UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

MAIN EXAMINATION MAY 2012

TITLE OF PAPER: **POWER SYSTEMS**

COURSE CODE: **EE 452**

TIME ALLOWED: **THREE HOURS**

Student Name:	
Student Number:	

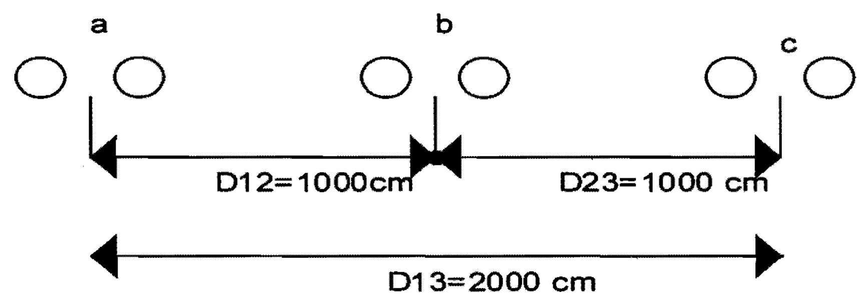
INSTRUCTIONS:
1. Answer all questions.
2. Give your answers on the question paper, and if more space is required, complete your answer on the back of the paper or in your answer book and mention about the place of your answer completion.
3. Put the question sheet inside the answer book upon submission 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 18.

Question 1: Solve the following questions (8 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 (26 marks)

A three phase 50 Hz, 450 kV (line-to-line) lossless transmission line is 320 Km long. The line inductance is 0.9 mH/Km per phase and the line capacitance is 0.01 μF /Km.

Note:

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

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)

c) Calculate the surge impedance loading SIL.

d) If the transmission line supplies a load of 600MVA, 0.8 pf lagging (as in a). Determine the capacitance of shunt capacitor to be installed at receiving end to keep receiving end voltage 450 kV (line-to-line) when the line energized with 450 kV (line to line) at sending end.

Question 3: Solve the following questions (20 marks)

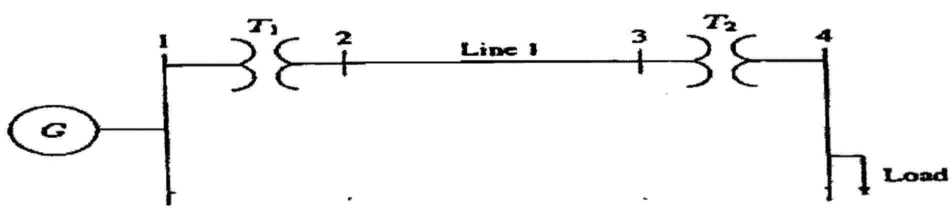
The one-line diagram of the three-phase power system is shown in the following figure. The data in ohm for each device as follows:

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 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 (15 marks)

Given the following network with

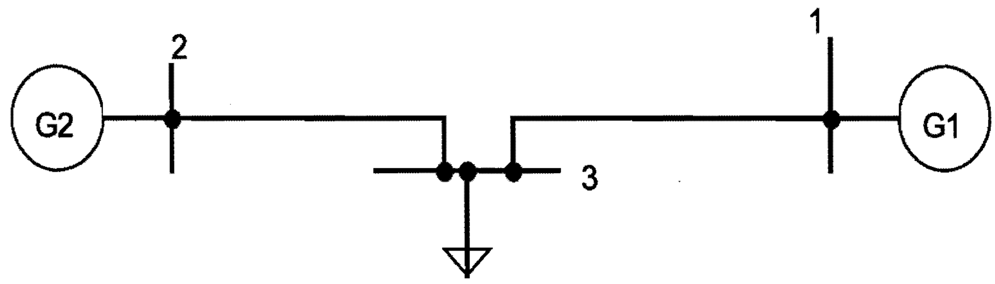
$V_1 = 1\angle 0\ pu$ *Slackbus*

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

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

$Y_{L23} = -j8pu$

$Y_{L13} = -j4pu$



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) The current flow in the line between bus 1 and bus 3 is given by

a) $I_{13} = (V_1 - V_3)Y_{13}$

b) $I_{13} = (V_1 - V_3) / YL_{13}$

c) $I_{13} = (V_1 - V_3)YL_{13}$

d) The active and reactive power flow in the line between bus 1 and bus 3 is given by

a) $P_{13} - jQ_{13} = V^*{}_3 I_{13}$

b) $P_{13} - jQ_{13} = V^*{}_1 I_{13}$

c) $P_{13} + jQ_{13} = V_1 I_{13}$

e) The current injected at bus 3 is given by

a) $I_3 = (Y_{L31}V_1 + Y_{L32}V_2 + Y_{L33}V_3)$

b) $I_3 = (V_3 - V_1)YL_{13}$

c) $I_3 = (Y_{31}V_1 + Y_{32}V_2 + Y_{33}V_3)$

f) The active and reactive power flow in the line between bus 1 and bus 3 is characterized by

a) $P_{13} + jQ_{13} = -P_{31} - jQ_{31}$

b) $P_{13} + jQ_{13} = P_{31} - jQ_{31}$

c) $P_{13} + jQ_{13} = P_{31} + jQ_{31}$

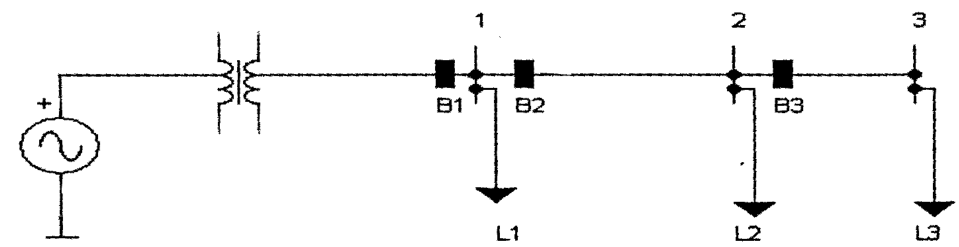
Question 5: Solve the following questions (14 marks)

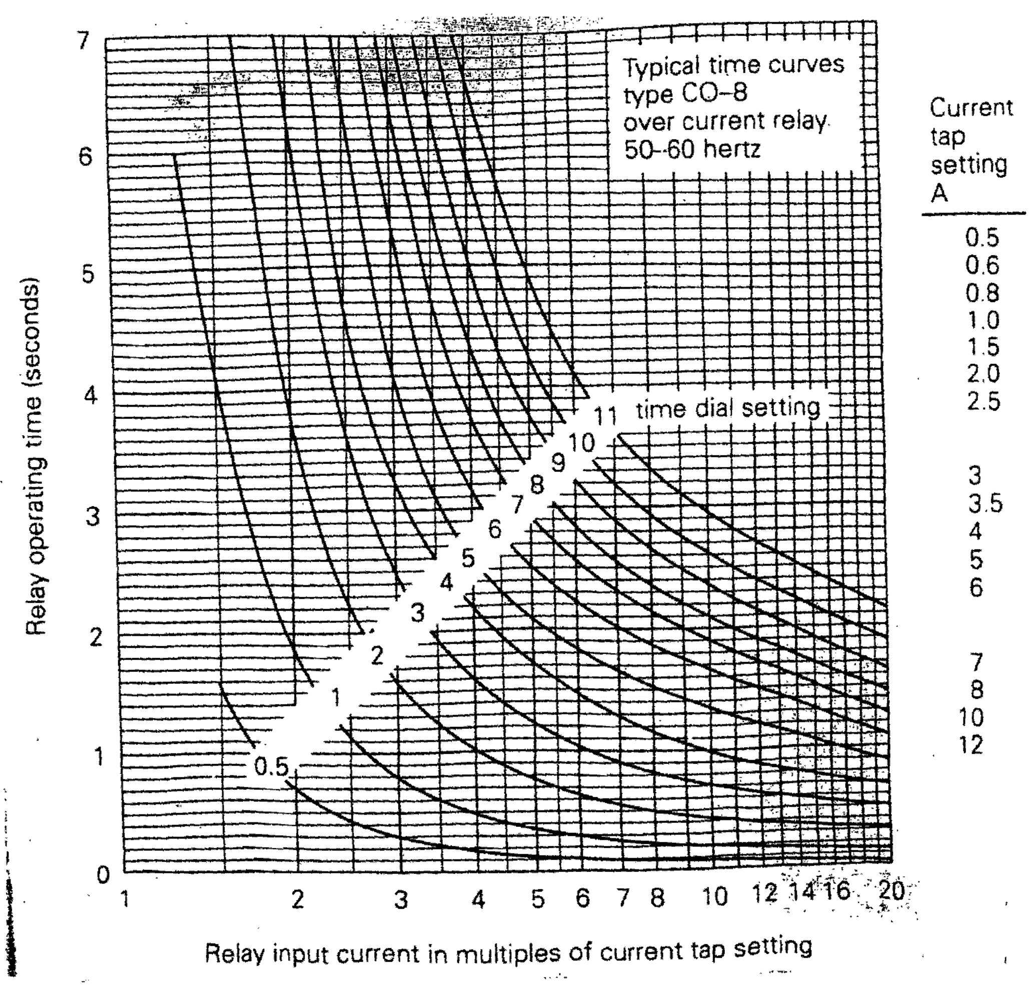
The objective is to select the tap settings (TS) and time dial settings to protect the system shown below from the fault. Assume that CO8 is used for each breaker, one for each phase with 0.5 sec coordination time intervals. The relay for each breaker is connected so that all of the three phases of breaker 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 (7 marks)

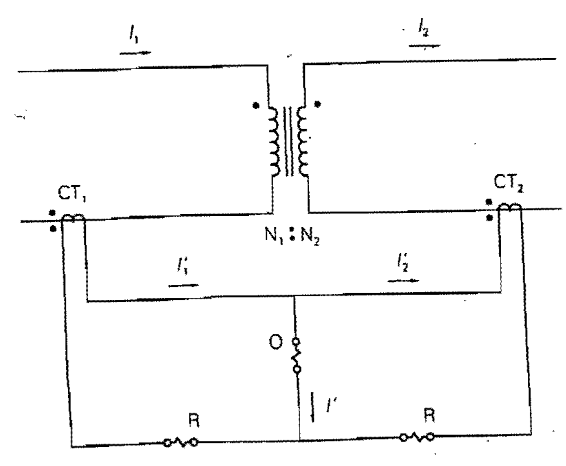
a) The CO8 with current tap setting TS=5 A and time dial setting 2 sec ($I_p = 5A$, $TDS = 3\sec$) is used with current transformer CT. Use the over current relay curves given in Question 5 to determine the operating time in case the current I' that flows in the CT has the following magnitudes:

I'=5A:

I'=10 A:

I'=20 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?



c) Is changing the voltage magnitude between two ends of the transmission line will affect the real or reactive power flow through the line? What is the direction of that type of power flow: from the higher voltage side towards the lower voltage side or from lower voltage side towards the higher voltage side.

d) Is changing the phase shift between two ends of the transmission line will affect the real or reactive power flow through the line? What is the direction of that type of power flow: from the lagging voltage side towards the leading voltage side or from leading voltage side towards the lagging voltage side.

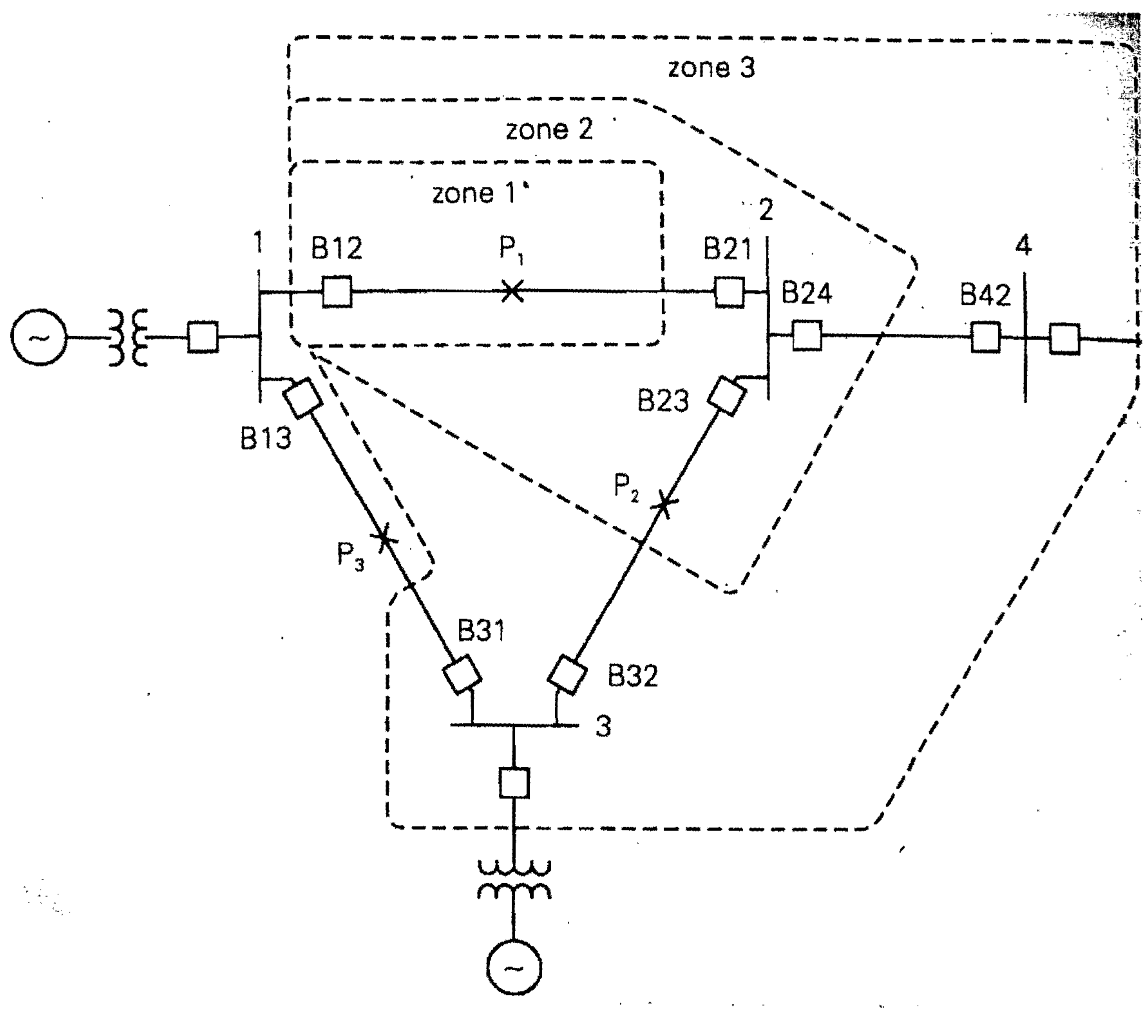
e) In a differential protection of a three phase Y-Δ connected transformer. How the CTs in the Y side and the CTs in the Δ side of the transformer should be connected, in Y-Δ or Δ-Y?

Question 7: Solve the following questions (10 marks)

Three zone impedance relays. The following table gives the positive sequence line impedances as well as the CT and VT ratios of the distance relay at B12 for 345 kV (line to line) system.

Line	Positive Sequence
1-2	12+j58
2-3	8+j33
2-4	10+j60
1-3	5+j28

Breaker	CT ratio	VT Ratio
B12	2000:5	3200:1



a) Determine the three impedance relay zones settings at B12 Z_{r1}, Z_{r2}, Z_{r3}, and time delay for the relay to trip in each zone.

b) If an impedance relay measures the impedance at the line 12 Z', and Zr1 is adjustable relay setting for zone 1, then the impedance relay will operate to trip the circuit breaker when

a) $Z' > Z_{r1}$

b) $Z' < Z_{r1}$

c) $Z' > 0$