A new method to obtain multiple load flow solutions

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Abstract. This paper presents a new method to obtain multiple load flow solutions efficiently, using a conventional Newton power flow analysis. The method is based on the estimation of initial values to start iterating, taking into account physical considerations such as the load level and area voltage profiles or nodes that can be considered as critical. The proposed method allows to obtain all the possible solutions, whether the system is working in a critical situation or not. When the system is heavily loaded, in such a way that it can be considered near to the voltage collapse, reaching the unstable solution, close to the stable one, provides information about the proximity to the voltage collapse. The algorithm presented has been applied to several test systems such as the Ward & Hale 6 bus system, the Klos & Kerner 11 bus system and the IEEE 14 and 118 bus systems.

Keywords

Multiple solutions, load flow, voltage collapse, voltage instability.

1. Introduction

The voltage stability phenomenon related to voltage collapse in power systems is one of the most challenging problems that has been studied over the last decades due to its importance in secure and reliable power system operation.

Although voltage collapse nature is essentially dynamic, it can be treated as a static problem if the parameters of the systems change slowly. Therefore, load flow calculation for determining proximity to voltage collapse has been widely used.

It is well known that the nonlinear load flow equations can present multiple solutions [1]. Usually, only one of these corresponds to the "stable" system operating point and the others correspond to "unstable" points of equilibrium, that are possible in analytical terms, but they are not feasible steady-state situations in the real power system operation.

As a norm the number of solutions decreases as the system is loaded, in such a way that, in the voltage collapse point neighbourhood, only a very similar pair of voltage solutions remains [2]. This solution pair, the stable operating point and the unstable close ones, can be used to predict proximity to voltage collapse or to obtain the loading margin.

Two main approaches are proposed in the bibliography for finding multiple load flow solutions. The first one is based on the optimal multiplier presented in [4]. In this case, a good initial estimation of the unstable solutions is used to obtain the multiple solutions. The method proposed in this paper can be included in this approach as a new alternative way to calculate initial estimations of the solutions.

Recently, a second approach is the use of symbolic algebraic techniques. The algebraic method to solve the load flow equations with Gröbner bases always obtains, and with certainty, all the solutions, but its implementation to solve normal sized systems is not yet mature [5] and much more research is necessary.

On the other hand, the continuation method that traces the P-V curves [3], locates the voltage collapse point as its main objective. This technique can also get the part of the curve P-V corresponding to the unstable solutions. In this sense, although it is not its objective, it may be considered as a method to find multiple solutions.

2. Aim of the work

The aim of this work is to present a new method for finding multiple solutions based in the search, from an electrical point of view, of a good initial estimation of the unstable solutions.

After mentioning the existing methods for obtaining unstable solutions and the relationship between multiple load flow solutions and voltage collapse, the proposed method is explained. The good performance of the method is showed with examples.

3. Main contributions

The new method estimates good initial values for calculating the multiple load flow solutions, simply performing a linear analysis of load modification.

The method is not dependent on the type of formulation used for the load flow equations and reactive generation limits may be considered.

The method may be used to obtain unstable solutions, whether the system is working in a critical situation or not. Examples presented on test systems of different size, show that it is possible to get easily unstable solutions. The Gröbner bases approach has been used in a small system to verify that all the existing solutions were obtained.

References

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