International Journal of Engineering, Management, Humanities and Social Sciences Paradigms (IJEMHS)
Volume 30, Issue 02, Quarter 02 (April to June 2018)
An Indexed and Referred Journal with Impact Factor: 2.75
ISSN (online): 2347-601x
www.ijemhs.com

Transmission Loss Allocation Methodology are Considered

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Publishing Date: June 16, 2018

Abstract

The restructuring of ELECTRICITY SUPPLY INDUSTRY (ESI) started in 20th century introduced deregulation and subsequent open access policy in electricity. And this restructured system brought competition in energy market. This transformation consists of two aspects that are related with each other; restructuring and privatization. However, due to this change, some problems and challenges have cropped up. Among all the problems, the issue of power losses allocation assumes significance. Allocation of transmission loss has become a contentious issue among the electricity producers and consumers. When electrical power is transmitted through a network, it will cause power losses. And the generating unit must generate more power to compensate these losses. And cause of deregulation and competition, no generating unit would like to generate more power to compensate losses. Logically, both generators and consumers are supposed to pay for the losses. If there is no specified method to handle this problem, then there is a probability that the Independent System Operator (ISO) which is a non-profit entity will be responsible for these power losses. It should be the operating units who should cover up these losses. This dissertation work focuses on presenting a strategy for loss allocation among the generating units. A closed form solution for transmission loss allocation does not exist due to the fact that transmission loss is a highly non- linear function of system states and it is a non- separable quantity. In absence of a closed form solution, different utilities use different methods for transmission loss allocation. Most of these techniques involve complex mathematical operations and time consuming computations.

Keywords: *Transmission Loss Allocation, ESI, ISO.*

Introduction

Electricity, one of the most widely used form of energy, has been discovered little more than a hundred years ago. After the breakthrough of Edison's electric bulb, electricity has been commercially produced and marketed in USA. Thomas Alva Edison, regarded as the pioneer of electric power system, first established "The Pearl Street Power Station" in New York, USA in 1882 [2]. Posterior more companies were established. In early days there was no regulation in electric power industries. Small companies operated small generators in municipal areas and sold power to industries and other users in that area. These companies were somewhat inefficient and redundant in the services they provided. Separate companies provided electricity for different needs such as street illumination, industrial power, residential lighting and street car service.

Starting from very small utility networks, electric utilities have grown one thousand million times larger. Now, electric power systems became widespread and composite in nature. From its birth to present, power system networks and utilities have gone through various stages of development. For the last one hundred years electric power systems operated as regulated monopolies.

In a regulated monopoly, an electric power system can be divided into four main functional zones; generation, transmission, distribution and retail service.

a) Generation – generation is the conversion of electric energy from other forms of energy like chemical (gas, coal, hydrogen), nuclear, solar, hydro energy, geothermal energy, wind and wave energy.
b) Transmission – transmission is the transfer of bulk electric energy from one place to another through some transmission network. It connects the generator network and distribution network.
c) Distribution – distribution is the process of delivering electric power from the local network to the consumers.

d) Retail Service – retail service can broadly called retail customer service. Its main function is measuring and billing customers for the power delivered.

Contrary to traditional vertically integrated power system, monopoly is fully removed from generation and distribution (including retail service) sectors in a deregulated power system. As a result, generation and distribution are competitive, with many different companies vying for those businesses. On the other hand, most governments and regulators realized that it is best to have only one transmission system. Therefore, in most cases transmission sector remained regulated. Brazil is trying to deregulate transmission sector, not by creating many transmission 7 lines, but by leasing sections of the transmission lines to different companies.

Transmission loss in electric power system is a natural phenomenon. Electric power has to be moved from generation place to the consumer's place through some wires for consumption. All wires have some resistance, which consume some power. The power consumed in this way is referred to as "loss". Most of this loss is attributable to the heating of the power lines by the electrical current flowing through them. The loss (i2 R) is then lost to the surrounding of the power lines. Transmission loss represents about 5% to 10% of total generation, a quantity worth millions of dollar per year. In Alberta alone, total transmission loss costs about 200 million dollars per year.

Power loss in a Transmission and Distribution network is influenced by a number of factors such as:
- The location of generating plant.
- Types of connected loads.
- Network configuration.
- Voltage levels and voltage unbalance.
- Dynamic factors associated with the operation of large alternating current networks (e.g. power factor, harmonics and the control of active and reactive power).
- The current in the line - this is a square law relationship where doubling the line current would quadruple the line loss.
- The design of lines, particularly the size, material and type of cables; and
- The types of transformers and their loadings.

The objective for this work is:
a) To model a small scale power system network using MATLAB in order to simulate transmission losses.
b) To develop experimental algorithm that can be implemented for small scale deregulated power system network in allocating the transmission losses using already available method.
c) To implement the algorithm for a standard IEEE test bus system.
d) To determine the losses in each line responsible for every generator.

Results and Discussion

The "Loss Function Decomposition" based method has been tested for three different test systems and tested against standard IEEE-3, IEEE-4 and IEEE 6-bus network with the help of Matlab. Matlab 7.8 is used to accomplish work and then the final results have been verified against [24] for 4-bus network and [38] for 6-bus network. For calculation of loss allocation a Mfile is framed according to algorithm.

IEEE-3 Bus Network

Here is the standard IEEE 4 bus network is shown in Figure with its power flow. And all the input data for the calculation of loss calculation is given in Table.

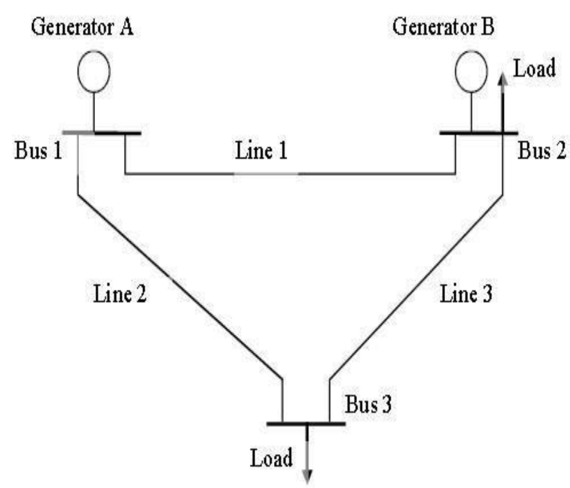

Figure: IEEE-3 bus system

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Results for 3-Bus Network

Table: Branch Power Flow Decomposition for Generators for 3-bus system

Line	G1(p.u.)
1-2	119.19287+34.26967j
	-29.26398-119.30376j
1-3	156.44413-6.40367j
	-141.39436-56.34078j
2-3	-66.65407+57.06369j
	-19.84719+83.79749j

Table: Branch Active Loss Allocation to Generators for 3-bus system

Line	G1(p.u.)
1-2	279.02678
1-3	222.36528
2-3	88.97733

In Fig. there are two generating station whereas result allocates the loss for generator, which is located at 1 bus. The reason behind this is that the difference between generated power and consumed power at bus 2 is negative. Which means the all power? Generated by generator 2 is supplied to the load on the same bus itself and hence plays no role transmission loss allocation.

IEEE-4 Bus Network

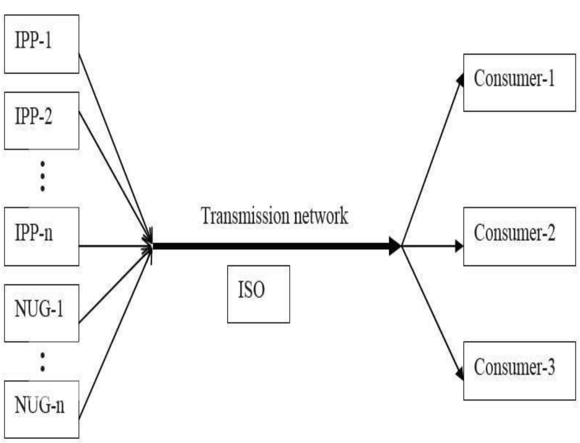

Figure: Four-bus cyclic system diagram and power flow solution

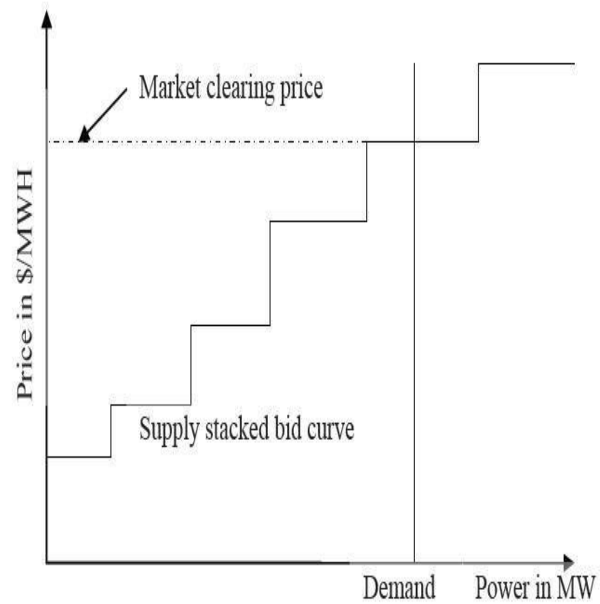

Figure: Converged load flow solution of IEEE-4 bus network

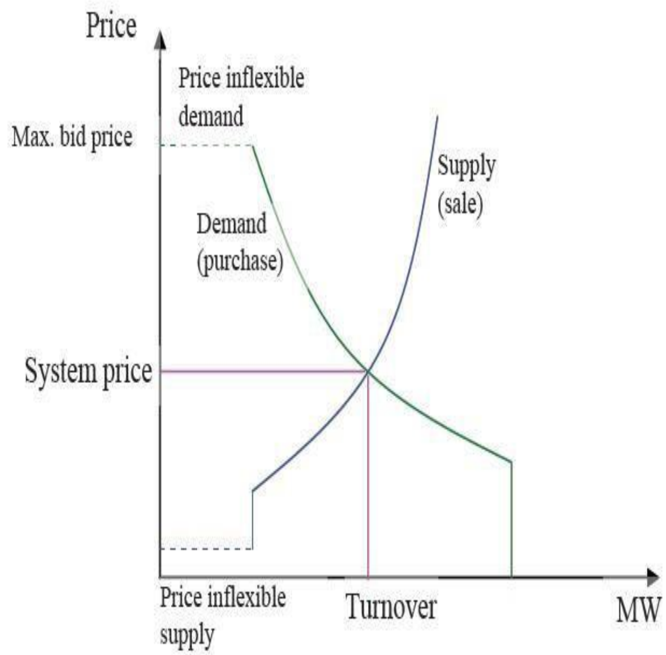

Figure: Line Parameter Data for 4-bus system

Results for 4-Bus Network

Table: Branch Power Flow Decomposition for Generators for 4-bus system

Line	G1(P.U)	G4(P.U)
1-2	0.20879+0.06245j	0.20460+0.04273j
	0.03161+0.00945j	0.03097+0.00647j
1-3	0.15389+0.05023j	0.15182+0.04065j
	-0.03142- [illegible]	-0.03099- [illegible]
3-2	0.01569+0.00117j	0.01552+0.00068j
	0.06998+0.00523j	0.06926+0.00303j
4-2	0.00698+0.00274j	0.00680+0.00190j
	0.23538+0.09251j	0.22928+0.06395j
4-3	-0.00387- [illegible]	0.00387-0.00248j
	0.26150+0.19518j	0.26180+0.16767j

Table: Branch Active Loss Allocation to Generators for 4-bus system

Line	G1(p.u.)	G4(p.u.)
1-2	0.00397	0.00060
1-3	0.00227	-0.00046
3-2	0.00013	0.00058
4-2	0.00017	0.00575
4-3	-0.00000	0.00000

To branch 4–3, its active loss is zero due to its zero resistance, so any allocated loss portions should be zero. To branch 3–2, since the power flow contributed by G4 is larger than that contributed by G1. G4 should be allocated more losses than G1 according to the relationship between the active losses and power flows. For the proposed method, it is consistent with the expected loss allocations.

IEEE-6 Bus Network

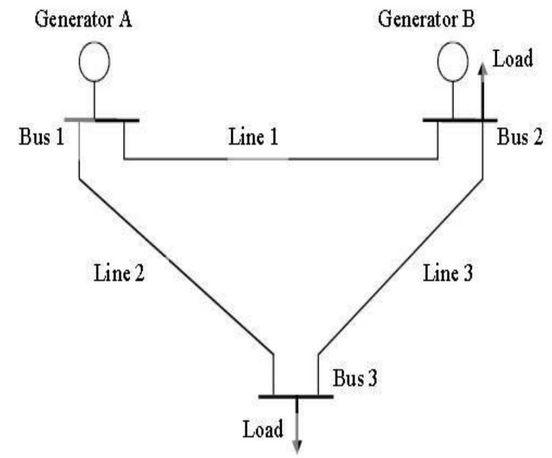

Figure 6: Bus system

Table 6.7: Line Parameter Data for 6-bus system

From Bus	To Bus	R(ohm)	X(ohm)
1	3	0.034200	0.18000
2	4	0.114000	0.60000
1	2	0.091200	0.48000
3	4	0.22800	0.12000
3	5	0.22800	0.12000
1	3	0.034200	0.18000
2	4	0.114000	0.60000
4	5	0.022800	0.12000
5	6	0.000000	0.12000

Table 6.8 Converged load flow solution of IEEE-6 bus network

Bus No.	P(pu)	Q(pu)	V(pu)	Θ(rad)
1	1.2000	0.3820	1.050	0.101
2	0.2636	0.2370	1.050	0.000
3	0.8500	0.4000	1.002	0.025
4	0.4000	0.2000	0.996	-0.001
5	0.2000	0.1000	0.988	-0.001
6	0.2000	0.1000	0.978	-0.015

Results for 6-Bus Network:

Table: Branch Power Flow Decomposition for Generators for 6-bus system

Line	G1(p.u.)	G2(p.u.)
1-3	0.03917	0.00571
2-4	0.00818	0.00707
2-1	0.00085	0.00058
3-4	0.00769	-0.00079
3-5	0.01299	0.00093
1-3	0.03917	0.00571
2-4	0.00818	0.00707
4-5	0.00033	0.00028
5-6	0.00000	0.00000

Table: Branch Active Loss Allocation to Generators for 6-bus system

LINE	G1(P.U)	G2(P.U)
1-3	0.98416+0.36543j	0.96294+0.27641j
	0.14336+0.05323j	0.14027+0.04026j
2-4	0.17809+0.10364j	0.16903+0.09814j
	0.15392+0.08957j	0.14609+0.08482j
2-1	-0.10618+0.06795j	0.11249+0.05690j
	0.03776-0.02417j	0.04000-0.02023j
3-4	0.19081+0.03641 j	0.19054+0.03125j
	0.01950-0.00372j	-0.01947-0.00319j
3-5	0.23058+0.01332j	0.22762+0.00722j
	0.01658+0.00096j	0.01637+0.00052j
1-3	0.98416+0.36543j	0.96294+0.27641j
	0.14336+0.05323j	0.14027+0.04026j
2-4	0.17809+0.10364j	0.16903+0.09814j
	0.15392+0.08957j	0.14609+0.08482j
4-5	0.07164+0.05272j	0.07107+0.05230j
	0.06016+0.04428j	0.05968+0.04392j
5-6	0.15319+0.03816j	0.15215+0.03565j
	0.03857+0.00961j	0.03831+0.00898j

The result for 6-bus system is verified against [38]. To branch 5–6, its active loss is zero due to its zero resistance, so any allocated loss portions should be zero.

Conclusion

A circuit-based method for branch loss orthogonal projection concept. Theoretical analysis and numerical results show that the proposed method has the following characteristics:

• It combines the circuit theories and the concept of orthogonal projection to yield the loss allocation of branches.

• The obtained branch loss allocation has the same expression as the loss allocation principle in[24,38]. Compared with the method in [24,38], the proposed method gives intuitively clear explanation of the obtained branch loss allocation.

• The obtained shares of the buses on the currents and power flows through branches accords with general physical principles, and are independent to the choice of the voltage reference bus.

The equivalence for power injections, the first step of the circuit- based methods, is also discussed. It could be concluded that the equivalence that loads (generators) are converted into equivalent admittances when generators (loads) are converted into current injections, conforms to the practical fact and thus it should be adopted when using the circuit-base methods in pool-based markets.

Future Scope

The presented Loss Function Decomposition to allocate the transmission loss was designed in such a way that it could account the power flow along with the topology of network. Changes in topology of network or may say the different arrangement of network will always
give you different results for loss allocation. A power system structure may also be changed 76
when a new generation station is added, a new transmission line is built or a new bus is added to the existing system, and therefore due to change in network conditions results will be different.

Further research can be carried out to design and develop a Technique to handle future expansions to merge this method with an intelligent unit to make it a universal structure. We can develop a hardware based on this intelligent unit. Utilizing this hardware a loss meter similar to a digital energy meter can be developed which will aggregate losses for generators or loads over a period of time.

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