CHAPTER 4

ELECTRICAL MACHINES

YEAR 2012 **ONE MARK**

MCQ 4.1 The slip of an induction motor normally does not depend on

(A) rotor speed
(B) synchronous speed
(C) shaft torque
(D) core-loss component

YEAR 2012 **TWO MARKS**

MCQ 4.2 A 220 V, 15 kW, 100 rpm shunt motor with armature resistance of $0.25\,\Omega$, has a rated line current of 68 A and a rated field current of 2.2 A. The change in field flux required to obtain a speed of 1600 rpm while drawing a line current of 52.8 A and a field current of 1.8 A is

(A) 18.18% increase
(B) 18.18% decrease
(C) 36.36% increase
(D) 36.36% decrease

MCQ 4.3 The locked rotor current in a 3-phase, star connected 15 kW, 4 pole, 230 V, 50 Hz induction motor at rated conditions is 50 A. Neglecting losses and magnetizing current, the approximate locked rotor line current drawn when the motor is connected to a 236 V, 57 Hz supply is

(A) 58.5 A
(B) 45.0 A
(C) 42.7 A
(D) 55.6 A

MCQ 4.4 A single phase 10 kVA, 50 Hz transformer with 1 kV primary winding draws 0.5 A and 55 W, at rated voltage and frequency, on no load. A second transformer has a core with all its linear dimensions $\sqrt{2}$ times the corresponding dimensions of the first transformer. The core material and lamination thickness are the same in both transformer. The primary winding of both the transformers have the save number of turns. If a rate voltage of 2 kV at 50 Hz is applied to the primary of the second transformer, then the no load current and power, respectively, are

(A) 0.7 A, 77.8 A
(B) 0.7 A, 155.6 W
(C) 1 A, 110 W
(D) 1 A, 220 W

YEAR 2011 ONE MARK

MCQ 4.5 A 4 point starter is used to start and control the speed of a

(A) dc shunt motor with armature resistance control

(B) dc shunt motor with field weakening control

(C) dc series motor

(D) dc compound motor

MCQ 4.6 A three phase, salient pole synchronous motor is connected to an infinite bus. It is operated at no load a normal excitation. The field excitation of the motor is first reduced to zero and then increased in reverse direction gradually. Then the armature current.

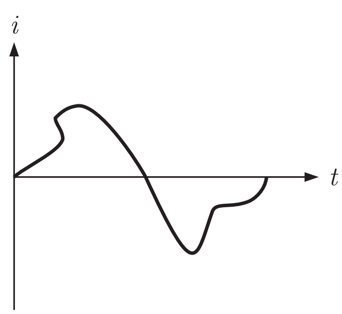
(A) Increases continuously

(B) First increases and then decreases steeply

(C) First decreases and then increases steeply

(D) Remains constant

MCQ 4.7 A single phase air core transformer, fed from a rated sinusoidal supply, is operating at no load. The steady state magnetizing current drawn by the transformer from the supply will have the waveform

(A)


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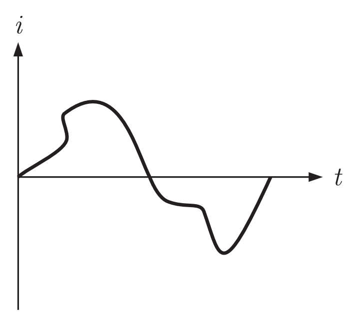

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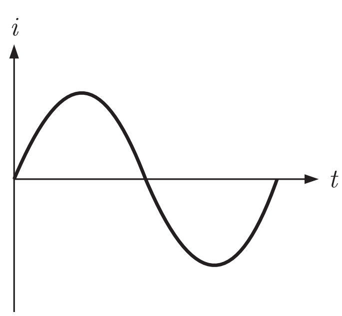
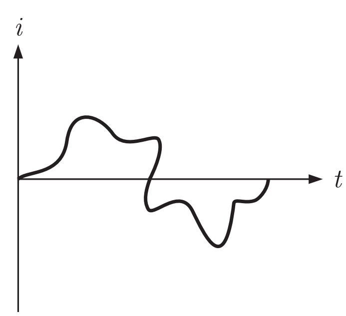


(D)


YEAR 2011 TWO MARKS

MCQ 4.8 A 220 V, DC shunt motor is operating at a speed of 1440 rpm. The armature resistance is $1.0\,\Omega$ and armature current is 10 A. of the excitation of the

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machine is reduced by 10%, the extra resistance to be put in the armature circuit to maintain the same speed and torque will be

(A) 1.79 Ω (B) 2.1 Ω

(C) 18.9 Ω (D) 3.1 Ω

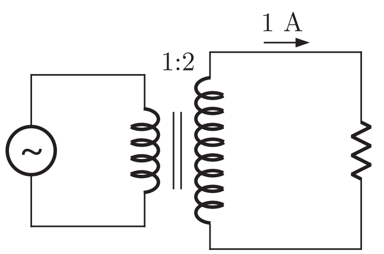
MCQ 4.9 A three-phase 440 V, 6 pole, 50 Hz, squirrel cage induction motor is running at a slip of 5%. The speed of stator magnetic field to rotor magnetic field and speed of rotor with respect of stator magnetic field are

(A) zero, −5 rpm (B) zero, 955 rpm

(C) 1000 rpm, −5 rpm (D) 1000 rpm, 955 rpm

YEAR 2010 ONE MARK

MCQ 4.10 A Single-phase transformer has a turns ratio 1:2, and is connected to a purely resistive load as shown in the figure. The magnetizing current drawn is 1 A, and the secondary current is 1 A. If core losses and leakage reactances are neglected, the primary current is



(A) 1.41 A (B) 2 A

(C) 2.24 A (D) 3 A

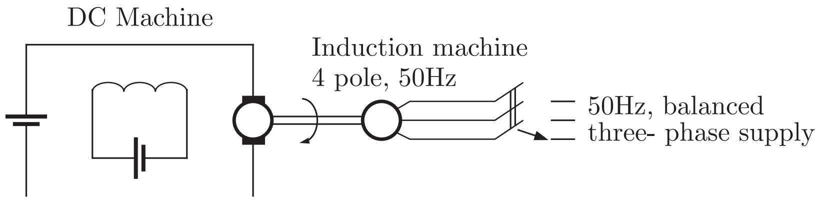
MCQ 4.11 A balanced three-phase voltage is applied to a star-connected induction motor, the phase to neutral voltage being V. The stator resistance, rotor resistance referred to the stator, stator leakage reactance, rotor leakage reactance referred to the stator, and the magnetizing reactance are denoted by r_s, r_r, X_s, X_r and X_m, respectively. The magnitude of the starting current of the motor is given by

(A) $\frac{V_s}{\sqrt{(r_s + r_r)^2 + (X_s + X_r)^2}}$ (B) $\frac{V_s}{\sqrt{r_s^2 + (X_s + X_m)^2}}$

(C) $\frac{V_s}{\sqrt{(r_s + r_r)^2 + (X_m + X_r)^2}}$ (D) $\frac{V_s}{\sqrt{r_s^2 + (X_m + X_r)^2}}$

YEAR 2010 TWO MARKS

MCQ 4.12 A separately excited dc machine is coupled to a 50 Hz, three-phase, 4-pole induction machine as shown in figure. The dc machine is energized first and the machines rotate at 1600 rpm. Subsequently the induction machine is also connected to a 50 Hz, three-phase source, the phase sequence being consistent with the direction of rotation. In steady state



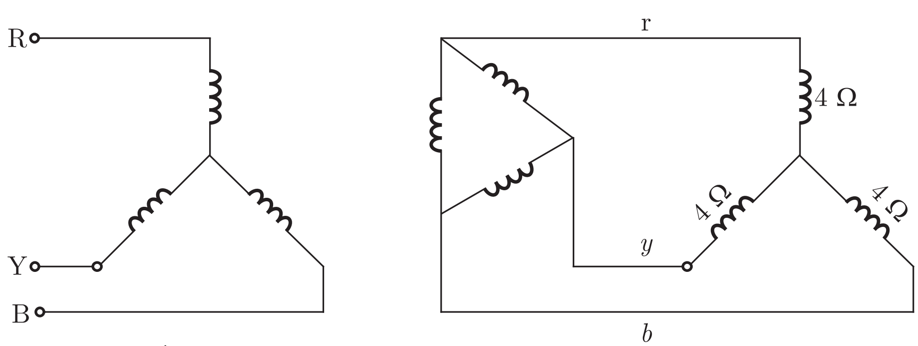
(A) both machines act as generator

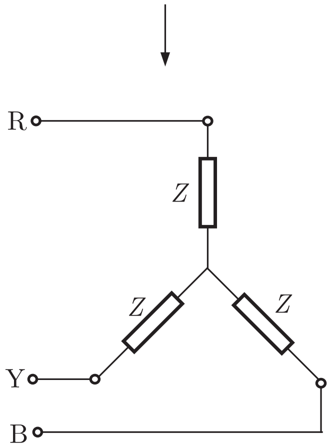
(B) the dc machine acts as a generator, and the induction machine acts as a motor

(C) the dc machine acts as a motor, and the induction machine acts as a generator

(D) both machines act as motors

MCQ 4.13 A balanced star-connected and purely resistive load is connected at the secondary of a star-delta transformer as shown in figure. The line-to line voltage rating of the transformer is 110 V/200 V.
Neglecting the non-idealities of the transformer, the impedance Z of the equivalent star-connected load, referred to the primary side of the transformer, is





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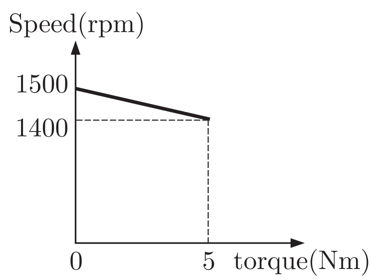
(A) $(3 + j0)\,\Omega$ (B) $(0.866 - j0.5)\,\Omega$
(C) $(0.866 + j0.5)\,\Omega$ (D) $(1 + j0)\,\Omega$

Common Data for Questions 14 and 15

A separately excited DC motor runs at 1500 rpm under no-load with 200 V applied to the armature. The field voltage is maintained at its rated value. The speed of the motor, when it delivers a torque of 5 Nm, is 1400 rpm as shown in figure. The rotational losses and armature reaction are neglected.



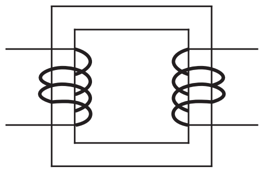
MCQ 4.14 The armature resistance of the motor is
(A) 2 Ω (B) 3.4 Ω
(C) 4.4 Ω (D) 7.7 Ω

MCQ 4.15 For the motor to deliver a torque of 2.5 Nm at 1400 rpm, the armature voltage to be applied is
(A) 125.5 V (B) 193.3 V
(C) 200 V (D) 241.7 V

YEAR 2009 ONE MARK

MCQ 4.16 A field excitation of 20 A in a certain alternator results in an armature current of 400 A in short circuit and a terminal voltage of 2000 V on open circuit. The magnitude of the internal voltage drop within the machine at a load current of 200 A is
(A) 1 V (B) 10 V
(C) 100 V (D) 1000 V

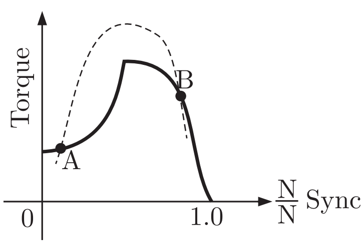
MCQ 4.17 The single phase, 50 Hz iron core transformer in the circuit has both the vertical arms of cross sectional area 20 cm^2 and both the horizontal arms of cross sectional area 10 cm^2. If the two windings shown were wound instead on opposite horizontal arms, the mutual inductance will



(A) double (B) remain same

(C) be halved (D) become one quarter

MCQ 4.18 A 3-phase squirrel cage induction motor supplied from a balanced 3-phase source drives a mechanical load. The torque-speed characteristics of the motor(solid curve) and of the load(dotted curve) are shown. Of the two equilibrium points A and B, which of the following options correctly describes the stability of A and B ?

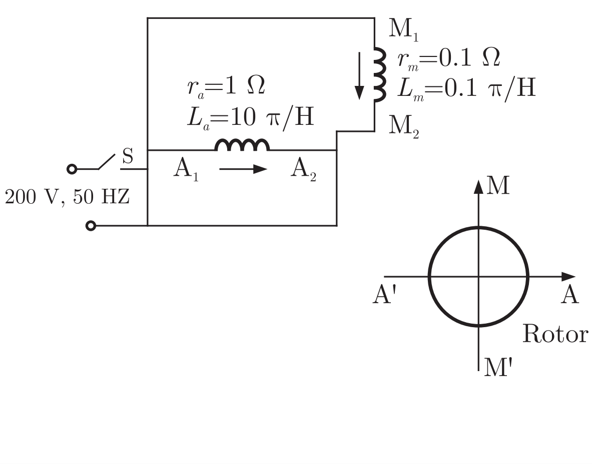


(A) A is stable, B is unstable (B) A is unstable, B is stable

(C) Both are stable (D) Both are unstable

YEAR 2009 TWO MARKS

MCQ 4.19 A 200 V, 50 Hz, single-phase induction motor has the following connection diagram and winding orientations as shown. MM' is the axis of the main stator winding(M_1M_2) and AA' is that of the auxiliary winding(A_1A_2). Directions of the winding axis indicate direction of flux when currents in the windings are in the directions shown. Parameters of each winding are indicated. When switch S is closed the motor



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(A) rotates clockwise

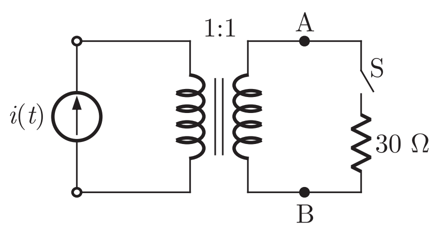
(B) rotates anti-clockwise

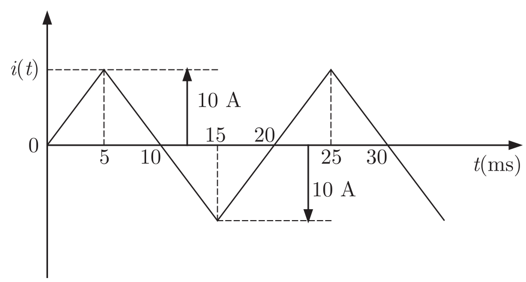
(C) does not rotate

(D) rotates momentarily and comes to a halt

Common Data for Questions 20 and 21 :

The circuit diagram shows a two-winding, lossless transformer with no leakage flux, excited from a current source, $i(t)$, whose waveform is also shown. The transformer has a magnetizing inductance of $400/\pi$ mH.





MCQ 4.20 The peak voltage across A and B, with S open is

(A) $\frac{400}{\pi}$ V (B) 800 V

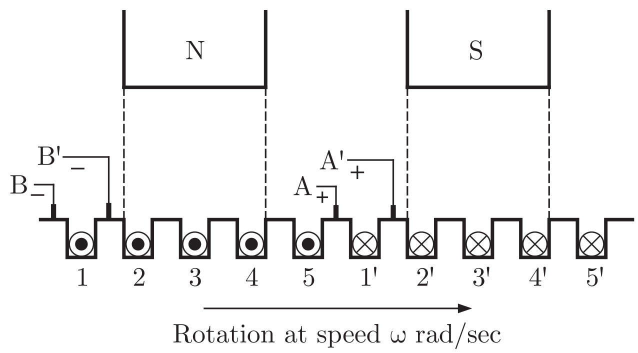
(C) $\frac{4000}{\pi}$ V (D) $\frac{800}{\pi}$ V

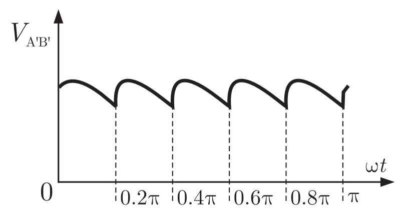
MCQ 4.21 If the wave form of $i(t)$ is changed to $i(t) = 10\sin(100\pi t)$ A, the peak voltage across A and B with S closed is

(A) 400 V (B) 240 V

(C) 320 V (D) 160 V

MCQ 4.22 Figure shows the extended view of a 2-pole dc machine with 10 armature conductors. Normal brush positions are shown by A and B, placed at the interpolar axis. If the brushes are now shifted, in the direction of rotation, to A' and B' as shown, the voltage waveform $V_{A'B'}$ will resemble



(A)


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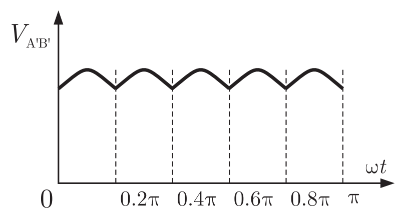

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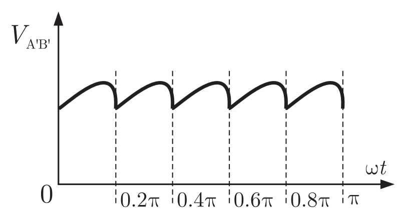
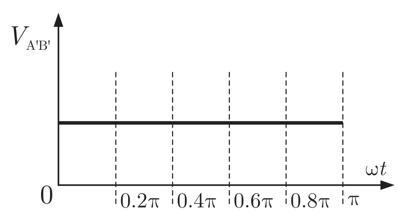
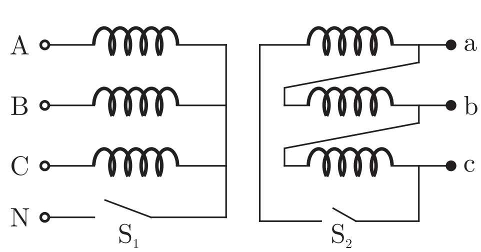


(D)


Common Data for Questions 14 and 15:



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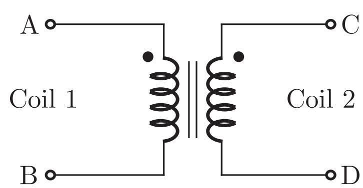
The star-delta transformer shown above is excited on the star side with balanced, 4-wire, 3-phase, sinusoidal voltage supply of rated magnitude. The transformer is under no load condition

MCQ 4.23 With both S1 and S2 open, the core flux waveform will be
(A) a sinusoid at fundamental frequency
(B) flat-topped with third harmonic
(C) peaky with third-harmonic
(D) none of these

MCQ 4.24 With S2 closed and S1 open, the current waveform in the delta winding will be
(A) a sinusoid at fundamental frequency
(B) flat-topped with third harmonic
(C) only third-harmonic
(D) none of these

Statement for Linked Answer Questions 25 and 26 :



The figure above shows coils-1 and 2, with dot markings as shown, having 4000 and 6000 turns respectively. Both the coils have a rated current of 25 A. Coil-1 is excited with single phase, 400 V, 50 Hz supply.

MCQ 4.25 The coils are to be connected to obtain a single-phase, $\frac{400}{1000}$ V, auto-transformer to drive a load of 10 kVA. Which of the options given should be exercised to realize the required auto-transformer ?
(A) Connect A and D; Common B
(B) Connect B and D; Common C
(C) Connect A and C; Common B
(D) Connect A and C; Common D

MCQ 4.26 In the autotransformer obtained in Question 16, the current in each coil is
(A) Coil-1 is 25 A and Coil-2 is 10 A
(B) Coil-1 is 10 A and Coil-2 is 25 A
(C) Coil-1 is 10 A and Coil-2 is 15 A
(D) Coil-1 is 15 A and Coil-2 is 10 A

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YEAR 2008 **ONE MARK**

MCQ 4.27 Distributed winding and short chording employed in AC machines will result in

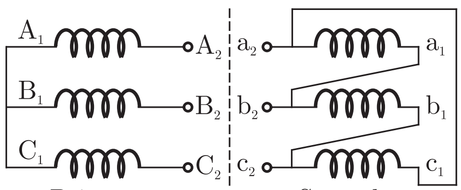
(A) increase in emf and reduction in harmonics

(B) reduction in emf and increase in harmonics

(C) increase in both emf and harmonics

(D) reduction in both emf and harmonics

MCQ 4.28 Three single-phase transformer are connected to form a 3-phase transformer bank. The transformers are connected in the following manner :



The transformer connecting will be represented by

(A) Y d0 (B) Y d1

(C) Y d6 (D) Y d11

MCQ 4.29 In a stepper motor, the detent torque means

(A) minimum of the static torque with the phase winding excited

(B) maximum of the static torque with the phase winding excited

(C) minimum of the static torque with the phase winding unexcited

(D) maximum of the static torque with the phase winding unexcited

MCQ 4.30 It is desired to measure parameters of 230 V/115 V, 2 kVA, single-phase transformer. The following wattmeters are available in a laboratory:

W_1 : 250 V, 10 A, Low Power Factor

W_2 : 250 V, 5 A, Low Power Factor

W_3 : 150 V, 10 A, High Power Factor

W_4 : 150 V, 5 A, High Power Factor

The Wattmeters used in open circuit test and short circuit test of the transformer will respectively be

(A) W_1 and W_2 (B) W_2 and W_4

(C) W_1 and W_4 (D) W_2 and W_3

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YEAR 2008 TWO MARKS

MCQ 4.31 A 230 V, 50 Hz, 4-pole, single-phase induction motor is rotating in the clockwise (forward) direction at a speed of 1425 rpm. If the rotor resistance at standstill is 7.8 Ω, then the effective rotor resistance in the backward branch of the equivalent circuit will be

(A) 2 Ω (B) 4 Ω

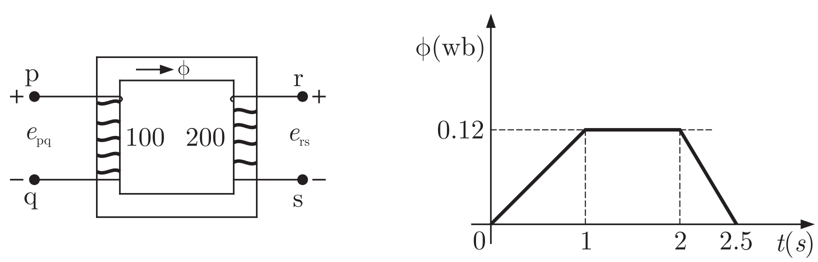
(C) 78 Ω (D) 156 Ω

MCQ 4.32 A 400 V, 50 Hz 30 hp, three-phase induction motor is drawing 50 A current at 0.8 power factor lagging. The stator and rotor copper losses are 1.5 kW and 900 W respectively. The friction and windage losses are 1050 W and the core losses are 1200 W. The air-gap power of the motor will be

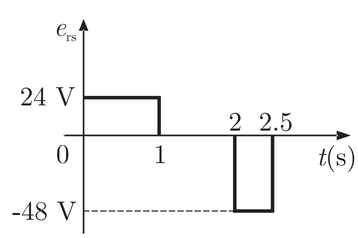
(A) 23.06 kW (B) 24.11 kW

(C) 25.01 kW (D) 26.21 kW

MCQ 4.33 The core of a two-winding transformer is subjected to a magnetic flux variation as indicated in the figure.



The induced emf (e_{rs}) in the secondary winding as a function of time will be of the form

(A)


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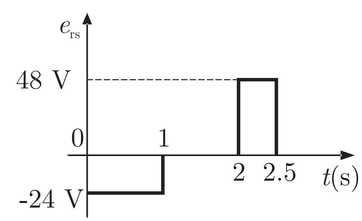
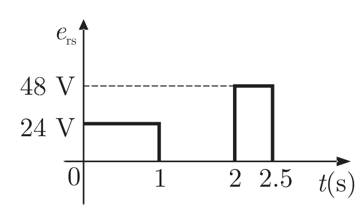


(C)


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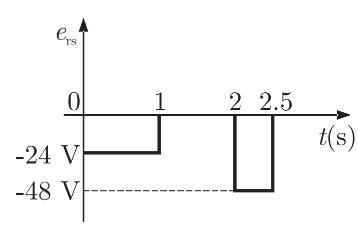

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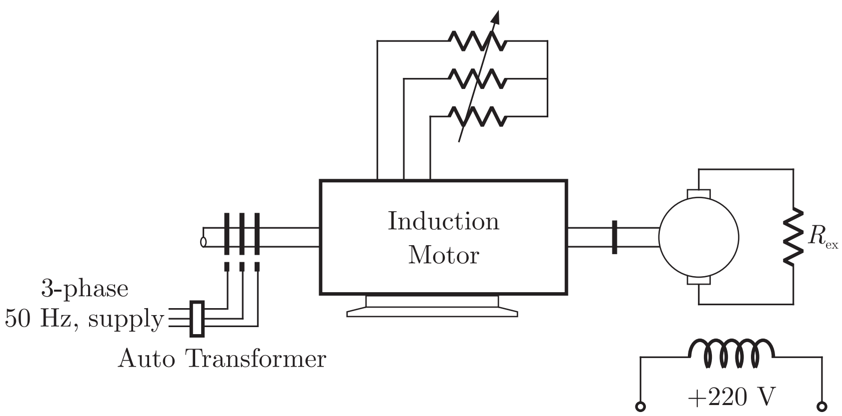
MCQ 4.34 A 400 V, 50 Hz, 4-pole, 1400 rpm, star connected squirrel cage induction motor has the following parameters referred to the stator:
$R'_r = 1.0\,\Omega, X_s = X'_r = 1.5\,\Omega$
Neglect stator resistance and core and rotational losses of the motor. The motor is controlled from a 3-phase voltage source inverter with constant V/f control. The stator line-to-line voltage(rms) and frequency to obtain the maximum torque at starting will be :

(A) 20.6 V, 2.7 Hz
(B) 133.3 V, 16.7 Hz
(C) 266.6 V, 33.3 Hz
(D) 323.3 V, 40.3 Hz

Common Data for Questions 35 and 36.

A 3-phase, 440 V, 50 Hz, 4-pole slip ring induction motor is feed from the rotor side through an auto-transformer and the stator is connected to a variable resistance as shown in the figure.



The motor is coupled to a 220 V, separately excited d.c generator feeding power to fixed resistance of 10 Ω. Two-wattmeter method is used to measure the input power to induction motor. The variable resistance is adjusted such the motor runs at 1410 rpm and the following readings were recorded $W_1 = 1800$ W, $W_2 = -200$ W.

MCQ 4.35 The speed of rotation of stator magnetic field with respect to rotor structure will be

(A) 90 rpm in the direction of rotation
(B) 90 rpm in the opposite direction of rotation
(C) 1500 rpm in the direction of rotation
(D) 1500 rpm in the opposite direction of rotation

MCQ 4.36 Neglecting all losses of both the machines, the dc generator power output and the current through resistance (R_{ex}) will respectively be

(A) 96 W, 3.10 A
(B) 120 W, 3.46 A

(C) 1504 W, 12.26 A (D) 1880 W, 13.71 A

Statement for Linked Answer Question 37 and 38.

A 240 V, dc shunt motor draws 15 A while supplying the rated load at a speed of 80 rad/s. The armature resistance is 0.5 Ω and the field winding resistance is 80 Ω.

MCQ 4.37 The net voltage across the armature resistance at the time of plugging will be

(A) 6 V (B) 234 V

(C) 240 V (D) 474 V

MCQ 4.38 The external resistance to be added in the armature circuit to limit the armature current to 125% of its rated value is

(A) 31.1 Ω (B) 31.9 Ω

(C) 15.1 Ω (D) 15.9 Ω

Statement for Linked Answer Question 39 and 40.

A synchronous motor is connected to an infinite bus at 1.0 pu voltage and draws 0.6 pu current at unity power factor. Its synchronous reactance is 1.0 pu resistance is negligible.

MCQ 4.39 The excitation voltage (E) and load angle (δ) will respectively be

(A) 0.8 pu and 36.86° lag (B) 0.8 pu and 36.86° lead

(C) 1.17 pu and 30.96° lead (D) 1.17 pu and 30.96° lag

MCQ 4.40 Keeping the excitation voltage same, the load on the motor is increased such that the motor current increases by 20%. The operating power factor will become

(A) 0.995 lagging (B) 0.995 leading

(C) 0.791 lagging (D) 0.848 leading

YEAR 2007 ONE MARK

MCQ 4.41 In a transformer, zero voltage regulation at full load is

(A) not possible

(B) possible at unity power factor load

(C) possible at leading power factor load

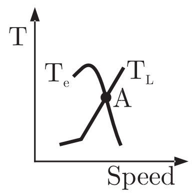
(D) possible at lagging power factor load

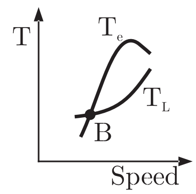
MCQ 4.42 The dc motor, which can provide zero speed regulation at full load without any controller is

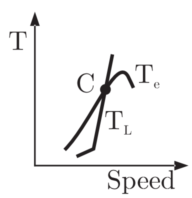
(A) series (B) shunt

(C) cumulative compound (D) differential compound

MCQ 4.43 The electromagnetic torque T_e of a drive and its connected load torque T_L are as shown below. Out of the operating points A, B, C and D, the stable ones are

(A)


(B)


(C)


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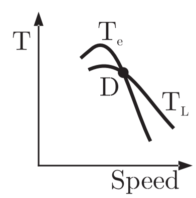

(A) A, C, D (B) B, C

(C) A, D (D) B, C, D

YEAR 2007 **TWO MARKS**

MCQ 4.44 A three-phase synchronous motor connected to ac mains is running at full load and unity power factor. If its shaft load is reduced by half, with field current held constant, its new power factor will be

(A) unity

(B) leading

(C) lagging

(D) dependent on machine parameters

MCQ 4.45 A 100 kVA, 415 V(line), star-connected synchronous machine generates rated open circuit voltage of 415 V at a field current of 15 A. The short circuit armature current at a field current of 10 A is equal to the rated armature current. The per unit saturated synchronous reactance is

(A) 1.731 (B) 1.5

(C) 0.666 (D) 0.577

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MCQ 4.46 A single-phase, 50 kVA, 250 V/500 V two winding transformer has an efficiency of 95% at full load, unity power factor. If it is re-configured as a 500 V/750 V auto-transformer, its efficiency at its new rated load at unity power factor will be

(A) 95.752% (B) 97.851%

(C) 98.276% (D) 99.241%

MCQ 4.47 A three-phase, three-stack, variable reluctance step motor has 20 poles on each rotor and stator stack. The step angle of this step motor is

(A) 3° (B) 6°

(C) 9° (D) 18°

MCQ 4.48 A three-phase squirrel cage induction motor has a starting torque of 150% and a maximum torque of 300% with respect to rated torque at rated voltage and rated frequency. Neglect the stator resistance and rotational losses. The value of slip for maximum torque is

(A) 13.48% (B) 16.42%

(C) 18.92% (D) 26.79%

Common Data for Question 49, 50 and 51:

A three phase squirrel cage induction motor has a starting current of seven times the full load current and full load slip of 5%

MCQ 4.49 If an auto transformer is used for reduced voltage starting to provide 1.5 per unit starting torque, the auto transformer ratio(%) should be

(A) 57.77 % (B) 72.56 %

(C) 78.25 % (D) 81.33 %

MCQ 4.50 If a star-delta starter is used to start this induction motor, the per unit starting torque will be

(A) 0.607 (B) 0.816

(C) 1.225 (D) 1.616

MCQ 4.51 If a starting torque of 0.5 per unit is required then the per unit starting current should be

(A) 4.65 (B) 3.75

(C) 3.16 (D) 2.13

YEAR 2006 ONE MARK

MCQ 4.52 In transformers, which of the following statements is valid ?

(A) In an open circuit test, copper losses are obtained while in short circuit test, core losses are obtained
(B) In an open circuit test, current is drawn at high power factor
(C) In a short circuit test, current is drawn at zero power factor
(D) In an open circuit test, current is drawn at low power factor

MCQ 4.53 For a single phase capacitor start induction motor which of the following statements is valid ?
(A) The capacitor is used for power factor improvement
(B) The direction of rotation can be changed by reversing the main winding terminals
(C) The direction of rotation cannot be changed
(D) The direction of rotation can be changed by interchanging the supply terminals

MCQ 4.54 In a DC machine, which of the following statements is true ?
(A) Compensating winding is used for neutralizing armature reaction while interpole winding is used for producing residual flux
(B) Compensating winding is used for neutralizing armature reaction while interpole winding is used for improving commutation
(C) Compensating winding is used for improving commutation while interpole winding is used for neutralizing armature reaction
(D) Compensation winding is used for improving commutation while interpole winding is used for producing residual flux

YEAR 2006 TWO MARKS

MCQ 4.55 A 220 V DC machine supplies 20 A at 200 V as a generator. The armature resistance is 0.2 ohm. If the machine is now operated as a motor at same terminal voltage and current but with the flux increased by 10%, the ratio of motor speed to generator speed is
(A) 0.87 (B) 0.95
(C) 0.96 (D) 1.06

MCQ 4.56 A synchronous generator is feeding a zero power factor (lagging) load at rated current. The armature reaction is
(A) magnetizing (B) demagnetizing
(C) cross-magnetizing (D) ineffective

MCQ 4.57 Two transformers are to be operated in parallel such that they share load in proportion to their kVA ratings. The rating of the first transformer is

500 kVA ratings. The rating of the first transformer is 500 kVA and its pu leakage impedance is 0.05 pu. If the rating of second transformer is 250 kVA, its pu leakage impedance is

(A) 0.20 (B) 0.10

(C) 0.05 (D) 0.025

MCQ 4.58 The speed of a 4-pole induction motor is controlled by varying the supply frequency while maintaining the ratio of supply voltage to supply frequency (V/f) constant. At rated frequency of 50 Hz and rated voltage of 400 V its speed is 1440 rpm. Find the speed at 30 Hz, if the load torque is constant

(A) 882 rpm (B) 864 rpm

(C) 840 rpm (D) 828 rpm

MCQ 4.59 A 3-phase, 4-pole, 400 V 50 Hz , star connected induction motor has following circuit parameters

$$r_1 = 1.0\,\Omega, r'_2 = 0.5\,\Omega, X_1 = X'_2 = 1.2\,\Omega, X_m = 35\,\Omega$$

The starting torque when the motor is started direct-on-line is (use approximate equivalent circuit model)

(A) 63.6 Nm (B) 74.3 Nm

(C) 190.8 Nm (D) 222.9 Nm

MCQ 4.60 A 3-phase, 10 kW, 400 V, 4-pole, 50Hz, star connected induction motor draws 20 A on full load. Its no load and blocked rotor test data are given below.

No Load Test:	400 V	6 A	1002 W
Blocked Rotor Test :	90 V	15 A	762 W

Neglecting copper loss in no load test and core loss in blocked rotor test, estimate motor's full load efficiency

(A) 76% (B) 81%

(C) 82.4% (D) 85%

MCQ 4.61 A 3-phase, 400 V, 5 kW, star connected synchronous motor having an internal reactance of 10 Ω is operating at 50% load, unity p.f. Now, the excitation is increased by 1%. What will be the new load in percent, if the power factor is to be kept same ? Neglect all losses and consider linear magnetic circuit.

(A) 67.9% (B) 56.9%

(C) 51% (D) 50%

Data for Q. 62 to Q 64 are given below.

A 4-pole, 50 Hz, synchronous generator has 48 slots in which a double layer winding is housed. Each coil has 10 turns and is short pitched by an angle to 36° electrical. The fundamental flux per pole is 0.025 Wb

MCQ 4.62 The line-to-line induced emf(in volts), for a three phase star connection is approximately

(A) 808 (B) 888

(C) 1400 (D) 1538

MCQ 4.63 The line-to-line induced emf(in volts), for a three phase connection is approximately

(A) 1143 (B) 1332

(C) 1617 (D) 1791

MCQ 4.64 The fifth harmonic component of phase emf(in volts), for a three phase star connection is

(A) 0 (B) 269

(C) 281 (D) 808

Statement for Linked Answer Questions 65 and 66.

A 300 kVA transformer has 95% efficiency at full load 0.8 p.f. lagging and 96% efficiency at half load, unity p.f.

MCQ 4.65 The iron loss (P_i) and copper loss (P_c) in kW, under full load operation are

(A) $P_c = 4.12, P_i = 8.51$ (B) $P_c = 6.59, P_i = 9.21$

(C) $P_c = 8.51, P_i = 4.12$ (D) $P_c = 12.72, P_i = 3.07$

MCQ 4.66 What is the maximum efficiency (in %) at unity p.f. load ?

(A) 95.1 (B) 96.2

(C) 96.4 (D) 98.1

YEAR 2005 **ONE MARK**

MCQ 4.67 The equivalent circuit of a transformer has leakage reactances X_1, X'_2 and magnetizing reactance X_M. Their magnitudes satisfy

(A) $X_1 >> X'_2 >> X_M$ (B) $X_1 << X'_2 << X_M$

(C) $X_1 \approx X'_2 >> X_M$ (D) $X_1 \approx X'_2 << X_M$

MCQ 4.68 Which three-phase connection can be used in a transformer to introduce a phase difference of 30° between its output and corresponding input line voltages

(A) Star-Star (B) Star-Delta

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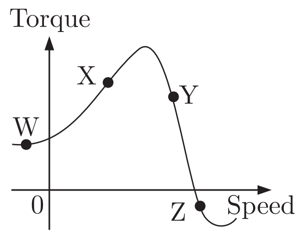
(C) Delta-Delta (D) Delta-Zigzag

MCQ 4.69 On the torque/speed curve of the induction motor shown in the figure four points of operation are marked as W, X, Y and Z. Which one of them represents the operation at a slip greater than 1 ?



(A) W (B) X

(C) Y (D) Z

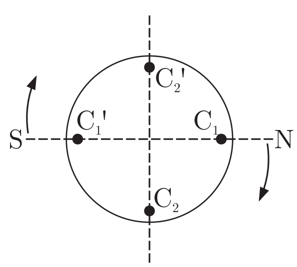
MCQ 4.70 For an induction motor, operation at a slip s, the ration of gross power output to air gap power is equal to

(A) $(1-s)^2$ (B) $(1-s)$

(C) $\sqrt{(1-s)}$ (D) $(1-\sqrt{s})$

YEAR 2005 TWO MARKS

MCQ 4.71 Two magnetic poles revolve around a stationary armature carrying two coil $(c_1 - c_1', c_2 - c_2')$ as shown in the figure. Consider the instant when the poles are in a position as shown. Identify the correct statement regarding the polarity of the induced emf at this instant in coil sides c_1 and c_2.



(A) $\odot$ in c_1, no emf in c_2 (B) $\otimes$ in c_1, no emf in c_2

(C) $\odot$ in c_2, no emf in c_1 (D) $\otimes$ in c_2, no emf in c_1

MCQ 4.72 A 50 kW dc shunt is loaded to draw rated armature current at any given speed. When driven

(i) at half the rated speed by armature voltage control and

(ii) at 1.5 times the rated speed by field control, the respective output powers delivered by the motor are approximately.

(A) 25 kW in (i) and 75 kW in (ii)
(B) 25 kW in (i) and 50 kW in (ii)
(C) 50 kW in (i) and 75 kW in (ii)
(D) 50 kW in (i) and 50 kW in (ii)

MCQ 4.73 In relation to the synchronous machines, which on of the following statements is false ?
(A) In salient pole machines, the direct-axis synchronous reactance is greater than the quadrature-axis synchronous reactance.
(B) The damper bars help the synchronous motor self start.
(C) Short circuit ratio is the ratio of the field current required to produces the rated voltage on open circuit to the rated armature current.
(D) The V-cure of a synchronous motor represents the variation in the armature current with field excitation, at a given output power.

MCQ 4.74 In relation to DC machines, match the following and choose the correct combination

	List-I Performance Variables		List-II Proportional to
P.	Armature emf (E)	**1.**	Flux(ϕ), speed (ω) and armature current (I_a)
Q.	Developed torque (T)	**2.**	ϕ and ω only
R	Developed power (P)	**3.**	ϕ and I_a only
		4.	I_a and ω only
		5.	I_a only

Codes:

	P	Q	R
(A)	3	3	1
(B)	2	5	4
(C)	3	5	4
(D)	2	3	1

MCQ 4.75 Under no load condition, if the applied voltage to an induction motor is reduced from the rated voltage to half the rated value,
(A) the speed decreases and the stator current increases
(B) both the speed and the stator current decreases
(C) the speed and the stator current remain practically constant
(D) there is negligible change in the speed but the stator current decreases

MCQ 4.76 A three-phase cage induction motor is started by direct-on-line (DOL) switching at the rated voltage. If the starting current drawn is 6 times the full load current, and the full load slip is 4%, then ratio of the starting developed torque to the full load torque is approximately equal to

(A) 0.24
(B) 1.44
(C) 2.40
(D) 6.00

MCQ 4.77 In a single phase induction motor driving a fan load, the reason for having a high resistance rotor is to achieve

(A) low starting torque
(B) quick acceleration
(C) high efficiency
(D) reduced size

MCQ 4.78 Determine the correctness or otherwise of the following assertion[A] and the reason[R]

Assertion [A] : Under V/f control of induction motor, the maximum value of the developed torque remains constant over a wide range of speed in the sub-synchronous region.

Reason [R] : The magnetic flux is maintained almost constant at the rated value by keeping the ration V/f constant over the considered speed range.

(A) Both [A] and [R] are true and [R] is the correct reason for [A]
(B) Both [A] and [R] are true and but [R] is not the correct reason for [A]
(C) Both [A] and [R] are false
(D) [A] is true but [R] is false

Statement for Linked Answer Questions 79 and 80.

A 1000 kVA, 6.6 kV, 3-phase star connected cylindrical pole synchronous generator has a synchronous reactance of 20 Ω. Neglect the armature resistance and consider operation at full load and unity power factor.

MCQ 4.79 The induced emf(line-to-line) is close to

(A) 5.5 kV
(B) 7.2 kV
(C) 9.6 kV
(D) 12.5 kV

MCQ 4.80 The power(or torque) angle is close to

(A) 13.9°
(B) 18.3°
(C) 24.6°
(D) 33.0°

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MCQ 4.81 A 500 kVA, 3-phase transformer has iron losses of 300 W and full load copper losses of 600 W. The percentage load at which the transformer is expected to have maximum efficiency is

(A) 50.0% (B) 70.7%
(C) 141.4% (D) 200.0%

MCQ 4.82 For a given stepper motor, the following torque has the highest numerical value
(A) Detent torque (B) Pull-in torque
(C) Pull-out torque (D) Holding torque

MCQ 4.83 The following motor definitely has a permanent magnet rotor
(A) DC commutator motor (B) Brushless dc motor
(C) Stepper motor (D) Reluctance motor

MCQ 4.84 The type of single-phase induction motor having the highest power factor at full load is
(A) shaded pole type (B) split-phase type
(C) capacitor-start type (D) capacitor-run type

MCQ 4.85 The direction of rotation of a 3-phase induction motor is clockwise when it is supplied with 3-phase sinusoidal voltage having phase sequence A-B-C. For counter clockwise rotation of the motor, the phase sequence of the power supply should be
(A) B-C-A (B) C-A-B
(C) A-C-B (D) B-C-A or C-A-B

MCQ 4.86 For a linear electromagnetic circuit, the following statement is true
(A) Field energy is equal to the co-energy
(B) Field energy is greater than the co-energy
(C) Field energy is lesser than the co-energy
(D) Co-energy is zero

YEAR 2004 **TWO MARKS**

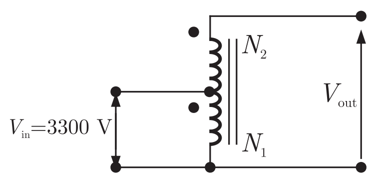
MCQ 4.87 The synchronous speed for the seventh space harmonic mmf wave of a 3-phase, 8-pole, 50 Hz induction machine is
(A) 107.14 rpm in forward direction
(B) 107.14 rpm in reverse direction
(C) 5250 rpm in forward direction
(D) 5250 rpm in reverse direction

MCQ 4.88 A rotating electrical machine its self-inductances of both the stator and the rotor windings, independent of the rotor position will be definitely not

develop
(A) starting torque
(B) synchronizing torque
(C) hysteresis torque
(D) reluctance torque

MCQ 4.89 The armature resistance of a permanent magnet dc motor is 0.8 Ω. At no load, the motor draws 1.5 A from a supply voltage of 25 V and runs at 1500 rpm. The efficiency of the motor while it is operating on load at 1500 rpm drawing a current of 3.5 A from the same source will be
(A) 48.0%
(B) 57.1%
(C) 59.2%
(D) 88.8%

MCQ 4.90 A 50 kVA, 3300/230 V single-phase transformer is connected as an auto-transformer shown in figure. The nominal rating of the auto- transformer will be



(A) 50.0 kVA
(B) 53.5 kVA
(C) 717.4 kVA
(D) 767.4 kVA

MCQ 4.91 The resistance and reactance of a 100 kVA, 11000/400 V, $\Delta-$ Y distribution transformer are 0.02 and 0.07 pu respectively. The phase impedance of the transformer referred to the primary is
(A) $(0.02 + j0.07)\,\Omega$
(B) $(0.55 + j1.925)\,\Omega$
(C) $(15.125 + j52.94)\,\Omega$
(D) $(72.6 + j254.1)\,\Omega$

MCQ 4.92 A single-phase, 230 V, 50 Hz 4-pole, capacitor-start induction motor had the following stand-still impedances
Main winding $Z_m = 6.0 + j4.0\,\Omega$
Auxiliary winding $Z_a = 8.0 + j6.0\,\Omega$
The value of the starting capacitor required to produce 90° phase difference between the currents in the main and auxiliary windings will be
(A) 176.84 μF
(B) 187.24 μF
(C) 265.26 μF
(D) 280.86 μF

MCQ 4.93 Two 3-phase, Y-connected alternators are to be paralleled to a set of common busbars. The armature has a per phase synchronous reactance of 1.7 Ω and negligible armature resistance. The line voltage of the first machine is adjusted to 3300 V and that of the second machine is adjusted to 3200 V. The machine voltages are in phase at the instant they are paralleled. Under

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this condition, the synchronizing current per phase will be

(A) 16.98 A (B) 29.41 A

(C) 33.96 A (D) 58.82 A

MCQ 4.94 A 400 V, 15 kW, 4-pole, 50Hz, Y-connected induction motor has full load slip of 4%. The output torque of the machine at full load is

(A) 1.66 Nm (B) 95.50 Nm

(C) 99.47 Nm (D) 624.73 Nm

MCQ 4.95 For a 1.8°, 2-phase bipolar stepper motor, the stepping rate is 100 steps/second. The rotational speed of the motor in rpm is

(A) 15 (B) 30

(C) 60 (D) 90

MCQ 4.96 A 8-pole, DC generator has a simplex wave-wound armature containing 32 coils of 6 turns each. Its flux per pole is 0.06 Wb. The machine is running at 250 rpm. The induced armature voltage is

(A) 96 V (B) 192 V

(C) 384 V (D) 768 V

MCQ 4.97 A 400 V, 50 kVA, 0.8 p.f. leading Δ-connected, 50 Hz synchronous machine has a synchronous reactance of 2 Ω and negligible armature resistance. The friction and windage losses are 2 kW and the core loss is 0.8 kW. The shaft is supplying 9 kW load at a power factor of 0.8 leading. The line current drawn is

(A) 12.29 A (B) 16.24 A

(C) 21.29 A (D) 36.88 A

MCQ 4.98 A 500 MW, 3-phase, Y-connected synchronous generator has a rated voltage of 21.5 kV at 0.85 p.f. The line current when operating at full load rated conditions will be

(A) 13.43 kA (B) 15.79 kA

(C) 23.25 kA (D) 27.36 kA

YEAR 2003 ONE MARK

MCQ 4.99 A simple phase transformer has a maximum efficiency of 90% at full load and unity power factor. Efficiency at half load at the same power factor is

(A) 86.7% (B) 88.26%

(C) 88.9% (D) 87.8%

MCQ 4.100 Group-I lists different applications and Group-II lists the motors for these

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applications. Match the application with the most suitable motor and choose the right combination among the choices given thereafter

	Group-I		Group-II
P.	Food mixer	**1.**	Permanent magnet dc motor
Q	Cassette tape recorder	**2.**	Single-phase induction motor
R.	Domestic water pump	**3.**	Universal motor
S.	Escalator	**4.**	Three-phase induction motor
		5.	DC series motor
		6.	Stepper motor

Codes:

	P	Q	R	S
(A)	3	6	4	5
(B)	1	3	2	4
(C)	3	1	2	4
(D)	3	2	1	4

MCQ 4.101 A stand alone engine driven synchronous generator is feeding a partly inductive load. A capacitor is now connected across the load to completely nullify the inductive current. For this operating condition.

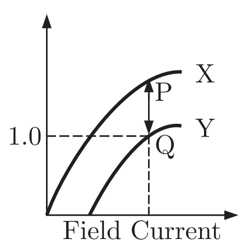
(A) the field current and fuel input have to be reduced

(B) the field current and fuel input have to be increased

(C) the field current has to be increased and fuel input left unaltered

(D) the field current has to be reduced and fuel input left unaltered

MCQ 4.102 Curves X and Y in figure denote open circuit and full-load zero power factor(zpf) characteristics of a synchronous generator. Q is a point on the zpf characteristics at 1.0 p.u. voltage. The vertical distance PQ in figure gives the voltage drop across



(A) Synchronous reactance
(B) Magnetizing reactance
(C) Potier reactance
(D) Leakage reactance

MCQ 4.103 No-load test on a 3-phase induction motor was conducted at different supply

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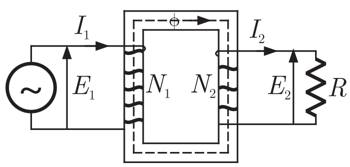
voltage and a plot of input power versus voltage was drawn. This curve was extrapolated to intersect the y-axis. The intersection point yields

(A) Core loss (B) Stator copper loss

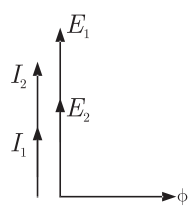
(C) Stray load loss (D) Friction and windage loss

YEAR 2003 TWO MARKS

MCQ 4.104 Figure shows an ideal single-phase transformer. The primary and secondary coils are wound on the core as shown. Turns ratio $N_1/N_2 = 2$.The correct phasors of voltages E_1, E_2, currents I_1, I_2 and core flux Φ are as shown in



(A)



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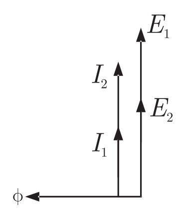

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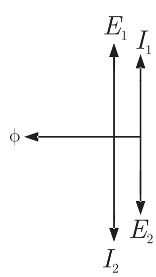
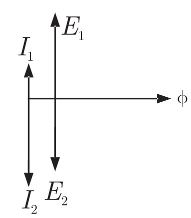


(D)



MCQ 4.105 To conduct load test on a dc shunt motor, it is coupled to a generator which is identical to the motor. The field of the generator is also connected to the same supply source as the motor. The armature of generator is connected to a load resistance. The armature resistance is 0.02 p.u. Armature reaction and mechanical losses can be neglected. With rated voltage across the motor, the load resistance across the generator is adjusted to obtain rated armature current in both motor and generator. The p.u value of this load resistance is

(A) 1.0 (B) 0.98

(C) 0.96 (D) 0.94

MCQ 4.106 Figure shows a $\Delta - Y$ connected, 3-phase distribution transformer used to step down the voltage from 11000 V to 415 V line-to-line. It has two switches S_1 and S_2. Under normal conditions S_1 is closed and S_2 is open.

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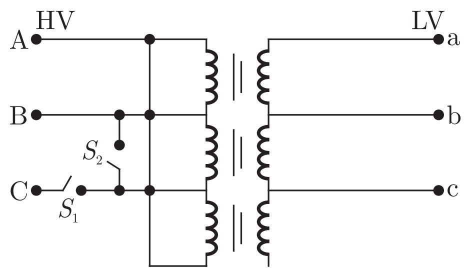
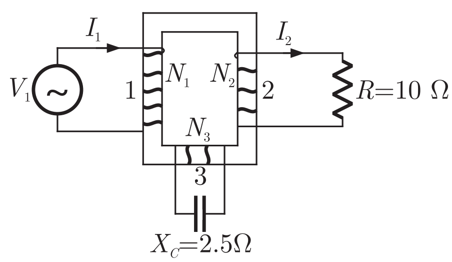
Under certain special conditions S_1 is open and S_2 is closed. In such a case the magnitude of the voltage across the LV terminals a and c is



(A) 240 V (B) 480 V

(C) 415 V (D) 0 V

MCQ 4.107 Figure shows an ideal three-winding transformer. The three windings 1, 2, 3 of the transformer are wound on the same core as shown. The turns ratio $N_1 : N_2 : N_3$ is 4:2:1. A resistor of 10 Ω is connected across winding-2. A capacitor of reactance 2.5 Ω is connected across winding-3. Winding-1 is connected across a 400 V, ac supply. If the supply voltage phasor $V_1 = 400\angle 0^\circ$, the supply current phasor I_1 is given by



(A) $(-10 + j10)$ A (B) $(-10 - j10)$ A

(C) $(10 + j10)$ A (D) $(10 - j10)$ A

MCQ 4.108 Following are some of the properties of rotating electrical machines

P. Stator winding current is dc, rotor winding current is ac.

Q. Stator winding current is ac, rotor winding current is dc.

R. Stator winding current is ac, rotor winding current is ac.

S. Stator has salient poles and rotor has commutator.

T. Rotor has salient poles and sliprings and stator is cylindrical.

U. Both stator and rotor have poly-phase windings.

DC machines, Synchronous machines and Induction machines exhibit some of the above properties as given in the following table.

Indicate the correct combination from this table

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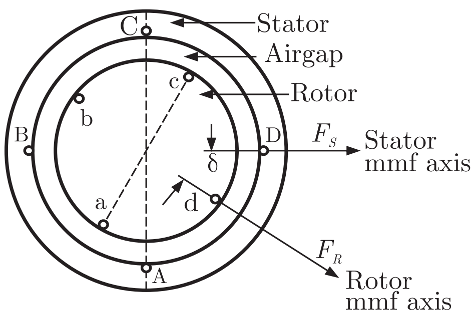
DC Machine	Synchronous Machines	Induction Machines
(A) P,S	Q,T	R,U
(B) Q,U	P,T	R,S
(C) P,S	R,U	Q,T
(D) R,S	Q,U	P,T

MCQ 4.109 When stator and rotor windings of a 2-pole rotating electrical machine are excited, each would produce a sinusoidal mmf distribution in the airgap with peal values F_s and F_r respectively. The rotor mmf lags stator mmf by a space angle δ at any instant as shown in figure. Thus, half of stator and rotor surfaces will form one pole with the other half forming the second pole. Further, the direction of torque acting on the rotor can be clockwise or counter-clockwise.



The following table gives four set of statement as regards poles and torque. Select the correct set corresponding to the mmf axes as shown in figure.

Stator Surface ABC forms	Stator Surface CDA forms	Rotor Surface abc forms	Rotor surface cda forms	Torque is
(A) North Pole	South Pole	North Pole	South Pole	Clockwise
(B) South Pole	North Pole	North Pole	South Pole	Counter Clockwise
(C) North Pole	South Pole	South Pole	North Pole	Counter Clockwise
(D) South Pole	North Pole	South Pole	North Pole	Clockwise

MCQ 4.110 A 4-pole, 3-phase, double-layer winding is housed in a 36-slot stator for an ac machine with 60° phase spread. Coil span is 7 short pitches. Number of slots in which top and bottom layers belong to different phases is

(A) 24 (B) 18

(C) 12 (D) 0

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MCQ 4.111 A 3-phase induction motor is driving a constant torque load at rated voltage and frequency. If both voltage and frequency are halved, following statements relate to the new condition if stator resistance, leakage reactance and core loss are ignored

1. The difference between synchronous speed and actual speed remains same
2. The airgap flux remains same
3. The stator current remains same
4. The p.u. slip remains same

Among the above, current statements are

(A) All (B) 1, 2 and 3

(C) 2, 3 and 4 (D) 1 and 4

MCQ 4.112 A single-phase induction motor with only the main winding excited would exhibit the following response at synchronous speed

(A) Rotor current is zero

(B) Rotor current is non-zero and is at slip frequency

(C) Forward and backward rotaling fields are equal

(D) Forward rotating field is more than the backward rotating field

MCQ 4.113 A dc series motor driving and electric train faces a constant power load. It is running at rated speed and rated voltage. If the speed has to be brought down to 0.25 p.u. the supply voltage has to be approximately brought down to

(A) 0.75 p.u (B) 0.5 p.u

(C) 0.25 p.u (D) 0.125 p.u

YEAR 2002 ONE MARK

MCQ 4.114 If a 400 V, 50 Hz, star connected, 3-phase squirrel cage induction motor is operated from a 400 V, 75 Hz supply, the torque that the motor can now provide while drawing rated current from the supply

(A) reduces

(B) increases

(C) remains the same

(D) increases or reduces depending upon the rotor resistance

MCQ 4.115 A dc series motor fed from rated supply voltage is over-loaded and its magnetic circuit is saturated. The torque-speed characteristic of this motor will be approximately represented by which curve of figure ?

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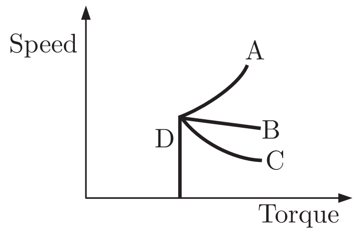
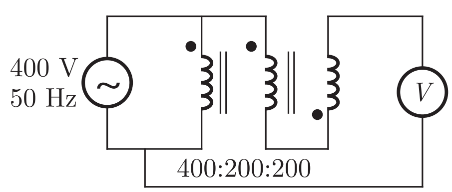


(A) Curve A (B) Curve B
(C) Curve C (D) Curve D

MCQ 4.116 A 1 kVA, 230 V/100 V, single phase, 50 Hz transformer having negligible winding resistance and leakage inductance is operating under saturation, while 250 V, 50 Hz sinusoidal supply is connected to the high voltage winding. A resistive load is connected to the low voltage winding which draws rated current. Which one of the following quantities will not be sinusoidal ?
(A) Voltage induced across the low voltage winding
(B) Core flux
(C) Load current
(D) Current drawn from the source

MCQ 4.117 A 400 V / 200 V / 200 V, 50 Hz three winding transformer is connected as shown in figure. The reading of the voltmeter, V, will be



(A) 0 V (B) 400 V
(C) 600 V (D) 800 V

YEAR 2002 **TWO MARK**

MCQ 4.118 A 200 V, 2000 rpm, 10 A, separately excited dc motor has an armature resistance of 2 Ω. Rated dc voltage is applied to both the armature and field winding of the motor. If the armature drawn 5 A from the source, the torque developed by the motor is
(A) 4.30 Nm (B) 4.77 Nm
(C) 0.45 Nm (D) 0.50 Nm

MCQ 4.119 The rotor of a three phase, 5 kW, 400 V, 50 Hz, slip ring induction motor is wound for 6 poles while its stator is wound for 4 poles. The approximate average no load steady state speed when this motor is connected to 400 V, 50 Hz supply is

(A) 1500 rpm (B) 500 rpm

(C) 0 rpm (D) 1000 rpm

MCQ 4.120 The flux per pole in a synchronous motor with the field circuit ON and the stator disconnected from the supply is found to be 25 mWb. When the stator is connected to the rated supply with the field excitation unchanged, the flux per pole in the machine is found to be 20 mWb while the motor is running on no load. Assuming no load losses to be zero, the no load current drawn by the motor from the supply

(A) lags the supply voltage

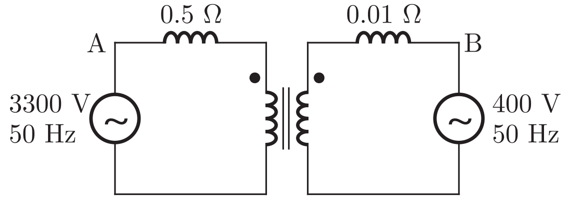
(B) leads the supply voltage

(C) is in phase with the supply voltage

(D) is zero

MCQ 4.121 *A 230 V, 250 rpm, 100 A separately excited dc motor has an armature resistance of $0.5\,\Omega$. The motor is connected to 230 V dc supply and rated dc voltage is applied to the field winding. It is driving a load whose torque-speed characteristic is given by $T_L = 500 - 10\,\omega$, where ω is the rotational speed expressed in rad/sec and T_L is the load torque in Nm. Find the steady state speed at which the motor will drive the load and the armature current drawn by it from the source. Neglect the rotational losses of the machine.

MCQ 4.122 *A single phase 6300 kVA, 50 Hz, 3300 V/ 400 V distribution transformer is connected between two 50 Hz supply systems, A and B as shown in figure. The transformer has 12 and 99 turns in the low and high voltage windings respectively. The magnetizing reactance of the transformer referred to the high voltage side is $500\,\Omega$. The leakage reactance of the high and low voltage windings are $1.0\ \Omega$ and $0.012\ \Omega$ respectively. Neglect the winding resistance and core losses of the transformer. The Thevenin voltage of system A is 3300 V while that of system B is 400 V. The short circuit reactance of system A and B are $0.5\,\Omega$ and $0.010\,\Omega$ respectively. If no power is transferred between A and B, so that the two system voltages are in phase, find the magnetizing ampere turns of the transformer.



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MCQ 4.123 *A 440 V, 50 Hz, 6 pole, 960 rpm star connected induction machine has the following per phase parameters referred to the stator :

$$R_s = 0.6\ \Omega, R_r = 0.3\ \Omega, X_s = 1\ \Omega$$

The magnetizing reactance is very high and is neglected. The machine is connected to the 440 V, 50 Hz supply and a certain mechanical load is coupled to it. It is found that the magnitude of the stator current is equal to the rated current of the machine but the machine is running at a speed higher than its rated speed. Find the speed at which the machine is running. Also find the torque developed by the machine.

MCQ 4.124 A 415 V, 2-pole, 3-phase, 50 Hz, star connected, non-salient pole synchronous motor has synchronous reactance of 2 Ω per phase and negligible stator resistance. At a particular field excitation, it draws 20 A at unity power factor from a 415 V, 3-phase, 50 Hz supply. The mechanical load on the motor is now increased till the stator current is equal to 50 A. The field excitation remains unchanged. Determine :

(a) the per phase open circuit voltage E_0

(b) the developed power for the new operating condition and corresponding power factor.

YEAR 2001 ONE MARK

MCQ 4.125 The core flux of a practical transformer with a resistive load

(A) is strictly constant with load changes

(B) increases linearly with load

(C) increases as the square root of the load

(D) decreases with increased load

MCQ 4.126 X_d, X'_d and X''_d are steady state d-axis synchronous reactance, transient d-axis reactance and sub-transient d-axis reactance of a synchronous machine respectively. Which of the following statements is true ?

(A) $X_d > X'_d > X''_d$ (B) $X''_d > X'_d > X_d$

(C) $X'_d > X''_d > X_d$ (D) $X_d > X''_d > X'_d$

MCQ 4.127 A 50 Hz balanced three-phase, Y-connected supply is connected to a balanced three-phase Y-connected load. If the instantaneous phase-a of the supply voltage is $V\cos(\omega t)$ and the phase-a of the load current is $I\cos(\omega t - \phi)$, the instantaneous three-phase power is

(A) a constant with a magnitude of $VI\cos\phi$

(B) a constant with a magnitude of $(3/2)\ VI\cos\phi$

(C) time-varying with an average value of $(3/2)\ VI\cos\phi$ and a frequency of

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100 Hz

(D) time-varying with an average value of $VI\cos\phi$ and a frequency of 50 Hz

MCQ 4.128 In the protection of transformers, harmonic restraint is used to guard against

(A) magnetizing inrush current

(B) unbalanced operation

(C) lightning

(D) switching over-voltages

MCQ 4.129 In case of an armature controlled separately excited dc motor drive with closed-loop speed control, an inner current loop is useful because it

(A) limits the speed of the motor to a safe value

(B) helps in improving the drive energy efficiency

(C) limits the peak current of the motor to the permissible value

(D) reduces the steady state speed error

YEAR 2001 TWO MARK

MCQ 4.130 An electric motor with "constant output power" will have a torque-speed characteristics in the form of a

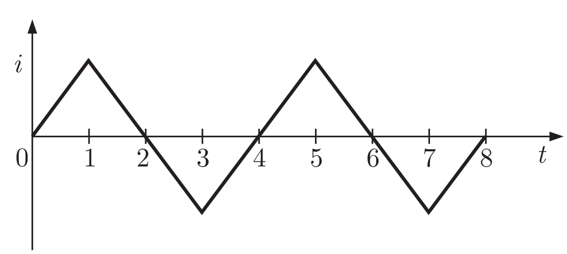
(A) straight line through the origin

(B) straight line parallel to the speed axis

(C) circle about the origin

(D) rectangular hyperbola

MCQ 4.131 *An ideal transformer has a linear B/H characteristic with a finite slope and a turns ratio of 1 : 1. The primary of the transformer is energized with an ideal current source, producing the signal i as shown in figure. Sketch the shape (neglecting the scale factor) of the following signals, labeling the time axis clearly



(a) the core flux ϕ_{oc} with the secondary of the transformer open

(b) the open-circuited secondary terminal voltage $v_2(t)$

(c) the short-circuited secondary current $i_2(t)$, and

(d) the core flux ϕ_{sc} with the secondary of the transformer short-circuited

MCQ 4.132 *In a dc motor running at 2000 rpm, the hysteresis and eddy current losses

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are 500 W and 200 W respectively. If the flux remains constant, calculate the speed at which the total iron losses are halved.

MCQ 4.133 *A dc series motor is rated 230 V, 1000 rpm, 80 A (refer to figure). The series field resistance is 0.11 Ω, and the armature resistance is 0.14 Ω. If the flux at an armature current of 20 A is 0.4 times of that under rated condition, calculate the speed at this reduced armature current of 20 A.

MCQ 4.134 *A 50 kW synchronous motor is tested by driving it by another motor. When the excitation is not switched on, the driving motor takes 800 W. When the armature is short-circuited and the rated armature current of 10 A is passed through it, the driving motor requires 2500 W. On open-circuiting the armature with rated excitation, the driving motor takes 1800 W. Calculate the efficiency of the synchronous motor at 50% load. Neglect the losses in the driving motor.

MCQ 4.135 *Two identical synchronous generators, each of 100 MVA, are working in parallel supplying 100 MVA at 0.8 lagging p.f. at rated voltage. Initially the machines are sharing load equally. If the field current of first generator is reduced by 5% and of the second generator increased by 5%, find the sharing of load (MW and MVAR) between the generators.
Assume $X_d = X_q = 0.8$ p.u, no field saturation and rated voltage across load. Reasonable approximations may be made.

****

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SOLUTION

SOL 4.1 Option (D) is correct.

Slip is given as $$S = \frac{n_s - n}{n_s}$$

where, n_s = synchronous speed

n = rotor speed

Thus, slip depend on synchronous speed and the rotor speed. Also, torque increases with increasing slip up to a maximum value and then decreases. Slip does not depend on core/loss component.

SOL 4.2 Option (D) is correct.

$$E \propto n\phi$$

where $n \rightarrow$ speed, $\phi \rightarrow$ flux and $E \rightarrow$ back emf

Given that, $V_t = 250\text{ V},\ R_a = 0.25\,\Omega$

$n_1 = 1000\text{ rpm},\ I_{L1} = 68\text{ A},\ I_{F1} = 2.2\text{ A}$

Armature current, $I_{a1} = I_{L1} - I_{F1} = 68 - 2.2 = 65.8\text{ A}$

$$E_1 = V_t - I_a, R_a$$

$$= 250 - (65.8)(0.25) = 203.55\text{ V}$$

Now, $n_2 = 1600\text{ rpm},\ I_{L2} = 52.8\text{ A},\ I_{F2} = 1.8\text{ A}$

Armature current, $I_{a_2} = I_{L2} - I_{F2} = 52.8 - 1.8 = 51\text{ A}$

$$E_2 = V_t - I_{a_2}R_a = 220 - (51)(0.25) = 207.25\text{ V}$$

$$\frac{E_1}{E_2} = \left(\frac{n_1}{n_2}\right)\left(\frac{\phi_1}{\phi_2}\right)$$

$$\frac{203.55}{207.45} = \left(\frac{1000}{1600}\right)\left(\frac{\phi_1}{\phi_2}\right)$$

$$\phi_2 = 0.6369\phi_1$$

$$\%\text{ reduce in flux} = \frac{\phi_1 - \phi_2}{\phi_1} \times 100 = \frac{\phi_1 - 0.6369\phi_1}{\phi_1} \times 100$$

$$\simeq 36.3\%$$

SOL 4.3 Option (B) is correct.

Given that magnetizing current and losses are to be neglected. Locked rotor line current.

$$I_2 = \frac{E_2}{Z_2} = \frac{E_2}{\sqrt{R_2^2 + X_2^2}} \qquad (R_2 = 0)$$

$$I_2 = \frac{E_2}{X_2} = \frac{E_2}{\omega L_2} \propto \frac{E_2}{f}$$

So $$\frac{50}{I_2'} = \left(\frac{230}{236}\right)\left(\frac{57}{50}\right)$$

$$I_2' = 45.0 \text{ A}$$

SOL 4.4 Option (B) is correct.

Since the core length of the second transformer is $\sqrt{2}$ times of the first, so the core area of the second transformer is twice of the first.

Let subscript 1 is used for first transformer and 2 is used for second transform.

Area $$a_2 = 2a_1$$

Length $$l_2 = \sqrt{2}\, l_1$$

Magnetizing inductance, $$L = \frac{N^2 \mu a}{l}$$

N = no. of turns

μ = length of flux path

a = cross section area

l = length

$$L \propto \frac{a}{l}$$ N and μ are same for both the transformer

$$\frac{L_1}{L_2} = \frac{a_1}{a_2} \cdot \frac{l_2}{l_1}$$

$$\frac{L_1}{L_2} = \frac{a_1}{2a_1} \cdot \frac{\sqrt{2}\, l_1}{l_1}$$

$$L_2 = \sqrt{2}\, L_1$$

Thus, magnetizing reactance of second transformer is $\sqrt{2}$ times of first.

Magnetizing current $$X_{m2} = \sqrt{2}\, X_{m1}$$

$$I_m = \frac{V}{X_m}$$

$$\frac{I_{m1}}{I_{m2}} = \frac{V_1}{V_2} \cdot \frac{X_{m2}}{X_{m1}} = \left(\frac{V_1}{2V_1}\right)\left(\frac{\sqrt{2}\, X_{m1}}{X_{m1}}\right) \qquad (V_2 = 2V_1)$$

$$I_{m2} = \sqrt{2}\, I_{m1}$$

Thus, magnetizing current of second transformer

$$I_{m2} = \sqrt{2} \times 0.5 = 0.707 \text{ A}$$

Since voltage of second transformer is twice that of first and current is $\sqrt{2}$ times that of first, so power will be $2\sqrt{2}$ times of first transformer.

$$P_2 = 2\sqrt{2} \times 55 = 155.6 \text{ W}$$

SOL 4.5 Option (A) is correct.

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The armature current of DC shunt motor

$$I_a = \frac{V - E_b}{R_a}$$

at the time of starting, $E_b = 0$. If the full supply voltage is applied to the motor, it will draw a large current due to low armature resistance.
A variable resistance should be connected in series with the armature resistance to limit the starting current.
A 4-point starter is used to start and control speed of a dc shut motor.

SOL 4.6 Option (B) is correct.
The Back emf will go to zero when field is reduced, so Current input will be increased. But when Field increases (though in reverse direction) the back emf will cause the current to reduce.

SOL 4.7 Option (C) is correct.
An air-core transformer has linear B-H characteristics, which implies that magnetizing current characteristic will be perfectly sinusoidal.

SOL 4.8 Option (A) is correct.
Initially $E_{b_1} = V - I_a R_a = 220 - 1 \times 10 = 210\text{ V}$
Now the flux is reduced by 10% keeping the torque to be constant, so the current will be

$$I_{a_1}\phi_1 = I_{a_2}\phi_2$$

$$I_{a_2} = I_{a_1}\frac{\phi_1}{\phi_2} = 10 \times \frac{1}{0.9} = 11.11\text{ A} \qquad \therefore \phi_2 = 0.9\phi_1$$

$$E_b \propto N\phi$$

$$\Rightarrow \quad \frac{E_{b_2}}{E_{b_1}} = \frac{N_2\phi_2}{N_1\phi_1} = 0.9 \qquad N_1 = N_2$$

$$E_{b_2} = 0.9E_{b_1} = 0.9 \times 210 = 189\text{ V}$$

Now adding a series resistor R in the armature resistor, we have

$$E_{b_2} = V - I_{a_2}(R_a + R)$$

$$189 = 220 - 11.11(1 + R)$$

$$R = 1.79\,\Omega$$

SOL 4.9 Option ( ) is correct.
The steady state speed of magnetic field

$$n_s = \frac{120 \times 50}{6} = 1000\text{ rpm}$$

Speed of rotor $n_r = (1 - S)\,n_s \qquad S = 0.05$

$$= 0.95 \times 1000 = 950\text{ rpm}$$

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In the steady state both the rotor and stator magnetic fields rotate in synchronism , so the speed of rotor field with respect to stator field would be zero.

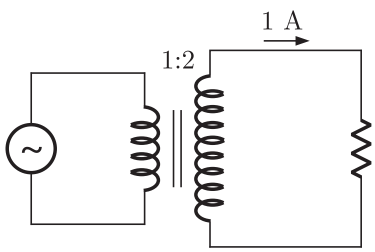
Speed of rotor which respect to stator field

$$= n_r - n_s = 950 - 1000 = -50 \text{ rpm}$$

None of the option matches the correct answer.

SOL 4.10 Option (C) is correct.

Given



$$I_0 = 1 \text{ amp (magnetizing current)}$$

$$\text{Primary current } I_P = ?$$

$$I_2 = 1 \text{ A}$$

$$I_2' = \text{secondary current reffered to Primary}$$

$$= \frac{2}{1} \times 1 = 2 \text{ amp}$$

$$I_P = \sqrt{i_0^2 + i_2^2} = \sqrt{1+4} = \sqrt{5} = 2.24 \text{ Amp}$$

SOL 4.11 Option ( ) is correct.

SOL 4.12 Option (C) is correct.

Synchronize speed of induction machine

$$N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

$$\text{Speed of machine} = 1600 \text{ rpm} = \text{Actual speed of induction machine}$$

$$\text{slip} = \frac{1500 - 1600}{1500} = \frac{-1}{15} = -0.066 \text{(negative)}$$

Hence induction machine acts as induction generator and dc machine as dc motor.

SOL 4.13 Option ( ) is correct.

SOL 4.14 Option (B) is correct.

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Given no-load speed $N_1 = 1500$ rpm

$$V_a = 200 \text{ V}, T = 5 \text{ Nm}, N = 1400 \text{ rpm}$$

emf at no load

$$E_{b1} = V_a = 200 \text{ V}$$

$$N \propto E_b \Rightarrow \frac{N_1}{N_2} = \frac{E_{b_1}}{E_{b_2}}$$

$$E_{b_2} = \left(\frac{N_2}{N_1}\right)E_{b_1} = \frac{1400}{1500} \times 200 = 186.67 \text{ V}$$

$$T = E_b(I_a/\omega) \Rightarrow \frac{186.67 \times 60}{2\pi \times 1400} I_a = 5$$

$$I_a = 3.926 \text{ A}$$

$$V = E_b + I_a R_a$$

$$R_a = \frac{V_a - E_b}{I_a} = \frac{200 - 186.67}{3.926} = 3.4 \ \Omega$$

SOL 4.15 Option (B) is correct.

$$T = 2.5 \text{ Nm at } 1400 \text{ rpm}$$

than $V = ?$

$$T = \frac{E_b I_b}{\omega}$$

$$2.5 = \frac{186.6 \times I_a \times 60}{2\pi \times 1400}$$

$$I_a = 1.963 \text{ A}$$

$$V = E_b + I_a R_a = 186.6 + 1.963 \times 3.4 = 193.34 \text{ V}$$

SOL 4.16 Option (D) is correct.

Given field excitation of = 20 A

Armature current = 400 A

Short circuit and terminal voltage = 200 V

On open circuit, load current = 200 A

So, Internal resistance $= \frac{2000}{400} = 5\,\Omega$

Internal vol. drop $= 5 \times 200$

$= 1000$ V

SOL 4.17 Option (C) is correct.

Given single-phase iron core transformer has both the vertical arms of cross section area 20 cm^2, and both the horizontal arms of cross section are 10 cm^2

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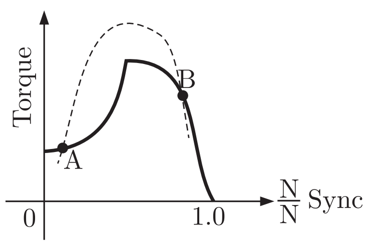
So, Inductance $= \frac{NBA}{1}$ (proportional to cross section area)

When cross section became half, inductance became half.

SOL 4.18 Option (A) is correct.

Given 3-phase squirrel cage induction motor.



At point A if speed ↑, Torque ↑
speed ↓, Torque ↓

So A is stable.

At point B if speed ↑ Load torque ↓

So B is un-stable.

SOL 4.19 Option ( ) is correct.

SOL 4.20 Option (D) is correct.

Peak voltage across A and B with S open is

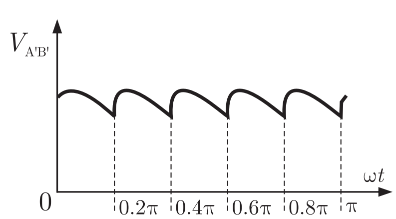
$$V = m\frac{di}{dt} = m \times (\text{slope of } I - t)$$

$$= \frac{400}{\pi} \times 10^{-3} \times \left[\frac{10}{5 \times 10^{-3}}\right] = \frac{800}{\pi}\text{ V}$$

SOL 4.21 Option ( ) is correct.

SOL 4.22 Option (A) is correct.

Wave form $V_{A'B'}$

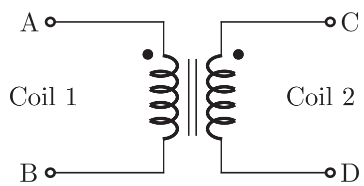


SOL 4.23 Option (B) is correct.

When both S1 and S2 open, star connection consists 3rd harmonics in line current due to hysteresis A saturation.

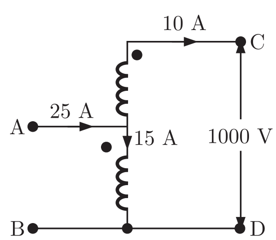
SOL 4.24 Option (A) is correct.
Since S2 closed and S1 open, so it will be open delta connection and output will be sinusoidal at fundamental frequency.

SOL 4.25 Option (A) is correct.



$$N_1 = 4000$$
$$N_2 = 6000$$
$$I = 25 \text{ A}$$
$$V = 400 \text{ V}, \ f = 50 \text{ Hz}$$

Coil are to be connected to obtain a single Phase, $\frac{400}{1000}$ V auto transfer to drive Load 10 kVA
Connected A & D common B



SOL 4.26 Option (D) is correct.
Given 3-phase, 400 V, 5 kW, Star connected synchronous motor.
Internal Resistance $= 10\,\Omega$
Operating at 50% Load, unity p.f.
So

$$\text{kVA rating} = 25 \times 400 = 1000$$

Internal Resistance $= 10\ \Omega$
So

$$\text{kVA rating} = 1000 \times 10 = 10000 \text{ kVA}$$

SOL 4.27 Option (D) is correct.

Distributed winding and short chording employed in AC machine will result in reduction of emf and harmonics.

SOL 4.28 Option (B) is correct.
Transformer connection will be represented by Y d1.

SOL 4.29 Option (D) is correct.
Detent torque/Restraining toque:
The residual magnetism in the permanent magnetic material produced.
The detent torque is defined as the maximum load torque that can be applied to the shaft of an unexcited motor without causing continuous rotation. In case the motor is unexcited.

SOL 4.30 Option (D) is correct.
Given: 1-ϕ transformer, 230 V/115 V, 2 kVA

W_1 : 250 V, 10 A, Low Power Factor
W_2 : 250 V, 5 A, Low Power Factor
W_3 : 150 V, 10 A, High Power Factor
W_4 : 150 V, 5 A, High Power Factor

In one circuit test the wattmeter W_2 is used and in short circuit test of transformer W_3 is used.

SOL 4.31 Option (B) is correct.
Given: 230 V, 50 Hz, 4-Pole, 1-ϕ induction motor is rotating in clock-wise(forward) direction

$$N_s = 1425 \text{ rpm}$$

Rotar resistance at stand still$(R_2) = 7.8\ \Omega$

So

$$N_s = \frac{120 \times 50}{4} = 1500$$

$$\text{Slip}(S) = \frac{1500 - 1425}{1500} = 0.05$$

$$\text{Resistance in backward branch } r_b = \frac{R_2}{2-S} = \frac{7.8}{2-0.05} = 4\ \Omega$$

SOL 4.32 Option (C) is correct.
Given: a 400 V, 50 Hz, 30 hp, 3-ϕ induction motor
Current = 50 A at 0.8 p.f. lagging
Stator and rotor copper losses are 1.5 kW and 900 W
fraction and windage losses = 1050 W

$$\text{Core losses} = 1200 \text{ W} = 1.2 \text{ kW}$$

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So,

$$\text{Input power in stator} = \sqrt{3} \times 400 \times 50 \times 0.8 = 27.71 \text{ kW}$$

$$\text{Air gap power} = 27.71 - 1.5 - 1.2 = 25.01 \text{ kW}$$

SOL 4.33 Option (A) is correct.

Induced emf in secondary $= - N_2 \frac{d\phi}{dt}$

During $-0 < t < 1$, $E_1 = - (100) \frac{d\phi}{dt} = - 12$ V

E_1 and E_2 are in opposition

$$E_2 = 2E_1 = 24 \text{ V}$$

During time $1 < t < 2$, $\frac{d\phi}{dt} = 0$, then $E_1 = E_2 = 0$

During $2 < t < 2.5$, $E_1 = - (100) \frac{d\phi}{dt} = - 24$ V

Then $E_2 = - 0 - 48$ V

SOL 4.34 Option (B) is correct.

Given 400 V, 50 Hz, 4-Pole, 1400 rpm star connected squirrel cage induction motor.

$$R = 1.00\ \Omega, X_s = X'_r = 1.5\ \Omega$$

So,

For max. torque slip

$$S_m = \frac{R'_r}{X_{sm} + X'_{rm}}$$

For starting torque $S_m = 1$

Then $X_{sm} + X'_{rm} = R'_r$

$$2\pi f_m L_s + 0.2\pi f_m L'_r = 1$$

Frequency at max. torque

$$f_m = \frac{1}{2\pi(L_s + L'_r)}$$

$$L_s = \frac{X_s}{2\pi \times 50} = \frac{1.5}{2\pi \times 50}$$

$$L'_r = \frac{1.5}{2\pi \times 50}$$

$$f_m = \frac{1}{\frac{1.5}{50} + \frac{1.5}{50}} = \frac{50}{3} = 16.7 \text{ Hz}$$

In const V/f control method

$$\frac{V_1}{f_1} = \frac{400}{50} = 8$$

$$\frac{V_2}{f_1} = 8$$

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So $V_2 = f_2 \times 8 = 16.7 \times 8 = 133.3$ V

Hence (B) is correct option.

SOL 4.35 Option (A) is correct.

Given 3-ϕ, 440 V, 50 Hz, 4-Pole slip ring motor

Motor is coupled to 220 V

$$N = 1410 \text{ rpm}, W_1 = 1800 \text{ W}, W_2 = 200 \text{ W}$$

So, $$N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

$$\text{Relative speed} = 1500 - 1410$$
$$= 90 \text{ rpm in the direction of rotation.}$$

SOL 4.36 Option (C) is correct.

Neglecting losses of both machines

$$\text{Slip}(S) = \frac{N_s - N}{N_s} = \frac{1500 - 1410}{1500} = 0.06$$

total power input to induction motor is

$$P_{in} = 1800 - 200 = 1600 \text{ W}$$

Output power of induction motor

$$P_{out} = (1 - S)P_{in} = (1 - 0.06)1600 = 1504 \text{ W}$$

Losses are neglected so dc generator input power = output power

= 1504 W

So, $$I^2R = 1504$$
$$I = \sqrt{\frac{1504}{10}} = 12.26 \text{ A}$$

SOL 4.37 Option (D) is correct.

Given: $V = 240$ V, dc shunt motor

$$I = 15 \text{ A}$$
$$\text{Rated load at a speed} = 80 \text{ rad/s}$$
$$\text{Armature Resistance} = 0.5\ \Omega$$
$$\text{Field winding Resistance} = 80\ \Omega$$

So, $$E = 240 - 12 \times 0.5 = 234$$
$$V_{plugging} = V + E = 240 + 234 = 474 \text{ V}$$

SOL 4.38 Option (A) is correct.

External Resistance to be added in the armature circuit to limit the armature current to 125%.

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So
$$I_a = 12 \times 1.25 = \frac{474}{R_a + R_{\text{external}}}$$
$$R_a + R_{\text{external}} = 31.6$$
$$R_{\text{external}} = 31.1\ \Omega$$

SOL 4.39 Option (D) is correct.

A synchronous motor is connected to an infinite bus at 1.0 p.u. voltage and 0.6 p.u. current at unity power factor. Reactance is 1.0 p.u. and resistance is negligible.

So,
$$V = 1\angle 0^\circ \text{ p.u.}$$
$$I_a = 0.6\angle 0^\circ \text{ p.u.}$$
$$Z_s = R_a + jX_s = 0 + j1 = 1\angle 90^\circ \text{ p.u.}$$
$$V = E\angle\delta + I_a Z_s = 1\angle 0^\circ - 0.6\angle 0^\circ \times 1\angle 90^\circ$$
$$E\angle\delta = 1.166\angle - 30.96^\circ \text{ p.u.}$$
$$\text{Excitation voltage} = 1.17 \text{ p.u.}$$
$$\text{Load angle } (\delta) = 30.96^\circ (\text{lagging})$$

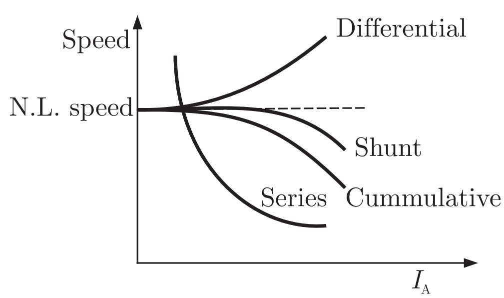
SOL 4.40 Option ( ) is correct.

SOL 4.41 Option (C) is correct.

In transformer zero voltage regulation at full load gives leading power factor.

SOL 4.42 Option (B) is correct.

Speed-armature current characteristic of a dc motor is shown as following



The shunt motor provides speed regulation at full load without any controller.

SOL 4.43 Option (C) is correct.

From the given characteristics point A and D are stable

SOL 4.44 Option (B) is correct.

When the 3-ϕ synchronous motor running at full load and unity power factor and shaft load is reduced half but field current is constant then it gives leading power factor.

SOL 4.45 Option (A) is correct.

Given star connected synchronous machine, $P = 100$ kVA

Open circuit voltage $V = 415$ V and field current is 15 A, short circuit armature current at a field current of 10 A is equal to rated armature current.

So,

Line synchronous impedance

$$= \frac{\text{open circuit line voltage}}{\sqrt{3} \times \text{short ckt phase current}}$$

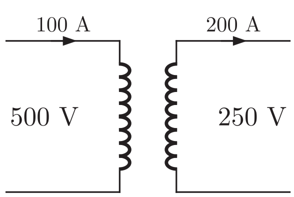
$$= \frac{415}{\sqrt{3} \times \left(\frac{100 \times 1000}{\sqrt{3} \times 415}\right)} = 1.722$$

SOL 4.46 Option (C) is correct.

Given 1-ϕ transformer

$P = 50$ kVA, $V = 250$ V/500 V

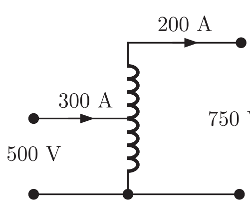
Two winding transformer efficiency 95% at full load unity power factor.



Efficiency $\quad 95\% = \frac{50 \times 1 \times 1}{50 \times W_{cu} + W_i}$

So $\quad W_{cu} + W_i = 2.631$

Reconfigured as a 500 V/750 V auto-transformer



auto-transformer efficiency

$$\eta = \frac{150}{150 + 2.631} = 98.276\%$$

SOL 4.47 Option (B) is correct.

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Given 3-ϕ, 3-stack

Variable reluctance step motor has 20-poles

$$\text{Step angle} = \frac{360}{3 \times 20} = 6^\circ$$

SOL 4.48 Option (D) is correct.

Given a 3-ϕ squirrel cage induction motor starting torque is 150% and maximum torque 300%

So

$$T_{Start} = 1.5\, T_{FL}$$

$$T_{max} = 3\, T_{FL}$$

Then $$\frac{T_{Start}}{T_{max}} = \frac{1}{2} \qquad ...(1)$$

$$\frac{T_{Start}}{T_{max}} = \frac{2S_{max}}{S^2_{max} + 1^2} \qquad ...(2)$$

from equation (1) and (2)

$$\frac{2S_{max}}{S^2_{max} + 1} = \frac{1}{2}$$

$$S_{max}^2 - 4S_{max} + 1 = 0$$

So $$S_{max} = 26.786\%$$

SOL 4.49 Option (C) is correct.

Given 3-ϕ squirrel cage induction motor has a starting current of seven the full load current and full load slip is 5%

$$I_{St} = 7 I_{Fl}$$

$$S_{Fl} = 5\%$$

$$\frac{T_{St}}{T_{Fl}} = \left(\frac{I_{St}}{T_{Fl}}\right)^2 \times x^2 \times S_{Fl}$$

$$1.5 = (7)^2 \times x^2 \times 0.05$$

$$x = 78.252\%$$

SOL 4.50 Option (B) is correct.

Star delta starter is used to start this induction motor

So

$$\frac{T_{St}}{T_{Fl}} = \frac{1}{3} \times \left(\frac{I_{St}}{I_{Fl}}\right)^2 \times S_{Fl} = \frac{1}{3} \times 7^2 \times 0.05$$

$$\frac{T_{St}}{T_{Fl}} = 0.816$$

SOL 4.51 Option (C) is correct.

Given starting torque is 0.5 p.u.

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So, $$\frac{T_{St}}{T_{Fl}} = \left(\frac{I_{sc}}{I_{Fl}}\right)^2 \times S_{Fl}$$

$$0.5 = \left(\frac{I_{sc}}{I_{Fl}}\right)^2 \times 0.05$$

Per unit starting current

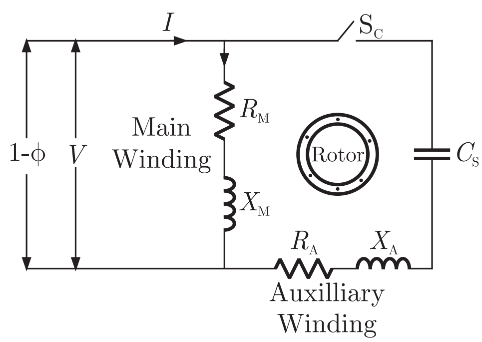
$$\frac{I_{sc}}{I_{Fl}} = \sqrt{\frac{0.5}{0.05}} = 3.16 \text{ A}$$

SOL 4.52 Option (D) is correct.

In transformer, in open circuit test, current is drawn at low power factor but in short circuit test current drawn at high power factor.

SOL 4.53 Option (B) is correct.

A single-phase capacitor start induction motor. It has cage rotor and its stator has two windings.



The two windings are displaced 90° in space. The direction of rotation can be changed by reversing the main winding terminals.

SOL 4.54 Option (B) is correct.

In DC motor, compensating winding is used for neutralizing armature reactance while interpole winding is used for improving commutation. Interpoles generate voltage necessary to neutralize the e.m.f of self induction in the armature coils undergoing commutation. Interpoles have a polarity opposite to that of main pole in the direction of rotation of armature.

SOL 4.55 Option (A) is correct.

Given: A 230 V, DC machine, 20 A at 200 V as a generator.

$$R_a = 0.2\ \Omega$$

The machine operated as a motor at same terminal voltage and current, flux increased by 10%

So for generator

$$E_g = V + I_a R_a$$

$$= 200 + 20 \times 0.2$$

$$E_g = 204 \text{ volt}$$

for motor $E_m = V - I_a R_a$

$$= 200 - 20 \times 0.2$$

$$E_m = 196 \text{ volt}$$

So $\dfrac{E_g}{E_m} = \dfrac{N_g}{N_m} \times \dfrac{\phi_g}{\phi_m}$

$$\frac{204}{196} = \frac{N_g}{N_m} \times \frac{1}{1.1}$$

$$\frac{N_m}{N_g} = \frac{196}{204 \times 1.1} = 0.87$$

SOL 4.56 Option (B) is correct.

A synchronous generator is feeding a zero power factor(lagging) load at rated current then the armature reaction is demagnetizing.

SOL 4.57 Option (B) is correct.

Given the rating of first transformer is 500 kVA

Per unit leakage impedance is 0.05 p.u.

Rating of second transformer is 250 kVA

So, Per unit impedance $= \dfrac{\text{actual impedance}}{\text{base impedance}}$

and, Per unit leakage impedance $\propto \dfrac{1}{\text{kVA}}$

Then $500\,\text{kVA} \times 0.05 = 250 \text{ kVA} \times x$

$$x = \frac{500}{250} \times 0.05 = 0.1 \text{ p.u.}$$

SOL 4.58 Option (C) is correct.

Given speed of a 4-pole induction motor is controlled by varying the supply frequency when the ratio of supply voltage and frequency is constant.

$f = 50$ Hz, $V = 400$ V, $N = 1440$ rpm

So $V \propto f$

$$\frac{V_1}{V_2} = \frac{f_1}{f_2}$$

$$V_2 = 400 \times \frac{30}{50} = 240 \text{ V}$$

$$T \propto \left(\frac{V^2}{f}\right) S$$

So $\dfrac{S_2}{S_1} = \left(\dfrac{V_1}{V_2}\right)^2 \times \dfrac{f_2}{f_1} \times \dfrac{T_2}{T_1}$

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Given $T_1 = T_2$

Then $S_2 = 0.04 \times \left(\frac{400}{240}\right)^2 \times \frac{30}{50}$

$S_2 = 0.066$

$N_r = N_s(1 - S)$

$N_r = \frac{120f}{P}$

So $N_r = \frac{120 \times 30}{4}(1 - 0.066) = 840.6 \text{ rpm}$

SOL 4.59 Option (A) is correct.

Given a 3-ϕ induction motor

$$P = 4,\ V = 400 \text{ V},\ f = 50 \text{ Hz}$$
$$r_1 = 1.0\ \Omega,\ r_2' = 0.5\ \Omega$$
$$X_1 = X'_2 = 1.2\ \Omega, X_m = 35\ \Omega$$

So, Speed of motor is

$$N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

Torque

$$T_{st} = \frac{180}{2\pi N_s} \times \frac{V^2 r'_2}{(r_1 + r'_2)^2 + X^2}$$

$$= \frac{180}{2 \times 3.14 \times 1500} \times \frac{\left(\frac{400}{\sqrt{3}}\right)^2 \times 0.5}{(1.5)^2 + (2.4)^2} = 63.58 \text{ Nm}$$

SOL 4.60 Option (B) is correct.

Given that 3-ϕ induction motor star connected

$$P = 10 \text{ kW},\ V = 400 \text{ V}, \text{Poles} = 4, f = 50 \text{ Hz}$$

Full load current $I_{Fl} = 20$ A

$$\text{Efficiency} = \frac{\text{output}}{\text{input}}$$

So

Cu losses at full load

$$= \left(\frac{20}{15}\right)^2 \times 762 = 1354.67$$

$$\text{Total losses} = 1354.67 + 1002 = 2356.67$$

$$\text{Efficiency} = \frac{10000}{10000 + 2356.67} \times 100 = 81\%$$

SOL 4.61 Option (A) is correct.

Given 3-ϕ star connected synchronous motor internal reactance = 10 Ω

Operating at 50% load, unity power factor, 400 V, 5 kW

Excitation increased = 1%

So,

full load current

$$I_{Fl} = \frac{5 \times 10^3}{\sqrt{3} \times 400 \times 1} = 7.22$$

$$E^2 = (V\cos\theta - I_a R_a)^2 + (V\sin\theta - I_a X_s)^2$$

So, $$E = \sqrt{\left(\frac{400}{\sqrt{3}}\right)^2 + (10 \times 3.6)^2} = 2133.7289$$

Excitation will increase 1% then E_2

$$E_2 = 2133.7289 \times 0.01 = 236$$

$$I_a X = \sqrt{(E_2)^2 - V^2} = \sqrt{(236)^2 - \left(\frac{400}{\sqrt{3}}\right)^2} = 48.932$$

$$I_a = \frac{48.932}{10} = 4.8932$$

$$\text{Load}(\%) = \frac{4.8932}{7.22} = 67.83\ \%$$

SOL 4.62 Option (C) is correct.

Given $P = 4$, $f = 50$ Hz

Slots = 48, each coil has 10 turns

Short pitched by an angle(α) to 36° electrical

Flux per pole = 0.05 Wb

So,

$$E_{ph} = 4.44\ f\phi T_{ph} K_W$$

$$\text{Slot/Pole/ph} = \frac{48}{4 \times 3} = 4$$

$$\text{Slot/Pole} = \frac{48}{4} = 12$$

$$\text{Slot angle} = \frac{180}{12} = 15^\circ$$

$$K_d = \frac{\sin(4 \times 15/2)}{4\sin(15/2)} = 0.957$$

$$K_p = \cos\frac{\alpha}{2} = \cos 18^\circ = 0.951$$

In double layer wdg

No. of coil = No of slots

$$\text{No. of turns/ph} = \frac{48 \times 10}{3} = 160$$

Then $$E_{ph} = 4.44 \times 0.025 \times 50 \times 0.957 \times 0.951 \times 160 = 808\ \text{V}$$

$$E_L = \sqrt{3} \times 808$$

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$$E_L = 1400 \text{ V (approximate)}$$

SOL 4.63 Option (A) is correct.

line to line induced voltage, so in 2 phase winding

$$\text{Slot/ pole/ph} = 6$$

$$T_{ph} = \frac{480}{2} = 240$$

$$\text{Slot angle} = \frac{180 \times 4}{48} = 15^\circ$$

$$K_d = \frac{\sin 6 \times (15/2)}{6 \sin (15/2)} = 0.903$$

$$K_p = \cos\left(\frac{36}{2}\right) = 0.951$$

$$E_{ph} = 4.44 \times 0.025 \times 50 \times 240 \times 0.951 \times 0.903 = 1143$$

SOL 4.64 Option (A) is correct.

Fifth harmonic component of phase emf

So $$\text{Angle} = \frac{180}{5} = 36^\circ$$

the phase emf of fifth harmonic is zero.

SOL 4.65 Option (C) is correct.

Given that: A 300 kVA transformer

Efficiency at full load is 95% and 0.8 p.f. lagging

96% efficiency at half load and unity power factor

So

For I[st] condition for full load

$$95\% = \frac{\text{kVA} \times 0.8}{\text{kVA} \times 0.8 + W_{cu} + W_i} \qquad ...(1)$$

Second unity power factor half load

$$96\% = \frac{\text{kVA} \times 0.5}{\text{kVA} \times 0.5 + W_{cu} + W_i} \qquad ...(2)$$

So $$W_{cu} + W_i = 12.63$$

$$0.25\, W_{cu} + 0.96\, W_i = 6.25$$

Then $$W_{cu} = 8.51,\ W_i = 4.118$$

SOL 4.66 Option (B) is correct.

$$\text{Efficiency } (\eta) = \frac{X \times \text{p.f.} \times \text{kVA}}{X \times \text{kVA} + W_i + W_{cu} \times X^2}$$

So $$X = \sqrt{\frac{4.118}{8.51}} = 0.6956$$

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$$\eta\% = \frac{0.6956 \times 1 \times 300}{0.6956 \times 300 + 4.118 + 8.51 \times (0.6956)^2}$$

$$\eta = 96.20\%$$

SOL 4.67 Option (D) is correct.

The leakage reactances X_1, and X_2' are equal and magnetizing reactance X_m is higher than X_1, and X_2'

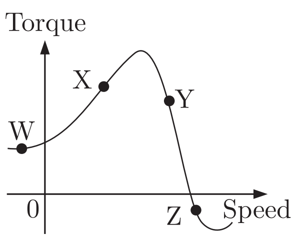
$$X_1 \approx X_2' << X_m$$

SOL 4.68 Option (B) is correct.

Three phase star delta connection of transformer induces a phase difference of 30° between output and input line voltage.

SOL 4.69 Option (A) is correct.

Given torque/speed curve of the induction motor



When the speed of the motor is in forward direction then slip varies from 0 to 1 but when speed of motor is in reverse direction or negative then slip is greater then 1. So at point W slip is greater than 1.

SOL 4.70 Option (B) is correct.

For an induction motor the ratio of gross power output to air-gap is equal to $(1 - s)$

So $$\frac{\text{gross power}}{\text{airgap power}} = (1 - s)$$

SOL 4.71 Option (A) is correct.

Given that two magnetic pole revolve around a stationary armature.

At c_1 the emf induced upward and no emf induced at c_2 and c_2'

SOL 4.72 Option (B) is correct.

Given A 50 kW DC shunt motor is loaded, then

at half the rated speed by armature voltage control

So $$P \propto N$$

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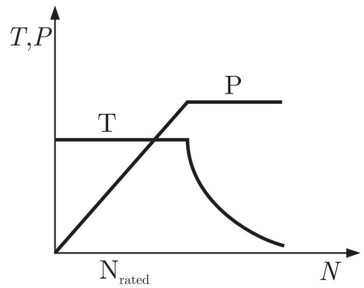


$$P_{new} = \frac{50}{2} = 25 \text{ kW}$$

At 1.5 time the rated speed by field control

$$P = \text{constant}$$

So $$P = 50 \text{ kW}$$

SOL 4.73 Option (C) is correct.

In synchronous machine, when the armature terminal are shorted the field current should first be decreased to zero before started the alternator.

In open circuit the synchronous machine runs at rated synchronous speed. The field current is gradually increased in steps.

The short circuit ratio is the ratio of field current required to produced the rated voltage on open to the rated armature current.

SOL 4.74 Option (D) is correct.

In DC motor, $$E = PN\phi\left(\frac{Z}{A}\right)$$

or $$E = K\phi\omega_n$$

So armature emf E depends upon ϕ and ω only and torque developed depends upon

$$T = \frac{PZ\phi I_a}{2\pi A}$$

So, torque(T) is depends of ϕ and I_a and developed power(P) is depend of flux ϕ, speed ω and armature current I_a.

SOL 4.75 Option ( ) is correct.

SOL 4.76 Option (B) is correct.

Given a three-phase cage induction motor is started by direct on line switching at rated voltage. The starting current drawn is 6 time the full load current.

Full load slip = 4%

So

$$\left(\frac{T_{\text{St}}}{T_{\text{Fl}}}\right) = \left(\frac{I_{\text{St}}}{I_{\text{Fl}}}\right)^2 \times S_{\text{Fl}}$$
$$= (6)^2 \times 0.04 = 1.44$$

SOL 4.77 Option (B) is correct.

Given single-phase induction motor driving a fan load, the resistance rotor is high

So

$$E_b = V - I_a R_a \qquad ...(1)$$
$$P_{\text{mech}} = E_a I_a$$
$$\tau = \frac{P_{\text{mech}}}{\omega_m} \qquad ...(2)$$

From equation (1) and (2) the high resistance of rotor then the motor achieves quick acceleration and torque of starting is increase.

SOL 4.78 Option (A) is correct.

Given V/f control of induction motor, the maximum developed torque remains same

we have, $E = 4.44 K_{w_1} f \phi T_1$

If the stator voltage drop is neglected the terminal voltage E_1. To avoid saturation and to minimize losses motor is operated at rated airgap flux by varying terminal voltage with frequency. So as to maintain (V/f) ratio constant at the rated value, the magnetic flux is maintained almost constant at the rated value which keeps maximum torque constant.

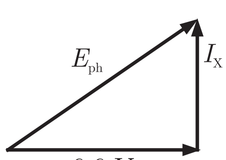
SOL 4.79 Option (B) is correct.

Given $P = 1000$ kVA, 6.6 kV

Reactance $= 20\ \Omega$ and neglecting the armature resistance at full load and unity power factor

So $P = \sqrt{3}\, V_L I_L$

$$I = \frac{1000}{\sqrt{3} \times 6.6} = 87.47 \text{ A}$$



So, $IX = 87.47 \times 20 = 1.75$ kV

$$E_{ph}^2 = \left(\frac{6.5}{\sqrt{3}}\right)^2 + (1.75)^2$$

$$E_{ph} = \sqrt{\left(\frac{6.5}{\sqrt{3}}\right)^2 + (1.75)^2}$$

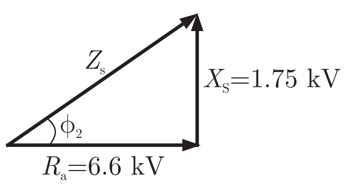
$$E_{ph} = 4.2 \text{ kV}$$

$$E_L = \sqrt{3}\, E_{ph} \quad \because \text{ Star connection}$$

$$E_L = 1.732 \times 4.2 = 7.26 \text{ kV}$$

SOL 4.80 Option (C) is correct.

Torque angle $\alpha_z = \tan^{-1}\left(\frac{X_s}{R_a}\right)$



$$\alpha_z = \tan^{-1}\left(\frac{\sqrt{3} \times 1.75}{6.6}\right) = 24.6^\circ$$

SOL 4.81 Option (B) is correct.

Given that

Transformer rating is 500 kVA

$$\text{Iron losses} = 300 \text{ W}$$

$$\text{full load copper losses} = 600 \text{ W}$$

Maximum efficiency condition

$$W_i = X^2 W_c$$

So,

$$X = \sqrt{\frac{W_i}{W_c}} = \sqrt{\frac{300}{600}} = 0.707$$

$$\text{efficiency\%} = 0.707 \times 100 = 70.7\%$$

SOL 4.82 Option (C) is correct.

Stepper motor is rotated in steps, when the supply is connected then the torque is produced in it. The higher value of torque is pull out torque and less torque when the torque is pull in torque.

SOL 4.83 Option (C) is correct.

The stepper motor has the permanent magnet rotor and stator has made of windings, it's connected to the supply.

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SOL 4.84 Option (D) is correct.

1-phase induction motor is not self starting, so it's used to start different method at full load condition, capacitor-run type motor have higher power factor. In this type the capacitor is connected in running condition.

SOL 4.85 Option (C) is correct.

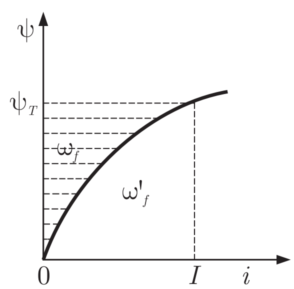
Given that if 3-ϕ induction motor is rotated in clockwise then the phase sequence of supply voltage is A-B-C. In counter clock wise rotation of the motor the phase sequence is change so in the counter clockwise rotation the phase sequence is A-C-B.

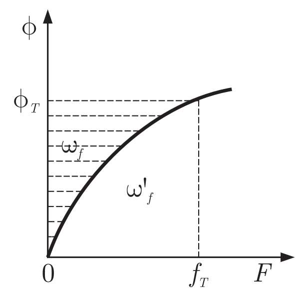
SOL 4.86 Option (A) is correct.

In linear electromagnetic circuit the field energy is equal to the co-energy.

$$W_f = W'_f = \frac{1}{2}Li^2 = \frac{1}{2}\psi_i = \frac{1}{2L}\psi^2$$

$$W_f = \text{field energy}$$
$$W'_f = \text{co energy}$$





SOL 4.87 Option (A) is correct.

Given that

8-Pole, 50 Hz induction machine in seventh space harmonic mmf wave.

So,

$$\text{Synchronous speed at } 7^{\text{th}} \text{ harmonic is} = N_s/7$$

$$\text{Speed of motor } N_s = \frac{120f}{P} = \frac{120 \times 50}{8} = 750 \text{ rpm}$$

$$\text{Synchronous speed is} = \frac{N_s}{7} = \frac{750}{7} = 107.14 \text{ rpm in forward direction}$$

SOL 4.88 Option (B) is correct.

Rotating electrical machines having its self inductance of stator and rotor windings is independent of the rotor position of synchronizing torque.

synchronizing torque

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$$T_{\text{synchronizing}} = \frac{1}{\omega_s} m \frac{dP}{d\delta} \text{ Nm/elect. radian}$$

$$= \left(\frac{1}{\omega_s} m \frac{dP}{d\delta}\right)\frac{\pi P}{180} \text{ Nm/mech.degree}$$

SOL 4.89 Option (A) is correct.

Given that the armature of a permanent magnet dc motor is

$$R_a = 0.8\,\Omega$$

At no load condition

$$V = 25 \text{ V},\ I = 1.5 \text{ A},\ N = 1500 \text{ rpm}$$

$$\text{No load losses} = E \times I$$

$$\because\ E = V - IR_a$$

So

$$\text{No load losses} = (25 - 1.5 \times 0.8)\,1.5 = 35.7 \text{ W}$$

At load condition

$$I = 3.5 \text{ A}$$

$$\text{Iron losses} = I^2 R = (3.5)^2 \times 0.8 = 9.8 \text{ W}$$

$$\text{Total losses} = \text{No load losses} + \text{iron losses}$$

$$= 35.7 + 9.8 = 45.5 \text{ W}$$

$$\text{Total power } P = VI$$

$$P = 25 \times 3.5$$

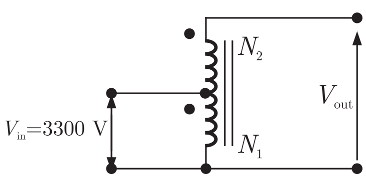
$$P = 87.5 \text{ W}$$

$$\text{Efficiency} = \frac{\text{output}}{\text{input}}$$

$$\eta = \frac{\text{total power} - \text{losses}}{\text{total power}} = \frac{87.5 - 45.5}{87.5} \times 100 = 48.0\%$$

SOL 4.90 Option (D) is correct.

Given that 50 kVA, 3300/230 V, 1-ϕ transform



$$V_{\text{in}} = 3300 \text{ V}$$

$$V_{\text{out}} = 3300 + 230 = 3530 \text{ V}$$

Output current I_2 and output voltage 230 V

So

$$I_2 = \frac{50 \times 10^3}{230} = 217.4 \text{ A}$$

When the output voltage is V_{out} then kVA rating of auto transformer will be

$$I_2 = 3530 \times 217.4$$
$$= 767.42 \text{ kVA}$$

SOL 4.91 Option (D) is correct.

Given that 100 kVA, 11000/400 V, Delta-star distribution transformer resistance is 0.02 pu and reactance is 0.07 pu

So pu impedance $Z_{pu} = 0.02 + j0.07$

Base impedance referred to primary

$$Z_{Base} = \frac{V_P^2}{V_L I_L/3} = \frac{(11 \times 10^3)^2}{\frac{100 \times 10^3}{3}} = 3630 \ \Omega$$

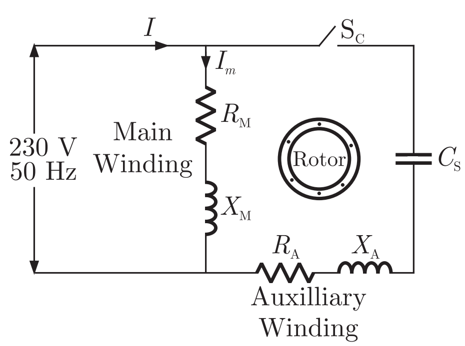
The phase impedance referred to primary

$$Z_{primary} = Z_{pu} \times Z_{Base} = (0.02 + j0.07)(3630) = 72.6 + j254.1$$

SOL 4.92 Option (A) is correct.

Given that

230 V, 50 Hz, 4-Pole, capacitor-start induction motor



$$Z_m = R_m + X_m = 6.0 + j4.0 \ \Omega$$
$$Z_A = R_A + X_A = 8.0 + j6.0 \ \Omega$$

Phase angle of main winding

$$\angle I_m = \angle - Z_m = - \angle (6 + j4) = - \angle 33.7^\circ$$

So angle of the auxiliary winding when the capacitor is in series.

$$\angle I_A = - \angle (8 + j6) + \frac{1}{j\omega C} = \angle (8 + j6) - \frac{j}{\omega C}$$

$$\alpha = \angle I_A - \angle I_m$$

So $$90 = - \tan^{-1}\left[\left(\frac{6 - \frac{1}{\omega C}}{8}\right) - (-33.7)\right]$$

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$$\frac{1}{\omega C} = 18 \qquad \omega = 2\pi f$$

So $$C = \frac{1}{18 \times 2\pi f} = \frac{1}{18 \times 2 \times 3.14 \times 50} = 176.8\ \mu\text{F}$$

SOL 4.93 Option (A) is correct.

Given that the armature has per phase synchronous reactance of 1.7 Ω and two alternator is connected in parallel

So,

both alternator voltage are in phase

So,

$$E_{f1} = \frac{3300}{\sqrt{3}}$$

$$E_{f2} = \frac{3200}{\sqrt{3}}$$

Synchronizing current or circulating current

$$= \frac{E_C}{T_{S1} + T_{S2}}$$

Reactance of both alternator are same

So $$= \frac{E_{f1} - E_{f2}}{T_{S1} + T_{S2}} = \frac{1}{\sqrt{3}}\left(\frac{3300 - 3200}{1.7 + 1.7}\right) = 16.98\ \text{A}$$

SOL 4.94 Option (C) is correct.

Given $V = 400$ V, 15 kW power and $P = 4$

$$f = 50\ \text{Hz, Full load slip } (S) = 4\%$$

So $$N_s = \frac{120f}{P} = \frac{120 \times 50}{4} = 1500\ \text{rpm}$$

Actual speed = synchronous speed − slip

$$N = 1500 - \frac{4}{100} \times 1500 = 1440\ \text{rpm}$$

Torque developed

$$T = \frac{P}{\omega_s(1-S)}, \qquad \text{where } \omega_s(1-S) = \frac{2\pi N}{60}$$

$$= \frac{15 \times 10^3 \times 60}{2\pi \times 1440} = 99.47\ \text{Nm}$$

SOL 4.95 Option (B) is correct.

Given 1.8° angle, 2-ϕ Bipolar stepper motor and stepping rate is 100 step/second

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So,
Step required for one revolution

$$= \frac{360}{1.8} = 200 \text{ steps}$$

$\because$ Time required for one revolution = 2 seconds

$$\text{rev/sec} = 0.5 \text{ rps}$$

and

$$\text{rev/min} = 30 \text{ rpm}$$

SOL 4.96 Option (C) is correct.
Given that:
$P = 8$ Pole, DC generator has wave-wound armature containing 32 coil of 6 turns each. Simplex wave wound flux per pole is 0.06 Wb

$$N = 250 \text{ rpm}$$

So,
Induced armature voltage

$$E_g = \frac{\phi ZNP}{60A}$$

$$Z = \text{total no.of armature conductor}$$

$$= 2CN_C = 2 \times 32 \times 6 = 384$$

$$E_g = \frac{0.06 \times 250 \times 3.84 \times 8}{60 \times 2}$$

$\because$ $A = 2$ for wave winding

$$E_g = 384 \text{ volt}$$

SOL 4.97 Option (C) is correct.
Given a 400 V, 50 Hz and 0.8 p.f. loading delta connection 50 Hz synchronous machine, the reactance is 2 Ω. The friction and windage losses are 2 kW and core losses is 0.8 kW and shaft is supply 9 kW at a 0.8 loading power factor
So

$$\text{Input power} = 9 \text{ kW} + 2 \text{ kW} + 0.8 \text{ kW} = 11.8 \text{ kW}$$

$$\because \text{Input power} = \sqrt{3}\, V_2 I_2 = 11.8 \text{ kW}$$

$$I_2 = \frac{11.8 \text{ kW}}{\sqrt{3} \times 400 \times 0.8} = 21.29 \text{ A}$$

SOL 4.98 Option (B) is correct.
Given that 500 MW, 3-ϕ star connected synchronous generator has a rated voltage of 21.5 kV and 0.85 Power factor

So $\sqrt{3}\, V_L I_L = 500 \text{ MW}$

$$I_L = \frac{500 \times 10^6}{\sqrt{3} \times 21.5 \times 10^3 \times 0.85} = 15.79 \times 10^3$$

$$I_L = 15.79 \text{ kA}$$

SOL 4.99 Option (D) is correct.

Given that 1-ϕ transformer, maximum efficiency 90% at full load and unity power factor

So $$\eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + P_i + P_c} = \frac{(L.F) \cos\phi_2}{(L.F)\cos\phi_2 + P_{i(Pu)} + P_c}$$

where $L.F.$ is the load fator.

At full load, load factor is

$$L.F. = \sqrt{\frac{P_i}{P_c}} = 1$$

$$\cos\phi_2 = 1 \text{ at unity power factor}$$

so, $$90\% = \frac{1 \times 1}{1 + 2P_i}$$

$$P_i = 0.0555 \text{ MVA}$$

At half load, load factor is

$$\text{L.F} = \frac{1}{2} = .5$$

So, $$\eta = \frac{0.5 \times 1}{0.5 \times 0.0555 \times (0.5)^2 + 0.0555} \times 100 = 87.8\%$$

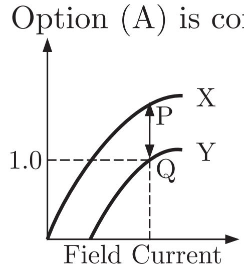
SOL 4.100 Option (C) is correct.

In food mixer the universal motor is used and in cassette tap recorder permanent magnet DC motor is used. The Domestic water pump used the single and three phase induction motor and escalator used the three phase induction motor.

SOL 4.101 Option (D) is correct.

Given a engine drive synchronous generator is feeding a partly inductive load. A capacitor is connected across the load to completely nullify the inductive current. Then the motor field current has to be reduced and fuel input left unaltered.

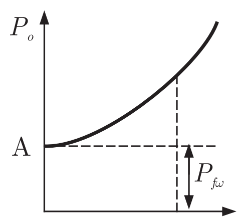
SOL 4.102 Option (A) is correct.



Given open circuit and full-load zero power factor of a synchronous generator. At point Q the zero power factor at 1.0 pu voltage. The voltage drop at point PQ is across synchronous reactance.

SOL 4.103 Option (D) is correct.

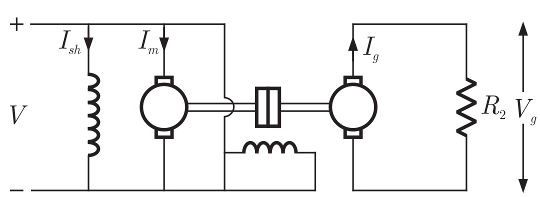
Given no load test on 3-ϕ induction motor, the graph between the input power and voltage drop is shown in figure, the intersection point yield the friction and windage loss.



Separation of fraction and windage loss

SOL 4.104 Option ( ) is correct.

SOL 4.105 Option (C) is correct.



Given that: The armature resistance in per unit is 0.2

so, $$R_a = 0.2$$

back emf equation of motor is

$$E_b = V - I_a R_a$$

given that no mechanical losses and armature reaction is neglected, so per unit value of emf induced by motor is

$$E_b = 0.98$$

The DC shunt motor is mechanically coupled by the generator so the emf induced by motor and generator is equal

$$E_g = E_b$$

so voltage generated by the generator is

$$V = 0.98 - 1 \times 0.2 = 0.96$$

per unit value of load resistance is equal to 0.96

SOL 4.106 Option (D) is correct.

Given that when the switch S_1 is closed and S_2 is open then the 11000 V is step down at 415 V output

Second time when the switch S_1 is open and switch S_2 is closed then 2-phase supply is connected to the transformer then the ratio of voltage is

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{11000}{415} = 26.50$$

The output terminal a and c are in opposite phase so cancelled with each other and terminal is equal to zero volt.

SOL 4.107 Option (D) is correct.

Given that

$$N_1 : N_2 : N_3 \text{ is } 4:2:1$$

Resistance $R = 10\ \Omega$

$$V_1 = 400 \text{ V}$$

so,

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{4}{2}$$

$$V_2 = \frac{2V_1}{4} = 200 \text{ V}$$

and

$$\frac{V_1}{V_3} = \frac{N_1}{N_3} = \frac{4}{1}$$

$$V_3 = 100 \text{ V}$$

so current in secondary winding

$$I_2 = \frac{V_2}{R} = \frac{200}{10} = 20 \text{ A}$$

The current in third winding when the capacitor is connected

so $$I_3 = \frac{V_3}{-jX_c} = \frac{100}{-j2.5} = j40$$

When the secondary winding current I_2 is referred to primary side i.e $I_1^{'}$

So $$\frac{I_1^{'}}{I_2} = \frac{N_2}{N_1} = \frac{2}{4}$$

$$I_1^{'} = \frac{20}{2} = 10 \text{ A}$$

and winding third current I_3 is referred to Primary side i.e $I_1^{''}$. I_3 flows to opposite to I_1

So $$\frac{I_1^{''}}{-I_3} = \frac{N_3}{N_1} = \frac{1}{4}$$

$$I_1^{''} = -j10$$

So total current in primary winding is

$$I_1 = I_1^{'} + I_2^{''} = 10 - j10 \text{ A}$$

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SOL 4.108 Option (A) is correct.

Given that:

P Stator winding current is dc, rotor winding current is ac

Q Stator winding current is ac, rotor winding current is dc

R Stator winding current is ac, rotor winding current is ac

S Stator has salient pole and rotor has commutator

T Rotor has salient pole and slip rings and stator is cylindrical

U Both stator and rotor have poly-phase windings

So

DC motor/machines:

The stator winding is connected to dc supply and rotor winding flows ac current. Stator is made of salient pole and Commutator is connected to the rotor so rotor winding is supply ac power.

Induction machines:

In induction motor the ac supply is connected to stator winding and rotor and stator are made of poly-phase windings.

Synchronous machines:

In this type machines the stator is connected to ac supply but rotor winding is excited by dc supply. The rotor is made of both salient pole and slip rings and stator is made of cylindrical.

SOL 4.109 Option (C) is correct.

Given that

F_s is the peak value of stator mmf axis. F_r is the peak value of rotor mmf axis. The rotor mmf lags stator mmf by space angle δ. The direction of torque acting on the rotor is clockwise or counter clockwise.

When the opposite pole is produced in same half portion of stator and rotor then the rotor moves. So portion of stator is north-pole in ABC and rotor abc is produced south pole as well as portion surface CDA is produced south pole and the rotor cda is produced North pole.

The torque direction of the rotor is clock wise and torque at surface is in counter clockwise direction.

SOL 4.110 Option (A) is correct.

Given that:

A 4-pole, 3-ϕ, double layer winding has 36 slots stator with 60° phase spread, coil span is 7 short pitched

so,

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$$\text{Pole pitch} = \frac{\text{slot}}{\text{pole}} = \frac{36}{4} = 9$$

$$\text{Slot/pole/phase} = 3$$

so, 3-slots in one phase, if it is chorded by 2 slots then

Out of 3 $\rightarrow$ 2 have different phase

Out of 36 $\rightarrow$ 24 have different phase.

SOL 4.111 Option (B) is correct.

Given that:

3-ϕ induction motor is driving a constant load torque at rated voltage and frequency. Voltage and frequency are halved and stator resistance, leakage reactance and core losses are ignored.

Then the motor synchronous speed and actual speed difference are same.

$$N_s = \frac{120f}{P}$$

The leakage reactance are ignored then the air gap flux remains same and the stator resistance are ignored then the stator current remain same.

SOL 4.112 Option (D) is correct.

Given that: 1-ϕ induction motor main winding excited then the rotating field of motor changes, the forward rotating field of motor is greater then the back ward rotating field.

SOL 4.113 Option (B) is correct.

Given that:

A dc series motor driving a constant power load running at rated speed and rated voltage. It's speed brought down 0.25 pu. Then

Emf equation of dc series motor

$$E = V - (R_a + R_{se})$$

$$R_a + R_{se} = R$$

so, $$E = V - IR = K\phi N$$

then $$N = \frac{E}{K\phi}$$

In series motor $\phi \alpha I$

so, $$N = \frac{V - IR}{KI}$$

At constant power load

$$E \times I = T \times W = \text{Const} \qquad ...(1)$$

$$T = K\phi I = KI^2 \qquad ...(2)$$

If W is decreased then torque increases to maintain power constant.

$$T \propto I^2$$
$$W = \frac{1}{4} \text{ then } T = 4$$

So current is increased 2 time and voltage brought down to 0.5 pu.

SOL 4.114 Option (A) is correct.

Given 400 V, 50 Hz, Y-connected, 3-ϕ squirrel cage induction motor operated from 400 V, 75 Hz supply. Than Torque is decreased.

$\because$ Machine is rated at 400 V, 50 Hz

and it is operated from 400 V, 75 Hz

so, speed of Motor will increase as $N = \frac{120f}{P} \Rightarrow N \propto f$

and we know Torque in induction motor

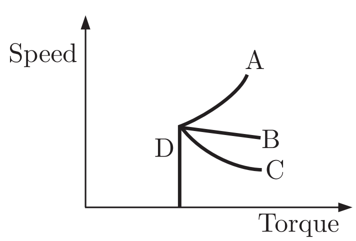
$$T_e = \frac{3}{W_s} I'^2_2 \frac{R_2}{S} \Rightarrow T_e \propto \frac{1}{N}$$

If speed increases, torque decreases.

SOL 4.115 Option (B) is correct.

Motor is overloaded, and magnetic circuit is saturated. Than Torque speed characteristics become linear at saturated region.

as shown in figure



actual torque-speed characteristics is given by curve B.

SOL 4.116 Option (D) is correct.

Given that transformer rating 1 kVA, 230 V/100 V, 1-ϕ, 50 Hz, operated at 250 V, 50 Hz at high voltage winding and resistive load at low voltage winding which draws rated current, than current drawn from the source will not be sinusoidal.

SOL 4.117 Option (A) is correct.

In this case voltmeter reading will be zero.

SOL 4.118 Option ( ) is correct.

SOL 4.119 Option (C) is correct.

Slip ring induction motor of 5 kW, 400 V, 50 Hz.

rotor = 6 Poles, stator= 4 Poles

than speed of motor = ?

speed = 0

$\because$ No. of rotor poles $\neq$ No. of stator poles

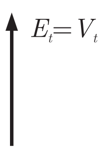
so motor will not rotate.

SOL 4.120 Option (B) is correct.

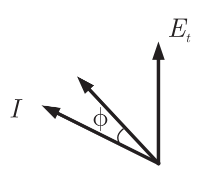
Flux per pole in synchronous motor when stator disconnected from supply is = 25 MWb

When stator connected to rated supply than flux per pole is = 20 MWb

As in first case stator is disconnected from supply.



Second case when stator connected to rated supply then terminal voltage decreases and current will lead from the supply voltage.



SOL 4.121 Option ( ) is correct.

Given: Separately Excited *dc* motor of 230 V, 250 rpm, 100 A

$$r_a = 0.5\ \Omega$$

It is driving a load.Torque speed characteristics as given below

$$T_L = 500 - 10\omega$$

Steady state speed = ?

$$\text{Back emf of motor } E_b = V - I_a R_a = 230 - 100(0-5) = 180 \text{ V}$$

$$\text{Torque is given as } T_e = \frac{E_b I_a}{\omega} = \frac{180 \times 100 \times 60}{250 \times 2 \times 3.14} = 687.54 \text{ Nm}$$

$$\text{Now given that } T_L = 500 - 10\omega$$

$$\omega = \frac{500 - T_L}{10} = \frac{500 - 687.54}{10} = -18.754 \text{ rad/sec}$$

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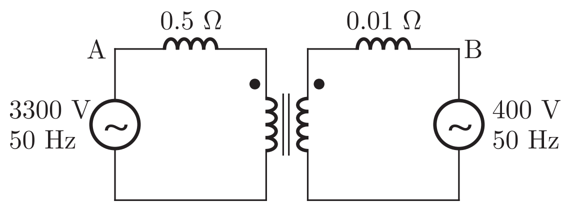
$$N = \frac{-18.756 \times 60}{2\pi} = -179.08 \text{ rpm}$$

$-$ve sign employs that rotor direction is opposite to that of generator.

SOL 4.122 *

Given

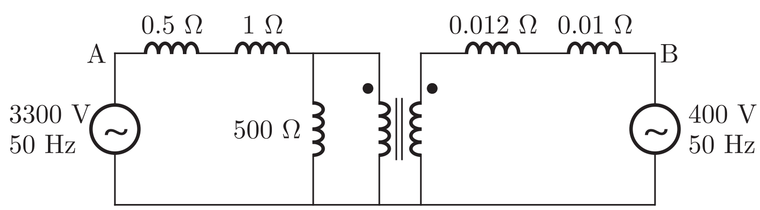


X_m referred to high voltage $X_m = 500\ \Omega$

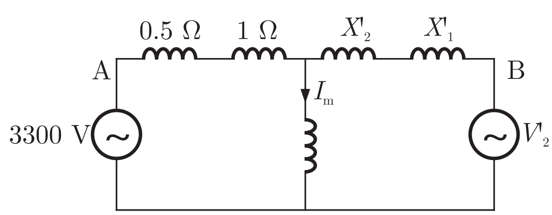
$X_{l1} = 1.0\ \Omega, X_{l2} = 0.012\ \Omega$ (Leakage reactance of high voltage and low voltage)

Magnetising $A_T = ?$

First we have to draw its equivalent circuit as



now equivalent circuit referred to high voltage side is as



$$X'_2 = \left(\frac{99}{12}\right)^2 \times 0.012 = 0.8167$$

$$X'_1 = \left(\frac{99}{12}\right)^2 \times 0.01 = 0.68$$

$$V'_2 = \left(\frac{99}{12}\right) \times 400 = 3300 \text{ V}$$

now magnetizing current

$$I_m = \frac{3300}{0.5 + 1.0 + 500} + \frac{3300}{0.8167 + 0.68 + 500} = 13.1605 \text{ Amp}$$

magnetizing ampere turns

$$A_T = 13.1605 \times 99 = 1302.84 \text{ Ampereturns}$$

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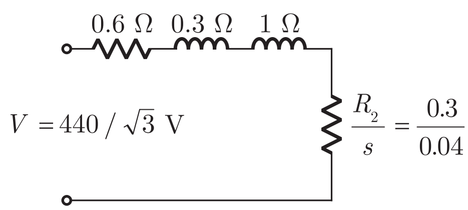
SOL 4.123 Option ( ) is correct.

Equivalent circuit of induction motor referred to stator side



$$N_s = \frac{120f}{P} = \frac{120 \times 50}{6} = 1000 \text{ rpm}$$

$$\text{slip} = \frac{N_s - N_r}{N_s} = \frac{1000 - 960}{1000} = 0.04$$

Current
$$I = \frac{V}{\sqrt{\left(R_s + \frac{R'_r}{S}\right)^2 + (X_s + X'_r)^2}}$$

$$= \frac{440}{\sqrt{3}\sqrt{\left(0.6 + \frac{0.3}{0.04}\right)^2 + (1+1)^2}} = 30.447 \text{ Amp}$$

Torque
$$T_e = \frac{3}{\omega_s} I_2^2 \left(\frac{r}{s}\right)$$

$$T_e = \frac{3 \times 60}{2\pi \times 1000} \times (30.447)^2 \times \frac{0.3}{0.04} = 199.18 \text{ N-m}$$

If it will work as generator than slip will be negative

$$S = \frac{N_s - N_e}{N_s}$$

$$-0.4 = \frac{1000 - N_r}{1000}$$

$$N_r = 1040 \text{ rpm}$$

SOL 4.124 Option ( ) is correct.

Given 415 V, 2-Pole, 3-ϕ, 50 Hz, Y-connected synchronous motor

$$X_s = 2\ \Omega \text{ per phase } I = 20 \text{ A at 4 PF}$$

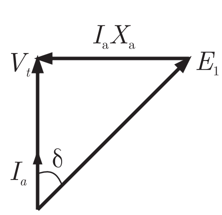
Mechanical load is increased till $I = 50$ A

Then

(a) Per phase open circuit voltage $E_0 = ?$

(b) Developed power $= ?$

In first case the UPF phasor diagram is being drawn as



from phasor diagram $E_0^2 = V^2{}_t + I^2{}_a \times s^2$

$$= \left(\frac{415}{\sqrt{3}}\right)^2 + 20^2 \times 2^2 = 242.91 \text{ V}$$

now I_a is increased than load angle and power factor angle is also increased as ($E_0 =$ constant)

Than $(I_a \times X_s)^2 = E_0^2 + V^2{}_t - 2E_0^2 V_t \cos\delta$

$$(50 \times 2)^2 = (242.91)^2 + \left(\frac{415}{\sqrt{3}}\right)^2 - 2 \times \frac{242.91}{\sqrt{3}} \times 415 \cos\delta$$

$$\cos\delta = \frac{(242.91)^2 + (239.6)^2 - (100)^2}{2 \times 242.91 \times 239.6}$$

$$\cos\delta = 0.914 \Rightarrow \delta = 23.90°$$

$$\text{Power } P_i = \frac{E_0 V_t \sin\delta}{X} = \frac{242.91 \times 239.6}{2} \sin 23.9 = 11789.87$$

$$P_i = VI\cos\theta = 11789.87$$

$$239.6 \times 50 \cos\theta = 11789.87$$

$$\cos\theta = 9841$$

$$\text{Power developed} = 3(P - I^2 R) = 3(11789.87 - 50^2 \times 2) = 35369.61 \text{ W}$$

SOL 4.125 Option (A) is correct.

We know that in case of practical transformer with resistive load, the core flux is strictly constant with variation of load.

SOL 4.126 Option (A) is correct.

In synchronous machine it is known that

$$X_d > X'_d > X''_d$$

where X_d = steady state d-axis reactance

X'_d = transient d-axis reactance

X''_d = sub-transient d-axis reactance

SOL 4.127 Option (B) is correct.

50 Hz, balanced 3-ϕ, Y-connected supply is given to Y-load instantaneous phase-a of supply is $V\cos\omega t$ and load current is $I\cos(\omega t - \phi)$ then 3-ϕ instantaneous power = ?

P = sum of individual power of all phases

$$= V_1 I_1 + V_2 I_2 + V_3 I_3$$

$$= V\cos\omega t[I\cos(\omega t - \phi)] + V\cos(\omega t - 120°) I\cos(\omega t - \phi - 120°) + V\cos(\omega t + 120°) I\cos(\omega t + 120° - \phi)$$

$$= \frac{VI}{2}[\cos(2\omega t - \phi) + \cos\phi + \cos(2\omega t - 240° - \phi) + \cos\phi$$

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$$+\cos(2\omega t + 240^\circ - \phi + \cos\phi)]$$

or $$P = \frac{VI}{2}[\cos(2\omega t - \phi) + 3\cos\phi + \cos(2\omega t - \phi)\cos 240^\circ$$

$$-\sin(2\omega t - \phi)\sin 240^\circ + \cos(2\omega t - \phi)\cos 240^\circ + \sin(2\omega t - \phi)\sin 240^\circ]$$

$$P = \frac{VI}{2}[\cos(2\omega t - \phi) + 3\cos\phi - \cos(2\omega t - \phi)] = \frac{3VI}{2}\cos\phi$$

Hence power is constant.

SOL 4.128 Option (A) is correct.

In transformer protection, harmonic restraint is used to guard against "Magnetizing inroush current".

SOL 4.129 Option (C) is correct.

For armature controlled separately excited dc motor drive with closed loop speed control. We use inner current loop because inner current loop limits the peak current of motor to the permissible value.

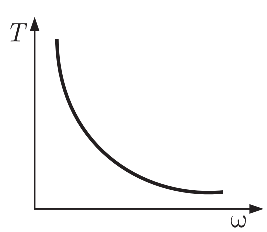
SOL 4.130 Option (D) is correct.

$\because$ Output of motor $= E_a I_a =$ constant

also power output $P_{o/p} = T\omega$

so $T\omega =$ costant

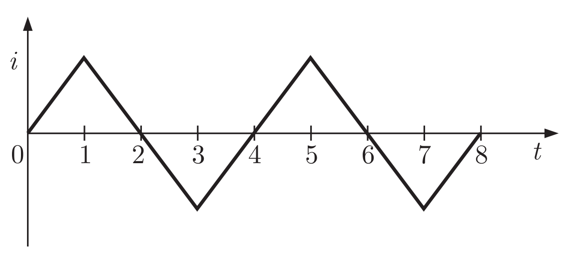
or $$T \propto \frac{1}{\omega}$$



So torque speed characteristics is a rectangular hyperbola.

SOL 4.131 Option ( ) is correct.

Ideal transformer of linear B-H with turn ratio 1:1



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(a) The flux ϕ_{oc}, when secondary is open

$\phi_{oc} \propto I$

so, it is same as current wave form.

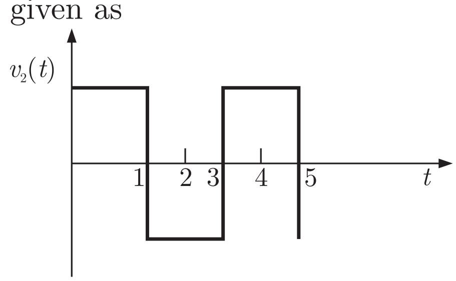
(b) Secondary open circuited terminal voltage : $v_2(t) = ?$

$$\text{we know } e_1 = -\frac{d\phi_{oc}}{dt}$$

and $$\frac{e_1}{e_2} = \frac{N_1}{N_2} = 1$$

So $$v_2(t) = e_2 = -\frac{d}{dt}(\phi_{oc}) \quad (\because \text{ secondary open circuited})$$

we know differentiation of triangular wave form is square. so waveform is given as

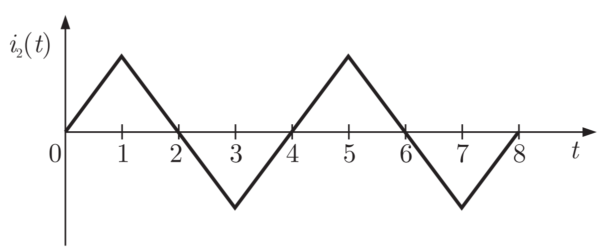


(c) Short circuited secondary current $[i_2(t)]$

$$\frac{i_1(t)}{i_2(t)} = \frac{N_2}{N_1} = 1$$

so $$i_2(t) = i_1(t)$$

It is same as primary current which is



(d) Short circuited secondary core flux.

$$\phi_{sc}(t) = ?$$

we know $$\phi_{sc}(t) \propto i_2(t)$$

so, it is same waveform as short circuit current in secondary.

SOL 4.132 *Option (B) is correct.

Given data

In dc motor $N = 2000$ rpm, $W_h = 500$ W, $W_e = 200$ W, $\phi =$ constant

N_1 os the speed at which is iron losses W_i is halved.

we know hysteresis loss $W_h = k_h f B_m$

and eddy current loss $W_e = k_e f^2 B_m$

$\because$ flux is constant so speed $\propto$ Frequency

again $W_h = k_1 N \Rightarrow 500 = k_1 \times 2000 \Rightarrow k_1 = \frac{1}{4}$

$$W_e = k_2 N^2 \Rightarrow 200 = k_2 (2000)^2 \Rightarrow k_2 = 5 \times 10^{-5}$$

We know that iron loss $W_i = W_n + W_e$

$$\frac{W_i}{2} = k_1 N_1 + k_2 N_1^2$$

$$350 = \frac{1}{4} N_1 + 5 \times 10^{-5} N_1^2$$

or $20 \times 10^{-5} N_1^2 + N_1 - 1400 = 0$

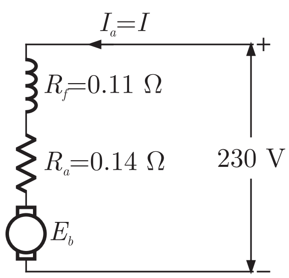
$$N_1 = 623 \text{ rpm}, - 1072.25 \text{ rpm}$$

as $N_1 = - 1072.25$ is not possible

so, $N_1 = 623$ rpm

SOL 4.133 *Option (B) is correct.

Given



rated

$$N = 1000 \text{ rpm}$$

$$I_a = 80 \text{ A}$$

ϕ at $I_a = 20$ A is 0.4 times of rated.

we have to calucalte speed at $I'_a = 20$ A

we know in case of series motor

$$N \propto E_b / \phi$$

$$\frac{N_1}{N_2} = \frac{E_{b1}}{E_{b2}} \times \frac{\phi_2}{\phi_1}$$

$$E_{b1} = V - I_a (R_a + R_f) = 230 - 80(0.14 + 0.11) = 210 \text{ V}$$

$$N_1 = 1000 \text{ rpm}$$

$$E_{b2} = V - I'_a (R_a + R_f) = 230 - 20(0.25) = 225 \text{ V}$$

$$N_2 = ?$$

$$\phi_2 = 0.4\phi_1$$

$$\frac{1000}{N_2} = \frac{210}{225} \times \frac{0.4\phi_1}{\phi_1}$$

$$N_2 = 1000 \times \frac{225}{210} \times \frac{1}{0.4}$$

$$N_2 = 2678.57 \text{ rpm}$$

SOL 4.134 *Option ( ) is correct.

Given 50 kW of synchronous motor driven by another motor.

excitation is off than driven motor takes 800 W of power

when armature is short circuited and rated $I_a = 10$ A, than it takes 2500 W

Open circuited armature takes $W_1 = 1800$ W

η of motor at 50 % load, neglecting losses of motor.

$\because$ excitation is off there is friction losses $W_f = 800$ W

short circuit loss

$$W_s = W_i - W_f = 2500 - 800 = 1700 \text{ W}$$

open circuit loss

$$W_0 = W_1 - W_f = 1800 - 800 = 1000 \text{ W}$$

$$\text{Total loss} = 800 + 1700 + 1000 = 3500 \text{ W}$$

at 50% load, output= 25 kW

$$\eta = \left(1 - \frac{\text{losses}}{\text{input}}\right)100$$

$$= 1 - \frac{3500}{25 \times 10^3 + 3500}$$

$$= 87.71\%$$

SOL 4.135 * Option ( ) is correct.

Given Two identical Generator each of 100 MVA in parallel

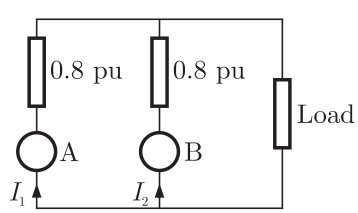
$$P = 100 \text{ MW at, p.f.} = 0.8 \text{ lagging}$$

Equal load sharing at initial.

If I_{f1} = reduced by 5% and I_{f2} = increased by 5%

Then load sharing of generator = ?

$$X_d = X_a = 0.8 \text{ Pu}$$



Case I

Load sharing of each generator equal i.e 50 MW at 0.8 p.f. lagging i.e 40 MW and 30 MVAR

$$V = I = 1 \text{ Pu}$$

Back emf of generators

$$E_{A1} = E_{B1} = V + IX_d \sin\phi$$
$$= 1 + 1 \times 0.8 \times 0.6 = 1.48 \text{ Pu}$$

Case II

Now in first generator field in decreased by 5% i.e

$$E_{A2} = 0.95(E_{A1}) = 0.95 \times 1.48 = 1.40 \text{ Pu}$$

And in second generator field is increased by 5% i.e

$$E_{B2} = 1.05, \quad E_{B1} = 1.05 \times 1.48 = 1.554 \text{ Pu}$$

In this case I_1 and I_2 are being given by as

$$I_1 = \frac{1.4 - 1}{0.48} = 0.846 \text{ Pu}$$

$$I_2 = \frac{1.554 - 1}{0.48} = 1.154 \text{ Pu}$$

so
$$P_A = 1 \times 0.846 = 0.846 \text{ Pu}$$
$$P_B = 1 \times 1.154 = 1.154 \text{ Pu}$$

Load sharing in MW by generator 1 $= 0.846 \times 40 = 33.84$ MW

by generator 2 $= 1.154 \times 40 = 46.16$ MW

MVAR load sharing by generator 1 $= 0.846 \times 30 = 25.38$ MVAR

MVAR load sharing by generator 2 $= 1.154 \times 30 = 34.62$ MVAR

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