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Optimal Generation Scheduling in Deregulated Power System Using Bus Admittance Matrix Method

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Abstract—In a deregulated environment power contracts play a major role. These are the long term power agreements made between the buyer and the seller. This paper presents a methodology for evaluating an optimum real power generation scheduling in a power system consisting of regulated and deregulated subsystems to get system optimal and economical. If the bilateral contracts are made using the concept of bus impedance matrix method, such a contract will ensure better system security such as a good voltage profile and will also reduce the losses involved in the bilateral transaction. In this paper the charges incurred in meeting loads like generation charge, transmission charge and charge due to losses are evaluated. Case study is carried out on a sample IEEE 6 bus system, considering ideal power contracts and deviated power contracts. Minimization of fuel cost is considered as the objective function for each generator of a subsystem participating in the economic dispatch in deregulated market. The results obtained based on Bus Impedance matrix approach are compared with that of the base case approach, and it is found that the bilateral contract made based on the Bus impedance matrix approach is both optimal , in system voltage and loss point of view and also economical.

Index Terms—Deregulated power system,Bus admittance matrix,optimal power flow.

1 INTRODUCTION

From early 1990's, competition has been allowed in power system operation and management with the multiple objectives of increasing efficiency and lowering cost, and offering quality product with higher reliability to customers. The electrical industry structure has been changing from a regulated to a deregulated environment, which has resulted in a new market called the deregulated electricity market.

The new market needs the Independent System Operator (1S0) as an independent coordinator to analyze the system situation, develop strategies and define transactions among participants by looking for the minimum price that satisfies the demand. Independent customers have choice rights to supply service utilities, So deregulation brings about great revolution of technology, controls, operation and management in powers systems. Different from other deregulated energy markets, the power system deregulation heightens the incentives for optimal deployment of resources in the competitive electricity market.

This paper concentrates on a conventional algorithm, the Optimal Power Flow in deregulated power systems. Typically, losses are treated as additional load on the system. Network losses cost millions of Indian Rupees (INR) every year as they can account for 5–10% of the total generation in the system. Fair allocation of the network losses has very important impact on all users.

This paper presents a methodology of evaluation of optimum real power generation scheduling in deregulated power systems. The optimization approach adopted for real power optimization problems to take advantage of decoupled load flow calculation, Minimization of fuel cost is considered as an objective function for each generator participating in economic dispatch in the deregulated market.

2 RELATED CONCEPTS

Consider a system where n is the total number of buses with 1, 2… g, g number of generator buses, and g + 1. . . n, remaining (n - g) buses. For a given system we can write,

$$\begin{bmatrix} I_G \\ I_L \end{bmatrix} = \begin{bmatrix} Y_{GG} & Y_{GL} \\ Y_{LG} & Y_{LL} \end{bmatrix} \begin{bmatrix} V_G \\ V_L \end{bmatrix} \quad (1)$$

$[I_G]$,$[I_L]$: injected currents of generator, load buses,

$[V_G]$,$[V_L]$: complexgenerator,load bus voltages,

$[Y_{GG}]$,$[Y_{GL}]$,$[Y_{LG}]$ and $[Y_{LL}]$ are corresponding portions of net work Y-bus matrix.

Eq. (1) can be written as,

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$$\begin{bmatrix} V_L \\ I_G \end{bmatrix} = \begin{bmatrix} Z_{LL} & F_{LG} \\ K_{GL} & Y'_{GG} \end{bmatrix} \begin{bmatrix} I_L \\ V_G \end{bmatrix} \quad (2)$$

Where $[F_{LG}] = -[Y_{LL}]^{-1}[Y_{LG}]$; $[K_{GL}] = [Y_{GL}][Y_{LL}]^{-1}$ and

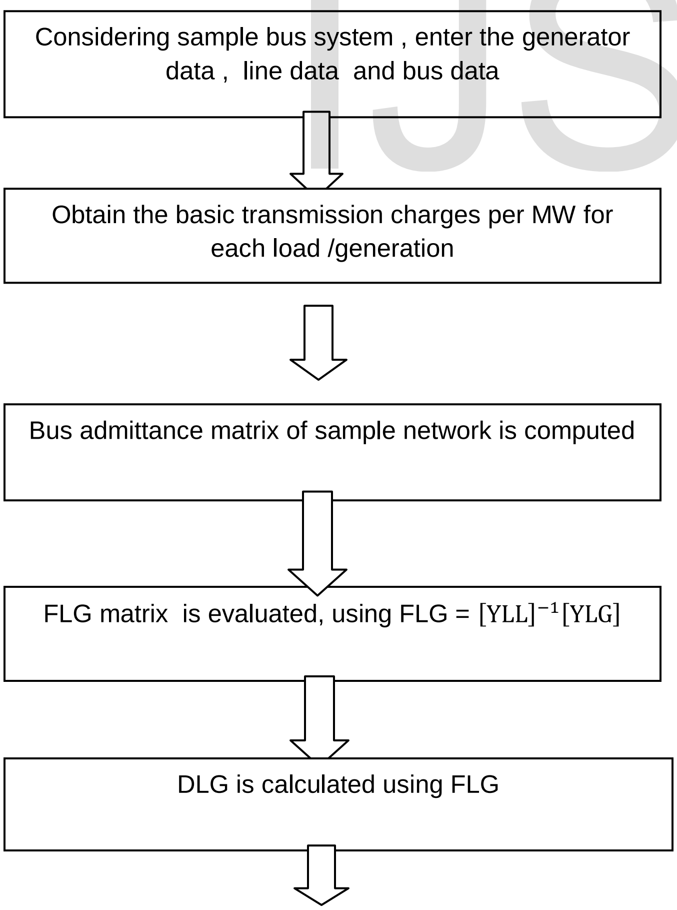
$[Y'_{GG}] = \{[Y_{GG}] - [Y_{GL}][Y_{LL}]^{-1}[Y_{LG}]\}$

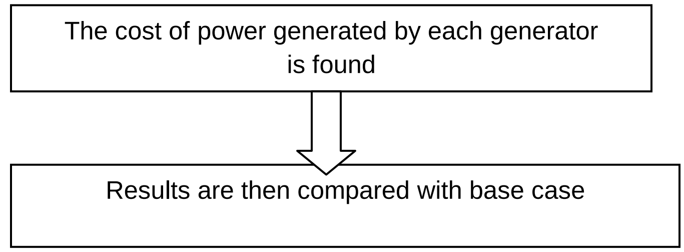
The elements of $[FLG]$ matrix are complex and its columns correspond to the generator bus numbers and rows correspond to the load bus numbers. This matrix gives the relation between load bus voltages and source bus voltages. It also gives information about the location of load nodes with respect to generator nodes that is termed as relative electrical distance between load nodes and generator nodes. Eq (2) can be re-written as,

$$[V_L] = [Z_{LL}][I_L] + [F_{LG}][F_G] \quad (3)$$

3 Proposed Approach

The approach considered in obtaining the cost incurred in meeting loads is explained as follows. The algorithmic flow is shown in fig.1





The losses for all the contracts are computed and they are shared by each generator in the same proportion as the load. Based on the utility practices the transmission primary, supplementary and loss charges are defined. With that information the charges incurred in the process of meeting loads are computed for all the contracts. The following section explains the approach with a sample example.

4 Case Study

To demonstrate optimum real power generation scheduling in deregulated power system IEEE six bus system as shown in fig.1 is created .It consistes of three generators and three loads and the corresponding data are as given in table.1 and table.2 .The sample system shown in fig.1 is also considered for explaining the steps to be carried out for obtaining the total cost incurred while meeting loads.

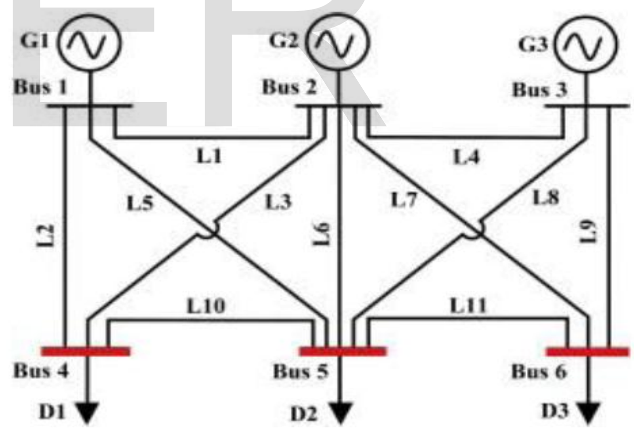


Figure.1 IEEE 6 bus system

Table.1 Bus Data

Branch No	From Bus	To Bus	R	X	Line Limit
1	1	2	0.1	0.2	40
2	1	4	0.05	0.2	60
3	1	5	0.08	0.3	40
4	2	3	0.05	0.25	40
5	2	4	0.05	0.10	80
6	2	5	0.1	0.30	30
7	2	6	0.07	0.20	90
8	3	5	0.12	0.26	70
9	3	6	0.02	0.10	90
10	4	5	0.2	0.40	20
11	5	6	0.1	0.30	40

Table.2 Line Data

Bus No	Type	Voltage	Pd	Pg	Qg	Qd	Qmax	Qmin
1	Slack	1.05	0	-	-	0	-0.2	1
2	PV	1.05	0	0.5	-	0	-0.2	1
3	PV	1.07	0	0.6	-	0	-0.25	1
4	PQ	1	0.7	0	0	0.7	0	0
5	PQ	1	0.7	0	0	0.7	0	0
6	PQ	1	0.7	0	0	0.7	0	0

The base case power flow analysis is carried out on IEEE six bus system using Power World Simulator and the generation by each generator to meet the load demand are evaluated. The cost of generation is calculated for base case which is without rescheduling.

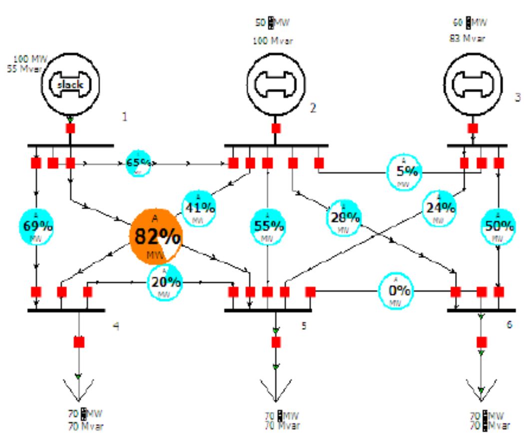


Figure.2 IEEE six bus system simulated in power world simulator

Evaluation of charges without rescheduling

The total generation of generator1 = 110.02 MW
The total generation of generator2 = 79.29 MW
The total generation of generator3 = 62.7 MW
The generation cost for all the three generators is considered to be equal to Rs 1000/MW
The total generation charge for the given system ideally is = Rs (110.02+79.29+62.7)*1000
= Rs252.01*1000=252010Rs

Evaluation of charges using admittance matrix

The sample system shown in Fig. 1 has three sources at buses 1, 2, 3 and three loads at buses 4,5,6. First Admittance matrix and hence FLG matrices are obtained for the sample system.

$$[F_{LG}]=\begin{bmatrix} 0.3387-0.0458j & 0.6105+0.0421j & 0.0509+0.0047j \\ 0.2708-0.0218j & 0.3649+0.0125j & 0.3643+0.0094j \\ 0.0487-0.0008j & 0.3317+0.0278j & 0.6197-0.0271j \end{bmatrix}$$

The elements of $[F_{LG}]$ matrix are complex and its columns correspond to the generator bus numbers and rows correspond to the load bus numbers. The absolute of FLG matrix gives us DLG matrix using which generation by each generator to meet the load is shared which gives us optimal scheduling.
For example to meet load at bus 4 generation by generators at 1, 2 and 3 must be in proportion with 33:61:5. Then adding the elements along the column nenerations at all generator busses are obtained.

The total generation of generator1 = 56.79 MW
The total generation of generator2 = 97.21 MW
The total generation of generator3 = 71.6 MW
The generation cost for all the three generators is considered to be equal to Rs 1000/MW
The total generation charge for the given system ideally is = Rs (56.79+97.21+71.6)*1000
= Rs225.6*1000=225600Rs

The generation/load patterns obtained here are called 'ideal', system security point of view. Proportions here are obtained based on the relative location of generation to load which result in minimum losses for a given load pattern. For a given load pattern, generation scheduling carried out using this method will result in optimal transmission line loading, however further network loading is also possible, compromising on the losses and voltages. It can therefore be said that the most optimal generation scheduling for a given load pattern can be obtained from this method.

7 Conclusion

In this paper charges incurred in power generation, transmission and in loss allocation while meeting loads are evaluated and compared with an existing method. The concept of relative electrical distance is used for evaluation of transmission and loss charges. The method allocates the transmission and loss charges based on the relative location of load nodes with respect to the generator nodes. The method is conceptually simple and can be implemented using the network configuration and generation/load conditions in a day-to-day operation of power systems. The proposed method has been tested on a sample system. Estimated cost for sample system is more economic compared to base case . And is minimum losses are generated using this sample system.

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