Grade: 50 /60 25 /30

University of Jordan | Faculty of Engineering & Technology | Electrical Engineering Department

EE371: Electrical Machines I | Second Exam | First Semester 2015-2016 | 07/12/2015 | Time: 2:30 - 4:00 pm

Student Name: [redacted] **Student ID#:** [redacted] **Serial #:** [redacted]

Questions # 1 (10 marks) **SHOW YOUR CALCULATIONS**

A single-phase 10 kVA, 7500/250 V, transformer has the following approximate equivalent circuit parameters:

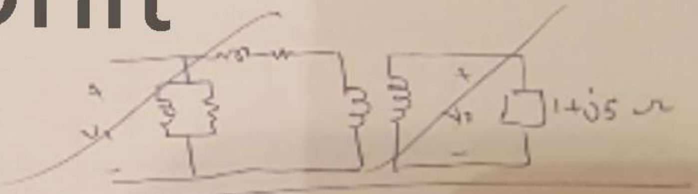
$Z_{eq} = 0.02 + j0.08$ pu. $R_c = 50$ pu, $X_m = 20$ pu,

Determine the transformer voltage regulation using the per-unit equivalent circuit assuming a rated voltage is applied to the transformer primary while a load of $Z_L = 1 + j5\ \Omega$ is connected to the secondary.

PF = 0.19

%VR =	8.23 %

Power Unit

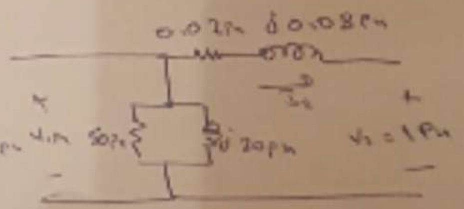


$S_{base} = 10\text{kVA}$

$V_{b1} = 7500\text{V}$

$V_{b2} = 250\text{V}$

$V_{2pu} = \frac{V_2}{V_{b2}} = \frac{250}{250} = 1\angle 0$ pu



$|I_{2pu}| = \frac{S_{pu}}{V_{pu}} = 1$ pu

$I_{2pu} = 1\angle -78.7$ pu

$V_{1pu} = V_{2pu} + I_{2pu}(0.02 + j0.08)$

$V_{1pu} = 1 + (1\angle -78.7)(0.02 + j0.08)$

$V_{1pu} = 1.0823\angle -0.02$

$VR = \frac{V_{1pu} - V_{rated\,pu}}{V_{rated\,pu}} \times 100\% = \frac{1.0823 - 1}{1} \times 100\% = 8.23\%$

$VR = 8.23\%$

Power Unit

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Questions 2 (15 mark) **SHOW YOUR CALCULATIONS**

A 25 kV/600 V, 60 Hz, 300 kVA 3-phase transformer is connected as shown in Fig. Q2. The typical per unit parameters of the primary and secondary windings and the magnetizing branch as provided by the manufacturer are

$$R_1 = 0.01 \quad X_1 = 0.02 \quad R_2 = 0.01 \quad X_1 = 0.02$$

The magnetizing branch real P_c and reactive Q_m power losses are 1% resistive and 1% reactive, respectively.

a. Obtain the actual parameters (R_1, X_1, R_2, X_2, R_c and X_m) in Ohms of the three-phase two winding transformer.
b. Draw its per-phase approximate equivalent circuit referred to the primary showing the actual values of the parameters.
c. Determine the vector group of the 3-ph transformer connection using the clock method. Illustrate your solution using schematic diagram.

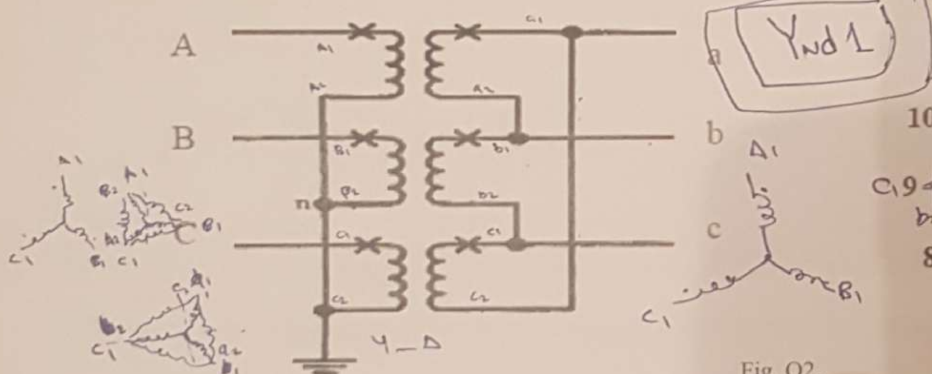
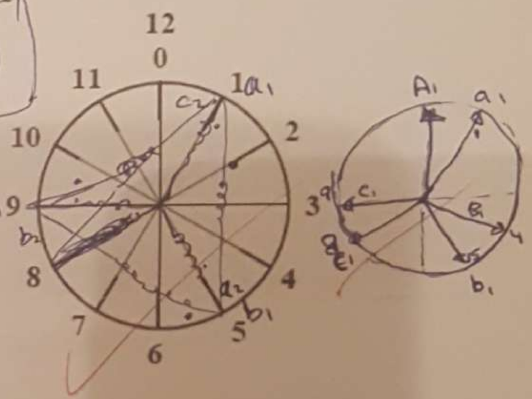


Fig. Q2.



$S_{b,1\phi} = 100\text{KVA}$

$V_{b1} = 14.43\text{ kV}$

$V_{b2} = 600\text{ V}$

$Z_{b1} = \frac{(V_{b1})^2}{S_{b,1\phi}} = 2083.3\ \Omega$

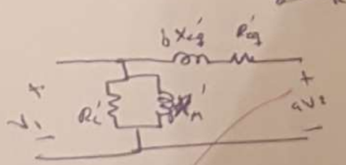
$Z_{b2} = \frac{(V_{b2})^2}{S_{b1\phi}} = 3.6\ \Omega$

$R_1 = Z_{b1} * 0.01 = 20.833\ \Omega$

$R_2 = Z_{b2} * 0.01 = 0.036\ \Omega$

$X_1 = Z_{b1} * 0.02 = 41.666\ \Omega$

$R_c = \frac{1}{0.01} = 100\ \Omega$



$R_1 =$	20.833	Ω
$R_2 =$	0.036	Ω
$X_1 =$	41.66	Ω
$X_2 =$	0.072	Ω
$R_C =$	208.3	kΩ
$X_m =$	208.3	kΩ
$R_{eq}' =$	41.66	Ω
$X_{eq}' =$	83.3	Ω

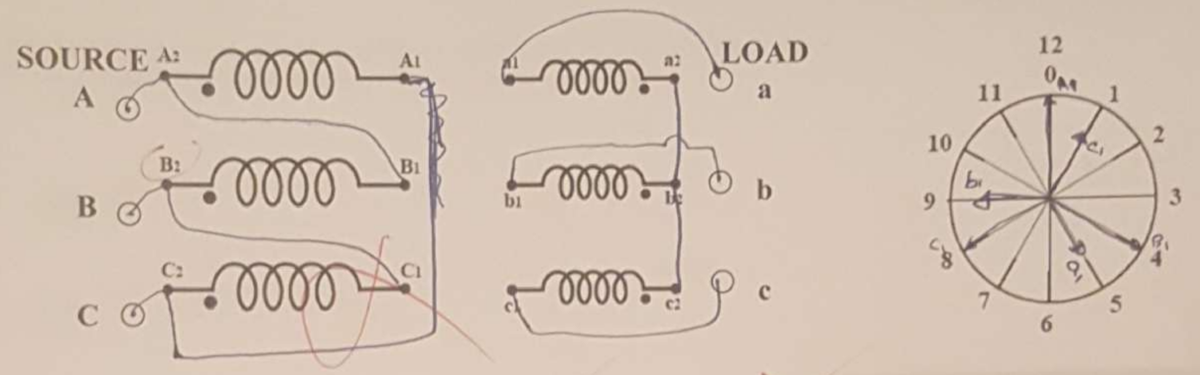
$R_{eq}' = R_1 + R_2 * 578.4$

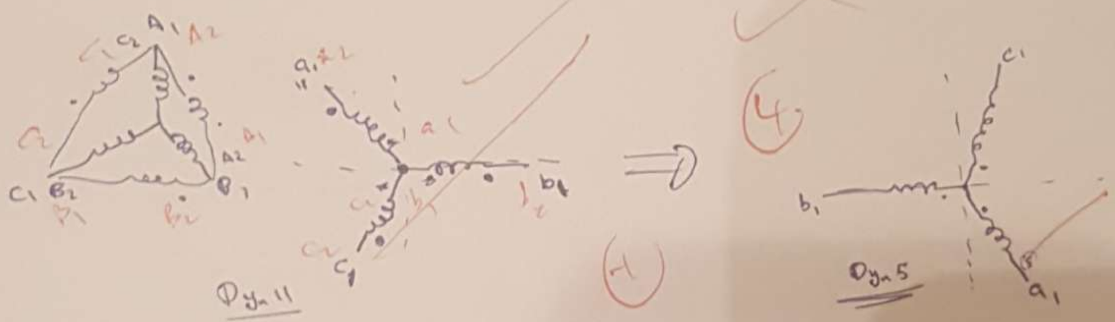
$X_{eq}' = X_1 = X_2 * 578.4$

Power Unit

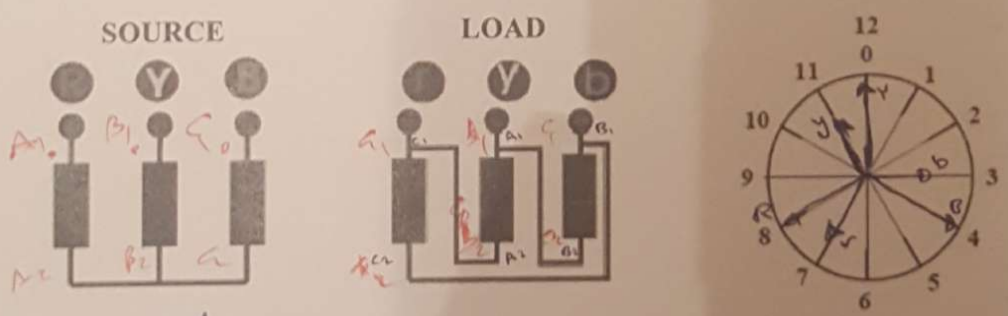
Question #3 (10 marks) **SHOW YOUR CALCULATIONS**

a. Draw a schematic connection diagram of a 3-phase transformer with Dyn5 vector group.



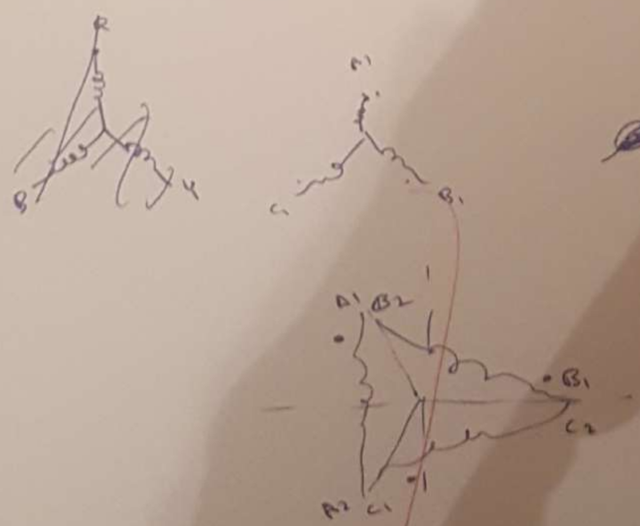


b. What is the vector group for the following 3-phase transformer connection?



Ynd

Ynd 11



Power Unit

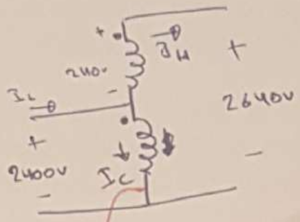
Question #4 (10 marks) **SHOW YOUR CALCULATIONS**

(8)

A 10-kVA, 60-Hz, 2400—240-V distribution transformer is reconnected for use as a step-up autotransformer with a 2640-V output and a 2400-V input. Draw the connection diagram and determine:

a. the rated primary current I_L and secondary current I_H when connected as an autotransformer.
b. the advantage factor, A_f.
c. the apparent-power rating $S_{I/O}$ when connected as an autotransformer.
d. power transferred by induction S_{ind} and conduction S_{cond}.

I_L =	458.37	A
I_H =	416.7	A
A_f =	11	
$S_{I/O}$ =	1100	kVA
S_{ind} =	100	kVA
S_{cond} =	1000	kVA



I_H rated $= \frac{100k}{240} = 416.7A$

$A_f = \frac{240 + 2400}{240} = 11$

$S_{ind} = 100 kVA$

$S_{I/O} = 11 \times 100k = 1100 kVA$

$S_{cond} = S_{I/O} - S_{ind} = 1000 kVA$

I_C rated $= \frac{100k}{2400} = 41.67 A$

~~I_C rated = 375.03 A~~

$\frac{2640}{2400} = \frac{I_L}{416.7}$

(-2)

Power Unit

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Question #5 (15 marks) **SHOW YOUR CALCULATIONS**

Three 10 kVA, 1330/230 V, 60 Hz single-phase transformers are connected to form a three-phase 2300/230 V Yd1 transformer bank. The equivalent impedance of each transformer referred to the LV side is $Z_{eqLV} = 0.12 + j0.25\ \Omega$ and the magnetizing branch is neglected. The transformer bank supplies a 230 V, 27 kVA three-phase load at PF of 0.9 lagging. The transformer connected to a three-phase source through a feeder line with an impedance of $Z_f = 0.5 + j2\ \Omega$ per phase as shown in Fig. Q5.

Draw the per phase equivalent circuit with all values referred to the HV side and determine

a. the magnitudes of the HV- and LV- winding currents (I_{HV} and I_{LV}) when the transformer bank supplies the above load at 230 V,

b. the magnitude of the line-to-line voltage at the HV side of the transformer, V_{HVLL},

c. the magnitude of the line-to-line source voltage at the three-phase source, V_{sLL},

d. the apparent power supplied by the source, S_{source} and power factor, PF_{source}.

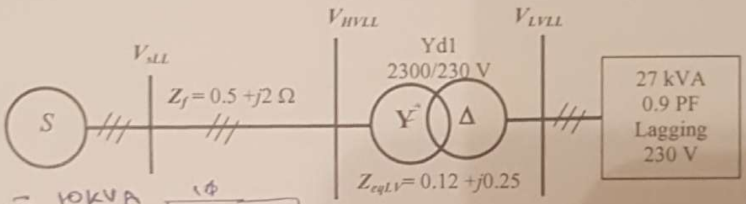

Fig. Q5

$S_{rated\,1\phi} = 10\text{kVA}$ — 1Φ [1330 / 230 V]

$S_{1\phi} = 9\text{kVA}$

PF = 0.9 lagging

$I_H = \frac{9k}{1330} \angle -\cos^{-1}(0.9)$

$I_H = 6.77 \angle -25.8$ A

$Z_{eqHV} = Z_{eqLV} \times \left(\frac{1330}{230}\right)^2$

$V_{HP} = 1330 + I_H \times (Z_{eqHV})$

Z_{eqHV} =	4 + j8.36 Ω
I_{HV} =	6.77 ∠ -25.8 A
I_{LV} =	39.13 ∠ -25.8 A
V_{HVLL} =	[illegible] V
V_{sLL} =	[illegible] V
S_{source} =	9.4 kVA
PF_{source} =	0.59 ≈ 0.6

Final Answer

$V_{HVLL} = 2389.6$ V

$V_{sLL} = 2405.8$ V

2405.8 V

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