UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

SUPPLEMENTARY EXAMINATION JULY 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.

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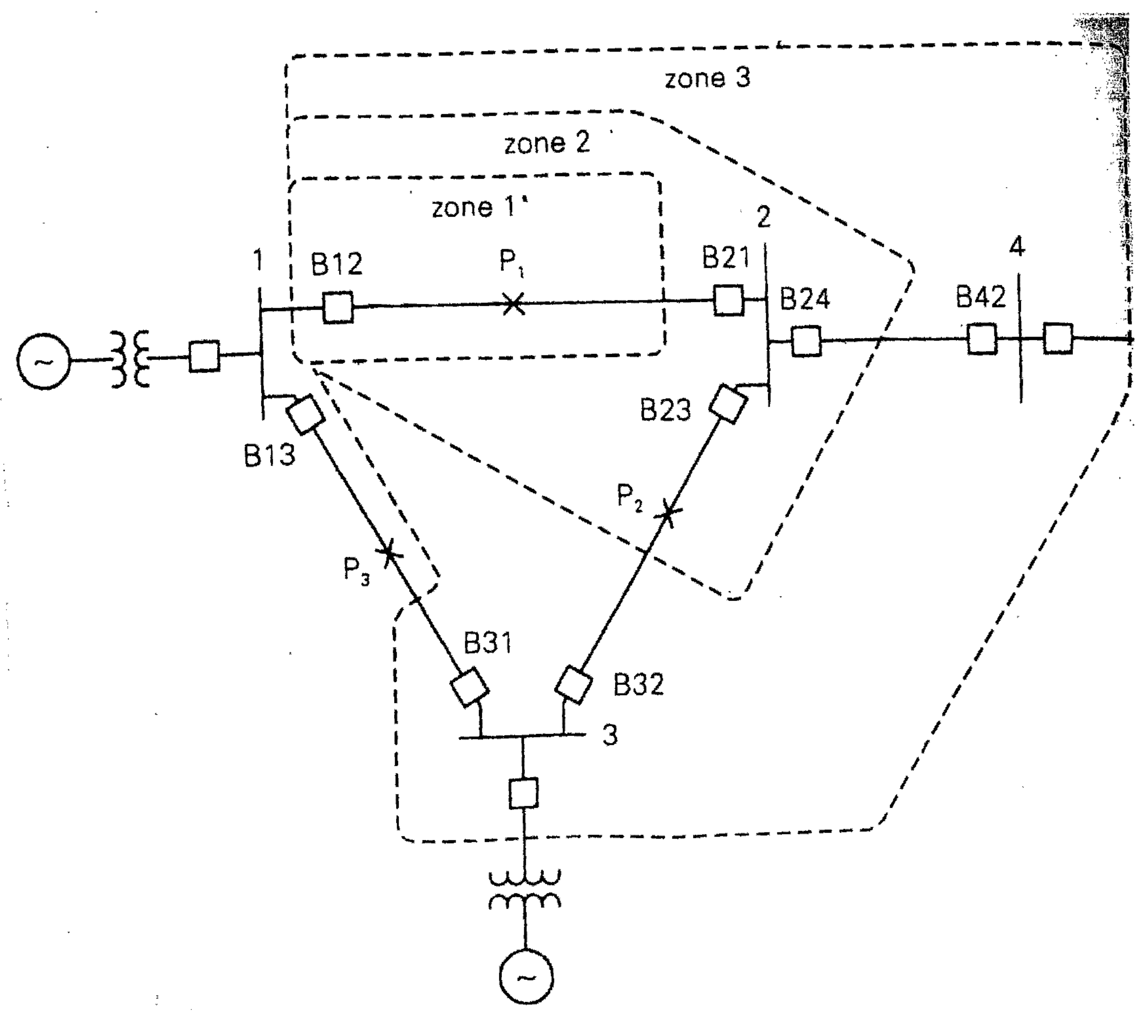
This paper starts at page 1 and ends at page 14.

Question 1: Solve the following questions (12 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	15+j60
2-3	7+j35
2-4	8+j55
1-3	6+j28

Breaker	CT ratio	VT Ratio
B12	1500:5	2700:1



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.

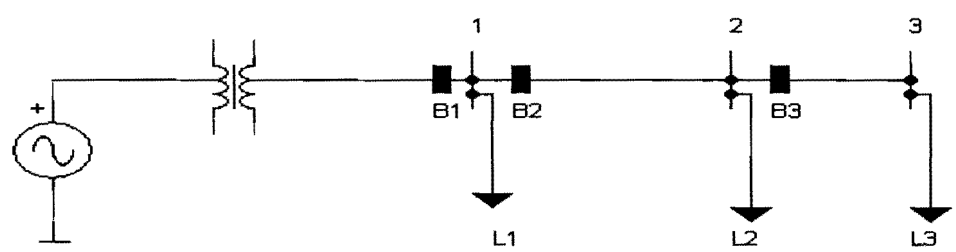
Question 2: Solve the following questions (16 marks)

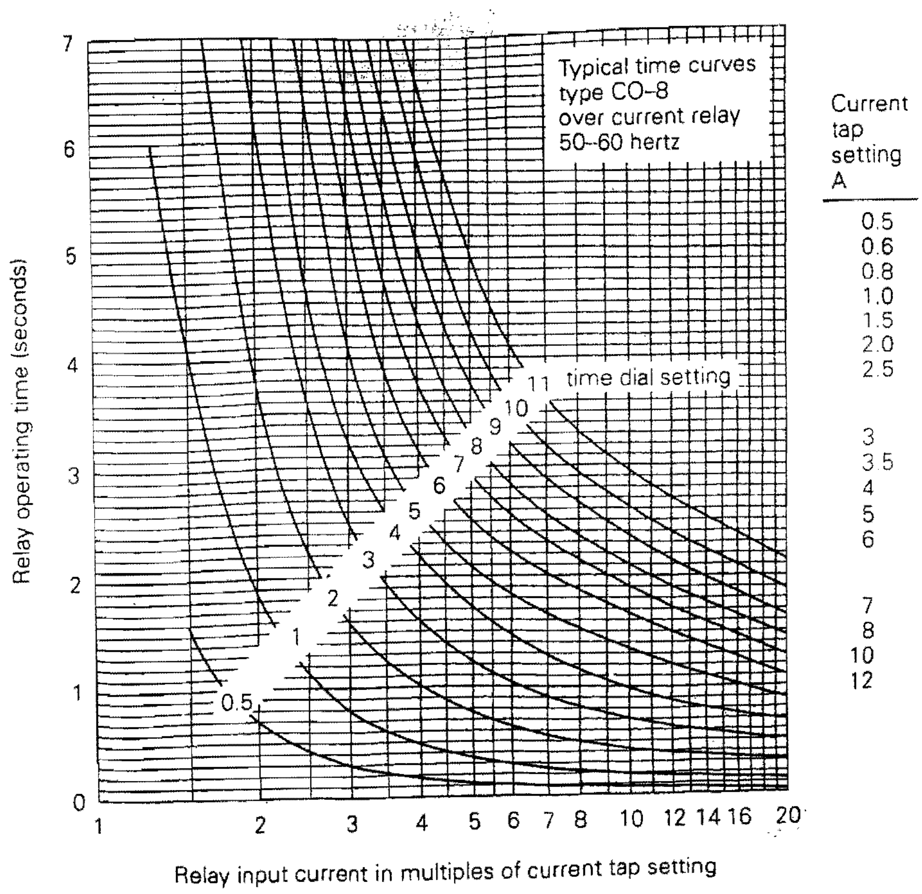
The objective is to select the tap settings (TS) and time dial settings to protect the system shown below from the fault. Assume that CO8 is used for each breaker, one for each phase with 0.4 sec coordination time intervals. The relay for each breaker is connected so that all of the three phases of breaker 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.

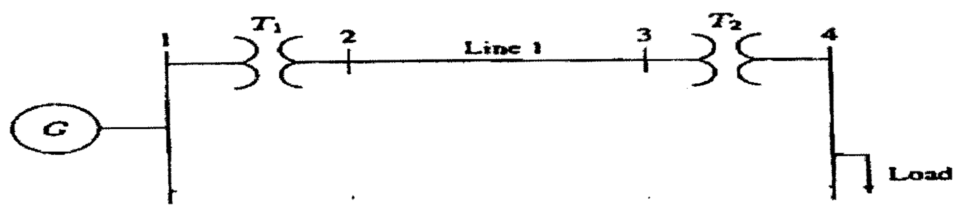
d) What is the time dial setting for breaker B3.

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 (24 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=j1.2 Ω.
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 j50 Ω.



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 (21 marks)

Given the following network with

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

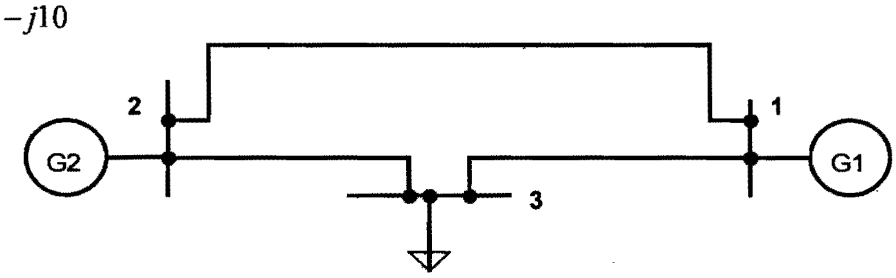
$P_2 = 2\ pu \quad |V_2| = 1.1\ pu \quad PVbus$

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

$Y_{L23} = -j8$

$Y_{L13} = -j6$

$Y_{L21} = -j10$



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

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 (11 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.