(t) = \sqrt{2} * 88 \sin(\omega t) A \Rightarrow i_{A,rms} = 88A$

$$Z = \frac{\text{phasor } V_{AN}}{\text{phasor } i_A} = \frac{110\angle 0^\circ}{88\angle 0^\circ} = 1.25\,\Omega$$

Y-Δ connection



$v_{ab} = 2 * V_{AN} = \sqrt{2} \cdot 220 \cdot \sin(\omega t)$

phase voltage with respect to starpoint of load is, (review Q 6)

$$= \frac{\sqrt{2} * 220}{\sqrt{3}} \sin(\omega t - 30^\circ)$$

$$i_a(t) = \frac{\sqrt{2} * 220}{\sqrt{3} \times 5} \sin(\omega t - 30^\circ)$$

$$i_{a_{rms}} = \frac{220}{5\sqrt{3}} = 25.4\,A$$

The current in secondary winding is,

$i_{as}(t) = i_a(t) + i_c(t)$

$$= \frac{\sqrt{2} * 220}{\sqrt{3} \cdot \sqrt{3} \cdot 5} \sin(\omega t - 30^\circ + 30^\circ)$$

$$= \frac{\sqrt{2} * 220}{15} \sin(\omega t)$$

$$i_A(t) = 2 i_{as}(t) = \sqrt{2} \cdot \frac{440}{15} \sin(\omega t)\ A = 29.33\,A.$$

$$Z = \frac{V_{AN}}{I_A} = 3.75\,\Omega.$$

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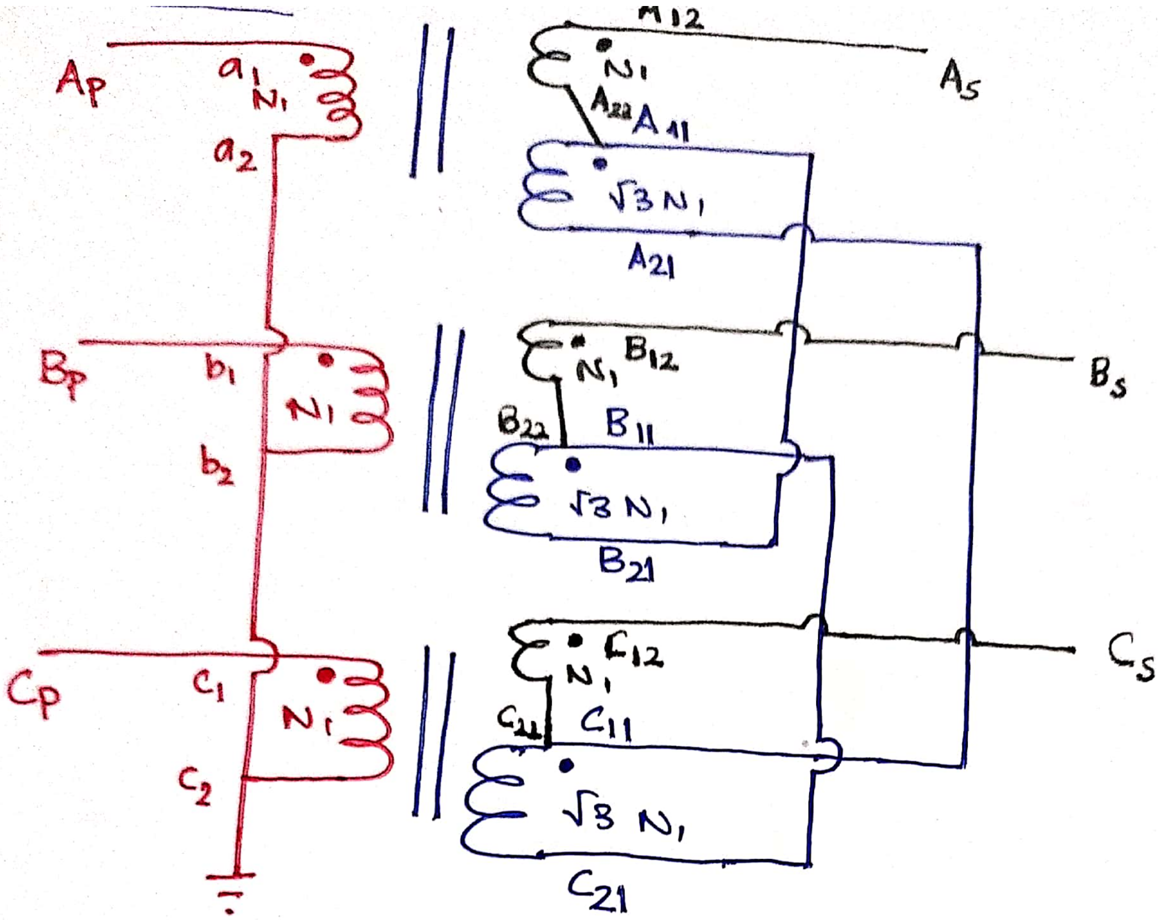
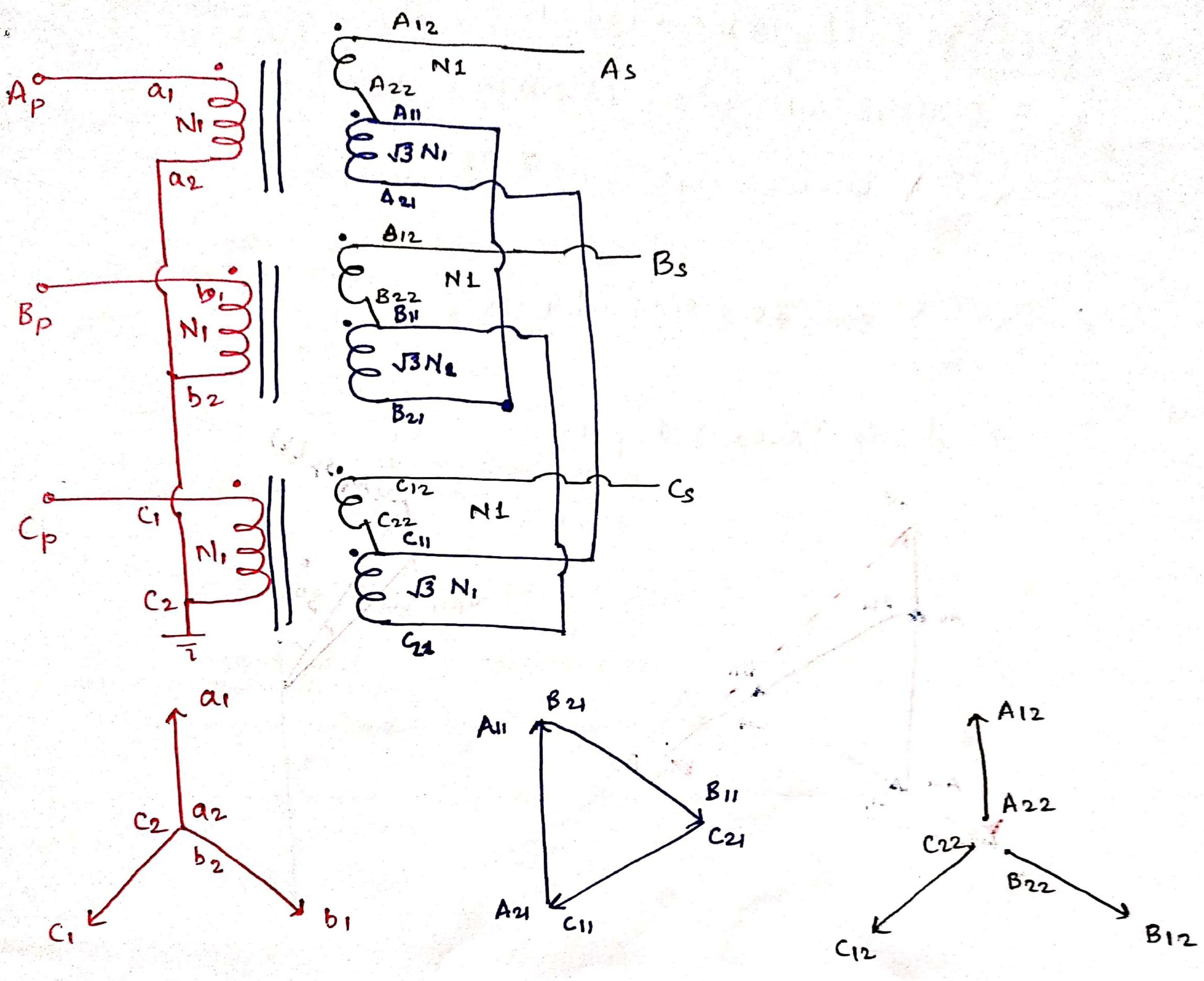

Ap
a1
N1
a2
N1
As
A22
A11
√3 N1
A21
Bp
b1
N1
b2
N1
B12
B22
B11
√3 N1
B21
Bs
Cp
c1
N1
c2
C12
N1
C22
C11
√3 N1
C21
Cs

Problem : 8



A12
N1
As
Ap
a1
N1
A22
A11
√3 N1
a2
A21
B12
Bs
Bp
b1
N1
B22
B11
√3 N1
b2
B21
Cp
c1
N1
C12
N1
Cs
C22
C11
√3 N1
C2
C21
a1
a2
C2
b2
c1
b1
B21
A11
B11
C21
A21
C11
A12
A22
C22
B22
C12
B12

$v_{a_1a_2}(t) = V\sin\omega t$

$v_{b_1b_2}(t) = V\sin(\omega t - 120^\circ)$

$v_{A11\,A21}(t) = \sqrt{3}V\sin\omega t$

$v_{B11\,B21}(t) = \sqrt{3}V\sin(\omega t - 120^\circ)$

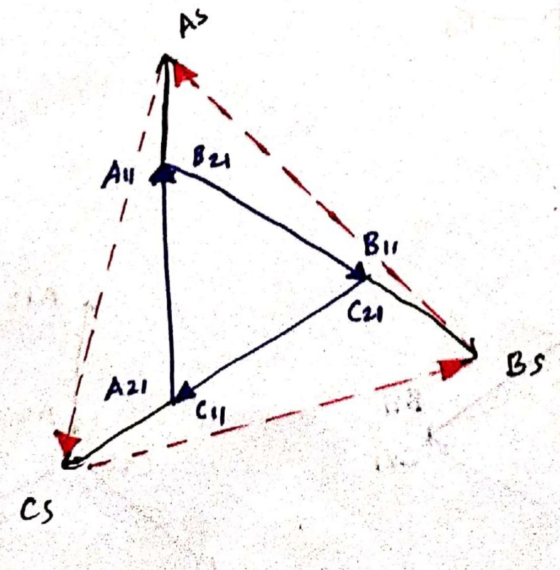
$v_{A12\,A22}(t) = V\sin\omega t$

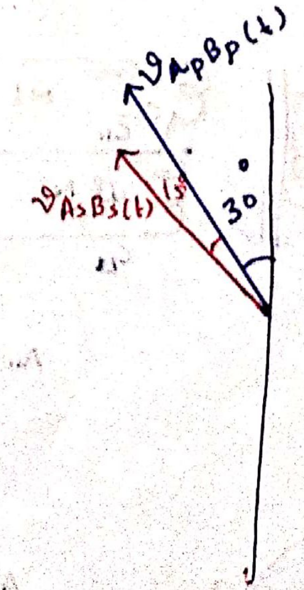
$v_{B12\,B22}(t) = V\sin(\omega t - 120^\circ)$

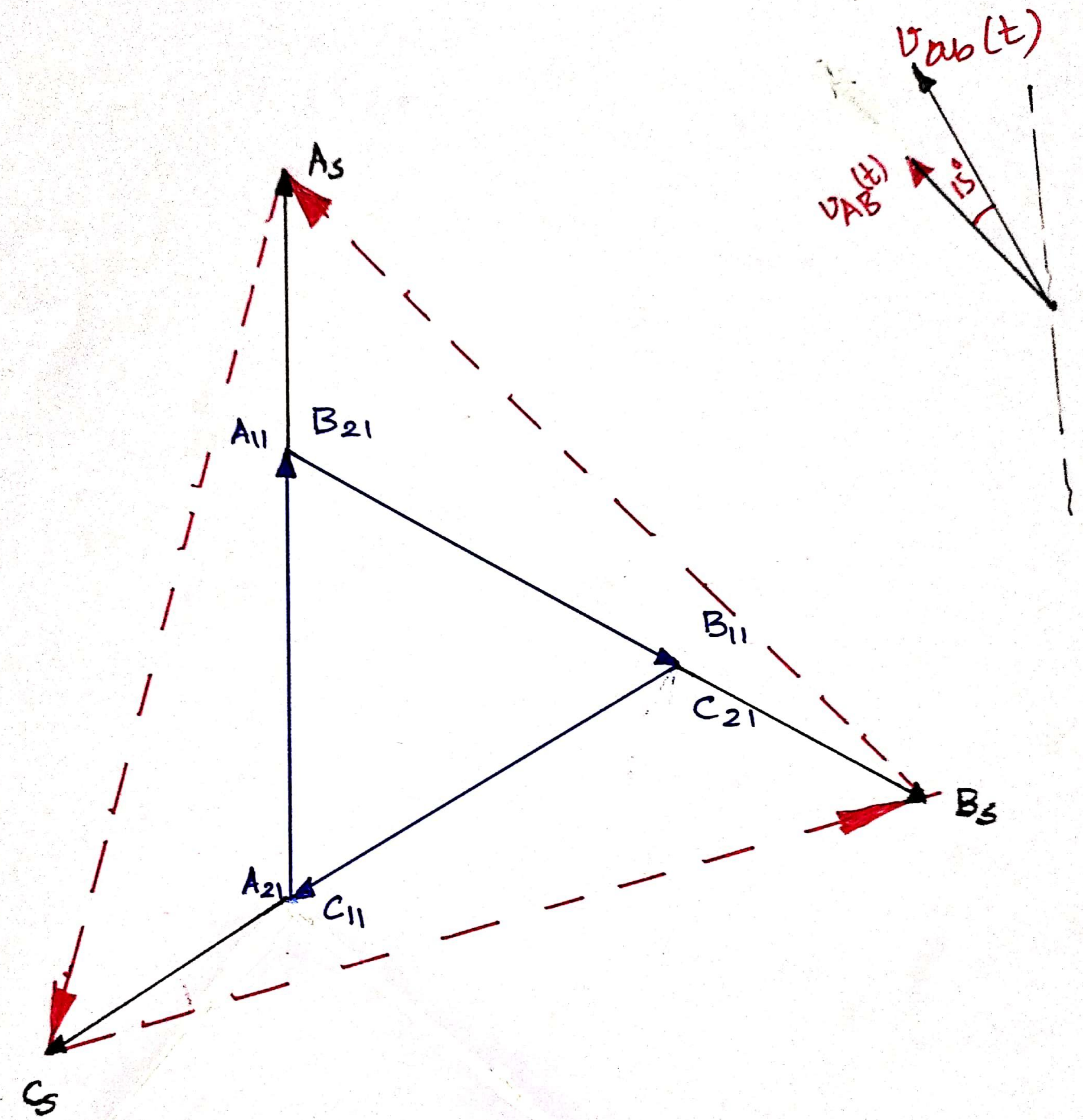
$$v_{A_pB_p}(t) = v_{a_1a_2}(t) - v_{b_1b_2}(t) = V(\sin(\omega t) - \sin(\omega t - 120^\circ))$$
$$= \sqrt{3}V\sin(\omega t + 30^\circ)$$

$$v_{A_sB_s}(t) = v_{A12A22}(t) + v_{B21B11}(t) + v_{B22B12}(t)$$
$$= V\sin(\omega t) - \sqrt{3}V\sin(\omega t - 120^\circ) - V\sin(\omega t - 120^\circ)$$
$$= \sqrt{3}V\sin(\omega t + 30^\circ) - \sqrt{3}V\sin(\omega t - 120^\circ)$$
$$= \frac{2\sqrt{3}V}{\cancel{\sqrt{2}}}\cos(\omega t - 45^\circ)\sin(75^\circ)$$
$$= \frac{2\sqrt{3}V}{\sqrt{2}}\sin(75^\circ)\sin(\omega t + 45^\circ)$$

Thus $v_{A_sB_s}(t)$ leads $v_{A_pB_p}(t)$ by 15°.






$v_{ab}(t)$
$v_{AB}(t)$
$15°$
A_s
A_{11}
B_{21}
B_{11}
C_{21}
B_s
A_{21}
C_{11}
C_s

Problem 12: (B).

Problem 13: (A).

Problem 14: (D) 4 mH.