MARKING SCHEME

School:……….*SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING*

Programme:… ***CERTIFICATE IV IN ELECTRICAL ENGINEERING***

Unit code:…… .***EEE447***

Unit Title:……*ELECTRICAL MACHINES*

Date:…………23/07/2014

Examiner:……*MR SUMENDRA KUMAR*

1. Field frame, end shield, field poles, field coils, armature, commutator, brush (3 marks)

2.

Advantages of three-phase systems over single-phase supplies include: 4 marks

(i) For a given amount of power transmitted through a system, the three-phase system requires conductors with a smaller cross-sectional area. This means a saving of copper (or aluminium) and thus the original installation costs are less.

(ii) Two voltages are available (see Section 20.3 (vii))

(iii) Three-phase motors are very robust, relatively cheap, generally smaller, have self-starting properties, provide a steadier output and require little maintenance compared with single-phase motors.

3. Single phase motors initially have no rotating field and therefore no starting torgue. A single phase motor can be wound with 2 windings having different inductances and resistance.The two currents have to be displaced by some to produce a rotating field. (2 marks)

4.During operation the running capacitor ensures correct phase displacement between the 2 winding currents thus providing a constant strength rotating magnetic field.

Run capacitor

Increase the breakdown torque
Improves full load efficiency and power factor
Reduces operational noise and vibration (2 marks)
Increases locked rotor torque

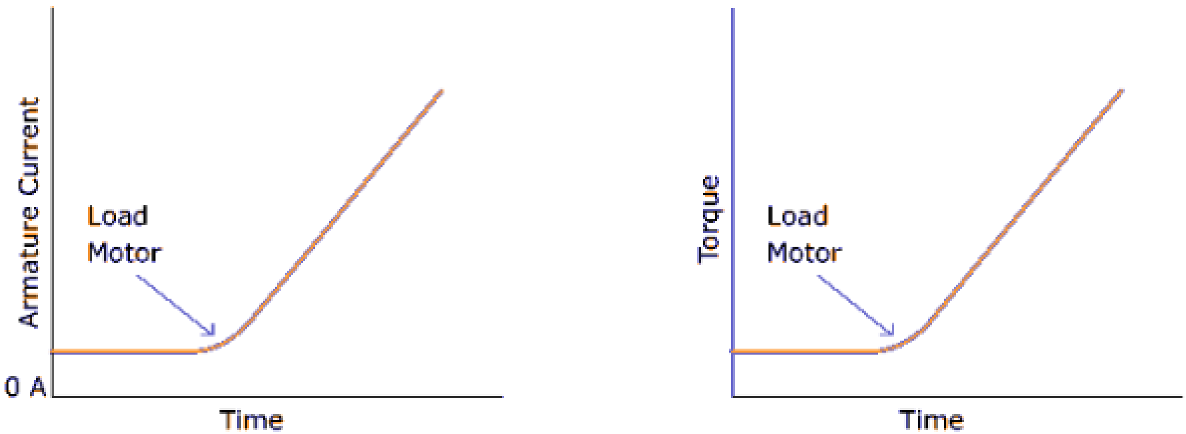
5. Fans,blowers,advertising signs,damper controllers,hair dryers..other uses where starting torque is minimal. (any two) (2 marks)

6. Power factor correction – the characteristic of being able to adjust the power factor of a synchronous machine motor while running by advancing the pf of a series of load fed from plant.

Voltage control – are installed at suitable locations along the line and their excitation adjusted to desired value.
Low speed drives – has good efficiency and at low speeds initial cost is low compensated by lower running cost.

(3marks)

7.



(4 marks)

8. Lenz's law is a common way of understanding how electromagnetic circuits obey Newton's third law and the conservation of energy. (2 marks)

9. interchange the leads (2 marks)

10. a) Separately excited permanent magnet

The most common use is in instruments such as tachogenerator where the linearity of output voltage to speed on light load is an advantage.

b) Wound field

The main use is in process control,rotary amplfiers .

c) Shunt excited

For electro plating

Battery charging

For excitation of Alternators (3marks)

11.

The principal **losses of machines** are:

(i) **Copper loss**, due to I^2R heat losses in the armature and field windings.

(ii) **Iron (or core) loss**, due to hysteresis and eddy-current losses in the armature. This loss can be reduced by constructing the armature of silicon steel laminations having a high resistivity and low hysteresis loss. At constant speed, the iron loss is assumed constant.

(iii) **Friction and windage losses**, due to bearing and brush contact friction and losses due to air resistance against moving parts (called windage). At constant speed, these losses are assumed to be constant.

(iv) **Brush contact loss** between the brushes and commutator. This loss is approximately proportional to the load current.

. (2 marks)

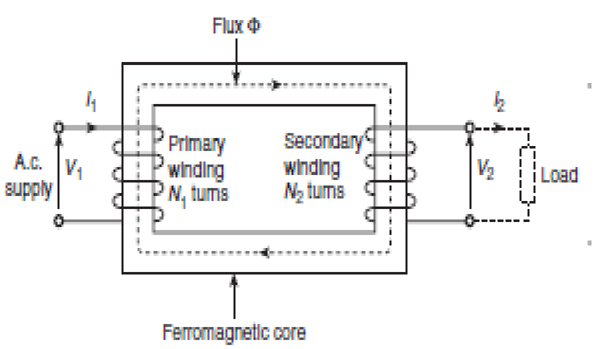
12. . a) Voltage should be same

b) Frequency should be same or identical

c) Phase sequence should be same]

d) The incoming machine should be in phase with the running machine (3 marks)

13.



When the secondary is an open-circuit and an alternating voltage V_1 is applied to the primary winding, a small current — called the no-load current I_0 — flows, which sets up a magnetic flux in the core. This alternating flux links with both primary and secondary coils and induces in them e.m.f.'s of E_1 and E_2 respectively by mutual induction.

(3 marks)

14. a) Saving in cost since less copper is needed.
   b) Less volume and hence less weight

   c) Higher efficiency, resulting from lower $I^2 R$

   d) Continuously variable output voltage is achievable if a sliding contact is used

   e) A smaller percentage voltage regulation (2 marks)

15. Air cooling

The air blast type of cooling is used on transformers where economy of space weight is required, or where oil cooling may be a fire hazard.

Oil cooling

The transformer tank is immersed in a tank of special transformer oil, providing as large a cooling surface area of the tank as possible. (2 marks)

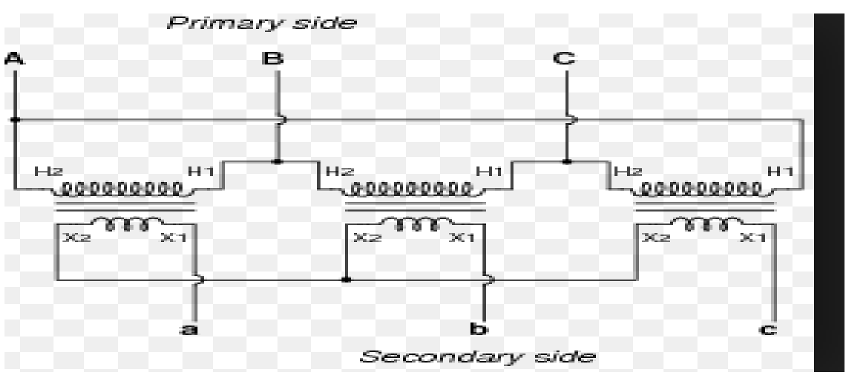
16. Tap changers are installed in situations where they can compensate for variations in voltage. A rising or falling voltage at the load end of the line can be corrected by the action of a tap changer at the supply end. (2 marks)

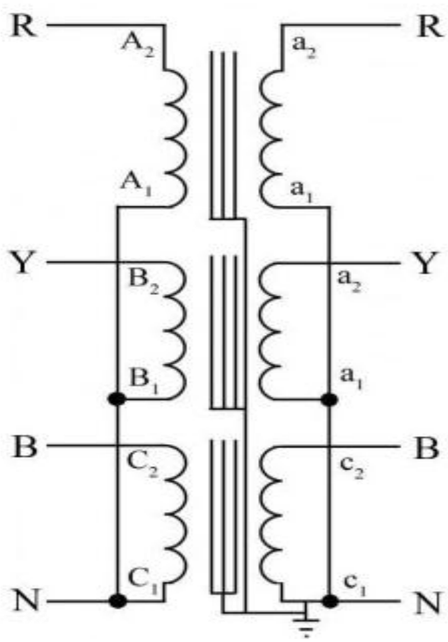
17. (i) Equal voltage.

(ii) Same phase sequence

(iii) Phase voltage to be in step (3 marks)

18.





(2 marks)

19. . Principle of Direct On Line Starter (DOL)

To start, the contactor is closed, applying full line voltage to the motor windings. The motor will draw a very high inrush current for a very short time, the magnetic field in the iron, and then the current will be limited to the Locked Rotor Current of the motor. The motor will develop Locked Rotor Torque and begin to accelerate towards full speed.

As the motor accelerates, the current will begin to drop, but will not drop significantly until the motor is at a high speed, typically about 85% of synchronous speed. The actual starting current curve is a function of the motor design, and the terminal voltage, and is totally independent of the motor load.

The motor load will affect the time taken for the motor to accelerate to full speed and therefore the duration of the high starting current, but not the magnitude of the starting current.

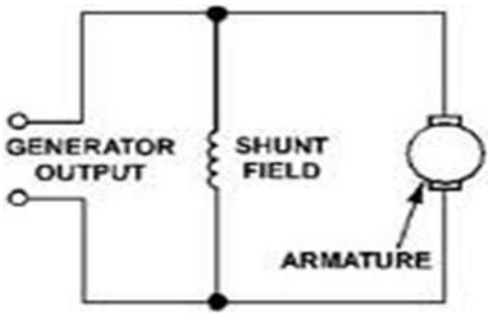
Provided the torque developed by the motor exceeds the load torque at all speeds during the start cycle, the motor will reach full speed. If the torque delivered by the motor is less than the torque of the load at any speed during the start cycle, the motor will stops accelerating. If the starting torque with a DOL starter is insufficient for the load, the motor must be replaced with a motor which can develop a higher starting torque.

The acceleration torque is the torque developed by the motor minus the load torque, and will change as the motor accelerates due to the motor speed torque curve and the load speed torque curve. The start time is dependent on the acceleration torque and the load inertia.

(4 marks)

SECTION B

1.



$R_a = 0.18\ \Omega$
$R_{sh} = 120\ \Omega$
$V_T = 240$ Volts

(a) $I_{FL} = \frac{20000}{240} =$ **83.3 Amps**

(b) Ish = 240/120 = **2 Amps**

(c) Total Arm Current It $= I_{FL} + I_{sh}$
= 83.3 + 2
= **85.3 Amps**

(d) Varm = It x Ra
= 85.3 x 0.18
Varm = 15.35 V

Induced armature voltage = 240 + 15.3
= **255.3 Volts** **(9 marks)**

2.

For an ideal transformer, voltage ratio = turns ratio i.e.

$$\frac{V_1}{V_2} = \frac{N_1}{N_2} \text{ hence } \frac{240}{V_2} = \frac{500}{3000}$$

Thus secondary voltage

$$V_2 = \frac{(240)(3000)}{500} = \mathbf{1440\ V \text{ or } 1.44\ kV}$$

(3 marks)

3.

A turns ratio of 8:1 means $(N_1/N_2) = (1/8)$ i.e. a step-down transformer.

$$\left(\frac{N_1}{N_2}\right) = \left(\frac{V_1}{V_2}\right) \text{ or secondary voltage}$$

$$V_2 = V_1\left(\frac{N_1}{N_2}\right) = 240\left(\frac{1}{8}\right) = \mathbf{30\ volts}$$

Also, $\left(\frac{N_1}{N_2}\right) = \left(\frac{I_2}{I_1}\right)$ hence secondary current

$$I_2 = I_1\left(\frac{N_1}{N_2}\right) = 3\left(\frac{8}{1}\right) = \mathbf{24\ A}$$

(4 marks)

4. 100: 5 | 11000: 110

90: x | 10500: x

100x = 90 X 5 | 11000 x = 10500 X 110

100x = 450 | = 1265000

Actual current = 4.5 Amps | Actual voltage = 115 Volts

Volt-ampere rating = V x I

= 115 X 4.5

= 517.5 VA

Wattmeter reading = 870/2 = 435 watts (5 marks)

5.

$E = 240$ V, $c = 2p$ (for a lap winding), $Z = 50 \times 16 = 800$ and $\Phi = 30 \times 10^{-3}$ Wb.

Generated e.m.f.

$$E = \frac{2p\Phi nZ}{c} = \frac{2p\Phi nZ}{2p} = \Phi nZ$$

Rearranging gives, speed,

$$n = \frac{E}{\Phi Z} = \frac{240}{(30 \times 10^{-3})(800)}$$

$$= \mathbf{10\ rev/s\ or\ 600\ rev/min}$$

(5 marks)

6.

$V = 350$ V, $R_a = 0.5\,\Omega$, $n = 15$ rev/s and $I_a = 60$ A.
Back e.m.f. $E = V - I_a R_a = 350 - (60)(0.5) = 320$ V.
From Equation (6),

$$\textbf{torque, } T = \frac{EI_a}{2\pi n} = \frac{(320)(60)}{2\pi(15)} = \mathbf{203.7\ Nm}$$

(3 marks)

7.

The motor has a two-pole system, hence p, the number of pairs of poles, is 1. Thus, synchronous speed, $n_s = (50/1) = 50$ rev/s $= 50 \times 60$ rev/min

$= \mathbf{3000\ rev/min}$.

(4 marks)

8.

(a) $f = 60$ Hz and $p = (2/2) = 1$. Hence **synchronous speed**, $n_s = (f/p) = (60/1) = $ **60 rev/s** or 60×60 $=$ **3600 rev/min**.

(b) Since slip,

$$s = \left(\frac{n_s - n_r}{n_s}\right) \times 100\%$$

$$2 = \left(\frac{60 - n_r}{60}\right) \times 100$$

Hence

$$\frac{2 \times 60}{100} = 60 - n_r$$

i.e.

$$n_r = 60 - \frac{2 \times 60}{100} = 58.8 \text{ rev/s}$$

i.e. the rotor runs at $58.8 \times 60 = $ **3528 rev/min**

(c) Since the synchronous speed is 60 rev/s and that of the rotor is 58.8 rev/s, the rotating magnetic field cuts the rotor bars at $(60 - 58.8) = 1.2$ rev/s.

Thus the frequency of the e.m.f.'s induced in the rotor bars, is $f = n_s p = (1.2)(\frac{2}{2}) = 1.2$ Hz.

(8 marks)

9.

(a) From Section 22.5, generated e.m.f. $E \propto \Phi n$

from which, $\dfrac{E_1}{E_2} = \dfrac{\Phi_1 N_1}{\Phi_2 N_2}$

Hence $\dfrac{150}{E_2} = \dfrac{(0.10)(20)}{(0.1)(25)}$

from which, $E_2 = \dfrac{(150)(0.10)(25)}{(0.10)(20)}$

$=$ **187.5 volts**

(b) $\dfrac{150}{E_3} = \dfrac{(0.10)(20)}{(0.08)(20)}$

from which, e.m.f., $E_3 = \dfrac{(150)(0.08)(20)}{(0.10)(20)}$

$=$ **120 volts**

(c) $\dfrac{150}{E_4} = \dfrac{(0.10)(20)}{(0.07)(24)}$

from which, e.m.f., $E_4 = \dfrac{(150)(0.07)(24)}{(0.10)(20)}$

$=$ **126 volts**

(9 marks)