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Tutorial: transformers

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1. $a = \frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{12\,740}{240} \approx 53$

2. $Z' = a^2 Z$

$a = \sqrt{\frac{Z'}{Z}}$

$\Rightarrow \frac{N_1}{N_2} = \sqrt{\frac{Z'}{Z}}$

$N_2 = N_1 \sqrt{\frac{Z}{Z'}} = 400\sqrt{\frac{6}{2000}}$

≈ 22

3. i_1 and $i_2 \Rightarrow 180°$ phase difference

i_2 and $i_3 \Rightarrow 0°$ phase difference

$Z_2' = a_{2,3}^{\ 2}(Z_3) + Z_2 = (\frac{1}{2})^2(8) + 3$

$= 5\Omega$

$Z_1' = (a_{1,2})^2(Z_2') + Z_1 = (\frac{3}{1})^2(5) + 5 = 50\Omega$

$i_1 = \frac{200\angle 90°}{50} = 4\angle 90° \text{ A}$

$i_2 = (a_{1,3})|i_1|\angle 90° + 180° = \frac{3}{1}(4)\angle 270°$

$= 12\angle -90° \text{ A}$

$i_3 = (a_{2,3})(i_2) = \frac{1}{2}(12)\angle -90° = 6\angle -90° \text{ A}$

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4. short-circuit test

Rated apparent power = 33 kVA

$V_{1,rated} = 960V$

$I_{1,rated} = \frac{33 \times 10^3}{960} = 34.375A$

$Z_{eq} = \frac{V_{means}}{I_{1,rated}} = \frac{63}{34.375} \approx 1.833\Omega$

$R_{eq} = \frac{P}{I_{1,rated}^2} = \frac{300}{34.375^2} \approx 0.25\Omega$

$X_{eq} = \sqrt{Z^2 - R_{eq}^2} = \sqrt{1.833^2 - 0.25^2} \approx 1.815\Omega$

$Z_{eq} = 0.25 + j1.815\Omega$

Open-circuit test

$V_{2,rated} = 120V$

$V_{1,rated} = 960V$

$I_2 = 6$

$I_1 = 6\left(\frac{120}{960}\right) = 0.75A$

$|Y| = \frac{I_1}{V_{1,rated}} = \frac{0.75}{960} \approx 0.00078\mho$

$P_2 = 320W = P_1$

$G = \frac{P_1}{V_{1,rated}^2} = \frac{320}{960^2} \approx 0.000347\mho = \frac{1}{R_m}$

$R_m = \frac{1}{G} = \frac{1}{0.000347} \approx 2881.8\Omega$

$B = \sqrt{Y^2 - G^2} = \sqrt{0.00078^2 - 0.000347^2} \approx 0.000699\mho$

$X_m = \frac{1}{B} = \frac{1}{0.000699} \approx 1430.61\Omega$

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