TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Chaitra

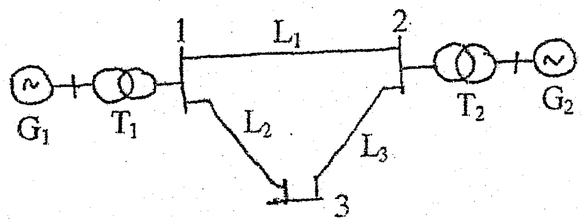
Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Power System Analysis II *(EE 605)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Assume suitable data if necessary.*

1. a) What are the consequences of mismatch between real and reactive power generation and demand in a power system? [4]

   b) Form the Y_{bus} matrix for the following network. All impedance values are in per unit system. [4]



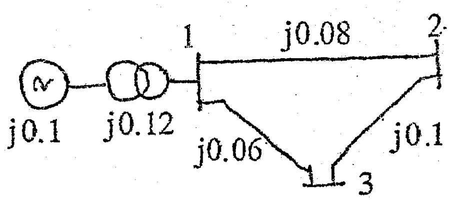
	Component						
	G_1	G_2	T_1	T_2	L_1	L_2	L_3
Z, pu	j0.1	j0.12	j0.1	j0.12	0.03+j0.08	0.02+j0.05	0.025+j0.06

   c) A 3-phase unbalanced source with voltage given by $V_{abc} = [200 < 25° \ 100 < -155° \ 80 < 100°]^T$ V is feeding a 3-phase star connected load with series impedance per phase of $Z_s = 8 + j24$ Ohms and load neutral impedance of $Z_n = j1.5$ Ohms. Determine the: [8]

   (i) Symmetrical components of voltage
   (ii) Symmetrical components of currents

2. a) How do the symmetrical components help us in analyzing unbalance electric power system? Explain briefly. [4]

   b) In the network given below, compute the short circuit MVA for a fault at bus 2. [6]

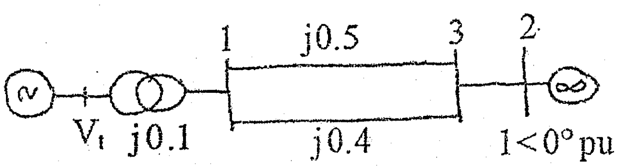


$S_{base} = 100$ MVA

   c) What is synchronizing power coefficient? Where it finds application? [6]

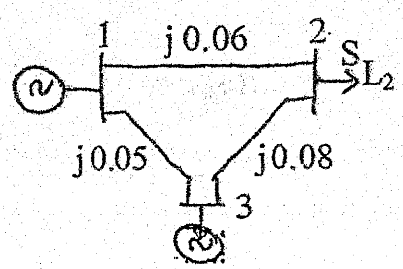
3. a) Derive the swing equation of rotor of a synchronous machine. [6]

   b) In the power system network shown below, find the rotor angle before occurrence of fault at bus 3 when the rotor was running at synchronous speed when the mechanical input to the generator is 1 p.u. Also compute the critical clearing angle. [10]



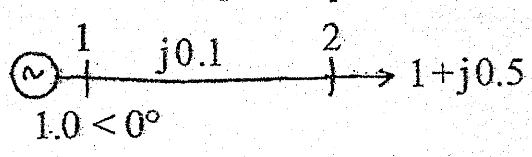
$|V_t| = 1.08$ pu
$X_d' = 0.2$ pu

4. a) For the network given below, compute the bus voltage magnitude and phase angles for 1 iterations by Gauss-Seidal method taking initial voltage magnitude estimates of 1.0 pu and phase angle estimates of for the required buses. [8]



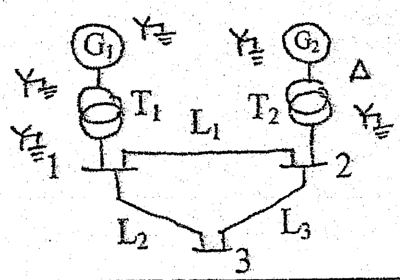
$V_1 = 1.05 < 0°$ pu
$|V_3| = 1.03$ pu
$Pg_3 = 2$ pu
$SL_2 = 3 + j\ 1.5$ pu

b) For the system given below, find the initial power mismatch matrix and initial Jacobian matrix. Take a flat start of $V_2^{(0)} = 1.0$ pu and $\delta_2^{(0)} = 0^0$. [8]



5. a) For a Double Line to Ground fault in an unloaded generator, show that the positive sequence network is connected series with the parallel connection of negative sequence and zero sequence networks. [6]

b) Compute the sequence currents for a LLG fault at bus 3 of the following network. The fault impedance is j 0.1 pu. All the parameters are in pu. [10]



Item	Base MVA	X_1	X_2	X_0
G_1	100	0.15	0.15	0.05
G_2	"	0.15	0.15	0.05
T_1	"	0.1	0.1	0.1
T_2	"	0.1	0.1	0.1
L_1	"	0.12	0.12	0.3
L_2	"	0.15	0.15	0.35
L_3	"	0.25	0.25	0.71

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Subject: - Power System Analysis II *(EE 605)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
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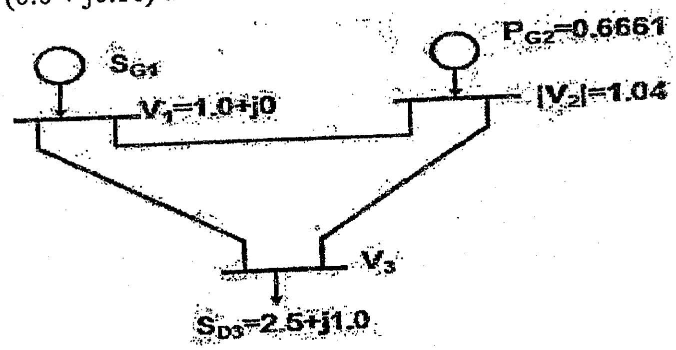
1. Clarify the concept of real power with frequency and reactive power with voltage in power system network. [8]
2. What are the approximations in fast decoupled method? How does this method imporve the computational efficiency than the NR method in power flow problem? Write an algorithm for this method. [2+2+4]
3. Define Sequence impedances. For the star connected load show that impedance matrix has non-zero elements on its diagonal matrix. [8]
4. The bus 1 is assumed as slack bus for the 3-bus system shown below. Find $|V_3|$, θ_3, and Q_{G2}. The transmission line is represented as nominal π equivalent network with series impedance of $z_L=(0.0 + j0.10)$ and half line charging admittance $y_c=j0.02$. [8]



5. Show that the sequence component are decoupled for complex power flow in a power system. [8]
6. Prove that the symmetrical component transformation is power invariant. Discuss also the significance of zero sequence circuit. [6+2]
7. Two alternators are operating in parallel and supplying a synchronous motor which is receiving 60MW power at 0.8 pf(lag) at 6kV. Single line diagram for the system and its data are given below. Compute the fault current when a single line to ground fault occurs at the middle of the line through a fault resistance of 4.033 ohm. [10]

   Data:

   G_1 & G_2 : 11 kV, 100MVA, $x_{g1}=0.20$ pu, $x_{g2}=x_{g0}=0.10$ pu

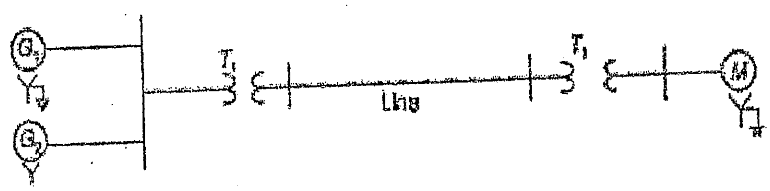
   T_1: 180MVA, 11.5/115KV, $x_{T1}=0.10$ pu

   T_2: 170 MVA, 6.6/115 KV, $x_{T2}=0.10$ pu

   M: 6.3 KV, 160 MVA, $x_{M1} = x_{M2} = 0.30$ pu, $x_{M0}=0.10$ pu

   Line:

   $x_{LINE1}= x_{LINE2}=30.25$ ohm, $x_{LINE0}=60.5$ ohm



8. Obtain the sequence network for double line to fault at alternator terminal with zero fault impedance. [6]

9. Find the maximum steady state power capability of a system consisting of a generator equivalent reactance of 0.4 pu connected to an infinite bus through a series reactance of 1.0 pu. The terminal voltage of the generator is held at 1.1 pu and the voltage of the infinite bus is 1.0 pu. [8]

10. How power system stability is classified? Derive the swing equation for the rotor angle of the synchronous machine. [8]

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- ✓ Candidates are required to give their answers in their own words as far as practicable.
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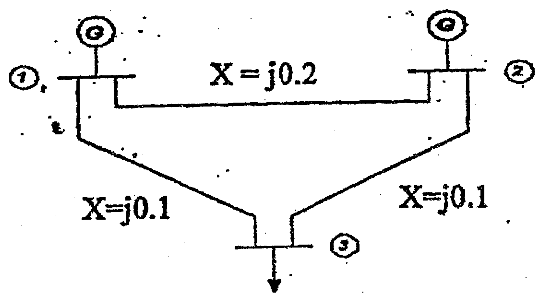
1. Explain bus classification in power flow analysis with their known and unknown quantities and hence formulate the bus admittance matrix for four bus system. [8]

2. A synchronous generator and motor are rated 30MVA, 13.2kV and both have subtransient reactances of 20%. The line connecting them has reactance of 8% on the base of the machine ratings. The motor is drawing 20MW at 0.8 pf leading and terminal voltage of 12.8 kV when a symmetrical three phase fault occurs at the motor terminals. Find the subtransient currents in the fault occurs at the motor terminals. Find the subtransient currents in the generator, the motor and fault by using the internal voltages of machines. [8]

3. For the system in figure below, perform the load flow analysis for the first iteration by G-S method. [8]

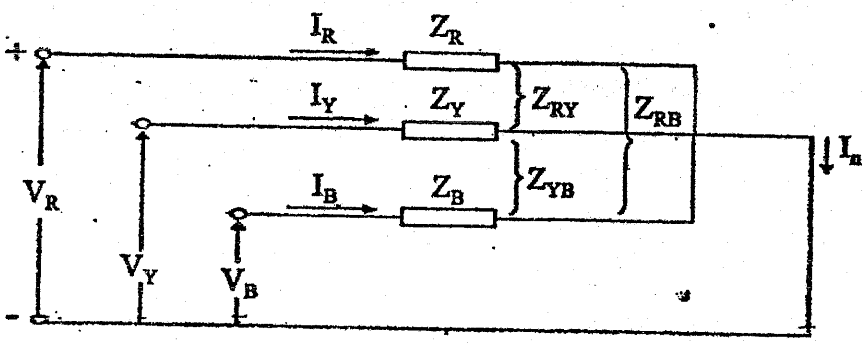
Bus No.	Voltage	Generator		Load	
		P	Q	P	Q
1	1.03 < 0° pu	-	-	-	-
2	1.01 pu	0.3 pu	-	-	-
3	-	-	-	0.4 pu	0.2 pu



4. Consider a three bus system of figure, each of the three lines has a series impedance of (0+j0.08) pu. The specified quantities at the buses are tabulated below. Perform single iteration of load flow using N-R method. (Note: Reactive power limit is $0 \le Q_{G2} \le 1.5$ pu) [8]

Bus	Demand		Generator		Voltage
	Real Power	Reactive Power	Real Power	Reactive Power	
1	-	-	-	-	1<0° pu
2	0	0	0.5 pu	-	1.02 pu
3	1.5 pu	0.6 pu	-	-	-

5. A three phase balanced Y-connected load with self and mutual elements is shown in figure below. The load neutral is grounded with Z_n=0.0. Determine the sequence impedance. [6]



6. Starting from a suitable point show that a 3-phase unbalanced system of voltages can be represented by a symmetrical components. [6]

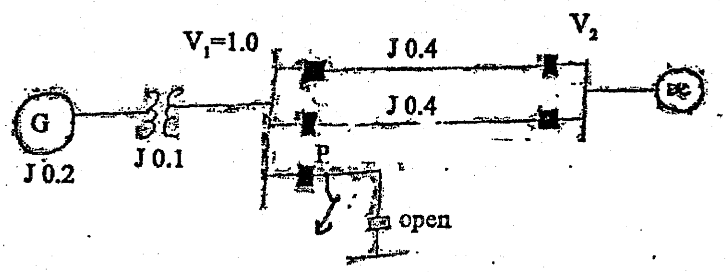
7. How do you represent 3-phase power of an unbalanced system in terms of symmetrical components of voltages and currents? [4]

8. A single line to ground fault occur at generator terminal of 20 MVA, 13.8 KV and having Z_1=j0.20 pu, Z_2=j0.3 pu. Find the fault current and line to line voltage under fault condition. [8]

9. Starting form suitable point, show that during a double line fault in a transmission line, zero sequence component is absent in the fault current. [8]

10. Derive an expression for the swing equation of a synchronous machine. Signify the importance of inertia constant in the machine. [6+2]

11. Calculate the critical clearing time and critical time and critical angle if the fault is at point P for the network having inertia 5 MJ/MVA shown below. The machine is delivering 1.0 pu and both the terminal voltage and the infinite bus voltage are 1.0 pu. [8]



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Exam.	Regular		
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Year / Part	III / I	Time	3 hrs.

Subject: - Power System Analysis II *(EE605)*

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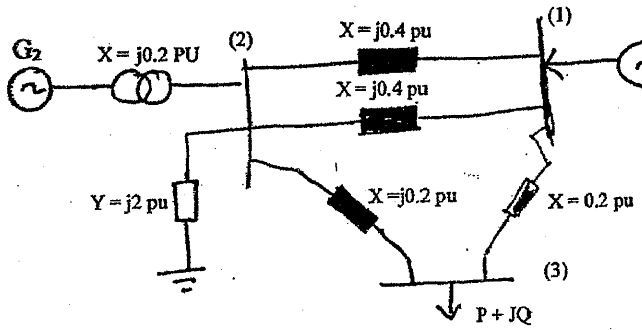
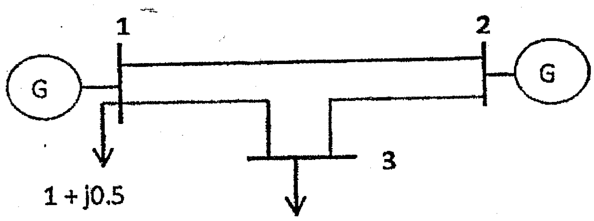
1. a) Compute Y-bus matrix for the following power system network shown in figure below and list out the type of buses used in the network. [8]



b) List out the advantages of interconnected power system over isolated power system. [4]

2. a) A three bus power system network is shown in figure below. The series reactance of each line is 0.1 per unit. Line resistances and shunt admittances are negligible. The bus specification and power input, etc, at the buses is as under:



Bus No.	P_{Gen}	Q_{Gen}	P_{Load}	Q_{Load}	Bus Voltage	Bus Type
1	?	?	1	0.5	1.03+j0	Slack
2	1.5	?	0	0	1.04	PV
3	0	0	1.2	0.5	?	PQ

(i) Form [Y_{bus}]
(ii) Find the mismatch matrix [M°] and Jacobian Matrix [J°]
(iii) Perform 1st iteration of load flow Analysis by Newton-Raphson method and calculate the above unknown quantities. [12]

b) In what respect Fast Decoupled Load Flow Method is different from the Newton-Raphson method? Describe the assumptions to be made for FDLF method. [4]

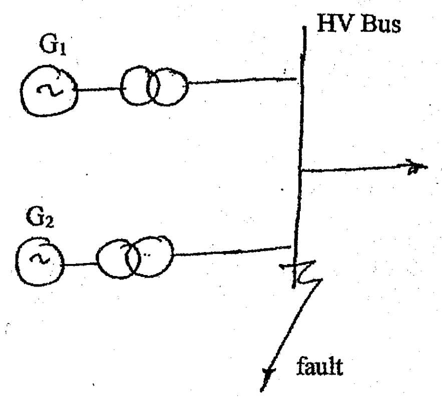
3. a) Figure below shows a three-phase power system.

(i) Calculate the short circuit MVA and the fault current when a 3-phase balanced short-circuit fault occurs at the High Voltage (HV) bus.

(ii) Calculate the ohmic value of reactor 'X' to be placed on the secondary side of transformer 'T_2' to limit the Fault Level to by 25%.

Assume the system data as under: [14]

Generators:	**Transformers:**
G_1: 20 MVA, 11 kV, X_{G1} = 50%	T_1: 20 MVA, 11/132 kV, X_{T1} = 5%
G_2: 30 MVA, 11 kV, X_{G2} = 50%	T_2: 30 MVA, 11/132 kV, X_{T2} = 5%

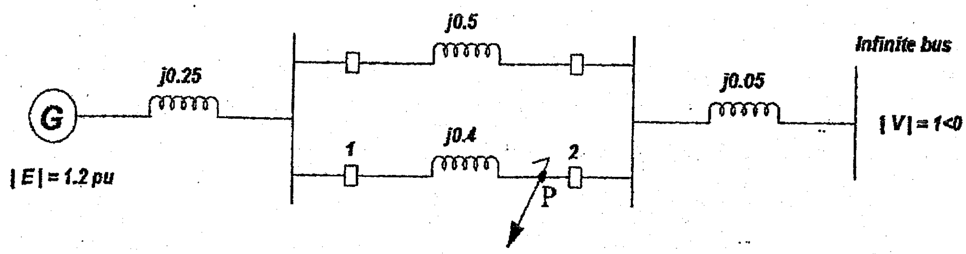


b) Describe the effects of short circuit faults on power system. Also, explain the importance of fault calculations. [4]

4. a) A double line to ground fault occur at generator terminal of 30 Mva, 11 Kv and having ZI = Z2 = j0.2 pu and Z0 = j0.05 pu. Find the line currents, fault current and line to neutral voltages under fault condition. [9]

b) Explain with necessary mathematical expressions and diagram how fault current is calculated when a line to line fault occurs in a three phase power system network. [9]

5. a) A three phase fault is applied at the point P as shown in below figure. Find the critical clearing angle for clearing the fault with simultaneous opening of the breakers 1 and 2. The reactance values of various components are indicated in the diagram. The generator is delivering 1.0 pu power at the instant preceding the fault. [10]



b) Describe the various method for improving transient stability of a power system. [6]

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1\. a) Describe the merits of interconnected power system over an isolated system. [4]

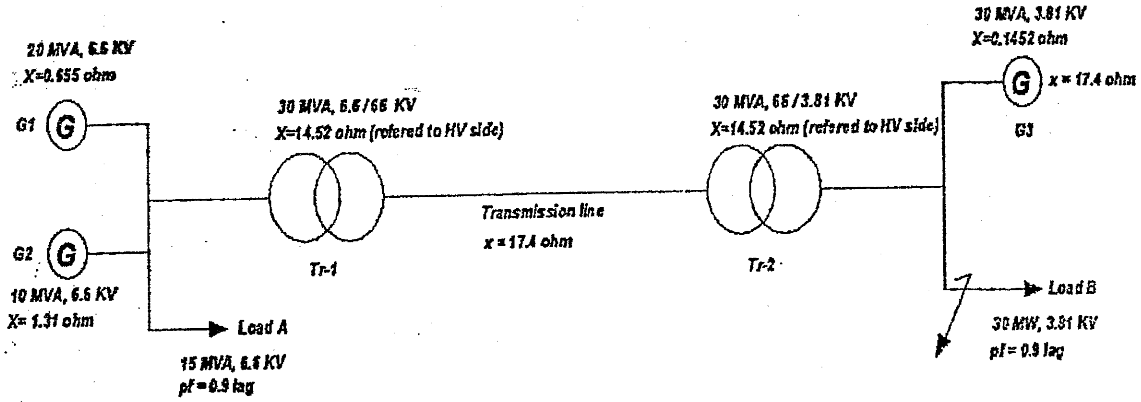
b) Explain the steps of forming Bus Admittance (Y_{BUS}) with an example of a 3-bus power system network. [8]

2\. a) Perform the two iterations of gauss-seidal load flow analysis for the data table given below to find the unknown variables of the busses after first iteration. Line impedance of each line is (0.026 + j0.11) pu. [12]

Bus no	PG	QG	PL	QL	Bus voltage	Type	Configuration
1	?	?	1.0	0.5	1.03 < 0	Slack	1-2
2	1.5	?	0.5	0	1.03	PV	2-3
3	0.0	0	1.2	0.5	?	PQ	3-1

b) Make a comparison between G-S method and N-R method of load flow analysis. [4]

3\. a) Calculate short circuit MVA and short circuit current when three phase fault occur at load B of the following single line diagram. [10]



b) A 25 MVA, 13.2 kv alternator with solidly grounded neutral had a sub-transient reactance of 0.25 pu. The negative and zero sequence reactances are 0.35 and 0.1 pu respectively. A line to line fault occurs at the terminals of an alternator. Determine the line to line voltages under fault conditions. Neglect resistance. [8]

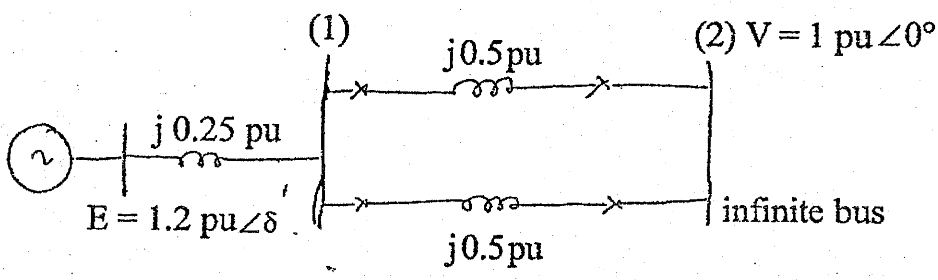
4. a) Derive the relationship to determine the fault current for a line-to-line fault on a power system. Draw a diagram showing interconnection of sequence networks for this type of fault. [6]

b) Three 6.6 kV, 3-phase, 10 MVA alternators are connected to a common bus. Each alternator has a positive sequence reactance of 0.15 pu. The negative and zero sequence reactances are 75% and 30% of positive sequence reactance. A single line-to-ground fault occurs on the bus. Find the fault current for the following cases:

(i) All the alternator neutrals are solidly grounded.
(ii) One alternator neutral is grounded through 0.3 ohm resistance and the other two neutrals are isolated. [12]

5. a) Discuss the difference between the transient stability, steady state stability and dynamic stability in power system. Also, explain the factors affecting transient stability of the system. [6]

b) The power system shown below is operating initially at power angle $\delta = 20°$. Calculate the power delivered to the infinite bus at normal operation. [10]



If a 3-phase to ground fault occurs at bus (1) and fault is cleared when the power angle δ reaches 45°. Determine, whether system come back to stable or not? If yes, calculate the maximum δ-swing angle.

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Year / Part	III / I	Time	3 hrs.

130

Subject: - Power System Analysis II *(EE605)*

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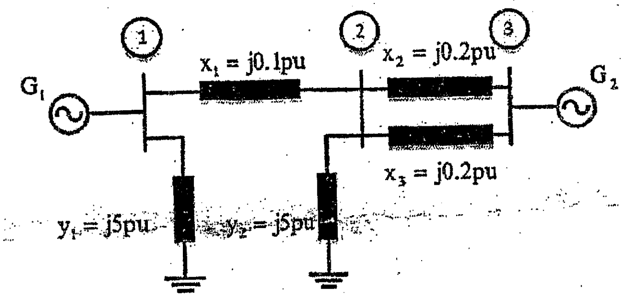
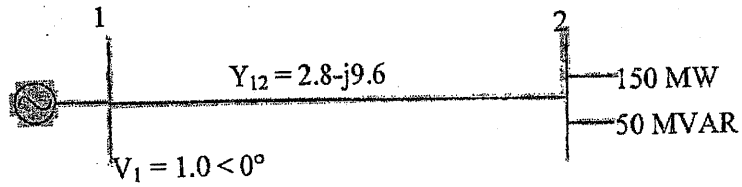
1. a) Compute Y-bus matrix for the following power system network shown in figure below. [8]



b) Explain how the mismatch in active power affects the system frequency and mismatch in reactive power affects the voltage magnitude in an-interconnected power system. [8]

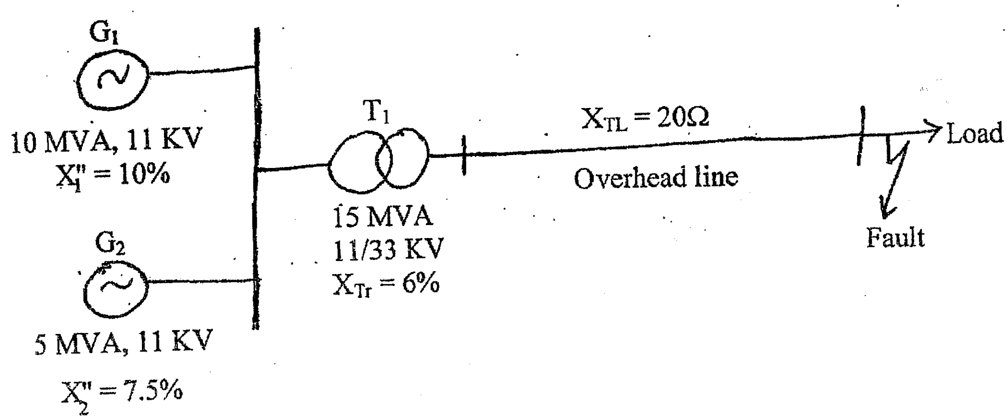
2. a) In the power system network shown in figure below, bus 1 is slack bus with $V_1 = 1.0\angle 0^0$ pu and bus 2 is a load bus with $S_2 = 150\text{ MW} + j50\text{ MVAR}$. The line admittance is $y_{12} = 10\angle -73.74^0$ pu on a base of 100 MVA. Perform two iterations of Newton Raphson load flow method to obtain the following: [10]

   i) Voltage magnitude and phase angle of bus 2
   ii) Real and reactive power supplied by slack bus and network losses



b) Describe about the assumptions to be made for decoupled load flow method, and hence derive the required equations. [6]

3. a) Figure below shows a three-phase system. Calculate the short circuit MVA and he fault current when 3-phase balanced short-circuit fault occurs at the load end of the transmission line. Also, determine the fault current supplied by each generator. [10]



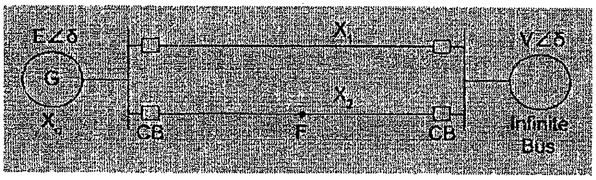
b) Derive an expression of 3-phase complex power in terms of symmetrical components of voltages and currents. [6]

4. a) Starting from suitable point, show that the three sequence networks are connected in series during a single line to ground fault in 3 phase power system network. [8]

b) A 30 MVA, 11kV generator has $Z_1 = Z_2 = j0.2\,pu, Z_0 = j0.05\,pu$. A line to line fault occurs on the generator terminals. Find the line currents, fault currents and line to neutral voltage under fault conditions. [8]

5. a) Describe about the concept of Equal Area Criterion in determining the stability of synchronous machines. [8]

b) A balanced 3-phase fault occurs at the middle point of line 2 when power transfer is 1.5 pu in the system shown in the figure below: [8]



Given: $E = 1.2, V = 1, X'_d = 0.2, X_1 = X_2 = 0.4$ pu

i) Determine whether the system is stable for a sustained fault.

ii) The fault is cleared at $\delta = 60°$. Is the system stable? If so find the maximum rotor swing

iii) Find the critical clearing angle.

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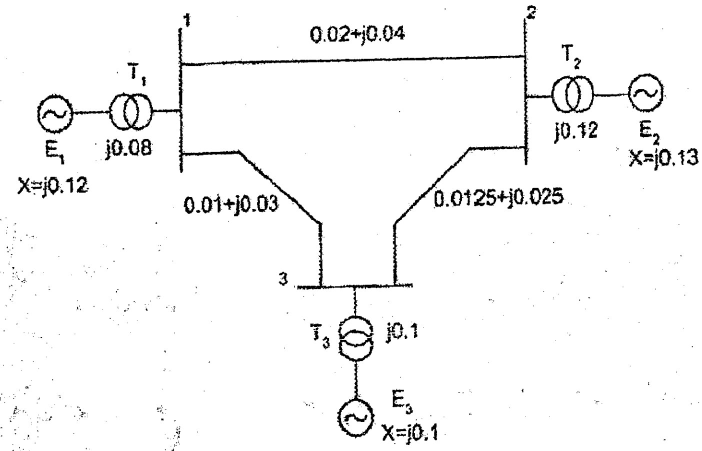
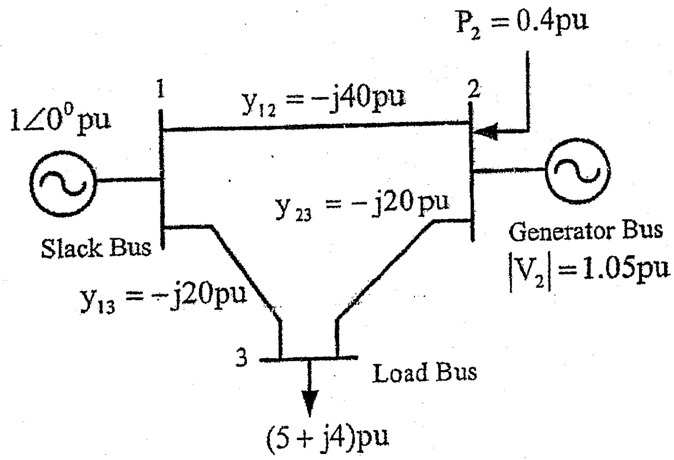
1. a) Describe about the importance of interconnection in power system. Explain briefly about the real power – frequency balance and reactive power – voltage balance in power system. [?]

   b) ... figure below, obtain node equations and then form bus ... impedances are marked in pu. [8]



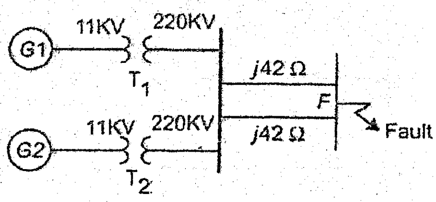
2. a) Figure below shows the single line diagram of 3 bus power system network. Determine the jacobian matrix, and perform load flow by N-R method up to one iteration. [8]



   b) Suppose you are given a 3-bus power system network with one reference bus, one load bus and one generator bus with reactive power limits and asked to perform the load flow analysis to determine the unknown variables and total losses in the network using Gauss-Siedal method. How will you proceed? Explain step wise and mention mathematical expressions where it is relevant. [8]

3. a) Figure below shows a generating station feeding a 220 kV system. Determine the total fault current, fault level and fault current supplied by each generator for a three phase fault at the receiving end of the line. [10]

G_1: 11 kV, 100 MVA, $X''_{g1} = j0.15$
G_2: 11 kV, 75 MVA, $X''_{g2} = j0.125$
T_1: 100 MVA, $X_{T1} = j0.10$, 11/220 kV
T_2: 75 MVA, $X_{T2} = j0.08$, 11/220 kV



b) The phase voltages across a certain load are given as: [6]

$$V_a = (176 - j132)\text{Volts}$$
$$V_b = (-128 - j96)\text{Volts}$$
$$V_c = (-160 + j100)\text{Volts}$$

Compute positive, negative and zero sequence component voltages.

4. a) Explain with necessary mathematical expressions and diagrams how fault current and bus voltages are calculated when a line-to-line fault occurs in a 3-phase power system network. [8]

b) A 30 MVA, 13.2 kV synchronous generator has a solidly grounded neutral. Its positive, negative and zero sequence impedances are 0.30, 0.40 and 0.05 pu respectively. Determine the following: [8]

i) The value of reactance that must be placed in the generator neutral so that the fault current for a line-to-ground fault of zero fault impedance shall not exceed the rated line current.

ii) The value of resistance to be placed in the neutral that will serve the same purpose.

5. a) Derive swing equation of a synchronous machine to be applicable in the study of power system stability. What is meant by swing curve? What information is supplied by the swing curve? [8]

b) A generator is delivering 0.9 pu to an infinite bus through a purely reactive transmission line. Maximum power that could be delivered is 1.5 pu. A fault occurs such that maximum electrical power output reduces to 0.5 pu. When the fault is cleared, the maximum power that can be delivered is 1.2 pu. Determine the critical clearing angle using equal area criterion. [8]

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25 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2072 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Power System Analysis II *(EE605)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ *Assume suitable data if necessary.*

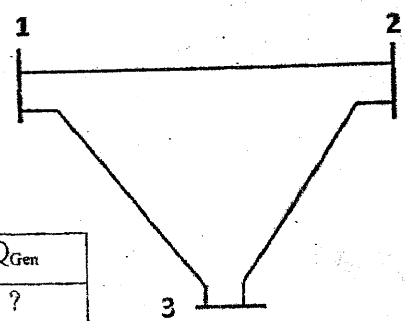
1. a) List out the advantages of interconnected power system over isolated power system. Explain how real power and frequency balance is maintained in an interconnected power system. [6]

   b) With the help of suitable 3-Bus Power System Network, deduce the expression for Y-Bus Matrix elements. Also discuss how the consideration of line shunt parameter affects the Y-Bus Matrix elements. [8]

2. a) Taking suitable power system network, develop the algorithm for Gauss-Siedel technique for load analysis considering all three types of buses and generator reactive power limitation into account. [8]

   b) A three bus power system network in figure below. The bus admittance matrix (Y_{Bus}) of the system in per unit is; [8]

$$Y_{Bus} = \begin{bmatrix} 4-j12 & -2+j6 & -2+j6 \\ -2+j6 & 4-j12 & -2+j6 \\ -2+j6 & -2+j6 & 4-j12 \end{bmatrix}$$

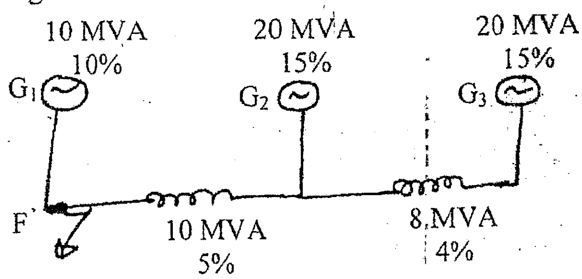


The power and bus voltages in per unit are as follows;

Bus No.	P_{Load}	Q_{Load}	P_{Gen}	Q_{Gen}
1	0	0	?	?
2	0.7	0.5	0	0
3	0.6	0.3	0	0

The load flow analysis results are: $V_1 = 1\angle 0^0$; $V_2 = 0.9\angle -10^0$, $V_3 = 0.95\angle -5^0$. Compute the network real and reactive power losses.

3. a) An interconnected generator reactor system has been shown in figure below. The base values for the given % reactance are the rating of individual pieces of equipments. Determine the fault current and fault MVA for a 3-phase short circuit fault at F. Assume bus bar voltage as 11 kV. [10]

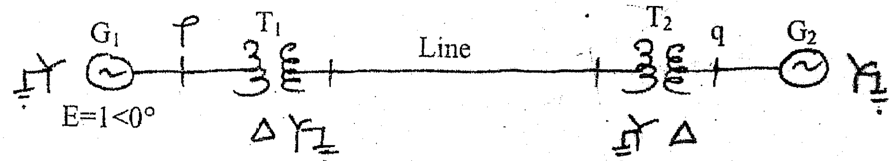


   b) Justify that in a delta connected system the zero sequence component of line currents are always zero. [6]

4. Calculate the fault currents in each phase for the system shown in figure below if (i) L-G (ii) L-L (iii) L-L-G fault occurs at (q) bus. Neglect the fault impedances. [16]

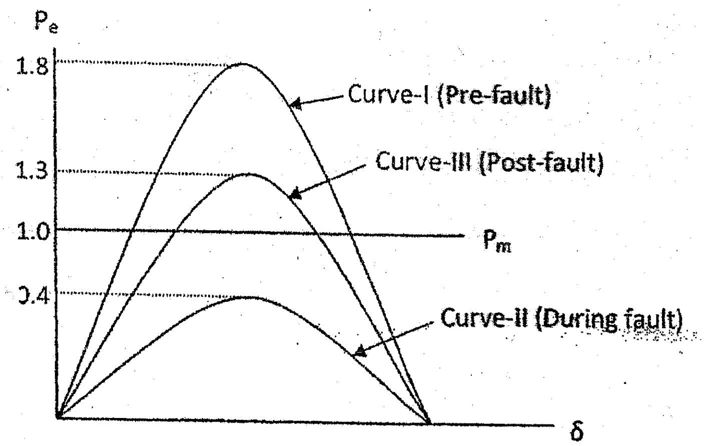
Data for equipments are (in p.u.):

G_1: $X_d'' = j0.16, X_2 = j0.17, X_1 = j0.06$	G_2: $X_d'' = j0.2, X_2 = j0.22, X_1 = j0.15$
T_1: $X_1 = X_2 = X_0 = j0.1$	T_2: $X_1 = X_2 = X_0 = j0.1$
Line: $X_1 = X_2 = j0.11$, $X_0 = j0.33$	



5. a) Discuss the transient stability enhancement Techniques in a power system. [6]

b) A generator is operating at rated voltage and is connected to infinite bus at 50 Hz with power transfer of 1.0 pu. A three-phase fault occurs and it is cleared after some time. Power angle (P_e-δ) curves for the pre-fault condition, during fault and after the fault is cleared is shown in figure below. Use equal area criterion to check whether the system is stable or not. If the system is stable, determine critical clearing angle. [12]



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26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Shrawan

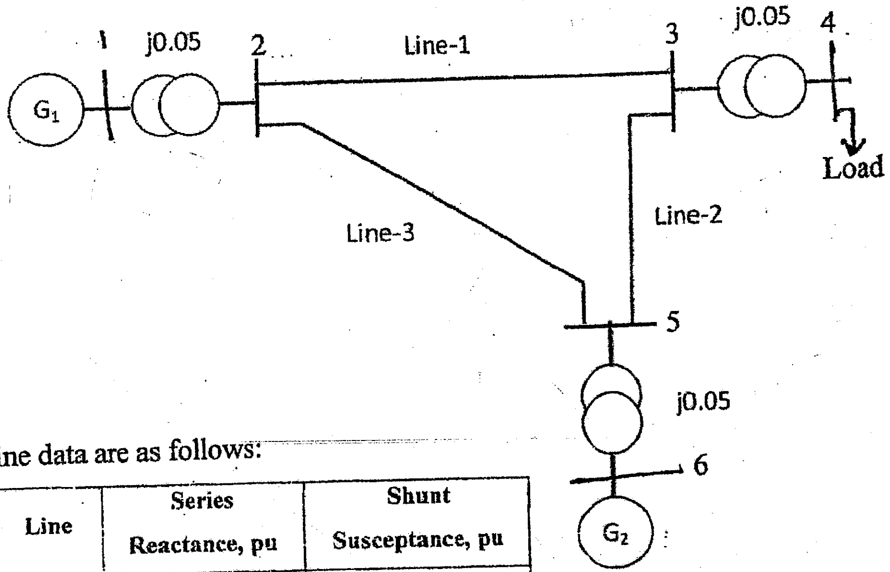
Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Power System Analysis II *(EE605)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) For a synchronous generator connected to infinite bus, discuss how the generator can supply or consume variable reactive power keeping its terminal voltage constant. [6]

   b) Obtain node equations and compute bus admittance matrix (Y_{Bus}) of the network shown in figure below. All voltages and impedances are marked in pu. [6]



Line data are as follows:

Line	Series Reactance, pu	Shunt Susceptance, pu
Line-1	0.40	0.02
Line-2	0.20	0.00
Line-3	0.40	0.02

2. a) Starting from Y-Bus, Bus voltage and injected current relationship deduce the basic load flow equations. [4]

   b) Classify and distinguish different buses used in load flow analysis. Mention the specified and variable to be obtained from load flow. [4]

   c) For the 2-bus power system, bus -1 is slack bus with $V_1 = 1.0 < 0°$. A load of 100 MW and 50 MVar is taken from bus-2. The line impedance is 0.12+j0.16 p.u on a base of 100 MVA. Using Newton Raphson load flow technique, determine the following after 2nd iteration. [10]

      i) Voltage magnitude and phase angle in degree of bus -2.
      ii) Real and reactive power supplied by slack bus and network losses.

3. a) Deduce the sequence networks for balanced Y connected load with neutral grounded through impedance Z_n and show also that current through neutral impedance is three times the zero sequence current. [8]

   b) For an unloaded 3-phase, ABC phase sequence, synchronous generator, starting from the boundary condition draw and justify the interconnection of sequence networks if a L-G fault occurs in phase B. [8]

4. a) A 3-phase generator rated 15 MVA, 13.2 kV has a solidly grounded neutral. Its positive, negative and zero sequence reactance are 40%, 30% and 5% respectively. [6]

   i) Find the value of reactance to be connected in neutral circuit so that fault current for a single line to ground fault (of negligible fault impedance) at No-load does not exceed line current.

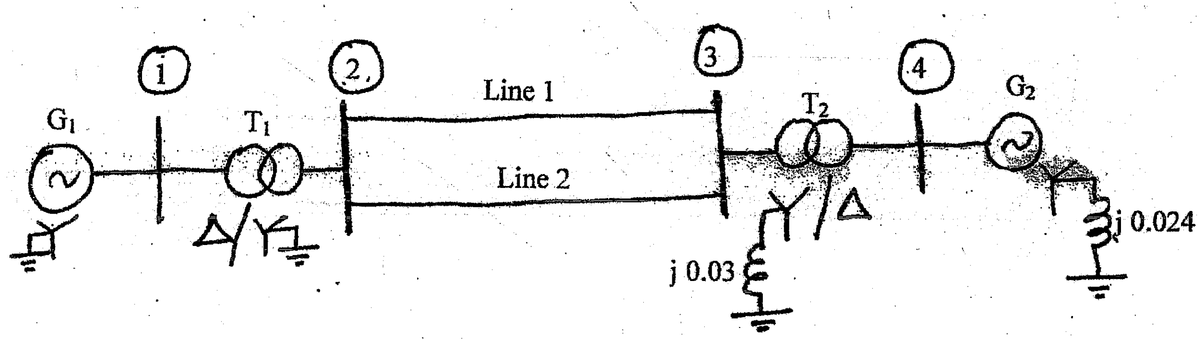
b) Figure below shows the power system network. [10]

   i) Draw positive, negative and zero sequence networks
   ii) Determine fault current in kA if line to line fault occurs at Bus 3.

System Data:

Equipment	MVA rating	Voltage rating	X_1 pu	X_2 pu	X_0 pu
Generator, G_1	50	11 kV	0.2	0.2	0.05
Generator, G_2	50	11 kV	0.15	0.15	0.03
Transformer, T_1	50	11/220 kV	0.1	0.1	0.1
Transformer, T_2	50	11/220 kV	0.075	0.075	0.075
Line-1	50	220 kV	0.12	0.12	0.42
Line-2	50	220 kV	0.12	0.12	0.42

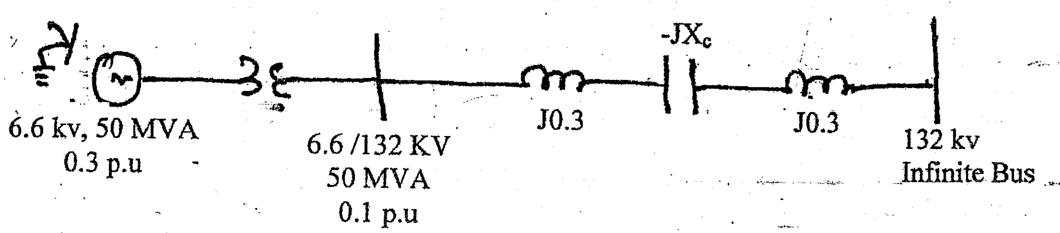
The pre-fault voltage at Bus -3 is 0.95 p.u at common base of G_1.



5. a) What do you mean by rotor angle? Derive the swing equation for a single synchronous generator connected to infinite bus. [6]

b) Explain the Equal area criterion to study the transient stability of single machine system connected to infinite bus with proper mathematical aids and diagram. [6]

c) For a synchronous generator connected to infinite bus as shown in figure below. Compute the value of series capacitor so that the power angle at steady state could be limited to 30° for generator supplying power of 1 p.u. [6]



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25 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Power System Analysis II *(EE605)*

145

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ *Assume suitable data if necessary.*

1.a) For a 3-bus network, the bus admittance matrix is given as follows (5)

$$Y_{bus} = \begin{bmatrix} -j30 & j12 & j18 \\ j12 & -j25 & j13 \\ j18 & j13 & -j31 \end{bmatrix}$$ pu, determine the respective branch impedances.

b) What will be the impact of mismatch in active and reactive power balance in an interconnected power system? Briefly describe the mechanism, which leads to this phenomenon. (5)

2. a) What do you mean by load flow studies and list down their applications in electric power system. (3)

b) What is the basis for development of decoupled load flow method and what are the advantages gained from decoupling? (3)

c) The following bus and line data are available for a power system, determine the line flows by Gauss Seidel method using voltages obtained after 1 iteration. Consider flat voltage start for all the load buses. (10)

Bus data:

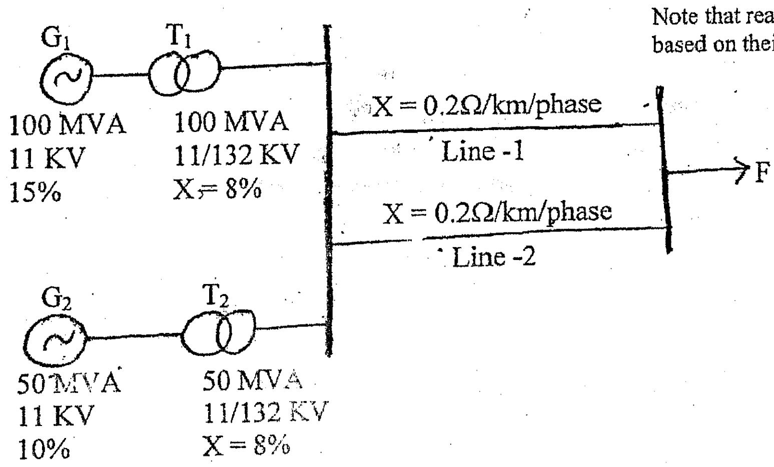
Bus No	P_G, pu	Q_G, pu	P_L, pu	Q_L, pu	|V|, pu	δ, degree
1	-	-	-	-	1.02	0
2	-	-	0.8	0.4	-	-
3	-	-	1.0	0.6	-	-

Line data:

Line	Series admittance, pu
1-2	0.01+j0.05
2-3	0.007+j0.037
3-1	0.012+j0.064

3. Figure below shows power system fed by two generators. The rating and reactances of the equipments are shown. A 3-phase balanced short circuit fault occurs at the receiving end bus of 132 kV. Find (a) Fault level and fault current at receving end (b) Fault current supplied by generators G_1 and G_2. (8)

Note that reactance of machines are based on their own rating.



4.a)A 3-phase supply system has following voltages $V_A=220<120^0V$, $V_B=120<30^0$ V and $V_C=240<210^0V$ and the currents are $I_A=10<150^0A$, $I_B=5<0^0A$ and $I_C=15<180^0A$. Determine sequence currents, voltages and powers. (5)

b) How do the different vector groups of transformer affect the fault current in the power system network? (5)

5 .a) In a power system network shown in figure below, single line to ground (SLG) fault occurs at bus β. (10)

i. Draw the positive, negative and zero sequence networks;

ii. Determine phase currents in per units and amperes;

iii. Phase voltages in per units and kilovolts.

Specifications of the equipments are as under:

G_1: 100 MVA, 13.8 kV, $X_1=X_2=15\%$ and $X_0=5\%$

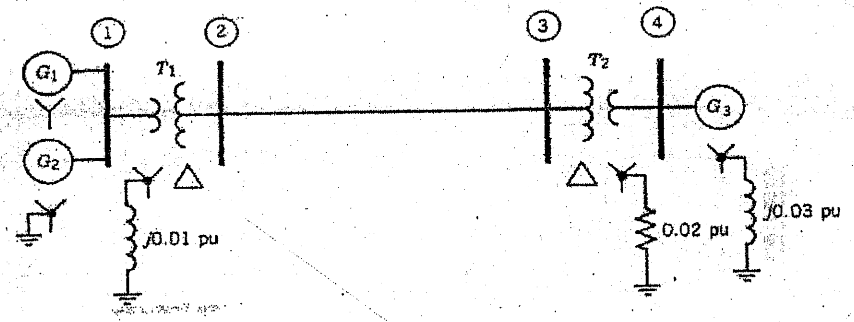
G_2: 100 MVA, 13.8 kV, $X_1=X_2=15\%$ and $X_0=5\%$

G_3: 100 MVA, 13.8 kV, $X_1=X_2=15\%$ and $X_0=5\%$

T_1: 100 MVA, 13.8/115 kV, $X_1=X_2=X_0=20\%$

T_2: 100 MVA, 115/13.8 kV, $X_1=X_2=X_0=18\%$

Line: 100 MVA, 115 kV, $X_1=X_2=30\%$ and $X_0=90\%$



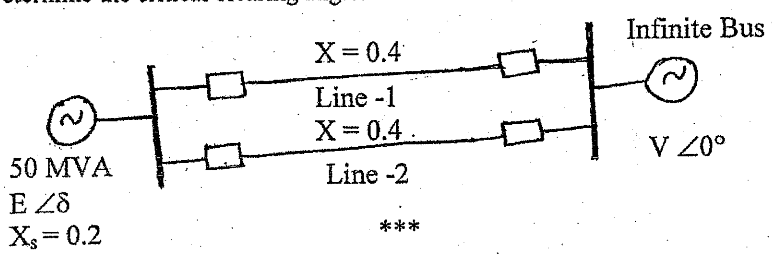
b) Show that positive and negative sequence currents are equal in magnitude but out of phase by 180° in a line to line fault on a power system network. Draw a diagram showing inter-connection of sequence networks for this type of fault. (6)

6.a) What do you mean by steady state and transient stability and their limits in a power system? Describe the factors affecting the transient stability of a power system. (8)

b) For the system shown in figure, the numerical values for different quantities are: E=1.04 pu, V= 1 pu, X_S= 0.2 pu, and reactances of each line is 0.4 pu. The generator is delivering a power of 1.2 pu to the infinite bus. If a 3-phase short circuit fault occurs at the mid point of one the transmission lines, perform the following: (12)

a) If the fault is cleared (swithing out of the faulted line) when power angle is 60^0, check whether the stable or not;

b) Determine the critical clearing angle.



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25 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Kartik

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Power System Analysis II *(EE605)*

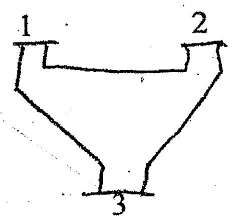
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain how reactive power and voltage balance is maintained in a power system. [5]

   b) What is a bus admittance matrix? Define its elements. [5]

2. a) What do you mean by decoupled load flow equations? List the assumptions to be made in Fast Decoupled load flow method. [6]

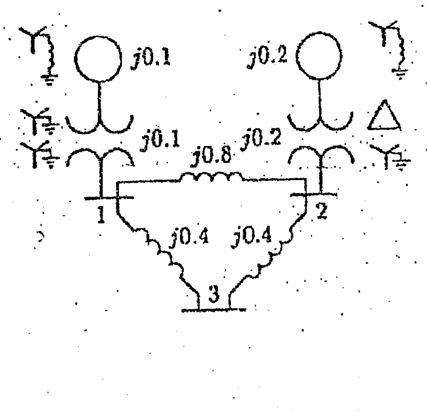
   b) In a 3-bus power system the series impedance and shunt admittance of each line are (0.015+j0.12) p.u. and (j0.02) p.u. respectively. Form Y bus and compute the magnitude and phase angles of voltage at bus 2 and 3 after 2[nd] iteration using G-S method. The data given below are in p.u. [10]



Bus	P_G	Q_G	P_U	Q_U	Bus voltage
1	-	-	-	-	$1.03\angle 0°$
2	1.5	-	0	0	1.03
3	0	-	1.2	0.5	-

3. a) What is the purpose of fault analysis in electric power system? What types of fault occur in a power system network? [4]

   b) A 3-phase symmetrical fault occurs at bus 3 in the given power system network. Determine the fault current. Per unit values of reactance are based on 100MVA base. [4]



4. a) Derive the expression to calculate symmetrical components of 3-phase un-balance currents. [5]

b) A 3 phase system has following voltage and currents: [5]

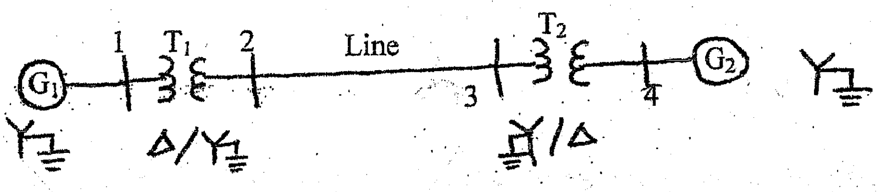
$V_a = 220V\angle 0°, V_b = 120V\angle -120°, V_c = 300V\angle -240°$

$I_a = 10A\angle -10°, I_b = 5A\angle -100°, I_c = 15A\angle -200°$

Calculate sequence voltages, currents and powers.

5. a) Starting from a suitable point, show that the three sequence networks are connected in series during a SLG fault in a 3-phase power system network. [6]

b) For the given power system network, draw sequence networks for DLG fault at bus no 2 and determine the fault current, short circuit MVA. [10]



$G_1: 100mVA, 15.75KV, X_1 = X_2 = 0.15pu, X_0 = 0.05pu$

$G_2: 100mVA, 15.75KV, X_1 = X_2 = 0.2pu, X_0 = 0.1pu$

$T_1 = T_2: 100mVA, 15.75/138KV, X_1 = X_2 = X_0 = 0.1pu$

$Line: X_1 = X_2 = 25\Omega, X_0 = 70\Omega$

6. a) What is the significance of H constant in stability of a synchronous machine? [4]

b) How Equal Area Criteria can be used to evaluate transient stability of a synchronous machine. [8]

c) A synchronous machine is connected to an infinite bus and the following condition exists during normal operation and the following relationship is valid during that period: [8]

$P_e = 2.1\sin\delta$

$P_m = 1.0pu$

Following a three phase symmetrical fault at the bus of synchronous generator, and fault is cleared at $\delta = 30°$. Check the stability. Calculate the maximum fault cleaning angle so as to maintain synchronism.

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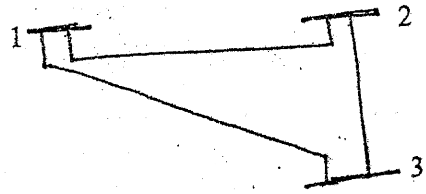
26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Shawan

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Power System Analysis II *(EE605)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ *Assume suitable data if necessary.*

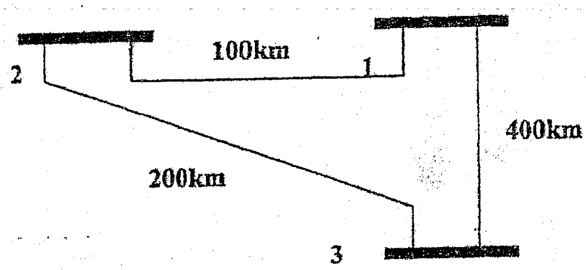
1. a) The single line diagram of a power system network is shown in figure below. If each line has series impedance of (0.05+j0.15) pu and shunt susceptance of j0.3 pu., find bus Admittance matrix for the system. [5]



b) What are the advantages of interconnected power system over isolated system? Also describe demerits of interconnected power system. [5]

2. a) The single line diagram of a power system network is shown in figure below. The Y_{bus} of the system is [8]

$$Y_{bus} = \begin{bmatrix} 4-j2 & -2+j6 & -2+j6 \\ -2+j6 & 4-j12 & -2+j6 \\ -2+j6 & -2+j6 & 4-j12 \end{bmatrix}$$



if the power and bus voltages with different buses are as follows:

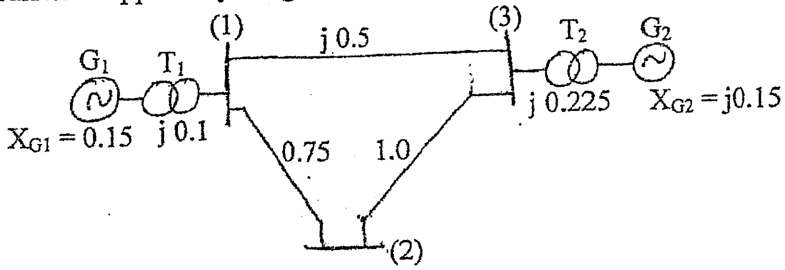
Bus No.	P_{Load}	Q_{Load}	P_{gen}	Q_{gen}	V	Bus Type
1	2.0	0.6	?	?	$1.05\angle 0$	Slack
2	0.7	0.5	1.2	?	1.0	PV
3	0.6	0.3	0	0	?	PQ

Assume limit on Q_{gen} of $0.1 \leq Q_{gen} \leq 0.4$;

Carry out the load flow analysis (only two iterations starting from assumptions of unknown voltage magnitudes as 1 p.u. and phase angles zero degree) using G-S to compute the unknown parameters in above table. Also compute the network real and reactive power losses.

b) Compare Gauss-Seidel method and Newton-Raphson method in load flow solutions. [8]

3. a) In the power system shown in figure below, the value marked are the per unit reactance taking 20 MVA and 11 kV as base values in the generator circuit. Both the transformers are rated for 11/110 kV. A three phase to ground fault with a fault impedance of 0.088 pu occurs at bus 2. Determine the actual values of fault current and the currents supplied by the generators. [8]



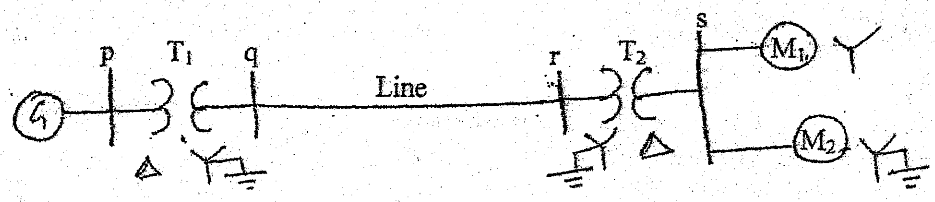
b) Deduce the sequence networks for balanced Y connected load with neutral grounded through impedance Z_n and show also current through neutral impedance is three times the zero sequence current. [10]

4. a) A single line diagram of a power system network is shown in figure below. The system data is given in the table below: [3+7]

Element	X_1 (pu)	X_2 (pu)	X_0 (pu)
G	0.1	0.12	0.05
M_1	0.05	0.06	0.025
M_2	0.05	0.06	0.025
T_1	0.07	0.07	0.07
T_2	0.08	0.08	0.08
Line	0.1	0.1	0.3

i) Draw sequence networks

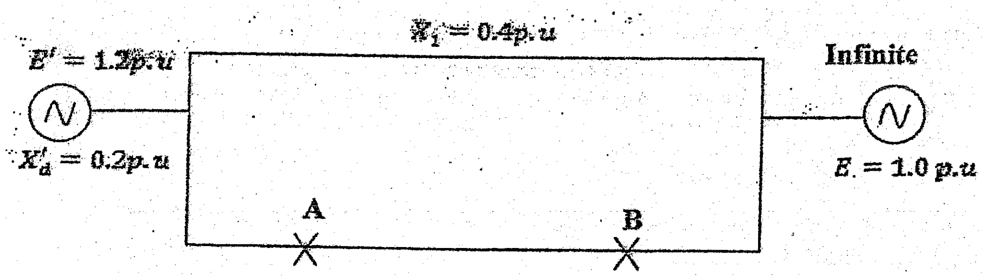
ii) Find fault current for a line-to-line fault on phase b and c at point q. Assume 1.0 pu pre-fault voltage throughout.



b) Develop a mathematical expression to obtain fault current of a single line to ground fault. [6]

5. a) Explain the effect of change of excitation on the steady state stability of a synchronous generator feeding an infinite bus bar. [4]

b) The power system shown in figure below is operating in steady state with which the generator delivering 1.5 p.u power to the infinite bus. The circuit breaker A suddenly opens and remain open. Find (i) whether the system remains stable or not. (ii) Angle to which the rotor swings. [6]



c) What do you understand by term 'Voltage stability'? What are the assumptions made and factors affecting Transient stability study? [1+3]

d) What is equal area criteria. How this criteria is utilized to study the transient stability. [6]

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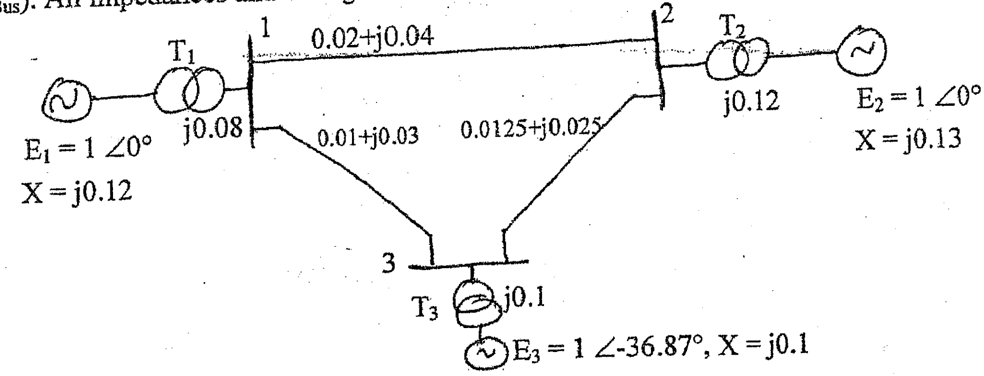
TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Power System Analysis II *(EE605)*

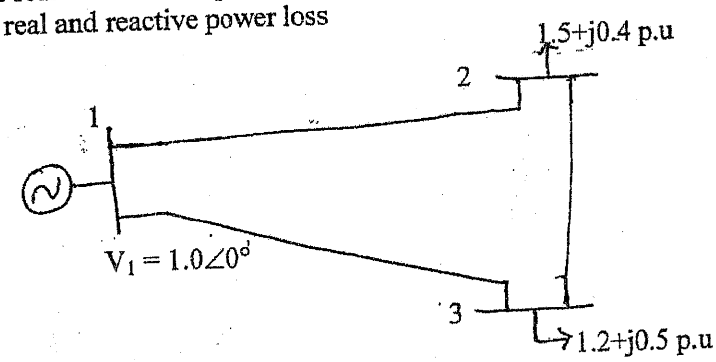
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) For the network given below, obtain node equations and then form admittance matrix (Y_{Bus}). All impedances and voltages are marked in pu. [5]



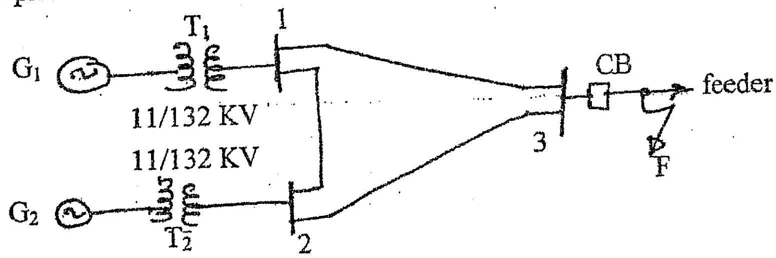
   b) Discuss role of interconnection in power system. Explain how reactive power can be controlled in power system network. [5]

2. a) For a network given below, series impedance of each line is 0+j0.12 pu. Shunt admittance of the line is negligible. Claculate: [10]
   i) Voltage at bus-2 and bus-3 using Gauss-Seidel method (upto two iterations)
   ii) Slack bus real and reactive power
   iii) Network real and reactive power loss



   b) Mention the various load flow techniques and hence compare them explaining their merits. demerits, usages and limitation. [4]

3. a) For the 3 bus power system shown in figure below the generators are rated 100 MVA with transient reactance of 10% each. Both the transformers are 100 MVA with a leakage reactance of 5%. The reactance of each of the line to a base of 100 MVA, 132 KV is 10%. Find the short circuit MVA of circuit breaker in outgoing feeder from bus-3, if a 3-phase fault occurs beyond the CB at point F. [8]



b) What is the difference between symmetrical components of positive, negative and zero phase sequence? A 3-phase synchronous generator with its neutral solidly grounded and operating at no load develops an L-G fault in one of the phase have fault impedance Z_f. Derive expressions for the fault currents and the line to ground voltage at the location of the fault at all the phases. [10]

4. a) A three phase synchronous generator whose neutral is grounded through a reactance X_n has balanced emfs and sequence reactance as X_1, X_2, and X_0 such that $X_1 = X_2 >> X_0$. [5+3+3+3]

   i) Derive the expression for fault current for soil line to ground fault on phase a.

   ii) Draw the sequence networks and their interconnection for above fault.

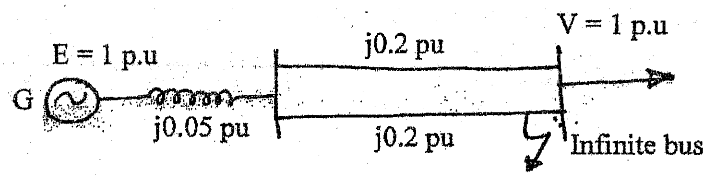
   iii) Show that if neutral is solidly grounded, L-G fault is more severe than 3-phase fault at the terminal of generator.

   iv) Find the limiting value of neutral grounding reactance so that fault current in L-G and 3-phase faults are equal.

b) Determine the symmetrical components of three unbalanced voltage $V_a = 200\angle 0°$, $V_b = 200\angle 245°$, $V_c = 200\angle 105°$V [4]

5. a) Define steady state and transient stability of power system. What are the methods of improving transient stability of a power system? Discuss various factors that affect power system transient stability. [2+4+4]

b) The figure below shows the generator connected to infinite bus using parallel transmission line. The generator is rated for 50 Hz and H constant of 2 pu. In steady state, the generator delivers a power of 1.2 pu to the infinite. A sudden 3 phase to ground fault occurs in one of the line near infinite bus as shown in figure. Determine the critical clearing angle and critical clearing time before which fault must be cleared so that system remains in stable state. [10]



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26 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2070 Ashad

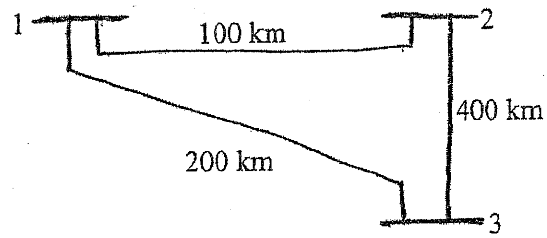
Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Power System Analysis II *(EE605)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt All questions.*
- ✓ *The figures in the margin indicate Full Marks.*
- ✓ *Assume suitable data if necessary.*

1. a) What do you mean by interconnected power system? Describe the advantages and the limitations of interconnected system. [4]

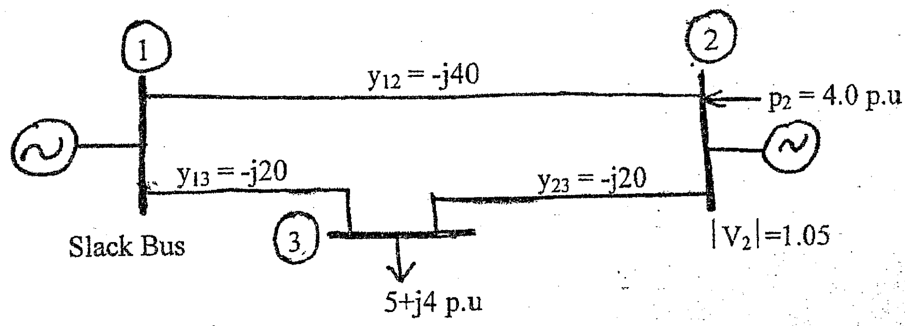
   b) The single line diagram of a power system is shown in figure below. If the per km line series reactance is 0.001 pu and shunt susceptance is 0.0016 pu. Find bus Admittance matrix using nominal pi-model of lines. [6]



2. a) Figure below shows the one line diagram of a power system with generators at buses 1 and 2. The line admittances are marked in pu in the diagram. Bus number, active power generation (P_G), reactive power generation (Q_G), active power load (P_L), reactive power load (Q_L), Bus voltage and bus type are tabulated below. All values are in pu. [4+8]

   i) Determine reactive power at bus-2 (use initial guess for unknown voltages)

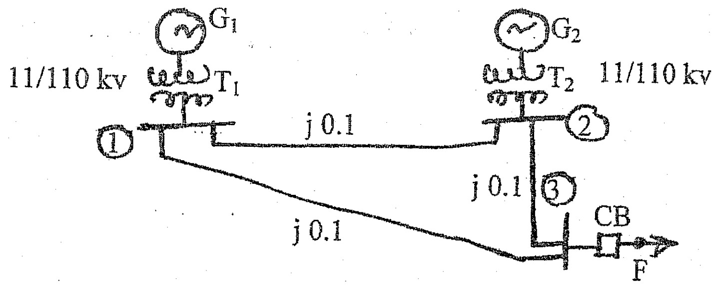
   ii) Determine Jacobian matrix (J^0) for the first iteration of N-R load flow method.



Bus No.	P_G	Q_G	P_L	Q_L	Bus voltage	Bus Type
1	?	?	0	0	1.0<0°	Slack
2	4.0	?	0	0	1.05	PV
3	0	0	5.0	4.0	?	PQ

   b) Mention the significance of various load flow techniques in an interconnected power system. [4]

3. For the 3 bus power system shown in figure below, the generators are rated 100 MVA with transient reactance of 10% each. Both the transformers ate 100 MVA with a leakage reactance of 5%. The reactance of each of the line to base of 100 MVA, 132 KV is 10%. Find the short circuit breaker in outgoing feeder from bus-3, if a 3-phase fault occurs beyond the CB at point F. [8]



Assume pre-fault voltage of bus-3 in 1 pu and pre-fault current through feeder is zero.

4. Derive an expression to determine sequence impedances for a balanced three-phase star-connected load with impedance Z in each phase and grounded neutral with impedance Z_N. [8]

5. a) A three phase synchronous generator whose neutral is grounded through a reactance X_n has balanced emfs and sequence reactance as X_1, X_2 and X_0 such that $X_1 = X_2 >> X_0$. [5+3+3+3]

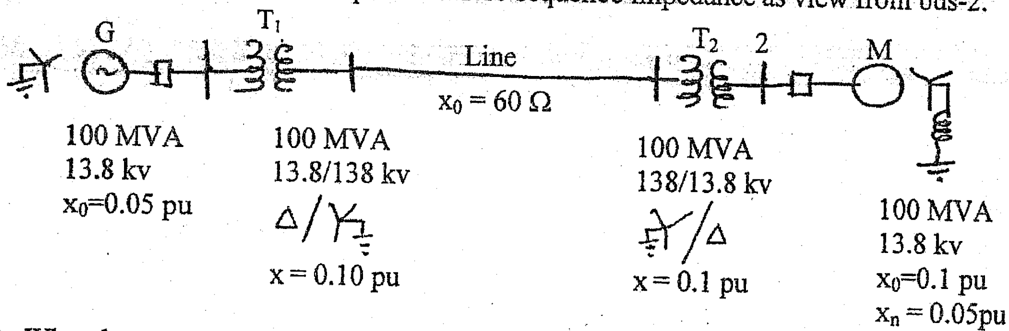
i) Derive the expression for fault current for solid line ground fault on phase a.

ii) Draw the sequence networks and their interconnection for above fault.

iii) Show that if neutral is solidly grounded, L-G fault is more severe than 3-phase fault at the terminal of generator.

iv) Find the limiting value of neutral grounding reactance so that fault current in L-G and 3 phase faults are equal.

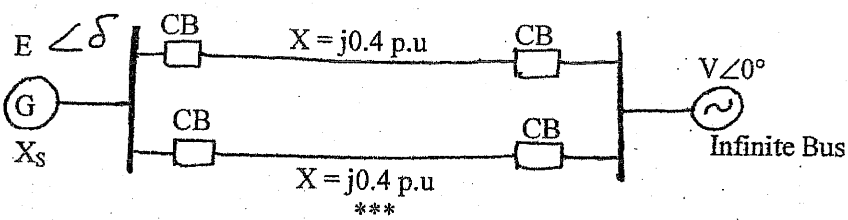
b) For the power system shown in figure below, draw the zero sequence network hence determine the Thevenin's equivalent zero sequence impedance as view from bus-2. [4]



6. a) What do you mean by steady state and transient stability in a power system? Describe the methods of improving transient stability of a power system. [8]

b) A 2 pole, 50 Hz, 11.5 KV turbo generator has a rating of 100 MW, power factor 0.85 lagging. Calculate the inertia constant in MJ/MVA on a base of 500 MVA and its momentum in MJ-sec/elec- degree. [4]

c) For the system shown in figure below, the numerical values for different quantities are: E = 1.2 pu, V = 1 pu, Xs = 0.2 pu and reactance of each line is 0.4 pu. Initially the generator is delivering a power of 1.5 pu. If one of the double circuit lines is now tripped out, using equal area criteria determine whether the system would be able to maintain its stability or not. [8]



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TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

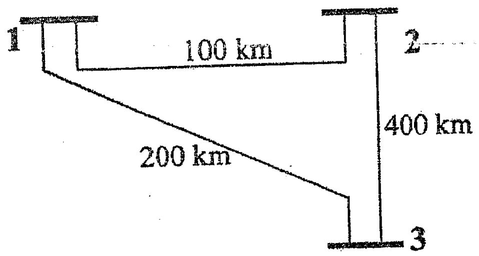
2069 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: Power System Analysis II *(EE605)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. The single line diagram of a power system network is shown in figure below. The per km line series reactance is 0.001 p.u and shunt suseptance is 0.0016 p.u.



The power and bus voltages are as follows;

Bus No.	P_{Load}	Q_{Load}	P_{gen}	Q_{gen}	V
1	0	0	?	?	$1.05\angle 0^0$
2	1.0	0.6	0	0	?
3	0.8	0.3	0	0	?

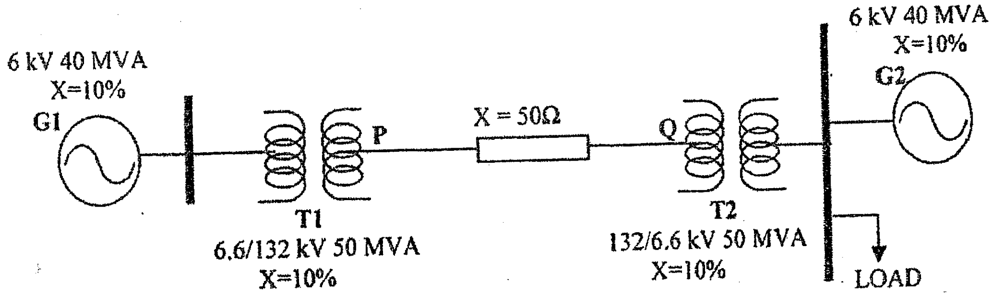
a. Find Y_{bus} using nominal pi-model of lines. [6]

b. Compute the voltage at bus 2 & 3 using G-S method for one iteration and also the slack bus complex power using the computed and specified bus voltages. **Start the analysis assuming unknown bus voltage magnitudes as 1 p.u. & phase angles zero degree.** [3×2+4]

2. Taking a suitable power system network describe the steps to be carried out to perform the load flow analysis using N-R method clearly defining the elements of Jacobean matrix of the example network. [10]

3. The single line diagram of a power system is shown in figure below. Compute the fault current in p.u. and in absolute value if a 3 phase to ground fault occurs at; (consider no fault impedance) [6+6]

   i. the point P i.e. connection point between transmission line and HV side of transformer T1
   ii. the point Q i.e. connection point between transmission line and HV side of transformer T1



4. a. With the help of suitable mathematical aid verify that, for a line to line fault in a synchronous generator the zero sequence component of current is absent and positive-sequence of current is equal to the negative sequence component of the current. [10]

b. Across a symmetrical star connected impedance system with Z=10ohms in each phase, a three phase unbalanced system of Voltages with $V_a=220\angle 0^0$, $V_b=200\angle -110^0$ & $V_c=180\angle +110^0$ volts is applied. Determine the line currents if the system neutral is (a) isolated (b) solidly grounded. [12]

5. a. What is equal area criterion for assessing the transient stability of a two machine system? Explain and justify with the help of a suitable example. [2+8]

b. A transmission line connecting a generator to an infinite bus has a series reactance of 0.8 p.u. Assuming the sending and receiving end voltage are at 1 p.u. each compute the following; [5+5]

i. Power angle if the line delivers a 1 p.u. power to infinite bus
ii. Series compensation required to bring the power angle to 30^0

26 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Chaitra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

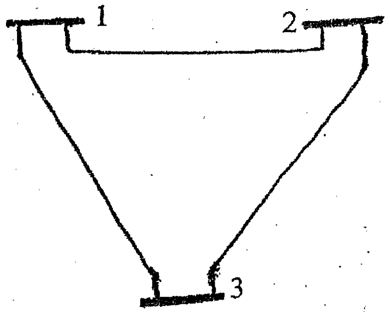
Subject: - Power System Analysis II ***(EE 605)***

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt __All__ questions.*
- ✓ *The figures in the margin indicate __Full Marks__.*
- ✓ *Assume suitable data if necessary.*

1. a) What do you mean by interconnected power system? Describe merits and demerits of the interconnected system. [1+5]

   b) Explain how real power/frequency control is maintained in a interconnected power system. [6]

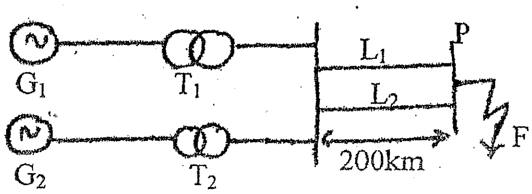
2. A 3-bus power system is shown in figure. The series impedance and shunt admittance of each line are 0.026+j0.11 pu and j0.04 pu respectively. The bus specification, power and bus voltage are as under. (P_G, Q_G, P_L, Q_L and bus voltages are in pu). [4×4]



Bus No.	P_G	Q_G	P_L	Q_L	Bus voltage	Bus type
1	?	?	1.0	0.5	1.03<0°	Slack
2	1.5	?	0.5	0	1.03	PV
3	0	0	1.2	0.5	?	PQ

   i) Form Y_{BUS}
   ii) Generator reactive power at bus 2 using Gauss-Seidel method (up to first iteration)
   iii) Voltage at bus 2 and 3using Gauss-Seidel method (up to first iteration)
   iv) Total network real power loss (after first iteration)

3. a) For a power system network a 3-ph to ground fault occurs at P as shown in figure calculate fault current and fault MVA.



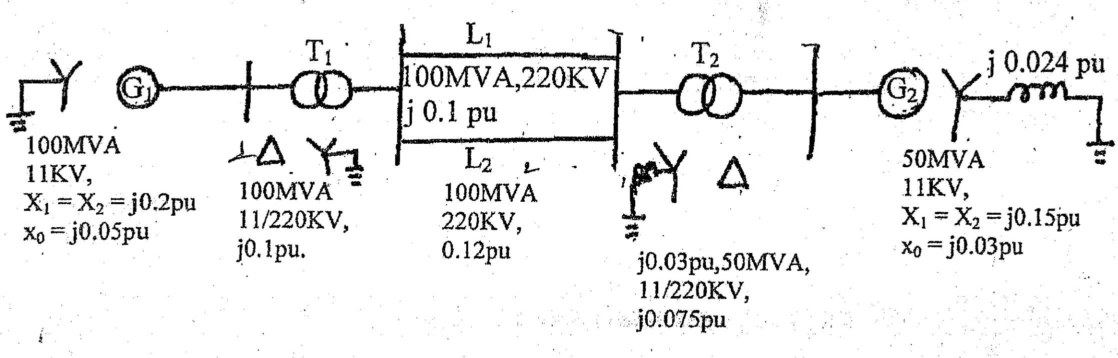
$G_1 \rightarrow$ 100MVA, 11KV, X = 15%
$G_2 \rightarrow$ 50MVA, 11KV, X = 10%

$T_1 \rightarrow$ 100MVA, 11/132KV, X = 10%
$T_2 \rightarrow$ 50MVA, 11/132KV, X = 8%.
L_1, $L_2 \rightarrow X$ = 0.2Ω/phase/Km

b) For a 3-phase symmetrical static circuit, Justify that sequence networks are decoupled. [8]

4. a) Explain with necessary mathematical expressions and diagrams how fault current is calculated when a line-to-line fault occurs in a 3-phase power system network. [8]

b) Draw positive, negative and zero sequence networks. If an unsymmetrical fault occurs at bus 3, determine equivalent Z_0, Z_1 and Z_2. [8]



5. a) Define steady-state and transient stability of a power system. Starting from the basic principle of dynamics, "Accelerating torque for a synchronous generator is given by the product of moment of inertia and the angular acceleration of the rotor" derive the swing equation of the rotor of the synchronous generator. [3+5+8]

b) A 3-phase, 50Hz generator is connected to an infinite bus via transmission line. The inertia constant of the generator is 6 MJ/MVA and mechanical power input is 1.0 pu. The maximum power that can be delivered by generator is 2.0 pu. A-3phase fault occurs at the infinite bus. Determine the critical clearing angle and critical clearing time. [8]

c) Explain factors affecting transient stability of a power system. [4]

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24 TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

Examination Control Division

2068 Baishakh

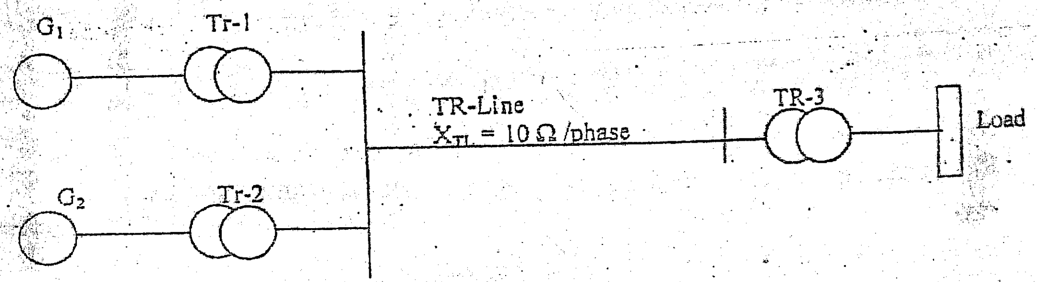
Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL, BEX	Pass Marks	32
Year / Part	III / I	Time	3 hrs.

Subject: - Power System Analysis

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt any* ***Five*** *questions.*
- ✓ *The figures in the margin indicate* ***Full Marks.***
- ✓ *Assume suitable data if necessary.*

1. a) Why transposition is done in three phase transmission line. Derive the equation to calculate inductance per unit length of a transposed 3-phase transmission line. [8]

   b) Develop the reactance diagram of the following network and express all the parameters in pu values based power = 1000 kVA and base voltage = 11 kV at low voltage side. [8]



G_1 : 1000 kVA, 11kV, X_{G1} = 2.5%

G_2 : 500 kVA, 11kV, X_{G2} = 0.1pu

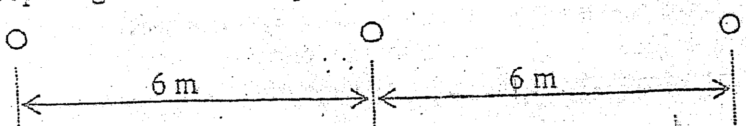
TR_1 : 1000 kVA, 11kV/66kV, X_{TR1} = 2%

TR_2 : 500 kVA, 12.5kV/75kV, X_{TR2} = 2%

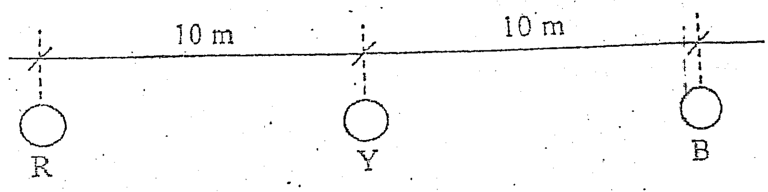
TR_3 : 1500 kVA, 66kV/ 400V, X_{TR3} = 2%

If the load draws a current of 1200 A, Calculate the current supplied by G_1 and G_2.

2. a) A 3-phase, 50 Hz transposed transmission line whose configuration is shown in figure below has an inductance of 1 mH/ph/km. Find the inductance of the same line if the line configuration would have been changed to symmetrical spacing keeping the minimum spacing between the adjacent conductors to be same. [8]



   b) Figure below shows the arrangement of a 3-phase transmission line. The line is transposed and the diameter of each conductor is 2.6cm. Calculate the capacitance of the line per phase per km neglecting the effect of ground. [8]



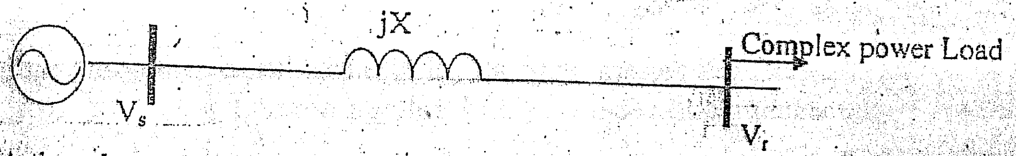
3. a) A three phase, 220 kV, 50 Hz transmission line supplies a power of 200 MW at a power factor of 0.8 lagging and the line has ABCD parameters as follows: [10]

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 0.9\angle 0.001^\circ & B\Omega \\ 1.14\times10^{-3}\angle 90^\circ & 0.9\angle 0.001^\circ \end{bmatrix}$$

Determine the following:

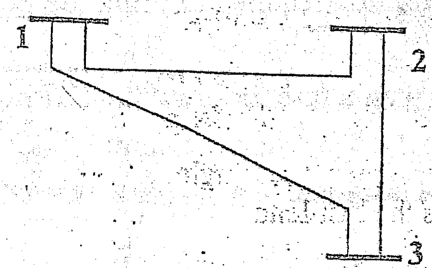
i) Sending end voltage
ii) No-load receiving end voltage
iii) Real and reactive power at sending end at full load
iv) Real and reactive power loss in the line at full load
v) Voltage regulation and line efficiency at full load

b) For the transmission line shown in figure below derive the expression for sending end voltage in terms of receiving end voltage, line reactance and complex power demand at the receiving end and hence justify that reactive power always flow from higher voltage towards lower. [6]



4. a) A three bus power system is shown in figure below. The Y_{bus} of the system in per unit is; [8]

$$Y_{BUS} = \begin{bmatrix} 4-j12 & -2+j6 & -2+j6 \\ -2+j6 & 4-j12 & -2+j6 \\ -2+j6 & -2+j6 & 4-j12 \end{bmatrix}$$



The bus power in p.u. are as follows;

Bus No.	P_{Load}	Q_{Load}	P_{gen}	Q_{gen}
1	0	0	?	?
2	0.9	0.6	0	0
3	0.8	0.4	0	0

The load flow analysis results $V_1 = 1\angle 0^0$ p.u. $V_2 = 0.85\angle -10^0$ p.u. $V_3 = 0.90\angle -5^0$ p.u. Compute the network real and reactive power losses.

b) Taking a suitable power system network, describe the steps to be carried out to perform the load flow analysis using N-R method, clearly defining the elements of Jacobean matrix of the example network. [8]