A Novel Non Iterative Load Flow Method For Loss Allocation And Early Warning System

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Abstract:

Transmission losses between the emerging participants and the consumers are one of the important factors that contribute to transmission cost. Losses of transmission happen when power is transferred from generators to centers of load. Therefore, to determine "fair" tariff, these losses must be reasonably assigned. This paper presents the current state of Kirchhoff and calculates energy fractions that reflect the contribution of generator power to the strength of elements.

Keywords: Transmission losses, Losses, Kirchhoff, Energy Fractions, load flow .

1. Introduction

Any load flow analysis is intended to calculate accurate steady-state voltages of the magnitudes and angles of all buses in the network, the actual and reactive power flows into each line and transformer, assuming known generation and load [1]. The power flow problem is fixed to determine the complicated static voltages at all network buses from which the active and reactive power flows are calculated in each transmission line and transformer [2].

There is a constant rise in the number of energy transactions between the emerging participants and the consumers. In a competitive electricity market, transmission losses are one of the important factors that contribute to transmission cost. Transmission losses occur when power is transmitted from generators to load centers. These losses therefore need to be fairly allocated for determining "fair" tariff. Most of the techniques used to allocate losses use load flow techniques to determine power flow on bus lines and injections. Conventional load flow analysis does not allow transmission losses to be unbundled. This paper implements a novel non iterative method of power fractions which not only enables a loss allocation but also overcomes many limitations of load flow techniques.

In the method of power fraction, a Kirchhoff state is defined and power fractions are calculated that represent the contribution of generator power to element powers. Injected power, node element incidence matrix and network parameters are the only quantities required. The power fractions do not contain any voltage or current phasor quantities explicitly. It provides a solution which is valid for any loading condition and therefore is useful for converging as well as no converging systems. This method therefore, proves to have advantages over the conventional load flow analysis. This paper presents comparative analysis between some other loss allocation methods with the power fraction method.

2. Literature survey

Wencheng Feng et al. [3] proposed early warning and safety countermeasure suggested and implemented for electrical security control. This proposed system has an open and loosely coupled plug-in architecture, which the five sub-systems of automatic monitoring-forecasting and early-warning system on electric supply and demand, static state security monitoring system, voltage security and transient security monitoring and analysis system, examination of protective relaying settings system and frequency monitoring and emergency treatment scheme system are organically integrated and the difficulties in concurrent consideration among the accuracy, continuity and real time acquisition of data in electric power security control monitoring are well settled.

Pragati P. Gupta et al. [4] propose a non-iterative method Modular Load Flow (MLF) not requiring PV or slack bus voltages. There are no issues of non-convergence and the outcome is a definite one-shot solution. Modular Load Flow is used to analyze a grid disruption. Iterative load flow limitations of slack and PV buses-likely causes of load flow non-convergence-do not occur in Modular Load Flow. The technique gives a system overview, can analyze contingencies, and can also be used for post-mortem research.

W. Xu et al. [5] present a non-iterative method for solving load flow equations and based on the Taylor series expansion of the inverse load flow function. Based on the series a non-iterative load flow solution algorithm was proposed and associated solution algorithms are developed which exhibits third-order convergence characteristics. A non-iterative method is is evaluated using four test system.

3. Test system

A three area interconnected system is configured for the study of power fraction. Configuration is done keeping in mind the basic principle of load-generation balance which is irrespective of the tie line parameters between the grids. Figure 1 shows the system taken for analysis indicating the interconnecting tie lines. The tie lines are named as follows: 1st line is between bus 2 and 14, 2nd line is between bus 7 and 4 and 3rd line is between bus 12 and 9. Two broad cases are considered: increase in load and decrease in generation.

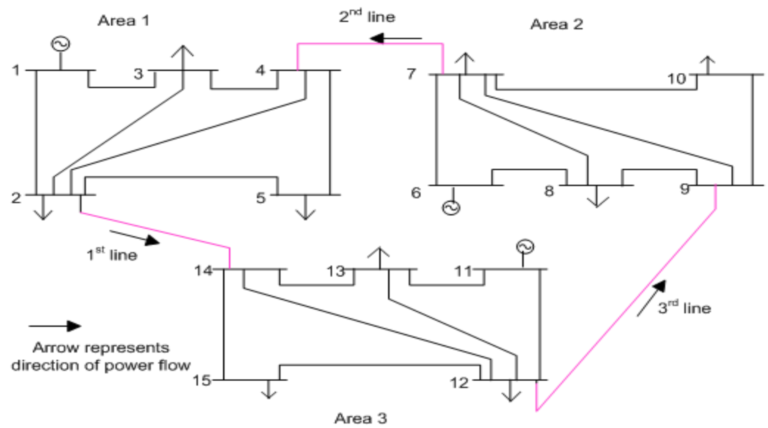

Figure 1 Test system

4. Early Warning System

Even for small changes in loads Vulnerability implies large changes in system conditions, which increases probability of serious outages and hence designs an early warning system for reliable operation of power system. This paper uses the power fraction method in order to design an early warning system. Two broad cases are considered namely: increase in load and decrease in generation, which puts a heavy stress on the tie lines thereby causing them to exceed their MW limit.

4.1 Early warning system due to increase in load

In this, three cases gets studied first the load of individual areas is increased, load of two areas taken together is increased and load of all three areas are increased proportionately and MW limit for all tie lines is taken to be 50 MW.

Load of three areas taken together is increased in a proportionate manner

The load of all the areas is increased proportionately and the power flow (MW) through the tie lines is monitored along with voltage profile.

Table 1 Power flow (MW) due to increase in load in area 1, 2, 3

Tie lines	**initial**	**10%**	**20%**	**40%**	**60%**	**80%**
1st line	28.66	28.63	28.59	28.50	28.39	28.28
2nd line	27.72	27.61	27.50	27.24	26.97	26.70
3rd line	27.94	27.82	27.70	27.44	27.16	26.87

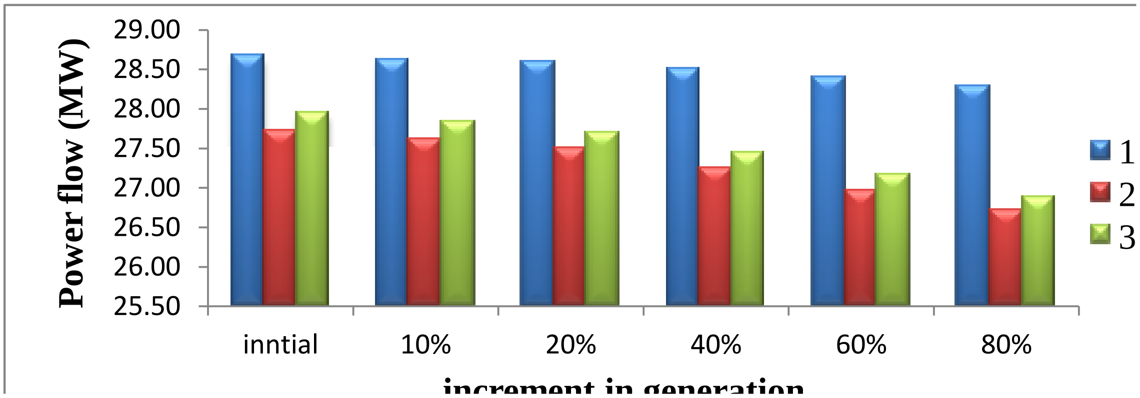

Figure 2: Power flow (MW) due to increase in load in area 1, 2, 3

Table 2 Voltage profile (pu) due to increase in load in area 1, 2, 3

Load node	initial	10%	20%	40%	60%	80%
2	0.996	0.948	0.906	0.835	0.778	0.731
3	0.994	0.945	0.902	0.831	0.772	0.724
5	0.975	0.925	0.882	0.808	0.749	0.699
7	1.000	0.952	0.910	0.839	0.781	0.733
8	0.991	0.943	0.900	0.829	0.771	0.723
10	0.976	0.927	0.883	0.809	0.750	0.700
12	0.996	0.948	0.906	0.835	0.778	0.730
13	0.990	0.942	0.899	0.828	0.770	0.722
15	0.974	0.924	0.880	0.807	0.748	0.698

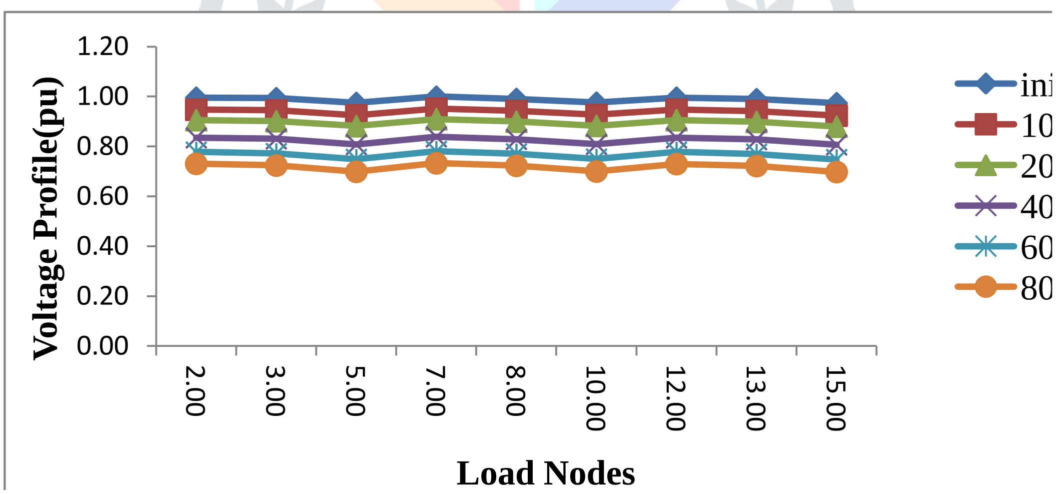

Figure 3: Voltage profile (pu) due to increase in load in area 1, 2, 3

4.2 Early warning system due to decrease in generation

In the three area system, first the generation of individual areas is decreased in a proportionate manner. Then the generation of two areas taken together is decreased proportionately. Finally analysis is done when the generation of all three areas is decreased proportionately. The MW limit for all tie lines is taken to be 50 MW.

<u>Generation of three areas taken together is decreased in a proportionate manner</u>

The generation of all the areas is decreased proportionately and the power flow (MW) through the tie lines is monitored along with voltage profile.

Table 3 Power flow (MW) due to decrease in generation in area 1, 2, 3

Tie lines	initial	10%	20%	40%	60%	80%
1st line	28.66	25.79	22.93	17.20	11.47	5.73
2nd line	27.72	24.96	22.19	16.66	11.11	5.55
3rd line	27.94	25.15	22.37	16.79	11.20	5.60

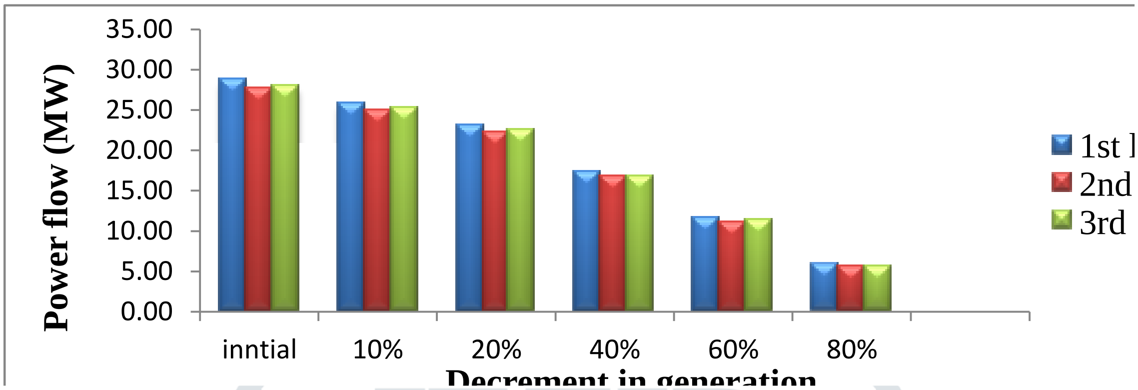

Figure 4: Power flow (MW) due to decrease in generation in area 1,2,3

Table 4 Voltage profile (pu) due to decrease in generation in area 1, 2, 3

Load node	initial	10%	20%	40%	60%	80%
2	0.996	0.946	0.892	0.772	0.631	0.446
3	0.994	0.943	0.889	0.770	0.629	0.445
5	0.975	0.925	0.873	0.756	0.617	0.436
7	1.000	0.949	0.895	0.775	0.633	0.448
8	0.991	0.941	0.887	0.768	0.628	0.444
10	0.976	0.927	0.874	0.757	0.618	0.437
12	0.996	0.945	0.891	0.772	0.631	0.446
13	0.990	0.940	0.886	0.768	0.627	0.443
15	0.974	0.924	0.871	0.755	0.616	0.436

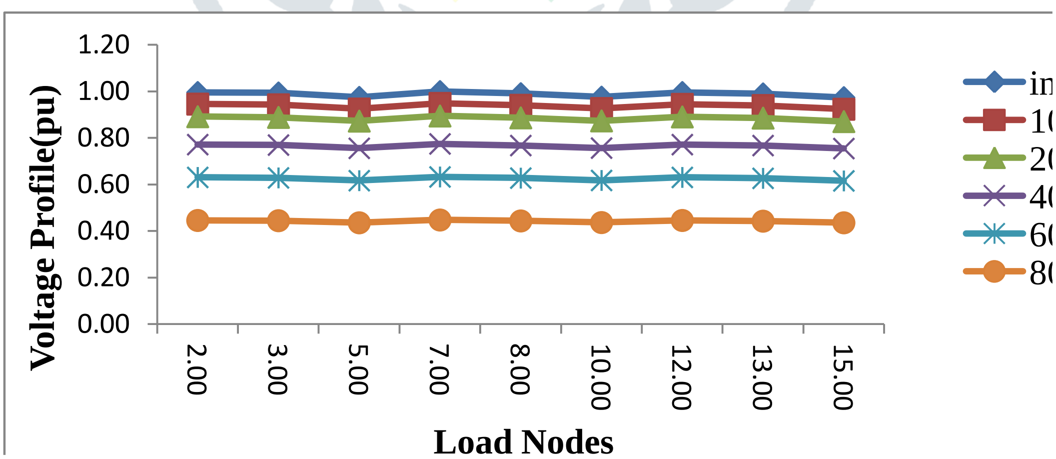

Figure 5: Voltage profile (pu) due to decrease in generation in area 1, 2, 3

5. Results Summary

In all the case studies the tie line gets overloaded at some point of loading or at some point of decrease in generation. This is accompanied by a voltage dip also. But in some cases the voltage dip is very severe which is not at all acceptable. This creates a need for measures to prevent such situations.

6. Conclusion

A deregulated power system consisting of an interconnected network does not operate with security as a main priority. Therefore, these systems are vulnerable to blackouts as compared to vertically integrated systems [11]. Under normal conditions, conventional load flow procedure enables calculation of power flows and voltages. When a system faces any vulnerable condition, the analysis by load flow becomes difficult. A system can be under vulnerable or stressed condition in many cases like in case of heavy loading. If such a condition persists, then it may lead to catastrophic incidents like blackout. In order to prevent any system from going in to such a situation it is very important to diagnose various factors which may take the system to a critical state. Early warning systems can be designed by conducting studies reported in the case studies. These studies cannot be performed by iterative load flow methods due to their limitations.

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