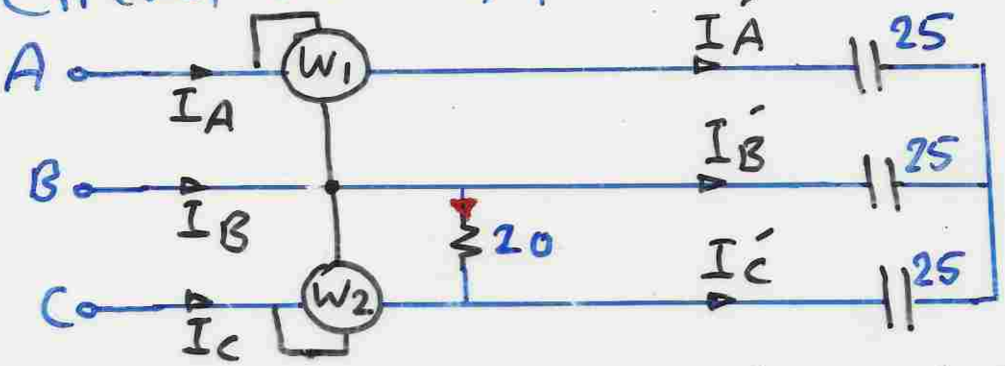
Example

For the Circuit shown, Find W_1 & W_2.

Supply Voltage 260V



$V_A = \frac{260}{\sqrt{3}} = 150\angle 0 \text{ v}$, $V_B = 150\angle -120 \text{ v}$, $V_C = 150\angle +120 \text{ v}$

$I_A = I_A' = \frac{150\angle 0}{25\angle -90} = \underline{6\angle 90 \text{ A}}$

$I_B' = \frac{150\angle -120}{25\angle -90} = \underline{6\angle -30 \text{ A}}$, $I_C' = \underline{6\angle 210}$ A.

$I_{BC} = \frac{V_{BC}}{20} = \frac{260\angle -90}{20} = 13\angle -90 \text{ A}.$

$\therefore I_B = I_B' + I_{BC} = 6\angle -30 + 13\angle -90 = 16.82\angle -72 \text{ A}$

$I_C = I_C' - I_{BC} = 6\angle 210 - 13\angle -90 = 11.27\angle 117.46 \text{ A}$

$W_1 = I_A V_{AB} \cos\psi_1$

$= 6 \times 260 \cos 60 = \underline{780} \text{ W}.$

$W_2 = I_C V_{CB} \cos\psi_2$

$= 11.27 \times 260 \cos 27.46$

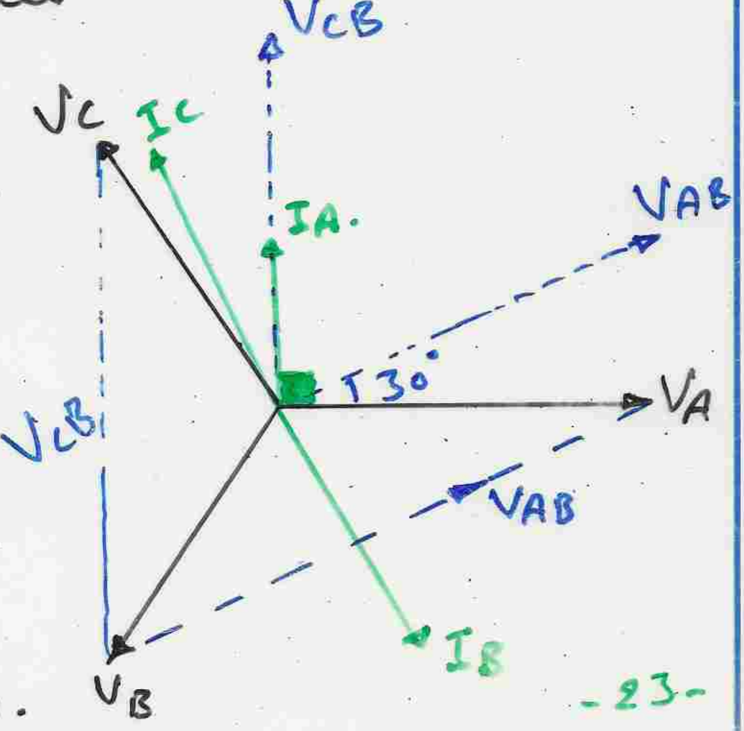
$= \underline{2600 \text{ W}}$

$P_T = W_1 + W_2$

$= 3380 \text{ W}$

Check $P_T = P_{20\Omega}$

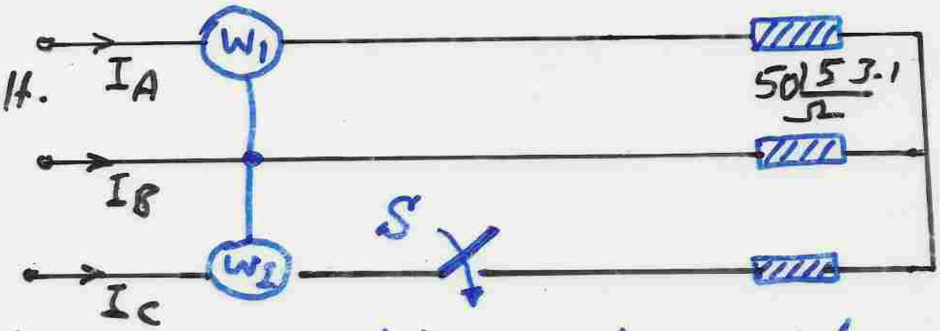
$= (13)^2 \times 20 = 3380 \text{ W}.$



Example

For the Circuit, find W_1 & W_2 when:
a) Switch (S) closed. b) Switch (S) open.

$V_\ell = \underline{346.4}$ Volt.



a)

$V_A = \frac{346.4\angle 0}{\sqrt{3}} = 200\angle 0$, $V_B = 200\angle{-120}$, $V_C = 200\angle{+120}$

$I_A = \frac{V_A}{Z} = \frac{200\angle 0}{50\angle 53.1} = \underline{4\angle{-53.1}}$ A

$\therefore I_B = 4\angle{-173.1}$ A , $\underline{I_C = 4\angle 66.9}$ A.

$W_1 = I_A V_{AB} \cos(30 + 53.1)$.

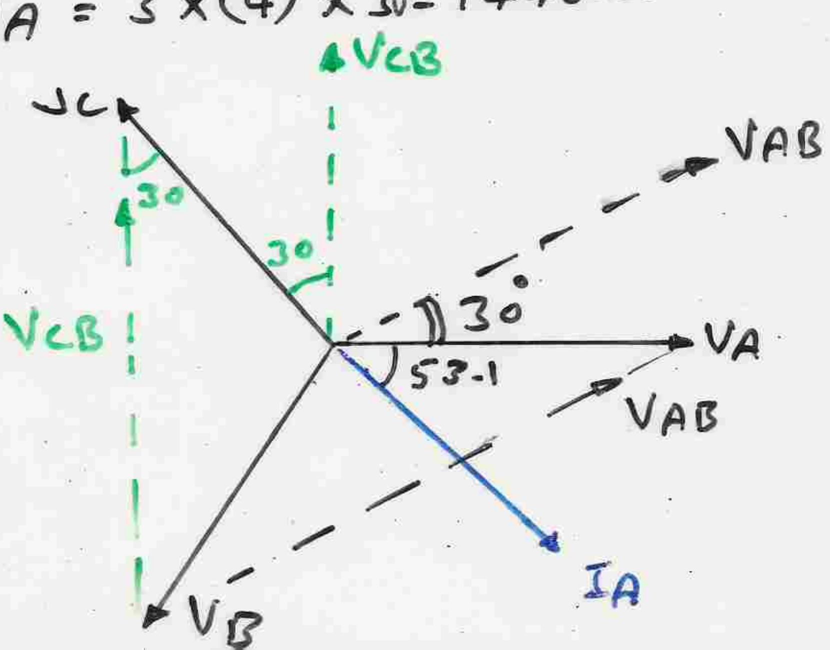
$= 4 \times 346.4 \cos 83.1 = \underline{166.46}$ W

$W_2 = I_C V_{CB} \cos(90 - 66.9)$

$= \underline{1274.5}$ W

$P_T = W_1 + W_2 = \underline{1440}$ W.

OR $P_T = 3P_A = 3 \times (4)^2 \times 30 = 1440$ W.



b) S is open.

$\therefore W_2 = 0 \quad (I_C = 0).$

$\therefore I_A = \frac{V_{AB}}{60+j80} = \frac{346.4\angle 30}{100\angle 53.1} = 3.464\angle -23.1 \text{ A}.$

$W_1 = I_A V_{AB} \cos(30 + 23.1).$

$= 3.464 \times 346.4 \cos 53.1$

$= 720\text{W}$

check $P = I_A^2 \times (30+30)$

$= (3.464)^2 \times 60 = 720\text{W}$

Example: For the circuit, find the value of (R & X_c) then the reading of W_3 & W_4.

$W_1 = 7738.3\ W$, $W_2 = 3061.7\ W$.

ans:

$$\tan\psi = \sqrt{3}\,\frac{(W_1 - W_2)}{(W_1 + W_2)} = \sqrt{3}\,\frac{4676.6}{10800} = 0.75 = \frac{X_c}{R}$$

$\therefore \psi = 36.86$

$$P_T = W_1 + W_2 = 10800 = \sqrt{3} \times V_\ell \times I_\ell . \cos\psi = \sqrt{3} . V_\ell . 30 . \cos 36.86$$

$\therefore V_\ell = 259.8$ Volt $\qquad \therefore V_{ph} = \frac{259.8}{\sqrt{3}} = 150$ Volt

$\therefore V_A = 150\angle 0$ & $I_A = 30\angle{+36.86}$ A

$$Z_A = Z_B = Z_C = \frac{V_A}{I_A} = \frac{150\angle 0}{30\angle{+36.86}} = 5\angle{-36.86}\ \Omega$$

$\therefore Z_A = (4 - j3)\ \Omega \qquad \therefore R = 4\ \Omega \quad X_c = 3\ \Omega$.

$\therefore V_{A'} = 30\angle 36.86 \times 3\angle{-90} = 90\angle{-53.14}$ V.

$\therefore V_{B'} = 90\angle{-173.14}$ V, $V_{C'} = 90\angle 66.86$ V.

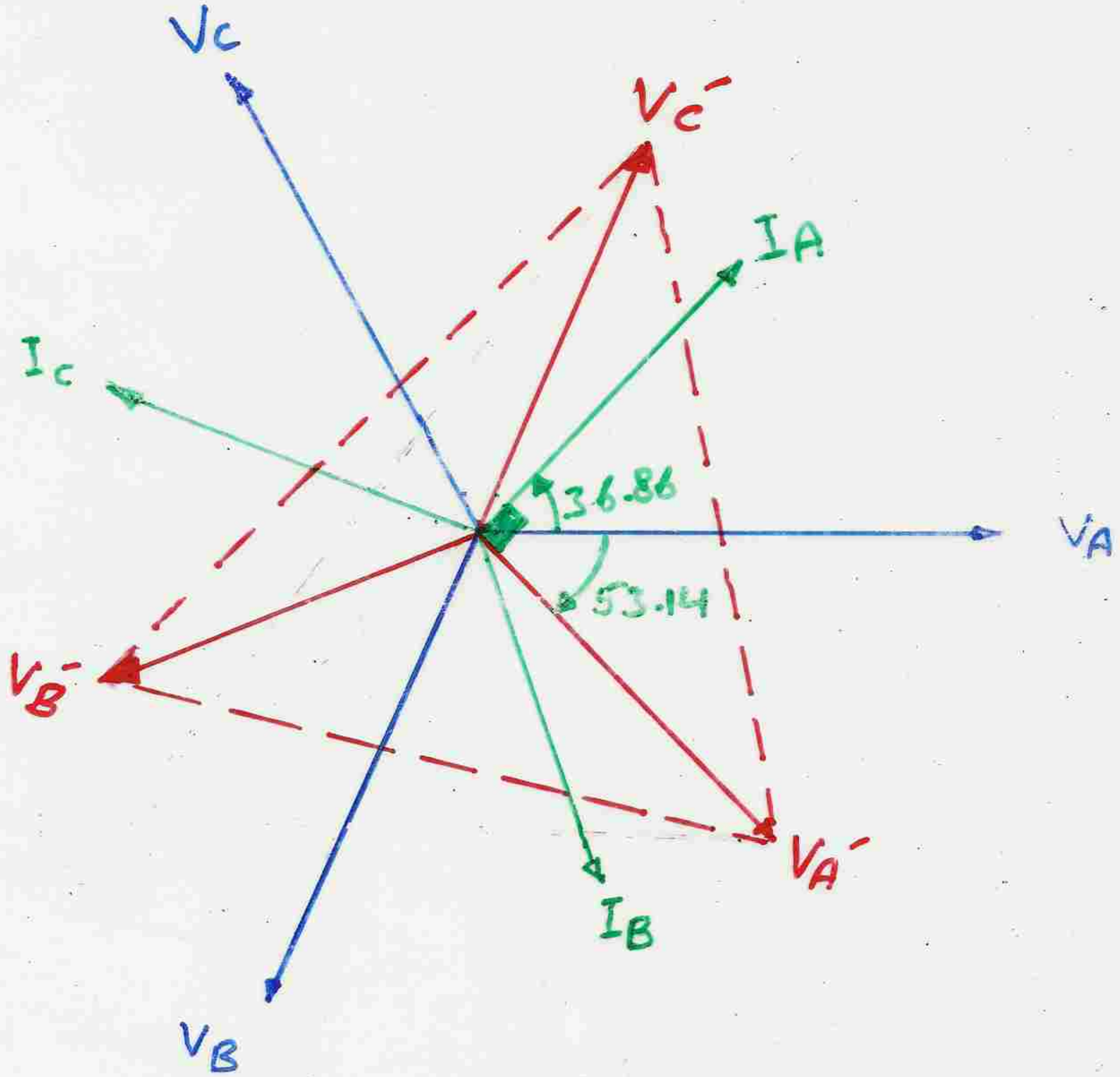
$$W_3 = I_B V_{B'A'} \cos x = \sqrt{3} \times 90 \times 30 \cos 120 .$$
$$= -2338.2 \text{ Watts}$$

$$W_4 = I_C V_{C'A'} \cos y = \sqrt{3} \times 90 \times 30 \cos 60 .$$
$$= 2338.2 \text{ Watts.}$$

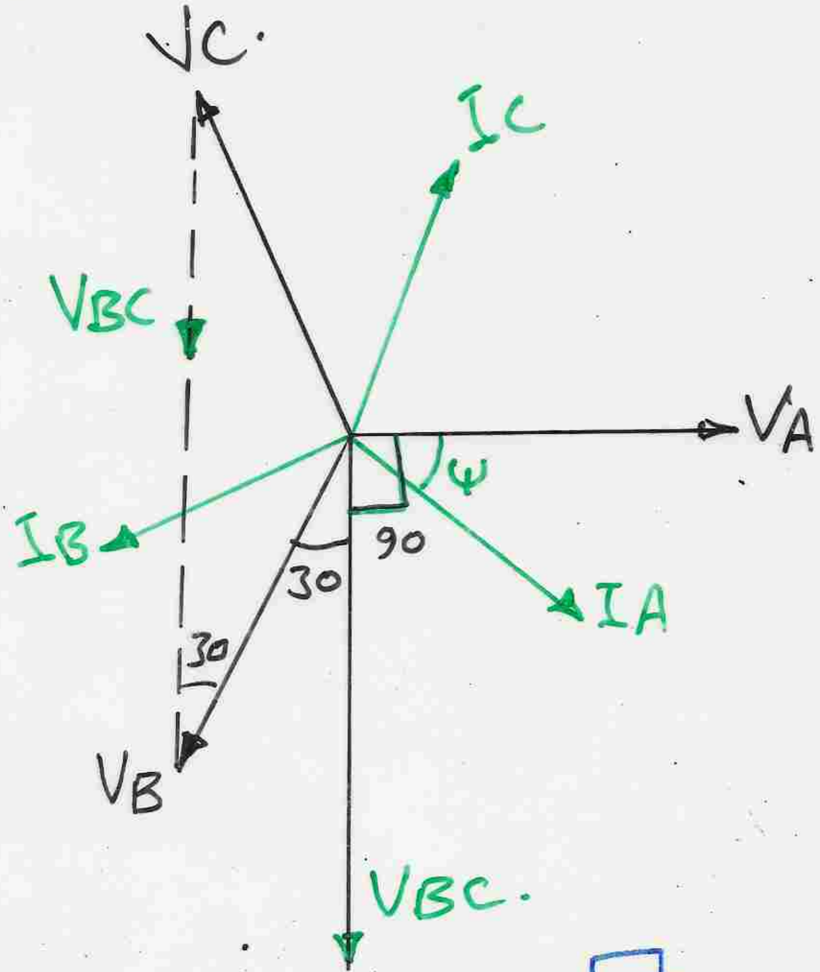
$Q_T = \sqrt{3}\,(W_3 - W_4) = 8100$ VAR.

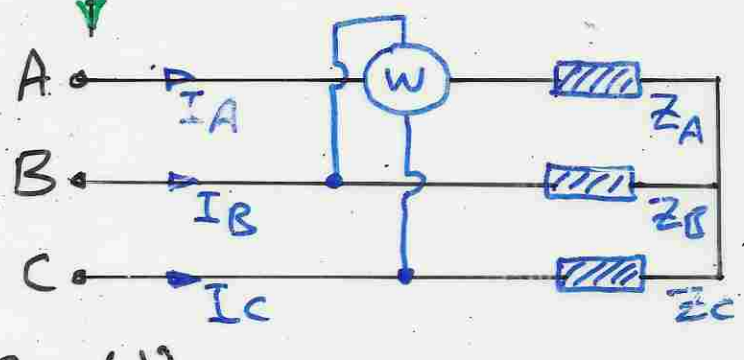
Check $Q_T = 3(I_A)^2 \times 3 = 8100$ VAR.

$I_A = 30\angle 36.86$, $I_B = 30\angle -83.14$, $I_C = 30\angle 156.86$.



Example: For the circuit shown ($Z_A = Z_B = Z_C$) prove with the aid of diagram that the inductive reactive power supplied to the circuit $Q = |\sqrt{3}W|$.





$$W = V_{BC} I_A \cos(90 - \psi).$$

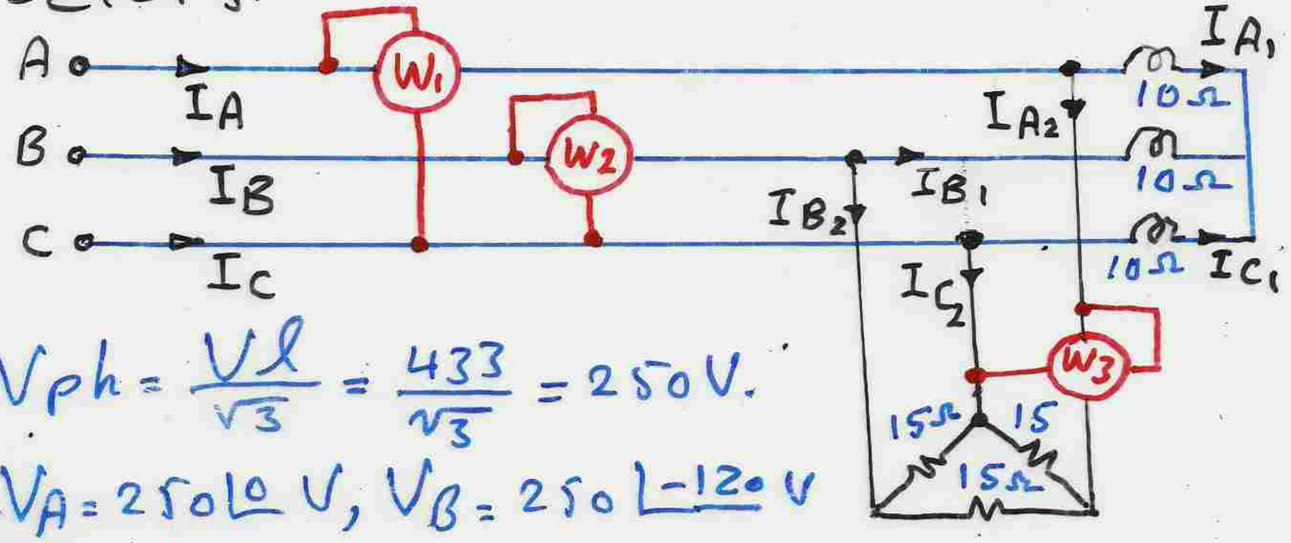
$$= V_l I_l [\cos\psi \underbrace{\cancel{\cos 90}}_{=0} + \sin\psi \sin 90]$$

$$W = V_l I_l \sin\psi$$

But $Q = \sqrt{3} V_l I_l \sin\psi$.

$$\therefore \quad Q = |\sqrt{3} W|.$$

Ex: For the circuit shown, the line voltage is (433V), find the current distribution and the reading of Wattmeters.



$$V_{ph} = \frac{V_l}{\sqrt{3}} = \frac{433}{\sqrt{3}} = 250\,V.$$

$\therefore V_A = 250\angle 0\ V,\ V_B = 250\angle -120\ V$

$V_C = 250\angle +120\ V.$

$$I_{A_1} = \frac{V_A}{j10} = \frac{250\angle 0}{10\angle 90} = 25\angle -90\ \text{Amp.}$$

$$I_{A_2} = \frac{V_A}{5} = \frac{250\angle 0}{5} = 50\angle 0\ \text{Amp.}$$

$$\therefore I_A = I_{A_1} + I_{A_2} = 55.9\angle -26.56\ \text{Amp.}$$

$$\therefore I_B = 55.9\angle -146.56\ A,\quad I_C = 55.9\angle 93.44\ A.$$

$$W_1 = I_A V_{AC} \cos\theta_1$$

$$= 55.9 \times 433 \cos(30 - 26.56).$$

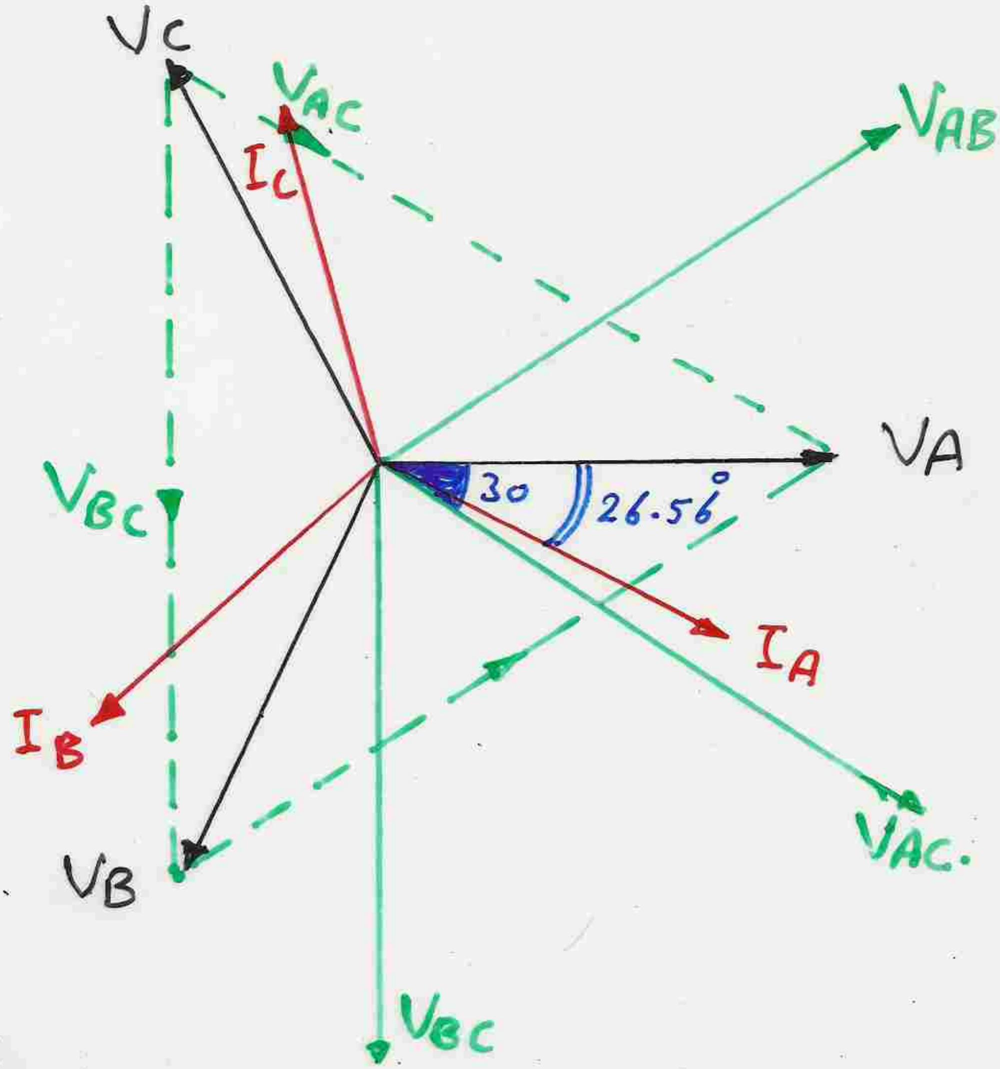
$$= 24161\ \text{Watts}.$$

$$W_2 = I_B V_{BC} \cos\theta_2$$

$$= 55.9 \times 433 \cos(146.56 - 90) = 13338.3\ \text{Watts}.$$

$$W_3 = I_{A_2} V_{AC} \cos\theta_3.$$

$$= 50 \times 433 \cos 30^\circ = 18749.45\ \text{Watts}$$



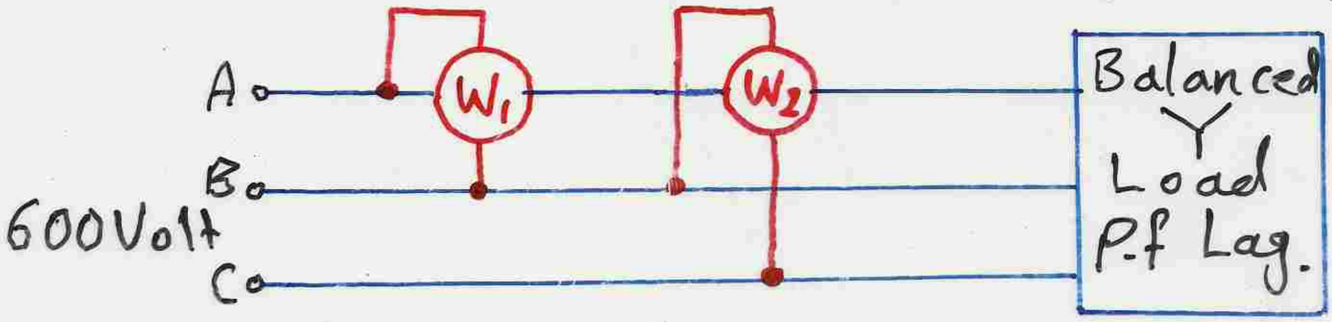
Check

$$P_T = W_1 + W_2 = 37500 \text{ Watts}.$$

& $P_T = 3 I_{A_2}^2 \times 5 = 3 \times 50^2 \times 5 = 37500 W$

& $W_3 = \frac{1}{2} P_T = 18749.45 W.$

Ex: For the Circuit, find the current distributions and the total active power?



$W_1 = 7500\,W$, $W_2 = 7500\,W$.

$W_1 = I_A V_{AB} \cos(\theta + 30)$.

$\therefore 7500 = 600 \times I_A . \cos(\theta + 30)$.

$W_2 = I_A V_{BC} \cos(90 - \theta)$.

$\therefore 7500 = 600 \times I_A . \cos(90 - \theta)$.

$\therefore \cos(\theta + 30) = \cos(90 - \theta)$.

$\therefore \theta = 30^\circ$.

$\therefore W_1 = 7500 = 600 \times I_A \cos 60$

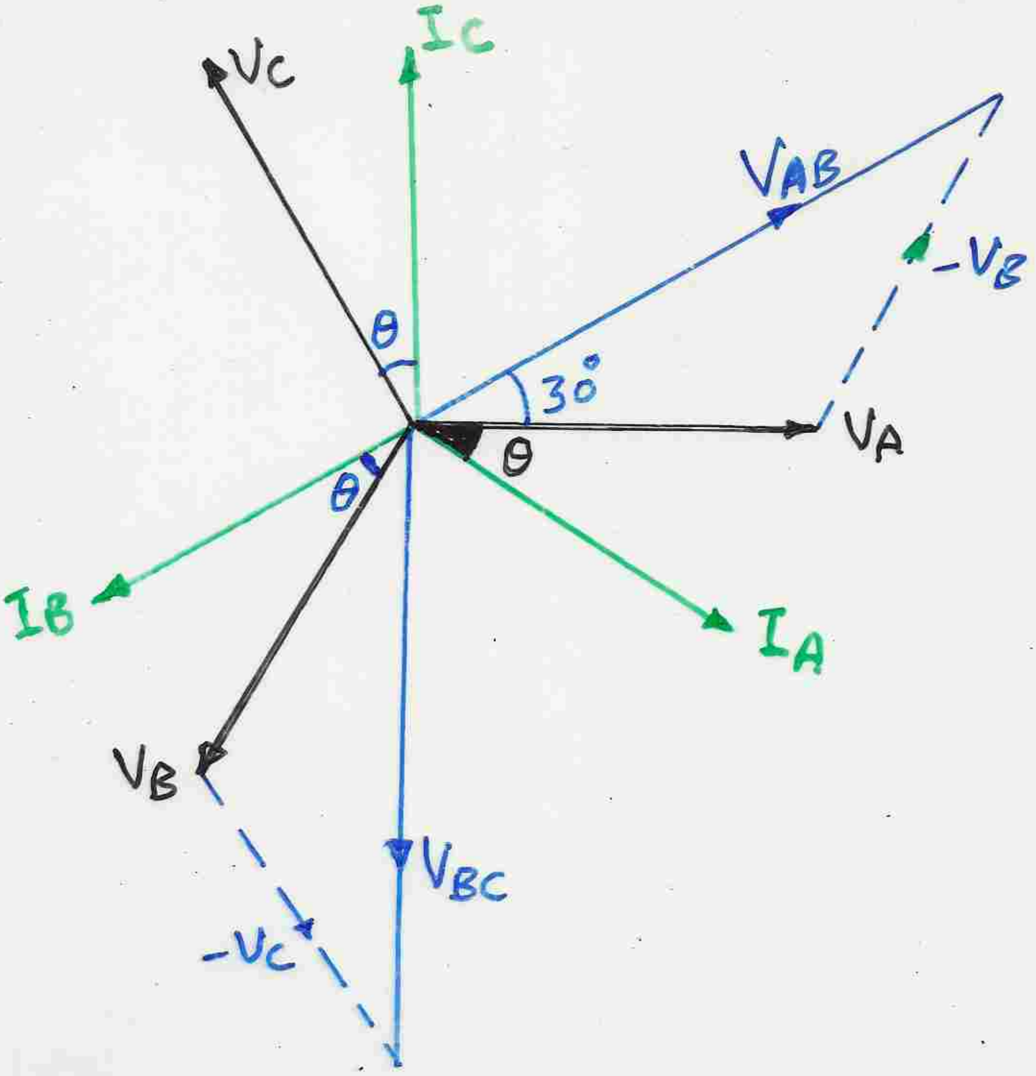
$\therefore I_A = 25$ Amp.

$\therefore I_A = 25 \angle -30$ A , $I_B = 25 \angle -150$ A., $I_C = 25 \angle 90^\circ$ A.

$P_T = 3 V_A I_A \cos 30^\circ$

$= 3 \times \frac{600}{\sqrt{3}} \times 25 \times \cos 30^\circ = 22500$ Watts.

Check the results.



Check:

Change the position of W_2.

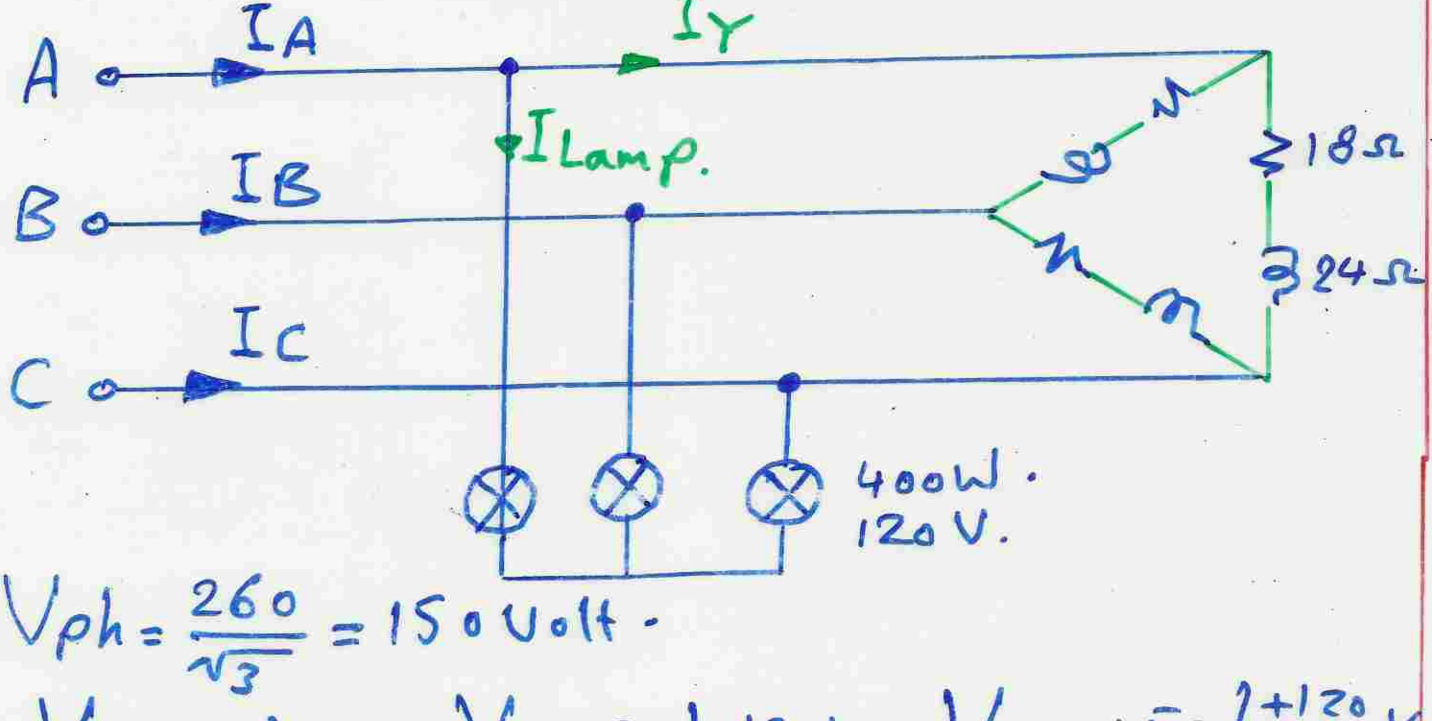
$\therefore W_2 = 15000$ Watts.

$P_T = 22500 = W_1 + W_2$.

Ex : Two Loads are connected to a 3-ph voltage of 260 Volt.

Load (1) is three coils of $Z = (18 + j24)\,\Omega$ each connected in Δ.

Load (2) is three Lamps of 400W, 120V, each. Find the Line currents and active power delivered to circuit



$$V_{ph} = \frac{260}{\sqrt{3}} = 150 \text{ Volt}.$$

$$\therefore V_A = 150\angle 0 \text{ v}, \quad V_B = 150\angle{-120} \text{ V}, \quad V_C = 150\angle{+120} \text{ V}$$

$$Z_Y = \frac{Z_\Delta}{3} = \frac{18 + j24}{3} = 6 + j8 = 10\angle 53.13\ \Omega.$$

$$\therefore I_Y = \frac{150\angle 0}{10\angle 53.13} = 15\angle{-53.13} \text{ Amp}.$$

$$* \text{Lamps} \rightarrow P = \frac{V^2}{R} \quad \therefore R = \frac{V^2}{P} = \frac{120^2}{400} = 36\ \Omega$$

$$I_{Lamp} = \frac{150\angle 0}{36} = 4.166 \text{ Amp}.$$

$$\therefore I_A = I_Y + I_{Lamp} = 15\angle{-53.13} + 4.166 = 17.8\angle{-42.}$$

$\therefore I_B = 17.8 \angle -162.3$ A , $I_C = 17.8 \angle 77.7$ Amp.

$\therefore P_{active} = \sqrt{3} V_l I_l \cos\psi$

$= \sqrt{3} \times 260 \times 17.8 \cos(42.3) = \underline{5928.8 \text{ W}}$

OR:

$P_{Lamp} = \sqrt{3} V_l I_l \cos\theta_1$

$= \sqrt{3} \times 260 \times 4.166 \cos 0 = \underline{1876 \text{ watts}}$

$P_Y = \sqrt{3} V_l I_l \cos\theta_2$

$= \sqrt{3} \times 260 \times 15 \cos(53.13) = \underline{4053 \text{ watts}}$

$P = P_{Lamp} + P_Y = \underline{5929 \text{ watt}}$

Check the results by connecting the wattmeters in any way you want to find same result.

« Non_Sinusoidal Waves »

* Average (mean) Value :-

The average (mean) Value of any current or Voltage is the value indicated on a D-C meter

$$\boxed{\text{Average(mean)Value} = \frac{\text{algebriac Sum of areas}}{\text{Length of curve}}}$$

OR

$$I(\text{average}) = \frac{1}{T}\int_0^T i \cdot dt$$

$$V(av) = \frac{1}{T}\int_0^T V \cdot dt$$

* Effective Value (r.m.s).

The effective value of alternating current is measured interms of the direct Constants current that produces the same heating effect in the same resistance for the same period of time.

Heat generated by current (I) for time (t) in a resistance (R) is:-

$\therefore$ $\boxed{\text{Heat generated} = I^2 \cdot R \cdot t}$ (Joules).

$\boxed{\text{Heat generated by a.c} = \int_0^T i^2 \cdot R \cdot dt}$ (Joules).

Heat generated by D.c current $= I_{eff}^2 \cdot R \cdot T$.

$$\therefore I_{eff}^2 \cdot \cancel{R} \cdot T = \int_0^T i^2 \cdot \cancel{R} \cdot dt.$$

$$\therefore I_{eff}^2 = \frac{1}{T}\int_0^T i^2 \cdot dt.$$

$$\boxed{\therefore I_{eff} = \underbrace{\sqrt{\underbrace{\frac{1}{T}\int_0^T \overbrace{i^2}^{\text{square}} \cdot dt}_{\text{mean}}}}_{\text{root}}}$$

The R.M.S Value of a Periodic Function.

Let the current wave be represented by Fourier Series :-

$$i(t) = I_0 + I_{1m} \sin(\omega t + \varphi_1) + I_{2m} \sin(2\omega t + \varphi_2) \text{ ----}$$

$$= \sum_{n=0}^{\infty} I_{nm} \sin(n\omega t + \varphi_n).$$

Where $\omega = \frac{2\pi}{T}$ represents the fundamental frequency of the periodic function $i(t)$. The multiples of ω, that is $2\omega, 3\omega, 4\omega$ ... are known as harmonic frequencies of $i(t)$. Thus 2ω is the second harmonic, 3ω is the third harmonic, and $n\omega$ is the nth harmonic of $i(t)$.

By definition the R.M.S. value of the current $i(t)$ could be found from the equation :-

$$I_{r.m.s} = \sqrt{\frac{1}{T}\int_0^T i^2(t)\, dt}.$$

$$\therefore I^2_{r.m.s} = \frac{1}{T}\int_0^T \left[\sum_{n=0}^{\infty} I_{nm} \sin(n\omega t + \varphi_n)\right]^2 dt.$$

$$= \frac{1}{T}\sum_{n=0}^{\infty}\int_0^T I^2_{nm} \sin^2(n\omega t + \varphi_n)\, dt \; +$$

$$\frac{1}{T}\sum_{\substack{k=0 \\ n=0 \\ n \neq k}}^{\infty}\int_0^T I_{nm} I_{km} \sin(n\omega t + \varphi_n)\sin(k\omega t + \varphi_k)\, dt$$

But

$$\sin mx \sin nx = \frac{1}{2}\left[\cos(m-n)x - \cos(m+n)x\right].$$

which means that the second term under the integral sign integrates to zero.

$$\therefore I^2_{r.m.s} = \sum_{n=0}^{\infty} \frac{1}{T}\int_0^T I^2_{nm} \sin^2(n\omega t + \varphi_n)\, dt.$$

But: $\sin^2 x = \dfrac{1-\cos 2x}{2}$.

$$\therefore I^2_{r.m.s} = I_0^2 + \sum_{n=1}^{\infty} \frac{I^2_{nm}}{2}.$$

$$\therefore \boxed{I_{r.m.s} = \sqrt{I_0^2 + \frac{I^2_{1m}}{2} + \frac{I^2_{2m}}{2} + \frac{I^2_{3m}}{2} + \cdots + \cdots}}$$

Ex:- Find the $I_{r.m.s}$ of the current shown

$$i(t) = 12 + 40\sin(200t + 20^\circ) + 25\sin(400t + 80^\circ) + 20\sin(600t + 120^\circ) + 5\sin(800t + 150^\circ).$$

$$I_{r.m.s} = \sqrt{12^2 + \frac{40^2}{2} + \frac{25^2}{2} + \frac{20^2}{2} + \frac{5^2}{2}}.$$

$$= 38.32 \text{ Amp}.$$

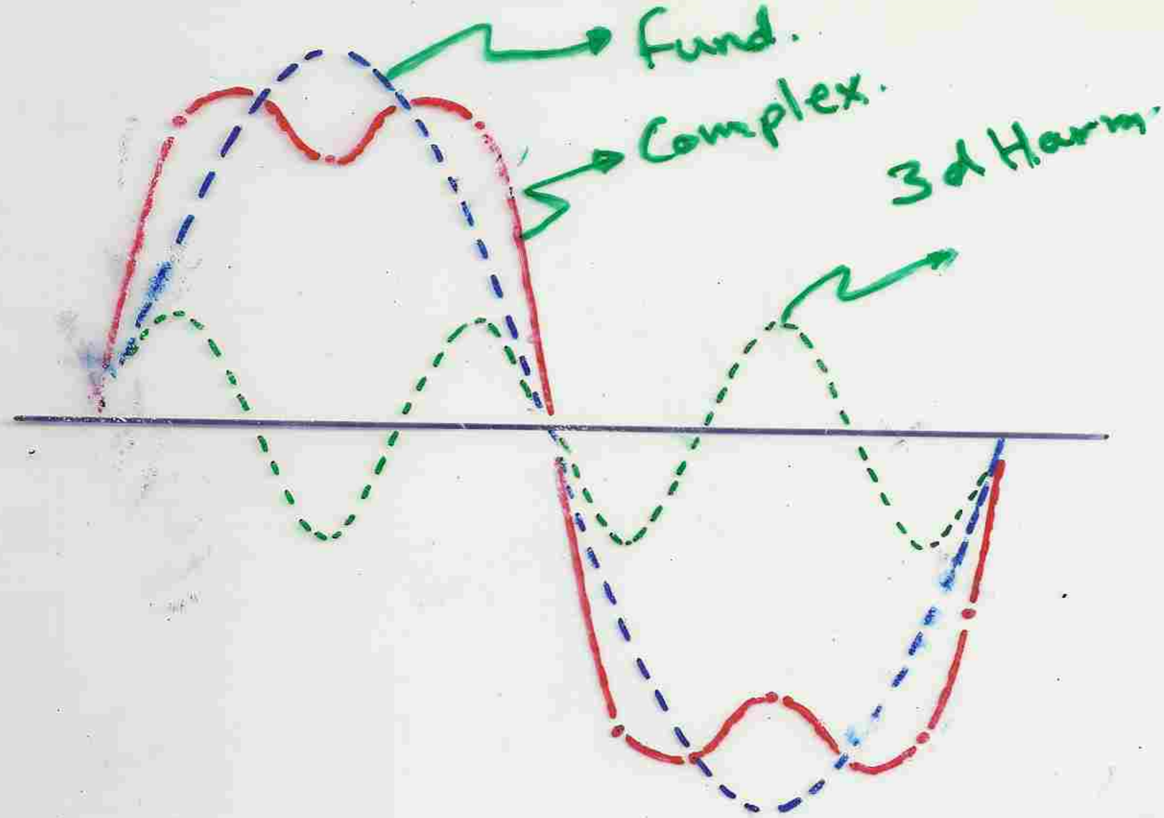


Fig. 1

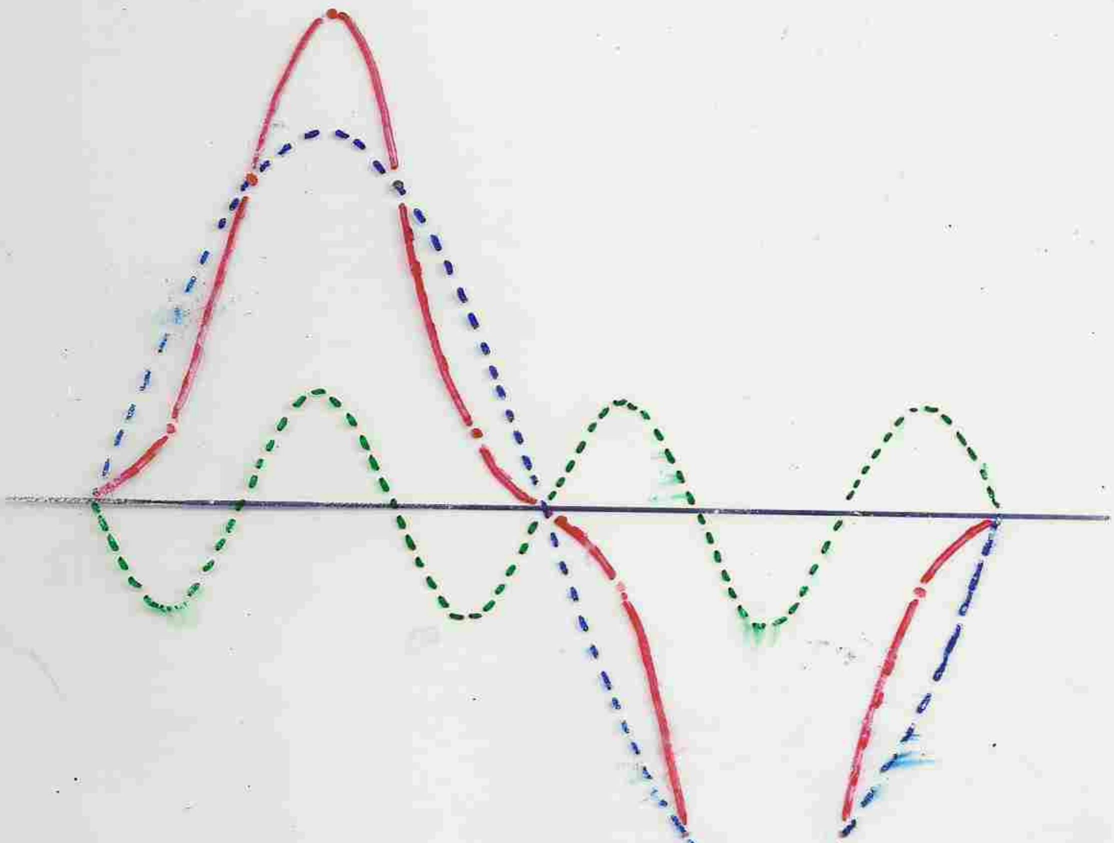
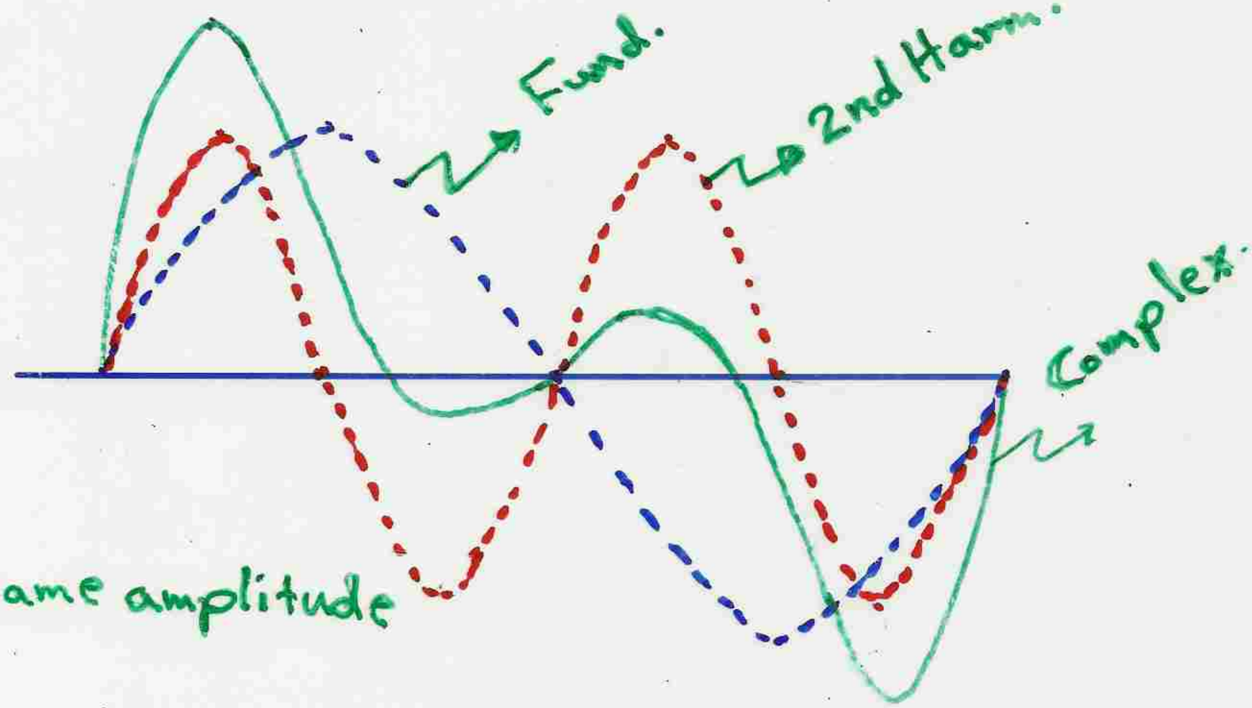


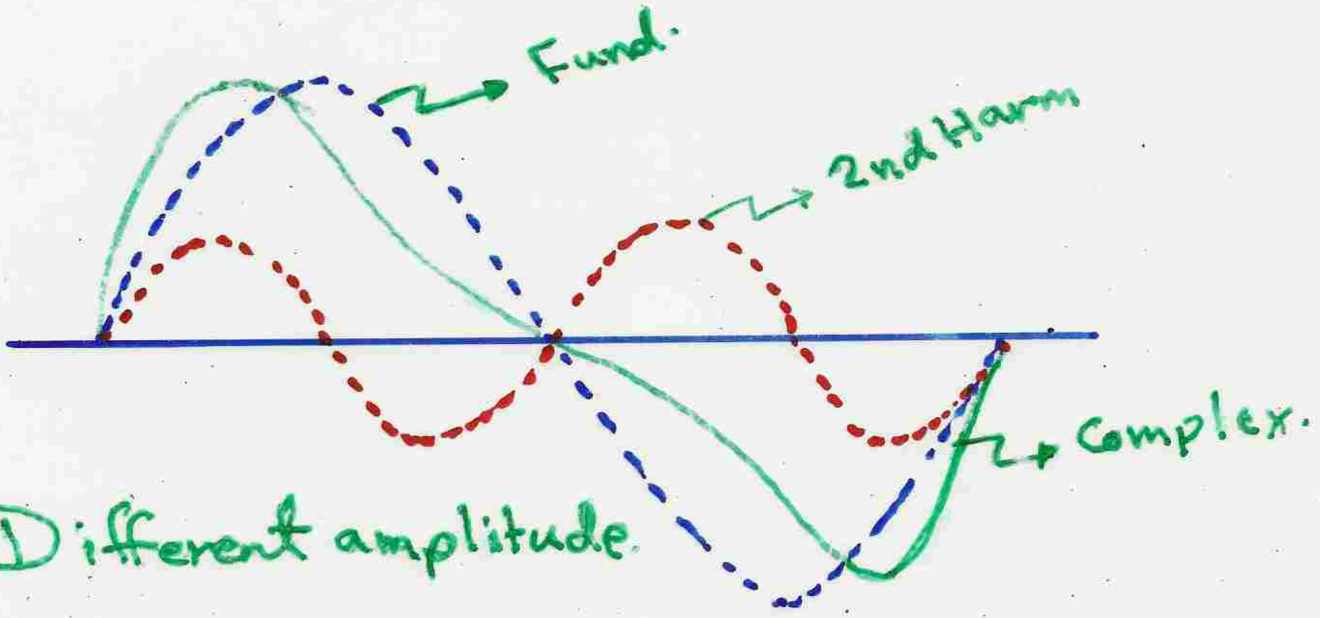
Fig. 2

Fig3



Same amplitude

Fig4



Different amplitude

Average power calculation with periodic Function.

The active power can be calculated in terms of $U(t)$ and $i(t)$ as:

$$P = \frac{1}{T}\int_0^T U(t)\, i(t)\, dt.$$

Writing the instantaneous voltage and current as Fourier series we shall have:

$$P = \frac{1}{T}\int_0^T \Big[\underbrace{\sum_{n=0}^{\infty} V_{nm}\sin(n\omega t+\psi_n)}_{U(t)}\Big]\Big[\underbrace{\sum_{n=0}^{\infty} I_{nm}\sin(n\omega t+\psi_n-\theta_n)}_{i(t)}\Big]\, dt.$$

** Only the products of harmonic components of the same order (that is having the same frequency). Shall contribute in the power expression. All other terms sum up to zero over the period.

$$P = \frac{1}{T}\int_0^T \sum_{n=0}^{\infty} V_{nm} I_{nm}\sin(n\omega t+\psi_n)\sin(n\omega t+\psi_n-\theta_n)\, dt.$$

$$= V_0 I_0 + \frac{1}{T}\sum_{n=1}^{\infty}\frac{V_{nm}I_{nm}}{2}\int_0^T\left[\cos\theta_n - \cos(2n\omega t+2\psi_n-\theta_n)\right] dt$$

The second term under the integral sign integrates to zero, therefore we shall have:

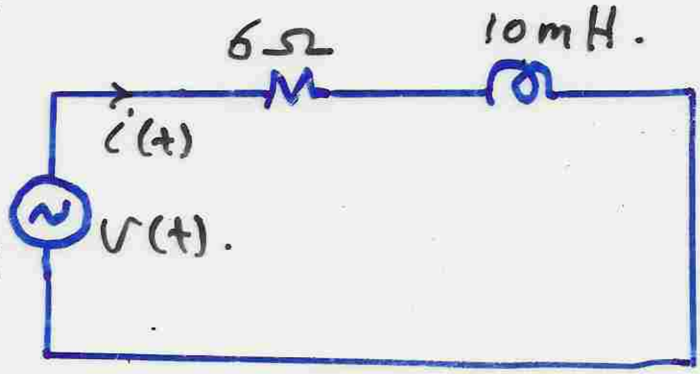
$$P = V_0 I_0 + \sum_{n=1}^{\infty}\frac{V_{nm} I_{nm}}{2}\cos\theta_n.$$

OR:

$$\boxed{\begin{aligned} P &= V_0 I_0 + V_1 I_1 \cos\theta_1 + V_2 I_2 \cos\theta_2 + \dots\dots \\ &= P_0 + P_1 + P_2 + P_3 + \dots\dots \end{aligned}}$$

An important result is obtained from the above equations. It means that the active power is the sum of active powers obtained from interaction of currents and voltages of the same frequency.

Ex: For the circuit shown the current $i(t)$ is given as:



$$i(t) = 15 + 10 \sin(1000t + 30^\circ) + 5 \sin(3000t + 45^\circ) \text{ Amp}$$

Find:-

1) The applied voltage equation.

2) The r.m.s values of voltage & current.

3) The active power supplied to the circuit.

$$Z_{D.C} = \underline{6}\ \Omega.$$

$$Z_1 = 6 + j10 = \underline{11.66}\ \angle 59^\circ\ \Omega.$$

$$Z_3 = 6 + j30 = 30.6\ \angle 78.7\ \Omega.$$

$$\therefore V_{D.C} = 15 \times 6 = \underline{90}\ \text{Volt}.$$

$$V_1 = 10\angle 30^\circ \times 11.66\angle 59 = \underline{116.6}\ \angle 89^\circ\ \text{Volt}.$$

$$V_3 = 5\angle 45 \times 30.6\angle 78.7 = 153\angle 123.7 \text{ Volt.}$$

$$\therefore V(t) = 90 + 116.6 \sin(1000t + 89) + 153 \sin(3000t + 123.7)$$

* $$V_{r.m.s} = \sqrt{90^2 + \frac{(116.6)^2}{2} + \frac{(153)^2}{2}} = 163.1 \text{ Volt.}$$

$$I_{r.m.s} = \sqrt{15^2 + \frac{10^2}{2} + \frac{5^2}{2}} = 16.96 \text{ Amp.}$$

* $$P = 15 \times 90 + \frac{10 \times 116.6}{2} \cos 59 + \frac{5 \times 153}{2} \cos 78.7.$$

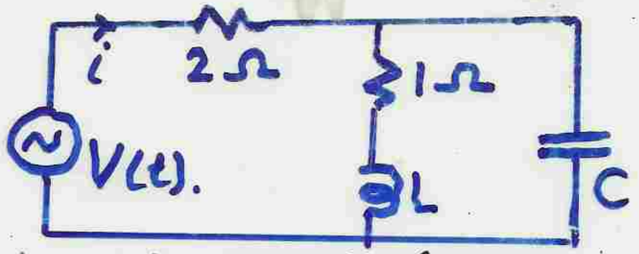
$$= \underline{\underline{1725.8}} \text{ watts.}$$

OR:

$$P = I^2_{r.m.s} \times R$$

$$= (16.96)^2 \times 6 = \underline{\underline{1725.8}} \text{ watts.}$$

Ex; For the Circuit Shown



$WL = 1\Omega$, $\frac{1}{WC} = 6\Omega$.

$V(t) = 60 + 30\,\text{Sin}\,\underline{Wt} + 25\,\text{Sin}(\underline{3W}t + 60) + 10\,\text{Sin}(\underline{6W}t + 30)$.

Find: 1- The applied current equation.

2- The r.m.s Voltage and Current.

3- The active power Supplied.

*

$Z_{D.C} = 3\Omega$.

$Z_1 = 2 + (1+j1)//-j6 = 2 + \frac{6-j6}{1-j5} = 3.52\angle 15.3\ \Omega$.

$Z_3 = 2 + (1+j3)//-j2 = 2 + \frac{6-j2}{1+j1} = 5.65\angle -45\ \Omega$.

$Z_6 = 2 + (1+j6)//-j1 = 2 + \frac{6-j1}{1+j5} = 2.36\angle -30.5\ \Omega$

$\therefore i_1 = \frac{30\angle 0}{3.52\angle 15.3} = 8.52\angle -15.3$ Amp.

$i_3 = \frac{25\angle 60}{5.65\angle -45} = 4.42\angle 105$ Amp.

$i_6 = \frac{10\angle 30}{2.36\angle -30.5} = 4.23\angle 60.5$ Amp.

$\therefore i(t) = 20 + 8.52\,\text{Sin}(\underline{Wt} - 15.3) + 4.42\,\text{Sin}(\underline{3Wt} + 105) +$

$+ 4.23\,\text{Sin}(\underline{6Wt} + 60.5)$. Amp.

$V_{r.m.s} = \sqrt{60^2 + \frac{30^2}{2} + \frac{25^2}{2} + \frac{10^2}{2}} = \underline{66.42}$ Volts.

$I_{r.m.s} = \sqrt{20^2 + \frac{(8.52)^2}{2} + \frac{(4.42)^2}{2} + \frac{(4.23)^2}{2}} = \underline{21.33}$ Amps

$P = 60 \times 20 + \frac{30 \times 8.52}{2}\cos 15.3 + \frac{25 \times 4.42}{2}\cos 45 +$

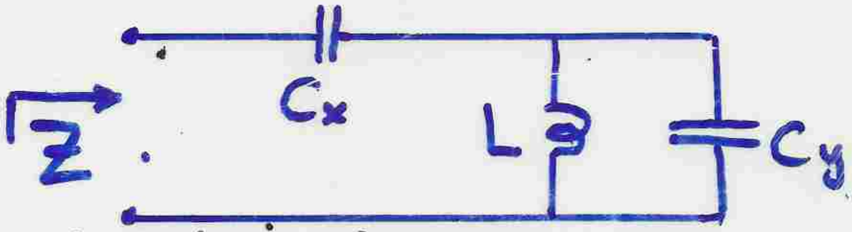
$+ \frac{10 \times 4.23}{2}\cos 30.5 = \underline{1380.4}$ Watts.

$P_{2\Omega} = (21.33)^2 \times 2 = \underline{910}$ Watts.

Ex: Find the value of X_{Cx} & X_{Cy} interms of X_L to Satisfy the following Conditions:

1- Total impedance for the first harmonic = 0.

2- Total impedance for the Sixth harmonic = ∞.



*

$$Z_1 = -\frac{j}{WC_x} + \frac{jWL\left(-\frac{j}{WC_y}\right)}{j\left(WL - \frac{1}{WC_y}\right)} = 0.$$

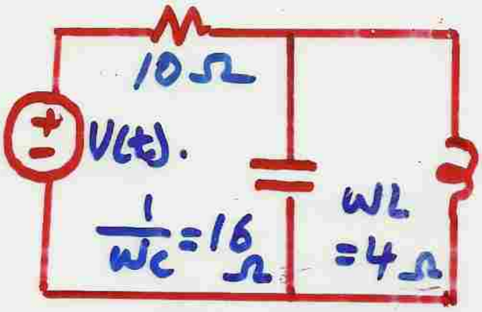
$$Z_6 = \frac{-j}{6WC_x} + \frac{j6WL\left(\frac{-j}{6WC_y}\right)}{j\left(6WL - \frac{1}{6WC_y}\right)} = \infty.$$

$$\therefore X_{Cx} = \frac{1}{WC_x} = \frac{36}{35} WL \; \Omega.$$

$$X_{Cy} = \frac{1}{WC_y} = 36 WL \; \Omega.$$

Ex: For the circuit shown

$V(t) = 60 + 50\sin\omega t + 40\sin(2\omega t + 30) + 35\sin(4\omega t + 45)$.



Find: 1) Total current
2) The active power supplied to the circuit.

** $Z_{D\text{-}C} = 10\,\Omega$.

$$Z_1 = 10 + \frac{j4(-j16)}{j4 - j16} = 10 + \frac{64}{-j12} = 10 + j5.33 = 11.33\angle 28.06\ \Omega$$

$$Z_2 = 10 + \frac{j8 \times -j8}{j8 - j8} = \infty$$

$$Z_4 = 10 + \frac{j16 \times (-j4)}{j16 - j4} = 10 - j5.33 = 11.33\angle -28.06\ \Omega.$$

** $I_{D\text{-}C} = \frac{60}{10} = 6$ Amp.

$$I_1 = \frac{50}{11.33\angle 28.06} = 4.41\angle -28.06 \text{ Amp.}$$

$I_2 = 0$.

$$I_4 = \frac{35\angle 45}{11.33\angle -28.06} = 3.08\angle 73.06 \text{ Amp.}$$

**$\therefore$ $i(t) = 6 + 4.41\sin(\omega t - 28.06) + 3.08\sin(4\omega t + 73.06)$.

$$I_{r.m.s} = \sqrt{6^2 + \frac{(4.41)^2}{2} + \frac{(3.08)^2}{2}} = 7.104 \text{ Amp.}$$

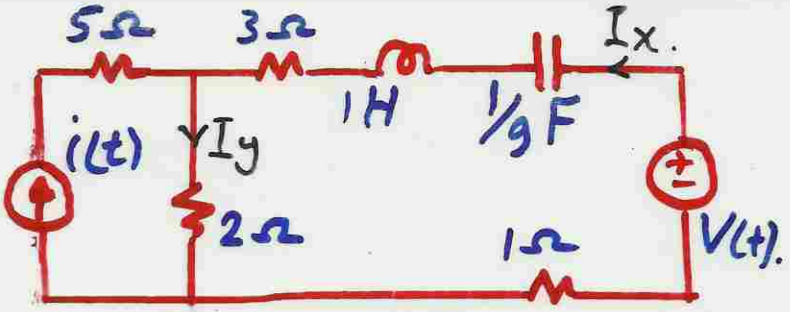
$$\therefore P = (I_{r.m.s})^2 . R = (7.104)^2 \times 10 = 504.6 \text{ Watts.}$$

OR

$$P = 60 \times 6 + \frac{50 \times 4.41}{2}\cos(-28.06) + \frac{35 \times 3.08}{2}\cos 28.06$$

$$= 504.6 \text{ Watt.}$$

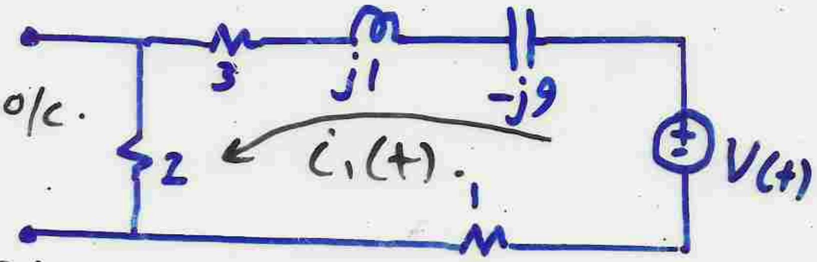
Ex: For the Circuit Shown
$v(t) = 70 + 60 \sin t$.
$i(t) = 10 + 9 \sin 3t$.
Find;



1) The current distribution (I_x & I_y).

2) Power delivered to the 2Ω.

** take $V(t) \rightarrow$



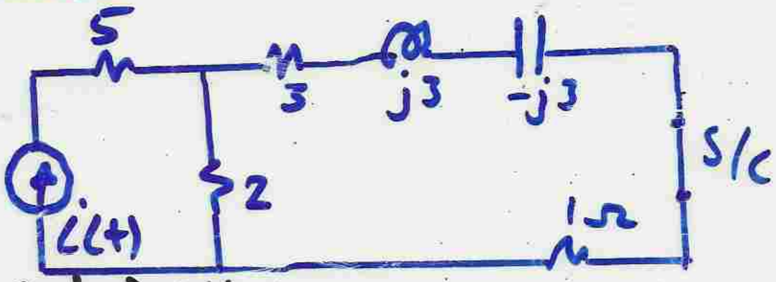
$Z_{D.C} = \infty$ $\quad I_{D.C} = 0$

$Z_1 = 6 - j8 = 10 \angle -53.1 \ \Omega$.

$\therefore I_1 = \dfrac{60\angle 0}{10\angle -53.1} = 6 \angle +53.1$. Amp.

$\therefore i_1(t) = 6 \sin(t + 53.1)$. Amp.

** take $i(t)$.



$I_{D-C} = 10$ Amp.

(Pass through 2Ω only) why.

* By $9 \sin 3t$ Amp.

$I_{2\Omega} = 9 \dfrac{4}{6} = 6$ Amp.

$I_{4\Omega} = 9 \dfrac{2}{6} = 3$ Amp.

$\therefore I_x = 6 \sin(t + 53.1) - 3 \sin 3t$.

$I_y = 10 + 6 \sin(t + 53.1) + 6 \sin 3t = I_{2\Omega}$.

$I_{r.m.s}$ of $I_y = \sqrt{10^2 + \dfrac{6^2}{2} + \dfrac{6^2}{2}} = 11.66$ Amp.

$\therefore P_{in\ 2\Omega} = (I_{r.m.s})^2 \cdot R$

$= (11.66)^2 \times 2 = 272$ watts.