POWER SYSTEM ANALYSIS-I FIRST EXAM
(Summer School - 2009)

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July 23, 2009

#1) Consider a single-phase load with an applied voltage $v(t) = 150\cos(\omega t + 10^\circ)$ volts and load current $i(t) = 5\cos(\omega t - 50^\circ)$

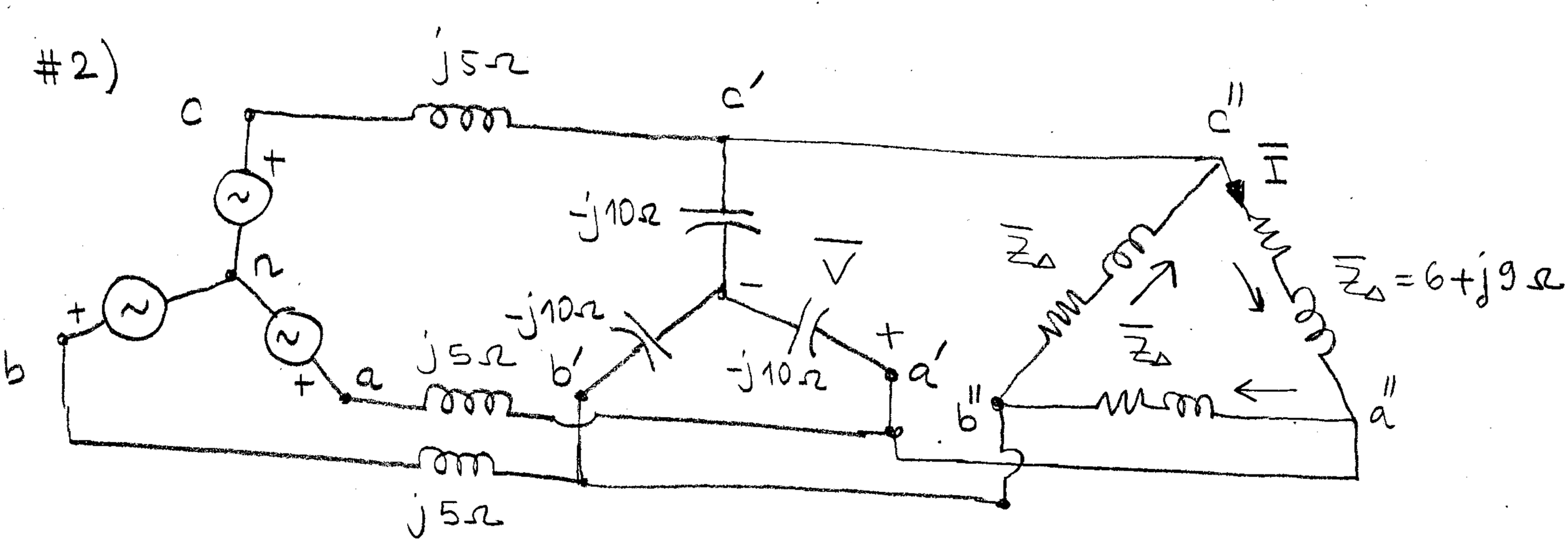
A.

a) Determine the power triangle.

b) Find the power factor and specify whether it is lagging or leading

c) Calculate the reactive power supplied by the capacitor in pavallel with the load that correct the power factor to 0,9 lagging.

#2)



Three-phase system given in the above figure is balanced and its phase sequence is abc. Calculate $\bar{I}$ and $\bar{V}$ values shown in the figure. Calculate also the complex power given by the source. Take $v_{bc}(t) = \sqrt{2}\,380\cos(\omega t)$ volt for the source.

#3) The real power delivered by the source to two impedances, $\bar{Z}_1 = 3+j4\,\Omega$, $\bar{Z}_2 = 10\,\Omega$ connected in pavallel, is 1100 W.

Determine:

a) the real power absorbed by each of the impedances

b) the source current.

POWER SYSTEM ANALYSIS-I FIRST EXAM
SOLUTION MANUAL (Summer School-2009)

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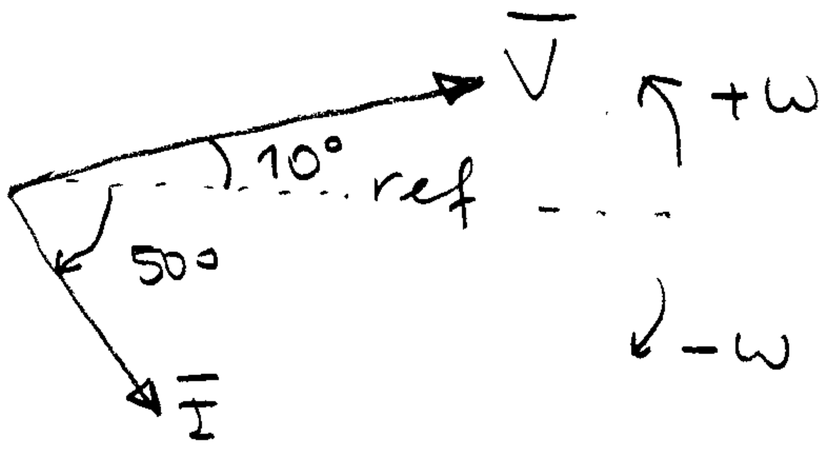
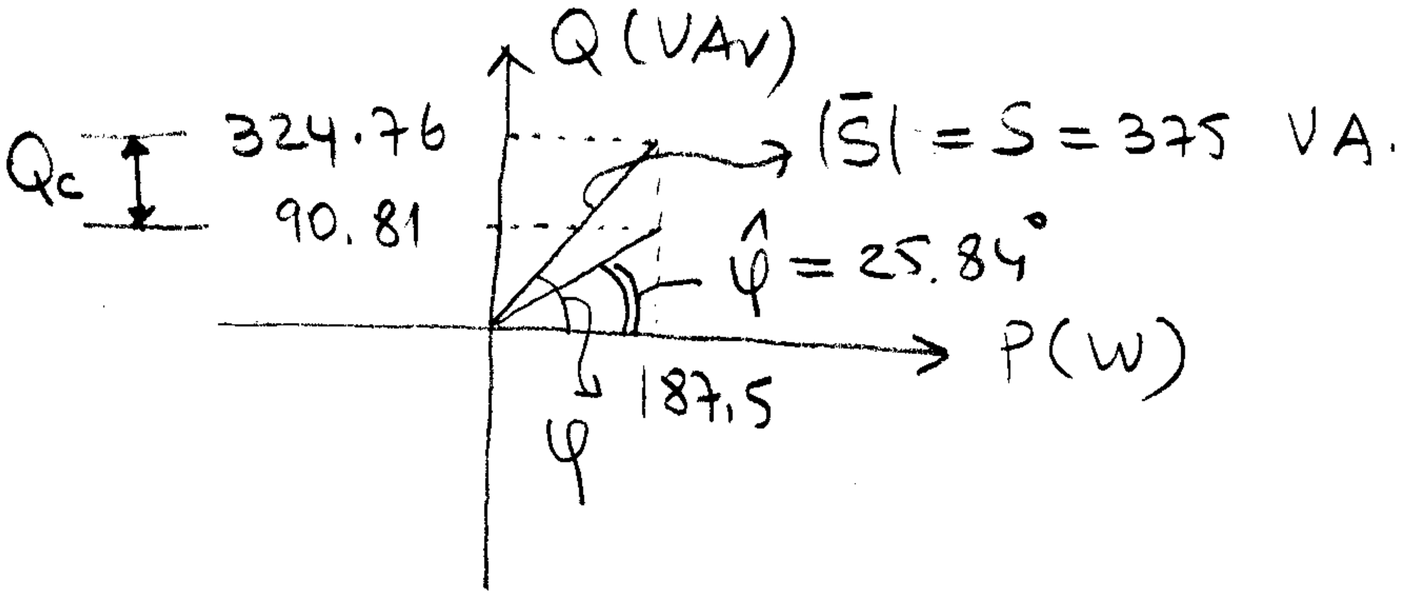
#1) $v(t) = 150\cos(\omega t + 10^\circ)$ V $\rightarrow \bar{V} = \frac{150}{\sqrt{2}} \angle 10^\circ$ volt

a) $i(t) = 5\cos(\omega t - 50^\circ)$ A $\rightarrow \bar{I} = \frac{5}{\sqrt{2}} \angle -50^\circ$ A.



$\bar{S} = V I^* = \frac{150 \times 5}{2} \angle 10+50$

$\bar{S} = 375 \angle 60^\circ = 187.5 + j\,324.76$ VA



b) power angle $= \varphi = \delta - \beta = 10^\circ - (-50^\circ) = 60^\circ$

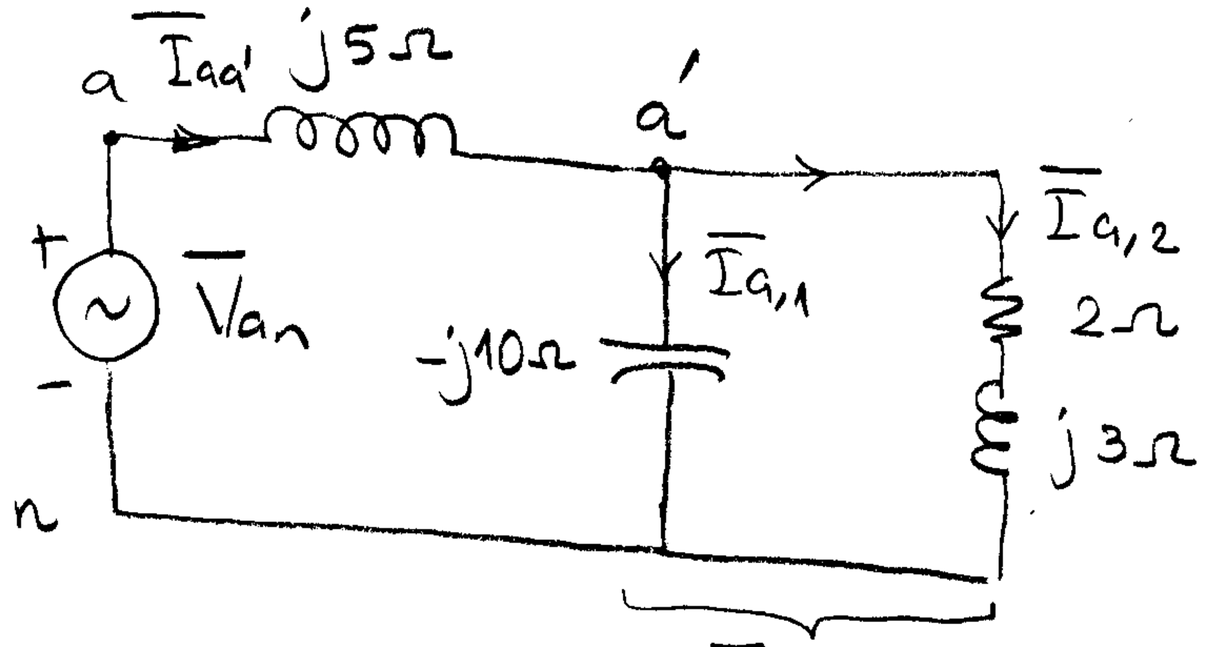
power factor $= \cos 60^\circ = 0.5$ lagging (current phasor lags voltage phasor)

c) $0.9 = \cos\hat{\varphi} \rightarrow \hat{\varphi} = \cos^{-1}(0.9) = 25.84$ lagging

$\hat{Q} = P \tan\hat{\varphi} = 187.5 \times \tan(25.84^\circ) = 90.81$ VAr

$Q_c = 324.76 - 90.81 = 234$ VAr

#2) Line-to-neutral equivalent circuit will be as follows;



$$v_{bc}(t) = \sqrt{2}\,380\cos(\omega t)\ V$$

$$\bar{V}_{bc} = 380\angle 0^\circ$$

$$\bar{V}_{bn} = \frac{380}{\sqrt{3}}\angle -30^\circ = 220\angle -30^\circ$$

$$\bar{V}_{an} = 220\angle 120^\circ - 30^\circ$$

$$\bar{V}_{an} = 220\angle 90^\circ \text{ Volt}$$

$$2+3j = 3.605\angle 56.3^\circ\ \Omega$$

$$\bar{Z}_{eq} = \frac{10\angle -90^\circ \times 3.605\angle 56.3^\circ}{-j10+2+3j}$$

$$\bar{Z}_{eq} = \frac{36.05\angle -33.7^\circ}{7.28\angle -74.05^\circ} = 4.952\angle 40.35^\circ\ \Omega = 3.774 + j3.206$$

$$\bar{I}_{aa'} = \frac{220\angle 90^\circ}{3.774+j(3.206+5)} = \frac{220\angle 90^\circ}{9.032\angle 65.3^\circ} = 24.357\angle 24.7^\circ\ A.$$

By using current division rule

$$\bar{I}_{a,1} = 24.357\angle 24.7^\circ \times \frac{3.605\angle 56.3^\circ}{7.28\angle -74.05^\circ} = 12.06\angle 155.05^\circ\ A$$

$$\bar{I}_{a,2} = 24.357\angle 24.7^\circ \times \frac{10\angle -90^\circ}{7.28\angle -74.05^\circ} = 33.45\angle 8.75^\circ\ A.$$

$$\bar{V} = \bar{V}_{a'n} = 10\angle -90^\circ \times 12.06\angle 155.05^\circ = 120.6\angle 65.05^\circ \text{ Volt}$$

$$\bar{I}_{c,2} = 33.45^\circ\angle 8.75^\circ + 120^\circ = 33.45^\circ\angle 128.75^\circ$$

$$\bar{I} = I_{c''a''} = \frac{\bar{I}_{c,2}}{\sqrt{3}}\angle 30^\circ = \frac{33.45^\circ}{\sqrt{3}}\angle 158.75^\circ = 19.312\angle 158.75^\circ$$

(Δ)

$$\bar{S}_s = 3\,\bar{V}_{an}\,\bar{I}_{aa'}^{*}$$

$$\bar{S}_{s,3\phi} = 3\times 220\angle 90^\circ \times 24.357\angle -24.7^\circ = 16075.62\angle 65.3^\circ \text{ VA}$$

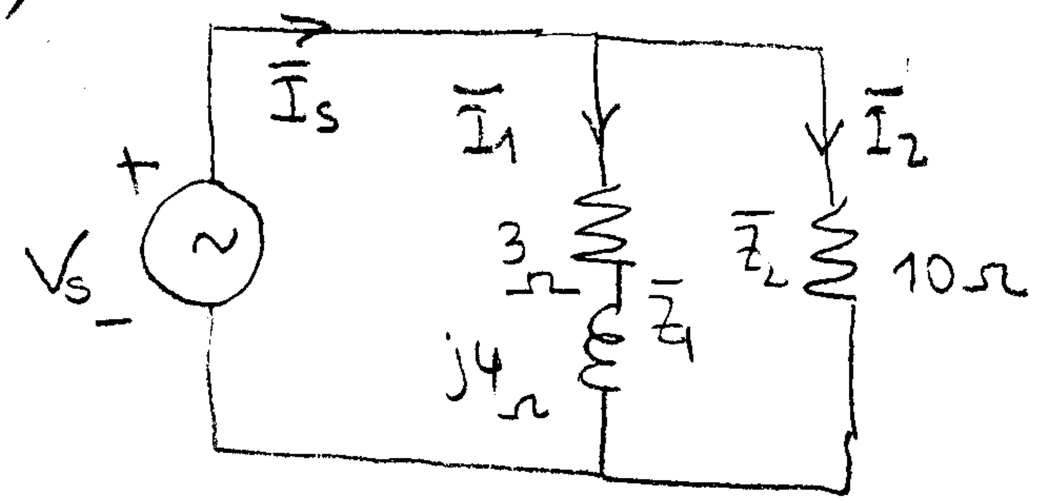
$$= 6717.47 + j\,14604.8 \text{ VA}$$

$P_{s,3\phi} = 6717.47$ W delivers

$Q_{s,3\phi} = 14604.8$ VAr delivers

#3) $\rightarrow P = 1100$ W

a)



$\bar{Z}_1 = 3 + j4 = 5\angle 53.13^\circ\ \Omega$

$\bar{Z}_2 = 10\angle 0^\circ\ \Omega$

$\bar{V}_s = V_s\angle 0^\circ$ volt.

$\bar{I}_1 = \frac{V_s}{5}\angle -53.13^\circ$ A, $\bar{I}_2 = \frac{V_s}{10}\angle 0^\circ$ A.

$\frac{V_s^2}{25}3 + \frac{V_s^2 10}{100} = 1100$ $\quad \frac{V_s^2(12+10)}{100} = 1100$ $\quad V_s = \left(\frac{1100\times 100}{22}\right)^{1/2}$

(4)

$V_s = 70.7106$ Volt.

$\bar{I}_1 = \frac{70.7106}{5}\angle -53.13^\circ = 14.142\angle -53.13^\circ$ A $= 8.4852 - j\,11.313$

$\bar{I}_2 = \frac{70.7106}{10} = 7.071\angle 0^\circ$ A.

$P_1 = (14.142)^2 \times 3 = 600$ W $\quad P_2 = (7.071)^2 \times 10 = 500$ W

b) $\bar{I}_s = (8.4852 + 7.071) - j\,11.313 = 15.5562 - j\,11.313$

$= 19.234\angle 36.02^\circ$ A.