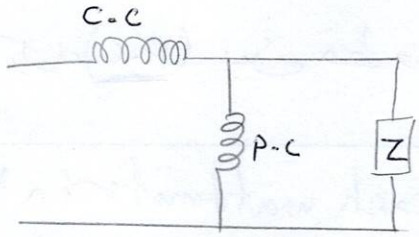
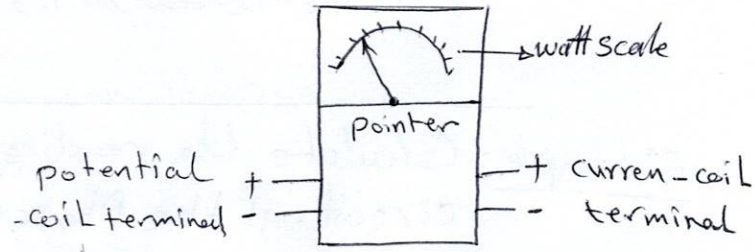
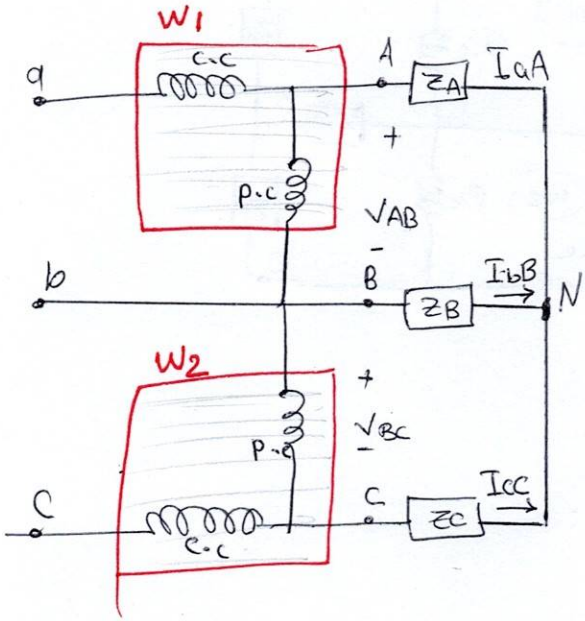
= Wattmeter Reading =







$$W_1 = |V_{AB}||I_{aA}| \cos(\theta_\varphi + 30)$$

$$W_2 = |V_{CB}||I_{cC}| \cos(\theta_\varphi - 30)$$

$$\therefore \rightarrow |V_{AB}| \Leftrightarrow |V_L| = |V_{CB}|$$

$$\rightarrow |I_{aA}| \Leftrightarrow |I_L| = |I_{CC}|$$

$$W_1 = V_L I_L \cos(\theta_\varphi + 30)$$

$$W_2 = V_L I_L \cos(\theta_\varphi - 30)$$

$$\theta = \tan^{-1}\left[\frac{\sqrt{3}(W_2 - W_1)}{W_2 + W_1}\right]$$

ملاحظة:-

١- يكون (C.C) على امتداد الخط . وناخذ منه قيمة (I_{Line}).

٢- يكون (P.C) بين خط وخط . وناخذ منه قيمة (V_{Line}).

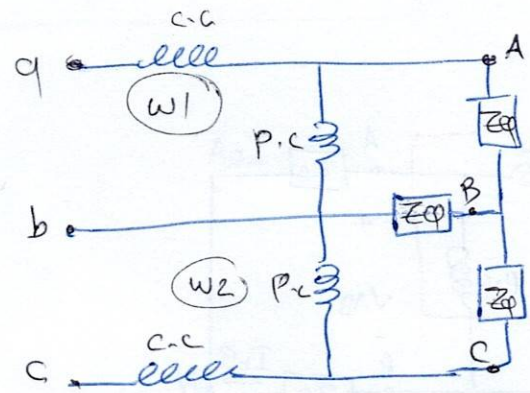
Example: Calculate the reading of each wattmeter in the circuit. if the Phase voltage at the load is (120) v.

a) $Z\varphi = 8+j6$ Ω

b) $Z\varphi = 8-j6$ Ω

c) $Z\varphi = 5+j5\sqrt{3}$ Ω

d) $Z\varphi = 10 \angle -75$ Ω



Solution:

(a) $Z\varphi = 8+j6$ Ω , $V\varphi = 120$ v.

$Z\varphi = r \angle \theta\varphi$

$Z\varphi = 10 \angle 36.87°$

$\therefore \theta\varphi = 36.87°$

∵ Y دول ← $V_L = \sqrt{3}\, V\varphi$, $I_L = I\varphi$

$V_L = 120\sqrt{3}$

$$I_L = I\varphi = \frac{V\varphi}{Z\varphi} = \frac{120 \angle 0}{10 \angle 36.87} = 12 \angle -36.87 \quad A$$

$$w_1 = |V_L||I_L| \cos(\theta\varphi + 30) = (120\sqrt{3})(12)\cos(36.87+30)$$

$w_1 = 979.75$ w

$w_2 = |V_L||I_L| \cos(\theta\varphi - 30) = 2476.25$ w

$P_T = w_1 + w_2 = 979.75 + 2476.25 = 3456$ w

(b) $Z_\varphi = 10 \angle -36.87$

$$I_L = I_\varphi = \frac{V_\varphi}{Z_\varphi} = \frac{120 \angle}{10 \angle -36.87} = 12 \angle 36.87 \text{ A}$$

$$W_1 = (120\sqrt{3})(12)\cos(-36.87 + 30) = 2476.25 \text{ w}$$

$$W_2 = (120\sqrt{3})(12)\cos(-36.87 - 30) = 979.75 \text{ w}$$

$$P_T = W_1 + W_2 = 3456 \text{ w}$$

(c) $Z_\varphi = 5 + j5\sqrt{3}$

$Z_\varphi = 10 \angle 60$

$$W_1 = (120\sqrt{3})(12)\cos(\underbrace{60 + 30}_{90}) \quad \rightarrow \cos 90 = 0$$

$W_1 = 0$

$$W_2 = (120\sqrt{3})(12)\cos(60 - 30) = 2160 \text{ w}$$

d) $Z_\varphi = 10 \angle -75$

$W_1 = 1763 \text{ w}$

$W_2 = -645.53 \text{ w}$

$P_T = 1118.1 \text{ w}$

ملاحظة / للتأكد من الحل بالنسبة للفرع (a)

$$P_T = 3(I^2) * R$$
$$= 3(12)^2 * 8 = 3456 \text{ w}$$

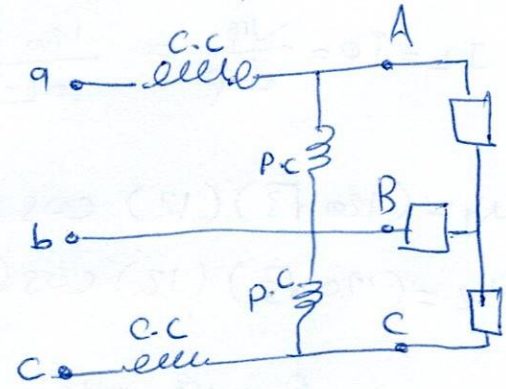
وكذلك بالنسبة لبقية الفروع.

Ex: the wattmeters have a data, Find Z_φ.

$W_1 = 40823.09$ W

$W_2 = 103176.91$ W

$V_L = 2400\sqrt{3}$ V.



Solution

$$\theta_\varphi = \tan^{-1}\left[\frac{\sqrt{3}(W_2 - W_1)}{W_2 + W_1}\right]$$

$$\boxed{\theta_\varphi = 36.87^\circ}$$

$$W_1 = V_L I_L \cos(\theta\varphi + 30)$$

$$40823.09 = (2400\sqrt{3})(I_L)\cos(36.87 + 30)$$

$$I_L = 25 \quad A$$

$$Z\varphi = \frac{V\varphi}{I\varphi}$$

$Y \Rightarrow I\varphi = I_L$, $V_L = \sqrt{3}\, V\varphi$

$$\therefore \boxed{I\varphi = 25 = I_L}$$

$$V\varphi = \frac{V_L}{\sqrt{3}} = \frac{2400\sqrt{3}}{\sqrt{3}} = 2400 \text{ V.}$$

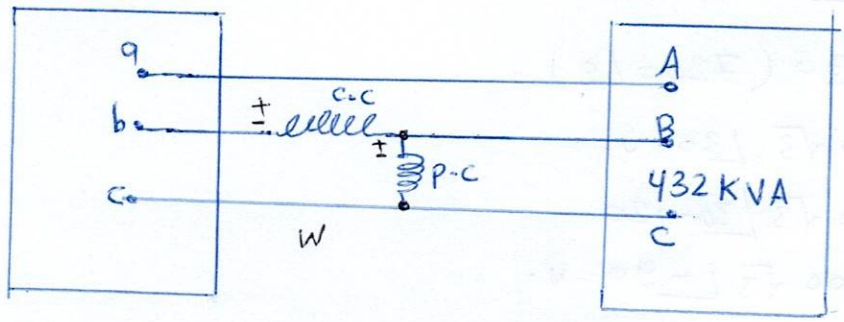
$$\therefore Z\varphi = \frac{2400}{25} = 96\ \Omega$$

$$\boxed{\therefore Z\varphi = 96\angle 36.87^\circ\ \Omega}$$ بالصيغة القطبية

Ex: A balanced 3-φ load shown in fig. below, is fed from a balanced positive sequence, 3φ, Y-connected source with p.f of (0.96) lagging. The line-to-neutral voltage at the source is 7200 V. Find:-

a) wattmeter reading in watt.

b) Phase impedance. Z_φ.



Solution:

* في البداية نحدد ماذا (wattmeter) تكي نعرف اي تيار واي فولتية تتاخذ القراءة.

(a)

$$p.f = 0.96 = \cos\theta$$

$$\theta = \cos^{-1}(0.96) = 16.26^\circ$$

$S = 432$ KVA → يجب أن تحول الى قيمة و زاوية

$$S = \frac{432}{3}\cos\theta + j\frac{432}{3}\sin\theta$$

$$S = 144 * 0.96 + j\,144 \sin(16.26^\circ)$$

$$S = 138.24 + j\,40.32 \quad \text{KVA}$$

also: $S = V_\varphi * I_\varphi^*$

$$I_\varphi = I_{aA} = I_L$$

$$I_{aA}^* = \frac{S}{V_\varphi} = \frac{(138.24 + j40.32) * 10^3}{7200} = \frac{(144\angle 16.26)10^3}{7200\angle 0} = 20\angle 16.26 \text{ A}$$

$$I_{aA} = 20\angle -16.26 \text{ A}$$

$I_{bB} = 20 \angle -16.26 - 120 = 20 \angle -136.26^\circ \quad A$

$V_{AN} = V_\varphi = 7200 \angle 0 \quad v.$

$V_{BN} = 7200 \angle 0 - 120 \quad v.$

$V_{CN} = 7200 \angle +120 \quad v.$

$V_{AB} = \sqrt{3} \angle 30 \; V_{AN}$

$V_{AB} = \sqrt{3} \angle 30 \; (7200 \angle 0).$

$V_{AB} = 7200\sqrt{3} \angle 30 \quad v.$

$V_{BC} = 7200\sqrt{3} \angle 30 - 120$

$V_{BC} = 7200\sqrt{3} \angle -90 \quad v.$

$W = |V_L| \, |I_L| \cos(\theta\varphi + 30)$

$W = |V_{BC}| \, |I_{bB}| \cos(16.26^\circ + 30^\circ)$

$W = (7200\sqrt{3})(20) \cos(46.26)$

$W = 172442.5 \quad w$

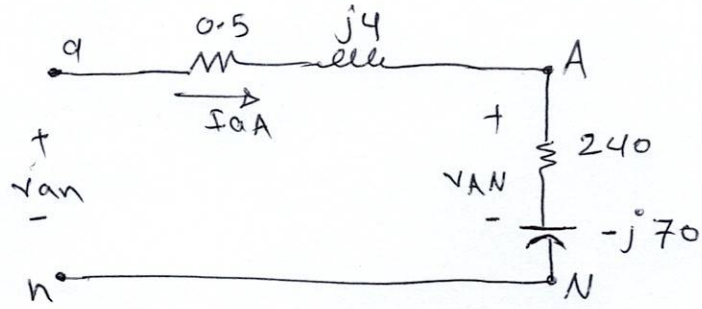
(b) $Z\varphi$

$$Z\varphi = \frac{V\varphi}{I\varphi} = \frac{V_{AN}}{I_{aA}} = \frac{7200 \angle 0}{20 \angle -16.26} =$$

$Z\varphi = 360 \angle 16.26^\circ \; \Omega \; / \varphi$

Ex: The magnitude of Line voltage at Y-load is 6600 v. the $Z_A = (240 - j70)\ \Omega/\varphi$. $Z_L = (0.5 + j4)\ \Omega/\varphi$. Find:-

① magnitude of line current.



Sol: Y-connected $\Rightarrow$ $\boxed{V_L = \sqrt{3}\, V_\varphi \quad ; \quad I_L = I_\varphi = I_{aA}}$

$V_L = 6600$

$V_\varphi = \frac{6600}{\sqrt{3}}$ v. $= V_{AN}$

$I_{aA} = \frac{V_{AN}}{Z_A} = \frac{6600/\sqrt{3}}{240 - j70} = 15.24 \angle 16.26^\circ$ A

$|I_{aA}| = |I_L| = 15.24$ A

② Magnitude of line voltage at the source.

$V_{an} = I_{aA} \times (Z_L + Z_A)$

$= (15.24 \angle 16.26) \times [(240 + 0.5) + j(4 - 70)]$

$= 3801.24 \angle 0.91^\circ$ v.

$V_{ab} = V_L \rightarrow$ at source

Y $\rightarrow V_L = \sqrt{3}\, V_\varphi$

$|V_{ab}| = \sqrt{3}\, |V_{an}| = \sqrt{3}(3801.24) = 6583.94$ v.