Analysis of electrical power and energy systems

Practical session 1

16 September 2021

1 Exercises[1]

1. Express the following voltages as phasors:
   (a) $v_1(t) = \sqrt{2} \times 100 \cos(\omega t - 30°)$ V
   (b) $v_2(t) = \sqrt{2} \times 100 \cos(\omega t + 30°)$ V

2. The following series R-L-C circuit (Figure 1) is in a sinusoidal steady state at a frequency of 60 Hz. $V = 120\text{V}$, $R = 1.5\Omega, L = 20\text{mH}$ and $C = 100\mu\text{F}$. Calculate $i(t)$ in this circuit by using the phasor-domain analysis.

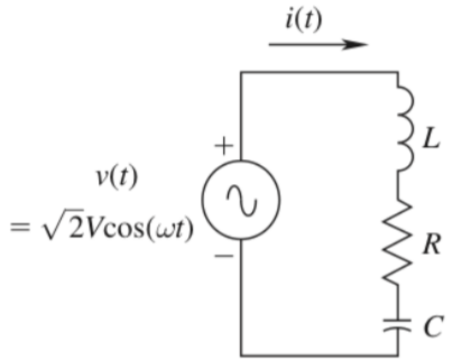

Figure 1: RLC series circuit.

3. In a linear circuit in sinusoidal steady state with only one active source $\overline{V} = 90\angle 30°$ V, the current in a branch is $\overline{I} = 5\angle 15°$ A. Calculate the current in the same branch if the source voltage were to be $100\angle 0°$V.

4. To the circuit of Figure 2, if a voltage of $100\angle 0°$ V is applied, calculate P, Q and the power factor. Show that $Q = \sum_k I_k^2 X_k$.

5. In the circuit (Figure 3) the complex power drawn by the load impedance was calculated as $P_L + jQ_L = (1858.4 + j1031.3)$ VA, calculate the capacitive reactance in parallel, necessary to make the overall power factor to 0.9 (leading) if the applied voltage has an rms value of 120 V.

[1] Exercises 2.1, 2.2, 2.4, 2.5 and 2.9 from Ned Mohan's book "Electric power systems, a first course"

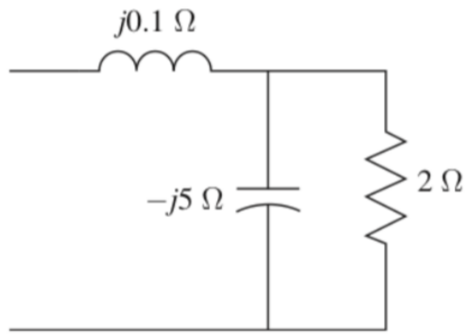

Figure 2: Ex 4 circuit.

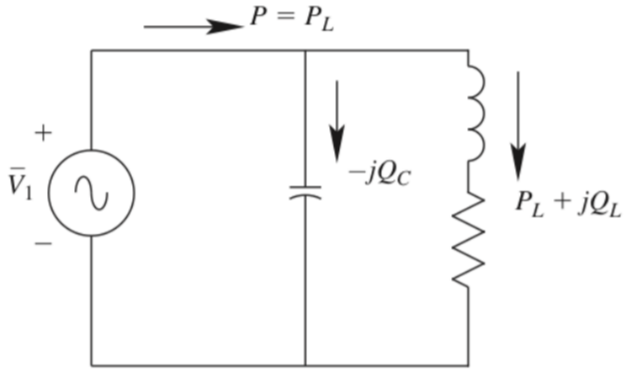

Figure 3: Power factor correction.

2 Solutions

Link to the python notebook shown during the session: Python Notebook TP1.

1. (a) $\overline{V}_1 = 100\angle -30°$ V (b) $\overline{V}_2 = 100\angle 30°$ V
2. $i(t) = 6.3\sqrt{2}\cos(376.99t + 1.49)$ A
3. $\overline{I} = 5.556\angle -0.262$ A
4. $P = 5192.64$ W, $Q = -1775.89$ var, $\cos\phi = 0.946$, $Q_R = 0$ var, $Q_L = 301.17$ var, $Q_C = -2077.06$ var
5. $X_C = -7.46\ \Omega$, $C = 0.356$ mF