CALCULATION OF POWER IN FOUR WIRE STAR CONNECTED UNBALANCED LOADS

FOR 3ϕ BALANCED LOAD 3ϕ POWER $= \sqrt{3}\, E\, I \cos\theta$

FOR 3ϕ UNBALANCED LOAD, THE ABOVE FORMULA CAN NOT BE USED

$$3\phi \text{ POWER} = V_{AN} I_A \cos\theta_{I_A}^{V_{AN}} + V_{BN} I_B \cos\theta_{I_B}^{V_{BN}} + V_{CN} I_C \cos\theta_{I_C}^{V_{CN}}$$

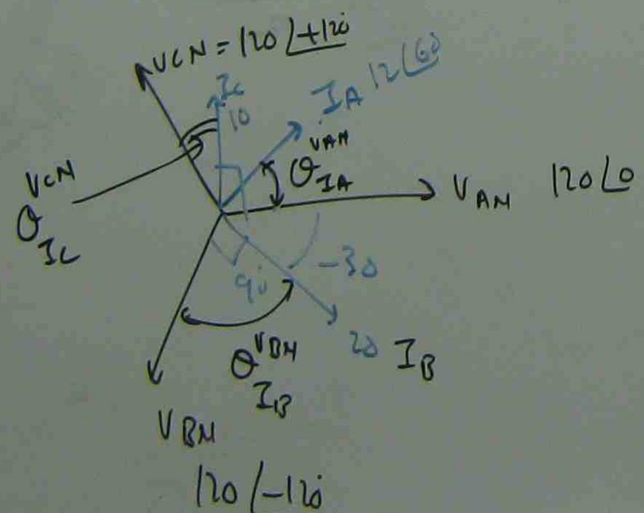
pb 3ϕ 208 V ABC, $Z_A = 10\angle -60$, $Z_B = 6\angle -90$, $Z_C = 12\angle 30$. FIND 3ϕ POWER

$$V_{AN} = \frac{208}{\sqrt{3}} = 120^\circ\ V$$

$$\bar{I}_A = \frac{\bar{V}_{AN}}{Z_A} = \frac{120\angle 0}{10\angle -60} = 12\angle 60^\circ\ A$$

$$\bar{I}_B = \frac{\bar{V}_{BN}}{Z_B} = \frac{120\angle -120}{6\angle -90} = 20\angle -30^\circ\ A$$

$$\bar{I}_C = \frac{\bar{V}_{CN}}{Z_C} = \frac{120\angle 120}{12\angle 30} = 10\angle 90^\circ\ A$$



$\theta_{I_A}^{V_{AN}} = 60^\circ$, $\theta_{I_B}^{V_{BN}} = 90^\circ$

$\theta_{I_C}^{V_{CN}} = 30^\circ$

$P_A = V_{AN} I_A \cos\theta_{I_A}^{V_{AN}}$
$= 120 \times 12 \times \cos 60 = 720$ WATT

$P_B = V_{BN} I_B \cos\theta_{I_B}^{V_{BN}}$
$= 120 \times 20 \times \cos 90 = 0$ WATT

$P_C = V_{CN} I_C \cos\theta_{I_C}^{V_{CN}}$
$= 120 \times 10 \times \cos 30 = 1039$ WATT

$P_T = P_A + P_B + P_C$
$= 720 + 0 + 1039$
$= 1759$ WATT

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FOR 3ϕ BALANCED LOAD $\quad 3\phi$ POWER $= \sqrt{3}\, E\, I \cos\theta$

FOR 3ϕ UNBALANCED LOAD, THE ABOVE FORMULA CAN NOT BE USED

$$3\phi \text{ POWER} = V_{AN}\, I_A \cos\theta^{V_{AN}}_{I_A} + V_{BN}\, I_B \cos\theta^{V_{BN}}_{I_B} + V_{CN}\, I_C \cos\theta^{V_{CN}}_{I_C}$$

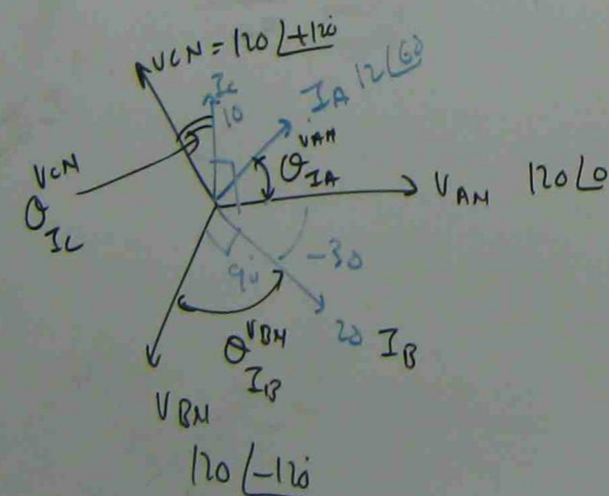
Pb 3ϕ 208 V ABC, $Z_A = 10\angle{-60}$, $Z_B = 6\angle{-90}$, $Z_C = 12\angle{30}$. FIND 3ϕ POWER

$$V_{AN} = \frac{208}{\sqrt{3}} = 120^\circ\ \text{V}$$

$$\bar{I}_A = \frac{\bar{V}_{AN}}{Z_A} = \frac{120\angle 0}{10\angle{-60}} = 12\angle{60^\circ}\ \text{A}$$

$$\bar{I}_B = \frac{\bar{V}_{BN}}{Z_B} = \frac{120\angle{-120}}{6\angle{-90}} = 20\angle{-30^\circ}\ \text{A}$$

$$\bar{I}_C = \frac{\bar{V}_{CN}}{Z_C} = \frac{120\angle 120}{12\angle 30} = 10\angle{90^\circ}\ \text{A}$$



$\theta^{V_{AN}}_{I_A} = 60^\circ$, $\theta^{V_{BN}}_{I_B} = 90^\circ$

$\theta^{V_{CN}}_{I_C} = 30^\circ$

$P_A = V_{AN}\, I_A \cos\theta^{V_{AN}}_{I_A}$

$= 120 \times 12 \times \cos 60 = 720$ WATT

$P_B = V_{BN}\, I_B \cos\theta^{V_{BN}}_{I_B}$

$= 120 \times 20 \times \cos 90 = 0$ WATT

$P_C = V_{CN}\, I_C \cos\theta^{V_{CN}}_{I_C}$

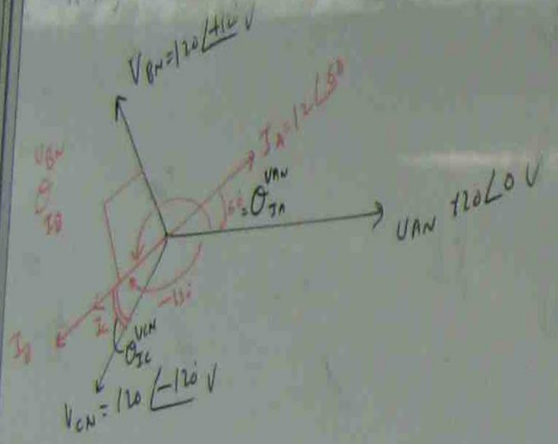
$= 120 \times 10 \times \cos 30 = 1039$ WATT

$P_T = P_A + P_B + P_C$

$= 720 + 0 + 1039$

$= 1759$ WATT

Pb IN ABOVE PROBLEM, IF THE PHASE SEQUENCE IS CHANGED TO ACB, FIND TOTAL 3ϕ POWER



$$\bar{I}_A = \frac{\bar{V}_{AN}}{Z_A} = \frac{120\angle 0}{10\angle -60} = 12\angle 60°\ A$$

$$\bar{I}_B = \frac{\bar{V}_{BN}}{\bar{Z}_B} = \frac{120\angle 120}{6\angle -90} = 20\angle 210°\ A$$

$$\bar{I}_C = \frac{\bar{V}_{CN}}{Z_C} = \frac{120\angle -120}{12\angle 30} = 10\angle -150°\ A$$

$$\theta_{I_A}^{V_{AN}} = 60°$$

$$\theta_{I_B}^{V_{BN}} = 90°$$

$$\theta_{I_C}^{V_{CN}} = 30°$$

$$P_A = V_{AN} I_A \cos\theta_{I_A}^{V_{AN}} = 120 \times 12 \cos 60 = 720\ W$$

$$P_B = V_{BN} I_B \cos\theta_{I_B}^{V_{BN}} = 120 \times 20 \cos 90 = 0$$

$$P_C = V_{CN} I_C \cos\theta_{I_C}^{V_{CN}} = 120 \times 10 \cos 30 = 1039\ W$$

$$P_T = P_A + P_B + P_C$$

$$= 720 + 0 + 1039$$

$$= 1759\ W$$

BY REVERSING THE PHASE SEQUENCE

(1) LINE CURRENT MAGNITUDE – THE SAME / PHASE ANGLE DIFFERENT

(2) DIFFERENT NEUTRAL CURRENT

(3) THE SAME TOTAL 3ϕ POWER.

EXERCISE

① A 3ϕ 4 WIRE 415 V SUPPLY IS CONNECTED TO AN UNBALANCED STAR CONNECTED LOAD WHERE

$$Z_A = 32\angle 30^\circ\ \Omega, \quad Z_B = 18\angle -30^\circ\ \Omega, \quad Z_C = 20\angle 45^\circ\ \Omega$$

PHASE SEQUENCE IS ABC. THE REFERENCE VOLTAGE IS V_{AN}.

CALCULATE (a) LINE CURRENTS $\bar{I}_A$, $\bar{I}_B$, $\bar{I}_C$

(b) NEUTRAL CURRENT $\bar{I}_N$

(c) DRAW PHASOR DIAGRAM

② A 3ϕ 4 WIRE 300 V SUPPLY IS CONNECTED TO AN UNBALANCED LOAD. THE LINE CURRENTS ARE $\bar{I}_A = 15\angle 30^\circ$ A, $\bar{I}_B = 10\angle -95^\circ$ A, $\bar{I}_C = 17\angle 90^\circ$ A. THE REFERENCE VOLTAGE IS V_{AN}.

THE PHASE ROTATION IS ABC.

CALCULATE (i) THE IMPEDANCES Z_A, Z_B, Z_C

(ii) THE NEUTRAL CURRENT $\bar{I}_N$.