Formelblad TSFS17 — 6 januari 2024

Komplexa tal

$$j^2 = -1 \Rightarrow \frac{1}{j} = -j \qquad \bar{Z}^* = (a+jb)^* = a - jb \qquad xx^* = |x|^2$$

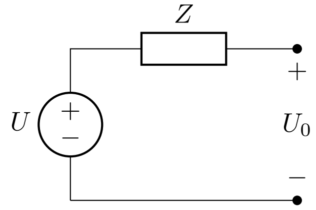
$$e^{j\varphi} = \cos\varphi + j\sin\varphi \qquad (\bar{Z}+\bar{Y})^* = x^* + y^* \qquad j^* = -j$$

$$\bar{Z} = a + jb = \sqrt{a^2+b^2}e^{j\varphi} = |\bar{Z}|e^{j\varphi} \qquad (xy)^* = x^*y^*$$

Grunder

$$U = ZI \qquad \frac{1}{R_p} = \sum_{i=1}^{n} \frac{1}{R_i}, \text{ parallellkoppling} \qquad R_s = \sum_{i=1}^{n} R_i, \text{ seriekoppling}$$

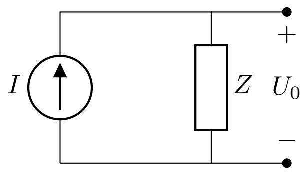
$$U_i = E\frac{R_i}{\sum_{i=1}^{n} R_i} \qquad I_1 = I\frac{R}{R_1+R}, R = R_2//R_3//\ldots//R_n$$



Thevenin ekvivalent

Ekvivalenta kretsar

$U=ZI$ $\Leftrightarrow$



Norton ekvivalent

Växelspänning - $j\omega$ metoden och komplexa impedanser

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

$$\bar{U} = \bar{Z}\cdot\bar{I} = (R + j\cdot X)\cdot\bar{I} \qquad \bar{Z} = R + j\cdot X \qquad R - \text{Resistans}, \quad X - \text{Reaktans}$$

Impedans:	$\bar{Z} = R + jX$	$\bar{U} = \bar{Z}\bar{I}$
Admittans:	$\bar{Y} = \frac{1}{\bar{Z}} = G + jB$	$\bar{I} = \bar{Y}\bar{U}$
Kapacitans:	$\bar{Z} = \frac{1}{j\omega C} = \frac{-j}{\omega C}$	(Dvs: $R = 0, \quad X = -\frac{1}{\omega C}$)
Induktans:	$\bar{Z} = j\omega L$	(Dvs: $R = 0, \quad X = \omega L$)
Konduktans:	$G = \frac{1}{R}$	(Dvs: $R = R, \quad X = 0$)
Reaktans:	$X = \omega L (= \frac{1}{\omega C})$	(Dvs: $R = 0, \quad X = X$)
Susceptans:	$B = \frac{1}{X} = \omega C$	

Distribuerad ledningsmodell

$$z = R + j\omega L \qquad Z_c = \sqrt{\frac{z}{y}} = \sqrt{\frac{L}{C}}$$

$$y = G + j\omega C \qquad \text{SIL} = \frac{V_{rated}^2}{Z_c}$$

$$\gamma = \sqrt{zy} = j\omega\sqrt{LC} = j\beta \qquad f\lambda = \frac{1}{\sqrt{LC}}$$

Maximal effekt för en transmissionsledning

$$P = \frac{V_{Spu}V_{Rpu}\sin\delta}{Z_c\sin\beta l} = V_{Spu}V_{Rpu}\text{SIL}\frac{\sin\delta}{\sin\left(\frac{2\pi l}{\lambda}\right)}$$

Effekt

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

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

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

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

Uttryck för enfaseffekt

$$S = |\bar{S}| = UI = \frac{U^2}{|\bar{Z}|} = |\bar{Z}|I^2 \qquad P = S\cos\varphi = UI\cos\varphi = \frac{U^2}{R_p} = R_s I^2$$

$$\bar{S} = \bar{U}\bar{I}^* = P + jQ \qquad Q = S\sin\varphi = UI\sin\varphi = \frac{U^2}{X_p} = X_s I^2$$

Reaktiv effekt i en kondensator och en spole

$$Q = -U^2\,\omega\,C \qquad Q = I^2\omega\,L = \frac{U^2}{\omega\,L}$$

Swing equation

$$\frac{2H}{\omega_{e,s}}\frac{d\omega_e}{dt} = P_{m,pu} - P_{e,pu} \qquad \frac{d\delta}{dt} = \omega_e - \omega_{e,s}$$

Per Enhet (pu)-system

$$\text{Storhet i per unit} = \frac{\text{Verkligt värde}}{\text{Basvärde för storheten}}$$

$$P_{base}, Q_{base}, S_{base} = V_{base}I_{base} \qquad Z_{p.u.new} = \frac{Z_{actual}}{Z_{basenew}} = \frac{Z_{p.u.old}Z_{baseold}}{Z_{basenew}}$$

$$R_{base}, X_{base}, Z_{base} = \frac{V_{base}}{I_{base}} = \frac{V_{base}^2}{S_{base}} \qquad Z_{p.u.new} = Z_{p.u.old}\left(\frac{V_{baseold}}{V_{basenew}}\right)^2\left(\frac{S_{basenew}}{S_{baseold}}\right)$$

Ekvationer och begrepp i relation till förnybar elproduktion

$$\text{Effekt i vind } P_w = \frac{1}{2}\rho A v^3 \qquad \text{Vindprofil } \left(\frac{v}{v_0}\right) = \left(\frac{H}{H_0}\right)^\alpha$$

$$\text{Efekt som utvinns } P_b = \frac{1}{2}\rho A v^3\left[\frac{1}{2}(1+\lambda)(1-\lambda^2)\right],\ \lambda = \frac{v_d}{v} \qquad \text{Vindenergi } E = \frac{1}{2}\rho A v^3 \Delta t$$

$$\text{TSR} = \frac{\text{Rotor tip speed}}{\text{Wind speed}} = \frac{\text{rpm}\,\pi\,D}{60 v_w} \qquad \text{Gear ratio} = \frac{\text{Generator rpm}}{\text{Rotor rpm}}$$

$$\text{Shockleys diodekvation: } I_d = I_0\left(e^{\frac{k}{qT}V_d} - 1\right) \qquad \frac{k}{qT} \approx 38.9 \text{ vid } 25°C$$