<u>*SOLUTION SET VIII*</u>

EXERCISE VIII.1 : ACTIVE AND REACTIVE POWER

A. $\mathrm{tg}\varphi = Q_s / P_s \;\Rightarrow\; \varphi = \underline{33{,}69°}$

B. $S = \sqrt{P_s^2 + Q_s^2} = U_s \cdot I \quad\Rightarrow\quad I^2 = \dfrac{P_s^2 + Q_s^2}{U^2} = \underline{83{,}6 \cdot 10^3\ A^2}$

Moreover, the powers are written :

$$P_{ch} = P_s - R \cdot I^2 = \underline{2{,}8\ MW} \quad \text{and :} \quad Q_{ch} = Q_s - X \cdot I^2 = \underline{0{,}746\ M\,var}$$

C. The reactive power is positive, both at the source and the load. At the source, the voltage is ahead of the current of 33,69° (point A.). At the level of the load, the voltage U_{ch} is ahead of the current of only 14,92° :

$$\mathrm{tg}\varphi_{ch} = Q_{ch} / P_{ch} \;\Rightarrow\; \varphi_{ch} = \underline{14{,}92°}$$

So the phase difference between the two voltages is : $\delta\varphi = \varphi - \varphi_{ch} = \underline{18{,}77°}$

EXERCISE VIII.2 : ACTIVE AND REACTIVE POWER

A. $R = |\underline{Z}| \cdot \cos\varphi = \underline{28{,}58\ \Omega} \qquad X = |\underline{Z}| \cdot \sin\varphi = \underline{16{,}5\ \Omega}$

B. $I = U / |\underline{Z}|$

$\Rightarrow \quad P = U \cdot I \cos\varphi = \dfrac{U^2}{|\underline{Z}|} \cdot \cos\varphi = \underline{1{,}388\ kW} \qquad Q = U \cdot I \sin\varphi = \dfrac{U^2}{|\underline{Z}|} \cdot \sin\varphi = \underline{0{,}801\ k\,var}$

$$S = U \cdot I = \frac{U^2}{|\underline{Z}|} = \underline{1{,}603\ kVA}$$

EXERCISE VIII.3 : APPARENT POWER

A. For system 1, we have : $S_1 = U \cdot I_1 = \underline{1{,}84\ \text{kVA}}$

$\cos\varphi_1 = P_1/S_1 \Rightarrow \varphi_1 = \pm\ 45{,}05° \quad \Rightarrow \quad Q_1 = U \cdot I_1 \sin\varphi_1 = \underline{\pm 1{,}302\ \text{k var}}$

For system 2, we have: $S_2 = U \cdot I_2 = \underline{2{,}30\ \text{kVA}}$

$\cos\varphi_2 = P_2/S_2 \Rightarrow \varphi_2 = \pm\ 42{,}34° \quad \Rightarrow \quad Q_2 = U \cdot I_2 \sin\varphi_2 = \underline{\pm 1{,}549\ \text{k var}}$

Remember that the cosφ does not tell us anything about the nature of the reactance (capacitive or inductive).

B. For both systems in parallel, it is interesting to represent each system as a resistance R_{pk} in parallel with a reactance X_{pk} (k=1 ; 2). We have :

$$R_{pk} = U^2/P_k \quad \text{et} \quad X_{pk} = U^2/Q_k \Rightarrow P_p = \frac{U^2}{R_{p1}} + \frac{U^2}{R_{p2}} \quad \text{and} \quad Q_p = \frac{U^2}{X_{p1}} + \frac{U^2}{X_{p2}}$$

P_p and Q_p being the active and reactive powers for all of both systems in parallel.

$$\Rightarrow \quad S_p = \sqrt{P_p^2 + Q_p^2}$$

Numerical application :

For impedances of the <u>same nature</u> (reactive powers of the same sign), we find :

$R_{p1} = 40{,}69\ \Omega$ $X_{p1} = 40{,}63\ \Omega$
$R_{p2} = 31{,}12\ \Omega$ $X_{p2} = 34{,}15\ \Omega$
$P_p = 3$ kW $Q_p = 2{,}85$ kvar

$\Rightarrow$ $S_p = \underline{4{,}14\ \text{kVA}}$

For impedances of <u>different natures</u> (negative reactive power for system 2), we find :

$R_{p1} = 40{,}69\ \Omega$ $X_{p1} = 40{,}63\ \Omega$
$R_{p2} = 31{,}12\ \Omega$ $X_{p2} = -34{,}15\ \Omega$
$P_p = 3$ kW $Q_p = -0{,}247$ kvar

$\Rightarrow$ $S_p = \underline{3.01\ \text{kVA}}$

C. For both systems in series, it is interesting to represent each system in the form of a resistance R_{sk} in series with a reactance X_{sk} (k=1 ;2). We have :

$$R_{sk} = P_k/I_k^2 \quad \text{et} \quad X_{sk} = Q_k/I_k^2$$

The total impedance formed by both systems connected in series :

$$\underline{Z}_s = (R_{s1} + R_{s2}) + j\,(X_{s1} + X_{s2}) \quad \text{et} \quad Z_s \equiv |\,\underline{Z}_s\,| = \sqrt{(R_{s1} + R_{s2})^2 + (X_{s1} + X_{s2})^2}$$

$$\Rightarrow \quad I_s = U/Z_s$$

$$\Rightarrow \quad S_p = U \cdot I_s = U^2/Z_s$$

Numerical application :

For impedances of the <u>same nature</u> (reactive powers of the same sign), we find :

$R_{s1} = 20{,}31\ \Omega$ $X_{s1} = 20{,}35\ \Omega$
$R_{s2} = 17\ \Omega$ $X_{s2} = 15{,}49\ \Omega$

$Z_s = 51{,}74\ \Omega$ $\Rightarrow$ $S_s = \underline{1{,}02\ \text{kVA}}$

For impedances of <u>different natures</u> (negative reactive power for system 2), we find :

$R_{s1} = 20{,}31\ \Omega$ $X_{s1} = 20{,}35\ \Omega$
$R_{s2} = 17\ \Omega$ $X_{s2} = -15{,}49\ \Omega$

$Z_s = 37{,}63\ \Omega$ $\Rightarrow$ $S_s = \underline{1{,}41\ \text{kVA}}$