**EEL 891: Selected Topics in Power Systems**
**Major Exam**
**05th May 2009**
**Maximum Marks: 40**
**Maximum Time: 2 Hours**

**Note:**

1. **All questions are compulsory.**
2. **Questions 1, 2 and 3 are objective type questions. Mark all correct answers.**
3. **Question 4 is a short-answer type question.**
4. **Elaborate your view in the answer of question 5.**

1. Locational Marginal Price (LMP) on a bus **(2 Marks)**
   a. Can be lesser than the price of the cheapest generator
   b. Will always be greater than or equal to price of the cheapest generator
   c. Can be negative sometimes
2. For a standard two bus lossless system, the power flow is from bus 1 to bus 2 and Lagrange multiplier associated with the global load-generation balance equation $(\lambda)$ is equal to 10. The Lagrange multiplier associated with inequality constraint of line flow limit is $\mu_{12} = -5$. The LMP on bus 2 is **(2 Marks)**
   a. 10
   b. 5
   c. 15
   d. Data insufficient or something wrong with the data
   e. None of the above
3. Which of the following power flow tracing algorithms fails to converge in the presence of circular flows? **(1 Mark)**
   a. Simultaneous equations approach
   b. Graph theoretic approach
   c. Both
   d. None
4. The bus voltage angles after obtaining converged load flow solution are given as: Bus 1: $-15°$, Bus 2: $8°$, Bus 3: $0°$, Bus 4: $5°$, Bus 5: $-3°$. Bus 3 is a reference bus. Write down an order in which you will carry out symbolic node elimination for upstream tracing. **(2 Marks)**
5. Is it possible to have 'reactive power market' operating on exactly the same principles of conventional real power exchange? Elaborate. **(3 Marks)**
6. The network data, bus data and a power flow solution for a six bus system is given in Table 1.
   a. Indentify the pure sink and pure source bus/es
   b. Carry out downstream power flow tracing (Generation side tracing). Evaluate contribution of each of the generators in each of the lines in tabular form.
   c. Calculate contribution of each of the generators in each of the loads in tabular form

**Table 1**

| Bus Data and Solution | | | | Line Data and Solution | | |
|---|---|---|---|---|---|---|
| **Bus No.** | **$\delta$ (Degrees)** | **PG (MW)** | **PD(MW)** | **Line No.** | **Flow (MW)** | **X (pu)** |
| 1 | 0° | 100 | 200 | 1 | $\lvert P_{12}\rvert = 100$ | 0.005 |
| 2 | 0.3° | 500 | 0 | 2 | $\lvert P_{23}\rvert = 100$ | 0.025 |
| 3 | −1.15° | 100 | 0 | 3 | $\lvert P_{26}\rvert = 300$ | 0.02 |
| 4 | −3.5° | 0 | 100 | 4 | $\lvert P_{34}\rvert = 200$ | 0.02 |
| 5 | −4.0° | 0 | 200 | 5 | $\lvert P_{46}\rvert = 100$ | 0.005 |
| 6 | −3.15° | 0 | 200 | 6 | $\lvert P_{45}\rvert = 200$ | 0.005 |

**(10 Marks)**

7. The block bids of five generators are given as follows:
   Gen A: 0-5 MW, 37 INR / MW, Pmax = 5 MW
   Gen B: 0-30 MW, 25 INR / MW, Pmax = 30 MW
   Gen C: 0-10 MW, 35 INR / MW, Pmax = 10 MW
   Gen D: 0-25 MW, 30 INR / MW, Pmax = 25 MW
   Gen E: 0-20 MW, 20 INR / MW, Pmax = 20 MW

   a. Calculate market clearing price for load of 70 MW.
   b. Which generator will be the 'marginal' generator?
   c. Suppose the marginal generator in this case is asked to provide a reserve of 10 MW, calculate new energy market clearing price
   d. What will be the opportunity cost of the marginal generator of the previous case?

   **(8 Marks)**

8. Data for four bus system shown in Figure 1 is given in Table 2:

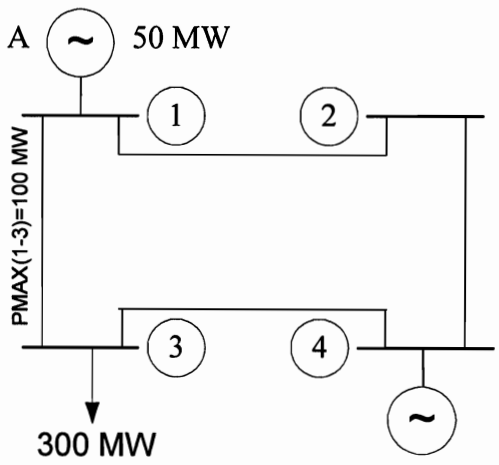


**Figure 1**

**Table 2**

| Bus No. | PD (MW) | Gen Cost (INR/MW) | PGMax (MW) | PGMin(MW) |
|---|---|---|---|---|
| 1 | 0 | 10 | 300 | 0 |
| 2 | 0 | - | - | - |
| 3 | 300 | - | - | - |
| 4 | 0 | 20 | 300 | 0 |

Real power carrying capacity of line 1-3 is 100 MW and other lines have infinite capacity. The loads are firm loads. Series reactance of each of the lines is 0.25 p.u. The market works on a centralized dispatch philosophy with commercial settlements done through LMPs, which are calculated using DC model. Table 3 shows three combinations of Financial Transmission Rights (FTRs).

**Table 3**

| Combination | From bus | To bus | MW |
|---|---|---|---|
| A | 1 | 3 | 100 |
| | 4 | 3 | 100 |
| B | 1 | 3 | 150 |
| | 3 | 4 | 100 |
| C | 1 | 3 | 100 |
| | 4 | 3 | 200 |
| | 4 | 2 | 50 |
| | 2 | 1 | 50 |

Determine which combination/s of FTRs satisfy the simultaneous feasibility condition from the point of view of revenue adequacy for FTRs, considering one combination at a time. **(12 Marks)**