THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMMUNICATIONS ENGINEERING

SEMESTER TWO FINAL EXAMINATION (2021)

EE442 – ADVANCED POWER SYSTEMS

FINAL YEAR ELECTRICAL ENGINEERING – POWER (BEEP 4)

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS:

1. You have **TEN (10) MINUTES** to read the paper. You must not begin writing during this time.

2. This is an **OPEN BOOK** Examination.

3. There are four (4) questions in this Examination. **Answer all questions.** All answers must be written in the **ANSWER BOOK** supplied.

4. **COMPLETE THE DETAILS REQUIRED ON THE FRONT COVER OF YOUR ANSWER BOOK – DO THIS NOW.**

5. Only drawing instruments, calculators and laptops with textbooks are permitted on your desk. NO phones allowed.

6. If you are found cheating in the Examination, the penalties specified by the University shall apply.

7. **TURN OFF** all Mobile Phones and place them on the floor under your seat before the start of Examination.

Question 1 **(20 marks)**

The single-line diagram of a three-bus network is shown in **Figure Q1**. Generators G1 and G2 have equal rating and so are transformers T1 and T2. The following are the system parameters.

Generators:	$x_1 = x_2 = 10\%, \quad x_0 = 5\%$
Transformers:	$x_1 = x_2 = x_0 = 5\%$
Trans. Lines	$x_1 = x_2 = 12\%, \quad x_0 = 40\%$

(a)Determine the positive, negative, and zero sequence networks for this system for a fault at bus 1.

(b) Determine the fault currents and fault levels for a solid fault at bus 2 for the following fault types:

(i) three-phase fault,
(ii) single line –to-ground fault,
(iii) line-to-line fault, and
(iv) double line-to-ground fault.

(Assume the prefault voltage is $V = 1.05\angle 0^{\circ}$ p.u)

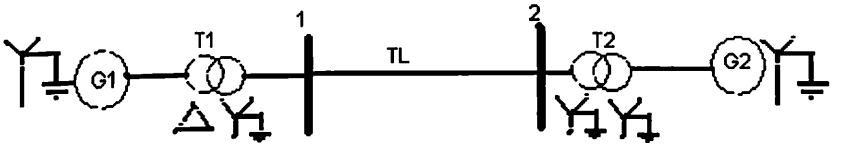

Figure Q1

Question 2 (20 marks)

(a) Two identical synchronous generators of 80 MW operate in parallel. The governor settings on the machines are such that they have 4 % and 3 % droops (no load to full load % speed drop). Determine the load taken by each machine for a load increase of 200 MW.

(b) A 500-MVA, 50-Hz turbine-generator has a regulation constant R=0.05 per unit based on its own rating. If the generator frequency increases by 0.01 Hz in steady-state, what is the decrease in turbine mechanical power output?

Assume a fixed reference power setting.

Question 3 (40 marks)

The data for the system given in **Figure Q3** is provided in **Table Q3**. Select the current tap settings (TSs) and time dial setting (TDAs) to protect the system from faults. Assume a three CO-8 relays for each breaker for the respective phases, with 0.25-second coordination time interval. The relays for each breaker are connected such that all three phases of each breaker open when a fault is detected on any phase. Assume a 33-kV (line-line) voltages at all buses during normal operation.

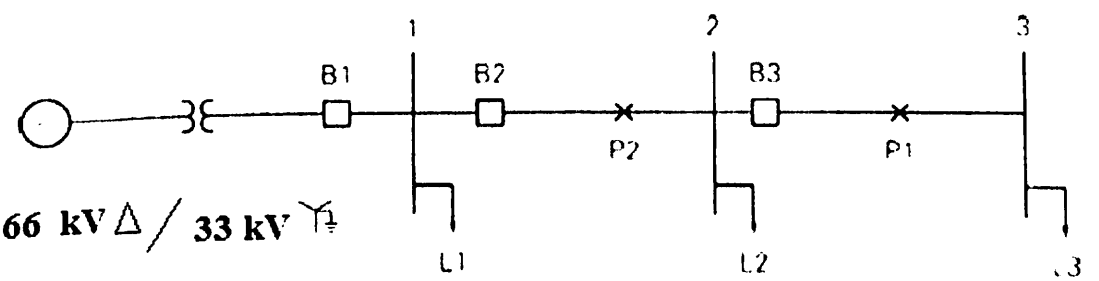

Figure Q3

Question 3 Cont'd

Table Q3

Bus	Maximum Load		Symmetrical Fault Current	
	MVA	Lagging p.f.	Maximum A	Minimum A
1	9.0	0.95	5000	3750
2	9.0	0.95	3000	2250
3	9.0	0.95	2000	1500

Breaker	Breaker Operating Time	CT Ratio	Relay
B1	5 cycles	600:5	CO-8
B2	5 cycles	400:5	CO-8
B3	5 cycles	200:5	CO-8

CO-8 relay Time dial characteristics is attached.

Question 4 (20 marks)

(a) With reference to diagram in **Figure Q4** and admittance matrix provided, determine V_2 using Gauss-Siedel iteration method. Take bus 2 as a load bus.

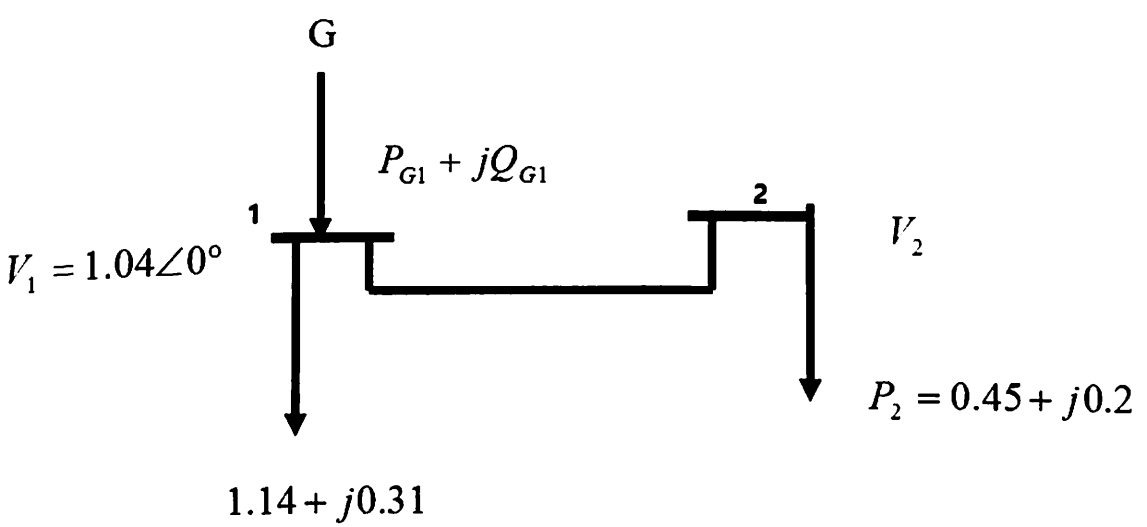

Figure Q4

Question 4 Cont'd

$$Y_{bus} = \begin{bmatrix} 1.841631\angle -80.485610° & 1.904443\angle 99.197819° \\ 1.904443\angle 99.197819° & 1.841631\angle -80.485610° \end{bmatrix}$$

Hints: Start with the guess $\delta_2^{(0)} = \angle -12°$ and $V_2^{(0)} = 0.94$ p.u

Use the equation $$V_2^{(v+1)} = \frac{1}{y_{22}}\left[\frac{P_2 - jQ_2}{\left(V_2^{(v)}\right)^*} - y_{21}V_1\right]$$

END OF EXAM

CO-8 relay Time dial characteristics