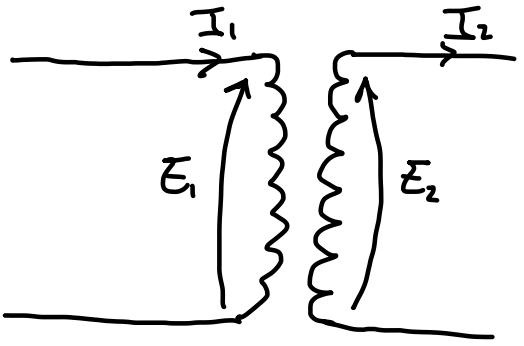
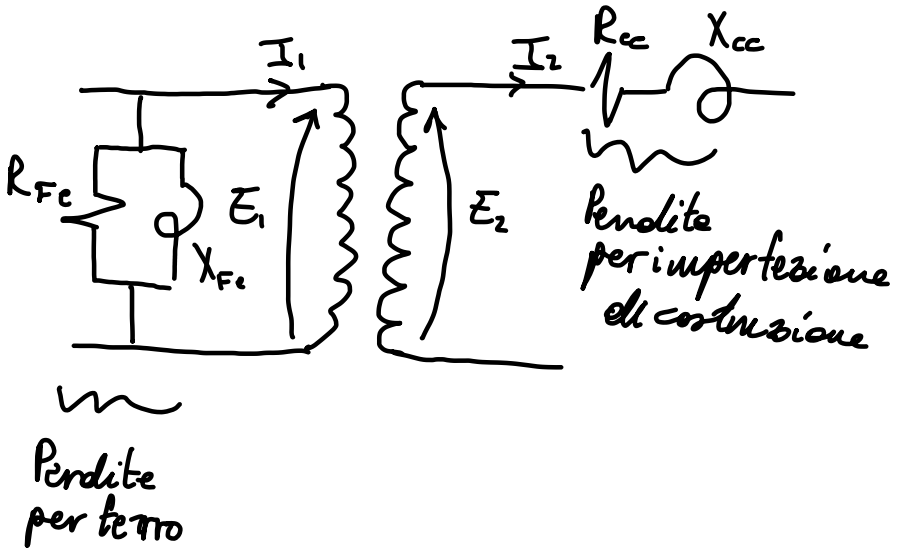
Esercitazione - Trasformatore

Normalmente li risolviamo con Boucherot, useremo esercizi con i numeri complessi (altri casi)
(99% dei casi)



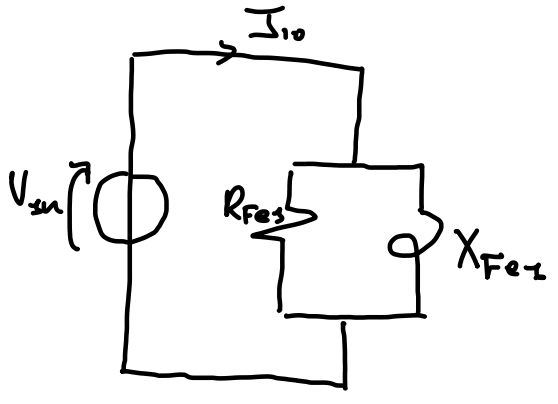
$$K = \frac{E_1}{E_2} = \frac{I_2}{I_1}$$

Reale:



Prove per determinare valori:

Prova a vuoto: → Per trovare R_{Fe} e X_{Fe}



Primario

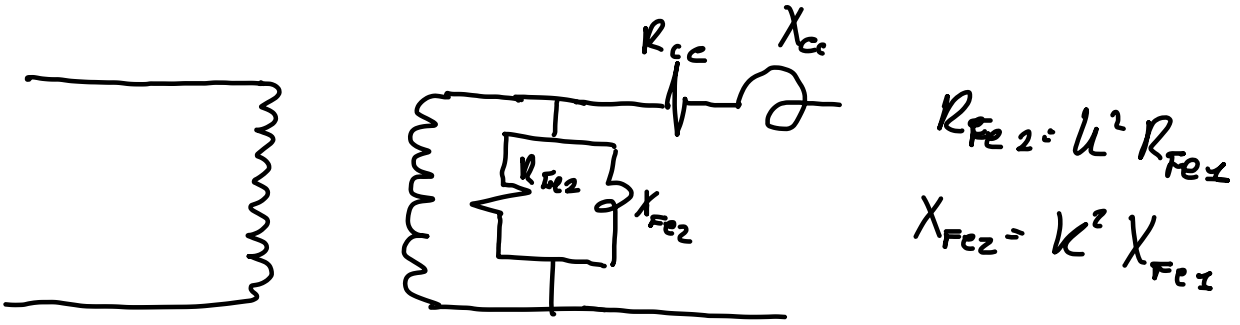
$$i_0\% = \frac{I_{10}}{I_{1n}} \cdot 100\%$$

$$P_0\% = \frac{P_0}{A_n} \cdot 100\%$$

$$Q_0\% = \frac{Q_0}{A_n} \cdot 100\%$$

$$\cos(\varphi_0) = \frac{P_0}{\sqrt{P_0^2 + Q_0^2}} = \frac{P_0}{V_{1n} I_{10}}$$

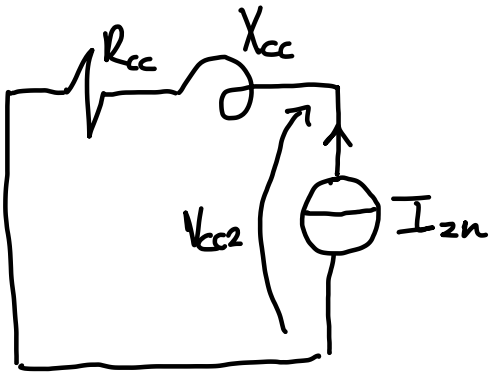
$$P_0 = \frac{V_{1n}^2}{R_{Fe}} \rightarrow \boxed{R_{Fe} = \frac{V_{1n}^2}{P_0}} \qquad Q_0 = \frac{V_{1n}^2}{X_{Fe}} \rightarrow \boxed{X_{Fe} = \frac{V_{1n}^2}{Q_0}}$$



$$R_{Fe2} = k^2 R_{Fe1}$$

$$X_{Fe2} = k^2 X_{Fe1}$$

Prova in corto circuito:



$$V_{cc}\% = \frac{V_{cc2}}{V_{2n}} \cdot 100 =$$

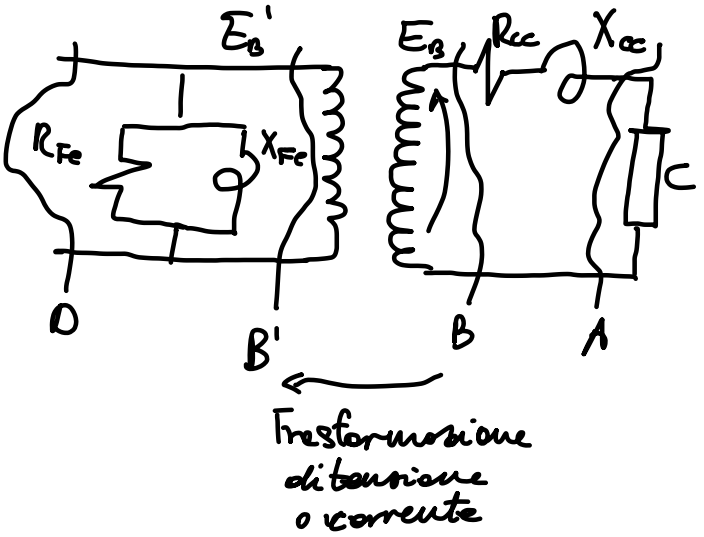
$$P_{cc}\% = \frac{P_{cc}}{A_n} \cdot 100\%$$

$$Q_{cc}\% = \frac{Q_{cc}}{A_n} \cdot 100\%$$

$$R_{cc} = \frac{P_{cc}}{I_{2n}^2}$$

$$X_{cc} = \frac{Q_{cc}}{I_{2n}^2}$$

$$\cos(\varphi_{cc}) = \frac{P_{cc}}{\sqrt{P_{cc}^2 + Q_{cc}^2}} = \frac{P_{cc}}{V_{cc2} \cdot I_{2n}}$$



Tensioni V — kV

Correnti A — kA

potenze W, VAR — MW, MVAR

Esercizio 1

Trasformatore Monofase

$A_n = 250\ kVA = 0{,}25\ MVA$

$V_{1n} = 15\ kV$

$V_{2n} = 400V = 0{,}4\ kV$

$P_{cc}\% = 2\%$

$i_0\% = 1\%$

$P_0\% = 0{,}5\%$

$\cos(\varphi_{cc}) = 0{,}35$

CARICO

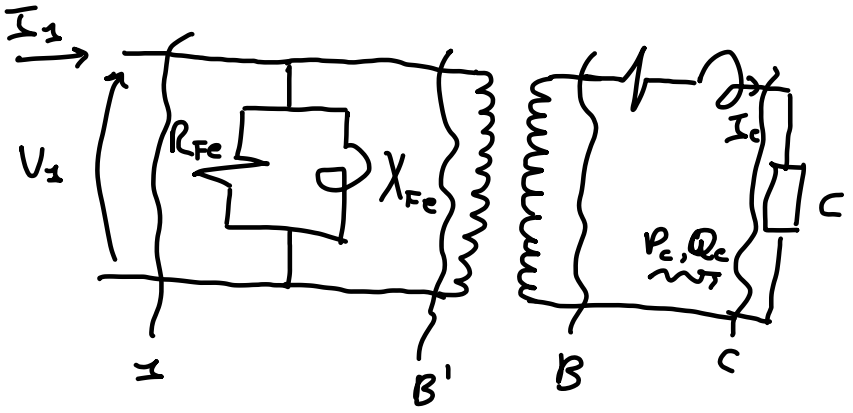
$P_c = 90kW = 0{,}09\ MW$

$V_c = 300V = 0{,}3\ kV$

$\cos(\varphi_c) = 0{,}9$ ritardo

Determinare

$V_1, I_1, \cos(\varphi_1)$



$$P_{cc} = A_n \cdot \frac{P_{cc}\%}{100\%} = 0{,}005\ MW$$

$$Q_{cc} = P_{cc} \cdot \frac{\sqrt{1-\cos^2(\varphi_{cc})}}{\cos(\varphi_{cc})} = 13382\ VAR$$

$$I_{2n} = \frac{A_n}{V_{2n}} = 625\ A = 0{,}625\ kA$$

$$R_{cc} = \frac{P_{cc}}{I_{2n}^2} = 0{,}0128\,\Omega$$

$$X_{cc} = \frac{Q_{cc}}{I_{2n}^2} = 0{,}0343\,\Omega$$

$$P_0 = A_n \cdot \frac{P_{0\%}}{100\%} = 1250\ W$$

$$I_0 = I_{1n} \cdot \frac{i_{0\%}}{100} = \frac{A_n}{V_{1n}} \cdot \frac{i_{0\%}}{100\%} = 0{,}1667\ A$$

$$Q_0 = \sqrt{A_0^2 - P_0^2} = \sqrt{V_{1n}^2 I_0^2 - P_0^2} = 2165{,}64\ VAR$$

$$R_{Fe} = \frac{V_{1n}^2}{P_0} = 180000\,\Omega$$

$$X_{Fe} = \frac{V_{1n}^2}{Q_0} = 103895\,\Omega$$

Sezione C

$$Q_C = P_C \cdot \frac{\sqrt{1-\cos^2(\varphi_C)}}{\cos(\varphi_C)} = 43589 \text{ VAR}$$

$$I_C^2 = \frac{P_C^2 + Q_C^2}{V_C^2} = \text{illegible } A^2$$

Sezione B

$$P_B = P_C + R_{cc} I_C^2 = 91422 \text{ W}$$

$$Q_B = Q_C + X_{cc} I_C^2 = 47400 \text{ VAR}$$

Sezione B'

P, Q rimangono uguali

$$V_B = \sqrt{\frac{P_B^2 + Q_B^2}{I_C^2}} = 308{,}94 \text{ V}$$

$$V_{B'} = k V_B = \left(\frac{V_{1n}}{V_{2n}}\right) \cdot V_B = 11585 \text{ V}$$

Sezione 1

$$P_1 = P_B + \frac{V_{B'}^2}{R_{Fe}} = 92167 \text{ W}$$

$$Q_1 = Q_B + \frac{V_{B'}^2}{X_{Fe}} = 48692 \text{ VAR}$$

$$I_1 = \frac{\sqrt{P_1^2 + Q_1^2}}{V_1} = 8{,}997\,A$$

$$\cos(\varphi_1) = \frac{P_1}{V_1 I_1} = 0{,}894$$

Esercizio2

Trasformatore Monofase

$A_n = 640\ kVA$

$V_{1n} = 23\ kV$

$V_{2n} = 400V = 0{,}4\ kV$

$V_{cc}\% = 4\%$

$P_{cc}\% = 0{,}8\%$

$i_0\% = 5\%$

$P_0\% = 0{,}4\%$

$V_1 = 21{,}5\ kV$

$f = 50\ Hz$

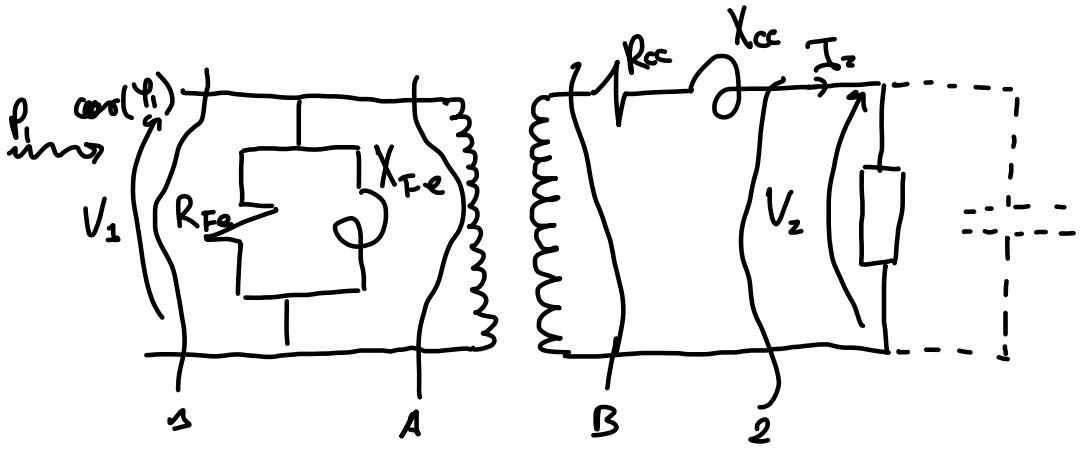
$P_1 = 180\ kW$

$\cos(\varphi_1) = 0{,}75$ ritardo

$V_2, I_2, \cos(\varphi_2)$?

rifasare (ideale) con condensatore C

tale che: $\cos(\varphi_{rif}) = 0{,}95$ ritardo



$$P_0 = A_n \cdot \frac{P_{0\%}}{100\%} = 2,560\ kW$$

$$I_0 = I_{1n} \cdot \frac{i_{0\%}}{100\%} = \frac{A_n}{V_{1n}} \cdot \frac{i_{0\%}}{100\%} = 0,278\ A$$

$$Q_0 = \sqrt{V_{1n}^2 I_0^2 - P_0^2} = 5864\ VAR$$

$$R_{Fe} = \frac{V_{1n}^2}{P_0} = 20664\ \Omega$$

$$X_{Fe} = \frac{V_{1n}^2}{Q_0} = 9018\ \Omega$$

$$P_{cc} = A_n \cdot \frac{P_{cc\%}}{100\%} = 5120\ W$$

$$V_{cc} = V_{2n} \frac{V_{cc\%}}{100\%} = 16\ V$$

$$Q_{cc} = \sqrt{V_{cc}^2 I_{2n}^2 - P_{cc}^2}$$

$$= \sqrt{V_{cc}^2 \frac{A_n^2}{V_{2n}^2} - P_{cc}^2} = \sqrt{A_n^2 \left(\frac{V_{cc\%}}{100\%}\right) - P_{cc}^2} = 25083\ VAR$$

$$R_{cc} = \frac{P_{cc}}{I_{1n}^2} = \frac{P_{cc} V_{1n}^2}{A_n^2} = 0{,}002\ \Omega$$

$$X_{cc} = \frac{Q_{cc} V_{1n}^2}{A_n^2} = 0{,}0098\ \Omega$$

Sezione 1

$$Q_1 = P_1 \frac{\sqrt{1^2(\varphi_1)}}{\cos(\varphi_1)} = 158743\ \text{VAR}$$

Sezione A

$$P_A = P_1 - \frac{V_1^2}{R_{Fe}} = 177763\ W = P_B$$

$$Q_A = Q_1 - \frac{V_1^2}{X_{Fe}} = 153619\ \text{VAR} = Q_B$$

$$V_B = \frac{V_1}{k} = \frac{V_A}{k} = \frac{V_{2n}}{V_{1n}} \cdot V_1 = 373{,}91\ V$$

$\uparrow \frac{1}{k}$

$$I_B^2 = \frac{P_B^2 + Q_A^2}{V_B^2} = 94808\ A^2$$

$$P_2 = P_B - R_{cc} I_B^2 = 176903\ W$$

$$Q_2 = Q_B - X_{cc} I_B^2 = 149750\ \text{VAR}$$

$$I_1 = \sqrt{I_B^2} = 628{,}33\ A$$

$$V_2 = \frac{\sqrt{P_2^2 + Q_2^2}}{I_2} = 368{,}016$$

$$\cos(\varphi_1) = \frac{P_2}{V_2 I_2} = 0{,}76$$

$$Q_{rif} = P_2 \frac{\sqrt{1-\cos^2(\varphi_{rif})}}{\cos(\varphi_{rif})} = 58 \text{ kVAR}$$

$$Q_c = Q_{rif} - Q_2 = -91882 \text{ VAR}$$

$$Q_c = -\frac{V_2^2}{X_c} = -V_2^2 \omega C = -2\pi f C \cdot V_2^2 \rightarrow C = \frac{-Q_c}{2\pi f V_2^2}$$

$$= 2{,}14 \text{ mF}$$

Esercizio 3

Monofase

Era impostato male graficamente

Abbiamo cambiato dove fosse posto il condensatore

$C =$