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A Review on Load Flow Analysis

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Abstract:
In present scenario demands are increase due to heavily loaded customers. In last decade the load are taken constant power i.e loads are depends on the active and reactive power. But now days the loads are very sensitive, so loads are depends on the voltage and frequency. The main objectives of this survey are to collect the information from the previous literatures.

Keywords: *Load flow Analysis, NR Method, GS Method, FDLF, Voltage Sensitive Load, Power Constant.*

1. Introduction

The power system all over the world is continuously expanding in size and growing in complexity. The need for various system studies is much more today than ever before. A large number of the technique have been reported in literature over the past quarter century for solving power flow and transient stability problems and yet there continues a constant and persistent search to find batter and still better solution algorithm in terms of speed, memory and reliability aspects. Electric power utilization must be improved in present scenario while taking into account the security and reliability of power flow. Overall voltage profiles are deteriorated and system stability and security are decreased due to the reason that, transmission line powers flows are not uniform. In some lines it's below the standard value whereas in some it's way above the normal power flow values. Due to this the low voltage condition comes into picture and hence most of the electrical loads are connected to low voltage power distribution systems.

Electrical loads of a system can be told to be comprising of various residential, industrial and municipal loads. Practically the active and reactive powers of loads of a distribution system are dependent on system voltage and frequency variations. Also, the active and reactive power characteristics of various types of load differ from each other. Frequency deviation is considered insignificant in case of static analysis like, load flow studies. The effects of voltage deviations are mainly taken into account for getting faster and accurate results. The results improve the quality of all following system studies that use the same load flow analysis for further calculations and simulations.

Load flow is the procedure used for obtaining the steady state voltages of electric power systems at fundamental frequency [1] Load flow in power system parlance is the steady state solution of the power system network. The power system is modeled by an electric network and solved for the steady state powers and voltage at various buses. The direct analysis of the circuit is not possible as the loads are given in terms of complex power rather than impedances and the generator behaves more like power sources than voltage source.

The main information obtained from the load flow study comprises of magnitudes and phase angle of load bus voltage, reactive powers and voltage phase angles at generator buses, real and reactive power flow on transmission line together with power at the reference bus, other variable being specified.

In load flow analysis, we are mainly interested in voltage at various buses and power injection in to transmission system. The power system network of today is highly complicated consisting of hundreds of buses and transmission links. Thus the load flow studies involve extensive calculations.

The main objectives of the survey are twofold to explore the possibilities of developing some improved load flow algorithms and to investigate the possibilities to exploring new and yet simple and efficient equivalency technique for realization of dynamic equivalents suitable for transient stability studies. Accordingly, the work reported in this thesis has been divided into two board sections, one dealing with development of some improved load flow algorithms and the other with the development of some new dynamic equivalents for transient stability studies.

The load flow study provides information about line and transformer loading (as well as losses) throughout the system and voltages at different points in the system for evaluation and regulation of the performance of the power systems. Further study and analysis of future expansion, stability and reliability of the power system network can be easily analyzed through this study. Increasing demand of the power and complexity of the power system network, power system study is a significant tool for a power system operator in order to take corrective actions in time. The advent of digital computers, load flow solutions were obtained using network analyzers.

2. Load Flow Methods

The studies for the load flow calculations started with the Ward & Hale hiethod [2] in 1956.
In general load flow methods can be classified in two categories:

- AC Load Flow Methods
- DC Load Flow Methods

2.1. AC Load Flow Methods

Generally AC Load flows Method are conventional Load flow Methods.
AC power flow analysis is basically a steady-state analysis of the AC transmission and distribution grid. Essentially, AC power flow method computes the steady state values of bus voltages and line power flows from the knowledge of electric loads and generations at different buses of the system under study. In this module, we will look into the power flow solution of the AC transmission grid only (the solution methodology of AC distribution grid will not be covered). Further, we will also study the power flow solution technique when an HVDC link is embedded into an AC transmission grid. Also, we will be considering only a balanced system in which the transmission lines and loads are balanced (the impedances are equal in all the three phases) and the generator produces balanced three phase voltages (magnitudes are equal in all the phases while the angular difference between any two phases is 120 degree).
The solution of the simultaneous nonlinear power flow equations requires the use of iterative techniques for even the simplest power systems
There are many methods for solving nonlinear equations, such as Gauss Seidel, Newton Raphson, and Fast Decoupled.
Due to robust convergence, Newton Raphson three-phase power-flow was proposed by Wasley and Shlash and later by Birt et al. [3]. The fast decoupled three-phase Newton Raphson was introduced by Arrillaga and Arnold [4].The Y Bus Gauss-Seidel method was introduced by Laughton *et al.* [5].
Gauss-Seidel method is a method used to solve a linear system of equations. The technique is named after the German mathematician Carl Friedrich Gauss and Philipp Ludwig von Seidel. The Gauss- Seidel method is an iterative technique for solving a set of non-linear algebraic equations [6]
Authors of [7] presented a fast approximated method for solving the ac power flow problem for line and generator outages. The method is significantly more accurate than any linear approximation and significantly faster than the Newton- Raphson method for an approximate solution. The method has applications in system planning and operations where approximate ac power flow solutions are acceptable. The method is applicable to system planning for rapid location of design criteria violations and it is particularly well adapted for system operation use as an on-line security monitor.
Efficiency is achieved through decoupling of real and reactive power equations, sparse matrix methods, an experimentally determined iteration scheme and the use of the matrix inversion lemma to simulate the effect of branch outages.
Authors of [8] treated the inexact Newton-Krylov method to solve load flow problems. Authors explore the use of an iterative method to solve the linear systems, leading to an inexact Newton-Krylov method.
The solution of the power flow is one of the most important problems in electrical power systems. These traditional methods such as Gauss-Seidel method and Newton-Raphson (NR) method have had drawbacks up to now such as initial values, abnormal operating solutions and divergences in heavy loads. In order to overcome these problems, the power flow solution incorporating genetic algorithm (GA) is introduced [9]
Authors of [10] present a method for load flow analysis in radially operated 3-phase distribution networks without solving the well-known conventional load flow equations. These methods can be applied for distribution systems in which the loads are unbalanced.Size of matrix used is very small compared to those in conventional methods, memory used is very small, the speed is very high, and the relative speed of calculation increases with the size of the system.
In paper [11] first order Newton Raphson and second order Newton Raphson load flow methods, were reviewed in term of convergence characteristics and mismatch vector, in well and ill conditioned system. From the reviewed, it was shown that second order load flow able to detect ill In order to study the SOLF effectiveness the method has been tested using IEEE 30 bus test system and 13 bus ill-conditioned system. It was found that SOLF is more superior to NR method in term of convergence and solution time.
In paper [12] shows as to how the application of Fuzzy technique in choosing an appropriate acceleration factor reduces the number of iteration and helps in obtain the solution at a faster rate with optimum number of iteration.
Author proves that application fuzzy logic concept to change the acceleration factor after every iteration helps in minimizing the number of iteration and improves the efficiency of the method.
Authors of [13] provides an algorithm for a fast continuation load flow to determining critical load for a bus with respect to its voltage collapse limit of an inter connected multi-bus power system using the criteria of singularity of load flow Jacobian matrix. The validity of the proposed method has been investigated for the IEEE 30 and IEEE 118 bus system.
In paper [14] a new method of load−flow technique, using fuzzy logic concept, for a balanced radial distribution network has been presented. The proposed technique does not consider the flat voltage for all the nodes and does not reduce the network into its equivalent network. Also in the proposed method the method of sequential numbering of the network has also been eliminated. It is

applicable to distribution network with any number of feeders, lateral(s) and sub−laterals having either sequential or non sequential branch or node numbering

In paper [15] a dual formulation for load flow studies is presented. It involves use of dual variables and specification for series connected devices in much the same way as for conventional load flow. Also load flow studies with and without FACTS devices are carried out on a sample eight-bus system and the effectiveness of these devices are studied from the load flow results.

In power system transmission, it is desirable to maintain the voltage magnitude, phase angle and line impedance.

Therefore, to control the power from one end to another end, this concept of power flow control and voltage injection is applied. The results obtained by these modes are explained in this paper. As it can observed from above, that in case of power flow control mode for the L-G and L-L-G fault, active power is increased with same reactive power with the use of UPFC. Also the simulation result shows the effectiveness of UPFC to control the real and reactive power. Modelling of the system and its result analysis has given clear indication that UPFC is very useful for organize and maintaining power system. The voltage profile of the system has improved which increase the net power flow between transmission lines. Transient stability is also improved by UPFC and faster steady state stability is achieved. This work can be further enhance in terms of finding optimal placement of UPFC in power system and other FACTS controller such as Inter-phase Power Controller (IPC) can be used in place of UPFC.[16]

Authors of [17] presents Data Compression Simulated algorithm for load flow calculation in electrical power systems. Real time monitor of grids required less computation time in calculation of power system analysis. The proposed algorithm used Data compression technique tested different systems and results shows it is efficiency. More accuracy for large systems will need more iterations calculation which mean increasing time consumption, while Run Length Encoding (RLE) algorithm is fitness to optimized calculation numbers to exact number cause it has no zero values included. Network structure was represented as one dimension vector instead of 2D Matrix and it is effectiveness results was valid, by avoid exponential increased, by utilized this algorithm. Matlab results obtained by applied this algorithm match theoretical results.

Authors of [18] introduce a multiple-frequency three-phase load flow model was developed. There are two new sub-models including the fundamental power flow (FPF) and harmonic frequency power flow (HPF) model. The proposed general-purpose methods are better performers than conventional power flow solutions and are very robust.

In paper [19] a simple and efficient computer algorithm has been presented to solve unbalanced radial distribution networks. The proposed method has good convergence property for any practical distribution networks with practical *R/X* ratio. Computationally, this method is extremely efficient.

Authors of [20] proposed a new efficient method is proposed for load-flow solution of radial distribution networks. Simple transcendental equations are used to relate the sending-end voltage, receiving-end voltage and voltage drops in each branch of the distribution system.

In paper [21] gives an overview of the various load flow techniques of the weakly meshed distribution system which are very efficient, because various classical methods are not having sufficient convergence criterion for solving the large distribution system.

In paper [22] a simple and powerful algorithm has been proposed for balanced radial distribution network to obtain power flow solution. It has been found from the cases presented that the proposed method has fast convergence characteristics when compared to existing methods. The algorithm is found to be robust in nature. The method can be easily extended to solve three phase networks also.

In paper [23] a procedure is established for solving the Probabilistic Load Flow in an electrical power network, considering correlation between power generated by power plants, loads demanded on each bus and power injected by wind farms. The method proposed is based on the generation of correlated series of power values, which can be used in a Monte Carlo simulation, to obtain the probability density function of the power through branches of an electrical net-work.

Author of [24] is given to the techniques to deal with balanced/unbalanced, radial/weakly meshed/mesh configuration, with or without Distributed Generation (DG) and convergence criteria.

In paper [25] a simple and fast load flow solution algorithm for distribution system was proposed, which is basically a power summation method. The proposed scheme of line identification makes the method quite fast. This scheme reduces a lot of memory and CPU time as it minimizes the search process in the radial distribution system. The convergence of the method is accelerated by a judicious choice of the initial voltages and power losses are taken into consideration from the first iteration. Load flow problem under different load conditions and for various ratios R/X has been successfully treated by out method.

C. S. Indulkar et al in paper [26] conducted load-flow analysis of a five-bus test system containing voltage sensitive loads for a typical five-bus seven-line sample power system. Generalized equations that are suitable for the voltage sensitive loads and applicable to the Newton-Raphson method are developed. As compared with the load flow solution for constant power load, it is shown that the constant current and constant impedance loads require additional iterations to obtain the solution. The load flow solutions with voltage sensitive loads are more accurate than those for the constant power load.

2.2. DC Load Flow Methods

DC Load flow is a tool used for contingency analysis. Due to its simplicity and robustness, it also becomes increasingly used for the real-time dispatch and techno economic analysis of power systems. DC power flow is a much used tool in power system analysis, especially in techno-economic studies, related to electricity markets, and contingency analysis. Earlier work quantified the main indexes of the power system for an accurate solution when utilizing DC power flow: especially a flat voltage profile and a high X/R ratio improve accuracy.

In this paper, the authors examined the usefulness of this tool when the power system contains power flow controlling devices, and especially PSTs. The issues with modeling of power flow controlling devices for DCpower flow are examined. This modeling introduces an additional error caused by the approximation of a sine function by its argument. The DC power flow methodology is tested on a modified version of the IEEE 300 bus system, to which a power flow controlling device is added. Overall, the introduced error by inaccurate representation of the power flow controlling device is relatively small, increasing with higher phase shifting angles (about 5 % of the line flow). However, this is an additional error and precaution has to be taken when drawing conclusions based on simulations using DC power flow when PSTs are involved [27]

3. Conclusion

This paper has presented a review literature of load flow. Generally in load flow analysis we are taken constant active and reactive power but now day the loads are very sensitive they depends on the voltage as well as frequency.

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