Electrical Power and Energy Systems 33 (2011) 1479–1488

Contents lists available at ScienceDirect

Electrical Power and Energy Systems

journal homepage: www.elsevier.com/locate/ijepes

Development of a new algorithm for power flow analysis

Sourav Mallick *, D.V. Rajan, S.S. Thakur, P. Acharjee, S.P. Ghoshal

Department of Electrical Engineering, National Institute of Technology, Durgapur 713 209, India

ARTICLE INFO

Article history:
Received 5 September 2010
Received in revised form 4 March 2011
Accepted 3 June 2011
Available online 14 July 2011

Keywords:
Power flow analysis
Impedance matrix (Z)
Taylor's series
Security constraints

ABSTRACT

This paper presents a new iterative solution technique for power flow analysis to reduce the computation complexity, hence time of the conventional solution techniques. In the proposed method, the impedance matrix has been used instead of admittance matrix. This method does not involve any other jacobian matrix or any other inversion of matrix, hence there is no problem of singularity. Memory requirement of the proposed method is also less. The new method has been tested on IEEE standard 5-bus, 14-bus, 30-bus, 57-bus, 118-bus and 300-bus test systems with high precession. The test results have been compared with the same of popular conventional solution methods. The method has also been tested under different practical security constraints. The test results presented reveal the superiority of the proposed method.

1. Introduction

Power flow studies are of great importance for stable, reliable and secure operation of a system [1,2] as well as in planning and design for future expansion. There are several methods for solving nonlinear power flow equations. An excellent review paper by Scott [3] provides a detailed account of power flow methods developed in earlier days. Amongst the popular power flow algorithms [1,2], two iterative schemes [4–8] based on nodal admittance matrix are known as Gauss-iterative and Gauss–Seidel (G–S) iterative schemes. Although the G–S method requires less arithmetic operations and utilizes the core memory efficiently, it has linear convergence characteristics, requiring more iterations. Newton's method [9] using nodal admittance matrix gained wide spread popularity because of quadratic convergence. Thereafter, several variants/improvements of Newton's method have been suggested in literatures [10–25].

The power flow problem may be sub-divided into the well-conditioned case and the ill-conditioned case [23–30]. In case of well-conditioned systems, the power flow solution exists with a flat voltage initialization in Newton–Raphson (N–R) method. In ill-conditioned systems, although solution of power flow problem exists, the popular standard methods fail to converge, starting from a flat initial guess. This situation arises due to narrow region of attraction of power flow solution i.e. far away from the initial guess. The failure of popular methods is due to the instability of numerical methods used in the solution of power flow equations. This fact has motivated to present a novel and efficient formulation of power flow problem in this paper, to provide solution not only for well-conditioned systems but also for the ill-conditioned systems.

2. Problem formulation

A balanced three phase system is assumed represented by its positive sequence network of lumped series and shunt parameters. For the purpose of analysis, it is convenient to regard loads as negative generators and lump the generator and load powers at the buses together.

Thus, at any given bus 'i', the net complex power injected is given by,

$$S_i = P_i + jQ_i = V_i I_i^* \quad \text{for } i = 1, 2, \ldots, n. \tag{1}$$

$$\text{Substituting, } I_i = \sum_{k=1}^{n} Y_{ik} V_k \tag{2}$$

$$S_i^* = P_i - jQ_i = V_i^* \sum_{k=1}^{n} Y_{ik} V_k \tag{3}$$

Defining,

$V_i = |V_i| e^{j\delta_i}$ and $Y_{ik} = G_{ik} + jB_{ik}$

and separating real and imaginary parts

$$P_i = \sum_{k=1}^{n} |V_i||V_k| \{G_{ik} \cos(\delta_i - \delta_k) + B_{ik} \sin(\delta_i - \delta_k)\} \tag{4}$$

* Corresponding author. Tel.: +91 9434205918.
E-mail addresses: sourav.nitdgp2009@gmail.com (S. Mallick), dvrdvc@gmail.com (D.V. Rajan), sst_nit_ee@yahoo.co.in (S.S. Thakur), parimal.acharjee@ee.nitdgp.ac.in (P. Acharjee), spghoshalnitdgp@gmail.com (S.P. Ghoshal).

0142-0615/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ijepes.2011.06.030