UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

SUPPLEMENTARY EXAMINATION JULY 2014

TITLE OF PAPER: **Power Systems**
COURSE CODE: **EE 452**

TIME ALLOWED: **THREE** HOURS

Student Name:	
Student Number:	

INSTRUCTIONS:

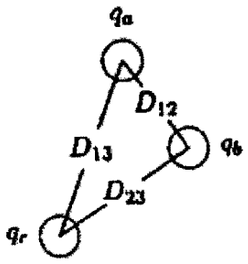
1. Answer all questions.
2. Give your answers on the question paper, and if more space is required, complete your answer on the back of the paper or in your answer book and mention about the place of your answer completion.
3. Put the question sheet inside the answer book upon submission of your exam paper.
   (DON'T FORGET TO SUBMIT BOTH OF THE ANSWER BOOK AND QUESTION PAPER)
4. Marks for different questions are indicated on the beginning of the question.
5. Rough work maybe done in the examination answer book and crossed through.

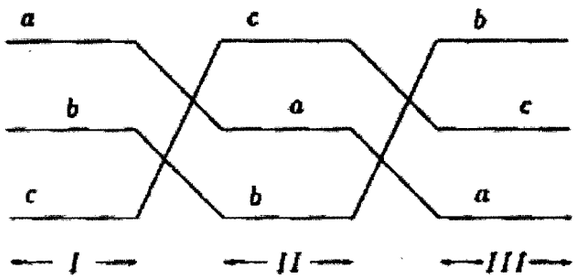
DO NOT OPEN THIS PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR

This paper starts at page 1 and ends at page 16

Question 1: Solve the following questions (9 marks)

a) Consider one meter length of three phase transposed transmission line with three long conductors of radius r as shown in the figure below. Derive an equation for the capacitance to neutral per phase.
(Note: Derive equation for C_n)





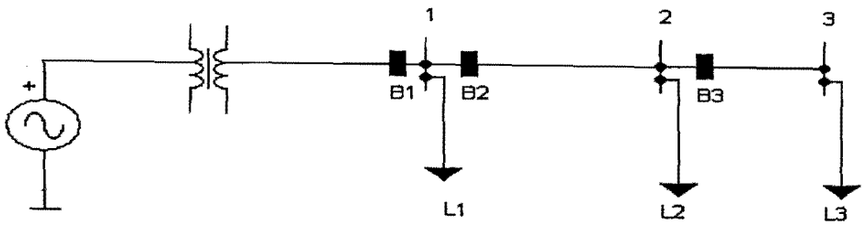
Question 2: Solve the following questions (14 marks)

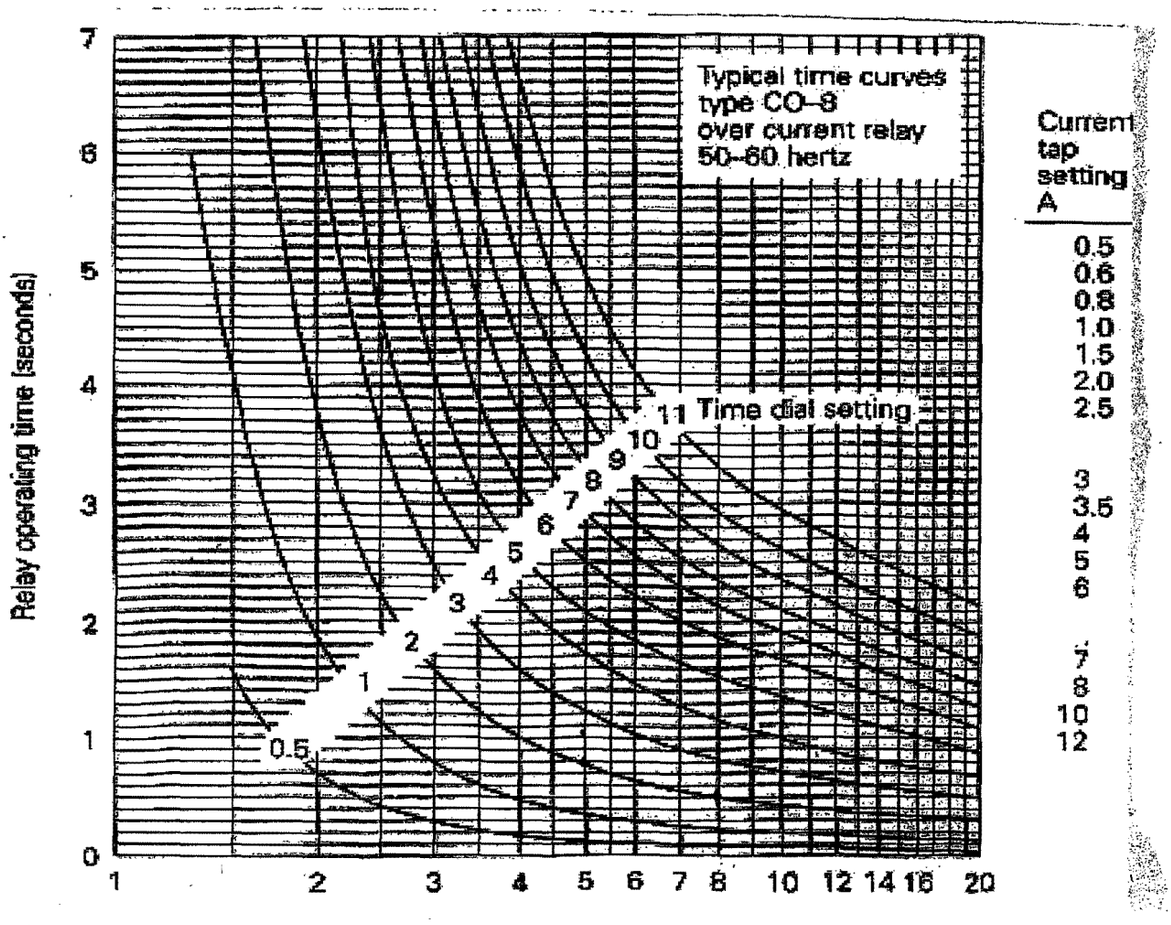
The objective is to select the tap settings (TS) and time dial settings to protect the system shown below from the fault. Assume that CO8 is used for each breaker, one for each phase with 0.4 sec coordination time intervals. The relay for each breaker is connected so that all of the three phases of breaker open when the fault is detected on one phase. A 40 kV line-to-line voltage is assumed at all buses during normal operation.

Bus	S	Lagging pf	CT
1	12 MVA	0.95	300/5
2	10 MVA	0.95	300/5
3	8 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.

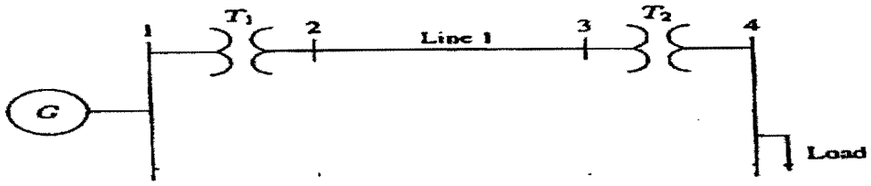
c) Calculate the tap setting for breaker B1.

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 $T_{coordination} = 0.4\,\text{sec}$.

Question 3: Solve the following questions (22 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, 90MVA, 25kV, Z=j1.2Ω.
Transformer T1: Y-Δ connected, 60MVA, 25kV / 220kV (line-to-line), Z=j0.8 Ω (referred to primary).
Transformer T2: Δ-Y connected, 60MVA, 220kV /11kV (line-to-line), Z=j0.4 Ω (referred to secondary).
The three-phase load at bus 4 absorbs 60 MVA, 0.8 power factor lagging at 10.5 kV. Line 1 has an impedance of j50Ω.



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

b) **Select a common base of 100 MVA and 25kV (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 line current in Amps.

Question 4: Solve the following questions (19 marks)

Given the following network with

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

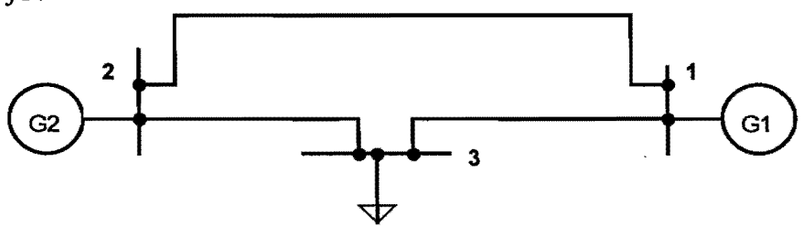
$P_2 = 2\ pu$ $|V_2| = 1.1\ pu$ *PVbus*

$P_3 = -2.5\ pu$ $Q_3 = -1.5\ pu$ *PQbus*

$Y_{L23} = -j8$

$Y_{L13} = -j6$

$Y_{L21} = -j10$



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

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

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

c) If the load flow solution for the previous network

$V_1 = 1\angle 0$

$V_2 = 1.1\angle 2.0662°$

$V_3 = 0.923\angle -9.3186°$

Find $I_{21}, S_{21}, P_{21}, Q_{21}$.

Question 5: Solve the following questions (16 marks)

A three phase 50 Hz, 400 kV (line-to-line) lossless transmission line is 350 Km long. The line inductance is 1.3 mH/Km per phase and the line capacitance is 0.02 μF/Km.

Note:

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

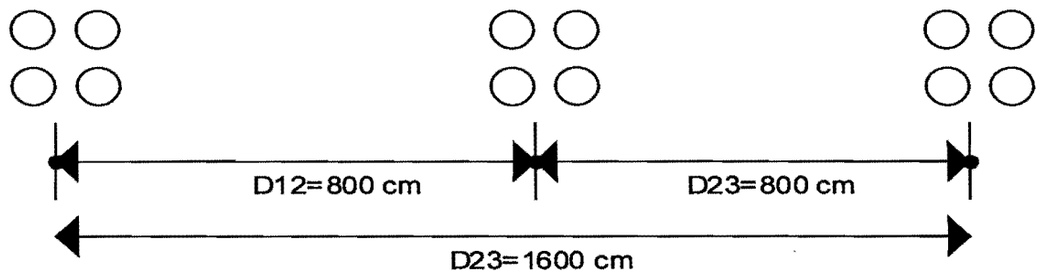
a) Determine the line phase constant β**, surge impedance** Z_C**.**

b) If the receiving end rated load is 800 MW, 0.8 pf lagging at 400 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**)**

c) List the compensation methods that can be used to increase the voltage level when under voltage is detected at the receiving end of transmission line.

Question 6: Solve the following questions (9 marks)

A 500 KV three phase transposed line composed of four ACSR conductors per phase with conductor's configuration shown in the figure below. The conductors have diameter of 2.5 cm. The line spacing measured from center of bundle is shown in the figure. Bundle spacing is 28 cm. Find the inductance and capacitance per phase per Km of the line.



Question 7: Solve the following questions (11 marks)

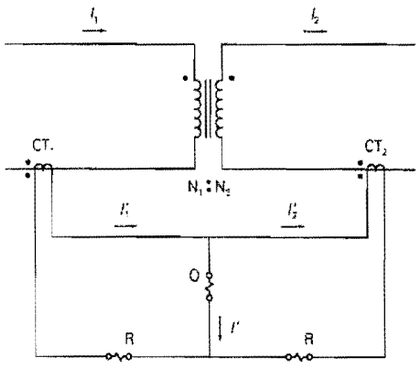
a) A CO8 over current relay with current tap setting TS=3 A and time dial setting TDS= 2 sec is used with current transformer CT. Use the CO-8 over current relay time delay characteristic curves given in Question 2 to determine the operating time in case the current I' that flows in the CT has the following magnitudes:

I' =3 A:

I' =15 A:

I' =24 A:

b) In a differential protection of a transformer, the current through the differential relay is i', the current through the CT in primary winding i'_1 and the current through the CT in secondary winding i'_2. Distinguish between the normal condition and the fault condition that causes the differential relay to operate? Derive the condition at which the scheme operates.



c) **If a voltage at the sending end of transmission line is $V_S = 30kV\angle 15°$ and the voltage at the receiving end of transmission line is $V_R = 20kV\angle 30°$**

Note: You don't need to do calculations

- **Will the active power flow from the sending end to receiving end or form the receiving end to sending end. Indicate the reason.**

- **Will the reactive power flow from the sending end to receiving end or form the receiving end to sending end. Indicate the reason.**

d) **In a differential protection of a three phase Δ-Y connected transformer, how the CTs in the Δ side and the CTs in the Y side of the transformer should be connected, in Y-Δ or Δ-Y?**