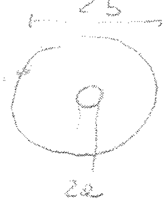
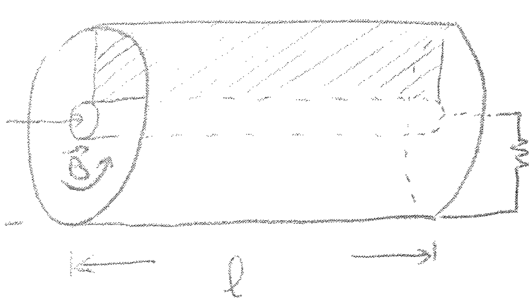
ESEMPIO — CAVO COASSIALE IN BASSA FREQUENZA CON PERDITE TRASCURABILI





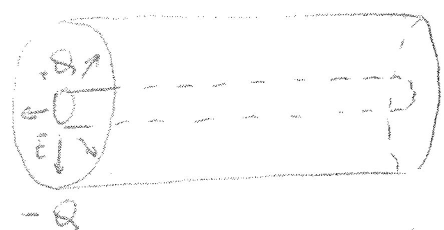
$$\boxed{L' = \frac{1}{\ell}\,\frac{\phi_s(B)}{I}}$$

$$S = (b-a)\,\ell \qquad dS = \ell\, dr$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$\phi(B) = \int_a^b B\, dS = \frac{\mu_0 I \ell}{2\pi}\int_a^b \frac{dr}{r} = \frac{\mu_0 I \ell}{2\pi}\ln(b/a)$$

$$\boxed{L' = \frac{\mu_0}{2\pi}\ln(b/a)} \qquad [L] = H/m$$



$$\boxed{C' = \frac{1}{\ell}\,\frac{Q}{V}}$$

$$E = \frac{Q}{2\pi\varepsilon_0 r}\,\frac{1}{\ell}$$

$$V = V(a) - V(b) = \int_a^b E\, dr = \frac{Q}{2\pi\varepsilon_0 \ell}\int_a^b \frac{dr}{r} = \frac{1}{\ell}\,\frac{Q}{2\pi\varepsilon_0\varepsilon_r}\ln(b/a)$$

$$\boxed{C' = \frac{2\pi\varepsilon_0\varepsilon_r}{\ln(b/a)}} \qquad [C] = F/m$$

OSTANTI PRIMARIE

$$\tilde{Z}_s = j\omega L = j\omega\frac{\mu_0}{2\pi}\ln(b/a)$$

$$\tilde{Y}_p = j\omega C = j\omega\frac{2\pi\varepsilon_0\varepsilon_r}{\ln(b/a)}$$

OSTANTI SECONDARIE

$$k_z^2 = \omega^2 LC = \mu_0\varepsilon_0\varepsilon_r\omega^2 \qquad k_z = n\frac{\omega}{c} \quad !!$$

$$Z_c = \sqrt{\frac{L}{C}} = \frac{1}{2\pi}\sqrt{\frac{\mu_0}{\varepsilon}}\ln(b/a) = \frac{Z_0}{2\pi n}\ln(b/a)$$

$$Z_0 = 377\,\Omega$$

CHE MODO E'?

Definizione ε', ε'', $\tan\delta$

$$\nabla \times \underline{H} = j\omega\varepsilon\underline{E} + \sigma\underline{E} = j\omega\left(\varepsilon + \frac{\sigma}{j\omega}\right)\underline{E}$$

$$= j\omega\left(\varepsilon - j\frac{\sigma}{\omega}\right)\underline{E} = j\omega\left(\varepsilon' - j\varepsilon''\right)\underline{E}$$

$$\boxed{\varepsilon' = \varepsilon_0\varepsilon_R}$$

$$\boxed{\varepsilon'' = \frac{\sigma}{\omega} \Rightarrow \sigma = \omega\varepsilon''}$$

$$\boxed{\tan\delta = \frac{\varepsilon''}{\varepsilon'}}$$

$$\boxed{\varepsilon_c = \varepsilon' - j\varepsilon''}$$

Definizione di R_S

Impedenza d'onda $\eta = \sqrt{\frac{\mu}{\varepsilon_c}} = \sqrt{\frac{j\omega\mu}{j\omega\varepsilon_c}} = \sqrt{\frac{j\omega\mu}{j\omega\varepsilon' + \sigma}}$

in mezzi buoni conduttori $\sigma \gg |\cancel{j}\omega\varepsilon'|$ e quindi

$$\eta = \sqrt{\frac{j\omega\mu}{\sigma}} = (1+j)\sqrt{\frac{\omega\mu}{2\sigma}} = (1+j)R_S$$

quindi

$$\boxed{R_S = \sqrt{\frac{\omega\mu}{2\sigma}}}$$

N.B. La conducibilità σ spesso è indicata con ϱ

Costante di propagazione γ
per basse perdite

$$\gamma = \sqrt{(R' + j\omega L')(G' + j\omega C')}$$

$$= \sqrt{R'G' + j\omega L'G' + j\omega C'R' - \omega^2 L'C'} =$$

$$= j\omega\sqrt{L'C'}\ \sqrt{1 + \frac{(\cancel{R'G'} + j\omega L'G' + j\omega C'R')}{j\omega L' \cdot j\omega C'}}$$

$$= j\omega\sqrt{L'C'}\left(1 + \frac{1}{2}\,\frac{\cancel{j\omega} L'G' + \cancel{j\omega} C'R'}{\cancel{j\omega} L' \cdot j\omega C'}\right)$$

$$= j\omega\sqrt{L'C'}\left(1 + \frac{1}{2j}\left(\frac{G'}{\omega C'} + \frac{R'}{\omega L'}\right)\right)$$

$$= j\omega\sqrt{L'C'} + \frac{\cancel{j}\cancel{\omega}\sqrt{L'C'}}{2\cancel{j}}\left(\frac{G'}{\cancel{\omega}C'} + \frac{R'}{\cancel{\omega}L'}\right)$$

$$= j\omega\sqrt{L'C'} + \frac{1}{2}G'\sqrt{\frac{L'}{C'}} + \frac{1}{2}R'\sqrt{\frac{C'}{L'}}$$

$$= \underbrace{\left(\frac{1}{2}G'Z_0 + \frac{1}{2}\frac{R'}{Z_0}\right)}_{\alpha} + j\underbrace{\omega\sqrt{L'C'}}_{\beta} = \alpha + j\beta$$