SOLUTIONS

Solution of pre-tutorial:

1. Fig. Q1(a) shows the connection of two wattmeters with the 3-phase load. The current $\boldsymbol{I_A}$ flows through the current coil of $\boldsymbol{W1}$ and $\boldsymbol{V_{AC}}$ is the voltage sensed by the voltage coil. Wattmeter $\boldsymbol{W1}$'s reading will be the product of the voltage across its voltage coil ($\boldsymbol{V_{AC}}$), the current through its current coil $\boldsymbol{I_A}$ and the cosine of the angle between $\boldsymbol{V_{AC}}$ and $\boldsymbol{I_A}$.

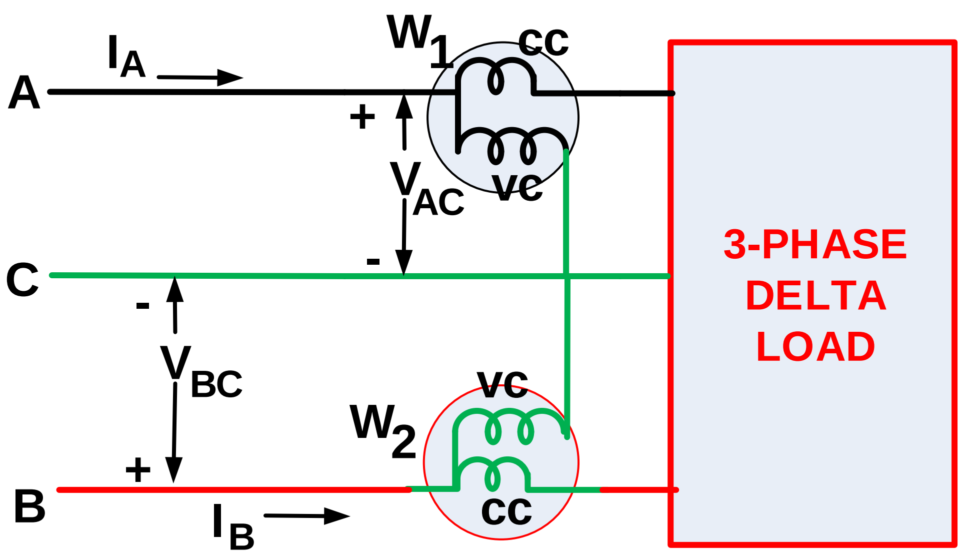


Fig. Q1(a)

From Fig. Q1(b), the reading of wattmeter, $\boldsymbol{W1}$, will be

$$\boldsymbol{W_1} = \boldsymbol{V_{AC} I_A \cos(\varphi)}$$

where, $\boldsymbol{\varphi}$ is the angle between VAC and $\boldsymbol{I_A}$. $\boldsymbol{V_{AB}}$ is the reference voltage and the corresponding phase current $\boldsymbol{I_{AB}}$ lags the phase voltages by an angle $\boldsymbol{\theta}$. In case of a delta connection, the line current lags the phase current by an angle of $\boldsymbol{30^0}$. $\boldsymbol{I_A}$ lags $\boldsymbol{I_{AB}}$ by an angle of $\boldsymbol{30^0}$. From Fig. Q1(b), it is seen that the angle between $\boldsymbol{V_{AC}}$ ***(-V***$\boldsymbol{_{CA}}$***)*** and $\boldsymbol{V_{AB}}$ is $\boldsymbol{60^0}$. Hence, the angle $\boldsymbol{\varphi}$ will be

$$\varphi = (60^0 - 30^0 - \theta)$$

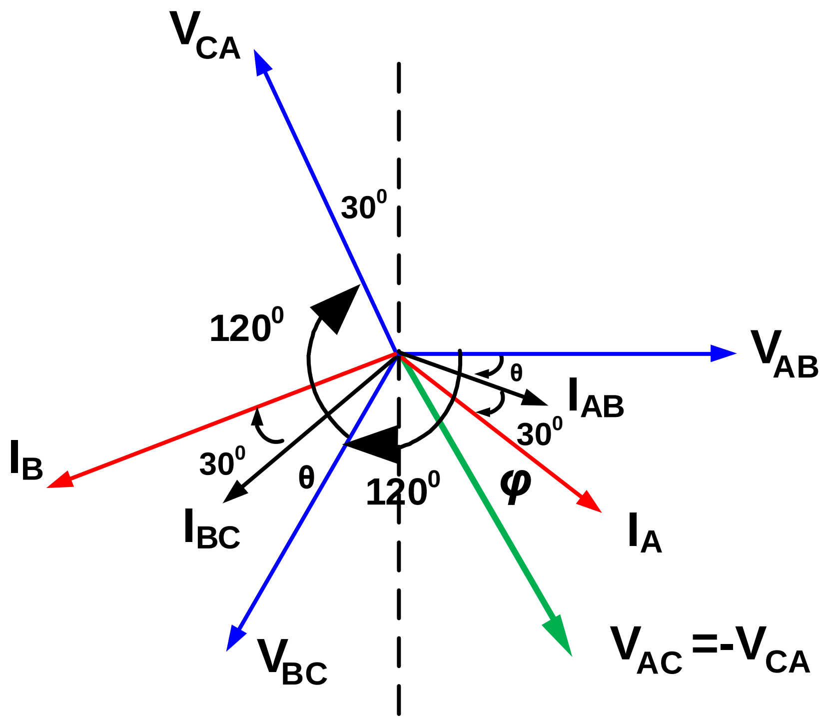


Fig. Q1(b)

$$W_1 = V_{AC}I_A\cos(\varphi) = V_{AC}I_A\cos(60^0 - 30^0 - \theta) = V_LI_L\cos(30^0 - \theta)$$

Similarly, $\boldsymbol{I_B}$ flows through the current coil of $\boldsymbol{W_2}$ and $\boldsymbol{V_{BC}}$ is the voltage across its voltage coil. The wattmeter reading $\boldsymbol{W2}$ will be

$$W_2 = V_{BC}I_B\cos(30^0 + \theta) = V_LI_L\cos(30^0 + \theta)$$

$$W_1 + W_2 = V_LI_L\{\cos(30^0 - \theta) + \cos(30^0 + \theta)\}$$

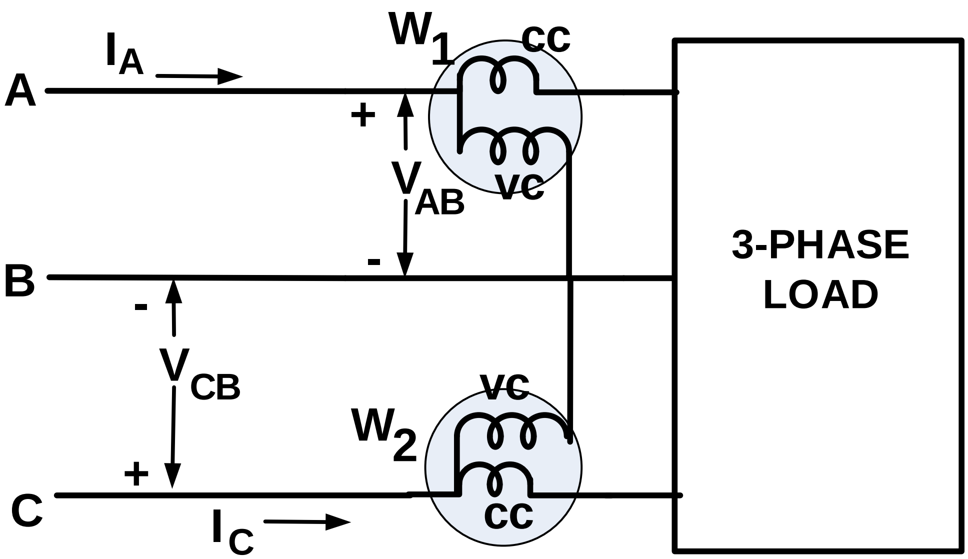
$$= V_LI_L\{2cos30^0.cos\theta\}$$

$$= \sqrt{3}V_LI_Lcos\theta = P = Total\ Power$$

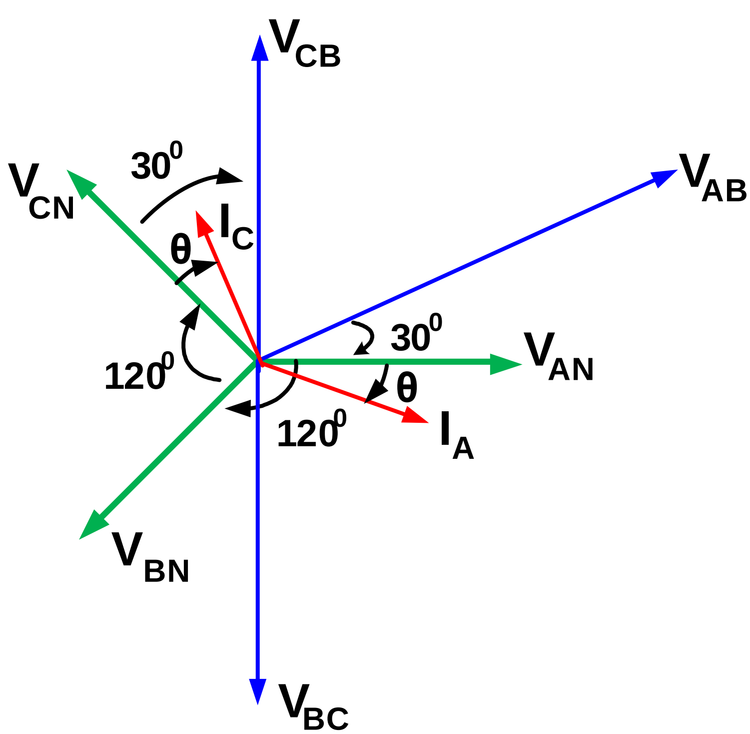
$$W_1 - W_2 = V_LI_Lsin\theta \qquad tan\theta = \sqrt{3}(\frac{W_1 - W_2}{W_1 + W_2})$$

$$Power\ Factor = \cos[\tan^{-1}\{\sqrt{3}(\frac{W_1 - W_2}{W_1 + W_2})\}]$$

2.



(a)



For star connection

Phase current = Line Current = Phase voltage / Per Phase Impedance

Phase voltage = Line voltage / √3 = 440 / √3 = 254 V = V_P

Per Phase Impedance = 20 + j 20 = Z_P

Line current $I_L = \frac{V_P}{Z_P} = 8.98 \angle -45^0$

In a two wattmeter power measurement method, the sum of the two wattmeter readings is equal to the total real power. The difference of the wattmeter readings is the reactive power divided by √3.

$$W_1 + W_2 = \sqrt{3} V_L I_L cos\, \theta = 4839.2$$

$$W_2 - W_1 = V_L I_L sin\, \theta = 2794$$

Solving the two equations

$$W_2 = 3.816\ kW \text{ and } W_1 = 1.022\ kW$$

(b) For delta connection

Line Current = √3 x Phase Current

Phase voltage = Line voltage = 440 V (given)

Per Phase Impedance = 20 + j 20 = Z_P

Line current $\boldsymbol{I_L = \sqrt{3}\frac{V_P}{Z_P} = 26.94 \angle -45^0}$

In a two wattmeter power measurement method, the sum of the two wattmeter

readings is equal to the total real power. The difference of the wattmeter readings is the reactive power divided by √3.

$$\boldsymbol{W_1 + W_2 = \sqrt{3} V_L I_L cos\, \theta = 14517.6}$$

$$\boldsymbol{W_2 - W_1 = V_L I_L sin\, \theta = 8381.76}$$

Solving the two equations

$\boldsymbol{W_2 = 11.448\ kW}$ and $\boldsymbol{W_1 = 3.067\ kW}$

3. It is a simple series magnetic circuit with its analog shown in Fig. 1(b).

Core length = $\boldsymbol{l_c = 2[(20-3)+(15-3)]-0.4 = 57.6cm}$

Cross-sectional area of core $\boldsymbol{A_c = 09cm^2}$

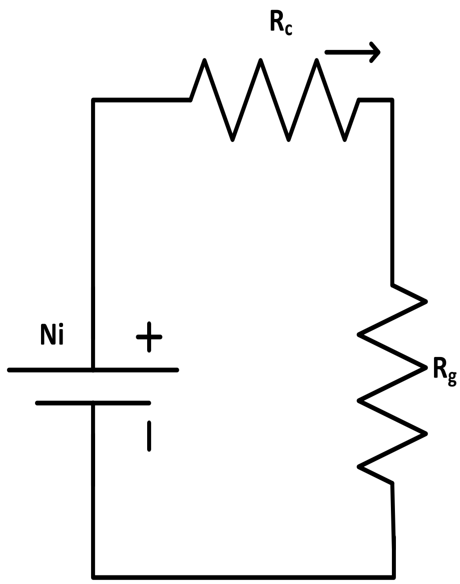


Fig. 1(b).

Core reluctance $\mathfrak{R}_c = \frac{l_c}{\mu_r \mu_0 A_c} = \frac{57.6\times10^{-2}}{4000\times4\pi\times10^{-7}\times9\times10^{-4}} = \mathbf{1.27 \times 10^5}$

Air gap length $\boldsymbol{l_g = 0.4\ cm}$

Area of air gap $\boldsymbol{A_g = 09cm^2}$

Air gap reluctance $\mathfrak{R}_g = \frac{l_g}{\mu_0 A_g} = \frac{0.4\times10^{-2}}{4\pi\times10^{-7}\times9\times10^{-4}} = \mathbf{35.36 \times 10^5}$

Total $\mathfrak{R} = \mathfrak{R}_c + \mathfrak{R}_g = \mathbf{36.63 \times 10^5} \boldsymbol{AT/Wb}$

Flux in the magnetic circuit, $\boldsymbol{\Phi = BA = 1.2 \times 9 \times 10^{-4} = 1.08\ mWb}$

Now

$\boldsymbol{Ni = \Phi(\mathfrak{R}_c + \mathfrak{R}_g) = \Phi\mathfrak{R} = 1.08 \times 10^{-3} \times 36.63 \times 10^5 = 3956AT}$

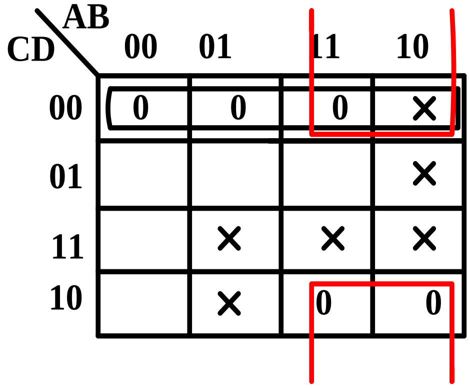
So Exciting current $\boldsymbol{i} = \frac{\Phi\mathfrak{R}}{N} = \frac{3956}{400} = \mathbf{9.89\ A}$

4. (a)

CD \ AB	00	01	11	10
00				×
01	1	1	1	×
11	1	×	×	×
10	1	×		

Minimal sum-of-products expression is f*(A,B,C,D)*= $\overline{A}C + D$.

(b) $f(A,B,C,D) = M(0,4,10,12,14) + \sum d(6,7,8,9,11,15)$

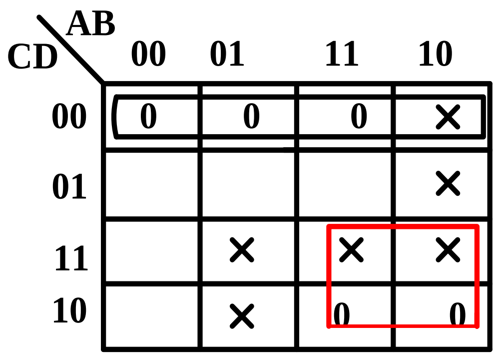


:. Minimal product-of-sums expression is *f(A,B,C,D)*=*(C+D)* $(\overline{A}+D)$

$$\Rightarrow f(A,B,C,D) = \overline{A}C + CD + \overline{A}D + D = \overline{A}C + D$$

Which is same as the expression obtained in (a) since the don't care terms used in (a) and (b) are different.

The alternative minimal product–of-sums expression can be obtained as follows.



$$\therefore f(A,B,C,D) = (C+D)(\overline{A}+\overline{C})$$

$$= \overline{A}C + \overline{A}D + \overline{C}D$$

This is not equivalent to the expression obtained in (a) since two don't care terms are common in both minterm and maxterm grouping.

5. the k-map for Boolean expression $f(A,B,C,D)=(A+B+D)(B+C)(\overline{A}+\overline{D})(\overline{A}+C)$ is as follows:

CD \ AB	00	01	11	10
00	0		0	0
01	0		0	0
11			0	0
10	0			

The k-map for the Boolean expression
$f(A,B,C,D)=(A+B+D)(\overline{A}+B+C)(\overline{A}+\overline{B}+C)(\overline{A}+\overline{B}+\overline{C}+\overline{D})$

CD \ AB	00	01	11	10
00	0		0	0
01			0	0
11			0	
10	0			

Comparing there two k-maps, the don’t care conditions are 1011 and 0001