

Evaluation of Transmission Wheeling Cost Using MW, MVAR and MVA Mile Methodologies

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ABSTRACT: In electrical power system, transmission wheeling is “the transmission system and associated facilities of the transmission utility are used by another person for conveyance” and this transmission wheeling provide transmission path for the flow of electrical energy between seller and buyer.

Transmission wheeling cost can be evaluated by using MW, MVAR and MVA-Mile methodologies. In MW, MVAR and MVA methods, three different approaches like reverse, absolute and dominant are used. In literature, evaluation of transmission wheeling cost using only MW mile methodology was implemented, where as in the proposed methods both MVAR and MVA Mile methodologies are implemented. These approaches are developed on IEEE 14-bus system in MATLAB software environment.

KEYWORDS: Deregulation, Transmission Wheeling, MW Mile, MVAR Mile, MVA Mile, Single transaction and Multi transaction.

I. INTRODUCTION

Now a days, demand for electricity increases day to day due to increases in population and their sophisticated requirements like air conditions, lightening, personal computers, home appliances, industrial applications etc. Hence, electricity plays a vital role in our daily life, because of the electricity demand, electric power industry is probably the most and largest complex industry in the world. That's why we need to utilize the existing power system in an optimal way. Large power companies dominate electric power industry for many years and they have an overall authority in all activities like generation, transmission and distribution of power. Such companies are refereed as vertically integrated utilities.

The main motive behind the call for deregulating the power industry has been consistent in most of the power industries is to achieve greater efficiency in the system management and promotes better tariff policies. Due to electricity sector competition, electric utilities are forced to innovate and operate in the most efficient and economic manner in order to survive and recover their costs. Encouraging private sectors to investment in power industry by reducing or removing restrictions on power industry is known as deregulation in power sectors. The main benefit in deregulated power industry to be able to provide customers with low cost and reliable electrical supply [2].

The competitive market for electricity has developed at generation end and supply end, but the transmission sector remains monopoly business. The Transco plays a vital role in restructuring of the power industry in the world. The basic parameter of the electric power transmission sector is large sunk and lumped investments need for parallel paths to meet security requirements. That's why it is a time to introduce third parties open access to the transmission network may be seen as a logical outcome. Transmission of active and reactive power from a seller to buyer through the transmission network owned by a third party is known as power wheeling transactions [1].

In literature, only MW mile method for single transaction was implemented. But, in the proposed method MW mile methodology for multi transaction is implemented and MVAR and MVA mile methods for single and multi transactions are implemented.

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II. MVAR-MILE METHODOLOGY

The reactive power flow-mile on each transmission line of the system due to a particular wheeling transaction is evaluated by obtaining the product of the transmission line length and the change in the magnitude of the reactive power flow caused by the transaction. The reactive power flow-miles of each transmission line are added up to represent the amount of the transmission resources used by the corresponding transaction.

Depending on the direction of reactive power flow, MVAR-Mile method can be described as absolute, dominant and reverse approaches [3]. Generally, for flow mile methods, the cost allocated to each individual user, C_k is calculated by using,

$$C_k = \sum_{i=1}^N \frac{L_i F_i Q_i^k}{Q_i}$$

Where

L_i = length of the circuit,

F_i = pre-determined unit cost reflecting the cost/mile of circuit i , (here Rs. /km),

N = total number of lines in the circuit,

Q_i^k = power flow imposed on the circuit i by user k ,

Q_i = capacity rating of circuit i .

A. Absolute MVAR-Mile Approach

The absolute MVAR-Mile method calculates the charges based on the magnitude of the MVAR-Miles of network used by ignoring the direction of the reactive power flow imposed on the circuit by the user. Reactive power flow imposed on the circuit i by the user k , Q_i^k is treated based on the following condition.

$$Q_i^k = |Q_i^k| \text{ for direct flows and reverse power flows}$$

B. Dominant MVAR-Mile Approach

In the dominant MVAR-Mile approach, reactive power flow imposed on the circuit i by the user k , Q_i^k is treated based on the following condition,

$$Q_i^k = Q_i^k \text{ for direct power flows,}$$

$$= 0 \text{ for reverse power flows.}$$

C. Reverse MVAR-Mile Approach

The reverse MVAR-Mile approach takes into account of the reactive power flows that are in reverse direction and the charge for each line is based on the net flows. The reason is that the reverse power flows decrease the burden on the line. Reactive power flow imposed on the circuit i by user k , Q_i^k is treated based on the following condition,

$$Q_i^k = + \text{ for direct power flows or}$$

$$= -ve \text{ for reverse power flows.}$$

III. MVA-MILE METHODOLOGY

As an alternative transmission charging methodologies, MW-Miles methodology has the advantage of acknowledge the extensiveness of the use of a network by the network users, but fails to respect the cost or benefit to the network due to reactive power. A charging method based on DC power flow will inevitably introduce errors in reflecting true cost to a network. MVA-Mile method is an enhanced charging methodology over MW-Mile and MVAR-Mile. It considers the extensiveness of the use of the network by network users due to their active and reactive power

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[4]. Generally, for flow mile methods the cost allocated to each individual user, C_k is calculated by using:

$$C_k = \sum_{i=1}^N \frac{L_i F_i S_i^k}{S_i}$$

Where

S_i^k = Apparent power flow imposed on the circuit i by user k ,

S_i = capacity rating of circuit i .

A. Absolute MVA-Mile Approach

Apparent power flow imposed on the circuit i by the user k , S_i^k is treated based on the following condition,

$$S_i^k = |S_i^k| \text{ for direct and reverse power flows}$$

B. Dominant MVA-Mile Approach

In the dominant MVA-Mile approach, apparent power flow imposed on the circuit i by the user k , S_i^k is treated based on the following condition,

$$\begin{aligned} S_i^k &= S_i^k \text{ for direct flows or} \\ &= 0 \text{ for reverse power flows.} \end{aligned}$$

C. Reverse MVA-Mile Approach

Apparent power flow imposed on the circuit i by user k , S_i^k is treated based on the following condition,

$$\begin{aligned} S_i^k &= +ve \text{ for direct power flows, or} \\ &= -ve \text{ for reverse power flows.} \end{aligned}$$

Since these three approaches of MW, MVAR and MVA mile methods are not able to capture the total cost of transmission, hence at each bus postage stamp is applied. Using the postage stamp approach, the residual costs will be apportioned to each user based on its load level. The residue to each individual user R_k , is calculated by using the relation [5].

$$R_k = \frac{TC.P_{LK}}{P_{LT}}$$

The total cost allocated to each individual user, TC_k is calculated by using,

$$TC_k = C_k + R_k$$

Where

TC= total unremunerated charges,

P_{LK} = load of user k ,

P_{LT} = Total loads of all users.

IV. CASE STUDY

The proposed method uses IEEE 5-machine 14-bus test system. The system contains of 5 generators at bus 1,2,3,6 and 8. The system has a total of 20 transmission lines. Total generation capacity is 490 MW and the initial load is 259 MW. The resistance and reactance are given in the below tables in per unit with a base of transmission line 100 MVA. The cost of each line is Rs 4800 per kilometre.

In this case study generating bus 1 is a slack bus and load is also represented on this bus, based on transmission pricing, there is no flow of power on this bus, so customer will not be charged on this bus.

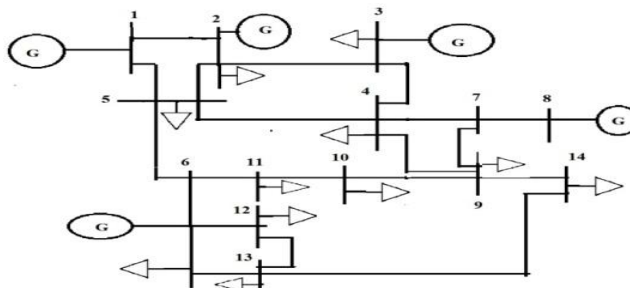


Fig 4-1: The IEEE 14-bus test system

V. RESULT

TABLE I
Newton Raphson load flow analysis for a base case

From Bus	To Bus	P MW	Q MVAR	S MVA	Line Loss MW
1	2	-0.072	26.92	26.920	0.125
1	5	10.717	10.80	10.78	0.111
2	3	25.062	7.753	25.628	0.296
2	4	18.749	3.275	18.813	0.193
2	5	14.292	3.30	14.394	0.112
3	4	-9.44	-1.93	9.740	0.060
4	5	-19.2	-0.33	19.280	0.047
4	7	-19.9	-10.2	20.153	0
4	9	0.531	-1.10	1.221	0
5	6	-2.14	-16.7	16.952	0
6	11	9.521	7.201	11.975	0.119
6	12	8.181	2.928	8.691	0.081
6	13	18.93	9.16	21.041	0.256
7	8	-60.0	-14.7	61.775	0
7	9	40.02	15.39	42.692	0
9	10	3.135	0.679	3.212	0.003
9	14	7.90	1.34	8.017	0.076
10	11	-5.86	-5.13	7.767	0.047
12	13	1.991	1.171	2.315	0.011
13	14	7.174	4.024	8.221	0.106

Newton raphson load flow analysis for a base case is presented in the above Table I, which presents the value of power flow which are transmitted between one bus to the another bus and shows the different line losses [7].

SINGLE TRANSACTION

The value of wheeling cost evaluated with the help of three approaches. These approaches are based on incremental power flow and distance to determine the wheeling cost. In results single and multi transactions are evaluated [6]. Single transaction means the transaction will be done at each bus single buyer at a time.

A. MVAR-Mile method on single transaction

As mentioned in the above the value of wheeling cost for 60MW transaction is evaluated in the three different methods have used in the incremental power flow and the corresponding data causes are shown in the below fig:5.1. In the first

method the value of direct flow is positive and the reverse flow is negative and the result is reduction of positive reactive power as shown in fig: 5.1(a). In second method the value of reverse flow is zero, so addition is only in positive reactive power shown in fig: 5.1(b). In third method, both direct flow and reverse flow are positive. Hence, the result is in positive reactive power shown in fig: 5.1(c).

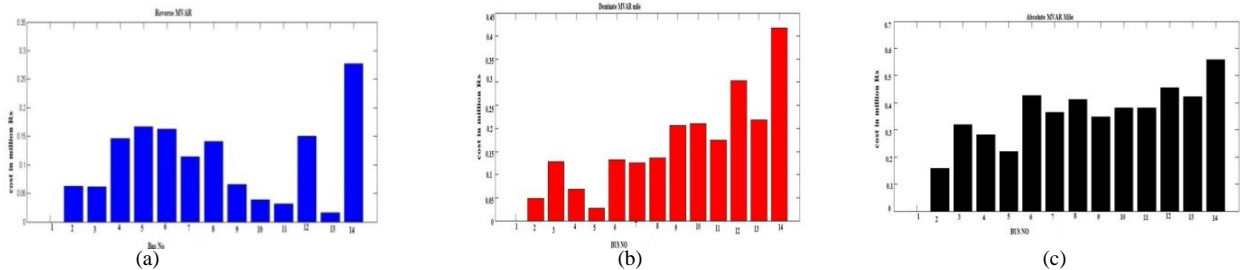


Fig 5.1 Wheeling cost evaluation for 60 MW transaction (a) Reverse approach (b) Dominant approach (c) Absolute Approach (Rs/MW/Year)

B. MVA-Mile method on single transaction

Similarly, the above mentioned three methods are implemented in MVA mile method on single transaction and the corresponding data causes are shown in below fig: 5.2.

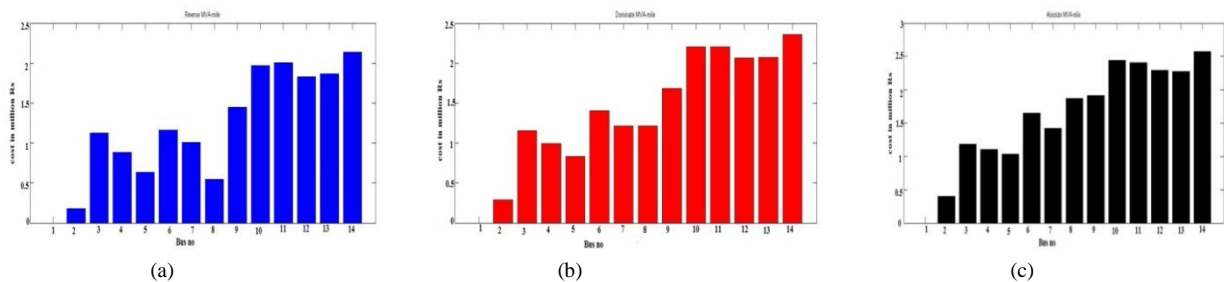


Fig 5.2 Wheeling cost evaluation for 60 MW transaction (a) Reverse approach (b) Dominant approach (c) Absolute Approach (Rs/MW/Year)

TABLE II
Transmission wheeling cost evaluation for 60 MW transaction by MVAR and MVA Mile methods for 14 bus

Bus No	MVAR-Mile method			MVA-Mile method		
	Reverse(Rs)	Dominant(Rs)	Absolute(RS)	Reverse(Rs)	Dominant(Rs)	Absolute(Rs)
1	0	0	0	0	0	0
2	52383.39	68160.71	158704.8	180162.3	292059.6	403957
3	61668.24	128347.3	318362.9	1124426	1155216	1186005
4	145668.5	168341.55	282351.6	881000.3	993501.3	1106002
5	166635	206978.07	220591.1	631221.1	833520.8	1035820
6	162843.7	182006.5	426856.8	1158673	1402240	1645807
7	114042.3	125682	365406.3	1007850	1214547	1421245
8	141281.4	135720.3	412722.1	548146.4	1210081	1872015
9	65303.29	206284.2	347265.1	1444796	1681308	1917820
10	38295.64	209742.9	381190.3	1971349	2204936	2438523
11	31993.36	174932.9	381859.2	2003656	2204079	2404502
12	150099.8	303015.4	455931	1831565	2062374	2293183
13	15551.13	218444.5	421337.9	1862315	2068593	2274872
14	276935.6	418070.7	559205.8	2142754	2358091	2573428

MULTI TRANSACTION

Transmission Wheeling cost evaluation for multi transactions are 80MW and 50MW are shown in below figures. In the first case 80MW of transaction T1 can be evaluated using reverse, absolute and dominant approaches. In the second case 50MW of transaction T2 can be evaluated using reverse, absolute and dominant approaches. Proportional Cost allocation in Percentage can be calculated for respective transactions.

A. MW-Mile on multi transaction

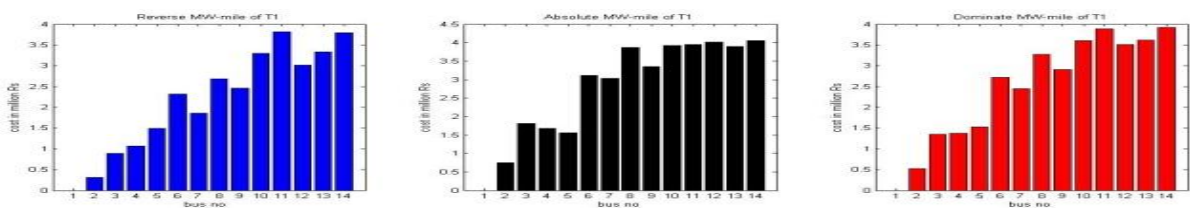


Fig 5.3 Wheeling cost evaluation for 80MW transaction T1

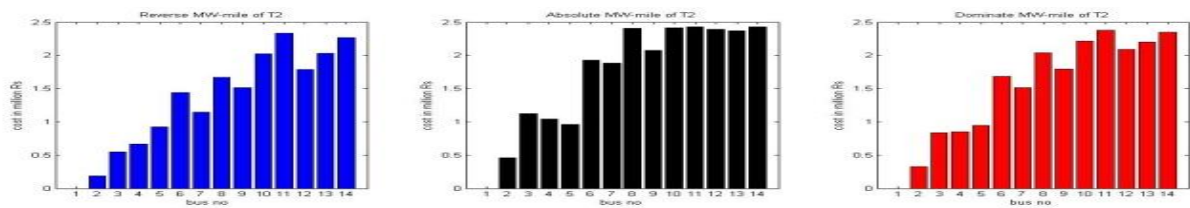


Fig 5.4 Wheeling cost evaluation for 50MW transaction T2

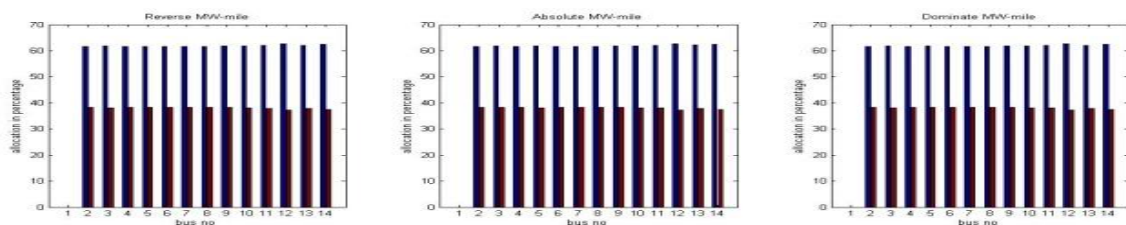


Fig 5.5 Proportional Cost allocation in Percentage by MW mile

B. MVAR-Mile on multi transaction

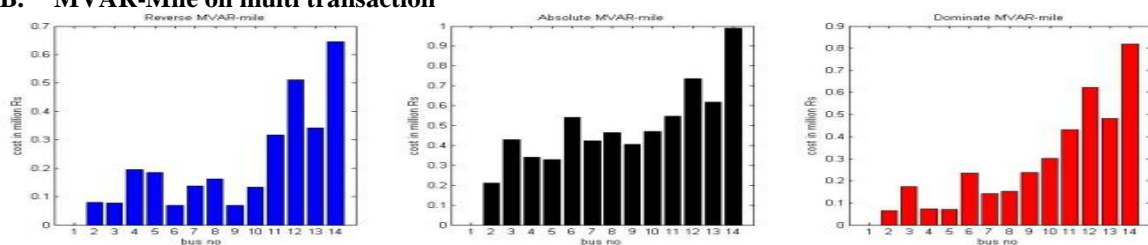


Fig 5.6 Wheeling cost evaluation for 80MW transaction T1

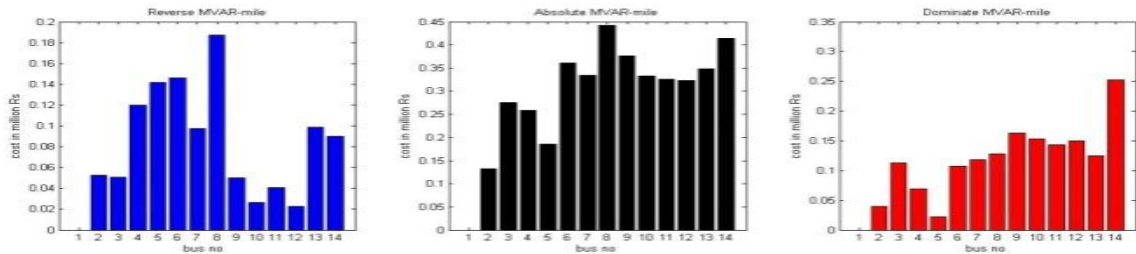


Fig 5.7 Wheeling cost evaluation for 50MW transaction T2

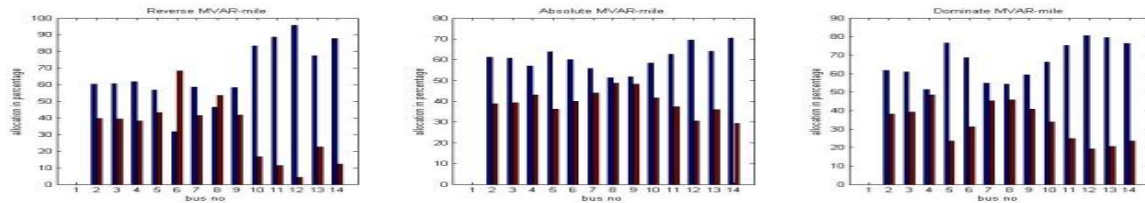


Fig 5.8 Proportional Cost allocation in Percentage by Mvar-mile

C. MVA-Mile on multi transaction

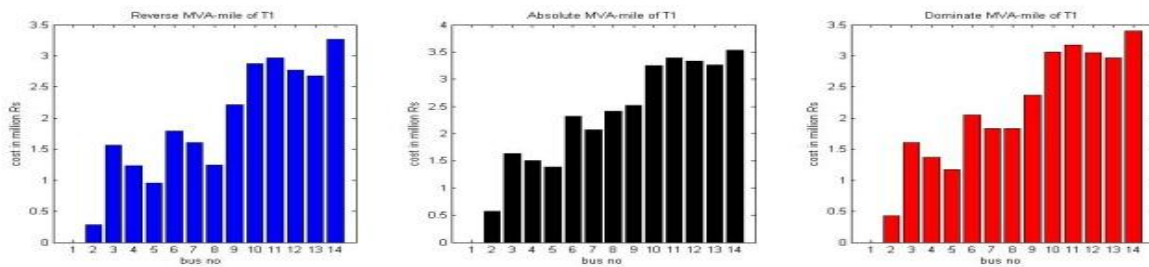


Fig 5.9 Wheeling cost evaluation for 80MW transaction T1

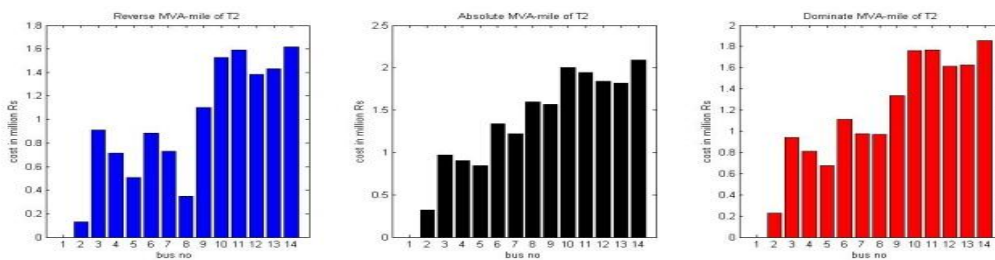


Fig 5.10 Wheeling cost evaluation for 50MW transaction T2

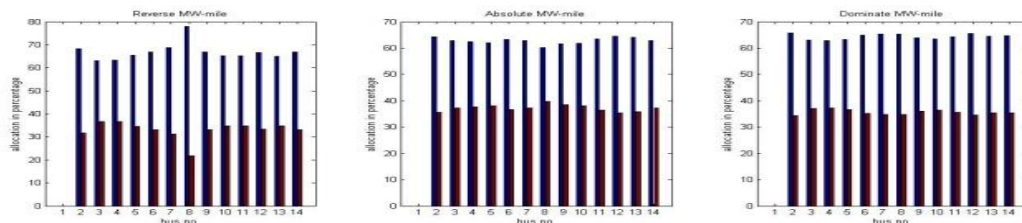


Fig 5.11 Proportional Cost allocation in Percentage by MVA-mile

Fig: 5.5, Fig: 5.8 and Fig: 5.11 shows the proportional cost allocation in percentage by MW, MVAR, and MVA mile methods to the customers.

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VI. CONCLUSION

Based on results it is clear that absolute method provides more revenue to the transmission owner for both single and multi transaction, when compare to reverse and dominate methods. Table II shows that absolute method provides more transmission wheeling cost in MW, MVAR and MVA mile methods for both single and multi transactions. From the results it is also cleared that MVA mile method provides more transmission wheeling cost to the transmission owner compare to the MW and MVAR methods. From the Fig : 5.5, Fig: 5.8 and Fig: 5.11 it is clear that the customer who is consumed less power is to be charged less cost, i.e. he will be charged less proportional to the consumption.

REFERENCES

- [1] Gaurav Jain, Kanwardeep singh and derma (2013) "Transmission wheeling cost evaluation using MW-Mile Methodology" IEEE transactions on power systems, Vol. 58, No 2
- [2] Operation of restructured power systems by kankar Bhattacharya, math H.J. bollen and Jappe E.daalder
- [3] Jing, Z. X., and Duan, X. Z., (2002) "The cost and pricing method of uniform transmission services", Proceedings of Power on International Conference on Power System Technology, Vol. 3,7, pp. 13-17.
- [4] D. Shirmohammadi, C. Rajgopalan, E.R. Award and C. L. Thomas "Cost of Transmission Transaction: Introduction", IEEE Trans. On Power System, Vol.6 No.4, Nov 1991, pp. 1546-1560
- [5] M y hasan,N.h rasid "wheeling charges methodology for deregulated electricity Markets using tracing based postage stamp methods'vol.3 No .2 2011
- [6] Hyde M. Merrill, Bruce W. Erickson, "Wheeling Rates Based on different transactions Marginal cost Theory", IEEE Trans. on Power System, Vol.4, No. 4, Oct 1989.
- [7] power system analysis by H.Saadat

BIOGRAPHY



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