

$$\vec{E} = \frac{1}{4\pi\epsilon} \frac{q_1 q_2}{r^2}$$

$$\vec{E}' = \frac{\vec{E}}{q}$$

$$d\mathcal{L} = -q \vec{E}' \cdot d\vec{l}$$

$$I = \int_S \vec{S} \cdot d\vec{S}$$

$$\vec{S} = \rho_e \vec{v}$$

$$a_{KJ} = \begin{cases} +1 & \text{bato } j \text{ incide nel nodo } K \text{ ed } i \text{ uscente} \\ -1 & \text{bato } j \text{ incide nel nodo } K \text{ ed } i \text{ entrante} \\ 0 & \text{il bato } j \text{ non incide in } K \end{cases}$$

$$\begin{cases} A_i = 0 \\ \vec{v} - A^T \vec{u} = 0 \end{cases}$$

$$\vec{v}^T \vec{u} = \vec{v} \vec{u}^T = 0 \quad | \quad \sum P_k = 0$$

$$P_{eq} = \sum v_k i_k \quad \text{Max Trans in R: } R = R_{TH}$$

- 1) Tensioni di bato in funzione dei pot. di nodo
 - 2) Trattare le eq. cor. si scrivono le correnti di bato
 - 3) Si risolvono i vari loop nodali.
- $$\begin{cases} K-O: \text{ rimuovi KCL in } K \text{ e aggiungi le eq. cor.} \\ K-h: \text{ rimuovi la singola b.b. e aggiungi le eq. cor.} \end{cases}$$

| SIMMETRICO | | |
|----------------|----------------------|----------------------|
| | RECIPROCO | |
| \mathcal{R} | $R_{12} = R_{21}$ | $R_{11} = R_{22}$ |
| \mathcal{G} | $G_{12} = G_{21}$ | $G_{11} = G_{22}$ |
| \mathcal{T} | $ \mathcal{T} = 1$ | $T_{11} = T_{22}$ |
| \mathcal{H} | $H_{12} = -H_{21}$ | $ \mathcal{H} = 1$ |
| \mathcal{H}' | $H'_{12} = -H'_{21}$ | $ \mathcal{H}' = 1$ |

- 1) Rinvio ind.
- 2) Ricavo approssimazioni annullando una delle due incognite
- 3) Calcolo contributo degli ind. studiando le porte con modelli appri

$$B^{-1} = G$$

$$P' = \underline{V}''^T \underline{I}' \quad P'' = \underline{V}'^T \underline{I}''$$

$$\text{reciproco: } P' = P'' \quad \forall \underline{V}', \underline{V}'', \underline{I}', \underline{I}''$$

$$\vec{F} = q(\vec{E}' + \vec{v} \times \vec{B})$$

$$\vec{B} = \frac{\mu_0}{4\pi} q \frac{\vec{v} \times \vec{v}_2}{r^2}$$

Stare:

$$d\vec{B} = \frac{\mu_0}{4\pi} I \frac{d\vec{l} \times \vec{v}_1}{r^2}$$

Uare:

$$I_{eq} = -\frac{d\Phi}{dt} \quad v = \frac{d\Phi}{dt}$$

STAR.

$$\oint \vec{E} \cdot d\vec{S} = \frac{Q}{\epsilon}$$

$$\oint \vec{B} \cdot d\vec{S} = 0$$

$$\oint \vec{E} \cdot d\vec{l} = 0$$

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I$$

VAR.

$$\oint \vec{E} \cdot d\vec{S} = \frac{Q}{\epsilon}$$

$$\oint \vec{B} \cdot d\vec{S} = 0$$

$$-\oint \vec{E} \cdot d\vec{l} = \int \frac{\partial}{\partial t} \vec{B} \cdot d\vec{S}$$

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I + \mu_0 \epsilon_0 \int \frac{\partial}{\partial t} \vec{E} \cdot d\vec{S}$$

$$i = C \frac{dv}{dt}$$

$$v = L \frac{di}{dt}$$

$$C = \epsilon \frac{S}{d}$$

$$L = \frac{\mu N^2 S}{\ell}$$

Regime stazionario:

$$\begin{cases} \equiv C.A \\ \equiv C.C. \end{cases}$$

$$\frac{d}{dt} x = \lambda x + u \rightarrow x = K e^{\lambda(t-t_0)} + x_{ip}$$

$$\lambda < 0 \rightarrow \text{stabile}$$

$$x = \underbrace{K e^{\lambda(t-t_0)}}_{\text{TRANSITORIO}} + \underbrace{x_{ip}}_{\text{REGIME}}$$

$$\cos^2(\alpha) + \sin^2(\alpha) = 1$$

$$\cos(\alpha - \beta) = \cos(\alpha) \cos(\beta) + \sin(\alpha) \sin(\beta)$$

$$\cos(\alpha + \beta) = \cos(\alpha) \cos(\beta) - \sin(\alpha) \sin(\beta)$$

$$\sin(\alpha - \beta) = \sin(\alpha) \cos(\beta) - \cos(\alpha) \sin(\beta)$$

$$\sin(\alpha + \beta) = \sin(\alpha) \cos(\beta) + \cos(\alpha) \sin(\beta)$$

$$\cos(\alpha + \pi/2) = -\sin(\alpha)$$

$$\cos(\alpha - \pi/2) = \sin(\alpha)$$

$$\frac{1}{2} [\cos(\alpha - \beta) + \cos(\alpha + \beta)] = \cos(\alpha) \cos(\beta)$$

$$x_m \cos(\omega t + \varphi) \leftrightarrow x_m e^{j\varphi}$$

$$x(t) = \text{Re}\{e^{j\omega t} \bar{x}\}$$

$$\frac{d}{dt} \bar{x} = j\omega \bar{x}$$

$$\bar{u} = j\omega C \bar{v} \Rightarrow \bar{u} \text{ anticipa } \frac{\pi}{2} \quad Q < 0$$

$$\bar{v} = j\omega L \bar{u} \Rightarrow \bar{v} \text{ anticipa } \frac{\pi}{2} \quad Q > 0$$

$$\bar{z} = \frac{\bar{v}}{\bar{u}} \quad \gamma = \bar{z}^{-1}$$

$$P_{eq}(t) = \frac{VI}{2} \cos(\varphi_v - \varphi_i) + \frac{VI}{2} \cos(\varphi_v - \varphi_i) \cos(2\omega t + 2\varphi_v) + \frac{VI}{2} \sin(\varphi_v - \varphi_i) \sin(2\omega t + 2\varphi_v)$$

$$\hat{A} = \frac{\sqrt{VI}}{2} = \bar{V}^{RMS} \cdot \bar{I}^{RMS} = P + jQ$$

$$\cos \varphi = \frac{P}{|\hat{A}|} \rightarrow P = |\hat{A}| \cos \varphi \quad Q = P \tan \varphi = |\hat{A}| \sin \varphi \quad \text{Max Trans in R: } R = R_{TH}$$

$$\frac{\sqrt{VI}}{2} = 0 \leftrightarrow \sum P_k + j \sum Q_k = 0 \quad \text{Riferenze: } \sum \{C||\bar{z}|\} = 0; \sum \{Q_k^{\pm}\} = 0$$

$$Q_C = -\omega C |\bar{V}|^2 \quad \hat{A} = \frac{2 |\bar{V}|^2}{2}$$

$$Q_L = \omega L |\bar{I}|^2$$

$$Q_C = |\hat{A}| \cos \varphi (\tan \varphi_n - \tan \varphi)$$

serie positiva:

$$\varphi_a = 0; \varphi_b = -\frac{2}{3}\pi; \varphi_c = -\frac{4}{3}\pi$$

serie negativa:

$$\varphi_a = 0; \varphi_c = -\frac{2}{3}\pi; \varphi_b = -\frac{4}{3}\pi$$

$$\vec{E}_v = |\vec{E}_v| e^{j\theta} \rightarrow P_a^{2\gamma} = 3 V_p I_p \cos \theta = \sqrt{3} V_L I_L \cos \theta$$

$$Q_a^{2\gamma} = 3 V_p I_p \sin \theta = \dots$$

$$X_{EFF} = \frac{X_m}{\sqrt{2}} \quad Z_\Delta = 3 Z_\gamma \quad \Delta \rightarrow \gamma: V_p^\gamma = \frac{V_\Delta}{\sqrt{3}} e^{-j\frac{\pi}{6}}$$

$$\gamma - \gamma: \bar{V}_L = \sqrt{3} \bar{V}_p e^{j\frac{\pi}{6}}; \quad \bar{I}_L = \bar{I}_p$$

$$\gamma - \Delta: \bar{V}_L = \sqrt{3} \bar{V}_p e^{j\frac{\pi}{6}}; \quad \bar{I}_L = \sqrt{3} \bar{I}_p e^{-j\frac{\pi}{6}}$$

$$\Delta - \Delta: \bar{V}_L = \bar{V}_p; \quad \bar{I}_L = \sqrt{3} \bar{I}_p e^{-j\frac{\pi}{6}}$$

$$\Delta - \gamma: \bar{V}_L = \bar{V}_p; \quad \bar{I}_p = \bar{I}_L$$

$$\begin{bmatrix} L_1 & M \\ M & L_2 \end{bmatrix} \xrightarrow{L} \text{acc. profilo per } |L|=0$$

| Circuito elettrico | Circuito magnetico |
|------------------------|--|
| R resistenza | \mathcal{R} riluttanza |
| i corrente | Ψ flusso |
| e forza elettromotrice | Ni forza magnetomotrice |
| v tensione elettrica | $v_H = \mathcal{R}\Psi$ "tensione magnetica" |

$$\begin{cases} V_1 = L_1 \frac{di_1}{dt} + M \frac{di_2}{dt} \\ V_2 = M \frac{di_1}{dt} + L_2 \frac{di_2}{dt} \end{cases} \quad K = \frac{M}{\sqrt{L_1 L_2}} \quad P_a = \frac{d}{dt} W_a$$

$$W_a = \frac{1}{2} L_1 i_1^2 + \frac{1}{2} L_2 i_2^2 + M i_1 i_2$$

serie equiv:

$$Z_{eq} = j(x_1 + x_2 + 2x_m)$$

serie contr:

$$Z_{eq} = j(x_1 + x_2 - 2x_m)$$

parallelo equiv:

$$Z_{eq} = j \frac{x_1 x_2 - x_m^2}{x_1 + x_2 - 2x_m}$$

parallelo contr:

$$Z_{eq} = j \frac{x_1 x_2 - x_m^2}{x_1 + x_2 + 2x_m}$$

$$KCL_m: \sum \psi_k = 0 \quad KVL_m: \sum v_{Hk} = \sum N_k i_k$$

$$\vec{B}' = \mu_0 (1 + \chi_m) \vec{H}' = \mu_0 \mu_r \vec{H}'$$

$$\mathcal{R} = \frac{\ell}{\mu_0 \mu_r S} \quad \Phi = N \Psi = \sum L_k i_k$$

Nel trasformatore: $\mathcal{R} = \mathcal{R}_F + \mathcal{R}_T$, se $\mu \gg \mu_0 \quad \mathcal{R} \cong \mathcal{R}_T$