



MACHAKOS UNIVERSITY

University Examinations for 2020/2021

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 502: POWER SYSTEM ANALYSIS

DATE: 16/8/2021

TIME: 8:30 – 10:30 AM

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **FIVE** questions. Question **ONE** is **compulsory**. Attempt any other two questions.

Do not write on the question paper.

QUESTION ONE (COMPULSORY) (30 MARKS)

- a) State any three advantages of per unit presentation of power systems. (3 marks)
- b) A single line diagram of a three phase power system is shown in FigQ1(a). Select a common base of 30MVA and 6.6kV of the generator. Draw per unit impedance diagram. (10 marks)

$$G_1 = 25\text{MVA}, 6.6\text{kV}, x_{g1} = 0.2\text{p.u}$$

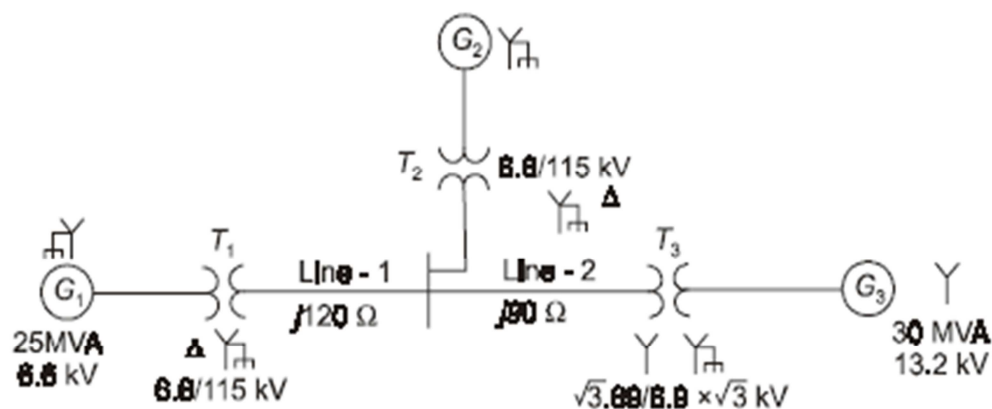
$$G_2 = 15\text{MVA}, 6.6\text{kV}, x_{g1} = 0.15\text{p.u}$$

$$G_3 = 25\text{MVA}, 6.6\text{kV}, x_{g1} = 0.15\text{p.u}$$

$$T_1 = 30\text{MVA}, 6.6\Delta/115\text{Y kV}, x_{T1} = 0.10\text{p.u}$$

$$T_2 = 15\text{MVA}, 6.6\Delta/115\text{YkV}, x_{T2} = 0.10\text{p.u}$$

$$T_3 = 10\text{MVA}, 6.9/69\text{kV}, x_{T3} = 0.10$$



FigQ1(b)

- c) Fig Q1(c) shows a single line diagram of a sample 3-bus power system. Data for this system are given in table 1 and table 2. Take bus 2 as the P-|v| bus. Using Gauss –Seidel method, determine:

- The phasor values of voltage at bus 2 and 3 (perform two iterations only)
- The slack bus real and reactive power after the second iteration.

(17 marks)

Table 1

Bus code	Assumed bus voltage	Generation		Load	
		Mwatts	MVAR	Mwatts	MVAR
1 (slack bus)	$1.05 + j0.0$	-	-	0	0
2	$1 + j0.0$	50	30	305.6	140.2
3	$1 + j 0.0$	0.0	0.0	138.6	45.2

Table 2.

Bus code i - k	Impedance Z_{ik}
1 - 2	$0.02 + j 0.04$
1 - 3	$0.01 + j 0.03$
2 - 3	$0.0125 + j0.025$

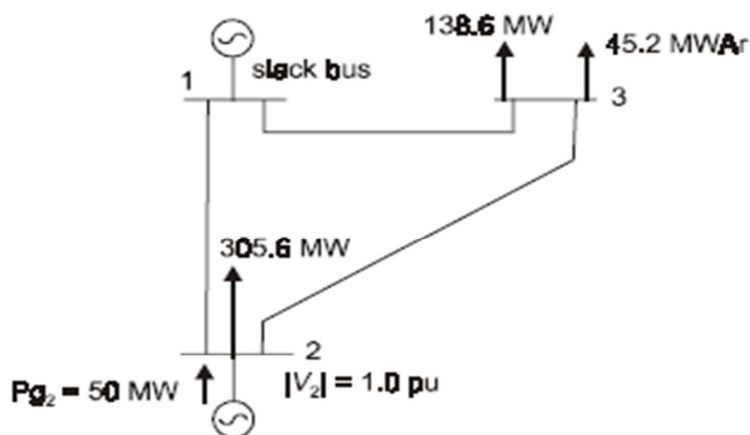


Fig Q1(c)

QUESTION TWO (20 MARKS)

a) With an aid of Fig 2(a) show that;

$$V_i = \frac{1}{Y_{ii}} \left\{ \frac{P_i - jQ_i}{V_i} - \sum_{\substack{k=1 \\ k \neq i}}^n Y_{ik} V_k \right\} \quad (10 \text{ marks})$$

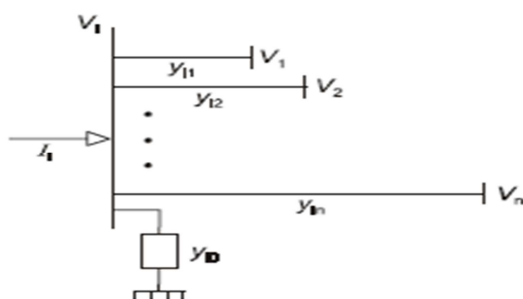


Fig 2(a)

b) A three bus system is shown in Fig Q2(b). Each of the lines has a series impedance of $0.02 + j0.8$ p.u and a total shunt admittance of $j0.02$ p.u. the specified quantities at the buses are give in table 2.

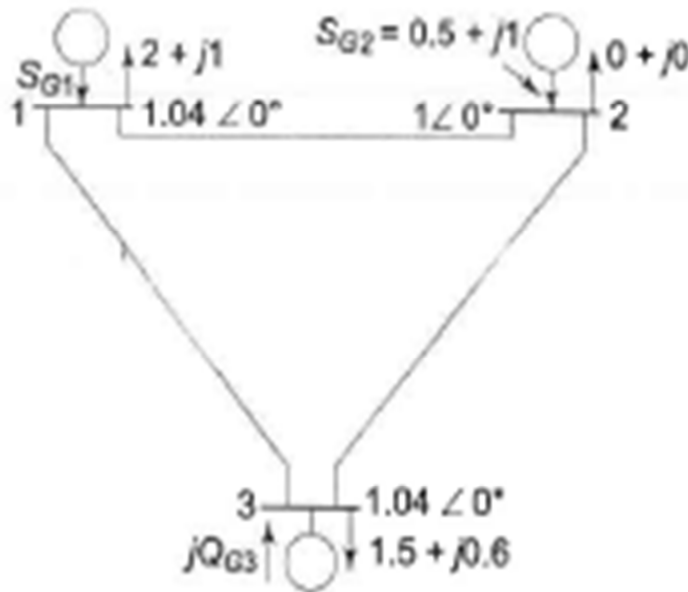
BUS	REAL LOAD DEMAND	REACTIVE LOAD DEMAND	REAL POWER GENERATION	REACTIVE POER GENERATION	VOLTAGE SPECIFICATION
	P_D	Q_D	P_G	Q_G	V
1	2.0	1.0	Unspecified	Unspecified	$1.04 + j 0.0$
2	0.0	0.0	0.5	1.0	Unspecified
3	1.5	0.6	0.0	$Q_{G3}=?$	1.04

Controllable reactive power source is available at bus 3 with constraint $0 \leq Q_{G3} \leq 1.5$ p.u

Using the Newton Raphson method, determine the load flow solution of the power network.

(10 marks)

Fig Q 2(b)



QUESTION THREE (20 MARKS)

- a) A 100MVA, two pole, 50HZ generator has a moment inertia of $40 \times 10^3 \text{ kg/m}^3$. Determine:
 - (i) Energy stored in the rotor at the rated speed
 - (ii) The corresponding angular momentum
 - (iii) Inertia constant

(10 marks)
- b) Determine the maximum steady state power capability of a system consisting of a generator equivalent reactance of 0.4 p.u connected to infinite bus through a series reactance of 1.0 p.u. the terminal voltage of the generator is held at 1.10 p.u and the voltage of the infinite bus is 1.0 p.u.

(10 marks)

QUESTION FOUR (20 MARKS)

- a) Incremental fuel cost in shs/Mwhr of a power plant consisting of two generating units are:

$$\frac{dc_1}{dP_{g1}} = 0.18P_{g1} + 41$$

$$\frac{dc_2}{dP_{g2}} = 0.36P_{g1} + 32$$

The generator limits are:

$$32\text{Mw} \leq P_{g1} \leq 180\text{Mw}$$

$$22\text{Mw} \leq P_{g2} \leq 130\text{Mw}$$

Determine the P_{g1} , P_{g2} and λ for the variation of the load from 54Mw to 310 Mw.

Assume that both generators are operating at all times. (14 marks)

- b) With an aid of waveforms show that the average power absorbed in a purely inductive circuit is zero. (6 marks)

QUESTION FIVE (20 MARKS)

- a) A motor receives 25% of the power that its supposed to receive from an infinite bus. If the load on the motor is doubled, determine the maximum value of the power angle δ during the swinging of the rotor around its new equilibrium. (12 marks)
- b) A single phase source delivers 100kw to a load operating at a power factor of 0.8 lagging. Determine the reactive power to be delivered by a capacitor connected in parallel with the load in order to raise the source power factor to 0.95 lagging. (8 marks)