INTI International College Penang

FINAL
Examination Paper

(COVER PAGE)

Session	:	**January 2020**
Programme	:	Diploma in Electrical & Electronic Engineering (DEEI)
Course	:	**EEE2113: Electric Power Systems and Machines**
Date of Examination	:	7 April 2020 (Tuesday)
Time	:	2.00pm – 5.00pm Reading Time : Nil
Duration	:	3 Hours
Special Instructions	:	

This paper consists of **FOUR (4)** questions. Answer all the **FOUR (4)** questions. All questions carry equal marks.

Materials permitted :

Nil

Materials provided :

Appendix (on page 4 & 5)

Examiner(s)	:	**Mr Alan Wong Kam Mun**
Moderator	:	Ms Shalyn Lim

*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: JAN2020 SESSION

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

Question 1

(a) 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
Calculate the following when the line used in supplying a balanced load of 1,000 kW at 33 kV, 0.8 p.f. lagging assuming a **π model** network:

(i) Sending end voltage (7 marks)

(ii) Line current (5 marks)

(iii) Power factor at the sending end (2 marks)

(iv) Efficiency of transmission (3 marks)

(b) A generating station has the following daily loads:

Time(24hrs)	0 – 6	6 – 10	10 – 12	12 - 16	16 - 20	20 - 24
Load(MW)	40	50	60	50	70	40

(i) Find maximum demand (in MW). (2 marks)

(ii) Units of energy generated per day (in MWh). (4 marks)

(iii) Average load (in kW). (2 marks)

Question 2

(a) The following Figure Q2a shows a single line diagram indicating a network connecting 4 generators and 2 reactors. The machine rating and percentage reactance are listed below the figure. A symmetrical fault developed along the feeder labelled G.

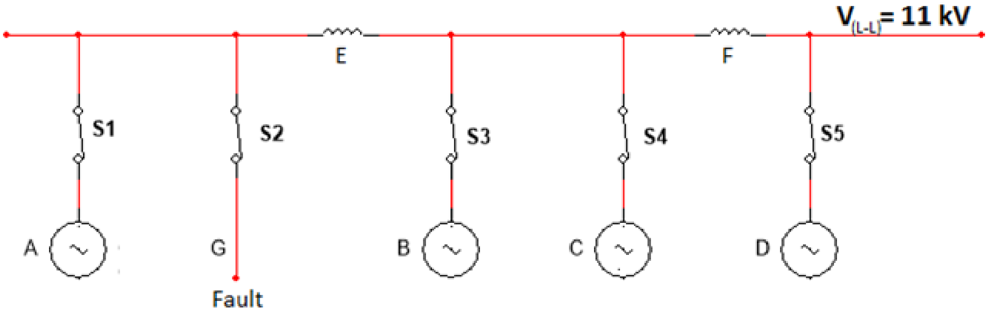

Figure Q2a

A: 10,000 kVA, 10%
B: 20,000 kVA, 15%
C: 20,000 kVA, 15%
D: 12,500 kVA, 12.5%
E: 8,000 kVA, 5%
F: 10,000 kVA, 5%

(i) Produce the per unit reactance on a power base of 25,000 kVA. (12 marks)

(ii) Sketch the reactance diagram of the system at fault. (3 marks)

(iii) Assess the rupturing capacity of the breaker on feeder G (7 marks)

(iv) Estimate the fault current. (3 marks)

Question 3

(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 p.f lagging, calculate the settings of the tap changer (in sec) 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 kVr.m.s.

(6 marks)

Question 4

(a) 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. (6 marks)

(iii) Total operating cost, F_T, that minimize F_T for the above-mentioned load demands. (6 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 (4 marks)

(ii) A flat rate of 40 sen per kWh (1 marks)

~The End~

Appendix of Equations:

D.C. Machines

$V_T = E_a + I_aR_{acir}$ (motor voltage and emf relationship)

$E_a = V_T + I_aR_{acir}$ (generator voltage and emf relationship)

$P_{mech} = V_T I_a - I_a^2 R_{acir}$ (mechanical power for separately excited DC motor)

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

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)

$$Z_{\text{p.u.}} = \frac{Z(\Omega)}{Z_{\text{base}}} = \frac{Z(\Omega) \times VA_{\text{base}}}{V_{\text{base}}^2}$$

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)

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

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

$$t_s = \sqrt{\frac{\frac{|V_{1(pu)}|}{|V_{2(pu)}|}}{1 - \frac{R_{(pu)}P_{(pu)} + X_{(pu)}Q_{(pu)}}{|V_{1(pu)}||V_{2(pu)}|}}}$$ (tap-changing transformer adjustment ratio)