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Review On Load Flow Of Distributed Energy Resources In Distribution System

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***Abstract*— Distribution system advancing is very important for many Researchers and power engineers. Fast load flow techniques are highly desired as conventional techniques are consuming very long time. Power flow in the distribution system is one of the most critical point in the grid for analysis study. The integration of variety of renewable energy for the sake of sustainability from consumers and utility to the existing grid requires extra modification to obtain the stability and cost-saving for consumer and utility. This paper presents a review of distribution network load flow analysis after the renewable energy resources penetrated the grid. It also reviews the main old techniques that are with us until today and some of their introduced modification.**

Keywords—Distribution sytem, Load flows, Techniques, distributed energy resources. Solar (PV), EV.

I. INTODUCTION

Distribution generations integrated into power distribution grids complicate load flow study. The purpose of reviewing LF in power distribution system is to obtain stability study to better analyze the difficulties the system might anticipate. High penetration of Distributed energy resources (DER) into the grid weather it is radial meshed or micro smart grid have a potential impact to the power analysis data [1,2]. Solar cells (PV) injected to the grid arises one of the top difficulties to power engineers and researchers [3]. In this review, some of the main difficulties will be discussed, also the techniques and some of the recent solutions that might help tackling the unexpected problems to the power grid will be mentioned.

In [4,5] planning the Power flow throughout the power system provides a better solution to uncertain conditions that may come. DER integration creates issues to the stability of power system since the existing grid is not designed for bidirectional power flow, although, it increases the energy efficiency and reduce the peak demand to a manageable level that is easily controlled by the electricity provider. Complexity of study must be taken into account to ensure the unwanted load levels are avoided when integrating the DER [6]. In low voltage side, the voltage will be increase rapidly so that unwanted back flow occurs.

In this paper, the first section is going to review load flow techniques and some of the modifications that have been added to them. Also, it presents some programs in which load flow study in distribution system can be more efficient. The second section will be about reviewing load flow when DS is penetrated with DER of solar cells (PV) and electric vehicle (EV) acting on the DS, it will help to study the performance of the power system network. The last section will present a brief of time series simulation which can be useful to the DS.

II. REVIEW ON LOAD FLOW TECHNIQUES

Load flow analysis can be done for online or offline studies. Coordinate method such as Gauss-seidel (GS), gradient method such as Newton Raphson (NR) method, or fast decouple method.

- To solve load flow using GS method will require a high number of iterations to converge to the closest point where the number of iterations is proportional to the number of buses, also, when the admittance matrix is ill-conditioned, divergence in GS method slow down the performance.
- To solve load flow using NR will only require a few iterations Thus, NR is mostly used for highly complex system. On the other hand, in NR the Jacobian matrix has to be calculated in each iteration so that some concern of time and storage takes place. To overcome this, a modified version of NR was introduced later to abolish ill-condition in LU factorization [7].
- Fast-Decoupled (FD) technique can be performed to find solutions regardless the size of the network. *in fact, it is an extension of NR method which leads to fast algorithms of PF solutions.

The above techniques are the main techniques which have been implemented into power system for a while to perform load flow study. In general, they are known as fast and efficient techniques in power system. However, [8] these conventional methods are insufficient when it comes to distribution network due to its ill-conditioned state. Modified versions of load flow techniques have been introduced by researchers along the way to overcome and tackle the ill-condition problem. A load impedance matrix (LIM) derived from conventional Forward backward sweep (FBS) method to calculate the bus voltage in a single step, whereas conventional FBS require two steps to perform the same [9].

For the sake of enhancement of fast decoupled power flow method, a complex per unit normalization (C*pu*) was discussed in [10]. The C*pu* concentrates on the use of Volt-Ampere (VA) base to overcome the numerical problems caused by high R/X ratios of the distribution feeders. As a result, FD Power flow makes it simple and effective to the power flow analysis.

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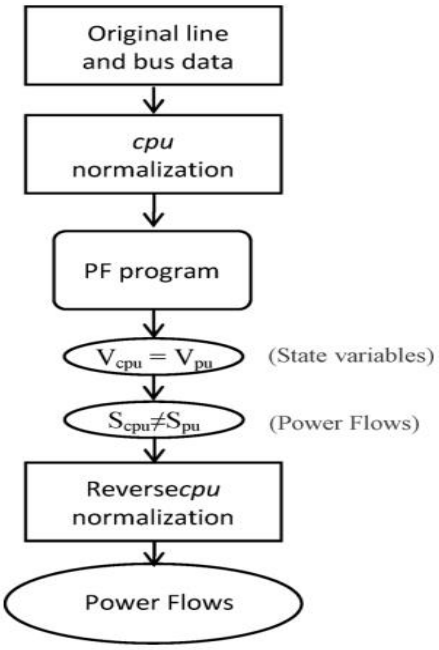

Fig. 1 Application of complex normalization.

C*pu* can be easily applied to existing power flow programs as shown in figure 1, C*pu* approach does not affect the origin of PF algorithms after applied to existing PF programs. The flowchart presents that the active and reactive PF final values can be obtained from the reverse C*pu.*

A virtual tool is discussed for load flow study and planning with low-cost and a reliable result developed in LabVIEW to monitor the medium voltage of the Distribution network (DN) of micro grid in [11].

III. REVIEW OF LOAD FLOW WITH DISTRIBUTED ENERGY RESOURCES

A. Solar (PV).

The solar PV integration in the distribution system is to support the network with local generation and reduction of power from the grid. Most of the grid connected inverters are designed to inject power at unity power factor. Due to this active power contribution to the network the power factor gets reduced as the Grid is supplying a lesser active power for the same reactive power of the network [12].

The technology of renewable energy is increasing day by day. Solar PV technology integration has become the target to both consumers and utilities. The reason for that is the availability of the sun and the cost of cells is decreasing dramatically. Many competitors of the semi-conductors' market is designing sophisticated cells with higher efficiency to be in top of the market. Therefore, solar PV could be the main challenging contribution in the power grid for power system researchers.

The solar PV is supporting the entire network with local generation and reduce the power that is coming from the grid. A lot of the inverters that are designed for the grid to connect to be connected between cells and the grid are designed to inject power at unity power factor. Because of high contribution of PV to the grid, power factor will be reduced since the consumer will be taken less power than normal from the grid. Thus, the grid will supply less active power, but the reactive will be the same. To solve this conflict, it can be addressed by a proper selection of inverters of solar PV that supports both active and reactive power to obtain a reactive power control.

B. Electric vehicle (EV)

The dramatically increasing of electric vehicle (EV) charging in distribution system leads to high uncertainty of the DS grid. This uncertainty in the load side is due to the new revolutionary EV, EV consumers are increasing day by day. A charge of a vehicle is not negligible. The full charge of one vehicle can consume somewhere between 20 KW up to 70 KW according to recent data research. [13] The main issue is that not only the massive charge of each vehicle consumption, but also different unknown parameters are taking place in this matter such as the time and duration of charging, the battery efficiency and capacity, number of charged vehicle. Because of that, high voltage drop and rise in power losses may occur [14].

To analyze and study the uncertainties of DER and EV, modelling approach like probabilistic methods which include input probability density functions (PDF) is introduced [15]. Probabilistic load flow (PLF) analysis is to study the uncertain inputs of power PF calculations. Three stages can be derived of PLF process. First, is the input uncertainty modelling, second, PLF computation and third is the analysis of the PLF output. The main aim of the uncertainty modelling input is to represent the uncertainties of all inputs of generations and loads in PDFs [6].

IV. TIME SERIES SIMULATION

Solar and wind information vary during seasonal changes, to achieve these change values, assumptions are considered such as minimum and maximum estimations based on values and seasons. In state control of stream examination of time series simulation, the power flow arrangement provides the nodal voltage with values from feeder real and reactive power. In [12] time series simulation is proposed in various time steps called as stochastic analysis, two methods of stochastic analysis are introduced. Direct method where the anticipated load demand is correlated with generator output. The second method is Monte Carlo which is based on the non-linearity multiple deterministic power flow analysis.

V. CONCLUSION

The uncertainty in the load side from EV charging and renewable energy generation such as PV has a huge effect in the load flow analysis in which solutions are needed to be derived. The paper has reviewed load flow techniques and some of the modifications which were developed over time, also it reviewed PV and EV effects on the distribution system. The integration of DGs can be critical to power researchers and load flow study. Implementation of fast techniques will enhance the performance of the Distribution system.

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