FNU FIJI NATIONAL UNIVERSITY

COLLEGE OF ENGINEERING, SCIENCE & TECHNOLOGY (CEST)
SCHOOL OF ELECTRICAL & ELECTRONICS ENGINEERING
CERTIFICATE IV IN ELECTRICAL ENGINEERING - Stage 2
EEE447- ELECTRICAL MACHINES
FINAL EXAMINATION – TRIMESTER-2, 2016

Day/Date: As per timetable Time: As per timetable Room: As per timetable

INSTRUCTIONS TO STUDENTS

1. You are allowed 10 minutes Extra reading time during which you are NOT to write.

2. Begin each answer on a fresh page and use both sides of the sheet.

3. Write your candidate-number at the top of each attached sheet

4. Insert all written foolscaps, graph paper, drawing paper, etc. in their correct sequence and secure with string

5. For all sheets of paper on which rough/draft work has been done, cross it though and you MUST ATTACH to your answer scripts.

6. Write clearly the number(s) of the question(s) attempted on the top of each sheet.

7. ANSWER ALL QUESTIONS.

8. Show all workings where necessary.

9. Do not use programmable calculators, especially the ones that does the conversions of number systems.

QUESTION 1 DC MACHINES (25 MARKS)

1.1 State any five basic parts of a d.c. machine (5 marks)

1.2 State the two groups' armature windings can be divided into (3 marks)

1.3 Draw a diagram showing the method of reversing the rotation of a shunt motor. (4 marks)

1.4 A 26 kW shunt-connected generator operates with a terminal voltage of 230 V. The armature has an effective resistance (Ra) of 0.18 Ω and the shunt field (R_{sh}) has a resistance of 100 Ω. Calculate:

(a) The full load current.
(b) The field current.
(c) The total armature current (8 marks)

1.5 An 8-pole, wave-connected armature has 625 conductors and is driven at 600rev/min. If the flux per pole is 20 mWb, determine the generated e.m.f (5 marks)

QUESTION 2 THREE ϕ & SINGLE ϕ INDUCTION MOTORS (25 MARKS)

2.1 Name three advantages that a three-phase induction motor has when compared with a d.c. motor (3 marks)

2.2 State two methods of starting squirrel-cage induction motors (2 marks).

2.3 State two advantages of cage rotor machines compared with wound rotor machines. (2 marks)

2.4 A stator winding supplied from a three-phase 60 Hz system is required to produce a magnetic flux rotating at 900 rev/min. Determine the number of poles. (2 marks)

2.5 Compare the characteristics of a single phase motor with a three phase motor. (4 marks)

2.6 Draw the circuit connections and label your diagram of the following single phase motors:

a) capacitor motor (3 marks)

b) capacitor start, capacitor run motor (3 marks)

c) series motor (3 marks)

2.7 List down the functions of the run capacitor in a capacitor start- capacitor run motor. (2 marks)

QUESTION 3 MOTOR STARTERS & SOFT STARTER (25 MARKS)

3.1 Outline the factors to be considered when selecting motor starters. (6 marks)

3.2 List four (4) applications for star – delta starters. (4 marks)

3.3 What are the major characteristics autotransformer starters? (5 marks)

3.4 Draw a single line diagram of a DOL starter and briefly explain its operation. (8 marks)

3.5 Name two typical soft start applications. (2 marks)

QUESTION 4 TRANFORMERS & SYNCHRONOUS MACHINES (25 MARKS)

4.1 Outline the operation of an on-load transformer with the aid of diagrams. (3 marks)

4.2 State two advantages of autotransformers (2 marks)

4.3. State and briefly discuss the two different methods of cooling transformers (3 marks)

4.4 Specify the purpose of having tap changers on transformers? (3 marks)

4.5 . A voltmeter, ammeter and wattmeter are connected to a single-phase circuit, by means of the appropriate instrument transformers, and the following results are obtained:

CT ratio	200:5
PT ratio	22 000:110
Voltmeter reading	20500 V
Ammeter reading	80 A
Wattmeter reading	1000 W

Calculate the actual voltage, current, volt-amperes and power in the secondary circuit. (6marks)

4.6. Illustrate three requirements that have to be met before synchronizing a Generator. (3marks)

4.7. A three-phase two-pole induction motor is connected to a 60 Hz supply. Determine the synchronous speed of the motor in rev/min (5 marks)

%%%%%%%%%%%%%%%% END OF PAPER %%%%%%%%%%%%%%%

MARKING SCHEME

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

Programme: ***Certificate IV IN ELECTRICAL ENGINEERING***

Unit code:…… .***EEE477***

Unit Title:……***ELECTRICAL MACHINES***

Date:…….**06/07/2016**

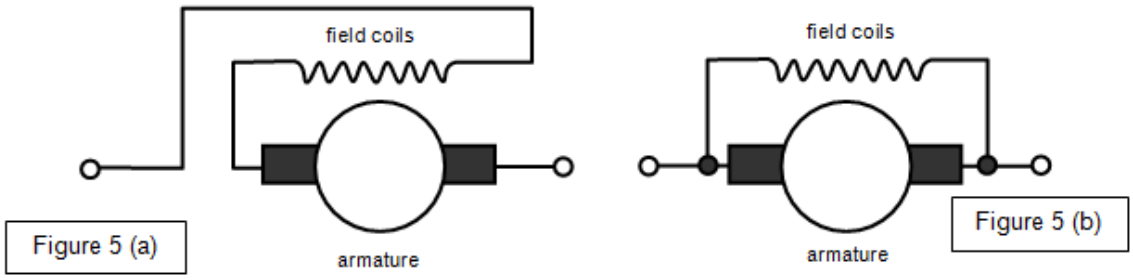
Examiner:……***MR SUMENDRA KUMAR***

QUESTION 1 **DC MACHINES**

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

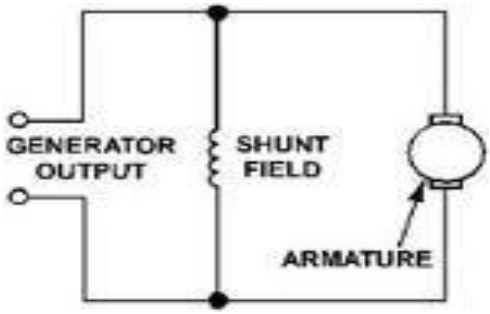
1.2 armature winding and lap winding (2 marks)

1.3



(4 marks)

1.4



240 V

Ra = 0.18 Ω
VT = 230 V
Rsh = 100 Ω

IFL = 26000/230 = **113.04 Amps** (2.5 Marks)

Ish = 230/100 = **2.3 Amps** (2.5 Marks)

Total Arm Current It = I FL + Ish

= 113.04 + 2.3

= 115.27 Amps (3 marks)

1.5

$Z = 600$, $c = 2$ (for a wave winding), $p = 4$ pairs, $n = 625/60$ rev/s and $\Phi = 20 \times 10^{-3}$ Wb.

Generated e.m.f.

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

$$= \frac{2(4)(20 \times 10^{-3})\left(\frac{625}{60}\right)(600)}{2}$$

$$= \mathbf{500\ volts}$$

(5 marks)

QUESTION 2 THREE PHASE INDUCTION MOTORS

2.1 Three phase induction motors are ;

i) very simple
ii) efficient
iii) rugged
iv) have a high degree of reliability. Any three

(3 marks)

2.2 DOL and Star- Delta

(2 marks)

2.3 i) are cheaper and more robust
(ii) have slightly higher efficiency and power factor
(iii) are explosion-proof, since the risk of sparking is eliminated by the absence of slip rings andbrushes. Any two (2 marks)

2.4

Synchronous speed,

$$n_s = 900\ \text{rev/min} = \frac{900}{60}\ \text{rev/s} = 15\ \text{rev/s}$$

Since

$$n_s = \left(\frac{f}{p}\right) \text{ then } p = \left(\frac{f}{n_s}\right) = \left(\frac{60}{15}\right) = 4$$

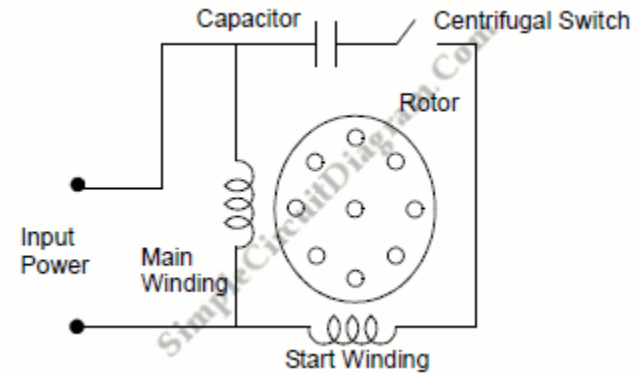
Hence **the number of pole pairs is 4** and thus **the number of poles is 8**

(2 marks)

2.5 The single phase motor:

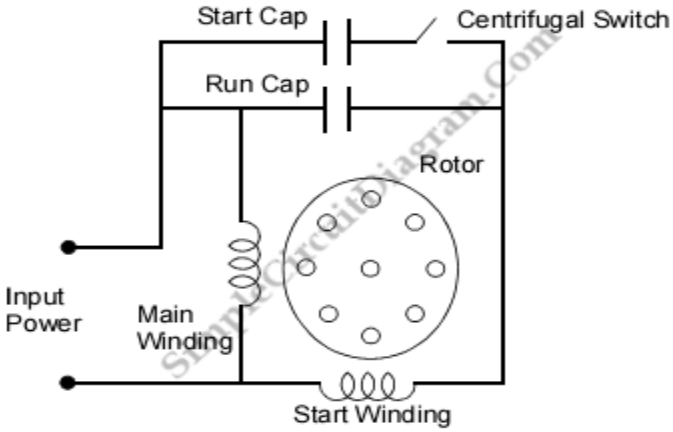
i) Has a characteristic vibration at twice the supply frequency
ii) Is noisier than a three phase motor
iii) Has a rather high no-load current at low power factor
iv) Has a power factor that improves with the addition of load.
v) Requires special starting techniques
vi) Has several versions based on the method of starting
(one mark each any four).

2.6 a) **capacitor start motor**



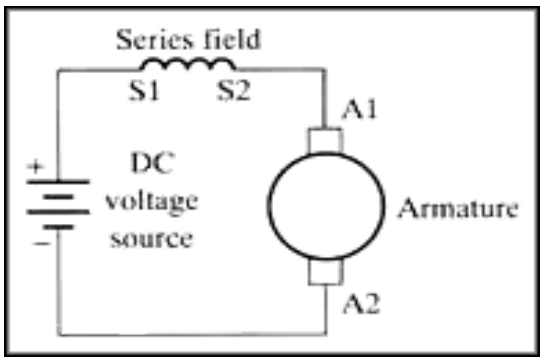
(3 marks)

b) **capacitor start, capacitor run motor**



(3 marks)

c) **series motor**



2.7 The run capacitor :

i) Increases the breakdown torque
ii) Improves full load efficiency and power factor
iii) Reduces operational noise
iv) Increases locked rotor torque.(any two) (2 marks)

QUESTION 3 MOTOR STARTERS & SOFT STARTER

3.1 Factors to be considered when selecting motor starters:

- protection of the motor against overloads and over heating
- isolation of the motor in the eventy of faults
- provision of interlocking the motors operation with that of other motors and machines
- motor reversal
- speed control
- motor braking

(6 marks)

3.2 Applications for star – delta starters.

- Centrifugal pumps
- Farm dam pumps
- Lathes with a clutch
- Large fans and blowers

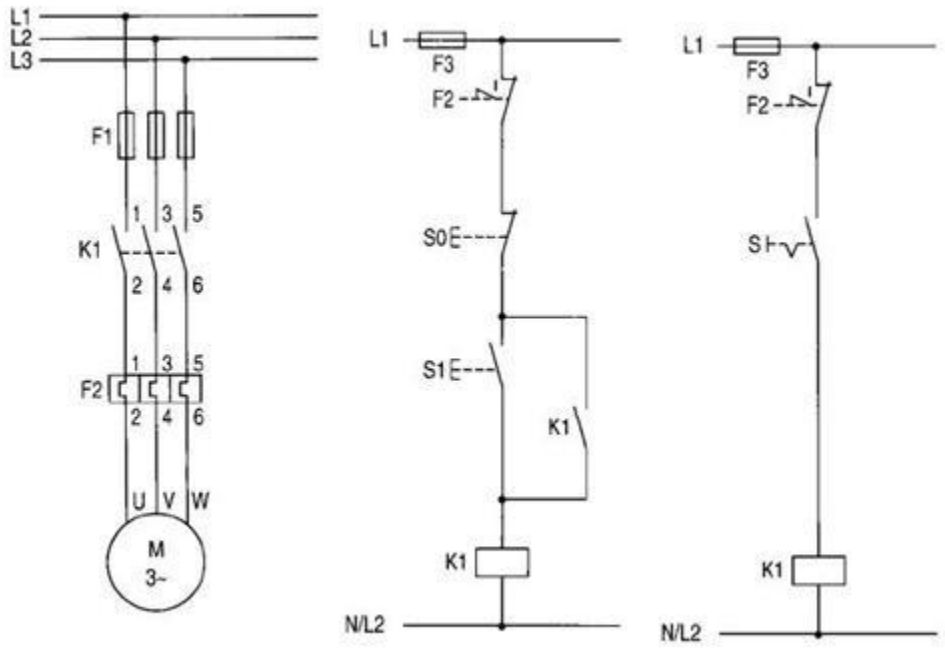
(4 marks)

3.3 Major characteristics of autotransformer starters:

- Low line current
- Low line power
- Low power factor
- Open circuit transition periods
- Acceleration in a series of steps,not continous

(5 marks)

3.4 Draw a single line diagram of a DOL starter and briefly explain its operation.



a) Main circuit

When contactor C is energized ,supply will be placed onto the motor terminals. Provided the motor has not tripped on over load ,when the start button is pressed contactor C will be energized and held in via the stop button and hold in contact C_1

(8 marks)

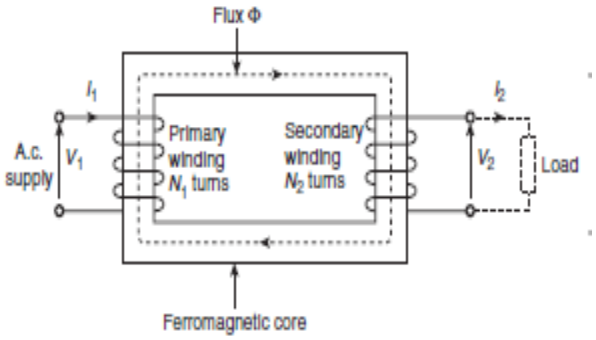
3.5 Typical soft start applications:

- Centrifugal fans
- Printing presses

(2 marks)

QUESTION 4 TRANFORMERS & SYNCHRONOUS MACHINES

4.1



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)

4.2). 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 (any two)

(2 marks)

4.3) 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.

(3 marks)

4.4). 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. (3 marks)

4.5). 200: 5
80: x

$200x = 80 \times 5$

$200x = 400$

Actual current = 2 Amps(1 mark)

22000: 110
20500: x

$22000\,x = 20500 \times 110$

Actual voltage = 102.5 Volts (1 mark)

Volt-ampere rating = V x I
= 102.5 X 2
= 205 VA (2 marks)

Wattmeter reading = 1000/2 = 500 watts (2 marks)

4.6 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)

4.7 The motor has a two pole system, hence p, the number of poles is 1 thus synchronous Speed Ns = (50/1) = 50 rev/s = 50*60 rev/min=3000rev/min (5 marks)