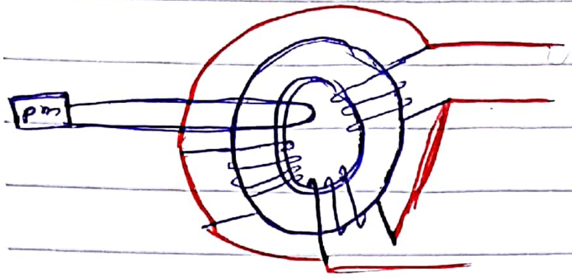
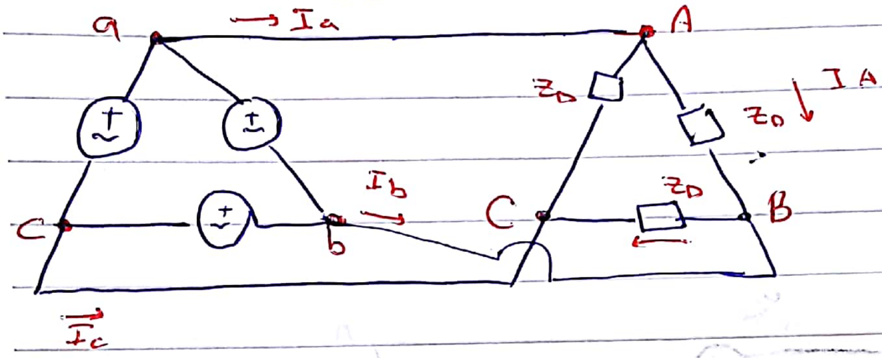
* Can we connected the source as a Δ ?



D – D Connected

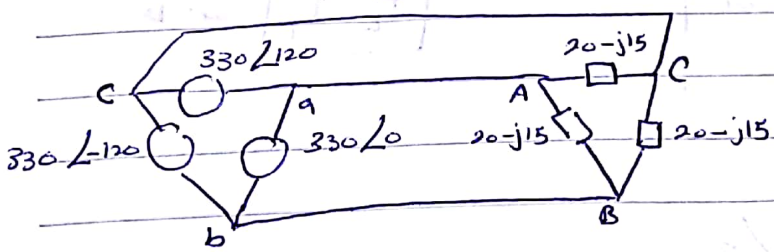


* The voltage across the load is (line to line voltage)
* $I_{Line} \neq I_{phase}$.
* $I_{line} = \sqrt{3} * I_{phase} \angle -30^\circ$

Ex:

a Balanced Δ connected load of $Z_D = 20 - j15\ \Omega$ is connect to Δ source with $V_{ab} = 330 \angle 0$, find phase & line current.

ـ قبل الاتصال انا بحاجة لأطلع ال I_{phase} مشان اطلع I_{Line}.



$$I_{AB} = \frac{U_{AB}}{Z_D} = \frac{V_{ab}}{Z_D} = \frac{330 \angle 0}{20 - j15} = 13.2 \angle 36.87.$$

$$I_{BC} = 13.2 \angle 36.87 - 120.$$

$$I_{CA} = 13.2 \angle 36.87 + 120.$$

* $I_{Line} = \sqrt{3}\, I_{phase} \angle -30$

$I_a = \sqrt{3}\, I_{AB} \angle -30$

$I_b = \sqrt{3}\, I_{BC} \angle -30$

$I_c = \sqrt{3}\, I_{CA} \angle -30$

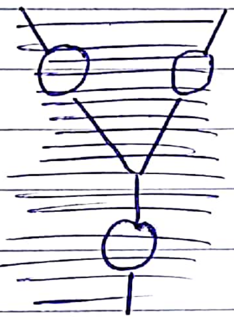
$I_a = \sqrt{3} * 13.2 \angle 36.87 - 30$

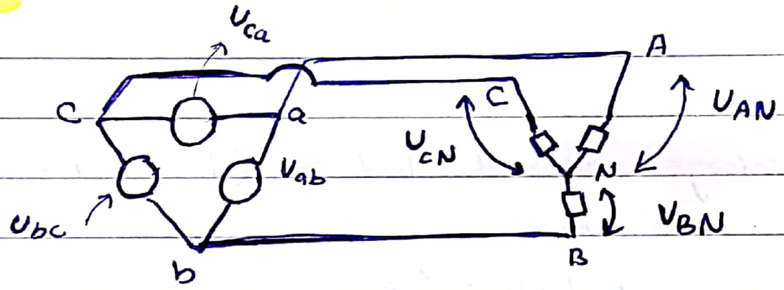
$= 22.86 \angle 6.87 \text{ A}$

$I_b = 22.86 \angle 6.87 - 120 \text{ A}$

$I_c = 22.86 \angle 6.87 + 120 \text{ A}$

D-Y connected.





* $\boxed{I_{Line} = I_{phase}}$

هاد الحكي بحدده مع طريقة توصيل ال load اذا كان التوصيل

Y connected

فأكيد $\boxed{I_L = I_p}$

* The voltage accross the load is line to nutral voltage

$$V_{LL} = \sqrt{3}\, V_{LN} \angle 30$$

(line to line) (line to nutral)

$$V_{LN} = \frac{V_{LL}}{\sqrt{3}} \angle -30^\circ$$

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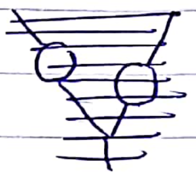
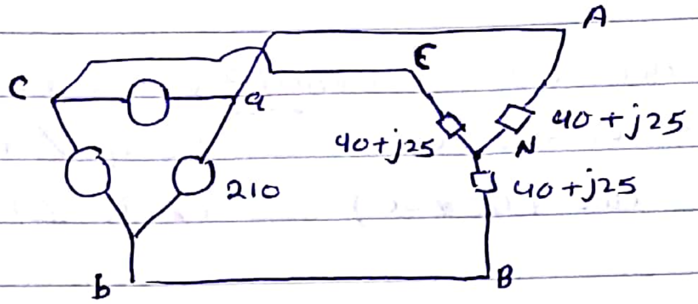
Example.

A Balanced Y- connected load with $Z_Y = 40 + j25$ is supplied by a D - connected source with a line voltage of 210 Volt.

Calculate the phasor & line currents, Take V_{ab} as your referenca.





$$I_a = \frac{U_{AN}}{Z_Y}.$$

$|U_{ab}| = 210$

$U_{ab} = 210 \angle 0$

$$U_{AN} = \frac{210}{\sqrt{3}} \angle -30 = 121.2 \angle -30 \text{ volt}.$$

$$I_a = \frac{121.2 \angle -30}{40 + j25}$$

$= 2.57 \angle -62$ A

$I_b = 2.57 \angle -62-120$ A.

$I_c = 2.57 \angle -62+120$ A.

phase currents. (= line current

V_{bc} ال لأن *

my referenca.

$V_{bc} = 210 \angle 0$

$V_{ab} = 210 \angle -120.$

$V_{ca} = 210 \angle 120$ or $\angle -240.$

$$V_{an} = \frac{210}{\sqrt{3}} \angle 90^\circ$$

* power in 3ϕ system.

$V_{AN} = \sqrt{2}\, V_p \cos(\omega t) \longrightarrow \sqrt{2} V_p \angle 0$

$V_{BN} = \sqrt{2}\, V_p \cos(\omega t - 120) \longrightarrow \sqrt{2} V_p \angle -120$

$V_{CN} = \sqrt{2}\, V_p \cos(\omega t + 120) \longrightarrow \sqrt{2} V_p \angle 120$

$\rightarrow$ Take $Z_Y = Z \angle \theta$

$i_a = \sqrt{2}\, I_p \cos(\omega t - \theta) \equiv (V_{AN}/Z_Y) \longrightarrow \sqrt{2} I_p \angle \theta$

$i_b = \sqrt{2}\, I_p \cos(\omega t - 120 - \theta) \longrightarrow \sqrt{2} I_p \angle -120 - \theta$

$i_c = \sqrt{2}\, I_p \cos(\omega t + 120 - \theta) \longrightarrow \sqrt{2} I_p \angle 120 - \theta$

$P_A = |I_p||V_p| \cos\theta \rightarrow (\theta - \phi)$

$P_B = |I_p||V_p| \cos\theta.$

$P_C = |I_p||V_p| \cos\theta$

phase current. (RMS value)

$P_{total} = P_{3\phi} = 3 |V_p||I_p| \cos\theta$

phase to nutral voltage. (RMS)

angle between phase to nutral voltage & phase current.

$P_{3\phi} = 3 * P_{1\phi}.$

$Q_{total} = Q_{3\phi} = 3|V_p||I_p| \sin\theta$

$= 3 * Q_{1\phi}$

$S_{(total)} = S_{3\phi} = 3\, V_p\, I_p^* = 3 * S_{1\phi}$

$S_{3\phi} = P_{3\phi} + j\, Q_{3\phi}.$

$|S_{(total)}| = 3|V_p||I_p| = 3 * |S_{1\phi}|$

$\hookrightarrow$ Apparent power.

* How to represent power quantities using line voltage & line current.

$P_{3\phi} = 3|V_p||I_p| \cos\theta$

Y- connected loads

$\boxed{I_p = I_L}$

$\boxed{|V_p| = \frac{|V_L|}{\sqrt{3}}}$

$P_{3\phi} = 3 * \frac{|V_L|}{\sqrt{3}} * |I_L| \cos\theta$

line to line.

angle between phase & neutral voltage

line current & phase current.

D - connected

$\boxed{V_p = V_L}$

$\boxed{|I_L| = \sqrt{3}|I_p|}$

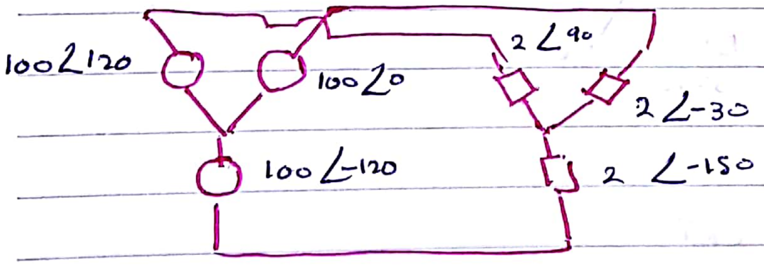
$P_{3\phi}$

$P_{3\phi} = 3|V_L|\frac{|I_L|}{\sqrt{3}} \cos\theta$.

$P_{3\phi} = \sqrt{3}|V_L||I_L| \cos\theta$

* $P_{3\phi} = 3|V_p||I_p| \cos\theta$.
* $P_{3\phi} = \sqrt{3}|V_L||I_L| \cos\theta$.

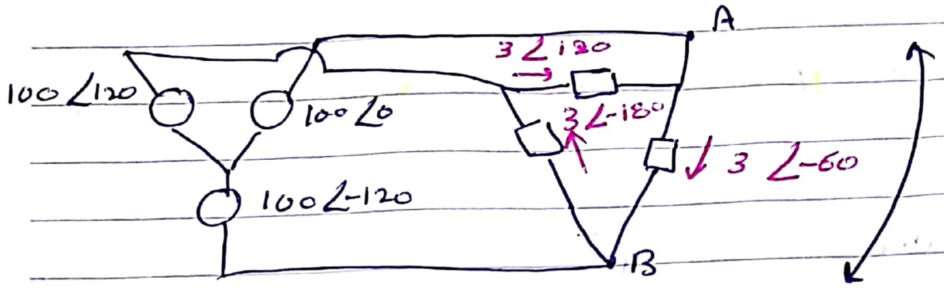
$\angle V_p \ \& \ I_p$



$P_{3\phi} = 3 * 100 * 2 * \cos(0 - -30)$
$= \sqrt{3} * 300$ w

Using line values :-

$P_{3\phi} = \sqrt{3} * \sqrt{3} * 100 * 2 \cos(30)$
$= 300\sqrt{3}$ w.



$U_{AB} = \sqrt{3}\, U_{AN} \angle 30$

$U_{AB} = 100\sqrt{3} \angle 30$

$P_{3\phi} = 3 |U_P| |I_P| \cos\theta$

$= 3 * [100 * \sqrt{3}] * 3 * \cos(30 - - 60) = \text{Zero}$

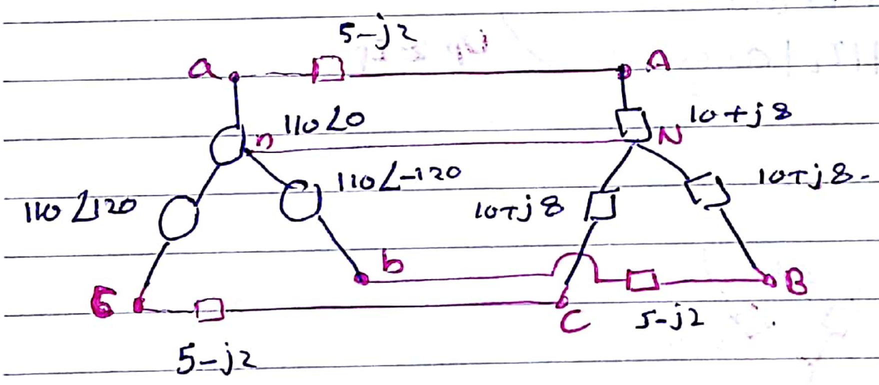
using line :-

$P_{3\phi} = \sqrt{3} |U_L| |I_L| \cos\theta$

$= \sqrt{3} * 100 * \sqrt{3} * \sqrt{3} * 3 * \cos(30 + 60) = \text{Zero}$

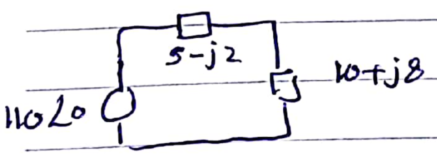
Ex.

given the CKT shown find the source complex power & the load complex power & the T.L losses.



* Single phase equivalent CKT

→ Take phase A.



$I_a = \frac{110\angle 0}{15 + j6} = 6.8 \angle -21.8°$

$S_{(source)\,3\phi} = 3 * U_P * I_P^*$

$= 3 * 110 \angle 0 * 6.8 \angle 21.8$

$= 2247 \angle 21.8$

$= \underbrace{2087}_{P_{3\phi}} + j\, \underbrace{834.6}_{Q_{3\phi}}$

S (load)

$$V_{AN} = \text{(voltage division)} = \frac{110 \angle 0 * (10 + j8)}{15 + 6j}$$

$$S_{load} = 3 V_p I_p^*$$
$$= 3 Z_p * I_p * I_p^*$$
$$= 3 Z_p |I_p|^2$$

$$= 3 * (10 + j8) * (6.8)^2$$
$$= 1392 + j1113 = 1782 \angle 38.66°$$

* power measurement.

→ power is measured in the lab using adevice called wattmeter.

How does wattmeter work :

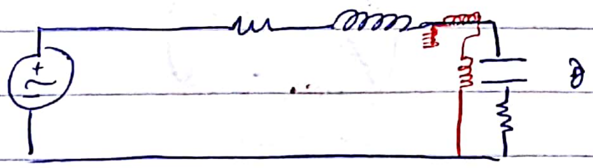
(displacement of pointer)
Deflection.

$P_{measured} \propto V, I, \cos\theta.$

$P = V_{rms} I_{rms} \cos(\theta - \phi)$

Ex.

find the wattmeter reading (find the real power absorbed by the load)



2 coils → parallel (voltage coil)
└→ Series (current coil)

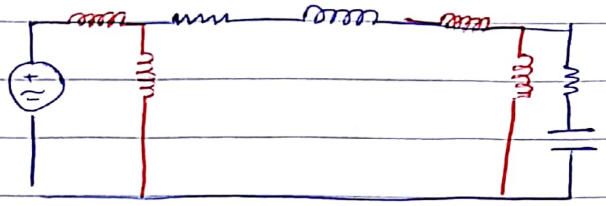
Current coil → load current.

Voltage coil → load voltage.

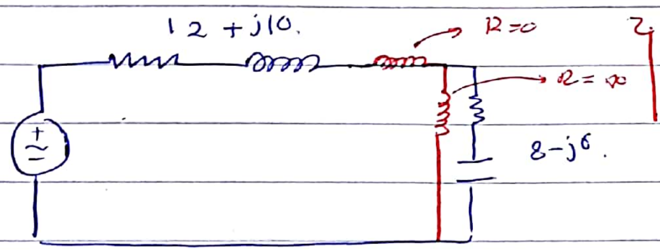
ال wattmeter بيحسب ال power لل load

لو بدي احسب ال power لل source كما

ال coils عنده.



Ex.



مشان ميرث ما بأثرو
على ال system

$P = V_{rms} I_{rms} \cos(\theta - \phi)$

$V_{load} \rightarrow$ voltage division $= \dfrac{150\angle 0 * (8-j6)}{(20+j4)} = 73.5 \angle -84^\circ$

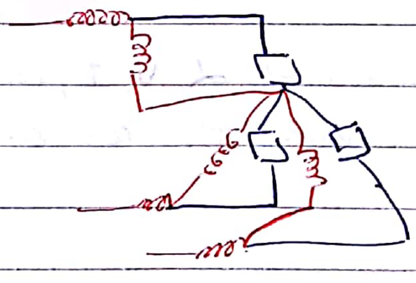
$I_{load} \rightarrow \dfrac{150\angle 0}{20+j4} = 7.35 \angle -11.3^\circ$

$W_{reading} = P(load) = V_{rms} I_{rms} \cos(\theta - \phi)$

$= 73.5 * 7.32 * \cos(-84 + 11.3)$

$= 432.1 \ W$

* Power measurement in 3 phase system

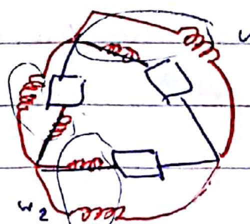


$P_{3\phi} = W_1 + W_2 + W_3$

if the load is Balanced

$P_{3\phi} = 3W_1$

* for a D connected load.

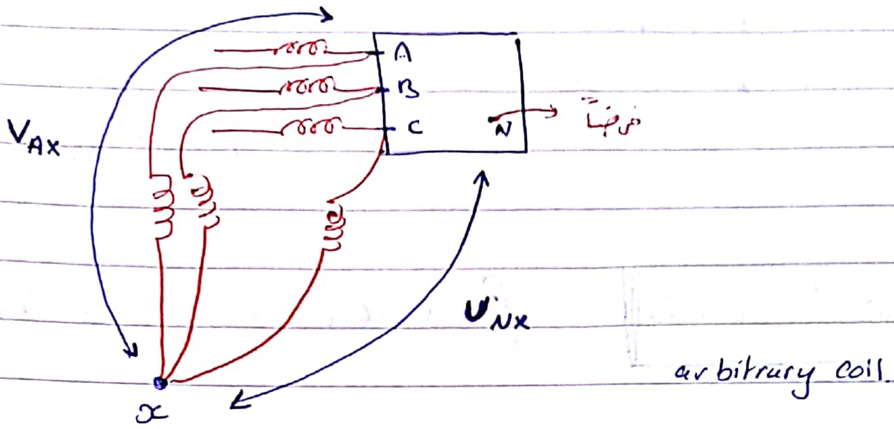


$P_{3\phi} = W_1 + W_2 + W_3$

If the load is Balanced

$P_{3\phi} = 3W$

(the nutral point is not accessible)



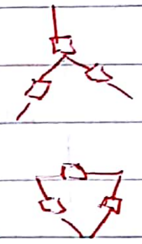
$$P_{3\phi} \overset{??}{=} w_1 + w_2 + w_3$$

$$w_1 = \frac{1}{T}\int_0^T U_{AN}(t) \cdot i_a(t) \cdot dt$$

$$w_2 = \frac{1}{T}\int_0^T U_{BN}(t) \cdot i_b(t) \cdot dt$$

$$w_3 = \frac{1}{T}\int_0^T U_{CN}(t) \cdot i_c(t) \cdot dt$$

for



$$w_1 = \frac{1}{T}\int_0^T U_{Ax}(t) \cdot i_a(t) \cdot dt$$

$$w_2 = \frac{1}{T}\int_0^T U_{Bx}(t) \cdot i_b(t) \cdot dt$$

$$w_3 = \frac{1}{T}\int_0^T U_{Cx}(t) \cdot i_c(t) \cdot dt$$

$$\boxed{\begin{aligned} U_{Ax} &= U_{AN} + U_{Nx} \\ U_{Bx} &= V_{BN} + U_{Nx} \\ U_{Cx} &= U_{CN} + U_{Nx} \end{aligned}}$$

$$P_{3\phi} = \frac{1}{T}\int_0^T (U_{AN} + U_{Nx})\, i_a(t) \cdot dt + \frac{1}{T}\int_0^T (U_{BN} + U_{Nx}) \cdot i_b(t) \cdot dt$$

$$+ \frac{1}{T}\int_0^T (V_{CN} + U_{Nx}) \cdot i_c(t) \cdot dt$$

$$= \frac{1}{T}\Big[U_{AN}(t) \cdot i_a(t) + U_{bn}(t) \cdot i_b(t) + U_{cN}\, i_c(t) + U_{Nx}\underbrace{(i_a + i_b + i_c)}_{=\text{zero}}\Big]$$

(in Δ & Y without nutral)

$$= \frac{1}{T}\int_0^T U_{AN}(t) \cdot i_a(t) \cdot dt + \frac{1}{T}\int_0^T V_{bn}(t) \cdot i_b(t) \cdot dt + \frac{1}{T}\int_0^T V_{cN}(t) \cdot i_c(t) \cdot dt$$

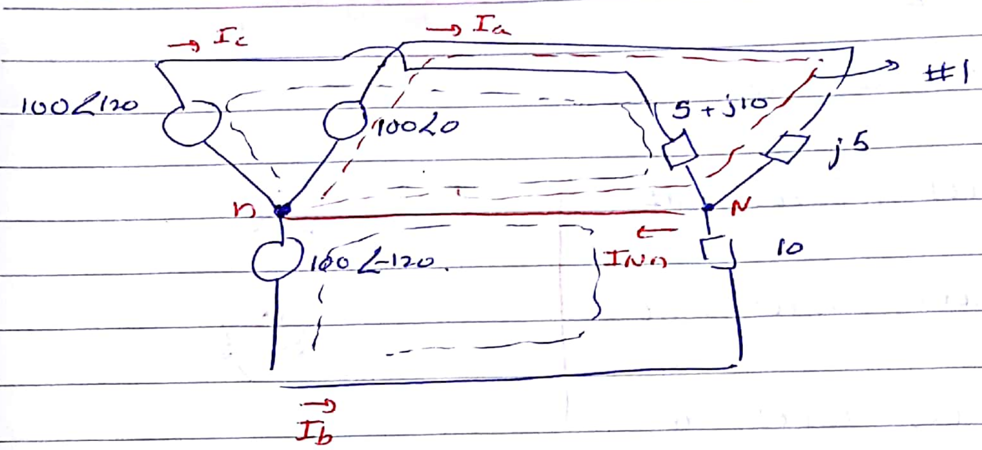
so.

$P_{3\phi} = W_1 + W_2 + W_3$.

the ~~~~ choice of point x B will not affect the total power (3ϕ power).

Unbalanced load

find I_a, I_b, I_c & I_{Nn}.



KVL at #1.

$-100\angle 0 + j5 I_a = 0$

$I_a = \dfrac{100\angle 0}{j5} = 20\angle -90^\circ$ A.

KVL

$I_b = \dfrac{100\angle -120}{10} = 10\angle -120$ A.

KVL

$I_c = \dfrac{100\angle +120}{5+10j}$ #

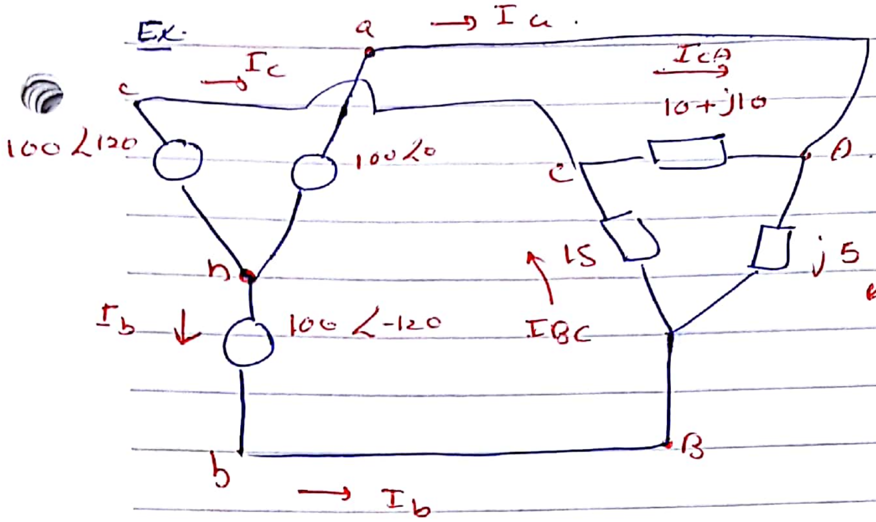
$I_{Nn} = I_a + I_b + I_c = 20\angle -90^\circ + 10\angle -120^\circ + \dfrac{100\angle 120}{5+10j} \neq$ zero.

$V_N = V_n = 0$.

alway = zero

مام يذكر غير ذلك

Ex.



find phase & line Currents.

$$I_{AB} = \frac{U_{AB}}{j5} = \frac{U_{ab}}{j5} = \frac{100\sqrt{3}\angle 30}{j5} = 20\sqrt{3}\angle -60 \text{ A.}$$

$$I_{BC} = \frac{U_{BC}}{15} = \frac{U_{bc}}{15} = \frac{100\sqrt{3}\angle -90}{15} = 6.66\sqrt{3}\angle -90 \text{ A.}$$

$$I_{CA} = \frac{U_{CA}}{j10} = \frac{U_{ca}}{10+j10} = \frac{\sqrt{3}\,*100\angle 150}{10+j10}$$ #

بينهم $120°$.

→ for Balanced load
$I_{line} = \sqrt{3}\, I_{phase} \angle -30.$

→ ~~for~~ here (non balanced load) we applied KCL

$I_a + I_{CA} = I_{AB}$

$I_a = I_{AB} - I_{CA}.$

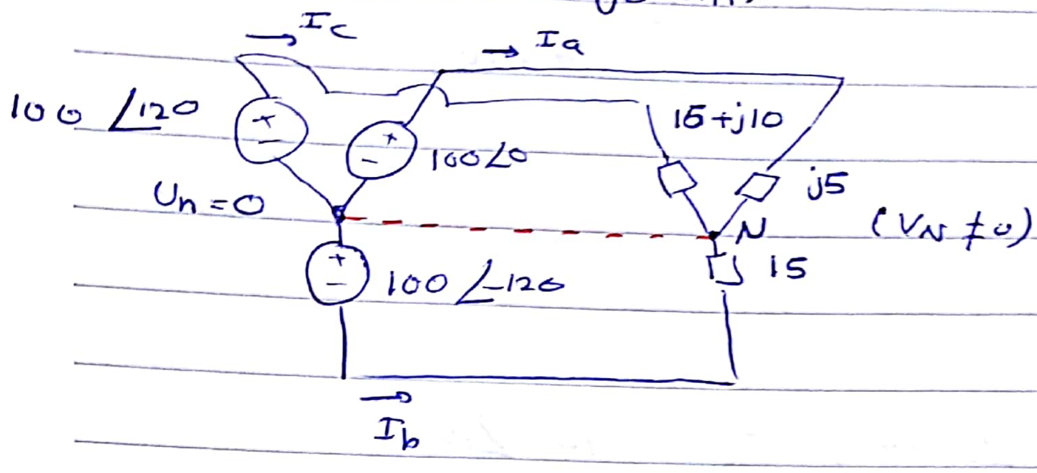
$I_b + I_{AB} = I_{BC}$

$I_b = I_{BC} - I_{AB}.$

$I_C + I_{BC} = I_{CA}.$

$I_C = I_{CA} - I_{BC}.$

* unbalanced system:-



KVL. (first way).

1. $-100\angle 0 + j5 - 15 I_b + 100\angle 120 = 0$
2. $-100\angle 120 + I_c(10+j10) + 15 I_b + 100\angle -120 = 0$
3. ----.

* ~~better way~~. Second way:

KCL.

$I_a + I_b + I_c = 0$, $U_N \neq 0$

* قبل ما اشيل سلك nN

$I_a + I_b + I_c = I_{Nn}$.

$U_N =$ Zero.

* بعد ما شلته :-

$I_a + I_b + I_c = 0$.

$U_N \neq 0$.

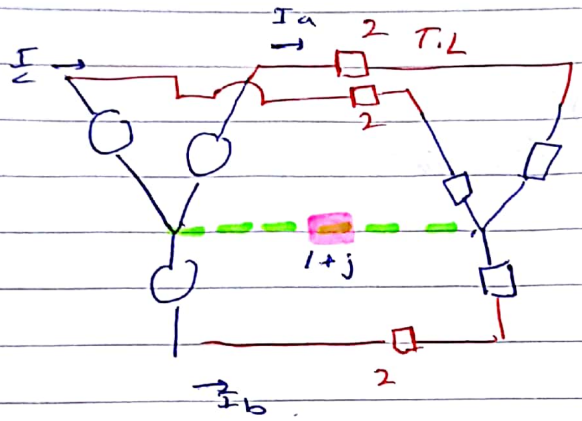
$* \; I_a = \dfrac{100\angle 0 - U_N}{j5}$

$* \; I_b = \dfrac{100\angle -120 - U_N}{15}$

$* \; I_c = \dfrac{100\angle 120 - U_N}{10 - j10}$

$$\frac{100\angle 0 - U_N}{j5} + \frac{100\angle -120 - U_N}{15} + \frac{100\angle 120 - U_N}{10+10j} = 0$$

* find U_N then I_a, I_b, I_c.



$I_a = \dfrac{100\angle 0 - U_N}{2+j5}$

$I_b = \dfrac{100\angle -120 - U_N}{12}$

$I_c = \dfrac{100\angle 120 - U_N}{17+10j}$

.(لو وصلت السلك)

$I_a = \dfrac{100\angle 0}{2+j5}$, $I_b = \dfrac{100\angle -120}{12}$, $I_c = \dfrac{100\angle 120}{17+10j}$

(لو وصلنا مقاومة على السلك)

$U_N \neq 0$

$I_{Nn} = \dfrac{U_N}{1+j} = I_a + I_b + I_c$

$I_a = \dfrac{100\angle 0 - U_N}{2+j5}$

$I_b = \dfrac{100\angle -120 - U_N}{12}$

$I_c = \dfrac{100\angle 120 - U_N}{17-j10}$

$$\frac{100 - U_N}{2+j5} + \frac{100\angle -120 - U_N}{12} + \frac{100\angle 120 - U_N}{17+j10} = \frac{U_N}{1+j}$$

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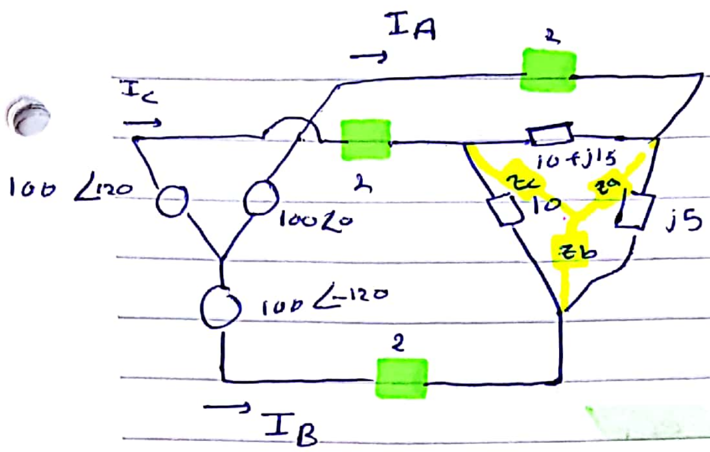


* without T.L impedence:-

$$\cancel{I_{AB} = \frac{U_{AB}}{j5} \angle 30 . \quad I_{BC} = \frac{U_{BC}}{j0}}$$

$$\cancel{I_{AB} = \frac{\sqrt{3}\,100 \angle 30}{j5} , \quad I_{BC} = \frac{\sqrt{3} + 100 \angle -90}{10} .}$$

$$I_{AB} = \frac{U_{AB}}{j5} = \frac{\sqrt{3} * 100 \angle 30}{j5} .$$

$$I_{BC} = \frac{U_{BC}}{10} = \frac{\sqrt{3} * 100 \angle -90}{10} .$$

$$I_{CA} = \frac{U_{CA}}{10+j15} = \frac{\sqrt{3} * 100 \angle 150}{j15+10} .$$

* with T. L.

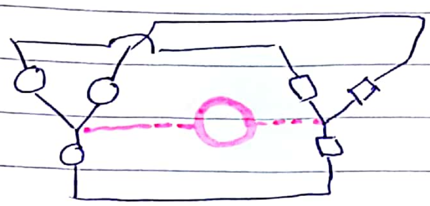
$U_{ab} \neq U_{AB}$.

$\Delta - Y$ transphormation.

$$Z_a = \frac{j5\,(10+j5)}{j5+10+j5+10} \quad \ldots .$$

$$I_a = \frac{100 \angle 0 - U_N}{2 + Z_a} .$$

Scanned by CamScanner



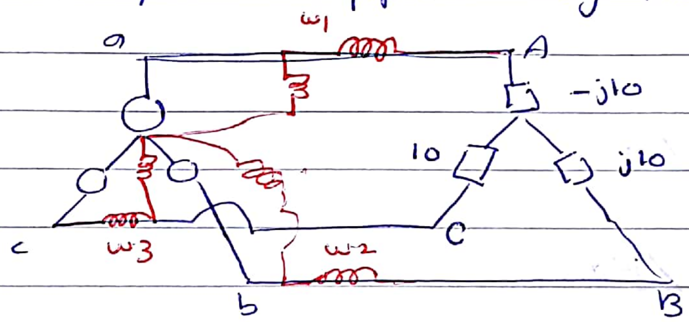
short circuit
(there is Nn line)

open ckT
(there is no Nn line)

~~Given that $V_{AB} = 230\angle 0$~~
~~→ find the reading at each~~

Find the reading of the 3 wattmeters & find the total power supplied by the source.

$V_{ab} = 100\angle 0$.



$w_1 \Rightarrow V_{an}$ & I_a. , $V_{an} = (100/\sqrt{3})\angle -30$.

$w_2 \Rightarrow V_{bn}$ & I_b. , $V_{bn} = (100/\sqrt{3})\angle -150$.

$w_3 \Rightarrow V_{cn}$ & I_c. , $V_{cn} = (100/\sqrt{3})\angle 90$

$$\frac{\frac{100}{\sqrt{3}}\angle -30 - V_N}{-j10} + \frac{\frac{100}{\sqrt{3}}\angle -150 - V_N}{j10} + \frac{\frac{100}{\sqrt{3}}\angle 90 - V_N}{10} = 0$$

→ find V_N then find I_a, I_b, I_c.

* $I_a = 19.32\angle 15$.
* $I_b = 19.32\angle 16.2$.
* $I_c = 10\angle -90$.

$W_1: P_1 = V_{an} * I_a * \cos(\theta_{V_{an}} - \phi_{I_a})$

$= \frac{100}{\sqrt{3}} * 19.32 * \cos(-30 - 15) = 788.7\,w$

$W_2: P_2 = V_{bn} * I_b * \cos(\theta - \phi)$

$= \frac{100}{\sqrt{3}} * 19.32 * \cos(-150 - 165)$

$= 788.7\,w$

$W_3: P_3 = V_{cn} * I_c * \cos(\theta - \phi)$

$= \frac{100}{\sqrt{3}} * 10 * \cos(90 + 90)$

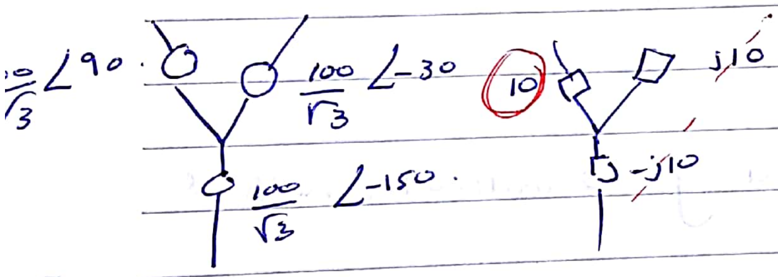
$= -577.4\,w$

total power supplied by the source is:

$P_{3\phi} = P_1 + P_2 + P_3$

$= W_1 + W_2 + W_3$

$= 788.7 + 788.7 - 577.4 = 1000\,w$



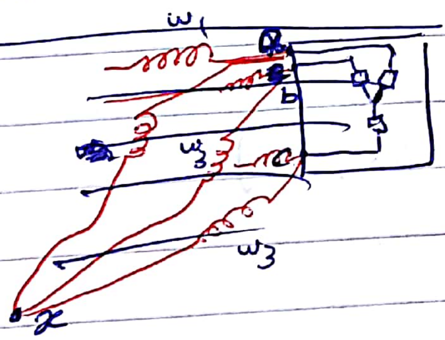
Real power only on 10Ω.

$P_{3\phi} = (I_c)^2 * R$

$= (10)^2 * 10$

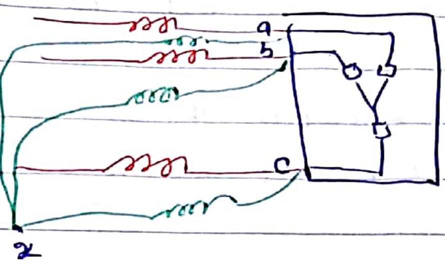
$= 1000\,w$ #

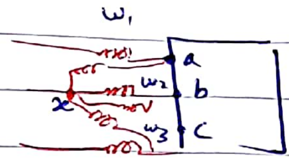
~~The two~~ watt meter method :-



The Two wattmeter method:

$\propto$: what if x is chosen such that x is put on one of phases

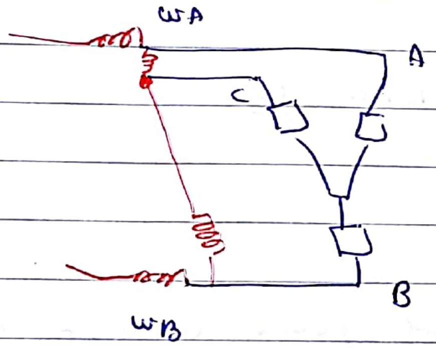




Zero = w_2 ←

يكفي الا نستخدم

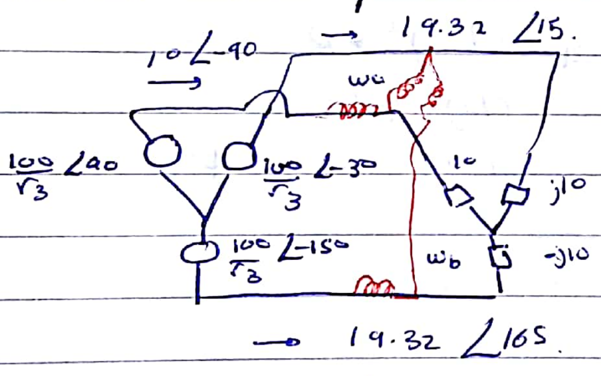
Two wattmeters.



$w_A \Rightarrow V_{AC}, I_a$.

$w_B \Rightarrow V_{BC}, I_b$.

* Solve the previous exp. using 2 wattmeter method.



$w_a : V_{ca}, I_c$

$w_b \Rightarrow V_{ba}, I_b$

$V_{AB} = \sqrt{3} V_{an} \angle 30$.

$V_{ab} = 100 \angle 0$. ($V_{ba} = -V_{ab} = 100 \angle 180$)

$V_{bc} = 100 \angle -120$

$V_{ca} = 100 \angle 120$

$w_a : P_a : |V_{ca}||I_c| \cos(\theta_{V_{ca}} - \phi_{I_c}) = 100 * 10 * \cos(120+90) = -886$

$w_b : P_b : |V_{ba}||I_b| \cos(\theta_{V_{ba}} - \phi_{I_b}) = 100 * 19.32 \cos(180-165)$

$= 1886$ w

$1886 - 886 = 1000$ w #

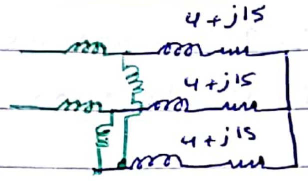
* Given that $V_{AB} = 230\angle 0$

→ find the reading of each wattmeter.

& the total power supplied to the load.

$W_A : V_{AC} : I_A$.

$W_B : V_{BC} , I_B$.



$V_{AB} = 230\angle 0$

$V_{BC} = 230\angle -120$.

$V_{CA} = 230\angle 120$, $V_{AC} = 230\angle 120 - 180$

$$I_a = \frac{V_{AN}}{4+j15} = \frac{(V_{AB}/\sqrt{3})\angle -30}{4+j15} = \frac{\frac{230}{\sqrt{3}}\angle -30}{4+j15} = 8.554\angle -105.1^\circ$$

$I_b = 8.554\angle -106 - 120$

$I_c = 8.554\angle -105.1 + 120$

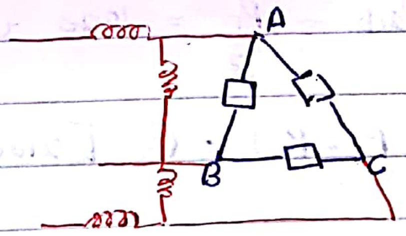
$w_1 : P_1 = 230 * 8.554 \cos(-60 + 105.1) = 1389$ w

$w_2 : P_2 = 230 * 8.554 \cos(-120 + 125.1) = -512$ w.

$P_T = P_1 + P_2 = 876.5$ w

تشيك $P_T = 3|I|^2 R = 3 * (8.554)^2 * 4$ w #

How to calculate the pF from the reading of wattmeter.



$W_A = |V_{AB}||I_A| \cos(\theta_{V_{AB}} - \phi_{I_A})$

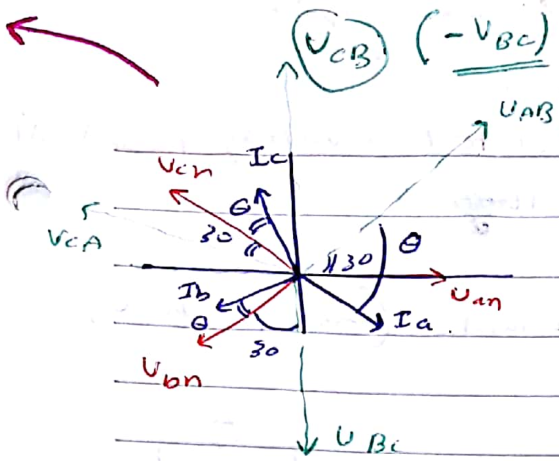
$= |V_{LL}||I_L| \cos(\theta_{V_{AB}} - \phi_{I_A})$

$W_B = |V_{CB}||I_C| \cos(\theta_{V_{CB}} - \phi_{I_C})$

$= |V_{LL}||I_L| \cos(\theta_{V_{CB}} - \phi_{I_C})$

⇒ Consider inductive load (voltage leads current.)

Scanned by CamScanner



$$P_A = V_{LL} I_L \cos(30+\theta)$$

$$P_B = V_{LL} I_L \cos(30-\theta)$$

$$\frac{P_A}{P_B} = \frac{\cancel{|V_{LL}|}\cancel{|I_L|} \cos(30+\theta)}{\cancel{|V_{LL}|}\cancel{|I_L|} \cos(30-\theta)}$$

$$\frac{P_A}{P_B} = \frac{\cos 30 \cos\theta - \sin 30 \sin\theta}{\cos 30 \cos\theta + \sin 30 \sin\theta}$$

$$= \left(\frac{\frac{\sqrt{3}}{2}\cos\theta - \frac{1}{2}\sin\theta}{\frac{\sqrt{3}}{2}\cos\theta + \frac{1}{2}\sin\theta}\right) \div \frac{2}{2} \div \frac{\cos\theta}{\cos\theta}$$

$$\frac{P_A}{P_B} = \frac{\sqrt{3} - \tan\theta}{\sqrt{3} + \tan\theta}$$

$$P_A(\sqrt{3} + \tan\theta) = P_B(\sqrt{3} - \tan\theta)$$

$$P_A\sqrt{3} + P_A \tan\theta = P_B\sqrt{3} - P_B \tan\theta$$

$$\tan\theta\,[P_A + P_B] = \sqrt{3}\,[P_B - P_A]$$

$$\tan\theta = \frac{\sqrt{3}\,[P_B - P_A]}{[P_A - P_B]}$$

$$\rightarrow \tan\theta = \frac{\sqrt{3}\,[P_2 - P_1]}{[P_1 + P_2]}$$

$P_2 = P_1$	$P_2 > P_1$	$P_2 < P_1$
(Resistive load)	(Inductive load)	(capacitive load)

* واحد من الواطميترات يكون عالي والتاني معكوس .

P_1 ← العالي

~~العكسي~~

P_2 ← المعكوس

$$P_T = P_1 + P_2 = V_{LL} I_L \cos(30+\theta) + V_{LL} I_L \cos(30-\theta)$$

$$= V_{LL} I_L \cos 30 \cos\theta - V_{LL} I_L \cancel{\sin 30 \sin\theta} + V_{LL} I_L \cos 30 \cos\theta$$

$$+ V_{LL} I_L \cancel{\sin 30 \sin\theta}$$

$$= 2 V_{LL} I_L \cos 30 \cos\theta = \boxed{\sqrt{3} V_{LL} I_L \cos\theta.} \equiv P_T.$$

$$\rightarrow \sqrt{3}[P_2 - P_1] = \sqrt{3} V_{LL} I_L \cos(30-\theta) - \sqrt{3} V_{LL} I_L \cdot \cos(30+\theta)$$

$$= \cancel{\sqrt{3} V_{LL} I_L \cos 30 \cos\theta} + \sqrt{3} V_{LL} I_L \sin 30 \sin\theta$$

$$- \cancel{\sqrt{3} V_{LL} I_L \cos 30 \cos\theta} + \sqrt{3} V_{LL} I_L \sin 30 \sin\theta.$$

$$= \sqrt{3} V_{LL} I_L \sin\theta = Q_T \quad \#$$

$$\boxed{\begin{aligned} P_T &= P_2 + P_1 \\ Q_T &= \sqrt{3}[P_2 - P_1] \\ |S| &= \sqrt{P_2^2 + P_1^2} \\ \tan\theta &= \frac{Q_T}{P_T} = \frac{\sqrt{3}[P_2 - P_1]}{[P_2 + P_1]}. \end{aligned}}$$

Ex. Tow wattmeters produce readings $P_1 = 1560$, $P_2 = 2100$ w when connected to 3ϕ load, find :

[1] $P_T = P_1 + P_2$

$= 1560 + 2100 = 3660$ w.

if the load is Balanced.

$P_{1\phi} = \frac{P_T}{3} = 1220$ w.

[2] $Q_T = \sqrt{3}[P_2 - P_1] = \sqrt{3}\,[2100 - 1560] = 935$ VAR.

if the load is Balanced.

$Q_{1\phi} = \frac{Q_T}{3} = 311.67$ VAR.

[3] $PF = \cos\left[\tan^{-1}\left[\frac{\sqrt{3}\,[2100 - 1560]}{2100 + 1560}\right]\right]$

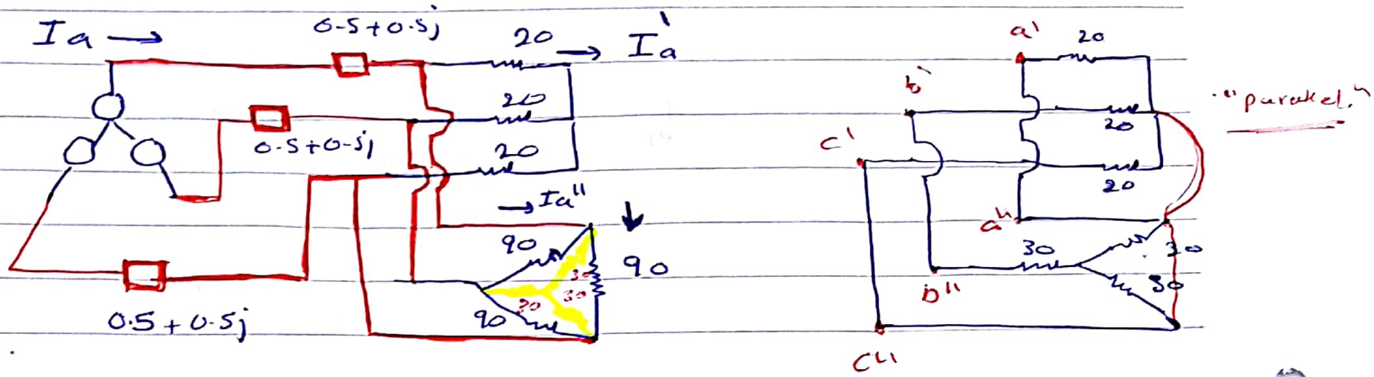
$= 0.9689$ lagging $(P_2 > P_1)$

Example:-

$\angle 0 \rightarrow$ بعملها زي ما بدي .
RMS.
line to line voltage (اذا ما حدد)

Voltage at generator = 208 voltage.

find the line currents & phase currents (every where)



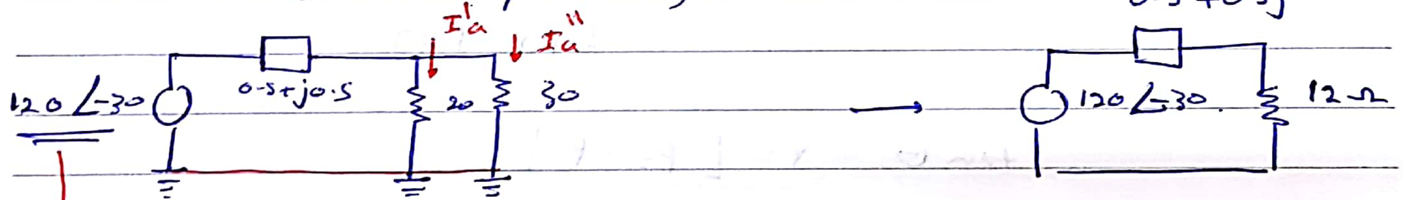
* convert Δ to Y.

$Z_Y = \frac{1}{3} Z_\Delta$ (balanced load)

$= 30\ \Omega$

* then single phase equivalent circuit.

(take phase A).



Take V_{AB} as our reference

$V_{AB} = 208 \angle 0$.

$V_{AN} = \frac{V_{AB}}{\sqrt{3}} \angle -30 = 120 \angle -30$.

$I_a = \frac{120 \angle -30}{12 + 0.5 + 0.5j}$

$I'_a = \frac{30}{50} I_a$.

$I''_a = \frac{20}{50} I_a$

current division.