QUIZ – ANSWER KEY

QUIZ NO: 96

TOPIC: ELECTRICAL ENGINEERING

DATE: 04/08/2022

1. If the load angle of 4 poles synchronous motor is 8^{o} electrical its value in mechanical degree is _________________ ?

   [A] 2

   [B] 8

   [C] 10

   [D] 4

Answer: D

Explanation:-

Mechanical Degree: Mechanical degree or angle is the angle at which the rotor of a machine is displaced mechanically.

Electrical Degree: The degree or the cycle of emf induced in a single conductor in a synchronous machine. In one electrical cycle, the electrical angle varies from 0-360 degree

- Consider a 4 pole machine there are 2 North and 2 South poles. So the rotor had to rotate 180 degrees mechanically to reach from one North pole to another North pole.
- That is to generate a complete cycle(360 degrees) electrically it has to rotate half cycle(180 degrees)mechanically.

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- So the relation between electrical and mechanical angle is dependent on the no of poles in the machine.

Electrical Degree = (No of poles/2) × Mechanical Degree

8 = (4/2) × Mechanical Degree

Mechanical Degree = 4°

2. In a synchronous motor, the synchronizing power comes into action when ?

[A] Rotor speed is less than synchronous speed

[B] Rotor speed is more than synchronous speed

[C] Rotor speed is equal to synchronous speed

[D] Rotor speed is either less or more than synchronous speed

Answer: D

Explanation:-

- The rate at which synchronous power, 'P' varies with load angle δ is called the synchronizing-power coefficient.
- It is also called stiffness of coupling, stability, or rigidity factor; It is represented as P_{syn}.

$$P_{syn}=(VE_f/X_s)\cos\delta$$

$$P\propto 1/X_s$$

- Synchronizing power of synchronous machines is inversely proportional to the synchronous reactance

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- A synchronous machine, when synchronized to infinite busbars has an inherent tendency to remain in synchronism
- At perfect synchronization, their synchronizing power is zero.
- Hence, an over-excited synchronous machine is more rigidly coupled than the one which is under-excited. A large air gap decreases the value of (synchronous reactance) X_s, thus a synchronous machine with a longer air gap is more stiffer than the one with smaller air-gap units of synchronizing power coefficient are watt per electrical radian.
- The variation of synchronous power with the change of load angle is called the synchronizing power. It exists only during the transient state, i.e. whenever there is a sudden disturbance in load (or steady-state operating conditions).
- Once the steady-state is reached, the synchronizing power reduces to zero.
- The synchronizing power flows from or to the bus in order to maintain the relative velocity between the interacting stator and rotor field, zero, once the equality is reached, the synchronizing power vanishes.

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3. The magnitude of field flux in a 3-phase synchronous motor___________

[A] Remains constant at all loads

[B] Varies with speed

[C] Varies with load

[D] Varies with power factor

Answer: A

Explanation:-

- In general, the counter emf or bac ef of any motor must be very nearly equal and opposite to the impressed terminal voltage so that if the latter is constant, the counter emf will be substantially constant.
- Now the counter emf is proportional to the speed and to the field flux, and since the speed is constant in the case of the synchronous motor, the field flux must likewise be substantially constant within the normal limits of operation.
- It follows, then, that if the field excitation is increased, thereby tending to increase the field flux that can vary only slightly, there must be an automatic change of the armature MMF in order to offset the effect of the increased field excitation
- The armature current must therefore contain a leading component, that a leading current in a synchronous motor exerts a demagnetizing effect.
- A weakening of the field excitation tends to draw a lagging current from the source of supply.

In short:- The magnitude of a field flux in a 3-phase synchronous machine remains constant at all loads because this motor runs at a constant speed for that The magnitude of field flux must be constant. The field is supplied from a d.c. source and the stator coils with a three-phase current.

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4. A 3-phase synchronous motor is running clockwise. In case the direction of its field current is reversed then ?

   [A] Winding of the motor will burn

   [B] Motor will run in the reverse direction

   [C] Motor will continue to run in the same direction

   [D] Motor will stop

   Answer: C

   Explanation:-

   Reversing a Synchronous Motor-

   - The direction of rotation of a synchronous motor is determined by its starting direction, as initiated by induction-motor action.
   - Thus, to reverse the direction of a three-phase synchronous motor, it is necessary to first stop the motor and then reverse the phase sequence of the three-phase connections at the stator like an induction motor.
   - The direction of rotation of a 3-phase synchronous motor can be changed by altering the phase sequence of the supply. I.e from RBY to RYB. Doing so will change the direction of rotation from clockwise to anticlockwise.
   - **Reversing the current to the field windings will not affect the direction of rotation. If the current in the field winding is reversed the motor will run in the same direction. The field side will only slip through a pole-pitch due to the reversal of the polarities of the field poles.**

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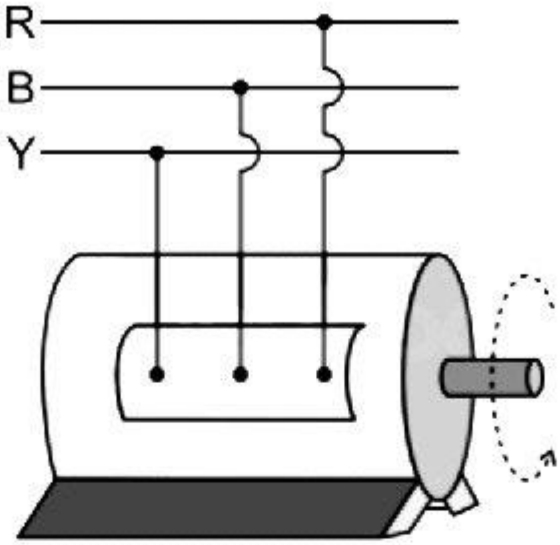

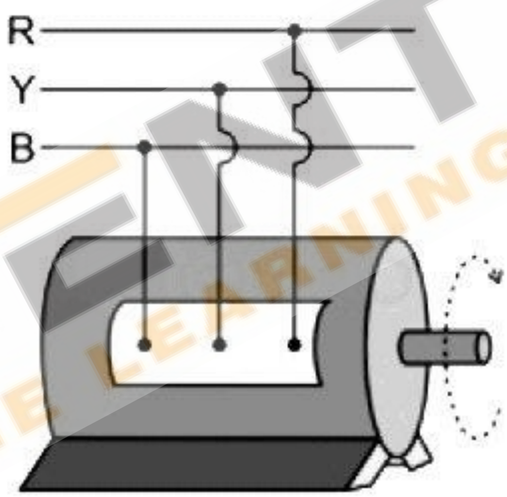

5. A Synchronous motor can operate at ?

   [A] Unity power factor

   [B] Leading power factor

   [C] Lagging power factor

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[D] Leading as well as lagging power factor

Answer: D

Explanation:-

For constant power output, a synchronous motor can be made to operate at either a lagging power factor, unity power factor or leading power factor by varying the field excitation.

Normal Excitation:- When the machine is operating as a normal excited motor, it has a unity power factor due to a normal field current. Under such conditions, the motor draws the minimum stator current.

Underexcited:- When the synchronous machine is operating as an under-excited motor, it has a lagging power factor due to a low field current. Here, the maximum power P_{max} is small and hence the machine operation is less stable. In this case, the motor behaves like an inductive load and the motor absorbs reactive power from the 3-phase line.

Note:- The power factor at which a synchronous machine operates and its stator (armature) current can be controlled by changing its field excitation.

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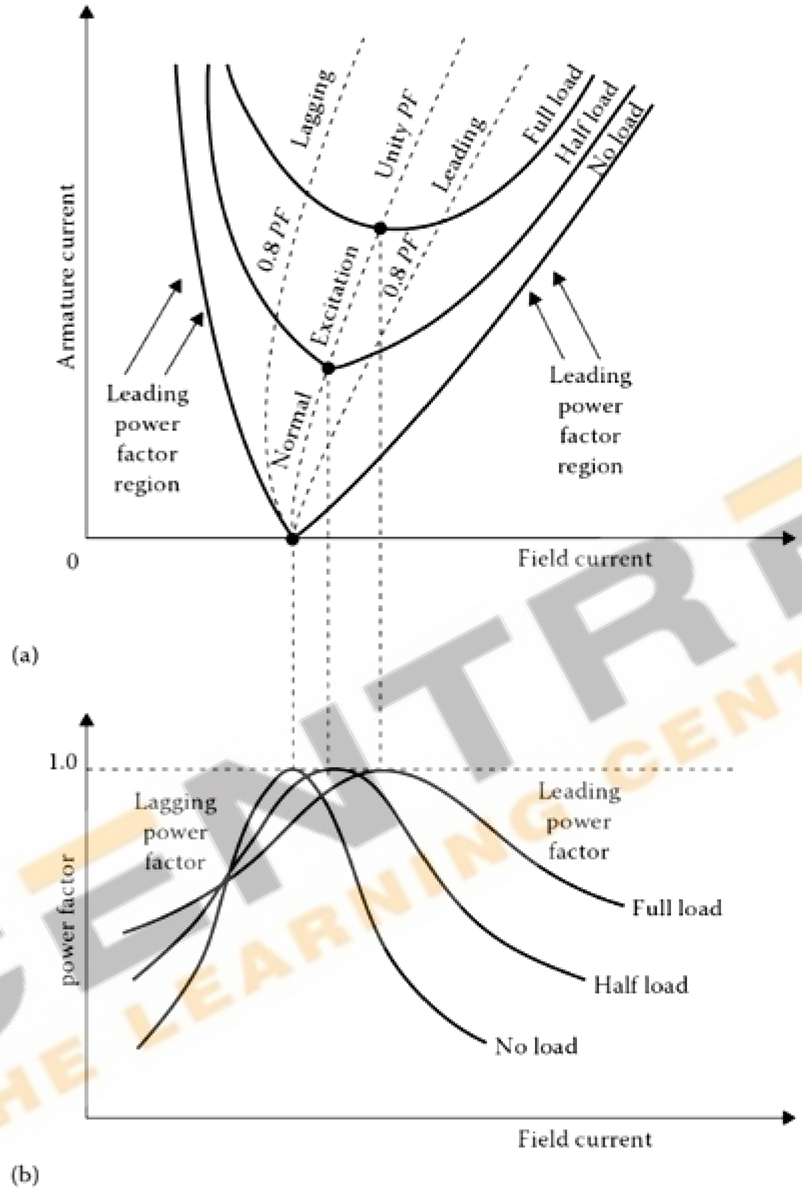

Overexcited:-When the machine is operating as an overexcited motor, it has a leading power factor due to a high field current. Therefore, the maximum power P_{max} is large and the machine operation is stable. An overexcited synchronous motor acts as a power factor correction device and is also known as a synchronous condenser.

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6. When the field of a synchronous motor is over excited, the power factor will be_______________ ?

[A] Leading

[B] Lagging

[C] Zero

[D] Unity

Answer: A

Explanation:-

An overexcited synchronous motor draws current at the leading power factor. If d.c. field excitation of a synchronous motor is such that the back emf E_b is greater than applied voltage V, then the motor is said to be over excited.

An overexcited synchronous motor acts as a power factor correction device and is also known as a synchronous condenser. The variation of armature current and power factor as a function of field current is plotted to give a better insight.

We can state that an over-excited synchronous motor draws a leading power factor current from the mains. The synchronous motor, therefore, when over-excited, in addition to driving some load, will work as a capacitor or condenser. A capacitor draws a leading power factor current. An over-excited synchronous motor draws the leading power factor current from the mains.

An over-excited synchronous motor is also called a synchronous condenser. Synchronous motors are used as constant-speed drive motors. Over-excited synchronous motors are used to improve the power factor of electrical loads in industries. Generally, the motor is run on load, and by overexcitation, the system power factor is also improved.

7. The maximum speed variation in a 3-phase synchronous motor is ?

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[A] 5%
[B] Zero
[C] 10%
[D] 3%

Answer: B

Explanation:-

- A synchronous motor runs at synchronous speed or not at all. Its speed is constant at all loads.
- The maximum speed variation in the synchronous motor is zero. The speed of operation remains constant from NO load to FULL load in the motor operating at constant frequency bus bars.
- A synchronous motor runs at one speed only i.e. synchronous speed. Consequently, slip is zero.

8. What is the ratio of no-load speed to full load speed of a 200 kVA, 12 poles, 2200 V, 3 phase, 60 Hz synchronous motor ?

[A] Infinite
[B] 1
[C] 1.1
[D] 1.21

Answer: B

Explanation:-

- The synchronous motor has the special property of maintaining a constant running speed under all conditions of load up to full load.
- This constant running speed can be maintained even under variable line-voltage conditions.

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- It should be noted that, if a synchronous motor is severely overloaded, its operation (speed) will suddenly lose its synchronous properties and the motor will come to a halt.
- The synchronous motor gets its name from the term synchronous speed, which is the natural speed of the rotating magnetic field of the stator.
- This natural speed of rotation is controlled strictly by the number of pole pairs and the frequency of the applied power.
- Like the induction motor, the synchronous motor makes use of the rotating magnetic field.
- In a synchronous machine, the rotor is magnetized and it runs at the same speed as the rotating magnetic field.
- The principle of operation of the synchronous motor is as follows: a multiphase source of AC is applied to the stator windings and a rotating magnetic field is produced.
- A DC current is applied to the rotor windings and a fixed magnetic field is produced.
- The motor is constructed such that these two magnetic fields react upon each other causing the rotor to rotate at the same speed as the rotating magnetic field.
- **If a load is applied to the rotor shaft, the rotor will momentarily fall behind the rotating field but will continue to rotate at the same synchronous speed.**
- Once the rotor's north and south poles line up with the stator's south and north poles the stator current is reversed, thus changing the south- and north-pole orientation in the stator, and the rotor is pushed again.
- This process repeats until the current in the stator stops alternating or stops flowing. In a three-phase motor, the stator magnetic flux rotates around the motor and the rotator actually follows this rotating magnetic field.
- This type of motor is called a synchronous motor because it always runs at synchronous speed (rotor and magnetic field of the stator are rotating at exactly the same speed).
- Maximum torque is achieved when the stator flux vector and the rotor flux vector are 90° apart.
- Synchronous motors operate at synchronism with the line frequency and maintain a constant speed regardless of load without sophisticated electronic control.

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- The synchronous motor typically provides up to a maximum of 140% of rated torque.

Here,

$N_s = 120 \times f/p = 120 \times 60/12 = 600$ rpm

Speed of the synchronous motor remains constant irrespective of the load of the motor ie; speed at no load and full load remains 600 rpm hence ratio of speed from no load to full load will be 1.

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9. In synchronous motor out of the following losses, which one will have the highest proportion ?
   - [A] Stator copper losses
   - [B] Iron losses
   - [C] Eddy current losses
   - [D] Friction and windage losses

Answer: B

Explanation:-

A synchronous machine is used to convert mechanical energy into electrical energy or vice-versa. While doing so, the whole of input energy does not appear at the output but a part of it is lost in the form of heat in the surroundings. This wasted energy is called losses in the machine. These losses affect the efficiency of the machine.

The various losses occurring in a synchronous machine can be sub-divided as;

1. Copper losses.
2. Iron losses.
3. Mechanical losses
4. Stray losses

1. Copper losses: The various windings of the synchronous machine such as armature and field winding are made of copper and have some resistance. When current flows through them, there will be power loss proportional to the square of their respective currents. These power losses are called copper losses.

In general, the various copper losses in a synchronous machine are:

(i) Armature copper loss = I^2R

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(ii) Field winding copper loss = $I^2_f R_f$

(iii) Brush contact loss = $I^2 R_b$

The brush contact loss is generally included in the field winding copper losses.

2. Iron losses: The losses which occur in the iron parts of the DC machine are called iron losses or core losses or magnetic losses. **Iron losses have a high proportion of losses occurring in the synchronous machine. Iron core losses in electrical induction machines operate with sinusoidal power supplies account for 15-25% of the total machine losses which are one of the major losses in electrical machines.** These losses consist of the following:

(i) Hysteresis loss: Whenever a magnetic material is subjected to reversal of magnetic flux, this loss occurs. It is due to the retentivity (a property) of the magnetic material. The Hysteresis losses are proportional to the frequency and the maximum flux density B_m in the air gap.
The loss is basically due to the reversal of the magnetization of the armature core. It occurs in the armature (stator core). To minimize this loss, the armature core is made of silicon steel which has low hysteresis constant.

(ii) Eddy current loss: When flux linking with the magnetic material changes (or flux is cut by the magnetic material) an emf is induced in it which circulates eddy currents through it. These eddy currents produce eddy current loss in the form of heat. The eddy current losses are proportional to the square of the electrical frequency. The electrical steel used in the stator and rotor of induction machines

The major part of this loss occurs in the armature core. To minimize this loss, the armature core is laminated into thin sheets (0·3 to 0·5 mm) since this loss is directly proportional to the square of the thickness of the laminations.

3. Mechanical losses: As the field system of a synchronous machine is a rotating part, some power is required to overcome:

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(i) Air friction of rotating field system (windage loss).

(ii) Friction at the bearing and friction between brushes and slip rings (friction loss).

These losses are known as mechanical losses. To reduce these losses proper lubrication is done at the bearings.

4. Stray losses:- In addition to the iron losses, the core losses are also caused by the distortion of the magnetic field under load conditions and losses in the insulation of armature and field winding, these losses are called stray lasses. These losses are also included while determining the efficiency of synchronous machines.

10. When a synchronous motor is connected to an infinite bus, while. operating on leading power factor ?

[A] Excitation voltage will be independent of the supply voltage
[B] Excitation voltage will be more than the supply voltage
[C] Excitation voltage will be less than the supply voltage
[D] Excitation voltage will be equal to the supply voltage

Answer: B

Explanation:-

The bus bars whose frequency and the phase magnitude of potential differences are not affected by changes in the condition of anyone machine connected to it are called infinite bus bars.

Or

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A network having zero impedance and infinite rotational inertia is also termed as Infinite bus-bars.

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