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FINAL
Examination Paper

(COVER PAGE)

Session	:	**August 2017**
Programme	:	Diploma in Electrical and Electronic Engineering (DEEI)
Course	:	**EEE 2113: Electric Power Systems and Machines**
Date of Examination	:	7 December 2017 (Thursday)
Time	:	2:00pm – 4:00pm 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: AUGUST 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) **List** 3 characteristics of an ideal transformer. (6 marks)

(b) **Explain** the reason that transformer is only applicable in A.C. circuit. (4 marks)

(c) A 75 kVA, 4,800/240 V, 60 Hz, single-phase transformer has the following parameters (in Ω):

$R_{LS} = 0.0060$	$R_{HS} = 2.4880$	$R_{fe,\,HS} = 44{,}202$
$X_{LS} = 0.0121$	$X_{HS} = 4.8384$	$X_{M,\,HS} = 7798.6$

The transformer is operating in the step-down mode, delivering one-half rated load at rated voltage.

i. **Determine** the equivalent impedance reflect to the primary side. (3 marks)

ii. **Determine** the input impedance of the transformer that include the load and the parameters. Assume unity power factor. (3 marks)

iii. **Calculate** the input impedance of the transformer with the load disconnected. (3 marks)

iv. **Calculate** the exciting current flowing into transformer when the load is removed. (3 marks)

v. **Calculate** the efficiency of the transformer when it is connected to the load. (3 marks)

Question 2

(a) A shunt generator delivers 200 A at a terminal voltage of 250 V. The armature resistance and shunt field resistance are 0.02 Ω and 50 Ω respectively. The iron and friction losses amount to 1 kW.

(i) **Calculate** the generated E.M.F. (4 marks)

(ii) **Estimate** the copper losses (3 marks)

(iii) **Calculate** the input power to the generator (3 marks)

(iv) **Estimate** the overall efficiency of the generator (3 marks)

(b) A 30 kW, 250 V, D.C. shunt machine has an armature resistance of 0.06 Ω and field resistance of 100 Ω.

(i) **Solve** for the total armature power developed when working as a motor taking 30 kW input. (6 marks)

(ii) **Solve** for the total armature power developed when working as a generator while delivering 30 kW of output. (6 marks)

Question 3

(a) The load duration curve of a system is as shown in the following figure Q3. 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.

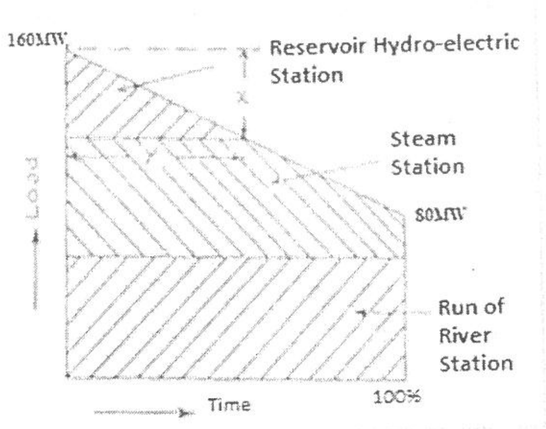

Figure Q3: Load duration curve

(25 marks)

Question 4

(a) A 50 Hz, 3-phase transmission line of 100 km delivers 20 MW, 0.9 p.f. lagging, at 110 kV. The resistance and reactance of the line per phase are 0.2 Ω/km and 0.4 Ω/km respectively, while capacitive admittance is 2.5 μS/km.

Using nominal T method:

(i) **Calculate** sending end voltage and sending end current (10 marks)

(ii) **Calculate** the 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 5×10^{12} Ω/m, calculate the following:

(i) **Determine** the capacitance of the cable, with $\varepsilon_o = 8.845 \times 10^{-12}$ Fm^{-1} (3 marks)

(ii) **Estimate** the insulation resistance (3 marks)

(iii) **Calculate** the charging current per conductor (2 marks)

(iv) **Determine** the dielectric loss (2 marks)

Question 5

The two generating units are supplying to the grid as indicated in Figure Q5. The per unit voltage, current and impedance value are given as below.

$I_1 = 1\angle 0°$
$I_2 = 0.8\angle 0°$
$V_1 = 1.05\angle 10°$
$V_2 = 1.07\angle 15°$
$Z_1 = 0.05 + j0.2$
$Z_2 = 0.06 + j0.3$
$Z_3 = 0.06 + j0.4$

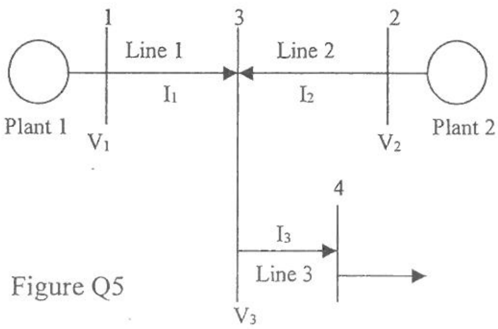

Figure Q5

(i) **Determine** the system line coefficients associated with Line 1, Line 2 and Line 3. (15 marks)

(ii) **Calculate** the penalty factor associated with each Plant (generating unit). (10 marks)

Question 6

(a) A single core cable of conductor 1.8cm and lead sheath of diameter 6.3cm is to be used on a 66kV(line voltage), *3 phase system*. There are two inter-sheaths of diameter 3.3cm and 4.8cm are introduced between the core and lead sheath.
Calculate the voltages on the inter sheaths if the maximum stress in the layers is the same. (15 marks)

(b) A 33 kV single core cable in a *single-phase* system has a conductor diameter of 1 cm and a sheath of inside diameter of 4 cm.
Determine the maximum and minimum stress in the insulation. (10 marks)

~The End~

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Summary 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)

$P_{mech} = V_TI_a - I_a^2R_{acir}$ 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)

$Z_{eq,HS} = R_{HS} + a^2R_{LS} + j(X_{HS} + a^2X_{LS})$ 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

$Z_{in,HS} = Z_{eq,HS} + a^2Z_{load}$ 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)

Cable Parameters

$L = 2 \times 10^{-7} ln\left(\frac{GMD}{GMR_L}\right)$ (H/m) (general per unit length inductance)

$C = \frac{2\pi\varepsilon}{ln\left(\frac{GMD}{GMR_C}\right)}$ (F/m) (general per unit length capacitance)

Cable Grading

$g = \frac{V12}{x ln\left(\frac{D2}{D1}\right)}$ (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)