Potencia

$P = \frac{E}{t}$ energía sobre el tiempo

$[E]$ = Joules

$[t]$ = Segundos

$[P]$ = Watts → pot. activa

= VA → pot. aparente

= VAR → pot. reactiva

potencia consumida por elementos reactivos

$P = v(t) \cdot i(t)$

Potencia instantánea

$v(t) = V_M \operatorname{sen}(\omega t + \theta_v)$

$i(t) = I_M \operatorname{sen}(\omega t + \theta_i)$

$P = V_M \operatorname{sen}(\omega t + \theta_v) \cdot I_M \operatorname{sen}(\omega t)$

$= V_M \cdot I_M \cdot \operatorname{sen}(\omega t + \theta_v) \cdot \operatorname{sen}(\omega t)$

$= V_{RMS} I_{RMS} \cos(\theta_z) - V_{RMS} I_{RMS} \cos\theta_z \cos(2\omega t) + V_{I_1} \operatorname{sen}(\theta_z) \operatorname{sen}(2\omega t)$

potencia media = constante, no varía en el tiempo

cosenoidal

senoidal

valores pico: V_M I_M

valores RMS: V I

$\frac{VI}{f_1}$

en un ciclo $T_1 = \frac{1}{f_1}$

$\frac{V_M \cdot I_M}{\sqrt{2}\sqrt{2}}$

$\frac{V_M I_M}{2}$

$\cos(\theta_z)$ = Factor de potencia $(P_f) = \frac{P}{P_S}$

Potencia (consumida) debida a un resistor ($\theta_z = 0°$)

$P = V \cdot I(1-\cos(2wt)) = VI - VI\cos(2wt)$ también $P = VI \rightarrow \frac{V \cdot V}{R} = \frac{V^2}{R}$

Potencia debida a un inductor ($\theta_z = 90°$)

$P = VI \text{ sen}(2wt)$ el inductor no disipa energía

$E_L = L \cdot I_m^2$ (joules)

$= L\left(\frac{I_m}{\sqrt{2}}\right)^2$

Potencia reactiva $= P_Q = VI \text{ sen } \theta_z$ = VAR

para reactancias $= \frac{V^2}{X} = I^2 X$

Potencia debida a un inductor ($\theta_z = -90°$)

$P = -VI \text{ sen}(2wt)$ tampoco disipa energía

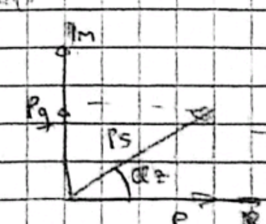
$E_C = C \cdot V_m^2 = C \cdot \frac{V_{rms}^2}{2}$

Potencia aparente → suma de activa y reactiva

$|P_S| = V_{rms} \cdot I_{rms}$ $P_S = V \cdot I^* = V_{rms} e^{j\theta_V} \cdot I_{rms} e^{-j\theta_I} = V_{rms} \cdot I_{rms}$

$P_S = V_{rms} \cdot I_{rms} \cdot \cos\theta_z + j V_{rms} \cdot I_{rms} \cdot \text{sen}\,\theta_z$

$|P_S| = \sqrt{P^2 + Q^2}$



Ejercicios de ejemplo

14.1) a) $P = V(t) \cdot I(t) = V_m \text{ sen}(wt + \theta_z) \cdot I_m \text{ sen}(wt + \theta_I)$

$P_{t_1} = 0w$

$P_{t_2} = 12v \cdot \text{sen}((1kHz \cdot 2\pi) \cdot t + 0°) \cdot 3A \cdot \text{sen}((1kHz \cdot 2\pi) \cdot t + 0°)$

$= 36w(\text{sen}((1kHz \cdot 2\pi) \cdot t))^2$

$P_{t_3} = 18w$

$P_{t_4} = 0w$

$P_{t_5} = -36w$ $P_{t_6} = 0w$

b)

c) $\frac{V_m \cdot I_m}{2} = \frac{12 \cdot 3A}{2}$ 18w

d) $\frac{12v \cdot 3A}{2 \cdot \pi}$

14.2) a) t = 0w

t2 = V_L = 7,07V $i_L = \frac{V_M}{X_L}$ sen(α − 90°)   45°

$= \frac{10V}{5\Omega}$ sen(α − 90°) = 2 sen(α − 90°)

= 2 sen(45° − 90°) = −1,414A

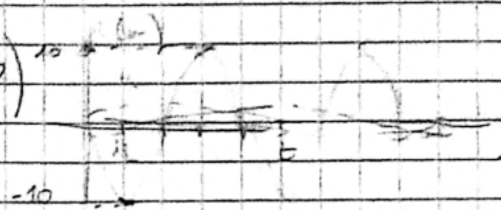
pL = 7,07V · −1,414A

= −10w

t3 = 10V · 2 sen(90 − 90)

= 0w

t4 = 10w
t5 = 0w

b) 
0 es el promedio

c) $\frac{V_M I_M}{2} = \frac{10V \cdot 2A}{2}$ = 10w

d) $\frac{V_M I_M}{2\omega} = \frac{10V \cdot 2A}{2(100rad/s)}$ = 50mJ

14.3) W = 100 + 200 + 300 = Pt

600W =

Pot. total disipada

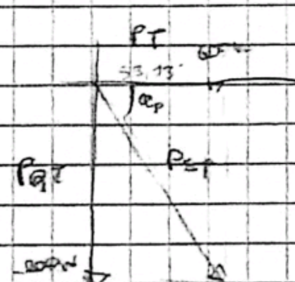
P_{QT} = 0 + 200 − 1800

= −800w

Pot. react resultante

$|P_{ST}| = \sqrt{600^2 + (-800)^2}$

= 1000w



$F_p = \frac{P_T}{|P_{ST}|}$ = 0,6

cos α_p = Fp

α_2 = $\cos^{-1}$ Fp = 53,13°

Ejercicios postos

14.1) a) P_T = 60w + 45w + 25w

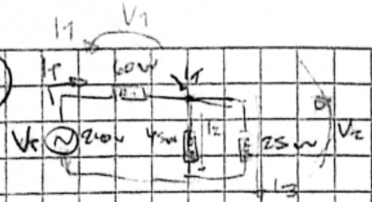
= 130w

b) No tiene sentido hablar de aparente dado que el circuito es puramente resistivo, osea solo sería 130VA.

Tampoco tiene reactiva porque no hay reactancias.

$E = V_1 + V_2$

c)



$V = V_1 + V_2$

$V_1 \cdot I_T = (V_1 + V_2) \cdot I_T$

$P_T = V_1 \cdot I_T + V_2 \cdot I_T$

$I_T = I_2 + I_3$

$P_T = P_1 + V_2 \cdot (I_2 + I_3)$

$= P_1 + P_2 + P_3$

$P_T = V_1 \cdot I_T + V_2 \cdot I_2 + V_2 \cdot I_3$

$180 W =$

$P_1 = V_1 \cdot I_T$ $P_2 = V_2 \cdot I_2$ $P_3 = V_2 \cdot I_3$

$\_\_ W = V_1$

$P_T = V_T \cdot I_T$

$130 W = 240 V \cdot I_T$

$I_T = 542 mA$

d) $R_T = \frac{V_T}{I_T} = 442,8 \Omega = R_1 + R_2 + R_3$

$R_1 = \frac{V_1}{I_T}$

$= 204,24 \Omega$

$V_2 = V_T - V_1$

$= 129,3 V$

$P_2 = V_2 \cdot I_2$

$45 W = 129,3 V \cdot I_2$

$348 mA = I_2$

$R_2 = 337,6 \Omega$

$R_3 = 665,41 \Omega$

e) $I_2 = 348 mA$ $I_3 = 193,3 mA$

2) a) $Z_T = 3 \Omega + j(9 \Omega - 5 \Omega)$ (4Ω)

$I_T = 2,94 A = \frac{50 V}{3 \Omega + 5 \Omega + 9 \Omega}$

$Z_T = 5 \Omega \, e^{j 53,13°}$

$I = \frac{50 V \, e^{j 0°}}{5 \Omega \, e^{j 53,13°}} =$

$= 10 A \, e^{-j 53,13°}$

Calculo potencia del resistor. (El X_C y X_L no consumen potencia, la devuelve):

$P_R = I^2 \cdot R$

$= 300 W$

b) $V_{R1} = 8,82$ $V_{R2} = 14,7 V$ $V_{R3} = 26,5 V$

$P_{R1} = 5,9 W$ $P_{R2} = 43,22 W$ $P_{R3} = 77,91 W$

NO SE QUE

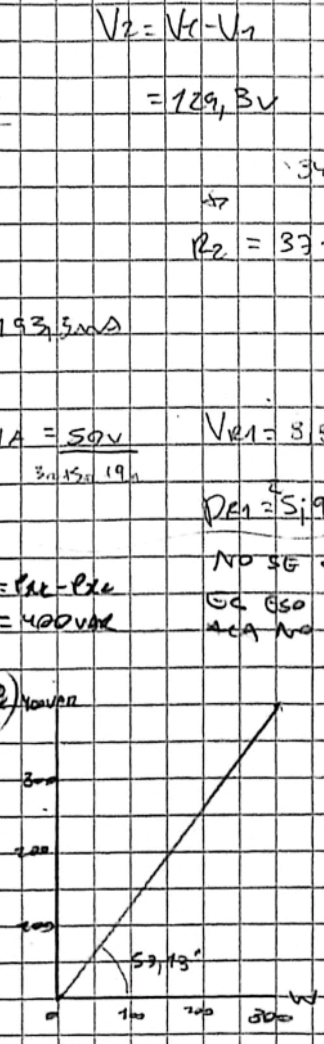
ES ESO PERO

ACA NO APLICA

d) $Q_T = P_{XL} - P_{XC}$

$= 400 VAR$

e)



$X_C = \frac{1}{wC}$

$C = \frac{1}{w \cdot X_C} = 530,5 \mu F$

g) $E_{XC} = C \cdot \frac{V^2}{2}$

$= 663 mJ$

$wL = X_L$

$L = \frac{X_L}{w}$

$= 23,87 mH$

$E_{XL} = L \cdot \frac{I^2}{2}$

$= 1,19 J$

b) $P_{XC} = 10 A^2 \cdot 5 \Omega$ $P_{XL} = 10 A^2 \cdot 9 \Omega$

$= 500 VAR$ $= 900 VAR$

c) $\sqrt{P_R^2 + (P_{XL} - P_{XC})^2} = 500 VA$

d) $\frac{P_T}{S_T} = 0,6$ (300 W / 500 VA)

f) $E = P \cdot t$

$= 300 W \cdot \frac{1}{60 Hz} s$ (frecuencia)

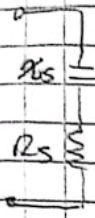
$= 5 J$

Cosas de factor de calidad

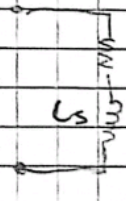
EN SERIE:

$$Q = \frac{\text{Potencia Reactiva}}{\text{Potencia Activa}} = \frac{I^2 \cdot X_s}{I^2 \cdot R_s} = \frac{X_s}{R_s}$$

↓ se comporta absorbiendo con corriente porque está en serie.

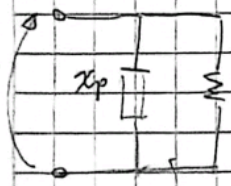


$$Q_{s\,cond} = \frac{X_{cs}}{R_s} = \frac{1}{\omega C_s R_s}$$

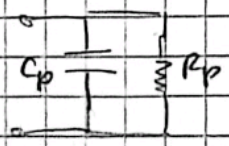


$$Q_{s\,ind} = \frac{\omega L_s}{R}$$

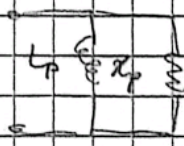
EN PARALELO:



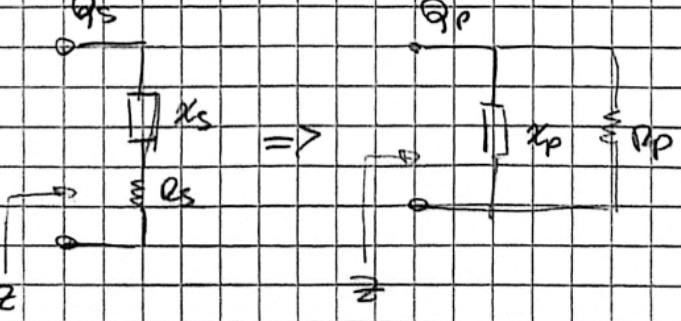
$$Q_p = \frac{|P_q|}{P} = \frac{\frac{V^2}{X_p}}{\frac{V^2}{R_p}} = \frac{\frac{1}{X_p}}{\frac{1}{R_p}} = \frac{1}{X_p} \cdot \frac{1}{R_p} = \frac{1}{X_p} \cdot R_p = \frac{R_p}{X_p}$$



$$Q_{R\,cap} = \frac{R_p}{\frac{1}{\omega C_p}} = R_p \cdot \omega C_p$$



$$Q_{p\,ind} = \frac{R_p}{\omega L_p}$$



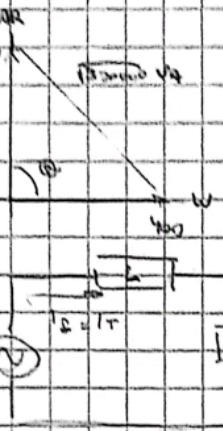
3) a) $P_T = 0W + 400W + 300W$ $\quad Q_T = 600\,var - 200\,var - 0\,var$ $\quad S_T = \sqrt{400W^2 + 400var^2}$

$= 400W$ $\quad = 400\,var$ $\quad = \sqrt{320000}\,VA$

$FP = \frac{P_T}{S_T}$

$= 0,71$

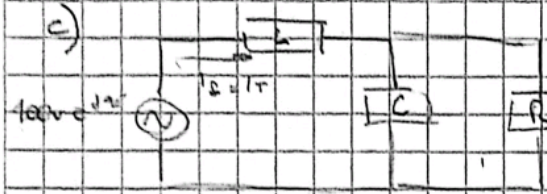
b)



$\theta = \cos^{-1} 0,71$

$= 44,77$

c)



$S_T = V_T \cdot I_T$

$\sqrt{320000}\,VA \angle 44,77° = 100V \angle 90° \cdot I_T$

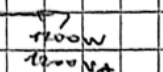
$5,66A \angle -44,77° = I_T$

4) a) $P_T = 500W + 500W + 100W$ $\quad Q_T = (-800 + 1200 + 600)\,VAR$ $\quad S_T = \sqrt{1200^2}\,VAR$

$= 1200W$ $\quad = 0\,VAR$ $\quad = 1200\,VAR$

b) $FP = 1$

c)



d) $S_T = V_T \cdot I_T$ $\quad \cos^{-1} 1 = 0$

$1200VAR \angle 90° = 200V \angle 0° \cdot I_T$

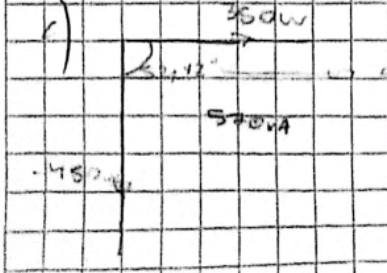
$6A \angle 90° = I_T$

5) a) $P_T = 300W + 100W + 50W + 0W$ $\quad Q_T = (100 + 50 - 300 - 400)\,VAR$ $\quad S_T = \sqrt{350^2 + (-450)^2}\,VA$

$350W$ $\quad = -450\,VAR$ $\quad = 570\,VA$

b) $FP = 0,614$

c)



$\cos^{-1} 0,614$

d) $I_T = \frac{570VA \angle 52,12°}{50V \angle 0°}$

$= 7A \angle 52,12°$

6) a) $P_R = \frac{V^2}{R}$ $Q_R = 0\ var$ $S_R = \sqrt{180^2}\ VA$

$= \frac{60V^2}{20\Omega}$ $= 180\ VA$

$= 180W$

b) $P_{XL} = 0W$ $Q_{XL} = \frac{60V^2}{10\Omega}$ $S_{XL} = \sqrt{360^2}\ VA$

$= 0W$ $= 360\ VAR$ $= 360\ VA$

c) $P_T = 180W + 400W + 0W$ $Q_T = (0 + 360 + 600)\ VAR$ $S_T = \sqrt{580^2 + 960^2}\ VA$

$= 580W$ $= 960\ VAR$ $= \sqrt{1258000}\ VA$

$Fp = \frac{580W}{\sqrt{1258000}}$

$= 0,52$

d) $\cos^{-1} 0,52 =$

$58,67°$

$I_f = \frac{S_T}{U}$

$= \frac{\sqrt{1258000}\, e^{j58,67°}}{60 e^{j0°}}$

$= 18,69 A\, e^{j58,67°}$

7) a) $P_R = \frac{V^2}{R}$ $P_{XC} = 0$ $P_{XL} = 0W$

$= 200W$

b) $Q_R = 0\ var$ $Q_{XC} = \frac{V^2}{X_C}$ $Q_{XL} = \frac{V^2}{X_L}$

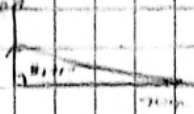
$= 80\ var$ $= 100\ var$

c) Las potencias aparentes son: 200 VA, 80 var, 100 VA porque la raíz se termina cancelando.

d) $P_T = 200W$ $Q_T = -80\ VAR + 100\ VAR$ $S_T = \sqrt{200^2 + 20^2}\ VA$ $Fp = \frac{200W}{201VA}$

$= 20\ VAR$ $= 201\ VA$ $\cos^{-1} \frac{200W}{201VA} = 5,72°$

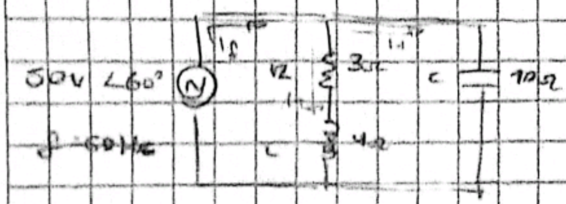
e)



f) $I = \frac{201 VA\, e^{j5,72°}}{20V\, e^{j0°}}$

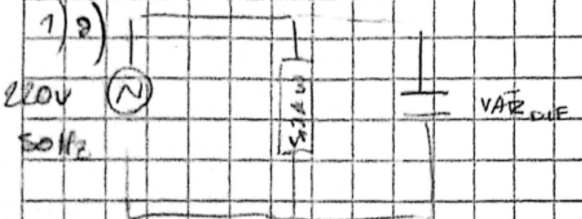
$= 10,05 A\, e^{j5,72°}$

8)

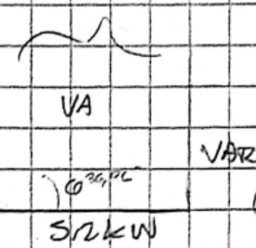


Compesación de Coseno φ

1) a)



Fp = 0,8

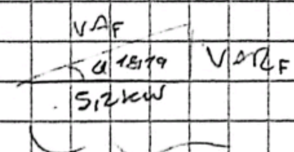


0,8 → 0,95

36,86° → 18,19°

VAR = tan φ . 5,2kW

= 3898



fp = 0,95

VAR_F = tan φ = $\frac{VAR_F}{5,2kW}$

5,2kW . tan φ = VAR_F

1708,67 VAR

$VAR_{cap} = VAR - VAR_F$

= 2189,33 → Potencia reactiva del cap.

b) $VAR_{cap} = \frac{V^2}{X_C}$

$2189,33 = \frac{220^2}{X_C}$

$X_C = 22,11 \Omega$ → $X_C = \frac{1}{\omega C}$ → $C = \frac{1}{\omega X_C}$

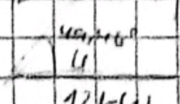
$= 144 \mu F$

2) a) TURNO MAÑANA: 12kW

0,65 → 49,46°

$\sqrt{12kW^2 + VAR^2}$ = VA

18461,71

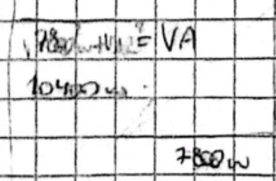


VAR = tan φ . 12kW

= 14030,35 VAR

TURNO TARDE: 7800W

0,75 → 41,41°



$\sqrt{7800^2 + VAR^2}$ = VA

10400 VA

VAR = 6879 VAR