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FINAL
Examination Paper

(COVER PAGE)

Session	:	**April 2016**
Programme	:	Diploma in Electrical and Electronic Engineering (DEEI)
Course	:	**EEE 2106: Electrical Power System**
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	:	Dr. Mandeep Singh

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

INTI INTERNATIONAL COLLEGE

DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING (DEEI)
EEE 2106: ELECTRICAL POWER SYSTEM
FINAL EXAMINATION: APR 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) Describe the usage of commonly used types of synchronous generators (alternators). (10 marks)

(b) A supply company offers the following alternative tariffs for a factory:

i. High voltage (h.v.) supply RM (75 / kVA + 0.03 / kWh)
ii. Low voltage (l.v.) supply RM (60 / kVA + 0.04 / kWh)

The annual cost of transformers and switchgears for the high voltage (h.v.) supply are RM 50 per kVA and full load transformation losses are 2%. The annual fixed charges on the capital cost of h.v. plant are 15%. If the factory runs for 8 hours per day, calculate the number of days for which the factory should be used so that high voltage (h.v.) supply is cheaper than low voltage (l.v.) supply. (15 marks)

Question 2

(a) Describe 3 advantages and disadvantages of wind energy.

(6 marks)

(b) Describe the operation of the wave energy converting devices in Figure Q2b.
Note: Since both devices are operating on similar principle, your explanation should apply equally well for any of them.

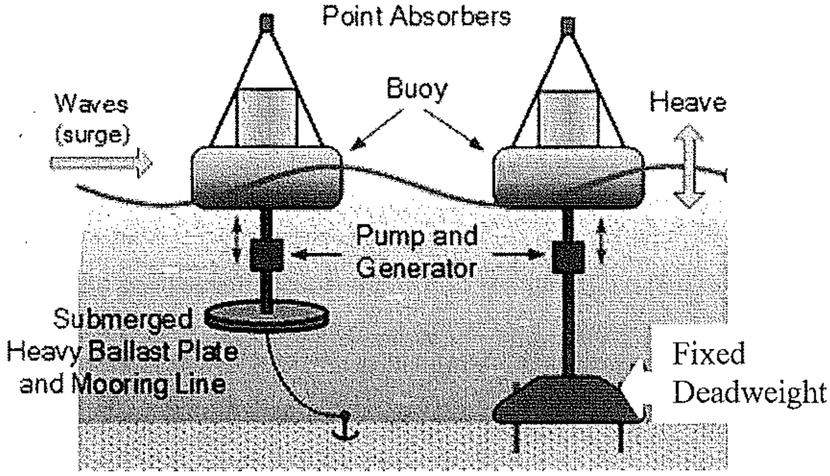

Figure Q2b: Point Absorbers (10 marks)

(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, calculate the average wave power.

(9 marks)

Question 3

(a) The transmission line can be represented with suitable 2-port network model. Describe the 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 Ω / phase

Inductive reactance = 20 Ω / phase

Capacitive susceptance = 4×10^{-4} mho / phase

When the line terminated in a balanced load of 1,000 kW at 33-kV, 0.8 p.f. lagging, calculate the following:

(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 Ω. 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
$F_1 = 655 + 6.8P_1 + 0.007P_1^2$ RM/hr
$F_2 = 695 + 6.5P_2 + 0.006P_2^2$ RM/hr
$F_3 = 755 + 6.0P_3 + 0.005P_3^2$ 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) 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%. Calculate the total cost of energy consumption per annum based on the following two tariffs offered:
 (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:

Alternative Energy Sources

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

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

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

Power (kW) approximately = 9.81 Q H ρ (power in water)

Avogadro's constant = 6.023×10^{23} per mole

1 eV = 1.602×10^{-19} Watt-sec (Joules)

$\eta = P_m / (E \times A_c)$ (solar panel efficiency)

$P = (\rho g^2/64\pi)H^2_{m0}T_e$ (wave power)

Load Study

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

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

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

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

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

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

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)

Transmission Line Model

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

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

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

$L = 2 \times 10^{-7} \ln (GMD/GMR_L)$ H/m (inductance)

$C = 2\pi\varepsilon / \ln (GMD/GMR_C)$ F/m (capacitance)

Cable Grading

$$g = \frac{V_{12}}{x \ln\left(\frac{D2}{D1}\right)}$$ (dielectric stress)

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