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A Review Article of Power Load Flow Analysis for Active Islanding Mode

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Abstract- Power flow studies are very important in the planning or expansion of power system. With the integration of distributed generation (DG), micro-grids are becoming attractive. So, it is important to study the power flow of micro-grids. In grid connected mode, the power flow of the system can be solved in a conventional manner. In islanded mode, the conventional method (like Gauss Seidel) cannot be applied to solve power flow analysis. Hence some modifications are required to implement the conventional Gauss Seidel method to islanded micro-grids.

Keywords- Y-matrix, Z-matrix, Load Flow, Fuzzy Logic, and Artificial Neural Network.

I. INTRODUCTION

With larger portion of growing electricity demand which is being fed through distributed generation (DG), the concept of microgrid has been introduced as one of the most promising technologies to modernize current power system. Being able to operate in both grid-connected and islanded mode, a microgrid manages and controls distributed energy resources, energy storage systems and loads, most of them are power electronic system interfaced, in a coordinated and hierarchical way [1], [2]. Similar to the bulk power system, the steady-state power flow analysis plays a very important role for the planning and operational stages of the microgrid in terms of systematic analysis, protection, coordination design, network optimization and optimal operation, and so on, which requires more investigation when applied to the microgrids, especially during islanded operation mode.

II. POWER FLOW

Power flow studies play an important role in the planning, expansion and optimal operation of power system. Well developed power flow methods (Gauss, Gauss-Seidel, NewtonRaphson) are presented in [3]. In the recent years, scientists have focused their research in the area of grid integration of renewable energy and distributed generation (DG), which has lead to the evolution of micro-grids.

These micro-grids operate either in grid connected or islanded modes. In grid connected mode, the frequency is maintained by the grid, but in islanded mode it are not constant. Several approaches have been proposed to solve power flow for islanded microgrids [4], [5]. However, these approaches are based on the assumption to classify the droop bus (the bus at which the DG is connected) either as slack, PV or PQ bus, which is invalid in case of islanded micro-grid because size of DGs are usually small and cannot act as an infinite source of power. Also in islanded micro-grid, classification of all the DGs to be PV or PQ buses is not possible [6].

POWERLFA is designed to perform the steady state load flow analysis for the given system. Fast-decoupled load flow algorithm is used to solve the non-linear power flow problem. Sparse storage and matrix ordering techniques are used in the program to reduce the memory requirements. Fast computational methods are made used to speed up the execution. Generation and load regulation characteristics are considered in the model to determine the new system steady state frequency at which the loads and generation are balanced. Power flow programs are used to study power system under both normal operating conditions and disturbance conditions. The essential requirements for successful power system operation under normal conditions require the following:

- Generators supply the load plus losses.
- Bus voltage magnitudes remain close to rated values.
- Generators operate within specified real and reactive power limits.
- Transmission lines and transformers are notoverloaded.

The power flow computer program POWERLFA, commonly called, as load flow is the basic tool for investigating the above requirements. This program computes the voltage magnitude and angle at each bus in a power system under balanced steady state conditions. Real and reactive power flows for all equipment interconnecting the buses, as well as equipment losses, are also computed. Both existing power systems and proposed changes including new generation and

transmission to meet projected load growth are of interest.

III. LITERATURE REVIEW

Fang Dazhong, "Power flow analysis of power system with UPFC using commercial power flow software": This paper proposes a new and efficient approach of load flow analysis for UPFC embedded power systems. The main characteristic of the approach is that an equivalent network without UPFCs, which is obtained easily according to two basic schemes of UPFC control, is used for load flow analysis of the original system including UPFCs. Then control parameters of each UPFC are determined by the load flow solution. The nature of the approach means that commercial software for power system analysis can be employed for load flow solutions of systems with UPFCs, hence it has the advantages of the conventional techniques in load flow analysis. Numerical examples are given to indicate that the approach is reliable and efficient.

Li Xiaobin, "Active power flow adjustment based on sensitivity analysis of DC load flow model":Power flow adjustment is absolutely significant and widely used in grid operation mode arrangement, static safety analysis, safety corrective control, and the transmission congestion management. According to the needs of active power control and adjustment, new and effective methods should be developed and used to alleviate the overloaded branches and tie line groups. A practical active power flow adjusting method based on the sensitivity analysis of DC load flow model is presented in this paper. In the proposed algorithm, firstly, DC load flow is used to calculate branch active power flow sensitivity with respect to the generator node active power injection. Further, the method of RAEM (reverse and equivalent match) is used to adjusting the value of generator node active power, and to avoid the involvement of balance machine. Simulative calculation of standard IEEE-30 test system proves that this approach is fast, practical, and robust.

G. Mueller, "PMU placement method based on decoupled newton power flow and sensitivity analysis": Complex power systems need more observability in critical situations. Synchron phasor measurement is a new technology that improves power supply reliability and quality. PMU measure various system parameters extremely precisely and rapidly. Every PMU measurement receives a GPS synchronized time stamp, thus making it possible to perform precise comparative analyses and obtain an overview of the complete system. Since system operators have to work economically and these units and their installation incur costs, they need an algorithm for their optimal placement. This paper presents a concept based on a decoupled Newton-Raphson power flow analysis and a sensitivity analysis, which helps place PMU optimally. The theory behind the algorithm is elucidated and results of a system test are presented.

H. Schau, "Identification of the dominant harmonic source in the LV network on the base of anomalous power flows considerations": The localization of the dominant harmonic distortion source in the electrical network is one of the practical tasks in the consideration of the power quality in electric power systems. The conventional methods of the estimating of the impacts of the utility and the customer to the harmonic distortion at the network node are the harmonic power flow analysis as well as the correlation analysis of the harmonic voltage and current phasors. The practical use of both methods is discussed below by means of the example of the identification of the dominant harmonic source in the LV supply feeder of an industrial consumer. Based on the analysis carried out it is shown that the direction of harmonic active power flows is a more common and reliable criterion in comparison with the correlation analysis for the identification of dominant harmonic sources in electric power systems.

Ming Lu, "Alternate iteration method for power flow analysis of interconnected system of fractional frequency transmission system and main grid": Fractional frequency transmission system (FFTS) is utilized to transmit large-scale and remote wind power. By adopting a lower frequency (50/3 Hz), FFTS could reduce the electric distance of transmission lines, thus lowering the transmission loss. In order to analyze the interconnected system of FFTS and main grid, the power flow calculation should be conducted. This paper introduces a new method to calculate the power flow of the interconnected system and analyzes the control strategy of reactive power of FFTS. Firstly, a quasi-steady model of the cycloconverter is elaborated. Secondly, the validity of the model is verified through power flow calculation and PSCAD/EMTDC simulation of a simplified system. Finally, an alternate iteration method for power flow calculation of the interconnected system is proposed. Based on the IEEE-30 system, the power factor control of FFTS is discussed considering various integration buses of wind power.

RaheelMuzzammel, "Non-linear analytic approaches of power flow analysis and voltage profile improvement": Power-flow analysis or load flow analysis is a numerical analysis of the flow of electric power in an interconnected system. The goal of this analysis is to obtain complete information of angle and magnitude of voltage for each bus in a power system for specified load and generator real power and voltage conditions. Once the required information is achieved, real and reactive power flow on each branch as well as generator reactive power output can be analytically determined. Due to the nonlinear nature of this problem, numerical methods are

employed to obtain a solution within an acceptable tolerance. In this paper, Gauss-Seidel, Newton-Raphson and Fast-Decoupled methods are compared with respect to their performances, convergence rates and outputs for IEEE 14 bus system. Further, fact controllers i.e., static VAR compensator for improvement in the voltage profile is also designed and implemented and a comparison will also be drawn between the voltage profiles with or without the absence of fact controllers.

Xiangping Kong, "Analysis on the Transmission Line Power Flow Control Strategy of the UPFC Project in Western Nanjing Power Grid": Among the versatile control strategies in the control system of unified power flow controller (UPFC), the transmission line power flow control strategy is the most important one, which can help UPFC to realize its core function of regulating power flow. Based on the UPFC project in western Nanjing power grid, which is the first modular multilevel converter (MMC) based UPFC project all over the world, the function configuration and hierarchical structure of the UPFC control system are introduced firstly in this paper. Besides, the details of the transmission line power flow control strategy are presented. With the above control strategy, the active power and reactive power of the transmission line can be regulated quickly, independently and safely. Eventually, the field test results are demonstrated to validate the effect of the above control strategy.

W.A. Mittelstadt, "Voltage stability analysis: V-Q power flow simulation versus dynamic simulation": The author congratulates the authors of the original paper (see ibid., vol.15, no.4, p.1354-9, 2000) on their excellent and needed comparison of two methods of performing voltage stability analysis. He argues that these results emphasize the importance of using the best possible model in planning and operating decisions affecting the reliability and cost of the electric transmission system. He believes that the two-step process suggested of using V-Q or P-Q analysis for screening, and using dynamic simulation for critical cases affecting operating limits or investment decisions, should be followed. The original authors' response to this discussion is also included.

Chunguang Liu, "Seismic security analysis and flow load control of power supply system": In this paper, seismic safety assessment method of power supply system is discussed, and the network model and system flow load control method are suggested. Specially, seismic sensitivity analysis and power flow control analysis methods of power system are studied deeply. Finally, an example of power supply system is analyzed, and some meaningful conclusions have been gotten. All of above will be a basis in anti-earthquake analysis, safety assessment and damage mitigation of power supply system.

Mehmet Kurban, "Parameters and Power Flow Analysis of the 380 -kV Interconnected Power System in Turkey": This paper presents all the general overview of the interconnected power system in Turkey which consists of 30 generation and 35 load buses, totaling 65 buses connected each other with 380-kV power transmission lines. Also the power flow analysis implemented using MATLAB is made to find optimal operating points of the system and to make power systems generation planning. All data used in this analysis is taken from TEIAS (transmission system operator of Turkey) and EUAS (electricity generation Co. Inc.).

Arif Ahmed, "Weather-Dependent Power Flow Algorithm for Accurate Power System Analysis Under Variable Weather Conditions": Accurate power flow analysis is essential to system operators for planning, design, analysis, and control of power networks. The accuracy of power flow analysis can be increased significantly by including the weather-dependent characteristics of the system. In this manuscript, a novel weather-dependent power flow algorithm is proposed and studied in comparison to the very well-known conventional power flow. The weather-dependent power flow algorithm is novel in the sense that it is explicitly parameterised in terms of typically available measured weather parameters (ambient temperature, solar irradiance, wind speed, and wind angle) to perform a fully-coupled weather-dependent power flow analysis.

Using this algorithm, the IEEE 30-bus power network was studied utilising real weather data by performing three year-long steady-state time-series power flow analyses. The study demonstrates that the proposed weather-dependent power flow algorithm accurately estimates the branch resistances, the system states (current and voltages), the power losses, the branch flows, and the branch loadings. These are made possible because the proposed algorithm accurately estimates branch conductor temperature due to the coupling of power flow with the nonlinear heat balance model. An analysis of the computational complexity of the proposed algorithm is also presented.

Xiaoming Dong, "Power Flow Analysis Considering Automatic Generation Control for Multi-Area Interconnection Power Networks": In addition to maintaining the power balance, the major tasks of multi-area automatic generation control (AGC) involve regulating the power exchange among subareas. This study presents a new power flow model allowing for multi-area AGC that achieves cooperation among the participating generators, which are deployed separately in the interconnected subarea networks. The formulations of the power exchange among the subareas are derived from the active power flow equations of the tie-lines.

The node parameters representing the level and allocation of the unbalanced power are introduced. Then, the proposed power flow model is established by integrating the formulations of the node power injection and power exchange. Meanwhile, the unknown variables in the integrated model can be synchronously adjusted by the Newton iteration method, which depends on the integrated Jacobian matrix. Furthermore, being improved based on the integrated formulations, some related algorithms, including but not limited to sensitivity analysis, are expected to produce more precise solutions. The case studies of the IEEE 5 bus test system, the IEEE RTS-1996 test system, and the IEEE 300 bus test system illustrate the convergence and efficiency of the proposed power flow method. Moreover, the case studies also demonstrate that the integrated formulations based sensitivity analysis can generate more reliable results.

Wang Hongfu, "An Approximate Power Flow Method to Deal with the Non-convergence Problem of Power Flow Calculation": A new concept of approximate power flow (APF) is proposed in this paper, aiming to help deal with the non-convergence problem of power flow calculation. In the approximate power flow model, active and reactive power decoupling strategy is adopted, and a branch model with virtual midpoint is the key foundation of the whole research. Based on the branch model, the approximate power flow equation is constructed and its iterative solving method with good characteristics of convergence is also introduced. Active and reactive power automatic adjustment measures are also used to improve the algorithm robustness. The effectiveness and feasibility of this approximate power flow model is proved by the error and robustness analysis for practical examples. The APF program has been developed based on the proposed method, and can be applied to the actual large-scale power grid.

EnesCengiz, "Importance of Power Flow and Load Analysis in Pre-Installation Power Systems": Electricity is indispensable for everyone. Many technological tools developed are powered by electricity. It is important that electrical energy is delivered to customers in a continuous and high-quality manner. For uninterrupted energy, the right infrastructure and the right design for the installation are required. An incorrect design during the installation phase will result in malfunctions that are difficult to correct after installation. Power generation and distribution should be realized with minimum cost but maximum efficiency. Optimal power flow (OPF) in power systems is essential for reliable and efficient operation of electrical networks. OPF, which is a basic optimization tool in the fields of operation and planning, plays an important role in the power system. The OPF tries to minimize both power distribution losses and the cost of power drawn from the substation without affecting voltage regulation. The expected results for load flow analysis are voltage magnitude, phase angle, actual and reactive power. In this study, the power flow model of a power system based on real data of 8 busbar of İzmir province is designed. Different scenarios have been applied for accurate analysis of the system.

JirasakLaowanitwattana, "Probabilistic Power Flow Analysis Based on Low Rank Approximation and Principle Component Analysis": Probabilistic power flow (PPF) analysis is usually applied for evaluating the effects of uncertain parameters on power system performances. This paper presents a technique to enhance the arbitrary polynomial chaos expansion (aPCE) based PPF analysis technique when applying to system with many uncertain parameters. The proposed method represents a power system response as low rank approximation (LRA). In addition, the principle component analysis (PCA) is applied to reduce the number of uncertain parameters and also de-correlate them. This combination enables the proposed method to perform PPF of the power system having large number of uncertain parameters. Based on preliminary numerical results on the modified IEEE 57-bus system, it can be noticed that the proposed modified method is able to find accurate statistical characteristics of the responses but uses less computation time compared to the MCS based PPF analysis.

IV. CONCLUSION

The standard and non-conventional approaches for load flow analysis that are currently accessible in the literature were presented in this study. This analysis provides an overview of the existing methodologies, analyses, and outcomes of the current state-of-the-art. This can provide researchers with information on the existing approaches, as well as allow them to compare and improve them.

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