AN OPTIMIZED FAST VOLTAGE STABILITY INDICATOR

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ABSTRACT: This paper proposes a simulated annealing optimization technique for optimal voltage stability profile through out the whole power network. The technique is applied to control the power elements of major influence on the voltage stability profile. Elements such as generator reactive generation, adjustable shunt compensation devices, transformer tap settings are optimally adjusted to reach the objective of minimizing the voltage stability index as well minimizing the global voltage stability indicator. Because of the optimal setting of the control elements, the maximum possible MVA voltage stable loading has been achieved and a the best voltage profile was obtained. Results of tests conducted on the 6-bus system are presented and discussed.

Keywords: Simulated Annealing, Voltage Stability Indicator and Margin.

1 INTRODUCTION

The power system ability to maintain constantly acceptable bus voltage is a very important characteristic of the system. The non-optimized control of VAR resources may lead to progressive and uncontrollable drop in voltage resulting in an eventual wide spread voltage collapse. In order to enhance the voltage stability profile through out the whole power network, simulated annealing (SA) optimization technique is applied to control the power elements of major influence on the voltage stability profile. Elements such as generator reactive generation, adjustable shunt compensation devices, transformer tap settings are optimally adjusted to reach the objective of increasing the distance from an unstable system state and therefore to increase the maximum possible system safe loading. The objective is achieved through minimizing the L-index values at every bus of the system and consequently the global power system L-index.

2 FAST VOLTAGE STABILITY INDICATOR

A fast indicator of voltage stability information covering the whole power system and evaluated at each individual bus is calculated at every operating point. For voltage stability bus evaluation, an indicator L-index is used. The indicator value varies in the range between 0 (the no load case) and 1 which corresponds to voltage collapse. The indicator uses the bus voltage and network information provided by the load flow program. For multi-node system

$$L_K = \left| 1 + \frac{V_{ok}}{V_K} \right|$$

L_k: L-index voltage stability indicator for bus k.

Stability requires that $L_k < 1$ and must not be violated on a continuous basis. Hence a global system indicator L describing the stability of the complete system is $L = L_{max} \{L_k\}$, where in $\{L_k\}$ all L bus indexes are listed. In practice L_{max} must be lower then a threshold value. The predetermined threshold value is specified at the planning stage depending on the system configuration and on the utility policy regarding the quality of service and the level of system decided allowable margin.

3 THE PROPOSED APPROCH

In order to enhance the voltage stability profile through out the whole power network, simulated annealing (SA) optimization technique is applied to control generator reactive generation, adjustable shunt compensation devices, and transformer tap settings. These control variables are optimally adjusted to reach the objective of increasing the distance from an unstable system state and therefore to increase the maximum possible system safe loading.

In this paper, the proposed objective function J is

$J = max$ {L-index at all load buses}

The SA algorithm has been applied to *Minimize J*. The problem constraints are the upper and lower limits of the adjustable variables.

4 TEST RESULTS AND DISCUSSION

The proposed approach has been applied to 6-bus system. Table given below shows a comparative list of results using both voltage stability evaluation of L-index with and without optimization. It can be seen that the values of L-index at load buses are reduced, therefore, the voltage stability of the system is enhanced. Consequently, the voltage stability distance from collapse has increased. The gain in power system MVA loading was found to be 23%. The above both positive results demonstrate the potential of the proposed approach to improve and enhance the system voltage stability.

L-INDEX WITH AND WITHOUT OPTIMIZATION

Bus Number	*L-index Without Optimization*	*L-index With Optimization*
3	0.288	0.234
4	0.211	0.178
5	0.278	0.234
6	0.258	0.218

5 CONCLUSIONS

This paper has proposed an optimized voltage stability index using fast voltage stability indicator minimized by the simulated annealing optimization technique. The developed system has show accurate results, success in convergence to optimal solution. The results are obtained fast and direct. The conducted application on standard system has satisfactory results for optimal voltage stability level as well for extending the loading level of the system.