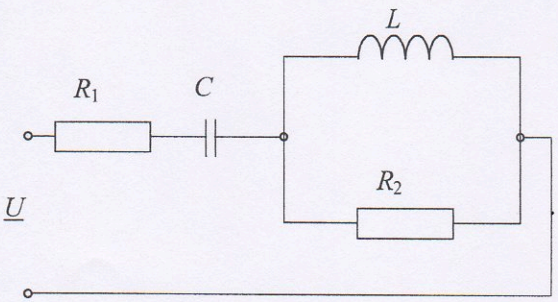
Ime in priimek:
vp. številka:

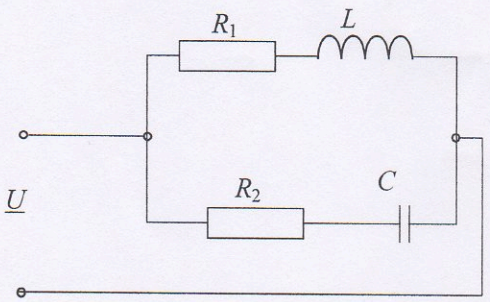
2. kolokvij iz Osnov elektrotehnike II
(26. 4. 2012)

1. Dve napravi sta vezani vzporedno. Napajamo ju z napetostjo $U = 230$ V in v vezje teče skupni tok $I = 15$ A. Skupna jalova moč vezave je $Q = 2{,}6$ kvar Faktorja moči obeh naprav sta $\cos\varphi_1=0{,}45$ in $\cos\varphi_2=0{,}75$. Izračunajte delovni moči naprav P_1 in P_2!

2. V vezju na sliki določite upornost R_2 tako, da bo vezje v resonanci pri $\omega=2\cdot10^3$ rad/s. ($C = 40$ µF, $R_1 = 30$ Ω, $L = 10$ mH)



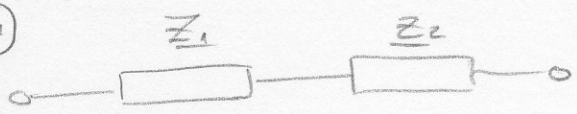
3. V vezju na sliki določite upornost R_2 tako, da bo v vezju še možna resonanca. ($C = 40$ µF, $R_1 = 30$ Ω, $L = 9$ mH)



4. Transformator z nazivno močjo $S_{nT}=20$ kVA je trenutno polno obremenjen z bremenom, ki ima $\cos\varphi=0{,}6$. Na transformator želimo priključiti še dodatno breme, ki ima navidezno moč $S_\Delta=8$ kVA in $\cos\varphi_\Delta=0{,}5$. Določite potrebno velikost kompenzacije Q_c, da bo transformator po kompenzaciji deloval pri $\cos\varphi_2=0{,}95$.

5. Na realnem kondenzatorju smo pri napetosti $U = 20$ V in frekvenci 5000 Hz izmerili tok $I = 10$ mA ter izgube $P = 1$ mW. Določite elemente nadomestne zaporedne vezave (R_z in C).

(1.)



$U = 230V$

$I = 15A$

$S = U \cdot I = \boxed{3450\ VA}$ $\quad P = \sqrt{S^2 - Q^2} = \boxed{2267{,}71\ W}$

$Q = 2{,}6\ kvar$ $\quad Q = Q_1 + Q_2$ $\quad P = P_1 + P_2$

$\cos\varphi_1 = 0{,}45$

$Q = \sin\varphi_1 S_1 + \sin\varphi_2 S_2$ $\quad P = \cos\varphi_1 S_1 + \cos\varphi_2 S_2$

$\cos\varphi_2 = 0{,}75$

$$S_1 = \frac{P - \cos\varphi_2 S_2}{\cos\varphi_1} = \boxed{1{,}21\ kVA}$$

$P_1, P_2 = ?$

$$\cos\varphi_1 Q = \sin\varphi_1 P - \sin\varphi_1 \cos\varphi_2 S_2 + \sin\varphi_2 \cos\varphi_1 S_2$$

$$S_2 = \frac{\cos\varphi_1 Q - \sin\varphi_1 P}{\sin\varphi_2 \cos\varphi_1 - \sin\varphi_1 \cos\varphi_2} = \boxed{2{,}29\ kVA}$$

$\sin\varphi_1 = \sin(\arccos(\varphi_1))$

$\sin\varphi_2 = \sin(\arccos(\varphi_2))$

AL:

$$Ax = B \Rightarrow x = A^{-1}B$$

$$\begin{bmatrix} \cos\varphi_1 & \cos\varphi_2 \\ \sin\varphi_1 & \sin\varphi_2 \end{bmatrix}^{-1} \cdot \begin{bmatrix} P \\ Q \end{bmatrix} = \begin{bmatrix} S_1 \\ S_2 \end{bmatrix}$$

$\Rightarrow S_1 = \boxed{1{,}29\ kVA}$

$\Rightarrow S_2 = \boxed{2{,}29\ kVA}$

$P_1 = \cos\varphi_1 \cdot S_1 = \boxed{544{,}23\ W}$

$P_2 = \cos\varphi_2 \cdot S_2 = \boxed{1723{,}48\ W}$

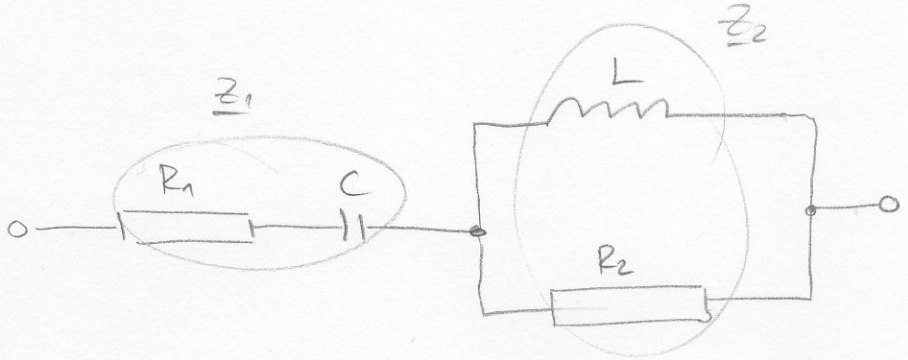
(2.)

$\omega = 2 \cdot 10^3$ rad/s

$C = 40\ \mu F$

$L = 10\ mH$

$R_1 = 30\ \Omega$



$R_2 = ?$ da bo

$Im(\underline{Z}) = \emptyset$

$\underline{Z} = \underline{Z}_1 + \underline{Z}_2$

$\underline{Z}_1 = 30 - j\,12{,}5\ \Omega$

$X_L = \omega L = \boxed{20\ \Omega}$

$X_C = \frac{1}{\omega C} = \boxed{12{,}5\ \Omega}$

$$\underline{Z}_2 = \frac{R_2 \cdot jX_L}{R_2 + jX_L} = \frac{R_2^2 jX_L + R_2 X_L^2}{R_2^2 + X_L^2}$$

$$\underline{Z} = R_1 - jX_C + \frac{R_2^2 jX_L + R_2 X_L^2}{R_2^2 + X_L^2}$$

$Im(\underline{Z}) = \emptyset$

$$-X_C + \frac{R_2^2 X_L}{R_2^2 + X_L^2} = \emptyset$$

$$R_2^2 X_C + X_L^2 X_C = R_2^2 X_L$$

$$R_2^2 (X_C - X_L) = X_L^2 X_C$$

$$R_2 = \sqrt{\frac{-X_L^2 X_C}{X_C - X_L}} = \sqrt{\frac{-5000}{-7{,}5}} = \boxed{25{,}82\ \Omega}$$

(3)

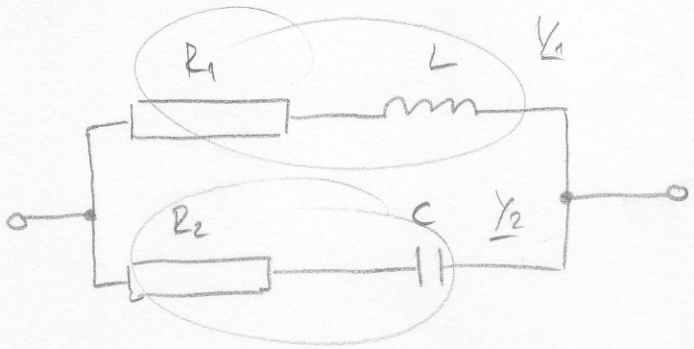
$R_1 = 30\,\Omega$

$L = 9\,mH$

$C = 40\,\mu F$

$R_2 = ?$ da bo

resonanca Re možna!



$$\underline{Y} = \underline{Y}_1 + \underline{Y}_2 \qquad \underline{Y}_1 = \frac{R_1 - j\omega L}{R_1^2 + \omega^2 L^2} \qquad \underline{Y}_2 = \frac{R_2 + j\frac{1}{\omega C}}{R_2^2 + \frac{1}{\omega^2 C^2}}$$

$$Y = \frac{R_1 - j\omega L}{R_1^2 + \omega^2 L^2} + \frac{R_2 + j\frac{1}{\omega C}}{R_2^2 + \frac{1}{\omega^2 C^2}}$$

$$Y = \underbrace{\left(\frac{R_1}{R_1^2 + \omega^2 L^2} + \frac{R_2}{R_2^2 + \frac{1}{\omega^2 C^2}}\right)}_{Re} \underbrace{-j\left(\frac{\omega L}{R_1^2 + \omega^2 L^2} - \frac{\frac{1}{\omega C}}{R_2^2 + \frac{1}{\omega^2 C^2}}\right)}_{Im}$$

$\mathcal{I}m(\underline{Z}) = 0$

$$\frac{\omega_0 L}{R_1^2 + \omega_0^2 L^2} = \frac{1}{R_2^2 \omega_0 C + \frac{1}{\omega_0 C}} \Rightarrow R_2^2 \omega_0^2 LC + \frac{L}{C} - R_1^2 - \omega_0^2 L^2 = 0$$

$$\omega_0^2 \left(R_2^2 LC - L^2\right) = R_1^2 - \frac{L}{C}$$

Resonanca bo Re možna, bo bo:

$$\omega_0 = \sqrt{\frac{R_1^2 - \frac{L}{C}}{R_2^2 LC - L^2}} = \sqrt{\frac{R_1^2 C - L}{R_2^2 LC^2 - L^2 C}}$$

$$R_2^2 LC^2 - L^2 C \geq 0$$

$$R_2^2 \geq \frac{L^2 \not{C}}{\not{L} C^{\not{2}}}$$

$$R_2 \geq \sqrt{\frac{L}{C}} \Rightarrow R_2 \geq \sqrt{\frac{9 \cdot 10^{-3}}{40 \cdot 10^{-6}}} \Rightarrow \boxed{R_2 \geq 15\,\Omega}$$

4.

$S_{nT} = 20\ kVA = S_1$

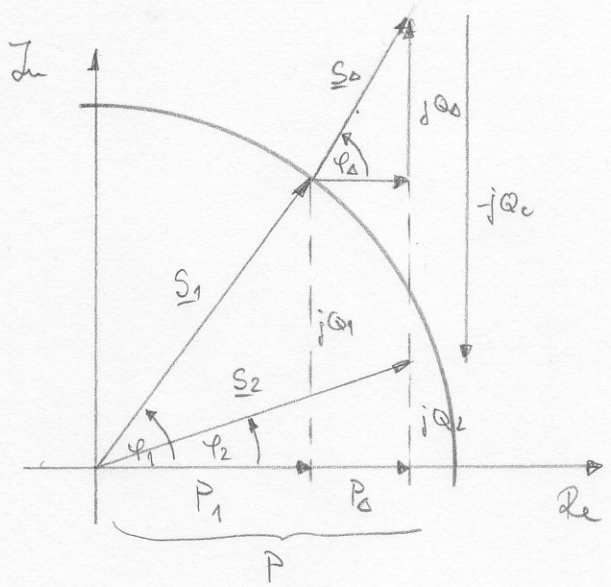
$\cos\varphi_1 = 0{,}6$

$S_\Delta = 8\ kVA$

$\cos\varphi_\Delta = 0{,}5$

$Q_c = ?$, da bo

$\cos\varphi_2 = 0{,}95$



$$Q_c = Q_1 + Q_\Delta - Q_2$$

$Q_1 = \sin\varphi_1 \cdot S_1 =$ **16 kvar**

$Q_\Delta = \sin\varphi_\Delta \cdot S_\Delta \doteq$ **6,93 kvar**

$Q_2 = tg\,\varphi_2 \cdot P \doteq$ **5,23 kvar**

$P_1 = \cos\varphi_1\ S_1 =$ **12 kW**

$P_\Delta = \cos\varphi_\Delta \cdot S_\Delta =$ **4 kW**

$P = P_1 + P_\Delta =$ **16 kW**

$Q_c = Q_1 + Q_\Delta - Q_2 \doteq$ **17,67 kvar**

5.

$U = 20\,V$

$f = 5000\,Hz$

$I = 10\,mA$

$P = 1\,mW$

$R_z, C = ?$

$U \approx U_c$

$S \approx Q_c$

$$X_c = \frac{U_c}{I} = \boxed{2000\,\Omega}$$

$$C = \frac{1}{\omega C} \doteq 1{,}59 \cdot 10^{-8}\,F = \boxed{15{,}9\,nF}$$

$$P = U \cdot I = I^2 \cdot R_z \Rightarrow \quad R_z = \frac{P}{I^2} = \boxed{10\,\Omega}$$