5042

POWER FACTOR CORRECTION

POOR POWER FACTOR – HIGHER LINE CURRENT
MORE VOLTAGE DROP
MORE POWER LOSS

IT NEEDS TO IMPROVE POWER FACTOR BY

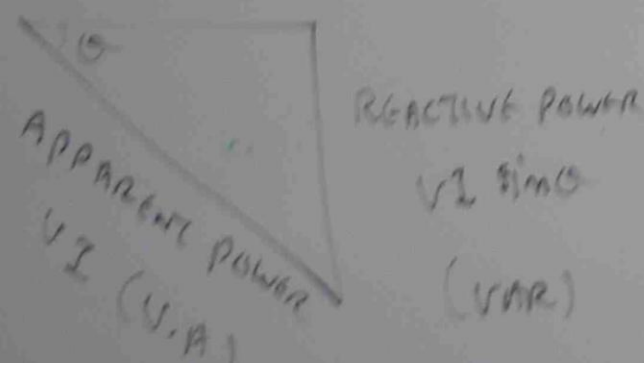
(1) FREE RUNNING SYNCHRONOUS MOTOR FOR SUBSTATION

(2) SVC (STATIC VAR CONTROL)

(AUTOMATIC VARIABLE P.F CONTROL SYSTEM)

1ϕ

ACTIVE POWER (P) WATT = $VI\cos\theta$



3ϕ

ACTIVE POWER = $\sqrt{3}\,VI\cos\theta$ (WATT)

REACTIVE POWER = $\sqrt{3}\,VI\sin\theta$ (VAR)

APPARENT POWER = $\sqrt{3}\,VI$ (V.A)

16

COMPLEX POWER $(S) = P \pm jQ$

S = APPARENT POWER

P = ACTIVE POWER

Q = REACTIVE POWER

$+ \rightarrow$ LEADING P.F

$- \rightarrow$ LAGGING PF

Pb FOUR 3ϕ 415 V 50HZ LOADS ARE CONNECTED TOGETHER IN AN INDUSTRIAL INSTALLATION.

DETERMINE (a) TOTAL LOAD

(b) TOTAL POWER FACTOR

(c) THE VALUE OF CAPACITOR REQUIRED TO RAISE P.F TO 0.95

LOAD (1) 100 KVA, 0.75 LAGGING

LOAD (2) 90 KW, 0.8 LAGGING

LOAD (3) 20 KVAR, 90 DEGREE LEADING

LOAD (4) 90 KVAR LAGGING.

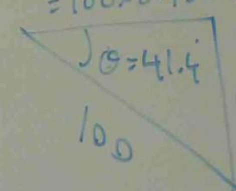
(a)

LOAD (1) $\cos\theta = 0.75 \rightarrow \theta = \cos^{-1} 0.75$

$= 41.4°$

$P_1 = 100 \cos\theta_1$

$= 100 \times 0.75 = 75\,KW$



$Q_1 = 100 \sin\theta_1$

$= 100 \sin 41.4$

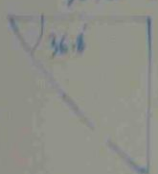
$= 66.1$ KVAR

LOAD (2)

$\cos\theta = 0.8$

$\theta = \cos^{-1} 0.8 = 36.8°$

50 kW ← P_2



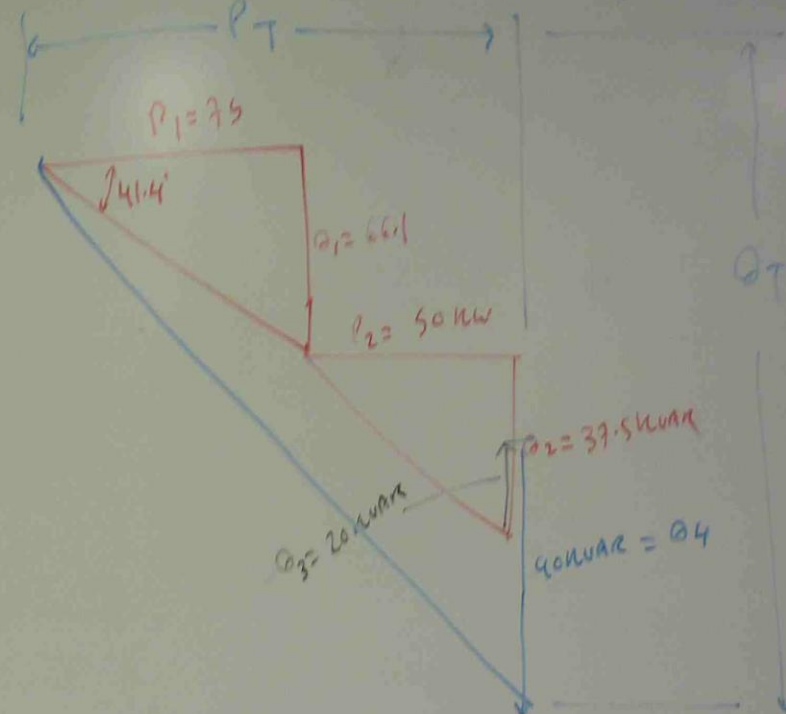
← $50 \tan 36.8 = 37.5$ kVAR ← Q_2

LOAD (3)

20 kVAR
90° LEADING

LOAD (4)

90 kVAR LAGGING



$$P_T = P_1 + P_2 + P_3 + P_4$$
$$= 75 + 50 + 0 + 0$$
$$= 125 \text{ kW}$$

$$Q_T = Q_1 + Q_2 - Q_3 + Q_4$$
$$= 66.1 + 37.5 - 20 + 90 = 173.6 \text{ kVAR}$$

$$S_T = \sqrt{P_T^2 + Q_T^2}$$

$$= \sqrt{125^2 + 173.6^2}$$

$$= 213.9 \text{ kVA}$$

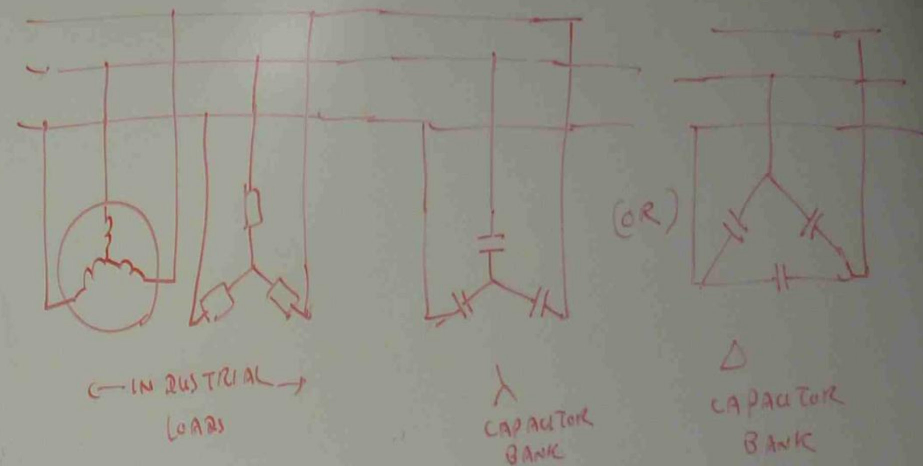
(d) $$\tan\theta_T = \frac{Q_T}{P_T} = \frac{173.6}{125}$$

$$\theta_T = \tan^{-1}\frac{173.6}{125}$$

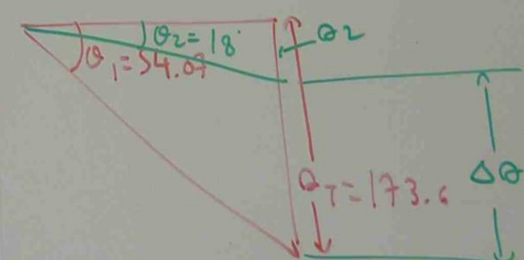
$$= 54.07^\circ$$

$$PF_T = \cos\theta_T = \cos 54.07$$

$$= 0.586 \text{ LAGGING.}$$



$P_T = 125$



$$\Delta Q = Q_T - P_T \tan\theta_2$$

$$= 173.6 - 125 \tan 18$$

$$= 131.25 \text{ kVAR}$$

$$\theta_2 = \cos^{-1} 0.95$$

$$= 18^\circ$$

$$C_{ph} = \frac{\Delta Q}{3V_{ph}^2 \times 2\pi f} = \frac{131.25\times10^3}{3\times\left(\frac{415}{\sqrt{3}}\right)^2 \times 2\times3.1416\times}$$

CAPACITOR PER PHASE

λ

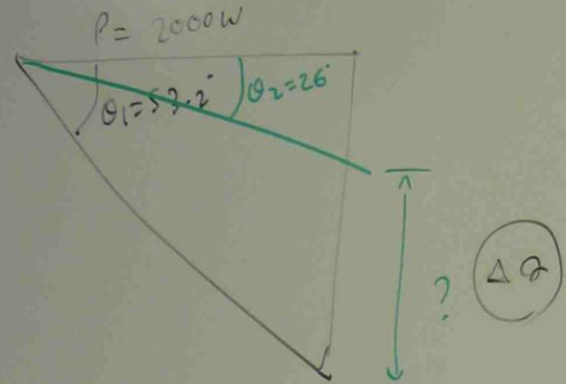
$$= 2417.7\times10^{-6} \text{ F}$$

$$= 2417.7\ \mu\text{F}$$

$\cos\theta_1 = 0.6 \longrightarrow \theta_1 = \cos^{-1} 0.6 = 53.2^\circ$

$\cos\theta_2 = 0.9 \longrightarrow \theta_2 = \cos^{-1} 0.9 = 26^\circ$

(a)



$P_1 = V_1 I_1 \cos\theta_1$

$2000 = 240 \times I_1 \times 0.6$

$$I_1 = \frac{2000}{240 \times 0.6} = 13.9\,A$$

$P_2 = V_2 I_2 \cos\theta_2$

$2000 = 240 \times I_2 \times 0.9$

$$I_2 = \frac{2000}{240 \times 0.9} = 9.26\,A$$

$$C_{ph} = \frac{\Delta Q}{V_{ph}^2 \times 2\pi f} \qquad (1\phi)$$

$$\Delta Q = P(\tan\theta_1 - \tan\theta_2)$$

$$= 2000(\tan 53.2 - \tan 26) = 1698\ \text{VAR}$$

$$C_{ph} = \frac{1698}{(240)^2 \times 2 \times 3.1416 \times 50}$$

$$= 5.41 \times 10^{-6}\ F$$

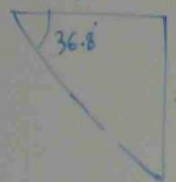
$$= 5.41\ \mu F$$

LOAD (2)

$\cos\theta = 0.8$

$\theta = \cos^{-1} 0.8 = 36.8°$

$50kW \leftarrow P_2$

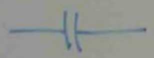


$\leftarrow 50 \tan 36.8 = 37.5\ kVAR \leftarrow Q_2$

LOAD (3)

20kVAR

90° LEADING

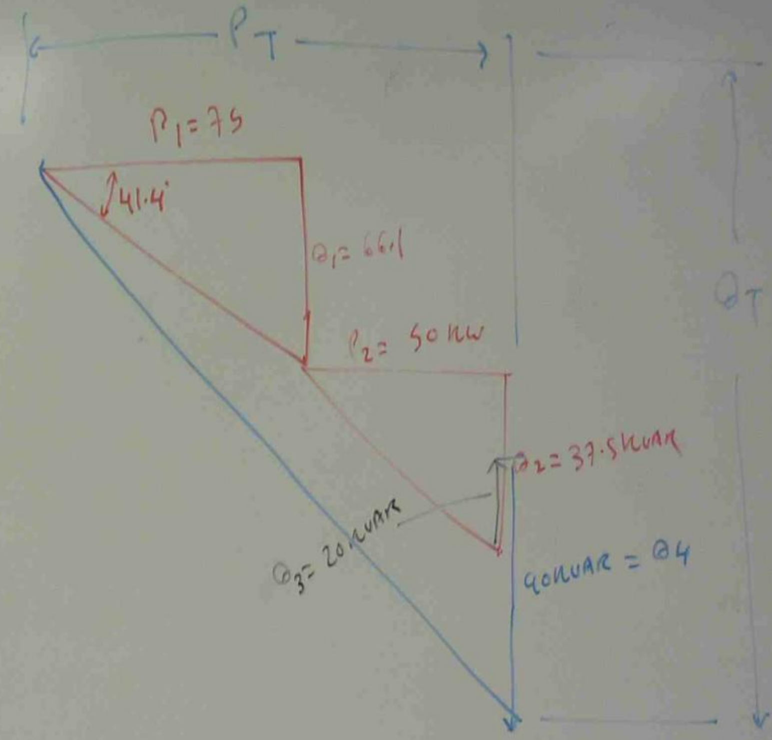


$Q_3 = 20\ kVAR$

LOAD (4)

90 kVAR LAGGING

$Q_4 = 90\ kVAR$



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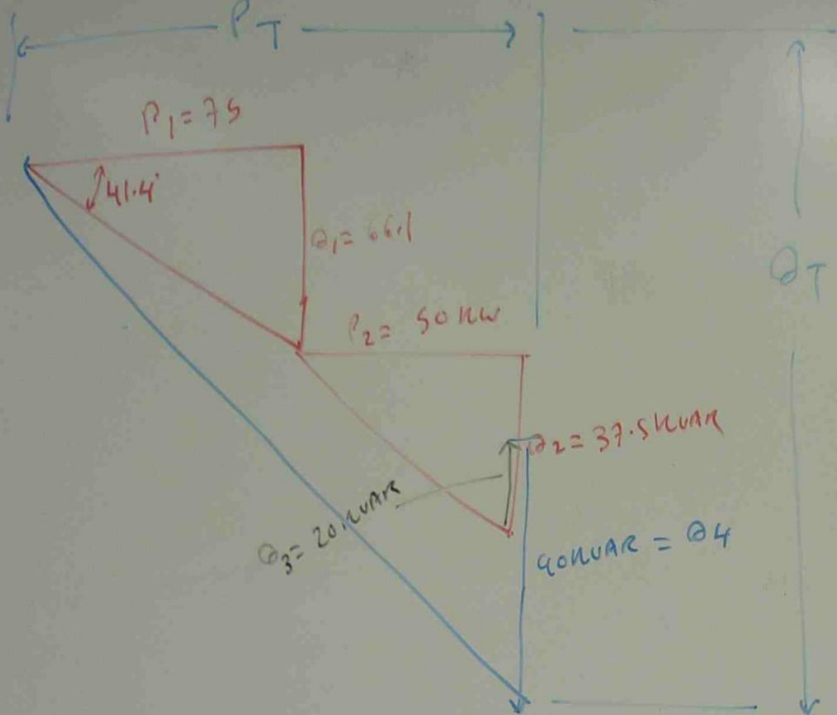

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$$S_T = \sqrt{P_T^2 + Q_T^2}$$
$$= \sqrt{125^2 + 173.6^2}$$
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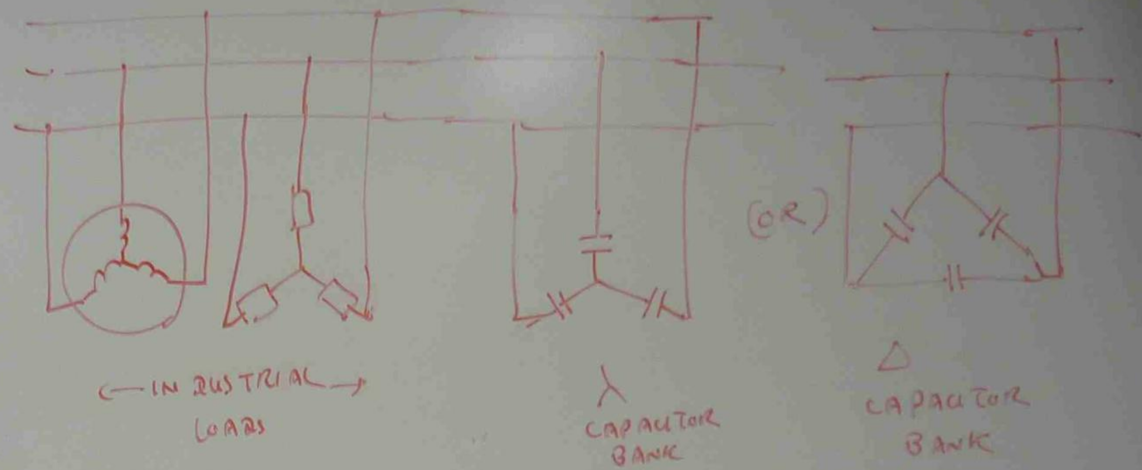

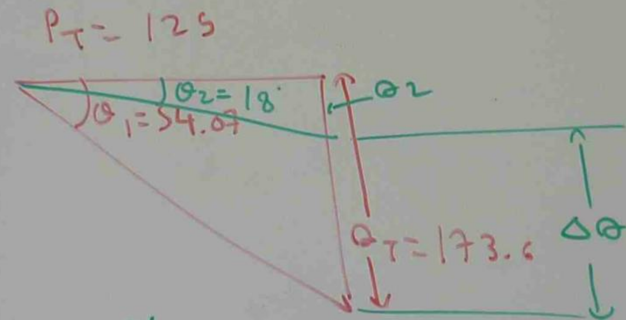

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CAPACITOR PER PHASE

λ

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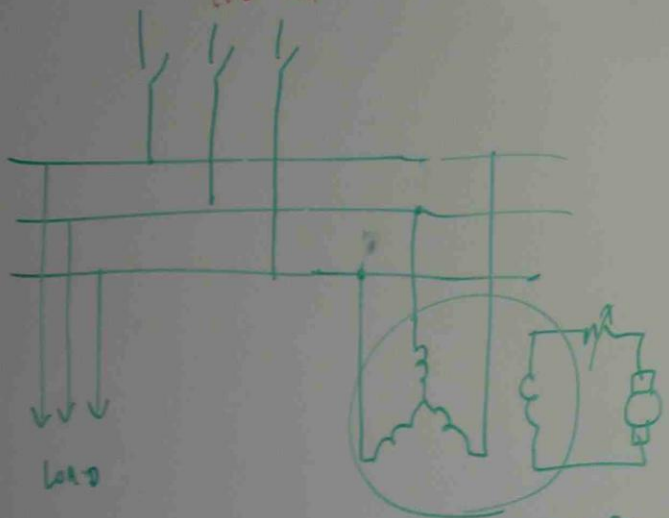
$= 2417.7\, \mu F$

IN ABOVE PROBLEM, IF THE CAPACITORS ARE CONNECTED IN Δ, WHAT WILL BE THE CAPACITANCE VALUE?



$$C_{ph} = \frac{\Delta Q}{3 V_{ph}^2 \times 2\pi f}$$

$$= \frac{131.25 \times 10^3}{3 \times (415)^2 \times 2 \times 3.1416 \times 50}$$

$$= 7251 \ \mu F$$

Pb. A LOAD WITH A POWER FACTOR OF 0.6 LAGGING DISSIPATES 2000 W FROM 240V, 50 HZ SUPPLY. IT IS REQUIRED TO CORRECT THIS P.F TO 0.9 LAGGING. FIND

(a) THE ORIGINAL AND FINAL CURRENTS

(b) THE VALUE OF THE COMPONENT TO BE ADDED IN PARALLEL WITH THE ORIGINAL LOAD TO ACHIEVE THE REQUIRED P.F CORRECTION.

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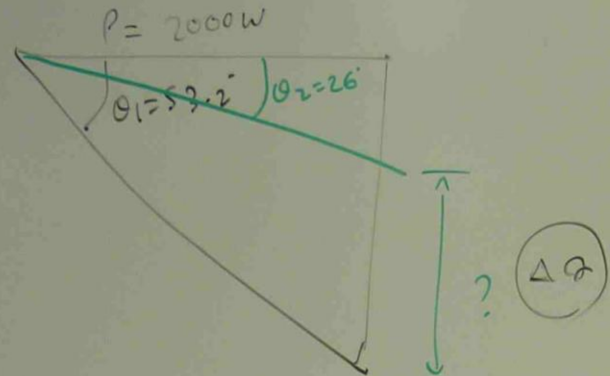
(a)



(1φ)

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