EE 111 (Introduction to Electrical Systems)

Quiz-3 FM: 30

Name: Roll No.

Q1) The mmf wave distribution in the air gap of an induction machine (from 0^0 to $+90^0$ and 0^0 to -90^0) due to only phase-A distributive winding is shown in Figure 1A. The mmf wave distribution from $+90^0$ to $+180^0$ and from $+180^0$ to -90^0 remains symmetric to that of the distribution shown between 0^0 to $+90^0$ and 0^0 to -90^0. The rotor conductors of the machine are removed. Each slot of the stator winding for phase-A of the machine shown in the figure 1B is having 5 conductors and each conductor is carrying 1 A of dc current. Indicate the current distribution (dots and/or crosses) in Figure 1B. **[5 marks]**

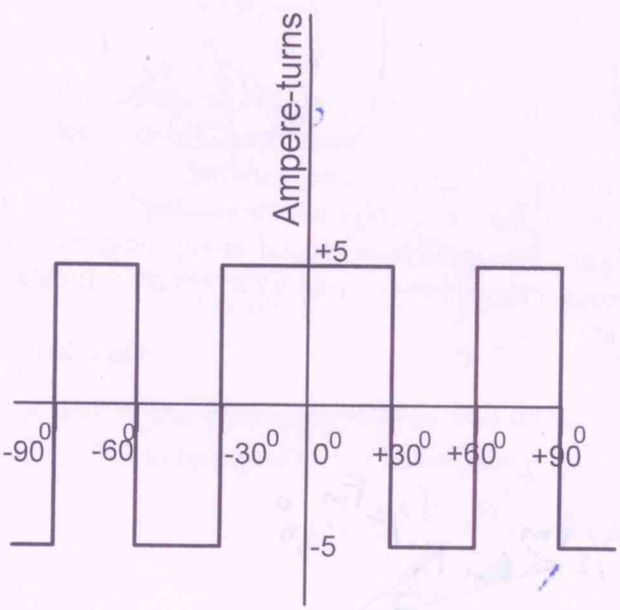


Figure 1A

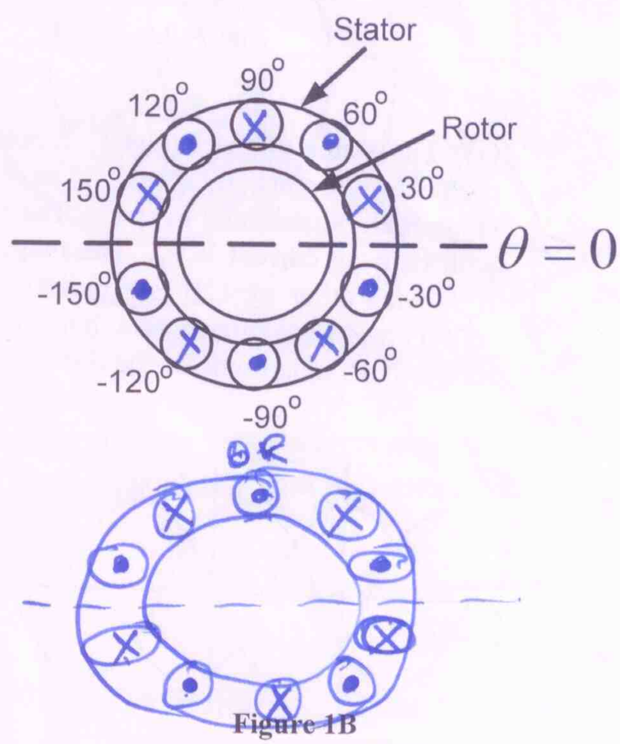


Figure 1B

Q2) The locations of Phase-A, Phase-B and Phase-C stator windings (they are distributed winding, however they are represented as concentrated one) of a three phase 2 pole induction machine is shown in Figure 2A and the location of the Phase-A windings of a three phase 4 pole induction machine is shown in Figure 2 B.

1) Indicate on the figure the mechanical angle that exists between 'a' and 'c' in Figure 2A.
2) Indicate the location $c_1, c_1^{/}$ and $c_2, c_2^{/}$ (as concentrated winding) in Figure 2B with properly indicating the mechanical angles that exist between them with respect to $a_1, a_1^{/}$ and $a_2, a_2^{/}$

[(2+5) marks]

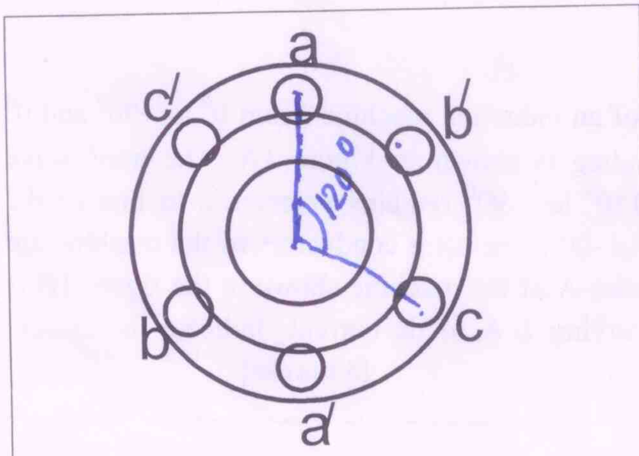


Figure 2A

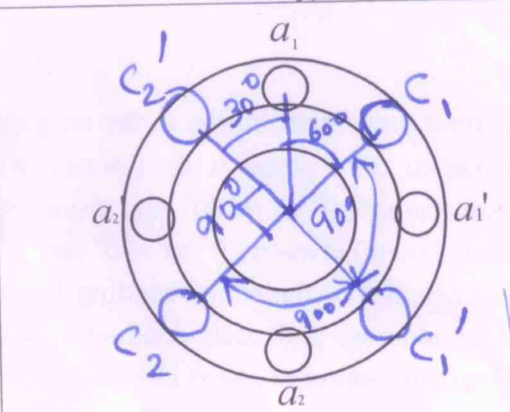
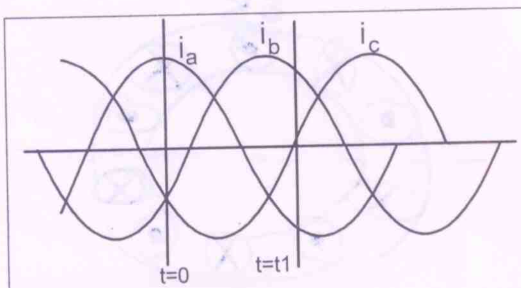


Figure 2B

Angle between a_1 and c_1 is $\boxed{60^0}$

Q3) The stator of the 3 phase, 2 pole induction machine of Figure 2A is excited with three sinusoidal currents, i_a, i_b, and i_c as shown in Figure 3A. The mmf produced by each coil is sinusoidally distributed in space. The peak mmf produced by a phase winding while it is excited with its peak current is F_m. The magnetic axes of the three coils which are displaced in space from each other by 120° are indicated in Figure 3B (mmf is produced along these axes when 'dot' currents are carried by a, b and c and 'cross' currents are carried by $a^{/}$, $b^{/}$ and $c^{/}$. Indicate the location and magnitude of the resultant mmf at $t = t_1$

[3 marks]

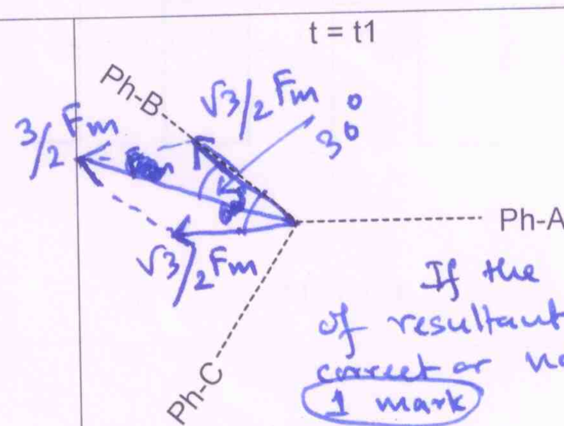


$i_a = I_m \cos \omega t$

$i_b = I_m \cos(\omega t - 120^0)$

$i_c = I_m \cos(\omega t - 240^0)$

Figure 3(A)



If the magnitude of resultant mmf is not correct or not given deduct 1 mark

Figure 3 (B)

If the location is not (±30°) mentioned but visually it appears to be correct deduct 0.5 mark.

Q4) The sinusoidally distributed rotating magnetic field in the airgap of an induction motor at a particular instant is as indicated in the diagrams, Figure 4(a) and 4(b) (N and S indicates the location of the peak of the rotating sinusoidal wave). The ends of all the rotor windings are shorted, however in the diagram only phase-a winding of the rotor is shown to be shorted. The rotor windings are distributed and hence the mmf of the rotor field is also sinusoidally distributed in space. At this instant indicate the magnetic field produced by the rotor by placing 'N_r' and 'S_r' at a suitable location on the rotor body so that location of N_r and S_r indicates the peak of the rotor produced rotating magnetic field in

1) Figure 4A considering the leakage inductance of the rotor to be zero. Indicate the angle between N and N_r

2) Figure 4 B considering the leakage inductance of the rotor to be finite. Indicate the approximate angle between N and N_r [5 marks]

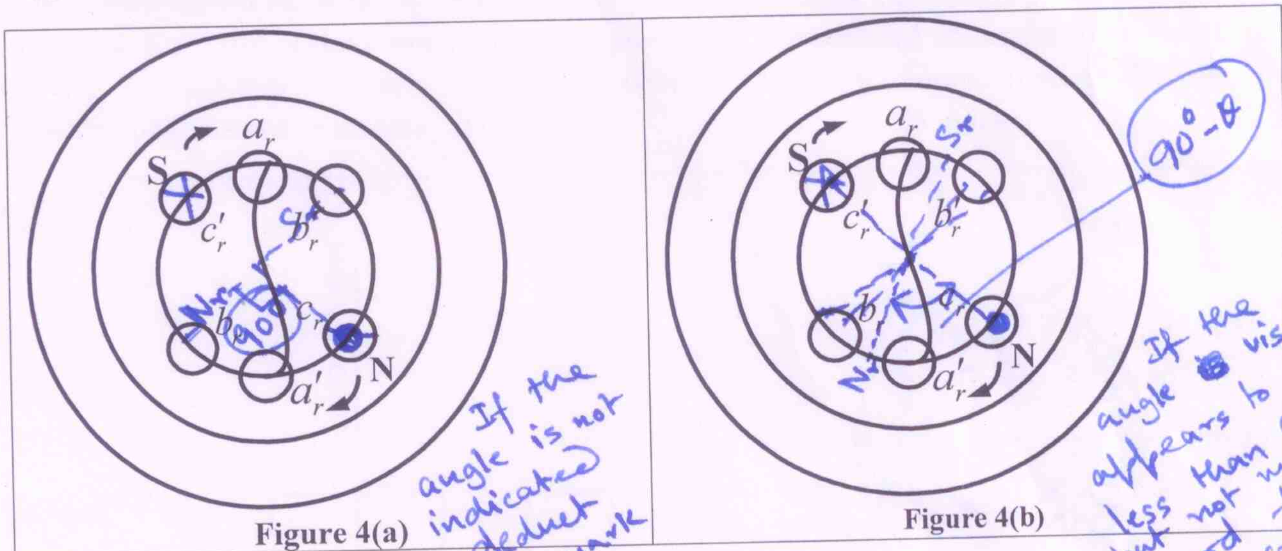


Figure 4(a) Figure 4(b)

If the angle is not indicated deduct 1 mark

If the angle visually appears to be less than 90°, but not marked, award full credit.

Q5) A 400 V, star connected, 50 Hz, 960 rpm slip ring induction motor with stator to rotor turns ration (N_s/N_r) to be equal to 1 is having the following per phase equivalent circuit parameters:

$R_1 = 0.0$, $X_1 = 0.0$, X_m = infinite, $x_2 = 0.0$, $r_2 = 0.4\ \Omega$.

Find

1) a) the rated current of the machine and b) the rated torque of the machine

2) the value of the per phase external rotor resistance to be connected so that rated torque is developed by the machine at starting. Neglect rotational and iron losses of the machine.

[(3+3+4) marks]

Q5. $N_s = 1000$ rpm

rated slip $= \dfrac{1000 - 960}{1000} = \dfrac{40}{1000} = 0.04$ 1 mark

Per phase voltage of the m/c $= 230.94 \simeq 231$ V.

Rated current $= \dfrac{231}{\frac{0.4}{0.04}} = \boxed{23.1 \text{ A.}}$ 2 marks

$\therefore$ Rated torque $= \dfrac{3}{\frac{2\pi 1000}{60}} \cdot I_2'^2 \dfrac{0.4.}{0.04}$ Nm

$= \dfrac{3 \times 60}{2\pi 1000} \times (23.1)^2 \times 10$ Nm 3 marks

$\boxed{= 152.86 \text{ Nm}}$

If rated torque is to be developed at starting, rated current is required to be drawn by the m/c ~~at~~ during starting.

$23.1 = \dfrac{231}{r_2' + r_x}$ $\therefore r_2' + r_x = 10$ 2 marks

$\therefore r_x = 10 - 0.4\ \Omega = \boxed{9.6\ \Omega.}$ 1 mark

Quiz-3

EE 111 (Introduction to Electrical Systems)

FM: 30

Name:

Roll No.

Q1) The mmf wave distribution in the air gap of an induction machine (from 0^0 to $+90^0$ and 0^0 to -90^0) due to only phase-A distributive winding is shown in Figure 1A. The mmf wave distribution from $+90^0$ to $+180^0$ and from $+180^0$ to -90^0 remains symmetric to that of the distribution shown between 0^0 to $+90^0$ and 0^0 to -90^0. The rotor conductors of the machine are removed. Each slot of the stator winding for phase-A of the machine shown in the figure 1B is having 5 conductors and each conductor is carrying 1 A of dc current. Indicate the current distribution (dots and/or crosses) in Figure 1B. **[5 marks]**

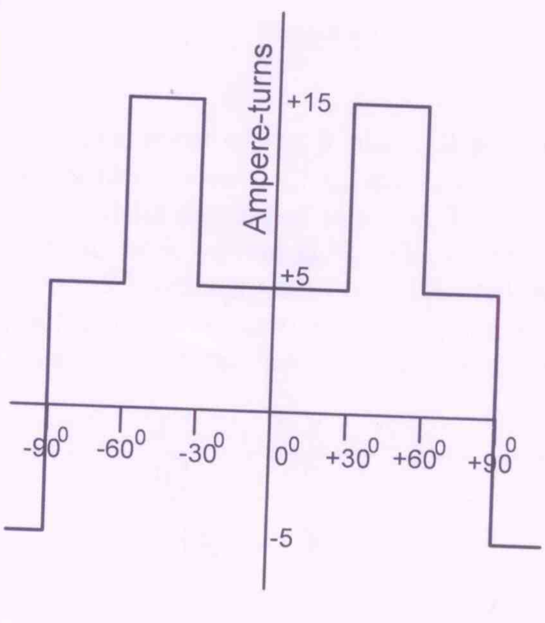


Figure 1A

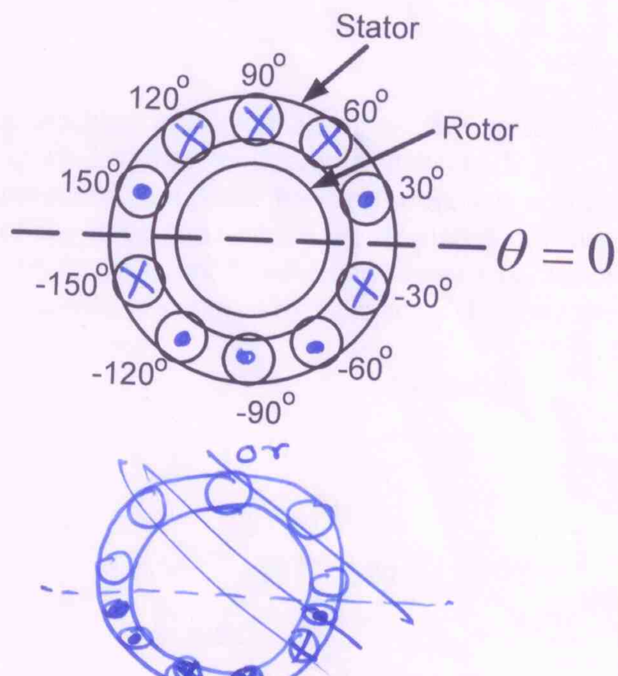
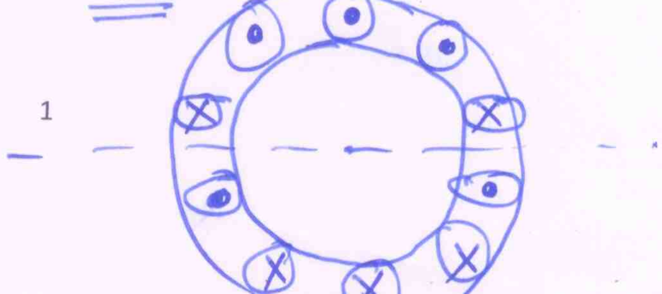


Figure 1B

OR.



Q2) The locations of Phase-A, Phase-B and Phase-C stator windings (they are distributed winding, however they are represented as concentrated one) of a three phase 2 pole induction machine is shown in Figure 2A and the location of the Phase-A windings of a three phase 4 pole induction machine is shown in Figure 2 B.

1) Indicate on the figure the mechanical angle that exists between 'a' and '$b^{/}$' in Figure 2A.
2) Indicate the location b_1, $b_1^{/}$ and b_2, $b_2^{/}$ (as concentrated winding) in Figure 2B with properly indicating the mechanical angles that exist between them with respect to a_1, $a_1^{/}$ and a_2, $a_2^{/}$

[(2+5) marks]

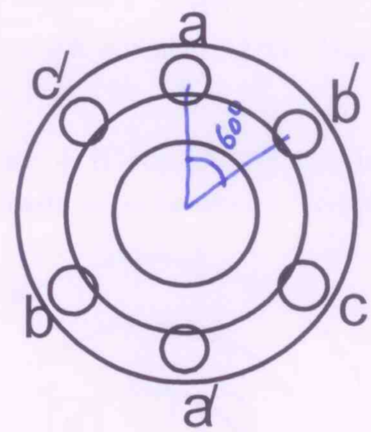


Figure 2A

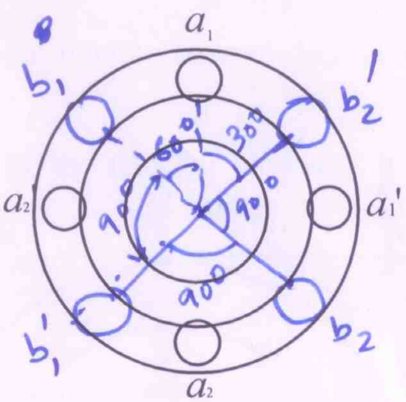
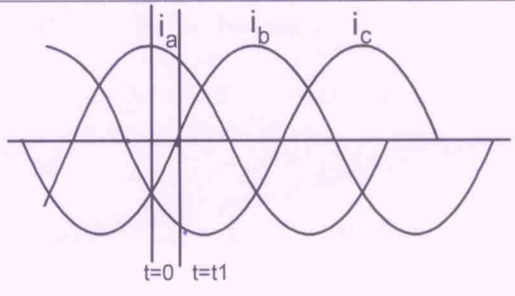


Figure 2B

Angle between a_1 and b_1 is $\boxed{60^0}$

Q3) The stator of the 3 phase, 2 pole induction machine of Figure 2A is excited with three sinusoidal currents, i_a, i_b, and i_c as shown in Figure 3A. The mmf produced by each coil is sinusoidally distributed in space. The peak mmf produced by a phase winding while it is excited with its peak current is F_m. The magnetic axes of the three coils which are displaced in space from each other by 120^0 are indicated in Figure 3B (mmf is produced along theses axes when 'dot' currents are carried by a, b and c and 'cross' currents are carried by $a^{/}$, $b^{/}$ and $c^{/}$. Indicate the location and magnitude of the resultant mmf at $t = t_1$

[3 marks]



$$i_a = I_m \cos \omega t$$

$$i_b = I_m \cos(\omega t - 120^0)$$

$$i_c = I_m \cos(\omega t - 240^0)$$

Figure 3(A)

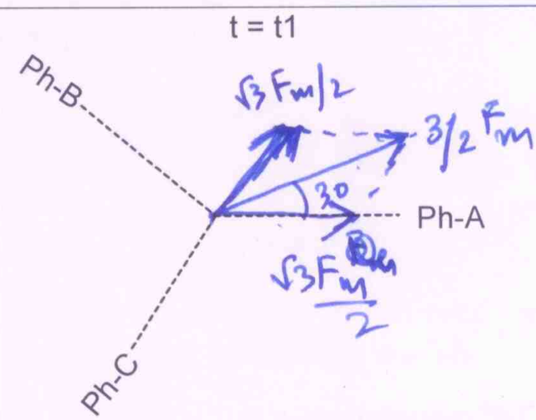


Figure 3 (B)

Q4) The sinusoidally distributed rotating magnetic field in the airgap of an induction motor at a particular instant is as indicated in the diagrams, Figure 4(a) and 4(b) (N and S indicates the location of the peak of the rotating sinusoidal wave). The ends of all the rotor windings are shorted, however in the diagram only phase-a winding of the rotor is shown to be shorted. The rotor windings are distributed and hence the mmf of the rotor field is also sinusoidally distributed in space. At this instant indicate the magnetic field produced by the rotor by placing 'N_r' and 'S_r' at a suitable location on the rotor body so that location of N_r and S_r indicates the peak of the rotor produced rotating magnetic field in

1) Figure 4A considering the leakage inductance of the rotor to be zero. Indicate the angle between N and N_r

2) Figure 4 B considering the leakage inductance of the rotor to be finite. Indicate the approximate angle between N and N_r [5 marks]

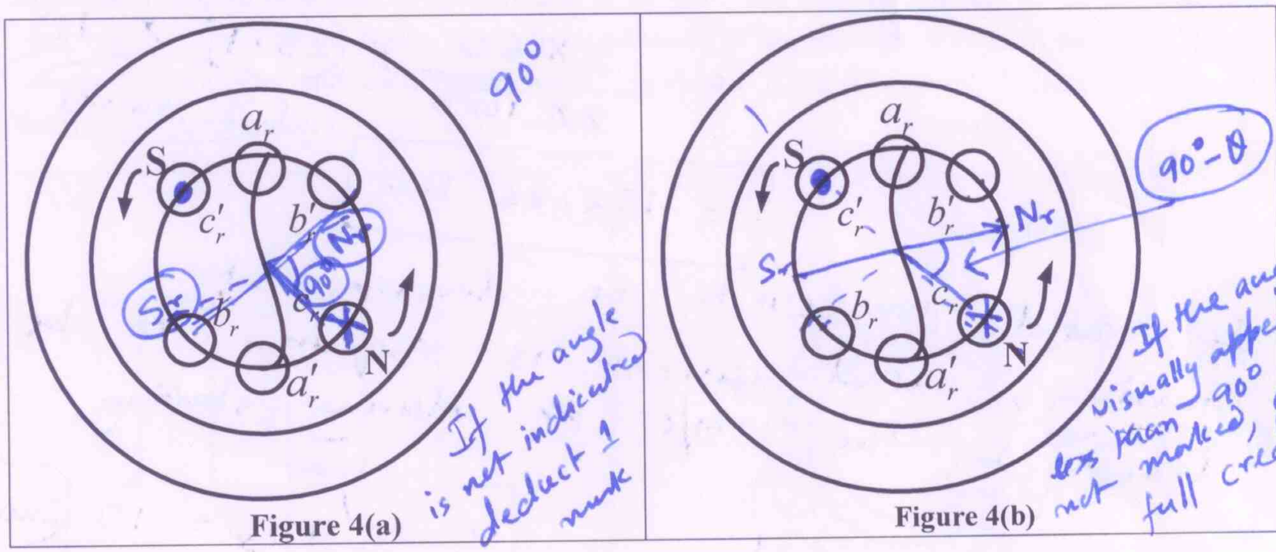


Figure 4(a) Figure 4(b)

Q5) A 400 V, star connected, 50 Hz, 960 rpm slip ring induction motor with stator to rotor turns ration (N_s/N_r) to be equal to 1 is having the following per phase circuit parameters:

$R_1 = 0.0$, $X_1 = 0.0$, X_m = infinite, $x_2 = 0.0$, $r_2 = 0.4\ \Omega$.

Find

1) a) the rated current of the machine and b) the rated torque of the machine

2) the value of the per phase external rotor resistance to be connected so that rated torque is developed by the machine at starting. Neglect rotational and iron losses of the machine.

[(3+3+4) marks]