# MANMOHAN TECHNICAL UNIVERSITY
## Office of the Controller Examinations
**2083 Bhadra Exam (2026 August) Model Question**

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|---|---|---|
| **School:** Engineering | **Level:** Master | **Time:** 3 Hours |
| **Program:** M.Sc.P.S.E. | **Year/Part:** I/I | **Full Marks:** 50 |
| **Subject:** EG801EE – Computer Aided power System Analysis | | **Pass Marks:** 25 |

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

**GROUP A (Attempt any FIVE Questions)** **[5x3=15]**

1. Explain the need of high voltage transmission in modern power system. Briefly discuss the relationship between active power and frequency in power systems.
2. Derive the basic equations for the load flow study using Gauss-Seidel method. With respect to this method, explain about acceleration factor.
3. Explain the need of DC power flow analysis in power systems.
4. What is meant by an ill-conditioned power flow problem? Mention any two methods used to deal with it.
5. Explain the application of OPF in a power system.
6. Explain the step-by-step procedure for the formation of bus impedance matrix using addition of branch and addition of link for the power system network.

**GROUP B (Attempt Any SEVEN Questions)** **[7x5=35]**

1. A 3-phase, 50Hz, 150 km long transmission line has the following parameters: r=0.15 ohm/km, x= 0.5 ohm/km and y=3*$10^{-6}$ mho/km. If the line is represented by nominal- $\pi$, determine: i) ADCD constant of the line. ii) Power at unity power factor that can be received if the voltage at each end is maintained at 220 KV.
2. Calculate the voltages and angles at all buses after first iteration by using Fast Decoupled Load Flow Method for the system given in table. The line parameters are given in per unit on a 100MVA base.

| Bus Data | | | | | |
|---|---|---|---|---|---|
| Bus | V (pu) | $P_G$ (MW) | $Q_G$ (MVAR) | $P_L$ (MW) | $Q_L$ (MVAR) |
| 1 | 1.03 | - | - | - | - |
| 2 | 1.01 | 200 | - | - | - |
| 3 | - | - | - | 100 | 50 |

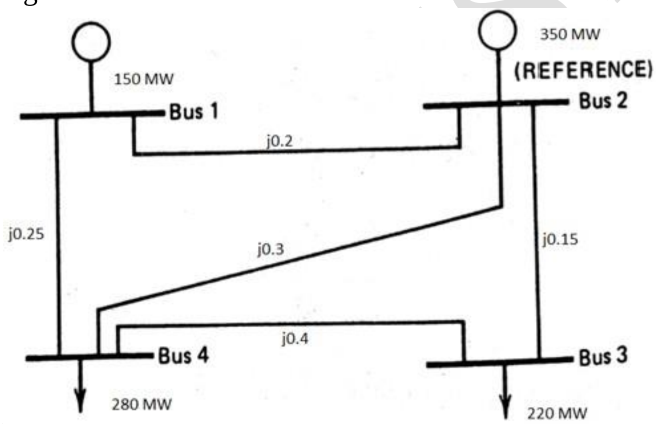
| Line Data | | | |
|---|---|---|---|
| Bus | | Impedance | line charging admittance |
| From | To | | |
| 1 | 2 | 0.15+j0.04 | j0.06 |

| | | | |
|---|---|---|---|
| 1 | 3 | 0.02+j0.05 | j0.04 |
| 2 | 3 | 0.01+j0.03 | 0 |

**3.** Two generators have the following quadratic fuel-cost functions:
$C_1 = 0.01P_1^2 + 20P_1 + 100$
$C_2 = 0.02P_2^2 + 15P_2 + 120$
The total load is 200 MW. Neglect transmission losses. Formulate the economic dispatch problem and determine the generation schedule using the equal incremental cost principle, subject to:
$50 \le P_1 \le 150$, $50 \le P_2 \le 150$.

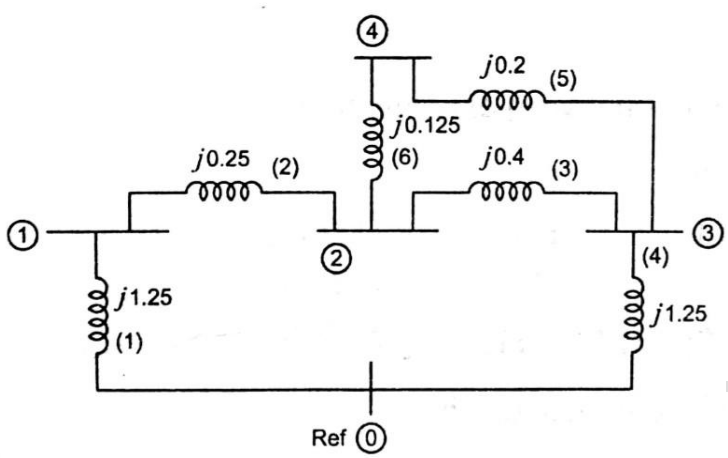
**4.** Explain Security Constrained Optimal Power Flow (SCOPF). Discuss their applications in power system operation and planning.

**5.** Figure shows a four-bus power system. Also given below are the impedance data for the transmission lines of the system as well as the generation and load values. Calculate the generation shift sensitivity coefficients for a shift in generation from bus 1 to bus 2. Take base 350 MW.

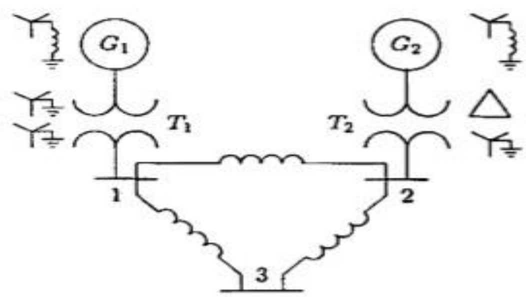



**6.** Explain the major transmission planning criteria and indices, including N-1 security, thermal loading limits, voltage constraints, Line Loading Index, ATC, VSM, and transmission loss index.

**7.** Determine bus impedance matrix using bus building algorithm for the network shown where the impedances labeled (1) through (6) are shown in pu preserve all buses on base 100MVA and 20KV.




**8.** The one-line diagram of a simple power system is shown in figure. The neutral of each generator is grounded through a current-limiting reactor of .25/3 p.u on a 100MVA base. The system data expressed in p.u on a common 100MVA base is tabulated below. The generators are running on no-load at their rated voltage and rated frequency with emfs in phase.
Calculate fault current for line-to-line fault at bus 3 with fault impedance of Zf=j0.1 p.u.




| Item | Base MVA | Voltage Rating kv | X1 | X2 | X0 |
|---|---|---|---|---|---|
| G1 | 100 | 20 | 0.15 | 0.15 | 0.05 |
| G2 | 100 | 20 | 0.15 | 0.15 | 0.05 |
| T1 | 100 | 20/220 | 0.1 | 0.1 | 0.1 |
| T2 | 100 | 20/220 | 0.1 | 0.1 | 0.1 |
| L12 | 100 | 220 | 0.125 | 0.125 | 0.3 |
| L13 | 100 | 220 | 0.15 | 0.15 | 0.35 |
| L23 | 100 | 220 | 0.25 | 0.25 | 0.7125 |

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| **School:** Engineering | **Level:** Master | **Time:** 3 Hours |
| **Program:** M.Sc.P.S.E. | **Year/Part:** I/I | **Full Marks:** 50 |
| **Subject:** EG802EE – Distribution System Design and Operation | | **Pass Marks:** 25 |

✓ *Candidates are required to give their answers in their own words as far as practicable.*

✓ *The figures in the margin indicate Full Marks.*

✓ *Assume suitable data if necessary.*

**GROUP A (Attempt any FIVE Questions)** **[5x3=15]**

1. Discuss the technical and economic considerations involved in selecting single-phase and three-phase distribution transformers for distribution systems.
2. Why are underground distribution systems generally preferred in urban areas? Discuss their technical and economic implications.
3. A radial feeder supplies the following loads:

| Load Point | Load (kVA) | Distance from Source (km) |
|---|---|---|
| A | 150 | 2 |
| B | 200 | 5 |
| C | 300 | 8 |

   Determine the MVA-km moment of the feeder. Briefly explain the significance of the MVAkm moment in conductor selection.

4. Explain the need for small-area load forecasting in distribution networks. How does it differ from system-wide load forecasting in terms of planning objectives?
5. Discuss the factors that influence the reliability of a radial distribution system
6. Explain how distribution automation benefits both electric u li es and consumers in modern distribution systems.

**GROUP B (Attempt Any SEVEN Questions)** **[7x5=35]**

1. Explain the importance of selecting an appropriate primary distribution voltage for a distribution system. Discuss how this choice affects the number of substations, distribution transformer ra ngs, LT feeder lengths and associated losses, and the reliability of power supply.
2. Assuming a uniformly distributed load along the length of a distribution feeder, derive the expressions for the feeder voltage drop and power loss. Clearly state the assumptions involved and comment on the practical significance of the derived expressions
3. Discuss the major causes of technical losses in distribution systems and explain practical measures for reducing transformer losses with suitable examples.
4. A 33/11-kV distribution substation supplies three outgoing feeders having the following maximum demands:

- Feeder A = 6 MW  Feeder B = 5 MW
- Feeder C = 4 MW

The diversity factor is 1.35.

(a) Determine the maximum diversified demand at the substation.

(b) Es mate the minimum transformer ra ng by considering a suitable design margin.

(c) Discuss the factors governing transformer capacity selection for distribution substations.

5. Explain the technical and economic considerations involved in conductor selection for primary distribution systems. Compare ABC and covered conductors for suitable applications.
6. Explain the coordination of protective devices in a radial distribution system using circuit breakers and auto-reclosers with the help of a suitable feeder arrangement.
7. A distribution feeder supplies 1,200 consumers. During one year, the feeder experienced six sustained interruptions, each affecting all consumers. The total customer interruption dura on was 1,800 consumer-hours. Calculate (a) SAIFI, (b) SAIDI, and (c) CAIDI. Interpret the significance of the obtained reliability indices.
8. Explain the role of a Distribution Management System (DMS) in modern smart grids. Discuss a method for service restoration in an automated distribution system.

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| **School:** Engineering | **Level:** Master | **Time:** 3 Hours |
| **Program:** M.Sc.P.S.E. | **Year/Part:** I/I | **Full Marks:** 50 |
| **Subject:** EG803EE – Extra High Voltage AC Systems | | **Pass Marks:** 25 |

✓ *Candidates are required to give their answers in their own words as far as practicable.*
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**GROUP A (Attempt any FIVE Questions)** **[5x3=15]**

1. Explain the design basis of high-voltage cable insulation systems. Discuss the important factors considered in cable insulation design.
2. Derive the expression for the capacitance per unit length of a long cylindrical conductor placed in a uniform dielectric medium.
3. Discuss the role of shielding wires/earth wires in EHV transmission systems. Explain how induced currents and voltages are developed in these wires and their effect on system performance.
4. A 3-phase, 50 Hz transmission line has conductors of 2 cm diameter arranged in an equilateral triangle with 3 m spacing. The surface irregularity factor is 0.85 and the air density factor is 1. Determine the disruptive critical voltage of the line. Assume the dielectric strength of air is 21.1 kV/cm (peak)
5. Explain the electrical characteristics required for insulating materials used in EHV underground cables.
6. Define Statistical Safety Factor and Risk of Flashover in EHV insulation coordination. How are they mathematically correlated using statistical distribution curves?

**GROUP B (Attempt Any SEVEN Questions)** **[7x5=35]**

1. An EHV AC line operates at $400\text{ kV}$. Derive the expressions for reactive power generated by line charging capacitance ($Q_C$) and consumed by line inductance ($Q_L$). Show analytically how series capacitor compensation affects the maximum power transfer capability and transient power angle.
2. A 3-phase, $400\text{ kV}$ horizontal EHV line uses a 2-conductor bundle per phase with sub-conductor radius $r = 1.5\text{ cm}$ and bundle spacing $B = 45\text{ cm}$. The phase-to-phase separation is $D = 11\text{ m}$.

   (a) Formulate the Maxwell's Potential Coefficient Matrix elements $[P]$ considering ground image effects for a line height $H = 18\text{ m}$ above ground.

   (b) Calculate the maximum surface voltage gradient ($E_{max}$) on the bundle sub-conductors

3. Explain the mechanisms of Electrical Treeing and Water Treeing in XLPE cable insulation. Describe Townsend's primary ($\alpha$) and secondary ($\gamma$) ionization processes in gases and derive the breakdown condition $\gamma(e^{\alpha d} - 1) = 1$
4. Explain the criteria for selection of conductors in high-voltage transmission lines based on corona performance. Discuss the influence of conductor diameter, spacing, surface condition and operating voltage on corona loss and radio interference.
5. Describe the working principle of partial discharge (PD) measurement and tan-delta testing. Explain how these non-destructive tests help in evaluating the insulation condition and remaining life of high-voltage equipment.
6. Distinguish clearly between glow, streamer, and leader types of electrical discharge mechanisms during corona formation. Explain the generation of Radio Interference (RI) and Audible Noise (AN) due to corona and outline conductor selection criteria to minimize these effects
7. Explain the origins and characteristics of switching overvoltage on EHV transmission lines. Discuss three practical methods used to suppress switching overvoltage during line energization.
8. Compare the breakdown strength and discharge mechanisms of long air gaps under non-uniform electric field geometries (such as point-plane and conductor-tower clearances) versus uniform/semi-uniform fields (such as sphere-sphere gaps).

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| **School:** Engineering | **Level:** Master | **Time:** 3 Hours |
| **Program:** M.Sc.P.S.E. | **Year/Part:** I/I | **Full Marks:** 50 |
| **Subject:** EG804EE - Power System Dynamics and Stability | | **Pass Marks:** 25 |

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

**GROUP A (Attempt any FIVE Questions)** **[5x3=15]**

1. Explain the concept of Park's transformation. Explain its mathematical significance in converting three-phase synchronous machine equations into direct (d) and quadrature (q) axis frame
2. Describe the three standard static load representations: Constant Impedance (Z), Constant Current (I) and Constant Power (P) models.
3. Define Critical Fault Clearing Time ($t_{cr}$) and Critical Clearing Angle ($\delta_{cr}$). How do they impact transient stability?
4. A synchronous generator supplying an infinite bus experience a sudden increase in mechanical input power. Explain qualitatively how the rotor angle, electrical power and frequency change immediately after the disturbance
5. Differentiate between local oscillation mode, inter-area oscillation mode and control mode in a multi-machine power system.
6. Explain why a power system with all eigenvalues having negative real parts is considered stable. What information is provided by the imaginary part of the eigenvalues?

**GROUP B (Attempt Any SEVEN Questions)** **[7x5=35]**

1. Explain how numerical methods are applied to solve the non-linear swing equation during transient stability analysis. Outline the basic step-by-step algorithm.
2. Discuss the dynamic mechanism of voltage instability and voltage collapse. Explain how $P$-$V$ and $Q$-$V$ curves are utilized to determine system voltage stability margins.
3. A generating station connected to an infinite bus undergoes a three-phase fault near its terminals. (a) Explain the sequence of events from fault inception to post-fault oscillation. (b) Discuss how fault location, clearing time, and generator inertia influence system stability
4. Describe the operation, tuning principles and functional requirements of a Power System Stabilizer (PSS) and Power Oscillation Damping (POD) controllers in mitigating low-frequency inter-area oscillations.
5. A transmission line delivers 1.0 pu power. Maximum transferable power is 2.0 pu.
   Calculate a) Initial power angle. b) Power angle after the transmitted power increases to 1.5 pu. Comment on the effect on transient stability margin.
6. Describe the step-by-step process of Modal Analysis using linearized system dynamics. How are left and right eigenvectors used to calculate participation factors to locate key oscillating generators?
7. Explain the operating principle of Automatic Generation Control (AGC) in a multi-area power system. Discuss the role of Area Control Error (ACE) in maintaining system frequency and scheduled tie-line power exchange.
8. A generator has a maximum power transfer capability of 2.5 pu and initially transfers 1.25 pu power. Calculate
   a. Initial power angle of the generator.
   b. New power angle if the transferred power increases to 2.0 pu.
   c. Discuss the impact of this change on transient stability margin.

***The End***

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| **School:** Engineering | **Level:** Master | **Time:** 3 Hours |
| **Program:** M.Sc.P.S.E. | **Year/Part:** I/I | **Full Marks:** 50 |
| **Subject:** EG806EE –Elective I- Operation Research and Optimization Techniques | | **Pass Marks:** 25 |

✓ *Candidates are required to give their answers in their own words as far as practicable.*
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✓ *Assume suitable data if necessary.*

**GROUP A (Attempt any FIVE Questions)** **[5x3=15]**

1. A distribution utility plans to install two types of distributed generation units at a substation. Each solar PV unit costs Rs. 8 lakhs, occupies 100 m² of land and delivers 50 kW of firm capacity. Each wind-power unit costs Rs. 5 lakhs, occupies 40 m² of land and delivers 80 kW of firm capacity. The utility has a capital budget of Rs. 80 lakh and only 800 m² of land is available. Formulate the problem as a linear programming problem (LPP) so as to maximize the total capacity installed.

2. Three generating stations $S_1$, $S_2$ and $S_3$ supply power to four load centers $D_1$, $D_2$, $D_3$ and $D_4$. The unit transmission costs (Rs. per MWh), the availabilities and the requirements are given in the table below. Obtain the initial basic feasible solution by the Least Cost Method and compute the corresponding total transmission cost.

| | $D_1$ | $D_2$ | $D_3$ | $D_4$ | Supply |
|---|---|---|---|---|---|
| $S_1$ | 3 | 1 | 7 | 4 | 35 |
| $S_2$ | 2 | 6 | 5 | 9 | 55 |
| $S_3$ | 8 | 3 | 3 | 2 | 20 |
| Demand | 20 | 25 | 40 | 25 | 110 |

3. The optimal simplex table of the LPP: Maximize $Z = 7x_1 + 9x_2$ subject to $-x_1 + 3x_2 \leq 6$, $7x_1 + x_2 \leq 35$, $x_1, x_2 \geq 0$ and integers, is given below. Generate the Gomory fractional cut constraint from the $x_2$ row and write it in the form suitable for adding to the table.

| Basis | $x_1$ | $x_2$ | $s_1$ | $s_2$ | Solution ($X_B$) |
|---|---|---|---|---|---|
| $x_1$ | 1 | 0 | −1/22 | 3/22 | 9/2 |
| $x_2$ | 0 | 1 | 7/22 | 1/22 | 7/2 |
| $C_j - Z_j$ | 0 | 0 | -28/22 | -15/22 | 63 |

4. Minimize $f(x) = x^2 - 6x - 3$ by the unrestricted search method with a fixed step size of 0.1, starting from $x = 0$, in the interval [-1,3].

5. Three maintenance crews A, B and C are to be assigned to three feeders $F_1$, $F_2$ and $F_3$, one crew to one feeder. The outage cost (in thousand rupees) of every possible assignment is given below. Determine the optimal assignment and the minimum total cost using the Hungarian method.

| **Crew** | **$F_1$** | **$F_2$** | **$F_3$** |
|---|---|---|---|
| **A** | 11 | 17 | 8 |
| **B** | 9 | 7 | 12 |
| **C** | 13 | 16 | 15 |

6. Using the method of dynamic programming, maximize $z = x_1 \cdot x_2$ subject to $x_1 + x_2 = 4$ and $x_1$, $x_2 \geq 0$.

**GROUP B (Attempt Any SEVEN Questions)** **[7x5=35]**

Maximize $Z = 5x_1 + 4x_2$ subject to $6x_1 + 4x_2 \leq 24$, $x_1 + 2x_2 \leq 6$, $x_1 \geq 0$, $x_2 \geq 0$. Use graphical method.

2. Solve the following LPP by the simplex method, showing all simplex tables: Maximize $Z = 4x_1 + 3x_2$ subject to $2x_1 + x_2 \leq 10$, $x_1 + 3x_2 \leq 15$, $x_1 \geq 0$, $x_2 \geq 0$.

3. Solve the following LPP by dynamic programming, treating each decision variable as one stage: Maximize $Z = 3x_1 + 4x_2$ subject to $2x_1 + x_2 \leq 8$, $x_1 + 2x_2 \leq 10$, $x_1 \geq 0$, $x_2 \geq 0$.

4. Minimize $f(x) = x^2 - 8x + 20$ in the interval [0, 6] by the golden section method. Carry out iteration till final interval of uncertainty reduce to 10% of initial level of uncertainty.

5. Minimize $f(x_1, x_2) = x_1 - x_2 + 2x_1^2 + 2x_1x_2 + x_2^2$ starting from the point $X_1 = (0, 0)^T$ using the Fletcher–Reeves conjugate gradient method.

6. Minimize $f(x_1, x_2) = x_1^2 + 2x_2^2 + 2x_1x_2 - 4x_1 - 6x_2$ starting from the point $X_1 = (0, 0)^T$ using the univariate method. Perform two iterations.

7. Two thermal units of a station supply a total load of 150 MW. Their fuel cost characteristics are $F_1 = 0.1P_1^2 + 20P_1 + 100$ Rs/h and $F_2 = 0.1P_2^2 + 30P_2 + 150$ Rs/h, where $P_1$ and $P_2$ are in MW. Using the Lagrangian multiplier method, determine the optimum generation schedule ($P_1$, $P_2$), the value of the multiplier $\lambda$ and the minimum total fuel cost.

8.Optimize $f(x_1, x_2) = 8x_1 + 12x_2 - x_1^2 - x_2^2$ subject to $x_1 + 2x_2 \leq 6$, $x_1 \geq 0$, $x_2 \geq 0$.

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