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INTERNATIONAL COLLEGE PENANG (507232-U)
LAUREATE INTERNATIONAL UNIVERSITIES

FINAL
Examination Paper

(COVER PAGE)

Session : August 2016

Programme : DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING

Course : EEE 2113 ELECTRIC POWER SYSTEMS AND MACHINES

Date of Examination : 7 December 2016 (Wednesday)

Time : 11:00am – 1:00pm Reading Time : Nil

Duration : 2 Hours

Special Instructions :

This paper consists of SIX (6) questions. Answer any FOUR (4) questions in the answer booklet provided. All questions carry equal marks.

Materials permitted :

Non-Programmable Scientific Calculator

Materials provided :

Nil

Examiner(s) : KEN KONG SENG KUOK

Moderator : CHEAH KEAN SENG

This paper consists of 6 printed pages, including the cover page.

INTI INTERNATIONAL COLLEGE PENANG

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
 EEE2113: ELECTRIC POWER SYSTEMS AND MACHINES
 FINAL EXAMINATIONS: AUGUST 2016 SESSION

Instructions: This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Question 1

- (a) Define interpoles. (2 marks)
 State the main function of interpoles in a D.C. Machine. (3 marks)
- (b) What are the minimum number of interpoles needed in a 2-pole D.C. Machine? State your reason to support your answer. (2 marks)
 (3 marks)
- (c) Consider the following wiring arrangement for a DC machine.

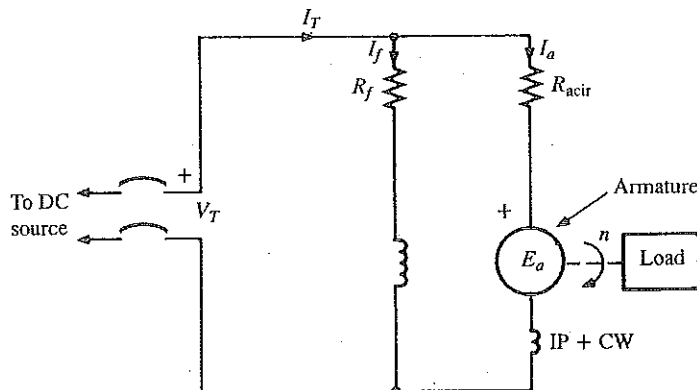


Figure 1(c): D.C. machine wiring arrangement

- (i) What is the name of the D.C. machine that this wiring arrangement usually refer to? Please list two characteristics of this type of D.C. machine. (3 marks)
- (ii) The DC source is supplying 430 V. The motor rated output is 1 kW. The shunt field wiring resistance is 180 Ω . The armature wiring resistance breakdown is as follow: armature winding: 0.2 Ω ; interpole winding: 0.1 Ω and compensating winding: 0.5 Ω . What is the rated counter-e.m.f. generated by the motor if the rotational losses are 3% of rated output power? Neglect the voltage drop across the brush in the calculation. (5 marks)
- (iii) At rated load, the motor is turning at rated speed of 1603 rpm. What is the value of torque experienced by the load? (2 marks)
- (iv) Find the input power to the motor if the voltage drop across the brush is 0.5V. What is the efficiency of the motor? (5 marks)

Question 2

- (a) State the input-output relationship of a typical transformer. (2 marks)
 List three popular transformer applications. (3 marks)
- (b) Describe all types of core that the power transformers are constructed on with proper illustration. (8 marks)
- (c) The high side equivalent resistance and reactance for a 37.5 kVA, 2400-600V, 50 Hz transformer are 2.8Ω and 6Ω , respectively. When a $10 \angle 20^\circ$ impedance is connected as load, determine the following:
- (i) Equivalent input impedance, including load. (6 marks)
 - (ii) The primary current, provided that primary voltage is 2400 V. (2 marks)
 - (iii) The voltage across the load (4 marks)

Question 3

- (a) A power station has the daily load curve given by the following:

Time (hrs)	12 pm – 7 am	7 – 9 am	9 – 11 am	11 am – 4 pm	4 – 10 pm	10 – 12 pm
Load (MW)	2	10	4.5	7	4	2.5

Plot the following curves:

- (i) Daily load curve (5 marks)
 - (ii) Load duration curve (5 marks)
 - (iii) Load energy curve (5 marks)
- (b) From the information in part (a), determine the total energy produced per annum and annual load factor if the capacity of the station is 18 MW. (10 marks)

Question 4

- (a) A 66 kV line is fed through an 11/66 kV step-up transformer from an 11 kV supply. At the load end of the line the voltage is step-down by another transformer of nominal ratio 66/11 kV. The total impedance of the line and transformers at 66 kV is $12.5 + j33 \Omega$. Both transformers are equipped with tap-changing facilities which are arranged so that the product of the two off-nominal settings is unity. If the load on the system is 50 MW at 0.8 pf lagging, calculate the settings of the tap changer required to maintain the voltage of the load busbar at 11 kV. Use the base power of 50 MVA. (13 marks)
- (b) A single core cable has a conductor radius r , internal radius of sheath R and V is the potential of the conductor relative to sheath. Prove that the potential gradient g_{max} will have a minimum value when $\frac{R}{r} = e$. (6 marks)
- (c) Calculate the economic size of a single core cable in which $g_{max} = 40,000$ V/cm and operating voltage is 50 kV. (6 marks)

Question 5

The variable operating cost of three generating units are given by

$$F_1 = 655 + 6.8P_1 + 0.007P_1^2 \text{ RM/hr}$$

$$F_2 = 695 + 6.5P_2 + 0.006P_2^2 \text{ RM/hr}$$

$$F_3 = 755 + 6.0P_3 + 0.005P_3^2 \text{ RM/hr}$$

If the total load demand varies from 150, 220 and 340 MW, determine the

- (i) incremental operation cost at each demand level, (8 marks)
- (ii) power output of each unit at the mentioned demand level, (10 marks)
- (iii) total operating cost, F_T , that minimize F_T for the above-mentioned load demands. (7 marks)

Question 6

- (a) Explain the following tariff:
- (i) Simple tariff (5 marks)
- (ii) Sliding scale tariff (5 marks)
- (iii) Two-part tariff (5 marks)
- (b) An electric supply company supplies a maximum peak load of 250 kW and load factor is 40%. Find the total cost of energy consumption per annum based on the following two tariffs offered:
- (i) RM 150 per kW of maximum demand plus 35 sen per kWh (5 marks)
- (ii) A flat rate of 40 sen per kWh (5 marks)

~The End~

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Summary of Equations:

D.C. Machines

$$V_T = E_a + I_a R_{acir}$$

(motor voltage and emf relationship)

$$E_a = V_T + I_a R_{acir}$$

(generator voltage and emf relationship)

$$P_{mech} = V_T I_a - I_a^2 R_{acir}$$

mechanical power

$$T_D = \frac{9.55 P_{mech}}{n}$$

developed torque

$$\eta = \frac{P_{out}}{P_{input}}$$

machine efficiency

Transformers

$$a = \frac{N_{HS}}{N_{LS}} \approx \frac{V_{HS}}{V_{LS}}$$

turns ratio

$$I_{HS} = \frac{1}{a} I_{LS}$$

(high side-low side current relationship)

$$Z_{eq,HS} = R_{HS} + a^2 R_{LS} + j(X_{HS} + a^2 X_{LS})$$

impedance referred to high side

$$Z_{eq,LS} = \frac{1}{a^2} R_{HS} + R_{LS} + j\left(\frac{1}{a^2} X_{HS} + X_{LS}\right)$$

impedance referred to low side

$$Z_{in,HS} = Z_{eq,HS} + a^2 Z_{load}$$

input impedance (referred to high side)

Load Study

$$\text{average demand}(W) = \frac{\text{total energy demand}(W\text{-hr})}{\text{total time}(hr)}$$

$$\text{load factor} = \frac{\text{average demand}(W)}{\text{maximum demand}(W)}$$

$$\text{demand factor} = \frac{\text{maximum demand}(W)}{\text{total connected load}(W)}$$

$$\text{diversity factor} = \frac{\text{sum of individual maximum demand}(W)}{\text{maximum demand on power station}(W)}$$

$$\text{plant capacity factor(plant factor)} = \frac{\text{average demand on the plant}(W)}{\text{total plant capacity}(W)}$$

$$\text{plant use factor(utilization factor)} = \frac{\text{actual energy produced}(W\text{-hr})}{\text{plant capacity}(W) \times \text{total time}(hr)}$$

Per Unit System

$$Z_{pu(new)} = Z_{pu(old)} \times \left(\frac{V_{b(old)}}{V_{b(new)}}\right)^2 \times \frac{VA_{base(new)}}{VA_{base(old)}}$$

(changing per unit value from one base reference to another base reference)

Cable Grading

$$g = \frac{V_{12}}{x \ln\left(\frac{D_2}{D_1}\right)}$$

(dielectric stress)

$$V_n = g_{max} r_{n-1} \ln\left(\frac{r_n}{r_{n-1}}\right); n = 1, 2, 3, \dots$$

(voltage distribution)

Optimal Dispatch

$$\lambda = \frac{P_D + \sum_{i=1}^n \frac{\beta_i}{2\gamma_i}}{\sum_{i=1}^n \frac{1}{2\gamma_i}}$$

(incremental cost)

$$P_i = \frac{\lambda - \beta_i}{2\gamma_i}$$

(power output)

Voltage Control Method

$$t_s = \sqrt{\frac{\frac{|V_1|}{|V_2|}}{1 - \frac{R P + X Q}{|V_1||V_2|}}}$$

(tap-changing transformer adjustment ratio)