ELG2331: DGD Chapters 3, 4, 5, and 7

Problem 3.5

At node 1

$$\frac{v_1}{200} + \frac{v_1 - v_2}{5} + \frac{v_1 - v_3}{100} = 0$$

At node 2

$$\frac{v_2 - v_1}{5} + i + 0.2 = 0$$

At node 3

$$-i + \frac{v_3 - v_1}{100} + \frac{v_3}{50} = 0$$

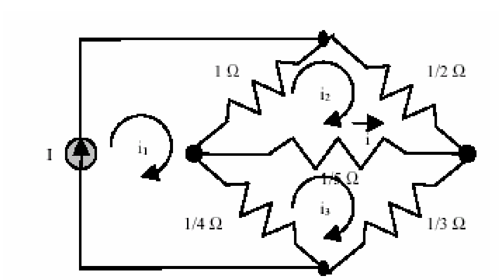
We have also

$$v_3 - v_2 = 50 \text{ V}$$

After solving these equations, we obtain:

$$v_1 = -45.53 \text{ V}$$
$$v_2 = \text{-}48.69 \text{ V}$$
$$v_3 = 1.31 \text{ V}$$
$$i = 491 \text{ mA}$$

Problem 3.19



Mesh 1:

$$i_1 = I$$

Mesh 2:

$$i_1(-1) + i_2\left(1 + \frac{1}{2} + \frac{1}{5}\right) + i_3\left(-\frac{1}{5}\right)$$

Mesh 3:

$$i_1\left(-\frac{1}{4}\right) + i_2\left(-\frac{1}{5}\right) + i_3\left(\frac{1}{4} + \frac{1}{3} + \frac{1}{5}\right) = 0$$

Solve these equations to obtain

$$i_2 = 0.65\, I$$
$$i_3 = 0.48\, I$$
$$i = i_3 - i_2 = 0.48\, I \text{ - } 0.65 I = \text{- } 0.16\, I$$

Problem 4.48

Apply current divider

$$I_R = I_S \frac{\frac{1}{R}}{\frac{1}{R}+\frac{1}{Z_C}} = 157\angle 99.04^0 \text{ mA}$$

$$i_R(t) = 157\cos(200\pi t + 99.040)\text{mA}$$

Problem 4.68

$$\frac{V_0 - 0}{Z_{R_L}} + \frac{V_0 - 0}{Z_C} + \frac{V - V_i}{Z_L} = 0$$

$$V_i = 4\angle 30^0 \text{ V}$$

$$Z_C = 80\angle -90^0$$

$$Z_L = 60\angle 90^0$$

$$V_0 = 7.155\angle -33.43^0$$

$$v_0(t) = 7.155 \cos(\omega t - 33.43^0)$$

Problem 5.24

Apply KCL:

$i_C(0^-) = 0$; $V_C(0^-) = 0$

$V_C(0^-) = V_C(0^+)$

At this moment the capacitor will be acting as a DC source but with zero voltage (short circuit)

Therefore all voltage V_1 will appear across R_1 and the current through R_1 is the current through the capacitor

$$i_c(0^+) + \frac{V_C(0^+)}{R_2} + \frac{V_C(0^+)}{R_1} = 0$$

$$i_c(0^+) = \frac{V_1}{R_1} = \frac{12}{400\times 10^{-3}} = 30 \text{ A (when the switch is closed)}$$

Problem 5.26

Apply KVL (At $t = 0^-$):

$$-V_S + i_L(0^-)R_S + V_L(0^-) = 0$$

$$i_L(0-) = \frac{V_S}{R_S} = \frac{12}{0.7} = 17.14$$

Apply KVL (At $t = 0^+$):

$$i_L(0+)R_1 + V_L(0^+) = 0$$
$$V_L(0^+) = -i_L(0^+)R_1 = -17.14 \times 22 \times 10^3 = -337.1\,\text{kV}$$

Problem 7.17:

The apparent power is

$$S = \frac{\tilde{V}^2}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}} = \frac{50^2}{\sqrt{20^2 + 26.5^2}} = 75.3\,\text{VA}$$

The real power is

$$P = S.\cos\theta = 75.3 \times \frac{20}{33.2} = 45.36\ \text{W}$$

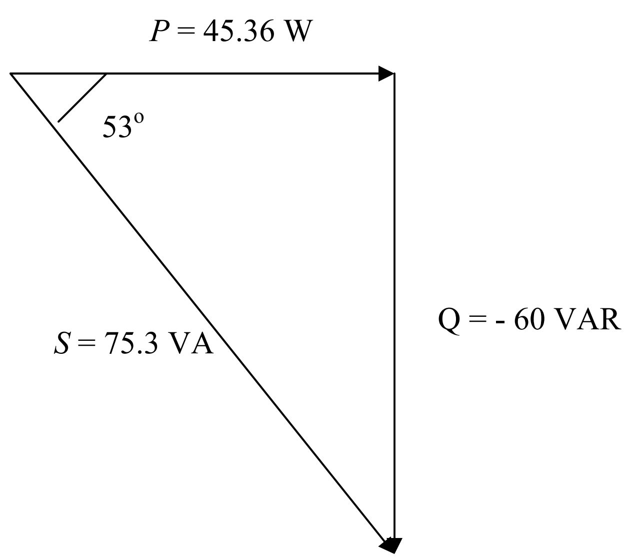
The reactive power is

$$Q = \sqrt{S^2 - P^2} = \sqrt{75.3^2 - 45.36^2} = -60\ \text{VAR}$$

The angle is

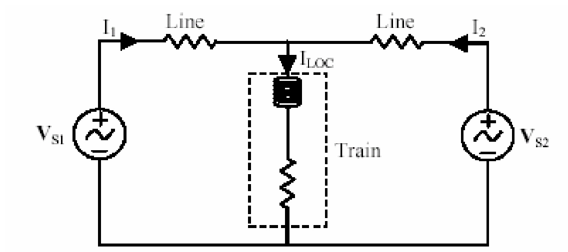
$$\theta = \cos^{-1}\left(\frac{R}{Z}\right) = 53^o$$

The power triangle is shown



Problem 7.21

a) The equivalent circuit is:



b) The locomotive current for the 10% voltage drop is:

$$I_{LOC} = I_1 + I_2 = 2I_1 = 2I_2 = \frac{P_{LOC}}{(V_S - 10\%)\cos(\theta)} = \frac{11\,\text{MW}}{22.5\,\text{kV} \times 0.8} = 611\,\text{A}$$

c) The reactive power is:

$$Q = \sqrt{S_{LOC}^2 - P_{LOC}^2} = \sqrt{(V_S - 10\%)^2 I_{LOC}^2 - P_{LOC}^2} = \sqrt{(13.75)^2 - (11)^2} = 8.25\,\text{MVAR}$$

d) The supplied real power is:

$$P = \sqrt{S^2 - Q^2} = \sqrt{(V_S.I)^2 - Q^2} = 12.85\,\text{MW}$$

The over-head line power loss is:

$$P_{line} = -P_{LOC} + \sqrt{(V_S.I)^2 - Q^2} = -11 + \sqrt{(15.27)^2 - (8.25)^2} = 1.85\,\text{MW}$$

The maximum distance between the two power stations is:

$$R_{Line} \;//\; R_{Line} = \frac{P_{Line}}{I_{LOC}^2} = 5\Omega$$

$$\text{Distance}_{\max} = \frac{2R_{Line}}{0.2\,\Omega/\text{km}} = 100 \text{ km}$$

e) The over-head line power loss is:

$$P_{LOC} = 10\% V_S.I_{LOC}.\cos(\theta) = 2500\text{ V} \times 489\text{ A} = 1.22\,\text{MW}$$

f) The over-head line power loss is:

$$I_{LOC} = \frac{0.25 P_{LOC}}{90\% \times V_{S.DC}} = \frac{2.75}{1350} = 2037\ \text{A}$$
$$P_{Line} = 10\% \times V_{S.DC} \times I_{LOC} = 305\ \text{kW}$$
$$R_{Line} \,//\, R_{Line} = \frac{P_{Line}}{I_{LOC}^2} = 0.0735\ \Omega$$
$$\text{Distance}_{\max} = \frac{2R_{Line}}{0.2\Omega/\text{km}} = 1.5\ \text{km}$$

Problem 7.26

$$Z = 7\angle 10^0\,\Omega = 6.89 + j1.21\Omega$$
$$Z_{eq} = \frac{ZZ_C}{Z+Z_C} = \frac{(R+jX)(-jX_C)}{(R+jX)+(-jX_C)} = \frac{XX_C - jRX_C}{R+j(X-X_C)}\frac{R-j(X-X_C)}{R-j(X-X_C)}$$
$$= \frac{(XX_C R - RX_C(X-X_C)) - j(R^2X_C - XX_C(X-X_C))}{R^2 + (X-XC)^2} = R_{eq} - jX_{eq}$$
$$\mathrm{I_S} = \frac{\mathrm{V_0}}{Z_{eq}}$$
$$Z_{eq} = R_{eq} - jX_{eq} = R_{eq} - 0$$
$$X_{eq} = 0$$
$$R^2X_C - XX_C(X-X_C) = 0$$
$$XC = \frac{R^2+X^2}{X} = 40.31\Omega = \frac{1}{\omega C}$$
$$C = \frac{1}{\omega X_C} = \frac{1}{377 \times 40.31} = 65.8\mu F$$