University of Jordan

Electrical Eng. Dept

EE 090371 Electrical Machines (1)

Second Exam.
5-4-2017

الرقم الجامعي　　**رقم التفقد(　)**　　**الاسم:**

Q1) Fill in the following Blanks: **[12]**

1. **The terminals of a 3-ph YΔ transformer are marked in such a way that:** The HV Lead LV by 30° in the +ve phase sequence and HV Lag " " " " " -ve " "

2. **The vector groups of 3-ph transformers indicate:** the classification of phase shift between HV and LV windings of 3-ph transformers where groups (1, 2, 3 and 4) corresponds to (0°, 180°, -30° and 30°) respectively.

3. **The effective turns ratio of a Yd transformer is equal to** $N_1/(N_2\sqrt{3})$

4. **Autotransformers are basically used when:** the voltage Ratio is around one.

5. **For specified magnitudes of voltage and current the (** PF of the load **) effects the voltage regulation of a transformer.**

6. **Armature windings are defined as:** The windings in which voltage is induced in case of generator or the windings to which current is applied in case of motors.

7. **In the operation of electrical machines, the factors required are:** (Conductor), (magnetic field) & (Relative motion between them)

8. **In a 4-pole stator winding the span between two phases is (** 60° mech **).**

9. **If i_a=5Sin ($2\pi 50.t$), then for 2-pole stator winding the speed of the rotating magnetic field is (** 50*60 **) rpm.**

10. **If the magnitude of the flux density generated by each phase is 0.5 T then the magnitude of the stator rotating flux is (**1.5 * 0.5 **).**
0.75

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Q2) A 20-kVA, (8000/240) V, 60Hz 1-ph transformer has an equivalent Impedance referred to the HV side as Z_{eq}= (38.4+j92) Ω.

a- If this transformer to be used as (8240/8000) step-down autotransformer, find the auto. equivalent impedance in PU. [7]

$Z_{Auto}(pu) = Z_{conv}^{(pu)} / \text{App. advantage}$.

$Z_{bHV} = V^2/S = (8000)^2 / 20*10^3 = 64*10^6 / 2*10^4 = 3200\,\Omega$

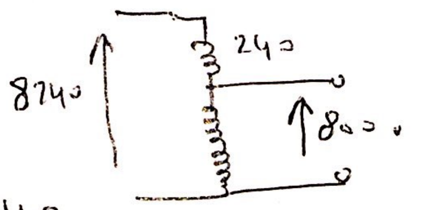
2 . $Z_{conv}(pu) = (38.4 + j92)/3200 = 0.012 + j\,0.029$

Auto

∴ App. advantage =

$(N_c + N_{se})/N_{se} =$

2 . $\frac{8000 + 240}{240} = 34.3$



Since $N \propto V$

∴ $N_{se} = 240$

$N_c = 8000$

3 . ∴ $Z_{Auto}(pu) = (0.012 + j0.029)/34.3 = 0.0003 + j\,0.0008$

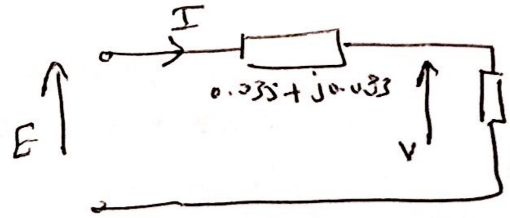
b-If this 1-ph transformer is used as a step-down transformer to supply full-load at 0.8 pf lagging, find its voltage regulation. [8]

⊗ Refer Z_{eq} to LV, Since the Secondary is LV

2 . ∴ $Z_{eq} = (38.4 + j92)\left(\frac{240}{8000}\right)^2 = 0.035 + j0.083$

1 . $V = 240\angle 0$

1 . $I = \frac{20*10^3}{240} \angle -\cos^{-1} 0.8 = 83.3\angle -36.87$



2 . ∴ $E = I Z_{eq} + V$

$= 83.3\angle -36.87\,(0.035 + j0.083) + 240\angle 0$

$= 83.3\angle -36.87 * 0.09\angle 67.1 + 240\angle 0$

$= 7.5\angle 30.23 + 240\angle 0 = 246.5 + j\,3.8 = 246.53\angle 0.9$

2 . ∴ $VR = \frac{|E| - |V|}{|V|} = \frac{246.53 - 240}{240} = 0.027 = 2.7\%$

Q3)a- If 3 single phase transformers, each one is rated at 25 MVA and (38.1/3.81)kV, are connected as 3-ph transformer bank in such a way the HV is rated at 66 kV and the LV has the lowest voltage, then:

1-Find the rating of this 3-ph transformer. [5]

Since usually Rated voltage represent LV, then,

$38.1 \times \sqrt{3} = \boxed{66}$ and $3.81 \times \sqrt{3} = 6.6$ for Y-connection

$\therefore$ HV is Y connected. $= 3.81$ for Δ-connection

3 $\therefore$ Voltage Rating is $(66\,Y / 3.81\,\Delta)$ kV

2 App. Power Rating is $25 \times 3 = 75$ MVA

2-If a balanced Δ-connected of (3+j6) Ω per phase is connected to the HV side, find the value of the load seen at LV side. [5]

↑ Per-phase

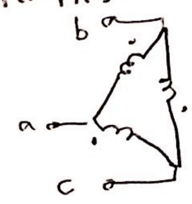
2 $Z_Y = Z_\Delta/3 = (3+j6)/3$

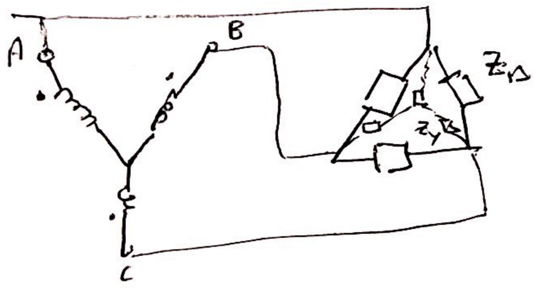
$= 1 + j2$

$\therefore$ Reflect Z_Y to LV side

3 $\therefore Z_{LV} = Z_Y \left(\frac{3.81}{66}\right)^2 = (1+j2) \times 0.003$

$= 0.003 + j0.006$





b-If a 3-ph transformer has $V_{AB}=173.2\angle 70^0$ kV and $V_{ab}=10\angle 40^0$ kV and $N_{HV}/N_{LV}=10$, find the connection designation and its vector group. [5]

Since there is a phase shift = 30° between HV and LV then the transformer is Y-Δ connection, with LV lag HV by 30°

(a) If HV is Y connected, then $N_{HV} \propto V_{\phi HV}$, $\therefore N_{HV} = 173.2/\sqrt{3}$ and in this case LV is Δ connected, $N_{LV} \propto V_{\phi LV} = 10$

$\therefore N_{HV}/N_{LV} = (173.2/\sqrt{3})/10 = \boxed{10}$

2 (b) If HV is Δ connected, then $N_{HV} = 173.2$, and in this case LV is Y connected, then $N_{LV} = 10/\sqrt{3}$

$\therefore \frac{N_{HV}}{N_{LV}} = \frac{173.2}{10/\sqrt{3}} = \frac{173.2 \times \sqrt{3}}{10} = \boxed{30}$

2 $\therefore$

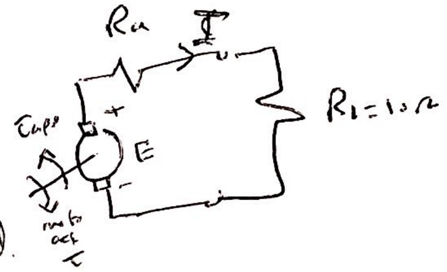
1 Connection Designation is $\boxed{Yd1}$, and vector group is (3) since Angle of LV w.r.t HV is $-30°$

Q4) a-A single loop rotating in a uniform magnetic field has the following data: B=1 T, r=0.1m, l=0.3 m and applied ω=377 rad/sec.

If the loop is connected to a 10 Ω resistance and has negligible armature resistance, evaluate the magnitude of developed motor action. **[8]**

Since Rotational motion is applied then the loop + field represent generator action.

∴ Developed motor action is a torque, τ.



$E = 2rlB\omega = 2 * 0.1 * 0.3 * 1 * 377$

3 $= 22.62$ V

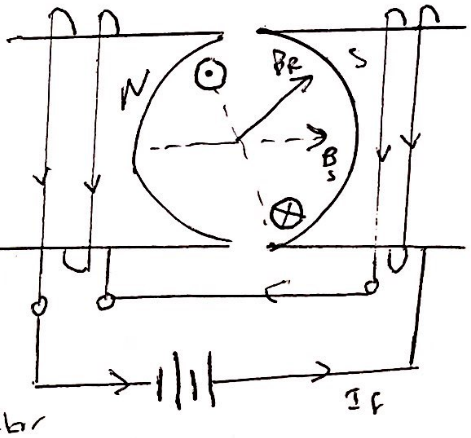
∴ $I = \frac{E}{R_a + R_L} = \frac{E}{R_L}$ since Ra is neglected.

3 ∴ $I = 22.62 / 10 = 2.262$ A

Motor action, $\tau = 2rlIB = 2 * 0.1 * 0.3 * 2.262 * 1 = 0.136$ N-m

2

b-For the given machine construction:



1-Find the direction of B_S and B_R and say how. [5]

according to direction of I_f and by using RHR one can find the polarity of poles

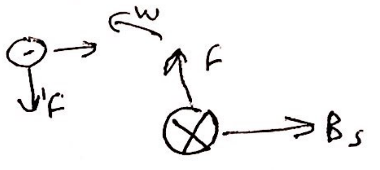
∴ Left pole is North (N) and Right pole is South (S)

3 B_S is from N to S

2 B_R can be found by applying RHR to current direction in the conductors, ⊥ on the conductor plane

2-If this machine is a generator; find the direction of its rotation. [5]

By applying RHR one can find direction of F on each conductor



∴ direction of rotation is CCW