جامعة بيرزيت

BIRZEIT UNIVERSITY

Electrical and Computer Engineering Department

Electrical Machines ENEE 2408

Short Exam # 2 (10*mins*)

Student Name: **ID:** **October 29, 2024**

A 100 kVA, 3300/400 distribution transformer has the following resistances and reactances:

$R_p = 10\Omega$	$R_s = 0.02\Omega$
$X_p = 15\Omega$	$X_s = 0.03\Omega$
$R_C = 200\ k\Omega$	$X_M = 30\ k\Omega$

The excitation branch impedances are given referred to the high-voltage side of the transformer.

a) Find the approximate equivalent circuit referred to the low voltage side

b) Assume that this transformer is supplying the rated load at 400V and 0.85 PF lagging, **use the approximate equivalent circuit** to find the transformer's input voltage

c) What is the voltage regulation under condition b)?

d) What is the efficiency of transformer under the condition of b)?

e) Draw the phasor diagram of voltages and current under the condition in b)

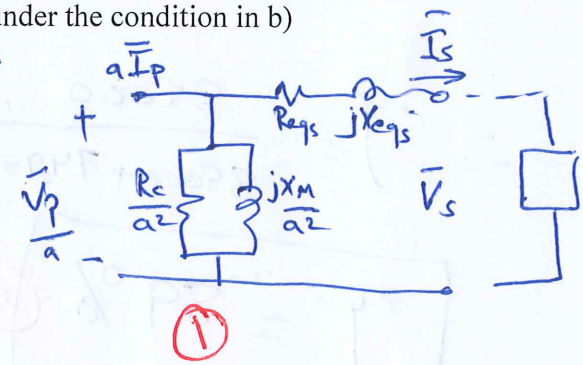
a) $a = \frac{3300}{400} = \boxed{8.25}$

$R_{eq_s} = R_s + \frac{R_p}{a^2} = 0.02 + \frac{10}{(8.25)^2} = \boxed{0.167\Omega}$ (0.25)

$X_{eq_s} = 0.03 + \frac{15}{a^2} = \boxed{0.25\Omega}$ (0.25)

$R_c' = \frac{R_c}{a^2} = \frac{200K}{(8.25)^2} = \boxed{2938.5\Omega}$ (0.25)

$X_m' = \frac{X_M}{a^2} = \frac{30K}{(8.25)^2} = \boxed{440\Omega}$ (0.25)



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b) $I_{s_{rated}} = \frac{S_{rated}}{V_{s\ rated}} = \frac{100K}{400} = 250\ A$

$\bar{I}_s = 250\angle -\cos^{-1}0.85 \Rightarrow \boxed{\bar{I}_s = 250\angle -31.8\ A}$ (0.5)

$\therefore \frac{\bar{V}_p}{a} = \bar{V}_s + \bar{I}_s R_{eq_s} + \bar{I}_s (jX_{eq_s}) = \bar{V}_s + \bar{I}_s (R_{eq_s} + jX_{eq_s})$ (0.5)

$= 400 + 250\angle -31.8 (0.167 + j0.25) = 400 + 250\angle -31.8 (0.3\angle 56.3)$

$\Rightarrow \frac{V_p}{a} = 400 + 75\angle 24.5 = 400 + 68.3 + j31.1 \Rightarrow \frac{\bar{V}_p}{a} = 468.3 + j31.1$ (1)

$\frac{\bar{V}_p}{a} = \boxed{469.3\angle 3.8\ V}$

c) $VR = \frac{\left|\frac{V_P}{a}\right| - |V_S|}{|V_S|} \times 100\%$ (1)

$= \frac{469.3 - 400}{400} \times 100\%$ (0.5)

$\Rightarrow$ **$VR = 17.33\%$** (0.5)

large +ve

d) $\eta = \frac{P_{out}}{P_{out} + P_{loss}} \times 100\%$ (1)

$P_{out} = S(pf) = 100k(0.85) =$ **85 KW** (0.25)

$P_{loss} = P_{core} + P_{cu}$

$P_{core} = \frac{|V_P/a|^2}{(R_c/a)} = \frac{(469.3)^2}{2938.5} =$ **74.95 W** (0.25)

$P_{cu} = |I_s|^2 R_{eqs} = (250)^2 (0.167) =$ **10.438 KW** (0.25)

$\therefore \eta = \frac{85000}{85000 + 74.95 + 10438} \times 100\%$

$\eta = 89\%$ (0.25)

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e) Phasor Diagram