UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

SUPPLEMENTARY EXAMINATION JULY 2013

TITLE OF PAPER:	**POWER SYSTEMS**
COURSE CODE:	**EE452**
TIME ALLOWED:	**THREE HOURS**

Candidate's Examination Number:	

INSTRUCTIONS:

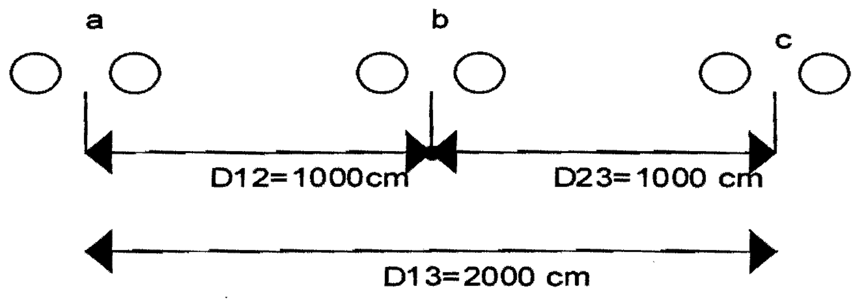
1. Answer all questions.
2. Write your answers in the space provided on the question paper, and if more space is required, continue your answer at the back of the paper or in your Examination Answer Book and mention the place where you continued writing your answer.
3. Put this question paper inside the Examination Answer Book upon completion of the examination.
   (DON'T FORGET TO SUBMIT BOTH OF THE ANSWER BOOK AND QUESTION PAPER)
4. Questions do not carry equal marks. Marks for each question are indicated at the beginning of the question.
5. Rough work may be done in the Examination Answer Book and crossed through.

DO NOT OPEN THIS PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR

This paper starts at page 1 and ends at page 15

Question 1: Solve the following questions (11 marks)

A 400 KV three phase transposed line composed of two ACSR conductors per phase with horizontal conductor configuration shown in the figure below. The conductors have diameter of 2.3 cm. The line spacing measured from center of bundle is shown in the figure. Bundle spacing is 40 cm. Find the inductance and capacitance per phase per Km of the line.



Question 2: Solve the following questions (22 marks)

A three phase 50 Hz, 450 kV (line-to-line) lossless transmission line is 320 Km long. The line inductance is 0.85 mH/Km per phase and the line capacitance is 0.01 μF /Km.

Note:

$\cosh(j\beta) = \cos(\beta)$, $\sinh(j\beta) = j\sin(\beta)$, $\tanh(j\beta) = j\tan(\beta)$

You need to evaluate the receiving end voltage and current first.

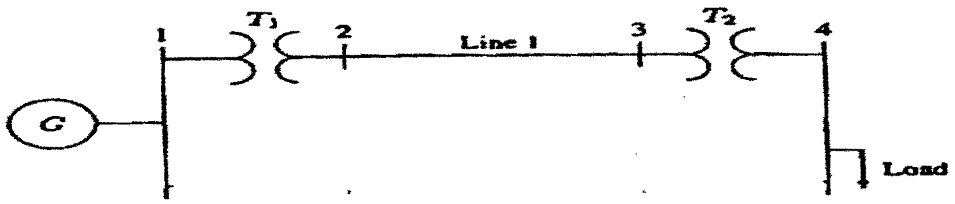
a) Determine the line phase constant β**, surge impedance** Z_C**.**

b) If the receiving end rated load is 600 MW, 0.8 pf lagging at 450 kV (line-to-line). Calculate the sending end voltage V_S, sending end current I_S and the voltage regulation VR.
(Calculate: V_S, I_S, VR)

Question 3: Solve the following questions (23 marks)

The one-line diagram of the three-phase power system is shown in the following figure. The data in ohm for each device as follows:
Generator: Y connected, 80MVA, 20kV, Z=j1 Ω.
Transformer T1: Y-Δ connected, 50MVA, 20kV/110 kV (line-to-line), Z=j0.9 Ω (referred to primary).
Transformer T2: Δ-Y connected, 50 MVA, 110/11 kV (line-to-line), Z=j0.2 Ω (referred to secondary).

The three-phase load at bus 4 absorbs 50 MVA, 0.85 power factor lagging at 10.4 kV. Line 1 has an impedances of j60 Ω.



a) **Calculate the ohmic value of the load impedance.**

b) **Select a common base of 100 MVA and 20kV (line to line) on the generator side. Find the base voltage and base impedance at each section of the system.**

c) Draw the equivalent diagram of the network with all impedances in per unit.

d) Calculate the internal generator emf in per unit.

e) Calculate the internal generator emf in Volts and the load current in Amps.

Question 4: Solve the following questions (18 marks)

Given the following network with

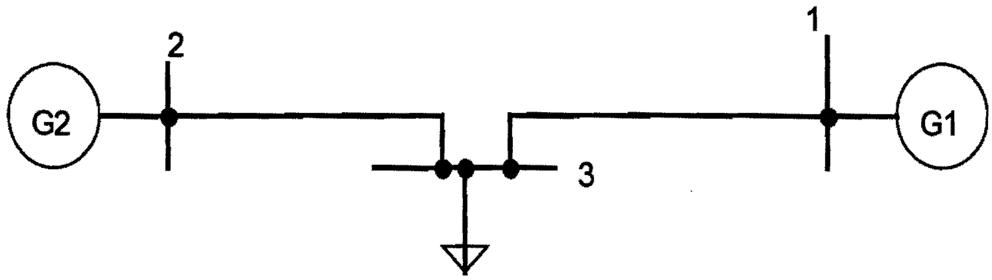
$V_1 = 1\angle 0\, pu$ *Slackbus*

$P_2 = 1.8\, pu$ $|V_2| = 1.05\, pu$ *PVbus*

$P_3 = -2\, pu$ $Q_3 = -1.2\, pu$ *PQbus*

$Y_{L23} = -j8\, pu$

$Y_{L13} = -j4\, pu$



a) **Find the admittance matrix of the system Ybus.**
Note: You don't need to derive the Ybus matrix.

b) Solve for the first iteration of V_2 using Gauss Seidel method.

c) If the solution to the load flow problem was $V_1 = 1pu$, $V_2 = 1.05\angle 10.566° pu$, $V_3 = 0.9019\angle -3.1780° pu$, calculate the active and reactive power flow in line 3-2 (P_{32}, Q_{32}).

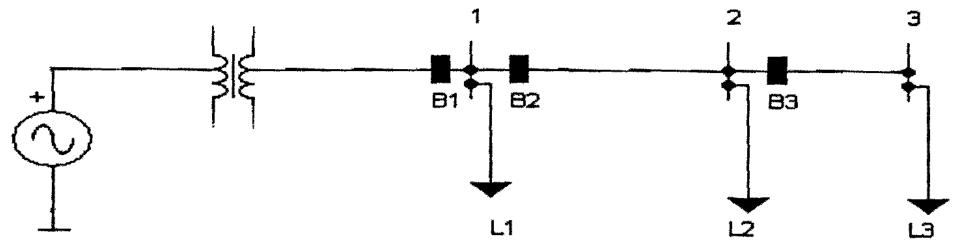
Question 5: Solve the following questions (17 marks)

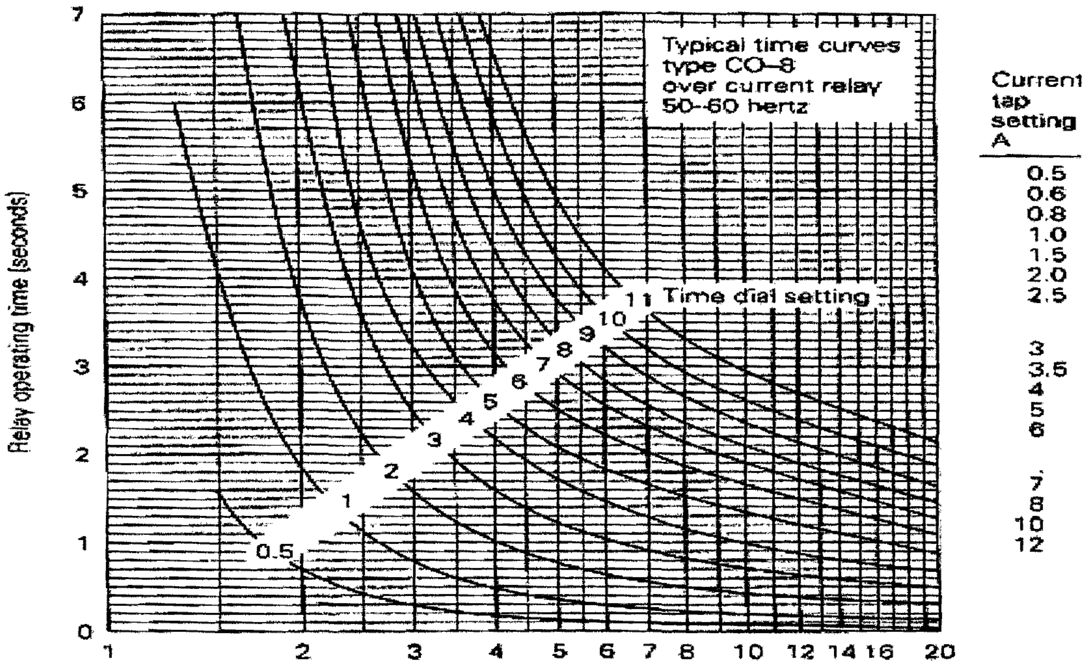
The objective is to select the tap settings (TS) and time dial settings to protect the system shown below from the fault. Assume that CO8 is used for each breaker, one for each phase with 0.5 sec coordination time intervals. The relay for each breaker is connected so that all of the three phases of breaker open when the fault is detected on one phase. A 30 kV line-to-line voltage is assumed at all buses during normal operation.

Bus	S	Lagging pf	CT
1	12 MVA	0.95	400/5
2	9 MVA	0.95	300/5
3	7 MVA	0.95	200/5

Fault data

Bus	Max fault current
1	3000
2	2000
3	1000





a) Calculate the tap setting for breaker B3.

b) Calculate the tap setting for breaker B2.

c) Calculate the tap setting for breaker B1.

d) What is the time dial setting for breaker B3.

e) Calculate the time dial setting for breaker B2. Assume the breaker B3 operating time $T_{breaker}$=0.0833 sec and the coordination time $T_{coordination} = 0.5\,\text{sec}$.

Question 6: Solve the following questions (9 marks)

a) Consider one meter length of single phase line consisting of two long solid conductors each having radius r. The two conductors separated by distance D. Conductor 1 carries charge q1 columbs per meter while conductor 2 carries charge q2 columbs per meter, where q1=-q2. Calculate the capacitance to neutral C_n.