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Genetic Algorithm Optimization of Generator Reactive Power

Rayudu Katuri[a], A.Jayalaxmi[b], G.Yesuratnam[c], Dedeepya Yeddanapalli[d]

[a]*Associate Professor,EEE Department, BVRIT,Narsapur,Medak-502313, India*
[b]*Professor, EEE Department,College of Engineering,JNTUH, Hyderabad-500085,India*
[c]*Professor,EEE Department, OUCollege of Engineering,Hyderabad-500017, India*
[d]*PG Scholar, EEE Department,College of Engineering,JNTUH, Hyderabad-500085,India*

Abstract

Reactive power optimization in the power system tends to maintain good voltage profile by improving the voltage quality other than decreasing the power loss. This paper presents an improved Genetic algorithm (GA) approach for voltage stability enhancement. The proposed technique is based on the minimization of the maximum of L-indices of load buses. Generator voltages, switchable VAR sources and transformer tap changers are used as control variables. A case study is made on all the optimization variables mentioned and the effect on generators reactive power output is analyzed. The comparison of two optimization techniques is explained in detail. The results obtained for the IEEE-24 bus power system had indicated that the GA not only improves the voltage stability but also reduces the effect on generators for the Reactive Power.

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1. Introduction

The unmatched generation and transmission capacity expansion, voltage instability is troubling the power engineers to optimize power system operation, while maintaining system security and quality of supply to customers. Under many disturbed conditions the operation of the power systems has to be restricted to design limits. It is turning complex to the power engineers to ensure the quality and reliability of supply to the customers by maintaining load bus voltages in their permissible limits. Despite of all, overloading in existing power transmission systems, voltage collapse and voltage stability are concerned as the major problems, to power system planning and operation engineers, which has to be enhanced. Voltage profile can be improved with reallocation of reactive power generations, by adjusting the controller parameters of transformer taps, generator exciters and Switchable VAR Compensator (SVC) settings to its best optimal values. Several have

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emerged earlier to solve this type of complex problems, like Linear programming (LP)[1] , Non-Linear Programming (NLP) [3]and Interior point method[4]. Though these techniques were applied for solving the reactive power dispatch problem, still some backdrops are associated with them. Linear Programming techniques with iterative schemes are proved to be the most promising tools for solving these types of problems earlier, with better results and good evaluation time. But this kind of approach is only limited to local minimum[5], where Genetic Algorithm technique (GA)[2] is being used as a recent trend which is a global minimum based optimization technique yielding to much more better results. The main advantages of GA[6]: It can find near optimal solution regardless the initial parameter values, Its convergence is fast It uses few number of control parameters. The system parameters V_e , V_s and $\sum L^2$ are calculated, along with the effect on the generators reactive power output. This paper presents an effective algorithm with GA approach with selected mutation rate and population size to find the optimized control settings for the given controllers. The optimized controller settings are considered and the power system parameters are again analyzed with new settings to minimize the sum of the squares of the L indices (V stability) and also to reduce the required reactive power through the generators in parallel. The algorithm is successfully applied to IEEE-24 bus system and is compared with the existing LP optimization values and presented for illustration purpose.

2.Analysis of Voltage Stability

A slow variation in the system operations, due to increase in loads results in the gradual decrease in the voltage magnitude. Careful monitoring and control action has to be taken from the operator when the operating point approaches the voltage stability limit. Recent literature presents many voltage stability and voltage collapse prediction methods. Among them, L index method is adopted in this paper for the calculation of Voltage stability which is described as follows.

2.1. *L-index method*

Consider a system where,

n=total number of busses, g=generator busses , s= SVC busses , t =number of OLTC transformers.A load flow result is obtained for a given system operating condition, which is otherwise available from the output of an on-line state estimator. Using the load flow results, the L-index [6] is computed as

$$L_j = \left| 1 - \sum_{i=1}^{g} F_{ji} \frac{V_i}{V_j} \right| \tag{1}$$

where $j=g+1 \ldots n$ and all the terms within the sigma on the RHS of (1) are complex quantities. The values F_{ji} are obtained from the Y bus matrix as follows

$$\begin{bmatrix} I_G \\ I_L \end{bmatrix} = \begin{bmatrix} Y_{GG} & Y_{GL} \\ Y_{LG} & Y_{LL} \end{bmatrix} \begin{bmatrix} I_L \\ V_G \end{bmatrix} \tag{2}$$

Where I_G, I_L and V_G , V_L represent currents and voltages at the generator nodes and load nodes. Rearranging (2) we get

$$\begin{bmatrix} V_L \\ I_G \end{bmatrix} = \begin{bmatrix} Z_{LL} & F_{LG} \\ K_{GL} & Y_{GG} \end{bmatrix} \begin{bmatrix} I_L \\ V_G \end{bmatrix} \tag{3}$$

where $F_{LG}=-[Y_{LL}]^{-1}[Y_{LG}]$ are the required values. The L-indices for a given load condition are computed for all load busses.

For stability, the bound on the index L_j must not be violated (maximum limit=1) for any of the nodes j. Hence, the global indicator L describing the stability of the complete subsystem is given by L= max of L_j for all j. An L-index value away from 1 and close to zero indicates an improved system security. For a given network, as the load/generation increases, the voltage magnitude and angles change, and for near maximum power transfer condition, the voltage stability index L_j values for load buses tends to 1, indicating that the system is near to voltage collapse. The stability margin is obtained as the distance of L from a unit value i.e. (1-L).

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