



FINAL
Examination Paper

(COVER PAGE)

Session : April 2017

Programme : Diploma In Electrical And Electronic Engineering (DEED)

Course : EEE2113: Electric Power Systems And Machines

Date of Examination : 3 August 2017 (Thursday)

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 : Dr. Ooi Beng Lee

This paper consists of 7 printed pages, including the cover page.

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DIPLOMA IN ELECTRICAL AND ELECTRONIC ENGINEERING PROGRAMME (DEEI)
EEE2113: ELECTRIC POWER SYSTEMS AND MACHINES
FINAL EXAMINATIONS: APRIL 2017 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) The following test results are obtained from tests performed on a 50-Hz, 15-kVA, 2,200/200 V transformer:
Open circuit (LV side meter readings): 220 V, 2.72 A, 185 W
Short circuit (HV side meter readings): 112 V, 6.3 A, 197 W
Determine the:
- (i) Iron loss (2 marks)
 - (ii) Copper loss at rated power (6 marks)
 - (iii) Rated power efficiency at 0.8 power factor lagging (5 marks)
- (b) The primary winding of a 20-kVA, single phase transformer is connected to 2.2-kV, 50-Hz A.C. supply source. There are 600 turns on the primary winding, and 40 turns on the secondary winding of the transformer. Calculate ideal transformer for:
- (i) The no-load voltage across the secondary terminals (5 marks)
 - (ii) The full-load currents of both primary and secondary sides (7 marks)

Question 2

- (a) The e.m.f. induced in a D.C. machine operating at 1200 r.p.m. driven by hydro-prime mover is 250 V. Calculate the e.m.f. induced in following situations:
- (i) The separately excited field flux decreased by 10% with the speed remaining unchanged. (5 marks)
 - (ii) The reduction of operating speed by 100 r.p.m. with the field flux density remaining unchanged. (5 marks)
- (b) A 240 V, 50 hp, 1500 rpm, compensated long-shunt compound motor has the following parameters:
- Armature resistance: 0.0675Ω
Total interpole and compensation winding resistance: 0.02Ω
Series winding resistance: 0.009Ω with 8 turns/pole
Shunt winding resistance: 86Ω with 750 turns/pole
The efficiency at rated load is 89%
- Determine the speed if a 25Ω resistor is inserted in series with the shunt field and the armature current is 200A. Neglect any saturation effects. (15 marks)

Question 3

- (a) The load duration curve of a system is as shown in the following figure Q1(a). The system is supplied by three stations – a steam station, a run of river station and a reservoir hydro-electric station. The ratios of number of units supplied by the three stations are as below:

Steam	:	Run of river	:	Reservoir
7	:	4	:	1

The run of river station is capable of generating power continuously and works as a base load station. The reservoir plant works as a peak load station. Estimate the maximum demand on each station and also the load factor of each station.

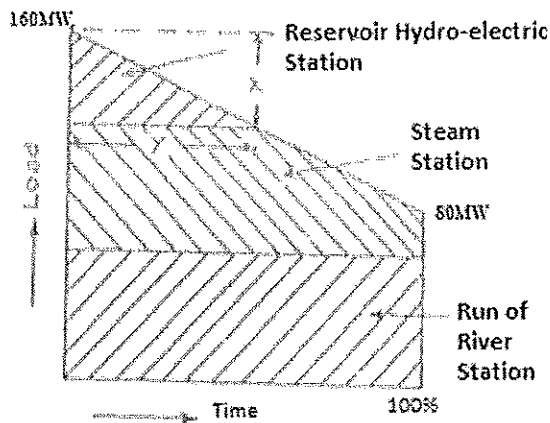


Figure Q1(a): Load duration curve

(25 marks)

Question 4

- (a) A 50 Hz, 3-phase transmission line of 100 km delivers 20 MW at 0.9 p.f. lagging and at 110 kV. The resistance and reactance of the line per phase are $0.2 \Omega/\text{km}$ and $0.4 \Omega/\text{km}$ respectively, while capacitive admittance is $2.5 \mu\text{S}/\text{km}$.
Calculate using nominal T method:
- (i) Sending end voltage and current (10 marks)
 - (ii) Efficiency of transmission (5 marks)
- (b) A single core cable of 0.5 km long has a core diameter of 0.5 cm and diameter under sheath of 2 cm. The relative permittivity of insulating material is 3.2. The supply voltage is 11 kV, 50 Hz. Take specific resistance of insulation as $5 \times 10^{12} \Omega/\text{m}$, calculate the following:
- (i) The capacitance of the cable, with $\epsilon_0 = 8.845 \times 10^{-12} \text{ Fm}^{-1}$ (3 marks)
 - (ii) The insulation resistance (3 marks)
 - (iii) The charging current per conductor (2 marks)
 - (iv) The dielectric loss (2 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 100, 200 and 300 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
$Z_{eq,LS} = \frac{1}{a^2} R_{HS} + R_{LS} + j(\frac{1}{a^2} X_{HS} + X_{LS})$	impedance referred to low side
$Z_{in,HS} = Z_{eq,HS} + a^2 Z_{load}$	input impedance (referred to high side)

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)
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Cable Parameters

$L = 2 \times 10^{-7} \ln\left(\frac{GMD}{GMR_L}\right)$ (H/m)	(general per unit length inductance)
$C = \frac{2\pi\epsilon}{\ln\left(\frac{GMD}{GMR_C}\right)}$ (F/m)	(general per unit length 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...	(voltage distribution)

Optimal Dispatch

$\lambda = \frac{P_D + \sum_{i=1}^n \frac{\beta_i}{2\gamma_i}}{\sum_{i=1}^n \frac{1}{\gamma_i}}$	(incremental cost)
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$$P_i = \frac{\lambda - \beta i}{2V_i}$$

(power output)

Voltage Control Method

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

ratio)

(tap-changing transformer adjustment

