Questions # 1 (7 points) **SHOW YOUR CALCULATIONS**

A balanced 3-ph *abc* sequence Y-connected source with phase voltage $V_{an} = 220\angle 0°$ V_{rr} supplying unbalanced 3-ph Y-connected load as shown below, determine:

$V_{bn} = 220\angle -120$
$V_{cn} = 220\angle +120$

a.	the load's phasor currents, I_a, I_b and I_C	I_a = 7,64 ∠20,32
		I_b = 10 ∠−120
		I_c = 16,92 ∠[illegible]
b.	the load's phase phasor voltages, V_{AN}, V_{BN} and V_{CN}	V_{AN} = 205,71 ∠−1,45
		V_{BN} = 200 ∠−120
		V_{CN} = 189,17 ∠123,5
c.	the load's phasor line voltages, V_{AB}, V_{BC} and V_{CA} 204,44 ∠−175,6; 132,9 ∠56,41	V_{AB} = [illegible]
		V_{BC} = [illegible]
		V_{CA} = [illegible]
d.	the load's complex power absorbed by each phase, S_A, S_B and S_C — S_c = 3201,16 ∠26,5	S_A = 1508,22 ∠−21,0
		S_B = 2000
		S_C = [illegible]
e.	the total complex power supplied by the source, S_{source}	S_{source} = 6058,08 ∠

$I_a = \frac{V_{an}}{2+(25-10j)} = \frac{220}{27-10j} =$ 7,64 ∠20,32

$I_b = \frac{220\angle -120}{2+20} = 10\angle -120$

$I_c = \frac{}{2+10+5j} = 16,92 \angle 97,35$

V_{AN} = 7,64 ∠20,32 × [25 − 10j] = 205,71 ∠−1,45

V_{BN} = 200 ∠−120

V_{CN} = 189,17 ∠123,5

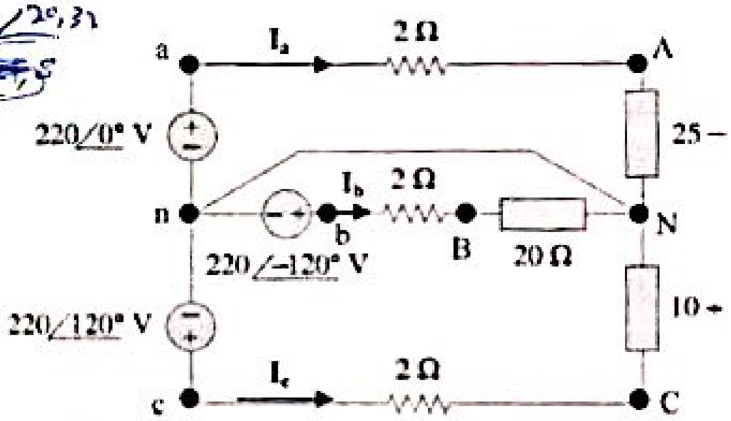
V_{AB} = [illegible]

$S_{T.L}$ = [illegible]

$S_A = I_a^* V_{AN}$ = 205,71 ∠−1,45 × 7,64 ∠−20,32

$S_B = V_{BN} I_b^*$ = 200 ∠−120 × 10 ∠120

S_C = 381,05 ∠150 × 16,92 ∠−97 =



(2)

Question # 2 (3 points) **SHOW YOUR CALCULATIONS**

A balanced Y-connected load as shown below is fed from a 50 Hz, three-phase Y-connected source with line voltage of 400 V_{rms}. The resistance R in each phase of the load is 10 Ω and the load draws a total power P_{tot} of 15 kW. Calculate:

a.	the magnitude of the line current drawn by the load, $\lvert I_L \rvert$	$\lvert I_L \rvert$ = 707,10
b.	the load power factor, PF	PF = 0,0306 lagging
c.	the total reactive power drawn by the load, Q_{tot} 4583,16	Q_{tot} = ~~23635,27~~
d.	the total apparent power drawn by the load, $\lvert S_{tot} \rvert$ 4530,74	$\lvert S_{tot} \rvert$ = ~~23695,82~~
e.	the load's inductance, L in mH.	L = ~~15,07 mH~~ 3,10 mm

~~$P_{tot} = \sqrt{3} |V_L| |I_L| \cos\theta$~~

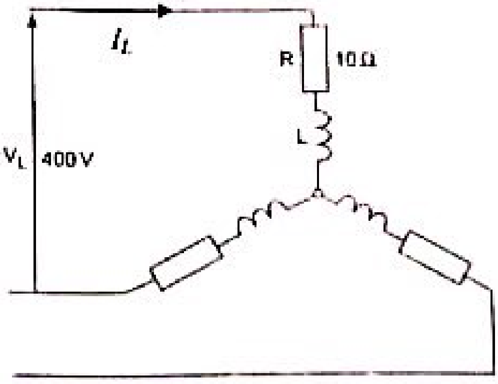
$P_{3\phi} = 15\,k$

$P_{1\phi} = \frac{15}{3} k$

$P_{1\phi} = |I_L|^2 \cdot R$

$\frac{15}{3} k = |I_L|^2 \cdot 10$ = $10 |I_L|^2 = 5000$, $\sqrt{500} = 10\sqrt{5} = 22,36$

$|I_L| = 707,10\ A$



$\Rightarrow P_{3\phi} = \sqrt{3} |V_L| |I_L| \cos\theta$

$15k = \sqrt{3} \cdot 400 \cdot 707,1 \cos\theta$

PF ⇒ $\cos\theta = 0,0306$

$\theta = 88,24$

$P = 15$

$\tan\theta = \frac{Q}{P}$

$Q = P \tan\theta$

$Q =$ ~~23635,27~~ 4583,16

$\vec{S} = 23695,82 \angle 88,24$

-1

$Q_{3\phi} = \sqrt{3} |V_L| |I_L| \sin\phi$

$Q = |I_L|^2 \cdot X_L$

$23635,27 = (707,1)^2 \cdot X_L$

$X_L = 0,0473 = \omega L = 2\pi f L$

$0,0473 = 100\pi L$

$L = 15,07\ mH$

$Q = |I_L|^2 \cdot X_L$

$4583,16 = (707,1)^2 \cdot X_L$

$X_L = \omega L = 100\pi L =$

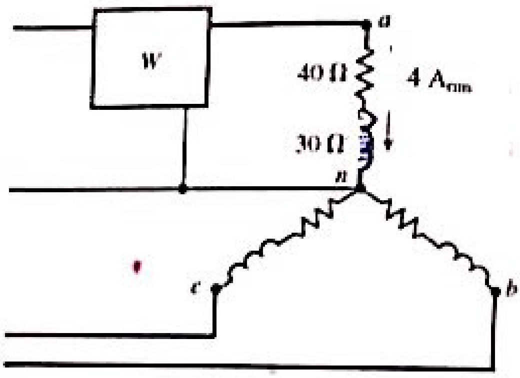
$L = 3,10 \times 10^{-6}$

3

Question # 3 (3 points)   **SHOW YOUR CALCULATIONS**

A three-phase *abc* Y-connected source feeds a balanced Y-connected load with an impedance as indicated in the figure shown below. If the load takes 4 A_{rms}, find

a.	the load's power factor, PF	PF = ~~1~~ $\boxed{0,8}$ lag
b.	the wattmeter reading, W	W = 640 W
c.	The total real, reactive and apparent power drawn by the load	P_{tot} = 1920 W Q_{tot} = 1439,43 VAr $\lvert S_{tot}\rvert$ = 2399,8 VA
d.	the magnitude of the load's line voltage	$\lvert V_{LL}\rvert$ = 346,41



$V_{an} = [40 + 30j]\,4$

$\boxed{V_{an} = 200 \angle 36,86}\ V_{ab}$

$\boxed{I_a = 4\angle 0}$

$P_a = W = |V_{an}|\,|I_a| \cos\theta$

$W = 200 \times 4 \cos 36,86$

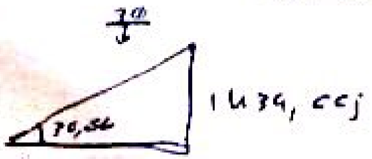
$\boxed{W = 640}$

~~$P_{tot} = \sqrt{3}\,|I_L|\,V_L \cos\theta$~~

$P_{3\phi} = 3P_a = \boxed{1920}$

$P_{3\phi} = 1920 = \sqrt{3}\,|V_L|\,|I_L| \cos\theta$ / $V_L = \sqrt{3}\ 200 = \boxed{346,41}$

$\cos\theta = PF_{load} = \dfrac{1920}{\sqrt{3}\cdot 346,41 \times 4} = \boxed{0,8}$



~~Q = sin~~

$Q = P \tan$

$\boxed{Q = 1439,43}$ VA

$\boxed{S = 2399,8 \angle 36,86}$

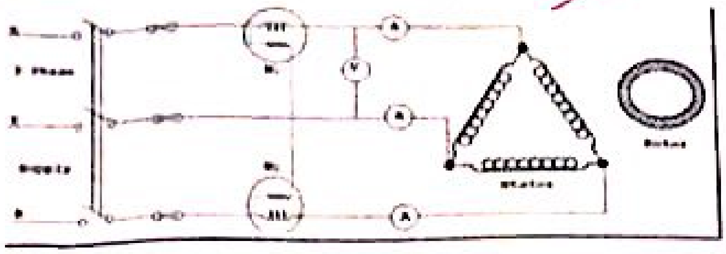
(2)

Questions # 4 (2 points) **SHOW YOUR CALCULATIONS**

In the figure shown below, two-wattmeter method have been used to measure the power input to a 440 V_{rms}, 3-ph induction motor running at full load. The wattmeter readings are W_1 = 115 kW and W_2 = 50 kW. Calculate:

a.	the total input real power to the motor in kW	P_{tot} = 165 kW
b.	the total input reactive power to the motor in kVAR	Q_{tot} = 112,58 kVA
c.	the motor's power factor	pf = 0,826 lagging
d.	the magnitude of the line current drawn by the motor.	$\lvert I_L \rvert$ = 262,08 A

V_{LL}=440 V_{rms}



$P_{total} = W_1 + W_2 = 115 + 50$

$P_{tot} = 165$

$Q = \sqrt{3}[W_1 - W_2]$

$Q = 112,58$ kVA

$\vec{S} = 199,74 \angle 34,3$

$PF = \cos 34,3 = 0,826$ lagging

$P_{tot} = \sqrt{3}\, |V_L| \cdot |I_L| \cdot \cos\theta$

$\frac{165\,k}{\sqrt{3} \cdot 440 \cdot \cos\theta} = |I_L|$

$|I_L| = 262,08$

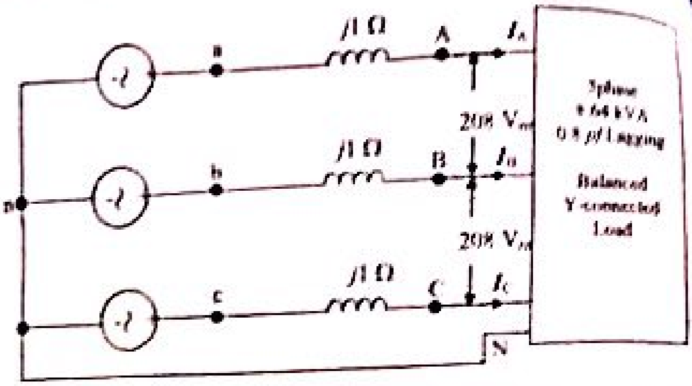
Question # 5 (5 points) **SHOW YOUR CALCULATIONS**

A balanced three-phase *abc* sequence Y-connected source is connected to a balanced Y-connected load through a transmission line with an impedance of $j1\ \Omega$ per phase as shown below. The load consumes 8.64 kVA at 0.8 *pf* lagging. Given the line-to-line voltage $V_{CB} = 208\angle 90°$ V_{rms} at the load terminals, answer questions 6.1-6.5.

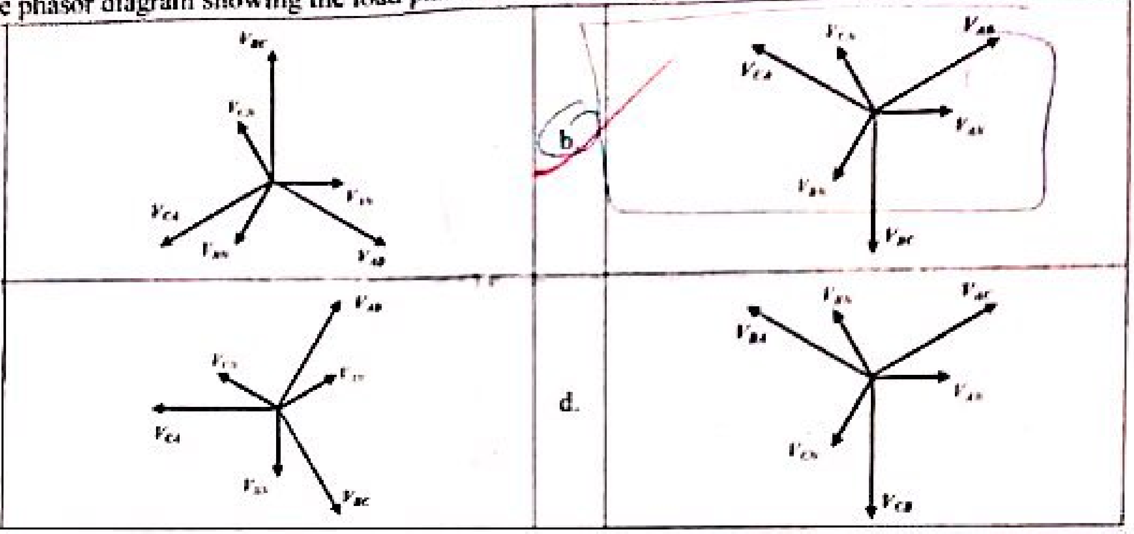
$V_{BC} = 208\angle 30$

$V_{BC} = -V_{CB} = 208\angle -90$

$V_{CA} = 208\angle 150$



6.1	the phasor diagram showing the load phase and line voltages is shown in Fig. (•).



6.2.	The load phase voltage V_{AN} is given as___.
V_{AN} =	120 ∠0 V_{rms}

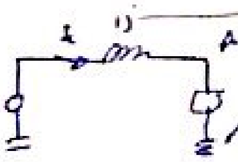
6.3	the phasor current I_A is____.
I_A =	39,97 ∠-36,86

6.4	the load impedance per phase Z_Y is___.
Z_Y =	3 ∠36 Ω

6.5	the magnitude of the source voltage $\lvert V_{an}\rvert$ is___.
V_{an} =	147,40 ∠12,51 V_{rms}

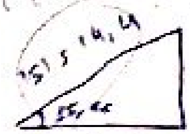
$V_{an} = I_A j + V_{AN}$ $\quad V_{AN} = \frac{V_{BC}}{\sqrt{3}} \angle -30$

$V_{an} = \frac{V_L}{\sqrt{3}} \angle 30$ $\quad V_{AN} \angle 0$



$Z = \frac{V_{AN}}{I_A} = \frac{120}{39,97\angle -36}$

$Z = 3\angle 36,86$



$Q = 5,64$

$P = 11,52$

$\tan\theta = \frac{Q}{P}$

$P = \frac{S}{\cos\theta}$

$P = 11,52\ k$

$P_{3\phi} = \sqrt{3}\,|V_L|\,|I_L| \cdot \cos\theta$

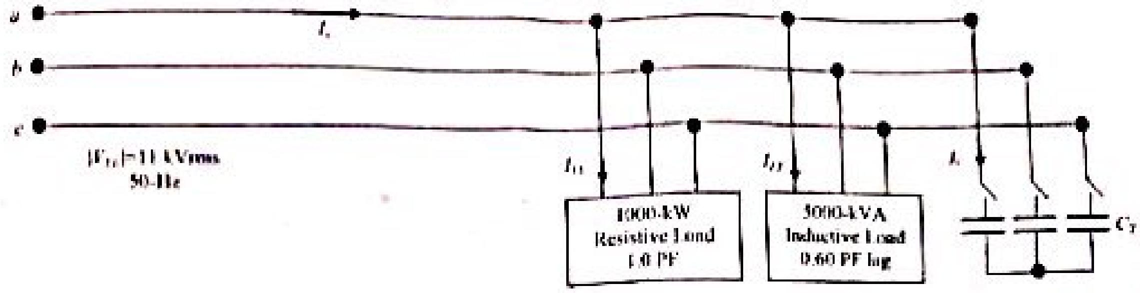
$\frac{11,52\ k}{\sqrt{3} \times 208 \times 0,8} = |I_L| = 39,97$

$V_{AN} =$

(3)

Question # 6 (10 points) **SHOW YOUR CALCULATIONS**

A small industrial plant has a 3-ph 1000-kW Y-connected resistive heating load and a 3-ph 5000-kVA, 0.6 PF lagging Y-connected inductive load as shown below. The two loads are connected to a 50 Hz 3-ph source with a line voltage of 11 kV_{rms}. Calculate:



a.	the magnitude of the line current drawn by the heating load, $\lvert I_{L1}\rvert$	$\lvert I_{L1}\rvert$ = 52,45
b.	the magnitude of the line current drawn by the inductive load, $\lvert I_{L2}\rvert$	$\lvert I_{L2}\rvert$ = 328,04
c.	the total real and reactive power P_{tot} and Q_{tot} supplied by the source in kW and kVAR	P_{tot} = 1003,75 kW Q_{tot} = 5000 kVA
d.	the power factor at the source, PF_s	PF_s = 0,196 lagging
e.	the magnitude of the source line current, $\lvert I_s\rvert$	$\lvert I_s\rvert$ = 330,52
f.	the size of the Y-connected capacitor bank, in terms of Q_c and C_Y, that must be placed in parallel with the two loads to raise the overall PF to 0.90 lagging	Q_c = 4520,07 kVA C_Y = 39,7 μF
g.	the magnitude of the capacitor line current, $\lvert I_C\rvert$	$\lvert I_C\rvert$ = 164,75
h.	the magnitude of the source current after adding the capacitor, $\lvert I_s\rvert$	$\lvert I_s\rvert$ = 545,27

$P_{3\phi} = \sqrt{3}\,|V_L|\,|I_L|\cdot\cos\theta$

$\frac{1000k}{\sqrt{3}\times 11k} = |I_{L1}| = 52,48$

$Q_{3\phi} = \sqrt{3}\,|V_L|\cdot|I_L|\,\sin 53,13$ $\quad \theta = 53,13$

$\frac{5000k}{\sqrt{3}\cdot 11k\cdot 0,7999} = |I_L| = 328,04$

$P_{tot} = P_1 + P_2 = 1000k + 3,5k = 1003,75\ kW$

$P_2 = \sqrt{3}|V_L||I_L|\cdot\cos 53,13$

$P_2 = 3550,80$

$Q_{tot} = Q_1 + Q_2 = 0 + 5000k\ VAR$

$\vec{S} = 1003,75 + 5000j$

$\vec{S} = 5099,04\ \angle 78,60\ kVA$

$\theta = 78,60$

$\cos\theta = 0,196$

$|S| = \sqrt{3}\,|V_L|\,|I_L|$

$\frac{5099,04k}{\sqrt{3}\times 11k} = I_L$

$I_{L1} + I_{L2} = I_s = 330,$

$\theta_{old} = 78,60$

$\theta_{new} = 25,84$

$Q_C = P[\tan\theta_{old} - \tan\theta_{new}]$

$Q_C = 4520,07$

$C = \frac{Q_C}{3\cdot\omega V_C^2} = \frac{4520,08k}{3\cdot 100\pi\cdot(11k)^2} = 39,7$