



FINAL
Examination Paper

(COVER PAGE)

Session : April 2016

Programme : Diploma in Electrical and Electronic Engineering (DEEI)

Course : EEE 2113: Electric Power Systems and Machines

Date of Examination : 27 July 2016, Wednesday

Time : 8.00am – 10.00am 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) : Mr. Ken Kong Seng Kuok

Moderator : Mr. Cheah Kean Seng

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

INTI INTERNATIONAL COLLEGE

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING (DEED)
 EEE 2113: ELECTRIC POWER SYSTEMS AND MACHINES
 FINAL EXAMINATION: APRIL 2016 SESSION

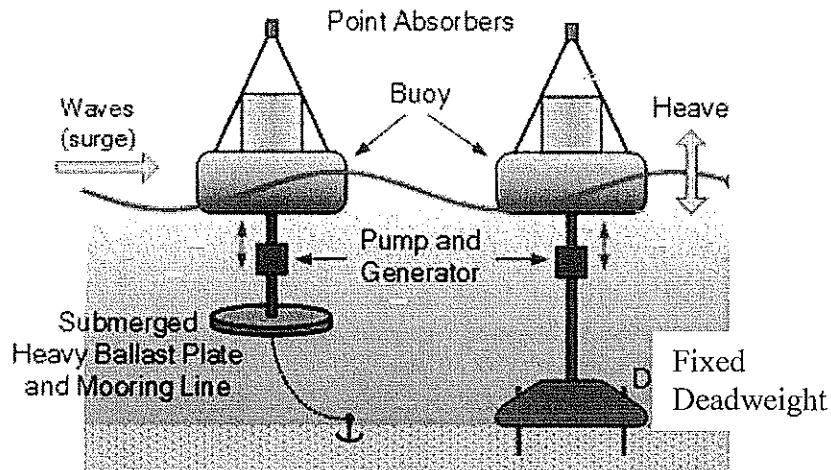
Instructions: This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Question 1

- (a) 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 2

- (a) Contrast 3 advantages and 3 disadvantages of wind energy. (6 marks)
- (b) Briefly describe the operation of the wave energy converting devices below.
 Note: Since both devices are operating on similar principle, your explanation should apply equally well for any of them.



(10 marks)

- (c) If the average significant wave height is 3.9 m, and average period is 8 second, while the density of salt water is 1027 kg/m^3 , what is the average wave power that could be expected?

(9 marks)

Question 3

- (a) The transmission line can be represented with suitable 2-port network model. What are conditions in terms of length and voltage magnitude for using the following?

- (i) short line model (2 marks)
- (ii) medium line model (2 marks)
- (iii) long line model (2 marks)

- (b) A 50-Hz 3-phase transmission line has the following constants:

$$R = 5 \Omega / \text{phase}$$

$$\text{Inductive reactance} = 20 \Omega / \text{phase}$$

$$\text{Capacitive susceptance} = 4 \times 10^{-4} \text{ mho} / \text{phase}$$

Calculate the following when the line used in supplying a balanced load of 1,000 kW at 33-kV, 0.8 p.f. lagging:

- (i) Sending end voltage (9 marks)
- (ii) Line current (5 marks)
- (iii) Power factor at the sending end (2 marks)
- (iv) Efficiency of transmission (3 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: (5 marks)
- (i) Block rate tariff (5 marks)
- (ii) Maximum demand tariff (5 marks)
- (iii) Power factor tariff (5 marks)
- (b) An electric supply company supplies a maximum peak load of 230 kW and load factor is 30%. Find the total cost of energy consumption per annum based on the following two tariffs offered: (5 marks)
- (i) RM 120 per kW of maximum demand plus 30 sen per kWh (5 marks)
- (ii) A flat rate of 35 sen per kWh (5 marks)

~The End~

Summary of Equations:

D.C. Machines

$$V_T = E_a + I_a R_{acir} \quad (\text{motor voltage and emf relationship})$$

$$E_a = V_T + I_a R_{acir} \quad (\text{generator voltage and emf relationship})$$

$$P_{mech} = V_T I_a - I_a^2 R_{acir} \quad (\text{mechanical power})$$

$$T_D = \frac{9.55 P_{mech}}{n} \quad (\text{developed torque})$$

$$\eta = \frac{P_{out}}{P_{input}} \quad (\text{machine efficiency})$$

Alternative Energy Sources

$$P_w = \frac{1}{2} \rho A v^3 \eta \quad (\text{wind power})$$

$$TSR = \frac{4\pi}{n} \quad (\text{tip speed ratio})$$

$$E_{potential} = mgH \quad (\text{potential energy in water})$$

$$\text{Power (kW) approximately} = 9.81 Q H \rho \quad (\text{power in water})$$

$$\text{Avogadro's constant} = 6.023 \times 10^{23} \text{ per mole}$$

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ Watt-sec (Joules)}$$

$$\eta = P_m / (E \times A_c) \quad (\text{solar panel efficiency})$$

$$P = (\rho g^2 / 64\pi) H^2 m_0 T_e \quad (\text{wave power})$$

Load Study

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

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

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

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

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

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

Per Unit System

$$Z_{pu(new)} = Z_{pu(old)} \times \left(\frac{V_{b(old)}}{V_{b(new)}} \right)^2 \times \frac{VA_{base(new)}}{VA_{base(old)}} \quad (\text{changing per unit value from one base reference to another base reference})$$

Transmission Line Model

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix} \quad (\text{short line model})$$

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} 1 + \frac{YZ}{2} & Z \\ Y + \frac{Y^2 Z}{4} & 1 + \frac{YZ}{2} \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix} \quad (\pi \text{ model})$$

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} 1 + \frac{YZ}{2} & Z + \frac{YZ^2}{4} \\ Y & 1 + \frac{YZ}{2} \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix} \quad (\text{T model})$$

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} \cosh \gamma l & Z_C \sinh \gamma l \\ \frac{1}{Z_C} \sinh \gamma l & \cosh \gamma l \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

(long, rigorous model)

Transmission Line Parameters

$$L = 2 \times 10^{-7} \ln (\text{GMD}/\text{GMR}_L) \text{ H/m}$$

(inductance)

$$C = 2 \pi \epsilon / \ln (\text{GMD}/\text{GMR}_C) \text{ F/m}$$

(capacitance)

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

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

ratio)

(tap-changing transformer adjustment)