Form No. T611

Philadelphia University
Faculty of Engineering

Student Name:
Student Number:

Dept. of Electrical Engineering
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Course Title: Electrical Machines I	Date: 14/11/2017
Course No: (610314)	Time Allowed: 50 Minutes
Lecturer: Dr. M. Abu-Naser, Dr. F. Obeidat	No. of Pages: 3

Question 1: *(5Mark)*

Objectives: This question is related to multiple choices

1) The basic function of a transformer is to change:
   a) The level of voltage.
   b) The power level.
   c) The frequency.
   d) The power factor.
2) Transformers use laminated core to:
   a) Reduce eddy current loss.
   b) Reduce eddy current and hysteresis loss.
   c) Ensure good magnetic coupling.
   d) All of the above.
3) Transformer action requires
   a) Constant magnetic flux.
   b) Increasing magnetic flux.
   c) Alternating magnetic flux.
   d) None of the above.
4) The leakage flux of primary and secondary windings can be reduced to the minimum by
   a) Winding primary and secondary coils on separate limbs.
   b) Winding primary and secondary coils one upon the other coaxially.
   c) Increase the number of turns.
   d) Employing low permeability magnetic material core.
5) Which of the following windings will be placed nearest to the core of transformer to reduce insulation requirements?
   a) Primary
   b) Secondary
   c) High voltage
   d) Low voltage

Question 2: (5Mark)

Objectives: This question is related to open circuit and short circuit tests

A single phase 10 KVA, 500/250V, 50 Hz transformer has the following constants:

primary reactance (X_1) = 0.2Ω   secondary reactance (X_2) = 0.05Ω

primary resistance (R_1) = 0.4 Ω   secondary resistance (R_2) = 0.1 Ω

core resistance (R_c) = 1500 Ω   magnetization reactance (X_m) = 750 Ω

What would be the reading of the instruments (wattmeter, voltmeter and ammeter) when the transformer is connected for the open circuit and short circuit tests (both tests are performed from primary side)?

From O.C test

$$I_{nxe} = \frac{V_1}{R_c} = \frac{500}{1500} = \frac{1}{3} A$$

$$I_m = \frac{V_1}{X_m} = \frac{500}{750} = \frac{2}{3} A$$

$$I_o = \sqrt{I_{nxe}^2 + I_m^2} = \sqrt{(\tfrac{1}{3})^2 + (\tfrac{2}{3})^2} = 0.745 A$$ 1

$$V_{oc} = 500 V$$ .5

$$P_{oc} = V_o I_o \cos\theta_o = V_o I_{nxe} = 500 \times \frac{1}{3} = 166.6 W$$ 1

$V_{oc} = 500V$	$I_{oc} = 0.745 A$	$P_{oc} = 166.6W$

From S.C test

$$R_{eq} = R_1 + R_2' = R_1 + a^2 R_2$$

$$a = \frac{V_1}{V_2} = \frac{500}{250} = 2$$

$$R_{eq} = 0.4 + 4 \times 0.1 = 0.8 \Omega$$

$$X_{eq} = X_1 + a^2 X_2 = 0.2 + 4 \times 0.05 = 0.4 \Omega$$

$$Z_{eq} = \sqrt{R_{eq}^2 + X_{eq}^2} = \sqrt{(0.8)^2 + (0.4)^2} = \sqrt{0.64 + 0.16} = \sqrt{0.8} = 0.894 \Omega$$

$$I_{sc} = \frac{10000}{500} = 20A$$ .5

$$V_{sc} = I_{sc} Z_{eq} = 20 \times 0.894 = 17.88 V$$ 1

$$P_{sc} = I_1^2 R_{eq} = 20^2 \times 0.8 = 320 W$$ 1

$I_{sc} = 20A$
$V_{sc} = 17.88V$
$P_{sc} = 320W$

Question 3: *(10Mark)*

Objectives: This question is related to transformer performance

A 15-kVA 8000/230-V distribution transformer has impedance referred to the primary of 80 + j300 Ω. The components of the excitation branch referred to the primary side are R_C= 350kΩ and X_m=70 kΩ

(a) If the primary voltage is 8000 V and the load impedance is Z_L=3.2+j1.5 Ω, what is the secondary voltage of the transformer? What is the voltage regulation of the transformer? What is the efficiency?

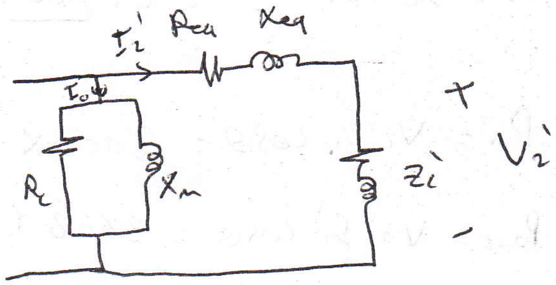
(b) If the load is disconnected and a capacitor of –j3.5 Ω is connected in its place, what is the secondary voltage of the transformer? What is its voltage regulation under these conditions? What is the efficiency?

(a)

$$a = \frac{V_1}{V_2} = \frac{8000}{320} = 34.78$$

$$Z_L' = (a)^2 Z_L = (34.78)^2 (3.2 + j1.5) = 3871 + j1815 \ \Omega$$

$$I_2' = \frac{V_1}{(R_{eq} + jX_{eq}) + (Z_L')}$$



$$= \frac{8000}{80 + j300 + 3871 + j1815}$$

$$= \frac{8000}{4481\angle 28.2} = 1.78\angle -28.2 \ A$$

$$V_2' = I_2' Z_L' = (1.78\angle -28.2) \times (3871 + j1815) = 7610\angle -3.1$$

$$V_2 = \frac{V_2'}{a} = \frac{7610\angle -3.1}{34.78} = 218.8$$

$$VR = \frac{V_{2NL} - V_{2FL}}{V_{2FL}} \times 100\% = \frac{230 - 218.8}{218.8} \times 100\% = 5.1\%$$

$$Y_m = \frac{1}{R_c} + \frac{1}{jX_m} = \frac{1}{350K} + \frac{1}{j70K} = (2.8 + j14.2)\mu\Omega = 14.5\angle 78.6 \ \mu\Omega$$

$$I_o = V_1 Y_m = 8000 \times 14.5 \times 10^{-6} \angle 78.6 = 0.11\angle 78.6$$

$$I_t = I_o + I_2' = 0.11\angle 78.6 + 1.78\angle -28.2 = 1.59 - j0.72 = 1.749\angle -24.5$$

$$P_{in} = V_1 I_1 \cos\theta = 8000 \times 1.749 \cos(-24.5) = 12732 \ W$$

$$P_{out} = V_2' I_2' \cos\theta = 1.78 \times 7610 \cos(-28.2 + 3.1) = 12266 \ W$$

$$\eta = \frac{P_{out}}{P_{in}} \times 100 = \frac{12266}{12732} \times 100\% = 96.3\%$$

b) $Z_L' = a^2 Z_L = (34.78)^2(-j3.5) = -j4233.7\ \Omega$

$$I_2' = \frac{V_1}{Z_{eq} + Z_L'} = \frac{8000}{80 + j300 - j4233.7} = 0.0413 + j2.03 = 2.03\angle 88.8$$

$$V_2' = I_2' Z_L' = 2.03\angle 88.8 \times 4233.7\angle -90 = 8606.5 - j175 = 8608.3\angle -1.2$$

$$V_2 = \frac{V_2'}{a} = \frac{8608.3\angle -1.1}{34.78} = 247.4 - j5 = 247.5\angle -1.2$$

$$VR = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\% = \frac{230 - 247.5}{247.5} \times 100\% = -7.07\%$$

$$I_1 = I_0 + I_2' = 2.03\angle 88.8 + 0.11\angle 78.6 = 0.064 + j2.13 = 2.13\angle 88.2$$

$$P_{in} = V_1 I_1 \cos\theta = 8000 \times 2.13 \cos 88.2 = 535.2\ W$$

$$P_{out} = V_2' I_2' \cos\theta = 8608.3 \times 2.03 \cos(88.8 + 1.2) = 0$$

$$\eta = \frac{P_{out}}{P_{in}} \times 100\% = 0\%$$