Benha University
Faculty of Engineering–Benha

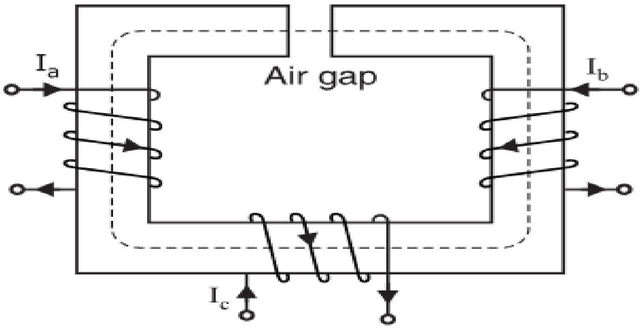
Department : Electrical Engineering	**Date : Sunday 16-1-2022**
Year : 3rd Power and Control	**Time : 3.0 hr.**
Exam : Final / Regular	**Code : E 1331**
Subject : Electrical Machines	**Examiner: Dr. Abdelnasser Nafeh**

Total Degrees: 90 Marks

Answer the Following Questions

Question 1: [20 Marks] [CLO = a1, a8, b1, c1]

1. A rectangular iron core is shown in Fig. 1. It has a mean length of magnetic path of 100 cm, cross-section of 2 cm × 2 cm, relative permeability of 1400 and an air gap of 5 mm cut in the core. The three coils carried by the core have number of turns Na = 335, Nb = 600 and Nc = 600 and the respective currents are 1.6 A, 4 A and 3 A. The directions of the currents are as shown in Fig. 1. ***Find*** the flux in the air gap.



2. A coil of 200 turns of wire is wound on a magnetic circuit of reluctance 2000 At/Wb. If a current of 1A flowing in the coil is reversed in 10 ms, ***find*** the average e.m.f. induced in the coil.

Question 2: [20 Marks] [CLO = a2, a6, b2, c2]

3. Data obtained from short-circuit and open-circuit tests of a 50-kVA, 2400—600-V, 60-Hz transformer are:

Open-circuit test (Low-side data)	Short-circuit test (High-side data)
V_{OC} = 600-V	V_{SC} = 76.4-V
I_{OC} = 3.34-A	I_{SC} = 20.8-A
P_{OC} = 484-W	P_{SC} = 754-W

Determine (a) the equivalent high-side parameters; ***(b)*** voltage-regulation; ***(c)*** efficiency at rated load and 92 % power-factor lagging.

4. The following 2400-240-V, 60-Hz transformers are to be operated as a parallel bank:

Transformer	KVA	Nameplate Impedance
A	50	3.53 %
B	75	2.48 %

Assume percent resistance is negligible. ***Can the bank be operated at its combined rating of 125-KVA without overheating? Show all work.***

Question 3: [20 Marks] [CLO = a1, a9, b1,b2, c3]

5. The electromagnetic torque developed in a DC machine is 80 Nm for an armature current of 30 A. ***What*** will be the torque for a current of 15 A? Assume constant flux. ***What*** is the induced emf at a speed of 900 rpm and an armature current of 15 A?

6. A 250 V, 20 kW shunt motor running at 1500 rpm has a maximum efficiency of 85 % when delivering 80 % of its rated output. The resistance of the shunt field winding is 125 Ω. ***Determine*** the efficiency and speed of the motor when it draws 100 A from the mains.

Question 4: Short Answer Type Questions [15 Marks] [CLO = a1, a8, b1, ,b2,c1,c2]

1. Does the magnetizing current of a transformer lie in-phase with the applied voltage? Justify.
2. What is the effect of saturation on exciting current of transformer?
3. What are the ill-effects of inrush current of transformer?
4. Even at no-load, a transformer draws current from the mains. Why?
5. Why does voltage drop in a transformer?
6. Is the regulation at rated load of a transformer same at 0.8 p.f. lagging and 0.8 p.f. leading?
7. How can iron loss be measured?
8. The transformers are often classified according to their applications. Discuss in details.
9. What do you expect if star-delta transformer is connected in parallel with a star-star transformer?
10. What is the necessity of parallel operation of three-phase transformers?
11. Why is commutator employed in DC machines?
12. For what type of DC machine lap winding is employed and for what type of DC machine, wave winding is employed?
13. How can the direction of rotation of a DC shunt motor be reversed?
14. Which method is adopted to control the speed of a DC shunt motor above its base speed?
15. What do you understand by self-excitation mode of DC machine? Name two DC machines working in this mode.

Question 5: Multiple Choice Questions [15 Marks] [CLO = a1, a2, b1,b4 c3,c4]

1. When a magnet is heated,
(a) it gains magnetism (b) it loses magnetism (c) it neither loses nor gains magnetism (d) none of the above.

2. *The magnetic material used in permanent magnets is*
(a) iron (b) soft steel (c) nickel (d) hardened steel.

3. The magnetic material used in temporary magnets is
(a) hardened steel (b) cobalt steel (c) soft iron (d) tungsten steel.

4. Magnetic flux density is a
(a) vector quantity (b) scalar quantity (c) phasor (d) none of the above.

5. One weber is equal to
(a) 10^6 lines (b) $4\pi \times 10^{-7}$ lines (c) 10^{12} lines (d) 10^8 lines.

6. Magnetic field intensity is a
(a) scalar quantity (b) vector quantity (c) phasor (d) none of the above.

7. The source of a magnetic field is
(a) an isolated magnetic pole (b) static electric charge (c) magnetic substances (d) current loop.

8. Magnetic lines of force
(a) intersect at infinity (b) intersect within the magnet (c) cannot intersect at all (d) none of the above.

9. If load on a DC shunt motor is increased, its speed is decreased due primarily to
(a) increase in its flux (b) decrease in back emf (c) increase in armature current (d) increase in brush drop.

10. The torque available at the shaft of a DC motor is less than the torque developed in the armature because of………losses. (a) copper (b) mechanical (c) iron (d) rotational.

11. If the voltage applied across the armature of a DC shunt motor is increased by 5% keeping its load current and field constant, what will be the effect on its speed?
(a) decrease by about 5 % (b) remain unchanged (c) increase by about 5 % (d) increase by 10 %.

12. A DC generator is considered to be an ideal one if it has…… voltage regulation.
(a) low (b) zero (c) positive (d) negative.

13. In a DC generator, the effect of armature reaction on the main field is to
(a) reverse it (b) distort it (c) reduce it (d) both (b) and (c).

14. In an auto transformer, there are
(a) always two windings (b) one winding only without taps (c) one winding with taps taken out (d) two windings put one upon the other.

15. The induced emf in the transformer secondary will depend on
(a) frequency of the supply only. (b) Number of turns in secondary only. (c) Frequency and flux in core. (d) Frequency, number of secondary turns and flux in the core.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Best wishes,

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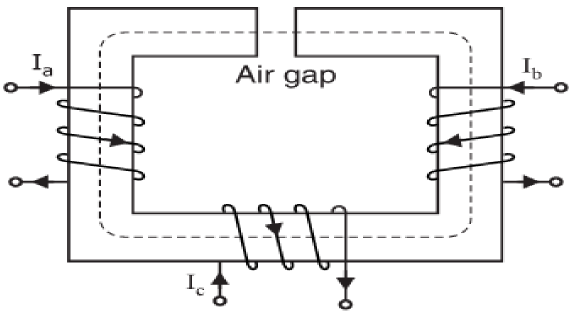

Fig. 8.12

Solution. By applying right-hand rule for the coil, it is easy to see that fluxes produced by currents I_a and I_b are in the clockwise direction through the iron core while the flux produced by current I_c is in the anticlockwise direction through the core.

$\therefore$ Net m.m.f. $= N_aI_a + N_bI_b - N_cI_c = 335 \times 1{\cdot}6 + 600 \times 4 - 600 \times 3 = 1136$ AT

$$\text{Reluctance of air gap} = \frac{l_g}{\mu_0 a} = \frac{5\times10^{-3}}{4\pi\times10^{-7}\times4\times10^{-4}} = 9{\cdot}946 \times 10^6 \text{ AT/Wb}$$

$$\text{Reluctance of iron path} = \frac{l_i}{\mu_0\mu_r a} = \frac{(100-0{\cdot}5)\times10^{-2}}{4\pi\times10^{-7}\times1400\times4\times10^{-4}} = 1{\cdot}414 \times 10^6 \text{ AT/Wb}$$

$\therefore$ Total reluctance $= (9{\cdot}946 + 1{\cdot}414) \times 10^6 = 11{\cdot}36 \times 10^6$ AT/Wb

The statement of the example suggests that there is no leakage flux. Therefore, flux in the air gap is the same as in the iron core.

$$\therefore \text{ Flux in air gap} = \frac{\text{Net m.m.f.}}{\text{Total reluctance}} = \frac{1136}{11{\cdot}36\times10^6} = 100 \times 10^{-6} \text{ Wb} = \mathbf{100\ \mu Wb}$$

2. A coil of 200 turns of wire is wound on a magnetic circuit of reluctance 2000 At/Wb. If a current of 1A flowing in the coil is reversed in 10 ms, **find** the average e.m.f. induced in the coil.

Solution. Flux in the coil $= \dfrac{\text{m.m.f.}}{\text{reluctance}} = \dfrac{200\times1}{2000} = 0{\cdot}1$ Wb

When the current (*i.e.* 1A) in the coil is reversed, flux through the coil is also reversed.

$$e = N\frac{d\phi}{dt}$$

Here, $N = 200$; $d\phi = 0{\cdot}1 - (-0{\cdot}1) = 0{\cdot}2$ mWb ; $dt = 10 \times 10^{-3}$s

$$\therefore \quad e = 200\times\frac{0{\cdot}2\times10^{-3}}{10\times10^{-3}} = \mathbf{4\ V}$$

Question 2: [20 Marks] [CLO = a2, a6, b2, c2]

3. Data obtained from short-circuit and open-circuit tests of a 50-kVA, 2400—600-V, 60-Hz transformer are:

Open-circuit test (Low-side data)	Short-circuit test (High-side data)
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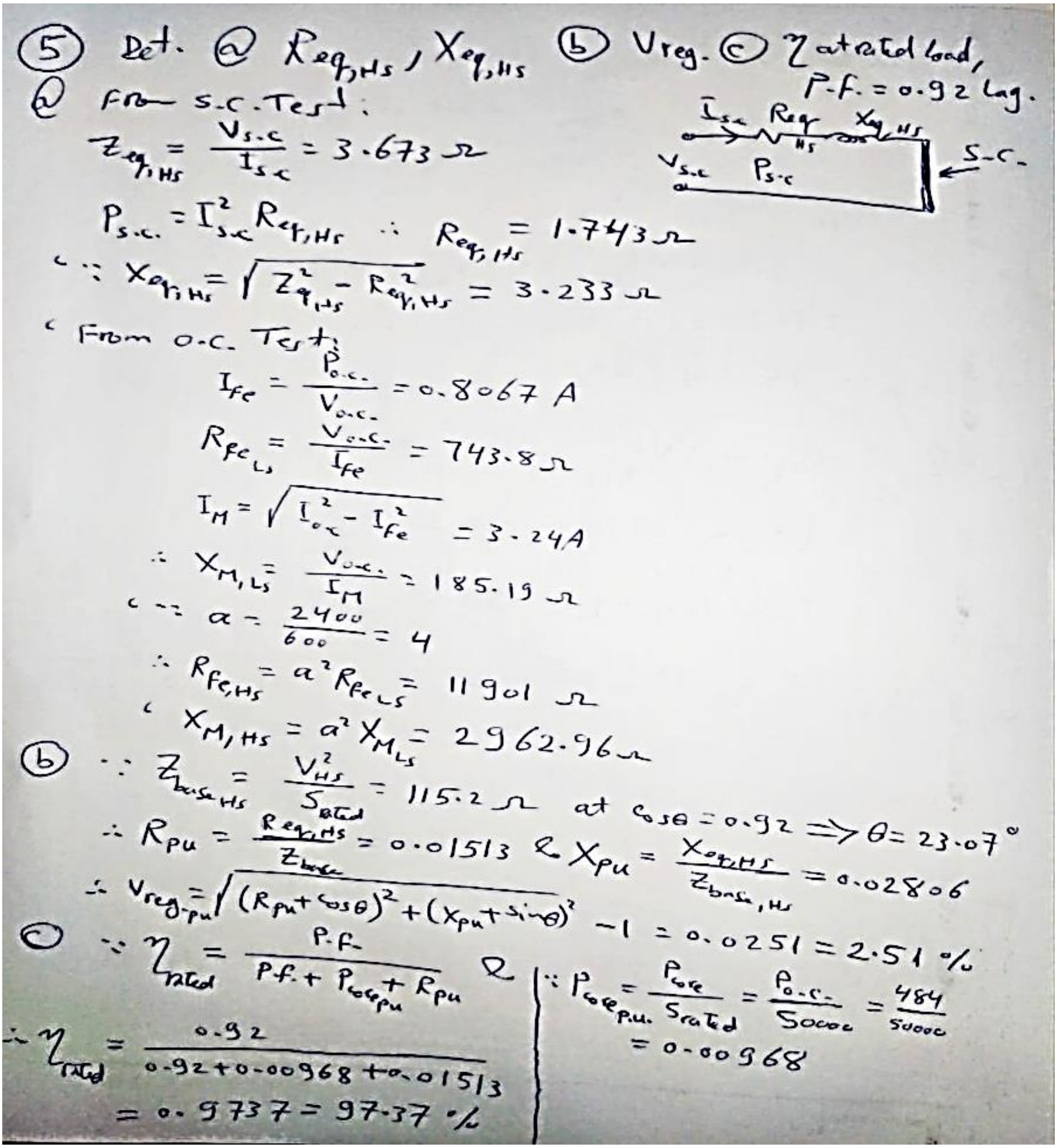
(5) Det. (a) $R_{eq,HS}$, $X_{eq,HS}$ (b) $V_{reg.}$ (c) η at rated load, P.F. = 0.92 Lag.

(a) From s.c. Test:

$Z_{eq,HS} = \frac{V_{s.c}}{I_{s.c}} = 3.673\ \Omega$

$P_{s.c.} = I_{s.c}^2 R_{eq,HS}$ $\therefore R_{eq,HS} = 1.743\ \Omega$

$\therefore X_{eq,HS} = \sqrt{Z_{eq,HS}^2 - R_{eq,HS}^2} = 3.233\ \Omega$

From o.c. Test:

$I_{Fe} = \frac{P_{o.c.}}{V_{o.c.}} = 0.8067\ A$

$R_{Fe,LS} = \frac{V_{o.c.}}{I_{Fe}} = 743.8\ \Omega$

$I_M = \sqrt{I_{o.c}^2 - I_{Fe}^2} = 3.24 A$

$\therefore X_{M,LS} = \frac{V_{o.c.}}{I_M} = 185.19\ \Omega$

$\because a = \frac{2400}{600} = 4$

$\therefore R_{Fe,HS} = a^2 R_{Fe,LS} = 11901\ \Omega$

$X_{M,HS} = a^2 X_{M,LS} = 2962.96\ \Omega$

(b) $\because Z_{base,HS} = \frac{V_{HS}^2}{S_{Rated}} = 115.2\ \Omega$ at $\cos\theta = 0.92 \Rightarrow \theta = 23.07°$

$\therefore R_{pu} = \frac{R_{eq,HS}}{Z_{base}} = 0.01513$ & $X_{pu} = \frac{X_{eq,HS}}{Z_{base,HS}} = 0.02806$

$\therefore V_{reg.pu} = \sqrt{(R_{pu} + \cos\theta)^2 + (X_{pu} + \sin\theta)^2} - 1 = 0.0251 = 2.51\ \%$

(c) $\because \eta_{rated} = \frac{P.F.}{P.F. + P_{core,pu} + R_{pu}}$ & $\because P_{core,p.u.} = \frac{P_{core}}{S_{rated}} = \frac{P_{o.c.}}{50000} = \frac{484}{50000} = 0.00968$

$\therefore \eta_{rated} = \frac{0.92}{0.92 + 0.00968 + 0.01513} = 0.9737 = 97.37\ \%$

4. The following 2400-240-V, 60-Hz transformers are to be operated as a parallel bank:

Transformer	KVA	Nameplate Impedance
A	50	3.53 %
B	75	2.48 %

Assume percent resistance is negligible. Can the bank be operated at its combined rating of 125-KVA without overheating? Show all work.

Given: 2400 – 240 V, 60 Hz Transf. operated in parallel

A 50 KVA $\%X_A = 3.53\% \Rightarrow Z_{p.u_A} = 0.0353$

B 75 KVA $\%X_B = 2.48\% \Rightarrow Z_{p.u,B} = 0.0248$

neglect $\%R_A$, $\%R_B$. Can the bank be operated at its combined rating 125 KVA w/o overheating, show all work

* $\because S_A \neq S_B \Rightarrow KVA_A \neq KVA_B \Rightarrow$ there will be Z_{base_A} & $Z_{base\,B}$

$\therefore I_{A,rated} = \frac{S_{A\,rated}}{V_{A\,rated}} = \frac{50000}{2400} = 20.8\,A$

& $I_{B,rated} = \frac{S_{B\,rated}}{V_{B,rated}} = \frac{75000}{2400} = 31.25\,A$

$\therefore Z_{base,A} = \frac{V_{rated,A}}{I_{rated,A}} = \frac{2400}{20.8} = 115.4\,\Omega$

& $Z_{base,B} = \frac{V_{rated,B}}{I_{rated,B}} = \frac{2400}{31.25} = 76.8\,\Omega$

$\therefore Z_{eq,A} = Z_{base,A} * Z_{pu,A} = 4.1\angle 90^\circ\,\Omega \Rightarrow Y_{eq,A} = \frac{1}{Z_{eq,A}} = 0.244\,S$

& $Z_{eq,B} = Z_{base,B} * Z_{pu,B} = 1.9\angle 90\,\Omega \Rightarrow Y_{eq,B} = \frac{1}{Z_{eq,B}} = 0.526\,S$

$\therefore Y_P = Y_{eq,A} + Y_{eq,B} = 0.77\,S$

$\therefore I_A = \frac{Y_A}{Y_P} I_{bank} = 0.317\,I_{bank}$ # ①

$I_B = \frac{Y_B}{Y_P} I_{bank} = 0.683\,I_{bank}$ # ②

$\therefore$ Bank rating Based on Transf. A $\therefore I_{bank} = \frac{I_{A\,rated}}{0.317} = \frac{20.8}{0.317} = 65.62\,A$

& 〃 〃 〃 〃 B = $I_{bank} = \frac{I_{B,rated}}{0.683} = \frac{31.25}{0.683} = 45.75\,A$

* $I_{bank} = \frac{S_{bank}}{V_{HS}} = \frac{125000}{2400} = 52.1\,A$

From ① $\therefore I_{A_{new}} = 0.317 * 52.1 = 16.52\,A$

& $I_{B_{new}} = 0.683 * 52.1 = 35.58\,A$

$\therefore S_{bank\,new\,max.} = V_{bank} I_{bank} = 2400 * 45.75 = 109.81\,KVA$

$\therefore S_{bank\,new\,max} < 125\,KVA$

$\because I_{A\,new} < I_{A\,rated}$ & $I_{B\,new} > I_{B\,rated}$ $\therefore$ this bank can not be operated in parrallel due to overheating of Transformr B

Question 3: [20 Marks] [CLO = a1, a9, b1,b2, c3]

5. The electromagnetic torque developed in a DC machine is 80 Nm for an armature current of 30 A. **What** will be the torque for a current of 15 A? Assume constant flux. **What** is the induced emf at a speed of 900 rpm and an armature current of 15 A?

Solution:

Torque developed, $T_1 = 80$ Nm

Armature current, $I_{a1} = 30$ A

Armature current, $I_{a2} = 15$ A

Let the torque developed is T_2 Nm when the armature current is 15 A.

Now $T \propto \phi I_a$

When flux ϕ is constant, $T \propto I_a$

$$\therefore \quad \frac{T_2}{T_1} = \frac{I_{a2}}{I_{a1}}$$

or $$T_2 = \frac{I_{a2}}{I} \times T1 = \frac{15}{30} \times 80 = \mathbf{40\ Nm}\ (Ans.)$$

Power developed in the armature = $E_2 I_{a_2} = \omega_2 T_2$

where $$\omega_2 = \frac{2\pi N_2}{60} = \frac{2\pi \times 900}{60} = 30\pi$$

$$\therefore \quad \text{Induced emf} = E_2 = \frac{\omega_2 T_2}{I_{a_2}} = \frac{30\pi \times 40}{15} = \mathbf{251{\cdot}33\ V}\ (Ans.)$$

6.) A 250 V, 20 kW shunt motor running at 1500 rpm has a maximum efficiency of 85 % when delivering 80 % of its rated output. The resistance of the shunt field winding is 125 Ω. **Determine** the efficiency and speed of the motor when it draws 100 A from the mains.

Solution:

$$\text{Rated output} = 20\ \text{kW} = 20000\ \text{W}$$

$$\text{Actual output} = \text{Operating } \eta \times \text{rated output} = 0.8 \times 20000\ \text{W}$$

$$\text{Maximum efficiency, } \eta_{\max} = 85\%$$

$$\text{Efficiency of machine, } \eta, = \frac{\text{Output}}{\text{Output} + \text{losses}}$$

or $$\text{Total losses} = \frac{1 - \eta_{\max}\ \text{output}}{\eta_{\max}} = \left(\frac{1}{\eta_{\max}} - 1\right) \times \text{actual output}$$

$$= \left(\frac{1}{0.85} - 1\right) \times 0.8 \times 20000 = 2824\ \text{W}$$

At maximum efficiency, constant losses (rotational losses + shunt field loss)

$$= \text{Variable armature circuit losses, } I_a^2 R_a$$

$$= \frac{\text{Total losses}}{2} = \frac{2824}{2} = 1412\ \text{W}$$

$$\text{Input to motor, } P_{in} = \text{Motor output, } P_{out} + \text{total losses}$$

$$= 20000 \times 0.8 + 2824 = 18824\ \text{W}$$

$$\text{Input line current, } I_{L1} = \frac{P_{in}}{V} = \frac{18824}{250} = 75.3\ \text{A}$$

$$\text{Shunt field current, } I_{sh} = \frac{V}{R_{sh}} = \frac{250}{125} = 2 \text{ A}$$

$$\text{Armature, } I_{a1} = I_{L1} - I_{sh} = 75.3 - 2 = 73.3 \text{ A}$$

$$\text{Armature copper loss, } I_{a1}^2 R_a = 1412 \text{ W}$$

or $$\text{Armature circuit resistance, } R_a = \frac{1412}{I_{a1}^2} = \frac{1412}{73.3^2} = 0.263 \ \Omega$$

$$\text{Now input of motor, } I_{L2} = 100 \text{ A}$$

$$\text{Armature current, } I_{a2} = I_{L2} - I_{sh} = 100 - 2 = 98 \text{ A}$$

$$\text{Armature copper loss} = I_{a2}^2 R_a = 98^2 \times 0.263 = 2{,}525 \text{ W}$$

$$\text{Motor input} = VI = 250 \times 100 = 25000 \text{ W}$$

$$\text{Motor output} = \text{Motor input} - \text{constant losses} - \text{armature copper losses}$$

$$= 25000 - 1412 - 2525 = 21063 \text{ W}$$

$$\text{Motor efficiency, } \eta = \frac{\text{Output}}{\text{Input}} \times 100 = \frac{21063}{25000} \times 100 = \mathbf{84.25\%} \ (Ans.)$$

Assuming flux remaining the same, the speed of the motor,

$$N_2 = N_1 \times \frac{E_{b2}}{E_{b1}} = N_1 \times \frac{V - I_{a2}R_a}{V - I_{a1}R_a}$$

$$= 1500 \times \frac{250 - 98 \times 0.263}{250 - 73.3 \times 0.263} = \mathbf{1458 \text{ rpm}} \ (Ans.)$$

Question 4: Short Answer Type Questions [15 Marks] [CLO = a1, a8, b1, ,b2,c1,c2]

16. Does the magnetizing current of a transformer lie in-phase with the applied voltage? Justify.

Ans. No, the phasor of magnetizing current lies in quadrature i.e., lags behind the applied voltage by 90º. It is because in pure inductive circuits, current lags behind the voltage by 90º.

17. What is the effect of saturation on exciting current of transformer?

Ans. When a transformer is operated in the saturated region of magnetization, the magnetizing current wave shape in further distorted and contains more percentage of harmonics.

18. What are the ill-effects of inrush current of transformer?

Ans. Following are the ill-effects of inrush current in a transformer:

(i) Improper operation of protective devices (ii) Momentary large voltage drops and (iii) Large humming.

19. Even at no-load, a transformer draws current from the mains. Why?

Ans. At no-load, what so ever current is drawn by a transformer that is used to meet with iron losses and to produce magnetic flux is the core.

20. Why does voltage drop in a transformer?

Ans. In a transformer, voltage drop occurs due to (i) Resistance of primary and secondary winding (ii) Reactance of primary and secondary winding.

21. Is the regulation at rated load of a transformer same at 0.8 p.f. lagging and 0.8 p.f. leading?

Ans. No, regulation at 0.8 p.f. lagging will be different to the regulation at 0.8 p.f. leading.

22. How can iron loss be measured?

Ans. Iron losses can be measured by performing no-load test on a transformer.

23. The transformers are often classified according to their applications. Discuss in details.

Ans. (i) Power Transformers: These transformers are used to step up the voltage at the generating station for transmission purposes and then to step down the voltage at the receiving stations. These transformers are of large capacity (generally above 500 kVA). These transformers usually operate at high average load, which would cause continuous capacity copper loss, thus affecting their efficiency. To have minimum losses during 24 hours, such transformers are designed with low copper losses.

(ii) Distribution Transformers: These transformers are installed at the distribution sub-stations to step down the voltage. These transformers are continuously energized causing the iron losses for all the 24 hours, generally the load on these transformers fluctuate from no-load to full load during this period. To obtain high efficiency, such transformers are designed with low iron losses.

(iii) Instrument Transformers: To measure high voltages and currents in power system potential transformer (P.T.) and current transformer (C.T.) are used, respectively. The potential transformers are used to decrease the voltage and current transformers are used to decrease the current up to measurable value. These are also used with protective devices.

(iv) Testing transformers: These transformers are used to step up voltage to a very high value for Carrying out the tests under high voltage, e.g., for testing the dielectric strength of transformer oil.

(v) Special purpose transformer: The transformers may be designed to serve special purposes, these may be used with furnaces, rectifiers, welding sets etc.

(vi) Auto-transformers: These are single winding transformers used to step down the voltages for starting of large three-phase squirrel cage induction motors.

(vii) Isolation transformer: These transformers are used only to isolate (electrically) the electronic circuits from the main electrical lines; therefore, their transformation ratio is usually one.

(viii) Impedance matching transformer: These transformers are used at the output stage of the amplifier for impedance matching to obtain maximum output from the amplifiers.

24. What do you expect if star-delta transformer is connected in parallel with a star-star transformer?

Ans. The phasor displacement cannot be compensated and the transformers will come under direct short circuit condition.

25. What is the necessity of parallel operation of three-phase transformers?

Ans. (i) It is desirable to place another transformer is parallel when the electrical load on the existing transformer increases beyond its rated capacity.

(ii) Parallel operation of transformers is necessary when the amount of power to be transformed is much more than that which can be handled by single unit (transformer). **(iii)** It is desirable to do parallel operation of transformers if we want to keep the spare transformer of smaller size.

26. Why is commutator employed in DC machines?

Ans. Commutator in employed in DC machines:

1. To convert AC into DC, in generator action, to deliver DC electric power to the load.
2. To convert DC into AC, in motor action, to develop unidirectional torque in armature.

27. For what type of DC machine lap winding is employed and for what type of DC machine, wave winding is employed?

Ans. **Lap winding** for high currents and low voltage rating machine and **wave winding** for low current and high voltage rating machine.

28. Which method is adopted to control the speed of a DC shunt motor above its base speed?

Ans. To obtain speeds above base speed, **field control** method is adopted.

29. How can the direction of rotation of a DC shunt motor be reversed?

Ans. Direction of rotation of a DC shunt motor can be reversed by reversing the current flow through either the armature winding or the field winding.

15. What do you understand by self-excitation mode of DC machine? Name two DC machines working in this mode.

Ans. The DC machine in which field winding(s) is/are excited by the current supplied by the machine itself is said to be in its self-excited made. In such machines the field coils are inter-connected with the armature winding. The self-excited machines may be (i) DC shunt machine (ii) DC series machine.

<u>Question 5: Multiple Choice Questions [15 Marks] [CLO = a1, a2, b1,b4 c3,c4]</u>

1. When a magnet is heated,

(a) it gains magnetism (b) it loses magnetism (c) it neither loses nor gains magnetism (d) none of the above.

2. ***The magnetic material used in permanent magnets is***

(b) iron (b) soft steel (c) nickel (d) hardened steel.

5. The magnetic material used in temporary magnets is

(a) hardened steel (b) cobalt steel (c) soft iron (d) tungsten steel.

6. Magnetic flux density is a

(a) vector quantity (b) scalar quantity (c) phasor (d) none of the above.

5. One weber is equal to

(a) 10^6 lines (b) $4\pi \times 10^{-7}$ lines (c) 10^{12} lines (d) 10^8 lines.

6. Magnetic field intensity is a

(a) scalar quantity (b) vector quantity (c) phasor (d) none of the above.

7. The source of a magnetic field is

(a) an isolated magnetic pole (b) static electric charge (c) magnetic substances (d) current loop.

8. Magnetic lines of force

(a) intersect at infinity (b) intersect within the magnet (c) cannot intersect at all (d) none of the above.

9. If load on a DC shunt motor is increased, its speed is decreased due primarily to

(a) increase in its flux (b) decrease in back emf (c) increase in armature current (d) increase in brush drop.

10. The torque available at the shaft of a DC motor is less than the torque developed in the armature because of………losses. (a) copper (b) mechanical (c) iron (d) rotational.

11. If the voltage applied across the armature of a DC shunt motor is increased by 5% keeping its load current and field constant, what will be the effect on its speed?

(a) decrease by about 5 % (b) remain unchanged (c) increase by about 5 % (d) increase by 10 %.

12. A DC generator is considered to be an ideal one if it has…… voltage regulation.

(a) low (b) zero (c) positive (d) negative.

13. In a DC generator, the effect of armature reaction on the main field is to

(a) reverse it (b) distort it (c) reduce it (d) both (b) and (c).

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
b	d	c	a	d	b	d	c	b	b	c	b	d	c	d

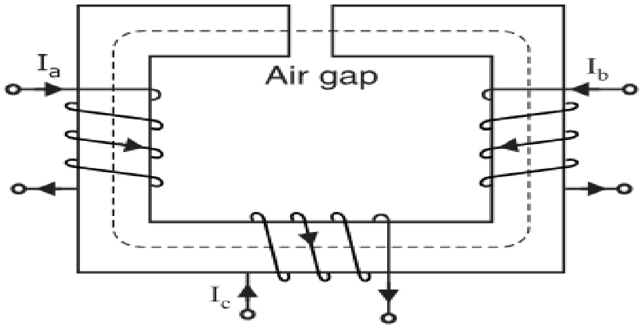
Best wishes,

Benha University
Faculty of Engineering–Benha

Department	**: Electrical Engineering**	**Date**	**: Sunday 16-1-2022**
Year	**: 3rd Power and Control**	**Time**	**: 3.0 hr.**
Exam	**: Final / Regular**	**Code**	**: E 1331**
Subject	**: Electrical Machines**	**Examiner:**	**Dr. Abdelnasser Nafeh**
Total Degrees: 90 Marks			

Answer the Following Questions

Question 1: [20 Marks] [CLO = a1, a8, b1, c1]



1. A rectangular iron core is shown in Fig. 1. It has a mean length of magnetic path of 100 cm, cross-section of 2 cm × 2 cm, relative permeability of 1400 and an air gap of 5 mm cut in the core. The three coils carried by the core have number of turns Na = 335, Nb = 600 and Nc = 600 and the respective currents are 1.6 A, 4 A and 3 A. The directions of the currents are as shown in Fig. 1. ***Find*** the flux in the air gap.

2. A coil of 200 turns of wire is wound on a magnetic circuit of reluctance 2000 At/Wb. If a current of 1A flowing in the coil is reversed in 10 ms, ***find*** the average e.m.f. induced in the coil.

Question 2: [20 Marks] [CLO = a2, a6, b2, c2]

3. Data obtained from short-circuit and open-circuit tests of a 50-kVA, 2400—600-V, 60-Hz transformer are:

Open-circuit test (Low-side data)	Short-circuit test (High-side data)
V_{OC} = 600-V	V_{SC} = 76.4-V
I_{OC} = 3.34-A	I_{SC} = 20.8-A
P_{OC} = 484-W	P_{SC} = 754-W

Determine (a) the equivalent high-side parameters; ***(b)*** voltage-regulation; ***(c)*** efficiency at rated load and 92 % power-factor lagging.

4. The following 2400-240-V, 60-Hz transformers are to be operated as a parallel bank:

Transformer	KVA	Nameplate Impedance
A	50	3.53 %
B	75	2.48 %

Assume percent resistance is negligible. ***Can the bank be operated at its combined rating of 125-KVA without overheating? Show all work.***

Question 3: [20 Marks] [CLO = a1, a9, b1,b2, c3]

5. The electromagnetic torque developed in a DC machine is 80 Nm for an armature current of 30 A. ***What*** will be the torque for a current of 15 A? Assume constant flux. ***What*** is the induced emf at a speed of 900 rpm and an armature current of 15 A?

6. A 250 V, 20 kW shunt motor running at 1500 rpm has a maximum efficiency of 85 % when delivering 80 % of its rated output. The resistance of the shunt field winding is 125 Ω. ***Determine*** the efficiency and speed of the motor when it draws 100 A from the mains.

Question 4: Short Answer Type Questions [15 Marks] [CLO = a1, a8, b1, ,b2,c1,c2]

1. Does the magnetizing current of a transformer lie in-phase with the applied voltage? Justify.
2. What is the effect of saturation on exciting current of transformer?
3. What are the ill-effects of inrush current of transformer?
4. Even at no-load, a transformer draws current from the mains. Why?
5. Why does voltage drop in a transformer?
6. Is the regulation at rated load of a transformer same at 0.8 p.f. lagging and 0.8 p.f. leading?
7. How can iron loss be measured?
8. The transformers are often classified according to their applications. Discuss in details.
9. What do you expect if star-delta transformer is connected in parallel with a star-star transformer?
10. What is the necessity of parallel operation of three-phase transformers?
11. Why is commutator employed in DC machines?
12. For what type of DC machine lap winding is employed and for what type of DC machine, wave winding is employed?
13. How can the direction of rotation of a DC shunt motor be reversed?
14. Which method is adopted to control the speed of a DC shunt motor above its base speed?
15. What do you understand by self-excitation mode of DC machine? Name two DC machines working in this mode.

Question 5: Multiple Choice Questions [15 Marks] [CLO = a1, a2, b1,b4 c3,c4]

1. When a magnet is heated,
(a) it gains magnetism (b) it loses magnetism (c) it neither loses nor gains magnetism (d) none of the above.

2. ***The magnetic material used in permanent magnets is***
(a) iron (b) soft steel (c) nickel (d) hardened steel.

3. The magnetic material used in temporary magnets is
(a) hardened steel (b) cobalt steel (c) soft iron (d) tungsten steel.

4. Magnetic flux density is a
(a) vector quantity (b) scalar quantity (c) phasor (d) none of the above.

5. One weber is equal to
(a) 10^6 lines (b) $4\pi \times 10^{-7}$ lines (c) 10^{12} lines (d) 10^8 lines.

6. Magnetic field intensity is a
(a) scalar quantity (b) vector quantity (c) phasor (d) none of the above.

7. The source of a magnetic field is
(a) an isolated magnetic pole (b) static electric charge (c) magnetic substances (d) current loop.

8. Magnetic lines of force
(a) intersect at infinity (b) intersect within the magnet (c) cannot intersect at all (d) none of the above.

9. If load on a DC shunt motor is increased, its speed is decreased due primarily to
(a) increase in its flux (b) decrease in back emf (c) increase in armature current (d) increase in brush drop.

10. The torque available at the shaft of a DC motor is less than the torque developed in the armature because of………losses. (a) copper (b) mechanical (c) iron (d) rotational.

11. If the voltage applied across the armature of a DC shunt motor is increased by 5% keeping its load current and field constant, what will be the effect on its speed?
(a) decrease by about 5 % (b) remain unchanged (c) increase by about 5 % (d) increase by 10 %.

12. A DC generator is considered to be an ideal one if it has…… voltage regulation.
(a) low (b) zero (c) positive (d) negative.

13. In a DC generator, the effect of armature reaction on the main field is to
(a) reverse it (b) distort it (c) reduce it (d) both (b) and (c).

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Best wishes,