SCHOOL OF ELECTRICAL AND ELECTRONIC ENGINEERING

CERTIFICATE IV IN ELECTRICAL ENGINEERING – STAGE 5

EEE451-ELECTRICAL MEASUREMENTS & MACHINES
FINAL EXAMINATION PAPER – 2014

DAY/DATE: THURSDAY / 31/07/2014 TIME: 9.00-11.10AM ROOM: E206

INSTRUCTIONS TO STUDENTS:

1. You are allowed 10 minutes extra reading time during which you are not allowed to write.
2. Begin each SECTION on a fresh page and use both sides of the sheet.
3. Write your candidate number at the top of each answer sheet.
4. Insert all 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 through and you must attach to the answer booklet.
6. Write clearly the number(s) of the question(s) attempted on top of each sheet.
7. **ATTEMPT ALL QUESTIONS**
8. Show all workings where necessary.
9. Programmable calculators are not allowed.

SECTION A **(35 MARKS)**

1. Outline the operation of an on-load transformer with the aid of diagrams.

(6 marks)

2. Specify the purpose of having tap changers on transformers?

(2 marks)

3. What are the advisable colors to be used on a transformer tank and state the reason for using the indicated colors?

(4 marks)

4. List five advantages of autotransformers

(5 marks)

5. Interpret the two losses in a transformer

(4 marks)

6. List the names of four different types of three phase transformer cores.

(4 marks)

7. Determine the relationship between the voltage and the number of turns of the two windings in a transformer. (3 marks)

8. State the three requirements for connecting a transformer in parallel and explain the effects of each. (3 marks)

9. State and briefly discuss the two different methods of cooling transformers.

(4 marks)

SECTION B **(25 MARKS)**

1. Draw and label clearly:
   (i) A basic alternator circuit (3 marks)
   (ii) A block diagram for an engine-driven standby alternator. (3 marks)

2. List three basic factors by which alternators are rated. (3 marks)

3. State the two main windings of an alternator, and specify where the two windings can be found in an alternator. (4 marks)

4. Explain the construction and application of current transformers. (3 marks)

5. Name and explain the three applications of synchronous motors. (6 marks)

6. Illustrate the three requirements that has to be met before synchronizing a Generator. (3 marks)

SECTION C **(40 MARKS)**

1. 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	100:5
PT ratio	11 000:110
Voltmeter reading	10500 V
Ammeter reading	90 A
Wattmeter reading	870 W

   Calculate the actual voltage, current, volt-amperes and power in the secondary circuit. (4 marks)

2. A step down autotransformer has a total of 240 turns, if the applied voltage V_1 is 240 V with turns ratio 1:1 and if a tapping is taken at 180 turns find the output voltage of the transformer. (6 marks)

3. Calculate the power loading in kilowatts of a three phase ,415 V,50 Hz alternator rated at 150 kVA at 0.8 power factor, if the load has a power factor of:
   (a) 0.8
   (b) 0.6 (4marks)

4. Determine the total copper loss of a transformer on full-load having secondary and primary currents of 100A and 20A respectively. (Winding resistance: secondary = 0.02Ω; primary = 0.05Ω) (6 marks)

5. A transformer operating at no load draws an exciting current I_o of 5A when primary is connected to a 120v 60Hz source from a wattmeter test it is known that iron losses are equal to 180W.

   Calculate:
   a) The reactive power absorbed by the core
   b) Value of R_m and X_m
   c) Value of I_f , I_m, I_o (6marks)

6. 6. A single phase transformer has a rating of 100kVA, 7200V/600V, 60 Hz. If it is reconnected as an autotransformer having a ratio of 7800V/7200V, calculate the load it can carry.
   (5 marks)

7. At what speed would the governor of a 12 pole diesel driven alternator have to set to establish a frequency of 50Hz.
   (3 marks)

8. Determine the:
   (i) Generated phase voltage of a 40kVA, 50Hz alternator with 420 conductors per phase, flux = 0.0035Wb, distribution constant = 0.8, and coil pitch constant = 0.90. (3 marks)

   (ii) Voltage regulation if the output on load is 240V. (3 marks)

_____END _____

MARKING SCHEME/SOLUTION GUIDE

College:..... **CEST** .....

School/Department: **SEEE**...

Programme: **SCHOOL OF ELECTRICAL & ELECTRONICS ENG.**

Unit Code/Title: **EEE451- ELECTRICAL MEASUREMENTS & MACHINES**

Date of Exam: **31/07/2014**

Time: **9:00 AM – 11:10 AM**

Examiner's Name: **Sumendra Kumar**

Signature:……

SECTION A **(40 marks)**

1. Transformer on-load circuit diagram and operation.

(6 marks)

3. 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)

4. Polished metallic surfaces inhibit the removal of heat from transformer oil and casings.
   Colors such as low sheen variations of black, green and grey enable the oil to run at lower temperatures.

(4 marks)

5. 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

(5 marks)

6. Transformer losses
   i) Iron loss – The power absorbed by the core of a transformer.
   ii) Copper loss – energy loss in the windings when the transformer is loaded.

(4 marks)

7. Three phase core type.
   Three phase shell type
   Three phase cruciform or stepped core
   Three phase toroidal (4 marks)

8. The ratio of the primary and secondary voltages it equal to the ratio of the number of turns n the primary and the secondarywindings

   Ie.

$$\frac{V1}{V2} = \frac{N1}{N2}$$

(3 marks)

9. (i) Equal voltage
. (1 mark)

(ii) Same phase sequence
. (1 mark)

(iii) Phase voltage to be in step
(1 mark)

10. 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.
(4 marks)

SECTION B **(25 marks)**

1. (i) Basic alternator circuit
(ii) A block diagram for an engine-driven standby alternator.
(3 marks each)

Fig 11.2 from Electrical Principles for Trades pg 254

2. - frequency (1 mark)
- Voltage (1 mark)
- Current (1 mark)

3. - Three phase a.c winding – can be found on the stator (2 marks)
- Winding carrying d.c – found on the rotor (2marks)

4. In current transformers the primary usually consists of one or two turns while the secondary can have several hundred turns. E.g. primary may have 2 turns and secondary200 turns thus primary current of 500 A.Current transformers isolate the ammeter from the main circuit and allow the use of standard range of ammeters giving full-scale deflection of 1A,2 A or 5A.For large currents the transformer core can be mounted around the conductor or busbar.
(3 marks)

5. 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.

(6 marks)

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)

SECTION C **(30 MARKS)**

1. 100: 5
95: x

$100x = 95 \times 5$
$100x = 475$
Actual current = 4.75 Amps

11000 : 110
10500: x

$11000\,x = 10500 \times 110$
$= 1265000$
Actual voltage = 115 Volts

Volt-ampere rating = V x I
= 115 X 4.75
= 546.25 VA

Wattmeter reading = 872/2 = 436 watts

(4 marks)

2. $V_1 = 240$ V, $N_1 = 240$, $N_2 = 180$

$V_2 = V_1 \times \frac{N_1}{N_2}$

$= 240 \times \frac{180}{240}$

$=$ 180 Volts

(6 marks)

3. The machine is rated at 150 kVA and 0.8 power factor, so at this load:
Power output = 150 X 0.8 = 120 kW
At 0.6 pf
Power output = 150 X 0.6 = 90 kW

$$P = \sqrt{3}\ VI\ pf$$
$$= \sqrt{3} \times 415 \times I \times 0.8$$
$$I = \frac{150\ 000}{\sqrt{3} \times 415 \times 0.8}$$

I = 208 Amps

(4 marks)

4. Primary copper loss = $I^2 X R_1$
$= (20)^2 X 0.05$
= 20 Watts (2 marks)

Secondary copper loss = $(I_2)^2 \times R_2$

$= (100)^2 \times 0.02$
= 200 watts (2 marks)

Total Copper loss = Primary copper loss + Secondary Copper loss
= 20 + 200
= 220 Watts (2 marks)

5.

a) apparent Power

$S = E_1 I_o$
$= 120 * 5$
$= 600VA$

Reactive Power

$Q = \sqrt{S^2 - P^2}$
$= \sqrt{600^2 - 180^2}$
$= 572$ var

b) $R_m = E_1^2/P_m$
$= 120^2 / 180$
$= 80\Omega$

$X_m = E_1^2 / Q_m$

$= 120^2 / 572$
$= 25.2\Omega$

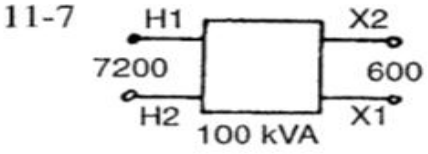
c) $I_f = E_1 / R_m$
$= 120/80$
$= 1.5A$

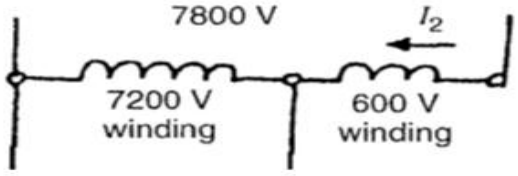
$I_m = E_1 / X_m$
$= 120/25.2$
$= 4.8A$

$I_o = \sqrt{1.5^2 + 4.8^2}$
$= 5A$

6.

11-7





I_1 on 7200 V side $= \dfrac{100\ 000}{7200}$
$= 13.9$ A
I_2 on 600 V side $= \dfrac{100\ 000}{600}$
$= 166.7$ A
We can load the transformer until $I_2 = 166.7$ A

I

$\therefore$ The input to the transformer can be $166.7 \times 7800 = 1300$ kVA. The load is also 1300 kVA – 13 times greater than the nameplate rating of the transformer.

7. $f = \dfrac{np}{120}$

$n = \dfrac{f(120)}{p}$

$= \dfrac{50(120)}{12}$

= 500 rpm (3 marks)

8. $Vg = 4.44 \text{Ø} f N_k d k_p$

$= 4.44(0.0035)(50)(420)(0.8)(0.9)$

$= \underline{234.96 \text{ V}}$ (3 marks)

$$Vg = \frac{V_{NL} - V_{Fl}}{V_{FL}}$$

$$= \frac{240 - 224.96}{240} \text{ x } 100$$

$= \underline{2.1 \%}$ (3 marks)

%%%%%%%%%**END OF MARKING SCHEME**%%%%%%%%%%%%%