



**INTI**  
**International College Penang**  
LAUREATE INTERNATIONAL UNIVERSITIES\*

**FINAL**  
Examination Paper

(COVER PAGE)

Session : August 2015

Programme : Diploma in Electrical and Electronic Engineering (DEEI)

Course : EEE 2106: Electrical Power System

Date of Examination : 11<sup>th</sup> December 2015 (Friday)

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.

**IMPORTANT NOTE : THIS PAPER SHOULD NOT BE TAKEN OUT OF THE EXAMINATION HALL**

Materials permitted :

Non-Programmable Scientific Calculator

Materials provided :

Nil

Examiner(s) :

Mr. Ken Kong Seng Kuok

Moderator :

Dr. 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 (DEED)  
 EEE 2106: ELECTRICAL POWER SYSTEM  
 FINAL EXAMINATION: AUG 2015 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 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 is run for 8 hours a day, find the number of days for which the factory should be used so that h.v. supply is cheaper than l.v. supply. (15 marks)

**Question 2**

- (a) Describe the operation of LIMPET, a wave energy converter installed on the Scottish island of Islay. (5 marks)
- (b) List 3 advantages and disadvantages of wind turbine. (6 marks)
- (c) A wind power generator is built with the following specification:  
 Blade length: 45 m  
 Blade number: 3  
 Height: 200 m  
 The average wind speed at this area is 35 miles/hour, where 1 m/s is equivalent to 2.237 miles/hour. The air density is taken as 1.225 kg/m<sup>3</sup>. The overall efficiency is 30%.  
 (i) Find out the power output of the generator. (7 marks)  
 (ii) What is the optimum revolution speed for the turbine blades in r.p.m.? (7 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:  
 $R = 10 \Omega / \text{phase}$   
 Inductive reactance =  $20 \Omega / \text{phase}$   
 Capacitive susceptance =  $4 \times 10^{-4} \text{ mho} / \text{phase}$   
 Calculate the following when the line used in supplying a balanced load of 10,000 kW at 66-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 for use on 11 kV, 50 Hz system has conductor area of  $0.645 \text{ cm}^2$  and internal diameter of sheath is 2.18 cm. The permittivity of the dielectric used in the cable is 3.5.  $\epsilon_0$  is  $8.854 \times 10^{-12}$ .
- (i) Determine the maximum electrostatic stress in the cable. (3 marks)
  - (ii) Determine the minimum electrostatic stress in the cable. (3 marks)
  - (iii) Determine the capacitance of the cable per km. (3 marks)
  - (iv) Find the corresponding charging current. (3 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 125, 230 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) Flat rate tariff (5 marks)
  - (ii) Two part tariff (5 marks)
  - (iii) Sliding scale 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:
  - (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~

EEE2106(f)aug2015

## Summary of Equations:

Alternative Energy Sources

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

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

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

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

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

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

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

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

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

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

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

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

$$\begin{bmatrix} V_S \\ I_S \end{bmatrix} = \begin{bmatrix} \cosh \gamma l & Z_c \sinh \gamma l \\ \frac{1}{Z_c} \sinh \gamma l & \cosh \gamma l \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix} \quad (\text{long, rigorous model})$$

Transmission Line Parameters

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

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

Cable Grading

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

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

### Optimal Dispatch

$$\lambda = \frac{P_D + \sum_{i=1}^n \frac{\beta_i}{2\gamma_i}}{\sum_{i=1}^n \frac{1}{2\gamma_i}} \quad (\text{incremental cost})$$

$$P_i = \frac{\lambda - \beta_i}{2\gamma_i} \quad (\text{power output})$$

### Voltage Control Method

$$t_s = \sqrt{\frac{\frac{|V_1|}{|V_2|}}{1 - \frac{R}{P} + \frac{X}{Q} \frac{|V_1||V_2|}}}} \quad (\text{tap-changing transformer adjustment ratio})$$