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Transmission Loss Allocation Using the Pro-Rata Method Modified for the Deregulated Electricity Supply

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***Abstract*—The main issue of transmission services in the deregulated electricity supply is how to compensate on harmonic losses associate with the transmission cost. The Harmonic factor is one component of losses caused by electronic devices on the customer in the network. In power system, the deregulation of electricity market is transparent and fair, then all user can transmission charge in accordance with the utilization and power quality. This paper proposes a new scheme and uses the method as a pro-rata modification. The proposal uses some of the harmonic models at each load condition to determine the transmission loss. Based on testing using the 5 bus simple, it can be seen the transmission loss based on the comparison harmonic content of the customer.**

Keywords—harmonic factor; loss allocation; pro-rata method; generalized harmonic distribution factor; deregualated power system

I. INTRODUCTION

Recently, main problem of the deregulated power system is compensation power losses for all user the network or with the transmission charge allocation. In the deregulated electricity supply, all participants in transmission user need one method that satisfy to determine of transmission pricing scheme. With regard to transparency in determine of transmission charge scheme, the method should have the following some features; charge the costumer for the actual usage in network; consider to new power plants about optimal locate that can be minimize of transmission congestion problem and losses; can be predictable and available to ensure recovery of transmission investor [1].

In electricity markets with under pool model, the contribution of users to power flow in a particular line is unknown therefore, a pricing tariff that traces users' contributions to line flow within the transmission grid is important will be introduce. The Generalized Generation Distribution Factors (GGDFs) and Generalized Load Distribution Factors (GLDFs) are DC distribution factors which allocate utilization of the transmission grid to generators and loads respectively [2], [3]. The use of these factors in deregulated power system remains popular whether for security analysis or calculation of transmission pricing and related issues. An approach method more efficient was developed based on AC calculations [4]. Unlike the GGDF which is reference bus, the factors developed from Z-bus overcome such defect and achieve calculations without limitations [5].

A Method has been proposed with using approach of the Bialek Tracing Algorithm [6]. This method that based on the proportional sharing principle by using the Kirchhoff's Current Law. It is assumes that the network node is combine with of incoming flows and the power passing through a node is transferred to lines leaving the node proportionally to the flows of those lines [7]. Then, an approach based on the same principle is known as Kirschen Tracing Algorithm [8]. According to the active power flows that obtained from the results of power flow program, the method introduces new concepts of domain, common, and link. Other approaches use the Graph theory [9] and Proportional Tree Method [10], where both based on the proportional sharing principle as Bialek and Kirschen tracing algorithms. The Graph theory method using concept of a generator to the load on the same bus. The main drawback of the proportional sharing algorithms is ignoring the counter-flow caused by the user in transmission lines. In order to achieve fairness in the electricity tariff that transparently for all user to allocate of transmission losses between all interested parties in a fair and non-discriminatory manner. However, it is not an easy task to perfectly identify the impact of every participant on the transmission losses. So, some models and techniques have been tested to identify the losses contributed to each user in pool electricity market [7]-[19]. Pro-rata method is one of the most common techniques for the loss allocation problem [11]. It is concept based on generators' injections or load in the network. However, the method ignores the user position within the network. i.e., it treats the far user as if it is located at the network center. Some methods have developed using the proportional sharing principle [7]-[10] whereas other approaches are based on circuit theory concepts [12]-[15]. From load flow analysis, the method proposed in [12] is based on the network's Z-bus matrix. The method exploits full set of network equations and does not require any simplifying assumptions. Ref in [16] proposed an approach utilizes the artificial neural network and another method by modified nodal equations to identify the power loss due generators and loads [17]. Like the Z-bus method, the modified nodal equation allocates losses only to the system's nodes as well as both methods generate negative loss allocation. In [19] a technique to allocate losses contribution in each branch for all user using the Current Adjustment Factors (CAFs). It assumes that network users can be effects to the system as well as their interactive effects which are dependent on their contribute to currents flows. According to the power flow optimization, can be to determine of these contributions and adjusts them, due to system nonlinearity, according to CAFs. However, its main drawback is that the method does not consider the counter flows and always allocates positive losses.

II. PROPOSED METHOD

To determine the transmission losses based on harmonic component, we can be formulate:

$$MW_{loss}^{h} = MW_{loss}(\sqrt{1+THD^2}) \quad (1)$$

Where:

$$THD = \frac{\sqrt{\sum_{h=2}^{\infty} I_h^2}}{I_1} \quad (2)$$

Meanwhile, we can be define contribute of harmonic distortion in each load j as C_j^h as follow;

$$MW_{loss,D}^{h} = \sum_{j=1}^{N} C_j^h . MW_{loss,Dj} \quad \text{N=Load} \quad (3)$$

So, Total Harmonic Distorsion (THD) factor for user's as L_{Dj}^{f} is:

$$L_{Dj}^{f} = [f_{TLA}(R)] + C_j^h . MW_{loss,D}^{h} \quad j \in NB; f_{loss,total} > 0 \quad (4)$$

Based on the Pro-rata method, the Equation of the Transmission Losses Allocate method that according to the line parameter R, and $f_{TLA}(R,)$ using Pro-rata method can be expressed as follows;

$$f_{TLA}(R) = L_{Dj} = \frac{L_R}{2}\left[\frac{P_{Dj}}{P_D}\right] \quad (5)$$

L_R = Total losses due line parameter R (Real component)

By assums sharing of load and Generator are 50%;50% resvectively, therefore;

$$L_{Dj} = \frac{L_R}{2}\left[\frac{P_{Dj}}{P_D}\right] + \left[\frac{THD_{Dj}}{\sum_{j=1}^{N} THD_{Dj}} . (MW_{loss,D}^{h})\right] \quad (6)$$

$$L_{Dj} = \frac{L_R}{2}\left[\frac{P_{Dj}}{P_D}\right] + [C_j^h . MW_{loss,D}^{h}] \quad (7)$$

Based on equation in [5], we get power loss without harmonic component as follows;

$$L_R = MW_{loss} . [1 - F_{THD,D}] \quad (8)$$

III. RESULT

The propose method has been test and compared with the Pro-rata method described in this section. Case study have been conducte using the simple test system in Fig.1. For simplicity the transmission charges are totally allocated to generators. The 5-bus test system shown in Fig. 4 and its parameters with the circuit cost reported in [23] used to show the robustness of the proposed pricing scheme.

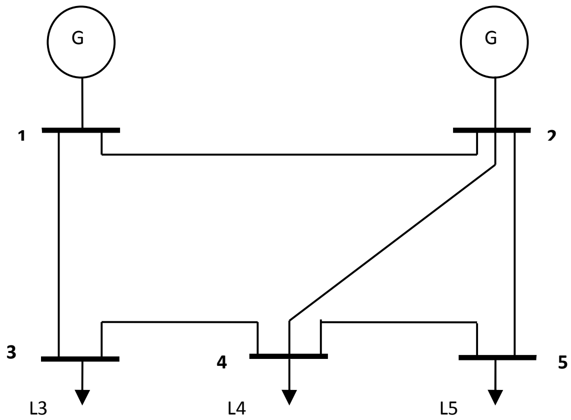

FIGURE I. THE 5 BUS TEST

TABLE I. TABLE 1. DC LOAD FLOW

No.	Generator,G	Load, L
BUS	(MW)	(MW)
1	70,652	0
2	30	0
3	0	15
4	0	28
5	0	55

TABLE II. TRANSMISSION LOSS ALLOCATE BASED PRO-RATA METHOD PROPOSE

G&L	PRO-RATA METHOD Existing (MW)	PROPOSE PRO RATA MODIFIED			
		Model#1(MW)	Model#2(MW)	Model#3(MW)	Model#4(MW)
G1	0,930776855	0,930776855	0,930776855	0,930776855	0,930776855
G2	0,395223145	0,395223145	0,395223145	0,395223145	0,395223145
G1+G2	1,326	1,326	1,326	1,326	1,326
L3	0,202959184	0,240319516	0,244714849	0,206714984	0,263051993
L4	0,378857143	0,383008291	0,397415216	0,438949953	0,382612943
L5	0,744183673	0,781544006	0,762741747	0,759206876	0,759206876
L3+L4+L5	1,326	1,404871813	1,404871813	1,404871813	1,404871813
TOTAL	2,652	2,730871813	2,730871813	2,730871813	2,730871813

Note:Total THD=35% (assums)
Model#1: THD(L1)=15%; THD(L1)=15%; THD(L1)=15%
Model#2: THD(L1)=15%; THD(L1)=10%; THD(L1)=10%
Model#3: THD(L1)=5%; THD(L1)=20%; THD(L1)=10%
Model#4: THD(L1)=20%; THD(L1)=5%; THD(L1)=10%

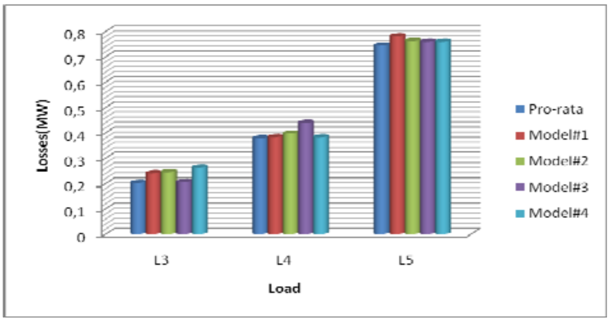

FIGURE II. COMPARISON OF LOSSES ON LOAD BASED ON MODELS

IV. DISCUSSION

Based on Table 2, by the assume of total harmonics on the system of 35% [THD = 35%], total loss of the transmission loss increase from 1.326 to 1.40487 MW MW (5.95%). While, total loss is cause by the influence of harmonics of 0.07887 MW. In this analysis used the pattern for the generator and load distribution (50%: 50%). Total loss of transmission loss allocation depends on the level of THD each load configuration according to the harmonic contribution of each load. In the table 2 also, we can be seen, the loss allocation will be reduce of loos in L4 in model # 4 because the THD is lower than the other loads (L3, L5).

In fig. 2, showing the relationship composition influences the distribution of power losses due to harmonics THD factor is related to the magnitude of each load. Composition of the L5 load nearly as large (54%) except for model # 1, because it has a THD of 15%, respectively, while the other 10%. Percentage distribution of transmission loss based on the contribution of THD on each load in grid.

V. CONCLUSION

The paper proposed has presented the effect of the harmonic factor on transmission usage allocation for line transmission. Customer (industry) who use electricity at THD higher will cost a higher transmission than the cost another users. The advantage this proposed give economic signal for all participant caused any reward and punishment. This proposal can be applied for all user in determining the cost of power or transmission rate.

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