Tutorial 11 **NAME:**

SINGLE PHASE SPLIT PHASE MOTOR

SECTION A

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

1. A single phase winding produces:-

   a) a stationary magnetic field;
   b) a rotating magnetic field;
   c) a steady magnetic field;
   d) an alternating magnetic field.

2. To develop a rotating magnetic field a split phase induction motor simulates a:-

   a) two phase motor;
   b) three phase motor;
   c) series universal motor;
   d) shaded pole motor.

3. If motor load is reduced from full load to three quarters of full load you wouldexpect that:-

   a) speed would increase and current would increase;
   b) speed would decrease and current would decrease;
   c) speed would increase and current would decrease;
   d) speed would decrease and current would increase;

4. The angle of phase displacement between the start and run winding currents of asplit phase induction motor is approximately:-

   a) 10 degrees;
   b) 30 degrees;
   c) 90 degrees;
   d) 120 degrees.

5. The single phase split phase motor is reversed by:-

   a) reversing the supply connections;
   b) reversing the auxiliary winding connection;
   c) reversing the armature connection;
   d) reversing both the auxiliary winding and armature connections.

6. If the centrifugal switch on a split phase motor goes permanently open circuit:-

   a) the motor will not start;
   b) the start winding will burn out;
   c) the start capacitor will burn out;
   d) starting torque will drop to about half of normal value.

7. The auxiliary winding switch should open when:-
   a) rotor speed is about 25 percent of rated speed;
   b) rated speed is about 25 percent of synchronous speed;
   c) rotor speed is about 75 percent of synchronous speed;
   d) slip speed is about 75 percent of synchronous speed.

8. The run winding in a split phase induction motor is placed in:-
   a) the top of the slot to increase inductance;
   b) the top of the slot to decrease inductance;
   c) the bottom of the slot to decrease inductance;
   d) the bottom of the slot to increase inductance.

9. Variable frequency speed control of split phase motors is not generally usedbecause:-
   a) the capacitor start motor has higher torque;
   b) the starting switch might not operate;
   c) voltage speed control in more efficient;
   d) pole changing gives smoother speed changes.

10. The auxiliary winding of a split phase motor always has:-
   a) a lower power factor than the main winding;
   b) a higher resistance than the main winding;
   c) a lower resistance than the main winding;
   d) a higher power factor than the main winding.

SECTION B

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

The single phase split phase induction motor has two windings. The_____(1)_____or _____(2)_____winding in designed to be permanently connected to the supply, and is placed in the_____(3)_____of the slot to_____(4)_____the inductive reactance of the winding to give the current a_____(5)_____angle of phase difference with the voltage. The winding is wound with a relatively_____(6)_____winding wire so that it does not overheat, giving the winding a relatively_____(7)_____ resistance.

The other winding, called the_____(8)_____or_____(9)_____ winding is designed for short periods of operation and will_____(10)_____if left connected for long periods. It is wound with_____(11)_____wire than the other winding and has a _____(12)_____number of turns. This gives it a relatively_____(13)_____resistance and_____(14)_____inductive reactance, making the phase angle between the winding current and voltage_____(15)_____than that of the first winding.

The winding is turned off at about_____(16)____ percent of synchronous speed by either a_____(17)_____ switch in the motor or a_____(18)_____ relay which turns off when the current in the_____(19)_____ winding_____(20)_____ to almost rated current.

The windings are displaced by_____(21)_____electrical degrees around the stator, and the phase angle between the two currents, which is typically_____(22)_____ electrical degrees is adequate to produce an imperfect rotating magnetic field sufficient to start the motor on_____(23)_____torque loads. The motor is reversed by reversing the connections on_____(24)_____winding.

SECTION C

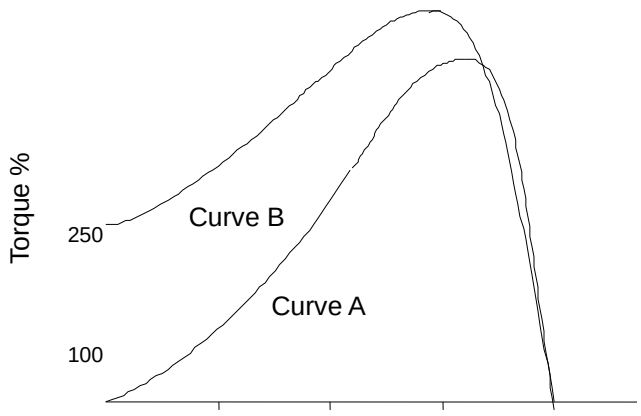
1. A single phase 240 volt 50 hertz 4 pole split phase motor runs at rated speed of1425 r.p.m. For full load determine:-
   a) the synchronous speed of the motor; (1 500 r.p.m.)
   b) the slip speed; (75 r.p.m..)
   c) the slip percent; (5%.)
   d) the rotor frequency. (2.5Hz)

SECTION D.

1. Figure 1 represents some torque speed curves for a single phase split phaseinduction motor.
   a) Which curve represents the torque speed characteristic for the main windingonly.

   _____

   b) If the centrifugal switch opens when the slip is 25 percent trace on the curves the total torque speed characteristic for the motor showing the transition fromstart to run condition.



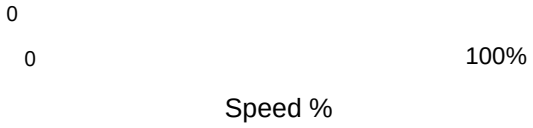


Figure 1

2. Figures 2(a) and (b) show the windings and centrifugal switch for a single phase split phase motor. Complete the circuit to show the connections for both forward and reverse rotations.

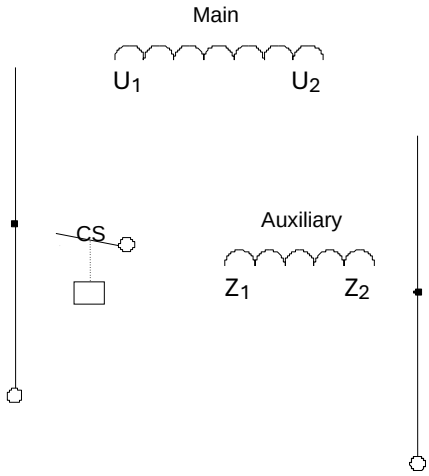


Figure 2 (a)

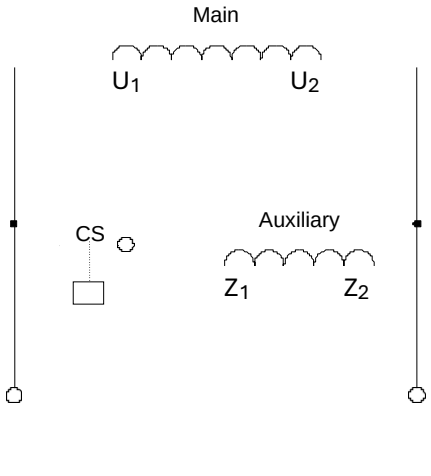


Figure 2 (b)

Tutorial 12 **NAME:**

CAPACITOR & SHADED POLE MOTORS

SECTION A

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

1. The capacitor start induction motor has a capacitor connected:-

a) in series with the auxiliary winding during starting;
b) in series with the running winding during starting;
c) in parallel with the main winding during starting;
d) in parallel with the start winding during starting.

2. The single phase induction motor that is commonly used to drive cooling

fans insmall appliances is the:-

a) permanently split capacitor motor;
b) shaded pole motor;
c) series universal motor;
d) split phase induction motor.

3. A capacitor start induction motor has an open circuited capacitor. The motor will:-

a) start with reduced torque;
b) fail to start;
c) start normally but stop when the centrifugal switch operates;
d) start in the reverse direction.

4. Impedance protection of shaded pole motors:-

a) reduces overheating when stalled;
b) reduces the starting current;
c) reduces unwanted tripping of overload devices;
d) limits motor current on no load.

5. Electrolytic capacitors are used in starting circuits:-

a) because of their low leakage current;
b) because of their small size;
c) because they are continuously rated;
d) because of their high dielectric strength.

6. If the centrifugal switch on a split phase motor goes permanently open circuit:-

a) the motor will not start;
b) the start winding will burn out;
c) the start capacitor will burn out;
d) starting torque will drop to about half of normal value.

7. The shading coils on a shaded pole motor are used to:-
   a) cause the flux to move across the pole face;
   b) reduce the noise of the motor;
   c) prevent the rotor "poling" or "cogging" with the stator;
   d) allow the motor to be reversed easily.
8. A starting switch is not required in:-
   a) a capacitor start, capacitor run motor;
   b) a split phase motor;
   c) a capacitor start motor;
   d) a shaded pole motor.
9. The single phase motor which would produce the highest starting torque whencompared to other motors of a similar rating is the:-
   a) split phase capacitor start;
   b) shaded pole;
   c) split phase;
   d) universal.
10. On a capacitor start, capacitor run induction motor the start capacitor may beidentified as having:-
   a) the lower capacitance and a continuous rating;
   b) the higher capacitance and a continuous rating;
   c) the lower capacitance and a short term rating;
   d) the higher capacitance and a short term rating.

SECTION B

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

The split phase motor has a maximum phase angle between the main and auxiliary winding currents of approximately_____(1)_____degrees. This angle is increased to approximately_____(2)_____degrees to produce improved starting characteristics by connecting a capacitor in_____(3)_____with the_____(4)_____winding. This makes the current in the start winding ____(5)____ the current in the run winding. There is a large ____(6)____ in starting torque due to the addition of the capacitor during starting, while the torque produced is the same as the split phase motor _____(7)_____the switch has operated, which occurs at about_____(8)_____ percent of synchronous speed. As with any induction motor, the initial starting current of the capacitor start motor is_____(9)_____and_____(10)_____as the motor accelerates to its operating speed. In larger motors the centrifugal switch may be replaced with a current relay with it's coil in series with the_____(11)_____winding.

The relay closes when the start current is_____(12)_____and opens when motor speed_____(13)_____and current_____(14)_____.

In the capacitor start, capacitor run motor the run capacitor has a_____(15)_____ value of capacitance than the start capacitor. The start capacitor is only connected in _____(16)_____with the_____(17)_____winding during starting, being open circuited by the_____(18)_____switch at about_____(19)_____percent slip. The run capacitor is left connected in_____(20)____with the_____(21)_____winding at all times the motor is running.

The_____(22)_____motor has two identical windings displaced by_____(23)_____ electrical degrees around the stator. The_____(24)_____may be connected in series with either winding depending on the desired_____(25)_____of rotation.

In the_____(26)_____motor, a short circuited turn of copper, or "***shading coil***", is fitted around one tip of each pole of the motor. This causes flux changes in the shaded part o the pole to occur_____(27)_____the same changes occur in the rest of the pole. As a result flux moves_____(28)_____the shaded side of the pole, creating a small torque in that direction. To reverse a shaded pole motor the_____(29)_____must be _____(30)_____in the stator.

SECTION C

1. A single phase 240 volt 50 hertz capacitor start induction motor has a run windingwhich takes 4 amperes at 0.6 lag power factor at start while the start winding/capacitor takes 3 amperes at 0.8 lead power factor. Determine:-
   a) the phase angle of each current and the angle between them; (53.1^{O}lag,36.9^{O}lead, 90^{O})
   b) the total current taken by the motor at starting. (5A.)
   c) the voltage across the 35uF capacitor. (273V.)

SECTION D.

1. This question relates to the motor illustrated in Figure 1 below.
   a) Identify the type of motor illustrated in Figure 1.
   b) Identify the parts of the motor labelled A, B, C and D.
   c) Is the direction of rotation of the motor clockwise or anti-clockwise?

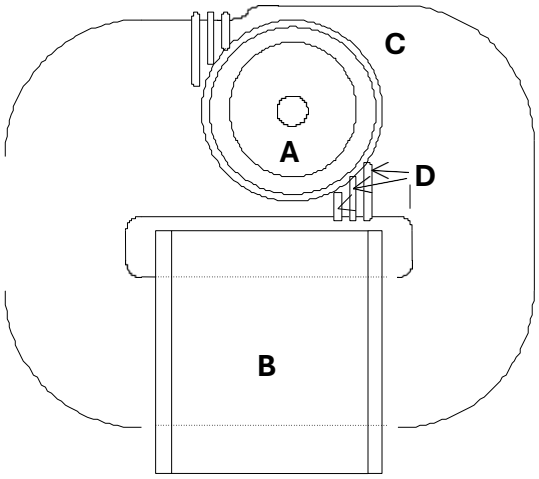


Figure 1

2. Figures 2(a) and (b) show the windings and capacitor for a permanent split capacitormotor. Complete each circuit for different directions of rotation.

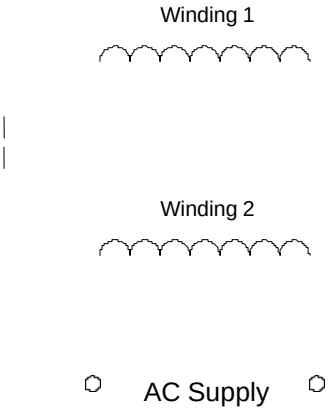


Figure 2(a)

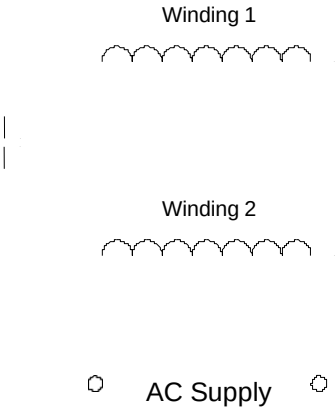


Figure 2(b)

Tutorial 13 **NAME:**

SERIES UNIVERSAL MOTORS

SECTION A

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

1. A single phase motor rated at 240 volt, 500 watt, 6000 r.p.m., 3 amperes, 50 Hzwould be:-
   a) a split phase motor;
   b) a shaded pole motor;
   c) a series universal motor;
   d) a permanent capacitor motor.

2. Voltage speed control of a constant torque load may be used with:-
   a) shaded pole motors;
   b) split phase motors;
   c) capacitor start motors;
   d) series universal motors.

3. The series universal motor is reversed by:-
   a) reversing the supply connections;
   b) reversing the armature and field connections;
   c) physically reversing the rotor in the field;
   d) reversing the armature connections.

4. A series universal motor driving a constant torque load has its armature voltagereduced from 200 volts to 100 volts using a series resistor. The result will be:-
   a) motor speed will remain unchanged;
   b) motor speed will double;
   c) motor speed will drop to half rated speed;
   d) motor current will decrease to half rated current.

5. The motor used in most mains powered portable hand tools is the:-
   a) shaded pole motor;
   b) split phase motor;
   c) capacitor start motor;
   d) series universal motor.

6. A series universal motor is identified by:-

a) its universal
b) its commutator
c) its series winding
d) its nameplate

7. The most commonly used motor for a 240 volt single-phase vacuum cleaner is:-
   a) split phase type;
   b) universal type;
   c) capacitor start type;
   d) shaded pole type.

8. A starting switch is not required in:-
   a) a capacitor start, capacitor run motor;
   b) a split phase motor;
   c) a capacitor start motor;
   d) a series universal motor.

9. A small shaded pole fan motor has new coils fitted to change the voltage rating ofthe motor. When re-assembled the fan rotation is reversed. This is most easily rectified by:-
   a) removing the new coils and turning them over;
   b) reversing the current in the motor winding;
   c) reversing the current in the shading coils;
   d) turning the rotor end for end.

10. For a given load the constant speed of a motor occurs when:-
   a) the input power is equal to the output power;
   b) the efficiency of the motor is at a maximum;
   c) the motor output torque equals the load input torque;
   d) the motor slip is at a maximum.

SECTION B

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

The series universal motor has a_____(1)_____starting torque. As the motor accelerates the back emf_____(2)_____causing the motor current to_____(3)_____ which_____(4)_____the strength of the stator and armature magnetic fields _____(5)_____torque and_____(6)_____speed. The motor will continue to accelerate until it reaches a speed at which the developed_____(7)_____equals that required by the load. If the load on the motor increases the motor speed _____(8)_____, back emf_____(9)_____, motor current_____(10)_____, producing_____(11)_____ flux and_____(12)_____ torque to meet the increase in load. The speed of the series universal motor is_____(13)_____on no load and very _____(14)_____on heavy loads.

In the universal series motor both the armature and field are laminated to reduce _____(15)_____loss and made from silicon steel to reduce_____(16)_____loss. The field windings and armature are connected in_____(17)_____but as the armature has two parallel circuits between the brushes the armature conductors may be _____(18)_____than the field conductors. If an open circuit occurs in an armature coil this will cause_____(19)_____at the commutator as the brush shorts out the open circuited coil.

SECTION C

1. A 240 volt series universal motor has a total winding/armature impedance of 60ohms. Determine:-
   a) the current taken by the motor at starting; (4A)
   b) the current taken by the motor when armature back emf is 120 volts. (2A.)
   c) the armature back emf when the motor takes rated current of 1.5 amperes;(150V)
   d) the starting torque as a percentage of rated torque if torque is proportional tocurrent squared; (711%)
2. A 240 volt series universal motor drives a constant torque load at rated load and rated current of 7 amperes at 4 000 r.p.m. If speed is to be reduced to 2 500 r.p.m.determine:-
   a) the voltage required (hint: at constant torque, speed is proportional tovoltage);(150V)
   b) the value of series resistance required to drop motor voltage to thisvalue.(12.86Ω)

SECTION D

1. The performance curves for a 240V, 50Hz, 45 watt single phase motor are shownbelow in Figure 1. From these curves estimate the following:-

   a) starting torque;
   b) full load torque;
   c) full load current;
   d) full load speed;
   e) breakdow ntorque;
   f) number of poles;
   g) slip speed at full load.

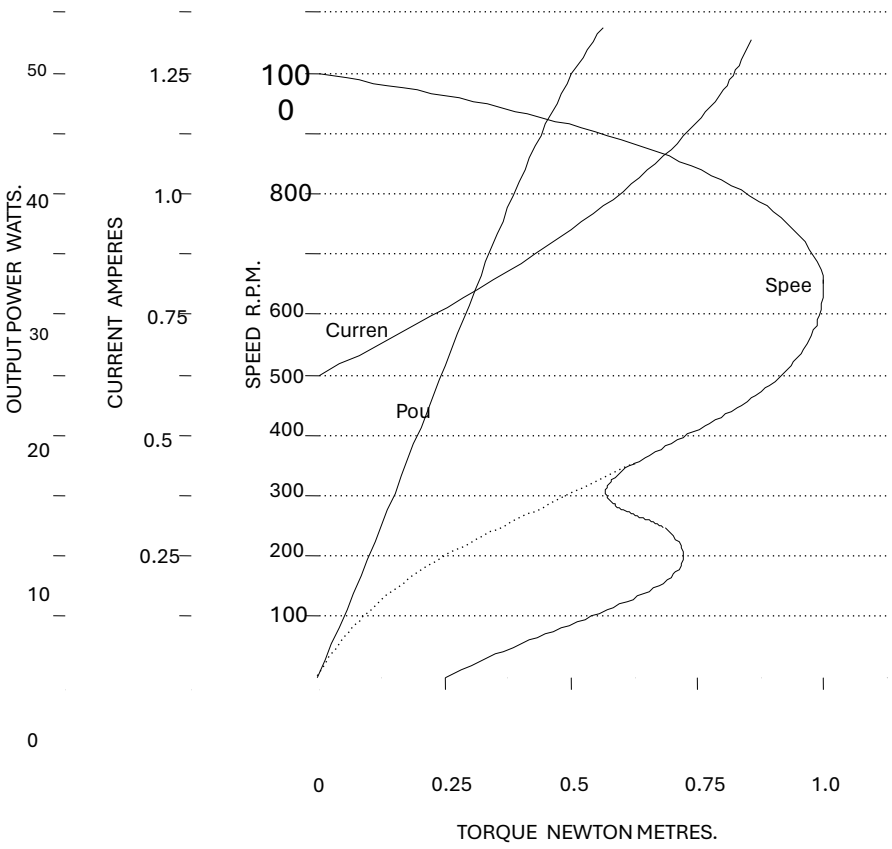


Figure 1.

2. For the current directions given in the series universal motor of Figure 2 determineand show:-

   a) the polarity of the field poles;
   b) the direction of the armature flux and pole location;
   c) the direction of rotation of the motor.

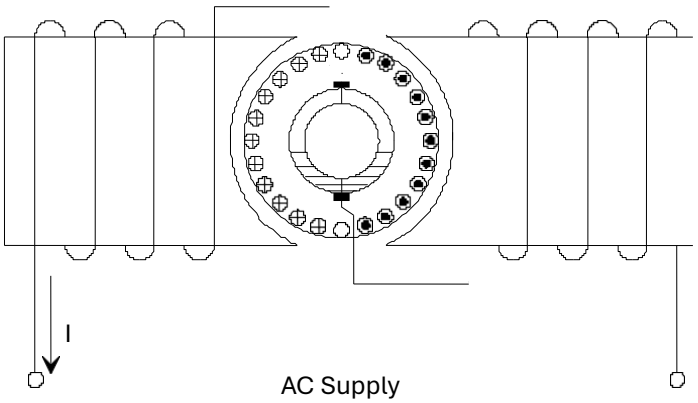


Figure 2.

Tutorial 14 **NAME:**

ALTERNATORS – PART 1

SECTION A

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

1. Alternators are generally run at a constant speed to maintain:-
   a) a constant output voltage;
   b) a constant load current;
   c) maximum efficiency;
   d) a constant output frequency.

2. Low speed rotating field alternators use:-
   a) salient pole rotors with many poles;
   b) cylindrical rotors with many poles
   c) salient poles rotors with two poles
   d) cylindrical rotors with two poles

3. The armature winding in a rotating field alternator is placed:-
   a) in slots in the laminated stator core;
   b) in slots in the solid stator core;
   c) in slots in the laminated rotor core;
   d) around the poles on the solid rotor core.

4. Most three phase alternators have their armature windings:-
   a) connected to a d.c. supply for excitation;
   b) connected to an a.c. supply for excitation.
   c) connected in star to allow earthing of the star point;
   d) connected in delta to increase the generated output voltage.

5. Cylindrical rotors are used in 50 Hz alternators with:-
   a) many poles driven at high speed;
   b) few poles driven at high speed;
   c) many poles driven at low speed;
   d) few poles driven at low speed.

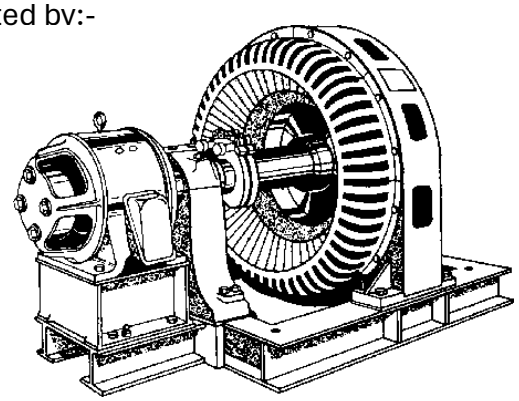
6. A suitable rating for a 50 hertz three phase alternator required to deliver a balancedline current of 100 amperes to a 400 volt delta connected load at 0.8 lag power factor would be:-
   a) 40 kVA
   b) 32 kW

c) 70 kVA

d) 55 kW

7. The armature winding in an alternator is rewound with the number of turns in eachcoil increased by twenty percent. This will:-
   a) increase the output current by 20%;
   b) increase the output voltage by 20%;
   c) increase the kVA rating by 40%;
   d) all of the above.

8. An alternator, and it's excitation generator are shown in Figure 1. The outputvoltage of the alternator is adjusted bv:-
   a) adjusting the field current in the d.c. generator;
   b) adjusting the speed of the d.c.generator;
   c) adjusting the three phase alternatorsupply voltage;
   d) adjusting the number of turns in thealternator field.



9. The open circuit characteristic of an alternator shows how:-
   a) generated voltage varies with field current;
   b) frequency varies with field current;
   c) generated voltage varies with frequency;
   d) speed varies with frequency.

10. Large alternators place the high voltage a.c. armature winding on the stator. This isbecause -
   a) this winding is larger than the field winding and the stator has more room;
   b) high voltage windings are easier to insulate if they are not rotating/vibrating;
   c) this allows the use of two low current slip rings rather than four high currentones;
   d) all of the above.

SECTION B

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

The three phase armature windings in alternators are generally connected in _____(1)_____.

The windings of three phase alternators are spaced_____(2)_____electrical degrees apart.

The field windings of an alternator are connected to a_____(3)_____supply.

In a low speed rotating field type 50 Hz alternator the field system would have a _____(4)_____number of poles and the rotor would be of the_____(5)_____type.

The open circuit characteristic of an alternator shows the change in_____(6)_____ voltage when the_____(7)_____current is changed.

Small alternators may be of the rotating_____(8)_____type while large alternators are normally of the rotating_____(9)_____type.

The frequency of the emfs produced by an alternator is directly proportional to _____(10)_____and_____(11)_____.

Cylindrical rotors are generally used in_____(12)_____speed alternators and normally have a_____(13)_____number of poles.

When the rotor in a 6 pole alternator has completed one revolution it will have generated_____(14)_____complete cycles and passed through_____(15)_____ electrical degrees.

If a star connected alternator in a power station is generating 15kV in each winding the output line voltage will be_____(16)_____kV.

The winding in the alternator that generates the output voltage is termed the _____(17)_____winding, regardless of whether it is on the rotating or stationary part of the machine.

The generated voltage of an alternator may be increased by_____(18)_____the _____(19)_____.

In a star connected alternator the phase angle between the phase and line voltages is _____(20)_____degrees.

SECTION C

1. At what speed must a 24 pole 50Hz alternator in a Hydro-electric power station bedriven? (250 r.p.m.)
2. How many poles would be required on a 25Hz alternator running at 375r.p.m.? (8poles)
3. Is it possible to design a 50Hz alternator that runs at 1200 r.p.m.?. Explain youranswer.
4. A three phase star connected 50Hz alternator is to be used as an emergency supply with an output line voltage of 11kilovolts. What voltage must be generated in eachphase winding? (5.6kV).
5. A 2 pole, 50 Hz, three phase, star connected alternator has a winding constant of0.97, a flux per pole of 81.mWb and 364 turns in the windings of each phase. Determine:-
   a) the speed of rotation of the alternator; (3 000r.p.m.)
   b) the generated phase voltage; (6 350V.)
   c) the output line voltage. (11 000V.)

SECTION D

1. Name the curves shown in Figure 2.
2. Why are there two curves in the graph? What does each curve represent?.
3. Starting from zero amperes how far must field current be increased to give an outputvoltage of 250 volts?
4. Will generated voltage drop to zero volts when field current is reduced to zeroamperes? Give reasons for your answer.

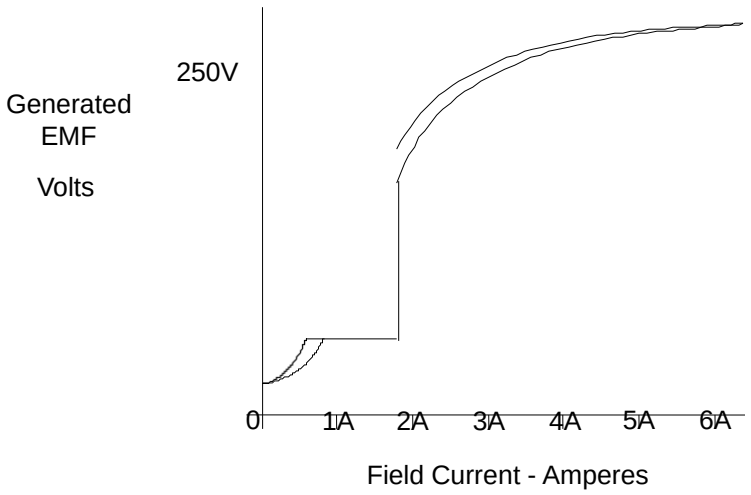


Figure 2

Tutorial 15 **NAME:**

ALTERNATORS – PART 2

SECTION A

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

1. The efficiency of an alternator is the ratio of:-
   a) kVA output to kVA input;
   b) kW output to kW input;
   c) kVA output to kW input;
   d) kW output to kVA input;

2. The terminal potential difference of a three phase 50 hertz alternator is adjusted tothe required value by means of:-
   a) altering the field excitation;
   b) changing the speed
   c) using a tapped winding;
   d) adjusting the number of poles.

3. Modern large alternators use hydrogen cooling. This is done to:-
   e) prevent the windings from oxidising;
   f) reduce the rotational losses in the machine;
   g) reduce the load on the alternator bearings;
   h) reduce air pollution caused by arcing.

4. Alternators are connected in parallel to:-
   a) increase the output voltage supplied to the load;
   b) increase the output current supplied to the load;
   c) allow two alternators to be driven by one prime mover;
   d) because two small alternators are more efficient than one large one.

5. As the power factor of a constant current load with a lagging power factor isimproved towards unity power factor the t.p.d. of the alternator will:-
   a) increase;
   b) decrease;
   c) remain unchanged;
   d) depend on load frequency.

6. Alternators are rated in terms of:-
   a) speed and voltage;
   b) current and voltage;
   c) voltage and kVA;

d) voltage and kW.

7. An alternator normally designed with a high voltage regulation to:-
   a) control output voltage;
   b) limit short circuit current;
   c) reduce losses in windings;
   d) limit open circuit speed.
8. If the terminal voltage on an alternator increases as load increases the type of load isa:-
   a) modern highly efficient load;
   b) lagging power factor load;
   c) unity power factor load;
   d) leading power factor load.
9. The load characteristic of an alternator shows the manner in which the:-
   a) excitation varies with load;
   b) speed varies with excitation;
   c) t.p.d. varies with load;
   d) t.p.d. varies with excitation.
10. Armature reaction in an alternator causes:-
   a) a reduction in torque due to load current;
   b) a change in field flux as load power factor changes;
   c) an increase in armature speed as load increases;
   d) a decrease in armature speed as load increases.

SECTION B

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

The percentage rise in terminal voltage of an alternator when full load is removed is called it's_____(1)_____.

The load characteristic of an alternator is a graph showing the variation in terminal voltage when a change occurs in the_____(2)_____current.

The effect of armature reaction in an alternator supplying a lagging power factor load is to_____(3)_____the t.p.d. compared to an equivalent unity power factor load.

Variations in t.p.d. which may occur due to changes in load on an alternator are minimised by the use of_____(4)_____.

Voltage regulation of an alternator is the difference between no-load voltage and full-load voltage expressed as a percentage of_____(5)_____voltage.

When operating alternators in parallel the load share of one alternator may be increased by increasing the_____(6)_____on the_____(7)_____.

When the rotor in a 6 pole alternator has passed through one complete revolution it has completed_____(8)_____electrical degrees.

Alternators are rated in kVA rather than kW because the voltage and kVA rating can be used to determine the maximum_____(9)_____ that the_____(10)_____can withstand..

The output voltage of an alternator is maintained constant as load current changes by using a_____(11)_____to monitor output voltage and adjust_____(12)_____.

SECTION C

1. An alternator has a t.p.d. of 415 volts when delivering full load at unity power factor. Calculate the no load t.p.d. if the alternator has a voltage regulation of 13percent. (468.95V)
2. A three phase 6 600 volt alternator supplies a current of 2 200 amperes at full load.Determine:-
   a) the rated kVA output; (25.15MVA or 25 150kVA)
   b) the output power at 0.8 lagging power factor. (20.1MW or 20 100kW)
3. An alternator with a full load t.p.d. of 415 volts has the terminal voltage increase to 499 volts on no load. Determine the percentage voltage regulation for the alternator.(20.24%)
4. The terminal voltage of a 70MVA, three phase, 50 hertz, star connected alternator is11.7kV. If the armature winding has a breadth factor (k) of 0.956 and the armature winding has 16 turns per phase determine:-
   a) the maximum flux per pole; (1.98Wb)
   b) the full load current rating of the alternator. (3 454A.)
5. The 70MVA alternator in the previous question has an efficiency of 92 percent when operating at full load and 0.8 power factor. Determine the power output of theprime mover at this load. (60.87MW)

SECTION D

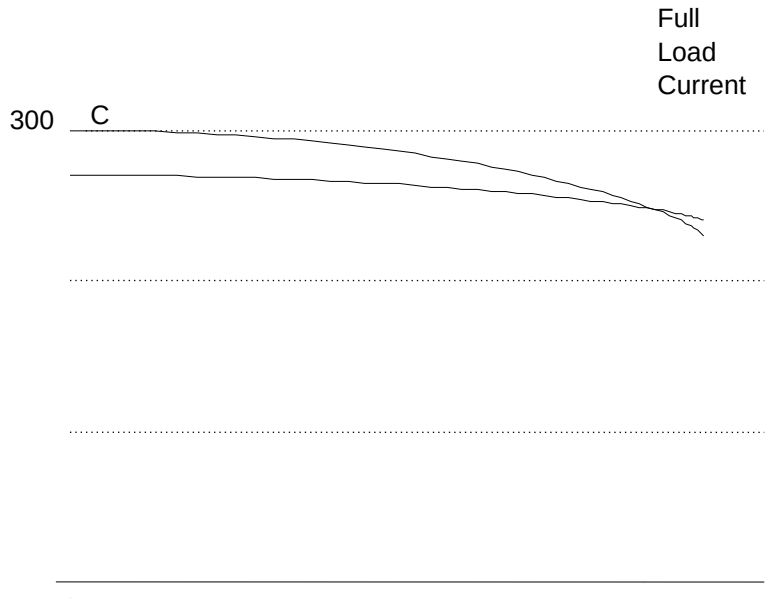
1. For the alternator load characteristic curves shown in Figure 1:-

a) indicate whether curve A, B and C are lagging, leading or unity power factor;A:-_____power factor;

B:-_____power factor;

C:-_____power factor;

b) for the rated current shown, determine the open circuit and full load voltage and then calculate the voltage regulation of the alternator for the leading, lagging andunity power factors shown.



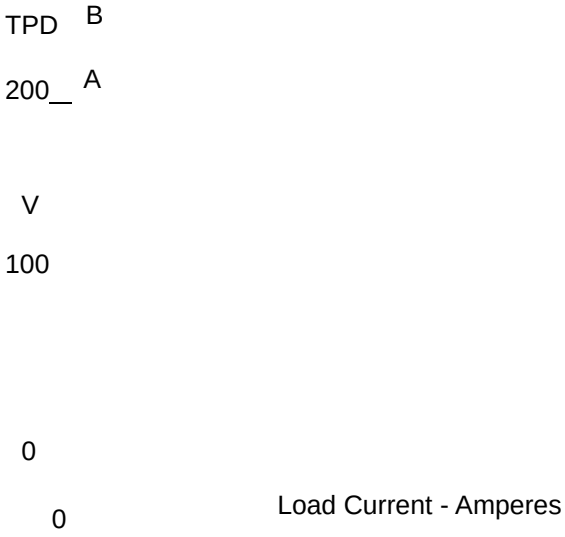


Figure 1

Tutorial 16 NAME:

SYNCHRONOUS MOTORS

SECTION A

In the following statements one of the suggested answers is best. Place the identifying letter on your answer sheet.

1. The speed of a synchronous motor:-
   a) depends on supply frequency;
   b) depends on the size of load;

c) depends on both frequency and load;
d) is constant regardless of frequency and load;

2. The operating power factor of a synchronous motor:-
   a) is affected by phase sequence of the supply:
   b) is affected by field excitation;
   c) is constant regardless of any changes;
   d) improves as load increases.

3. "Normal excitation" of a synchronous motor at full load:-
   a) is the rated field current on the nameplate;
   b) gives minimum power factor and maximum current;
   c) gives minimum power factor and minimum current;
   d) gives unity power factor and minimum current.

4. Synchronous motors develop a torque by:-
   a) electromagnetic induction between stator and rotor;
   b) mutual induction between stator and rotor;
   c) attraction between stator and rotor fields;
   d) stator field hunting the rotor field.

5. The advantages of operating a synchronous motor with "over excitation" are:-
   a) increased pull out torque and increased power factor;
   b) decreased line current and a leading motor power factor;
   c) decreased line current and a leading motor power factor;
   d) increased pull out torque and a leading motor power factor.

6. The "V Curves" of a synchronous motor show how:-
   a) line current and speed vary with excitation;
   b) line current and power factor vary with excitation;
   c) speed and power factor vary with load;
   d) line current and power factor vary with load.

7. "Pull out torque" of a synchronous motor:-

   a) may be increased by increasing excitation current in the field;
   b) is the maximum torque produced during starting;
   c) varies with variations in load;
   d) decreases as motor speed increases.

8. An "under excited" synchronous motor would operate with:-

   a) a leading power factor at more than synchronous speed;
   b) a leading power factor at synchronous speed;
   c) a lagging power factor at synchronous speed;
   d) a lagging power factor at less than synchronous speed.

9. Synchronous motors are:-

   a) all self starting and produce high starting torque;
   b) started as induction motors or with a pony motor;
   c) started as a d.c. motor by connecting d.c. to the stator;
   d) started as a slip ring motor by connecting a.c. to the rotor.

10. Damper windings or amortisseur windings are used in synchronous motors to:-

   a) start the motor and reduce hunting on reciprocating loads;
   b) reduce the amount of direct current required in the field windings;
   c) reduce the amount of current taken from the supply during starting;
   d) bring the motor to a stop quickly after being turned off.

SECTION B

Blank spaces in the following statements represent omissions. Write the appropriate information on your answer sheet.

As load on a synchronous motor increases the load or torque angle will _____(1)_____. This angle is the angle between the centres of_____(2)_____and _____(3)_____poles.

The term "synchronous capacitor" is used to describe a_____(4)_____motor which has been_____(5)_____excited.

If the exciter is used to bring the synchronous motor up to speed it is necessary to have a separate_____(6)_____supply.

A three phase synchronous motor may be started as an induction motor if the motor is fitted with_____(7)_____windings.

If a pony motor is used to bring a synchronous motor up to speed it is necessary to start the motor on_____(8)_____load or have a_____(9)_____between the motor and load.

The synchronous induction motor uses a rotor similar to a _____(10)_____motor, is started with_____(11) connected in the rotor circuit, which is disconnected and reconnected to a_____(12)_____when close to synchronous speed.

The stator winding of the synchronous motor, when connected to a three phase supply, produces a_____(13)_____magnetic field at_____(14)_____speed.

A three phase synchronous motor with a four pole salient pole rotor would have _____(15)_____slip rings, and a stator winding which produces a_____(16)_____ pole field.

SECTION C

1. A four pole synchronous motor is connected to a 60Hz supply. Determine the speedof the motor. (1 800 r.p.m.)
2. A three phase four pole 415 volt synchronous motor takes a current of 75 amperes atfull load with normal excitation while driving a 50kW load. Determine:-
   a) the input power to the motor; (53.91kW)
   b) the efficiency of the motor under these conditions; (92.75%)
   c) the speed of the motor; (1 500r.p.m.)
   d) the torque delivered to the load at normal excitation; (318.3Nm)
   e) the current taken if excitation is reduced until power factor is 0.8 lagging.(93.75A)

SECTION D

1. For the curves drawn for a three phase synchronous motor shown in Figure 1:-

a) What do we call this family of curves?

b) Use the labels on the curves (A, B, C, and D) to indicate which curve is:-

i. the curve of power factor vs field current for no load;

ii. the curve of power factor vs field current for full load;

iii. the curve of stator current vs field current for no load;

iv. the curve of stator current vs field current for full load.

c) What is the value of field current for the motor at normal excitation on full load?

d) What is the value of stator current taken by the motor at normal excitation on noload?

e) If the field current is 4 amperes while the motor is driving full load:-

i. What is the stator current taken?

ii. What is the power factor?

iii. Is the power factor leading, lagging or unity?

iv. Is the motor under, over or normally excited?

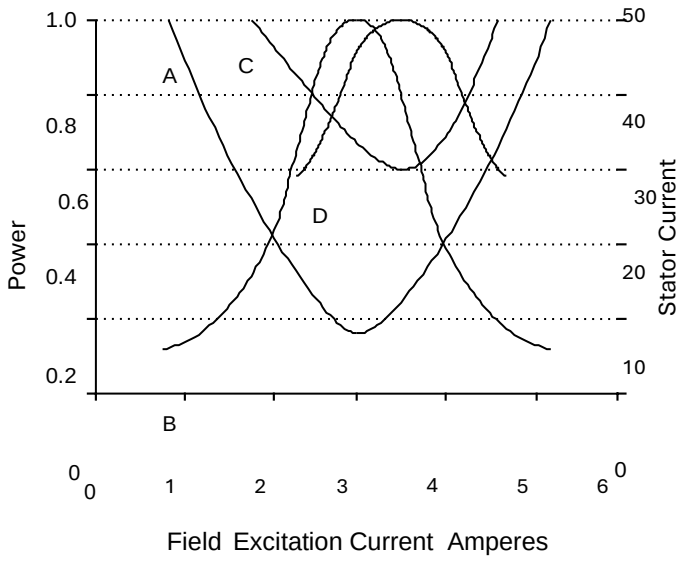


Figure 1