Q1) A 3-winding transformer gave the following results when a short-circuit test was performed on it:

- Leakage reactance X_{ps} measured in primary with secondary short-circuited and tertiary on open circuit = 0.25Ω
- Leakage reactance X_{pt} measured in primary with tertiary short-circuited and secondary on open circuit = 0.10Ω
- Leakage reactance X_{st} measured in secondary with tertiary short-circuited and primary on open circuit = 0.50Ω

The windings of the transformer have the following ratings:

- Primary: Star-connected, 11 kV, 20 MVA
- Secondary: Star-connected, 6.6 kV, 15 MVA
- Tertiary: Delta-connected, 1.1 kV, 10 MVA

On a base of 20 MVA, 11 kV, compute the reactances of the star-connected equivalent circuit.

Q2) A 500 kVA single-phase transformer delivers a lagging 0.8 pf load, and its secondary voltage is 400V. The resistance and reactance of the transformer are 0.01 pu and j0.05 pu respectively. Now when the system load is increased to 750 kVA at 0.8 pf, a smaller 250 kVA transformer is connected in parallel with the system. The second transformer has a resistance of 0.015 pu and reactance of j0.04 pu. The smaller transformer has the same secondary voltage which is 400 V. Calculate the portion of the load in kVA drawn by both transformers.

Q3) A 480V, 60 Hz, 6 pole delta connected synchronous motor is supplying 400 HP at 0.8 pf lagging. It has a synchronous reactance of 1.1 ohms. Assume the motor is lossless and the armature winding resistance is negligible. Calculate (i) The magnitude of generated voltage E_a. (ii) The maximum value of torque the motor can produce. (iii) If the generated voltage is increased by 15%, what is the new value of armature current?

Q4) A single phase 60 Hz transmission line and a telephone line, both are supported on a horizontal cross arm in the same horizontal plane. The spacing between transmission line conductors is 2.5 m and conductors of the telephone line are of solid copper spaced 0.6 m between centers. The distance between the nearest conductors of the two lines is 20 m. A current of 150A is flowing over the power line. Calculate (i) the value of the mutual inductance between the circuit and (ii) the value of voltage per km induced in the telephone line.

Q5) A three-phase 50 Hz overhead transmission line is feeding a 0.8 power factor lagging load with both the sending end and receiving end line voltages held at 110 kV. The sending end voltage leads the receiving end voltage by 15 and the line constants are as follows: A= $0.96\angle 1^0$, B=$100\angle 83^0$ Ohm/phase

i. How much active power and reactive power are demanded by load?
ii. If a compensating device is required to meet the demand of the load, calculate the VAR rating of the device.
iii. Calculate the efficiency of the line.

Q6) A single-phase overhead line delivers 1200 kW power to a load at 11 kV and at 0.8 pf lagging. The resistance and reactance of the line are 3 ohms and 4.5 ohms respectively. Calculate the following values.

i. The voltage at sending end

ii. Power factor at sending end
iii. Voltage regulation
iv. Efficiency of the transmission

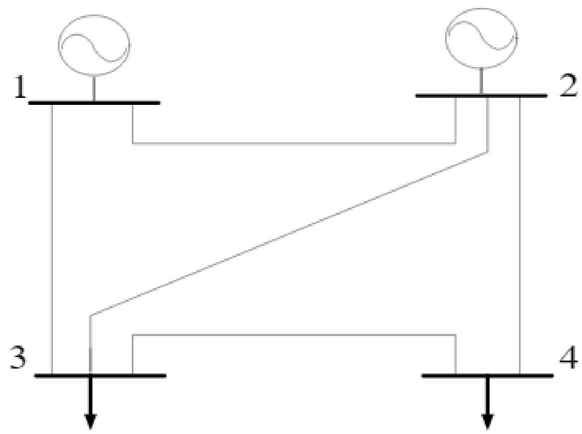
Q7) Obtain the load flow solution at the end of the first iteration of the power system shown in the figure below. The data is given in the table below.

Line Data:

Sending End Bus	Receiving End Bus	R (p.u.)	X (p.u.)
1	2	0.05	0.15
1	3	0.1	0.30
2	3	0.15	0.45
2	4	0.10	0.30
3	4	0.05	0.15

Bus Data:

Bus No.	P_i (p.u.)	Q_i (p.u.)	V_i (p.u.)
1	-	-	$1.04\angle 0°$
2	0.5	-0.2	-
3	-1.0	0.5	-
4	-0.3	-0.1	-



The solution is to be obtained for the following cases:

i. All buses except Bus 1 are PQ buses.
ii. Bus 2 is a PV bus whose voltage magnitude is specific as 1.04.
iii. Case (ii) if $0.25 \leq Q2 \leq 1.0$ p.u.

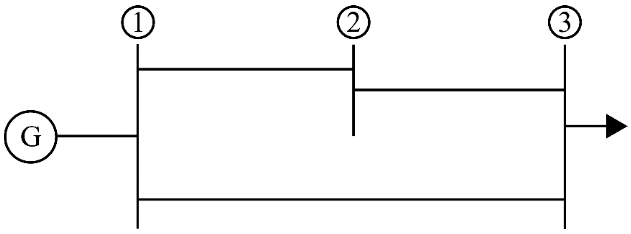
Q8) Obtain the voltages at all buses for the three-bus system shown in the figure below, at the end of the first iteration by NR method. The data is given in the tables below.

Line Data:

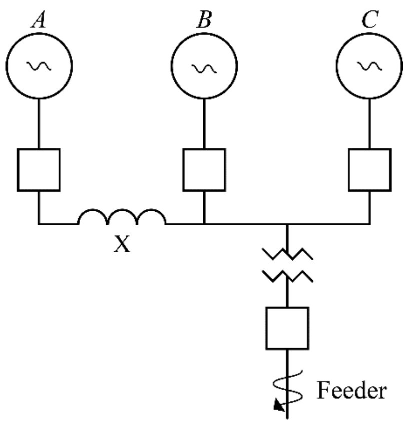
Sending Bus	Receiving Bus	R (p.u.)	X (p.u.)	$B_c/2$ (p.u.)
1	2	0.0	0.1	0.0
2	3	0.0	0.2	0.0
3	3	0.0	0.3	0.0

Bus Data:

Bus No.	P_g	Q_g	P_L	Q_L	V_i
1 (Slack)	-	-	-	-	1.0
2 (PV)	5.3217	-	-	-	1.1
3 (PQ)	-	-	3.6392	0.5359	-



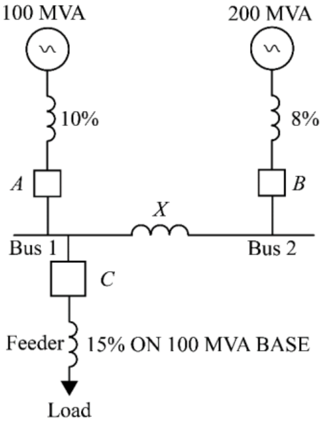
Q9) A power system circuit diagram is shown in the figure below. The generators G1, G2 and G3 have individual fault levels of 1000 MVA with their respective circuit breakers open. Feeder transformer reactance is 10% on 50 MVA base. Choose a common base of 100 MVA and let the voltage before fault is 1.0 pu.



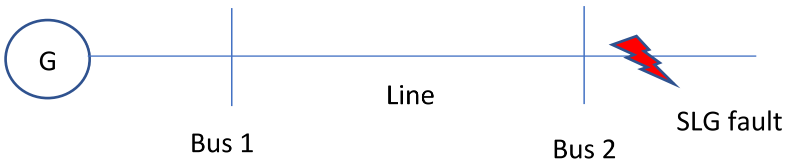
Find the value of current limiting reactor X such that feeder breaker rating does not exceed 425 MVA.

Q10) A 100 MVA generator with 10% reactance and a 200 MVA generator with 8% reactance are connected as shown in figure. Choose the base MVA as 100 MVA.

i. If the fault level on bus 1 is limited to be 1500 MVA, calculate value of the reactance of bus bar reactor X.
ii. Calculate fault MVA at bus 2.
iii. Calculate MVA rating of circuit breaker C.



Q11) Consider the power system shown in the figure in which an SLG fault occurs at bus 2 at the far end of the line. The specifications are given as follows.

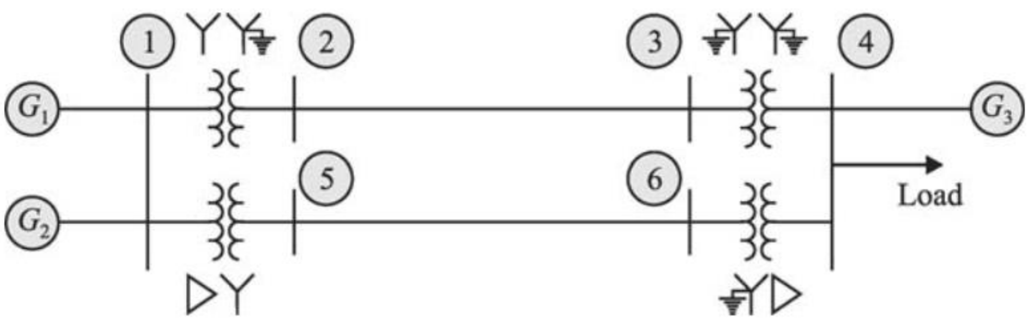


Component	Positive sequence impedance	Negative sequence impedance	Zero sequence impedance
50 MVA, 3-phase generator	0.2 pu	0.2 pu	0.1 pu
33 kV line	10 ohms	10 ohms	20 ohms

i. If the generator neutral is solidly grounded and fault impedance is zero, calculate fault current
ii. If the generator neutral is solidly grounded and fault impedance is 0.1 pu on 50 MVA, 33 kV base, calculate fault current.
iii. If the generator neutral is reactance grounded with X_n= 0.1 pu on 50 MVA, 33 kV base and fault impedance is 0.1 pu on 50 MVA, 33 kV base, calculate fault current.

Q12) A power system is shown in the figure below with the following parameters:

- Generator 1:40 MVA, 6.6 kV, $X_1 = X_2 = 0.10$ p.u., $X_0 = 0.20$ p.u.
- Generator 2: 60 MVA, 6.6 kV, $X_1 = X_2 = 0.15$ p.u., $X_0 = 0.20$ p.u.
- Generator 3: 50 MVA, 11 kV, $X_1 = X_2 = 0.12$ p.u., $X_0 = 0.15$ p.u.
- Transformer 1-2: 50 MVA, 6.6/132 kV, $X_1 = X_2 = X_0 = 0.10$ p.u.
- Transformer 1-5: 70 MVA, 6.6/220 kV, $X_1 = X_2 = X_0 = 0.08$ p.u.
- Transformer 3-4: 30 MVA, 11/132 kV, $X_1 = X_2 = X_0 = 0.06$ p.u.
- Transformer 6-4: 25 MVA, 11/220 kV, $X_1 = X_2 = X_0 = 0.075$ p.u.
- Transmission line 2-3: (30 +j90) Ω
- Transmission line 5-6: (50 +j80) Ω
- Load: 50 MVA at 0.8 power factor lagging at 11 kV



i. An SLG fault occurs at node 4 of the power system shown in the figure. Determine the fault current, in amperes, sequence voltages, phase and line voltages at the point of fault. Assume a fault resistance Z_r = 0.05 p.u.
ii. Analyse the power system shown for (a) LL, (b) LLG, and (c) three-phase faults at node 4. Discuss the severity of the various shunt faults. Assume $Z_g = 0$.

iii. Neglecting pre-fault currents, determine the voltage at node 5 under the fault condition described in Case (i).
iv. Compute the fault current and fault voltages, for a three-phase fault at node 1.
v. Determine the distribution of the fault currents and fault voltages at all the nodes of the power system for the condition in Case (iv).
vi. Calculate the fault currents and voltages for a LLG fault in the middle of the transmission line 5-6. Assume $Z_f = (5 + j0)\ \Omega$ and $Z_g = (10 + j0)\ \Omega$. How will the fault currents and voltages change for $Z_g = \infty$?
vii. An LL fault occurs at 25% of the distance from node 2 in transmission line 2-3. Compute the fault currents and voltages at the fault point $Z_f = (5 + j0)\ \Omega$. What will happen if Z_f is made equal to zero?

Q13) A 50-Hz synchronous generator is connected to an infinite bus of voltage $1.0\angle 0°$ via two parallel lines each having a reactance of 0.4pu. If the generator delivers 0.75 p.u. real power at 0.85 lagging power factor to the infinite bus, compute:

i. The damping factor, and
ii. The natural frequency of oscillations

when a disturbance of $\Delta\delta = 12.5°$ occurs due to a temporary opening and immediate closing of one of the circuit breakers. Assume the following data for the generator: transient reactance =0.4 p.u., inertia constant H = 8 MJ/MVA, and coefficient of power damping = 0.15. Write a MATLAB function to plot rotor angle and frequency versus time.

Note: The MATLAB code needs be included with the solution sheet along with the plotted graphs.