ISY/Fordonssystem

2019-03-03

Formelblad för TMEI01 Elkraftteknik

Växelspänning - $j\omega$ metoden

$$u = \hat{u} \cdot \sin(\omega t - \varphi) \qquad U = \frac{\hat{u}}{\sqrt{2}} \qquad \bar{U} = U \cdot e^{-j\varphi}$$

$$\bar{U} = \bar{Z} \cdot \bar{I} = (R + j \cdot X) \cdot \bar{I} \qquad \bar{Z} = R + j \cdot X$$

Resistans: $\bar{Z} = R$ (Dvs: $R = R, \quad X = 0$)

Kapacitans: $\bar{Z} = \frac{1}{j\omega C} = \frac{-j}{\omega C}$ (Dvs: $R = 0, \quad X = \frac{-j}{\omega C}$)

Induktans: $\bar{Z} = j\omega L$ (Dvs: $R = 0, \quad X = j\omega L$)

Effekt

$$P = U \cdot I \cdot \cos\varphi \qquad Q = U \cdot I \cdot \sin\varphi \qquad S = U \cdot I$$

$$P = R \cdot I^2 = \frac{U^2}{R} \qquad Q = X \cdot I^2 = \frac{U^2}{X} \qquad S = |\bar{Z}| \cdot I^2 = Z \cdot I^2 = \frac{U^2}{Z}$$

$$P_{3\text{fas}} = \sqrt{3} \cdot U_H \cdot I_L \cdot \cos\varphi \qquad Q_{3\text{fas}} = \sqrt{3} \cdot U_H \cdot I_L \cdot \sin\varphi \qquad S_{3\text{fas}} = \sqrt{3} \cdot U_H \cdot I_L$$

$$P_{3\text{fas}} = 3 \cdot R \cdot I^2 \qquad Q_{3\text{fas}} = 3 \cdot X \cdot I^2 \qquad S_{3\text{fas}} = 3 \cdot |\bar{Z}| \cdot I^2 = 3 \cdot Z \cdot I^2$$

Trefassystemet

$$U_H = \sqrt{3} \cdot U_F$$

$$\mathbf{U}_1 = U_F \cdot e^{j \cdot 0^\circ} \qquad \mathbf{U}_2 = U_F \cdot e^{-j \cdot 120^\circ} \qquad \mathbf{U}_3 = U_F \cdot e^{-j \cdot 240^\circ}$$

$$\mathbf{U}_{12} = U_H \cdot e^{j \cdot 30^\circ} \qquad \mathbf{U}_{23} = U_H \cdot e^{-j \cdot 90^\circ} \qquad \mathbf{U}_{31} = U_H \cdot e^{-j \cdot 210^\circ}$$

Tvåwattmetermetoden - Symmetrisk last

$$P = P_I + P_{II} \qquad P_I = U_H \cdot I_L \cdot \cos(30^\circ + \varphi) \text{ [W]} \qquad P_{II} = U_H \cdot I_L \cdot \cos(30^\circ - \varphi) \text{ [W]}$$

$$Q = \sqrt{3} \cdot (P_{II} - P_I)$$

Transformatorn

$$\frac{U_1}{U_2} = \frac{N_1}{N_2} \qquad \frac{I_1}{I_2} = \frac{N_2}{N_1} \qquad Z_2' = Z_2 \left(\frac{N_1}{N_2}\right)^2$$

$$\eta = \frac{x \cdot P_{2M}}{x \cdot P_{2M} + P_{F0} + x^2 \cdot P_{FKM}} \qquad Z_K = \frac{u_z}{100}\frac{U_M^2}{S_M}\ [\Omega], \text{ där } u_z \text{ anges i } \%$$

Trefas (spänningar är huvudspänningar)

$$P_{F0} = \frac{U_0^2}{R_0}$$

$$P_{FKM} = 3 \cdot R_{1K} \cdot I_{1M}^2 = 3 \cdot R_{2K} \cdot I_{2M}^2$$

$$\frac{U_{20}}{\sqrt{3}} \approx \frac{U_2}{\sqrt{3}} + I_2 \cdot (R_{2K} \cdot \cos(\varphi) + X_{2K} \cdot \sin(\varphi))$$

Enfas (spänningar är fasspänningar)

$$P_{F0} = \frac{U_0^2}{R_0}$$

$$P_{FKM} = R_{1K} \cdot I_{1M}^2 = R_{2K} \cdot I_{2M}^2$$

$$U_{20} \approx U_2 + I_2 \cdot (R_{2K} \cdot \cos(\varphi) + X_{2K} \cdot \sin(\varphi))$$

Likströmsmaskinen

$$E_a = k_1 \cdot \Phi \cdot n = k_2 \cdot \Phi \cdot \omega \qquad M = k_2 \cdot \Phi \cdot I_a \qquad k_1 = k_2 \cdot \frac{2 \cdot \pi}{60}$$

$\Phi = k \cdot I_m$ för linjär motor $\qquad P_{avg} = E_a \cdot I_a - P_{F0} \qquad P_{F0}$ = tomgångsförluster

Motordrift

$$U = E_a + \sum R_a \cdot I_a \qquad n = \frac{U - \sum R_a \cdot I_a}{k_1 \cdot \Phi}$$

Generatordrift

$$U = E_a - \sum R_a \cdot I_a \qquad n = \frac{U + \sum R_a \cdot I_a}{k_1 \cdot \Phi}$$

Trefas asynkronmaskinen

$$s = \frac{n_1 - n_2}{n_1} \qquad \omega = \frac{2 \cdot \pi \cdot n}{60} \qquad M = k_1 \cdot U^2 \cdot \frac{s}{R_2} \qquad M = k_1 \cdot U^2 \cdot s \cdot \frac{R_2}{R_2^2 + (s \cdot X_2)^2}$$

$$P_2 = \omega_2 \cdot M \qquad P_{12} = P_1 - P_{Fe1} - P_{Cu1} = \omega_1 \cdot M \qquad P_2 = P_{12} - P_{Cu2} = (1 - s) \cdot P_{12}$$

$$P_{F2} = P_{Cu2} = s \cdot P_{12} = s\frac{P_2}{1 - s} \qquad P_{2a} = P_2 - P_{FR} \qquad n_s = \frac{120\, f}{p}$$

$$t_{ST} = \frac{0.11 \cdot J}{m_{ST} \cdot P_{2M} - P_L} \cdot \left(\frac{n_2}{100}\right)^2 \qquad t_{ST} = \frac{J\omega_2}{m_{ST}\frac{P_{2M}}{\omega_2} - \frac{P_L}{\omega_2}}$$

Spänningsfall i trefasledningar

$$U_1 = U_2\sqrt{\left(1 + \frac{P_2 \cdot R_L + Q_2 \cdot X_L}{U_2^2}\right)^2 + \left(\frac{P_2 \cdot X_L - Q_2 \cdot R_L}{U_2^2}\right)^2}$$

$$U_1 \approx U_2(1 + \frac{P_2 \cdot R_L + Q_2 \cdot X_L}{U_2^2}) \qquad P_F = R_L \cdot \frac{P_2^2 + Q_2^2}{U_2^2} \qquad Q_F = X_L \cdot \frac{P_2^2 + Q_2^2}{U_2^2}$$

$R_{LCu} = \frac{17,2}{a}$ Ω/km och fas (a = tvärsnittsarea i mm^2)

Reaktiv effekt i en kondensator

$Q = -U^2 \cdot \omega \cdot C$ [VAr]

Likriktat medelvärde

$$U_L = \frac{1}{T}\int_0^T |\hat{u} \cdot \sin(\omega t)|\, dt$$