$\underline{Z_e} = R_e + j X_e$ $\quad Z_e = \sqrt{R_e^2 + X_e^2}$ $\quad Y_e = \sqrt{G_e^2 + B_e^2}$

$\underline{Y_e} = G_e - j B_e$

$\begin{cases} G_e = \text{conductance} \\ B_e = \text{susceptance} \end{cases}$

$R_e = \mathrm{Re}\{Z\}$

$X_e = \mathrm{Im}\{Z\}$

$G_e = \mathrm{Re}\{Y\}$

$B_e = -\mathrm{Im}\{Y\}$

$Z = \frac{1}{Y} \qquad R = \frac{1}{G}$

Loop Current

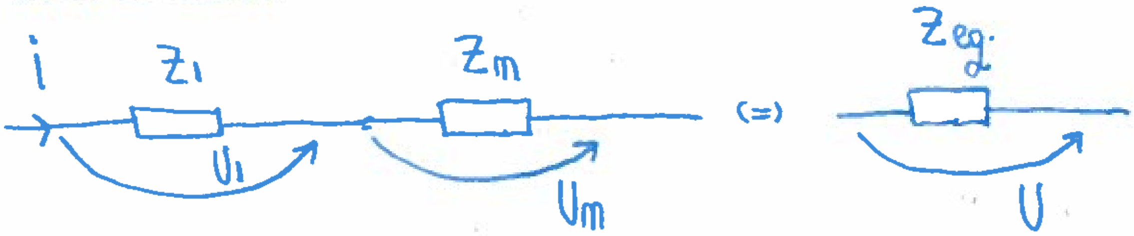
$$\begin{cases} \sum_{j=1}^{L} \underline{Z}_{hg} \underline{I}'_g = \sum \underline{E}'_h \qquad h = \overline{1, L} \qquad L = B - N + 1 \\ \begin{cases} \underline{Z}_{11} I'_1 + \underline{Z}_{12} I'_2 + \dots + \underline{Z}_{1L} I'_L = \underline{E}'_1 \\ \dots\dots\dots \\ \underline{Z}_{L1} I'_1 + \underline{Z}_{L2} I'_2 + \dots + \underline{Z}_{LL} I'_L = \underline{E}'_2 \end{cases} \end{cases}$$

Node Potential Method

$$\sum_{j=1}^{N-1} Y_{ij} V_j = I_{sc\,i} \qquad i = \overline{1, N-1}$$

$$\begin{cases} \underline{Y_{11}} V_1 + \underline{Y_{12}} V_2 + \dots + \underline{Y_{1N-1}} V_{N-1} = \underline{I_{sc\,1}} \\ \dots\dots\dots \\ Y_{N-1,1} V_1 + Y_{N-1,2} V_2 + \dots + Y_{N-1,N-1} V_{N-1} = I_{sc\,N-1} \end{cases}$$

Series Connection

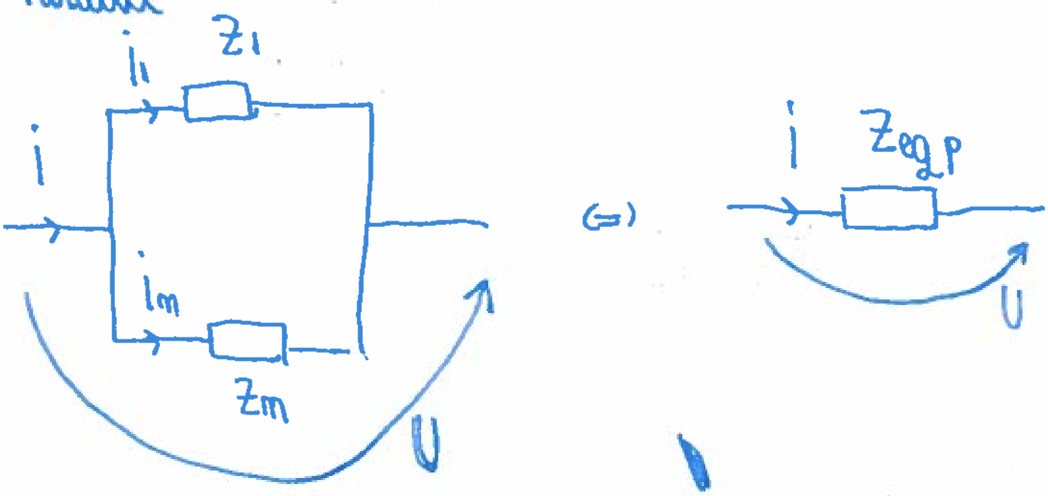


$$Z_{eq} = \sum Z_k$$

$$U = U_1 + \ldots + U_m = Z_1 i + \ldots + Z_m i = (Z_1 + \ldots + Z_m) \cdot i$$

$$\underline{U}_k = \underline{Z}_k \cdot \underline{i} = Z_k \cdot \frac{U}{Z_{eq}}$$

Parallel



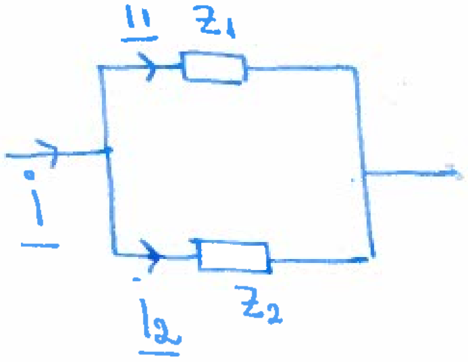
$$i = i_1 + \ldots + i_m$$

$$\frac{U}{Z_{eqp}} = \frac{U}{Z_1} + \ldots + \frac{U}{Z_m}$$

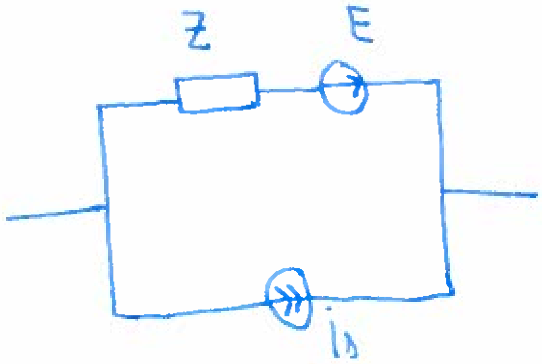
$$Z_{eqp} = \frac{1}{\sum_K \frac{1}{R_K}} = \frac{1}{\sum_K Y_K}$$

!

$$i_K = \frac{U}{Z_K} = \frac{\underline{i} \cdot \underline{Z}_{eqp}}{Z_K}$$



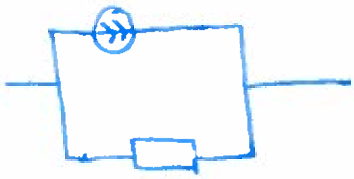
$$\begin{cases} i_1 = \dfrac{i Z_2}{Z_1+Z_2} \\[2ex] i_2 = \dfrac{i\cdot Z_1}{Z_1+Z_2} \end{cases}$$



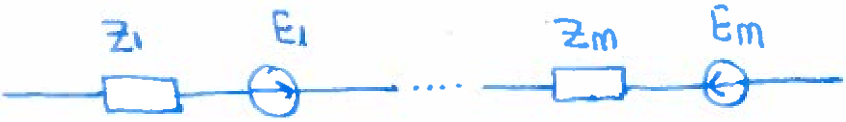
$\Leftrightarrow$

$Z_e = Z$ $\qquad E_e = E + Z\cdot i_s$

$i_{se} = i_s + E\cdot Y$



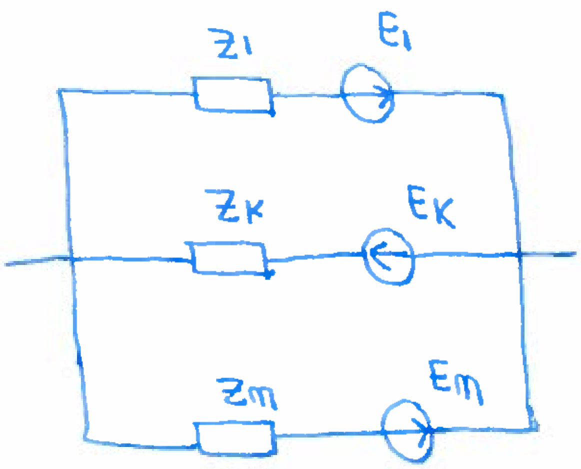
$Y = \dfrac{1}{Z}$



$\Updownarrow$

$Z_e = \sum Z_k$

$E_e = \sum E_k$ (algebrical)

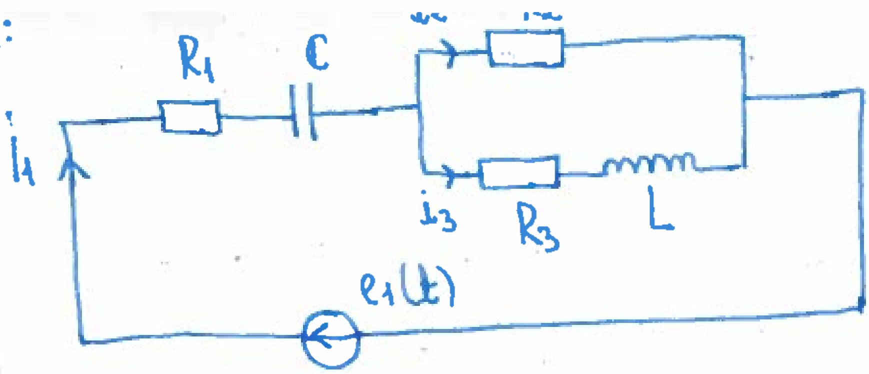


$\Leftrightarrow$

$$Z_e = \frac{1}{\sum Y_k} \qquad E_e = \frac{\sum E_k Y_k}{\sum Y_k}$$

algebrical

EX:



$\Leftrightarrow$

$$e_1(t) = 20\sqrt{2}\,\sin\left(100t - \frac{\pi}{3}\right)\ (V)$$

$R_1 = R_3 = 5\,\Omega \qquad R_2 = 10\,\Omega$

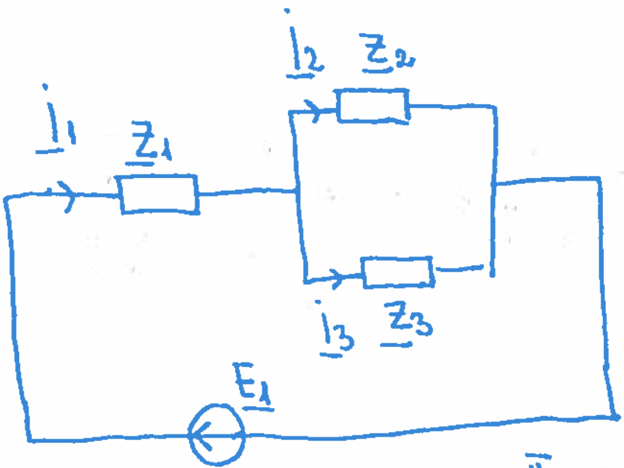
$L = 50\sqrt{3}\ mH \qquad C = \frac{2}{\sqrt{3}}\ mF$

$f(t) = F\sqrt{2}\,\sin(\omega t + \varphi)$

$E_1 = 20 \qquad \underline{F} = F \cdot e^{j\varphi}$

$\omega = 100$

$\varphi = -\frac{\pi}{3}$



$$\underline{E_1} = E_1 e^{j\varphi} = 20\, e^{j\left(-\frac{\pi}{3}\right)}$$

$$\underline{E_1} = 20\left(\underbrace{\cos\left(-\frac{\pi}{3}\right)}_{\frac{1}{2}} + j\,\underbrace{\sin\left(-\frac{\pi}{3}\right)}_{-\frac{\sqrt{3}}{2}}\right) = 10(1 - \sqrt{3}j)$$

$$\underline{Z_1} = \underline{Z_{R_1}} + \underline{Z_C} = R_1 + j\cdot\frac{1}{\omega C} = 5 + j\,\frac{1}{10^2\cdot\frac{2}{\sqrt{3}}\cdot 10^{-3}}$$

$$= 5 - 5\sqrt{3}j$$

$$\underline{Z_2} = \underline{Z_{R_2}} = 10$$

$$\underline{Z_3} = \underline{Z_{R_3}} + \underline{Z_L} = R_3 + j\omega L = 5 + j\cdot 10^2\cdot 50\sqrt{3}\cdot 10^{-3} = 5 + 5\sqrt{3}j$$

$$\underline{Z}_{eq} = \underline{Z}_1 + \underline{Z}_{23} \qquad \underline{Z}_{23} = \frac{Z_2 Z_3}{Z_2+Z_3} = \frac{10\cdot \cancel{5}(1+\sqrt{3}j)}{\cancel{5}(3+\sqrt{3}j)}$$

$$= \frac{10(3+3\sqrt{3}j - \sqrt{3}j + 3)}{12} = \frac{\cancel{10}^{5}(\cancel{6}^{3}+\cancel{2}^{1}\sqrt{3}j)}{\cancel{12}\,\cancel{6}\,3} = \frac{5(3+\sqrt{3}j)}{3}$$

$$Z_{eq} = 5-5\sqrt{3}j + \frac{5(3+\sqrt{3}j)}{3} = \frac{15-15\sqrt{3}j+15+5\sqrt{3}j}{3} = \frac{30-10\sqrt{\,}}{3}$$

$$\underline{I} = \frac{E_1}{\underline{Z}_{eq}} = \frac{\cancel{10}(1-\sqrt{3}j)\cdot 3}{\cancel{10}(3-\sqrt{3}j)} = \frac{3(1-\sqrt{3}j)}{(3-\sqrt{3}j)} = \frac{3(1-\sqrt{3}j)(3+\sqrt{3}j)}{12}$$

$$= \frac{3+\sqrt{3}j-3\sqrt{3}j+3}{4} = \frac{3-\sqrt{3}j}{2}$$

$$\underline{I}_1 = \frac{3-\sqrt{3}j}{2} = \frac{\sqrt{3}}{2}(\sqrt{3}-j) = \sqrt{3}\Big(\underbrace{\frac{\sqrt{3}}{2}}_{\cos} - \underbrace{\frac{j}{2}}_{\sin}\Big) = \sqrt{3}\left(\cos\left(-\frac{\pi}{6}\right) + j\sin\left(-\frac{\pi}{6}\right)\right)$$

$$= \sqrt{3}\cdot e^{j-\frac{\pi}{6}}$$

$$\rightarrow i_1(t) = \sqrt{3}\cdot\sqrt{2}\cdot\sin\left(100t - \frac{\pi}{6}\right) \ (A)$$

$$\underline{I}_2 = \underline{I}\,\frac{Z_3}{Z_2+Z_3} = \frac{3-\sqrt{3}j}{2}\cdot\frac{\cancel{5}(1+\sqrt{3}j)}{\cancel{5}(3+\sqrt{3}j)} = \frac{(9-6\sqrt{3}-3j)(1+\sqrt{3})}{2\cdot 12}$$

$$= \frac{\cancel{2}(3-\sqrt{3}j)(1+\sqrt{3}j)}{\cancel{2}\cdot 12} = \frac{3+\sqrt{3}j}{6} = \frac{\sqrt{3}}{6}(\sqrt{3}+j)$$

$$\underline{I}_2 = \frac{\sqrt{3}}{3}\Big(\underbrace{\frac{\sqrt{3}}{2}}_{\cos\frac{\pi}{6}} + \underbrace{\frac{1}{2}j}_{\sin\frac{\pi}{6}}\Big) = \frac{\sqrt{3}}{3}e^{j\pi/6}$$

$$\longrightarrow i_2(t) = \frac{\sqrt{3}}{3}\cdot\sqrt{2}\cdot\sin\left(100t + \frac{\pi}{6}\right)$$

$$\dot{I}_3 = \dot{I}_1 - \dot{I}_2 = \frac{3-\sqrt{3}j}{2} = \frac{3+\sqrt{3}j}{6} = \frac{6-4\sqrt{3}j}{6} = \frac{3-2\sqrt{3}j}{3}$$

$$\underline{\dot{I}_3} = \frac{3-\sqrt{3}j}{2} - 1 = \frac{1-\sqrt{3}j}{2} = 1\left(\frac{1}{2} - \frac{\sqrt{3}}{2}j\right) = 1 \cdot e^{j\left(-\frac{\pi}{3}\right)}$$

$$\rightarrow i_3(t) = \sqrt{2} \cdot \sin\left(100t - \frac{\pi}{3}\right)$$