Voltage Stability Improvement Using Intelligence Technique

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ABSTRACT

Numerous Artificial Intelligence procedures have been anticipated for reactive power dispatch to maintain voltage stability of the power system. This paper presents particle swarm optimization (PSO) approach for framework boundaries improvement and ideal reactive power dispatch. The transformers tap transformers, Generator exciters, switchable VAR sources/Static VAR compensators (SVC) are utilized as control factors for progression of framework boundaries and voltage stability. The recommended procedure depends on the minimization of total of the squares of L-index value at all load bus. The PSO Algorithm is tested on an IEEE 30 bus test system. The presentation of PSO is compared with conventional technique and results are introduced for illustration purpose. The margin of voltage stability is estimated in terms of system parameters.

Keywords— Voltage Stability; Voltage collapse; Reactive Power Dispatch; L index; particle swarm optimization;

1. INTRODUCTION

Reactive power can be characterized as the control of generator excitation, variable transformer tap settings, and flexible VAR compensating devices to improve the system voltage stability, voltage profile, and accordingly to limit the active power losses in the system. Various traditional calculations have been proposed in the literature for the improvement of voltage security by improving the system parameters. If we increase the speed of response of algorithm we can keep away from the voltage breakdown. For these, numerous computerized reasoning methods like fuzzy logic, Genetic Algorithm, Ant optimization techniques and artificial bee colony techniques have been presented by the researchers. The thought behind the ideal reactive power control is to obtain the upgraded control factors like generator excitation settings, settings of on - load tap changing transformers (OLTC) and Static Var compensation settings (SVC) fulfilling equality and inequality requirements for the specific target work like minimization of aggregate of L-index value of all load buses.

2. VOLTAGE STABILITY ANALYSIS

Mohamed, et al have discussed in the power system planning and operation voltage instability issue is one of the significant problems in the power system. The various methods have been proposed to find the voltage collapse point and this paper display a static method that can produce a fast voltage stability calculation. The line stability index is used as an indicator to identify the voltage collapse in the interconnected systems. To explore the adequacy of this method, it is compared with other voltage instability indicators [1].

Moghavvemi.M, et al have discussed that due to economic and environmental changes, power systems are running maximum to their limits. It is very important to analyze the power system under a stressed condition to manage the network without losing its reliability. In the electric utilities monitoring on-line is an important factor. So, for the real-time application to increase the security by monitoring the system is explained. Each line of the network was evaluated in this technique the value will be range between zero and one. The VCPI index method is obtained from the theory of maximum power transfer in the corresponding line. This index is simple and easy to manipulate. This method is suitable for the online application to avoid voltage collapse [2].

K. R. C. Mamandur built up a technique for ascertaining under-voltages, and infringement of receptive force cut-off points of generators. The proposed strategy considers all VAR control factors and brings down the general changes in accordance with be performed. This is basically on the control factors like generator excitations and on load-tap changing transformers which would be helpful for the framework administrator voltage control applications in crisis [3].

Bansilal, D Thukaram and K Parthasarathy introduced a calculation for checking and improving voltage security in power frameworks. This depends on L-index of burden transports. The proposed straight programming calculation gives an ideal setting of different control gadgets like generator excitation, switchable VAR compensators [4].

Mahmoud Moghawemi, et al have proposed a method using power flow for each line, a scalar index is evaluated known as line stability indicator. If the index value reaches the maximum (1.0), it may proceed to system voltage collapse. The proposed method is not complicated matrix calculation or time-consuming calculations are related. The line stability index can be carryout for online usage [5].

Zambroni De Souza, et al have discussed on the voltage collapse problems. In the analysis of voltage stability calculating eigenvalue corresponding increases of load produce wrong information related to weak bus or area. Instead of using a minimum Eigen value appropriate value of Eigen should be obtain. A voltage stability index is to be identifying such that it gives information related to the weak bus. This method is evaluating the vanishing Eigenvalue to find out accurate voltage collapse time in a faster way [6].

Claudia Reis, et al have discussed the major factors relevant to voltage stability index in the power system network. The comparison of different line index based on the performance and effectiveness is given here. The proposed method is verified in the standard IEEE test bus system in different load conditions [7].

Subrami.C, et al have discussed the voltage stability analysis using the line stability index. When the power system is operating nearer to their maximum limit, it may force to voltage instability. Identify the voltage collapse is a major part of the power system for each gradually increasing load and also line outage line stability indices are calculated. The value of line stability is reaching the value of one, and then the power system reaches its maximum limit [8].

Claudia Reis, et al have discussed the comparison between different methods for voltage stability analysis. The voltage stability indices such as Q-V curve, local load margin index, model analysis, V/Vo index, line stability index are efficient methods compared to others [9].

This paper presents PSO based methodology for reactive power control. It focuses on the motivation behind assessment and enhancement of voltage profile improvement and thus voltage dependability of a system. The issue is detailed with the connection between L-index estimation of each load bus and controlling capacity of controlling devices. Control factors considered are switchable VAR compensators, OLTC transformers and generator excitations. The target chose is voltage profile improvement which is to limit the amount of the squares of the L-index estimations of the load bus. The proposed PSO is tried on an IEEE 30 node system. The performance is compared with traditional optimization technique like LP. Acceptable results are thus obtained.

3. Line Index Voltage Stability Method

Let us have the system with N total number of buses. Ng- Number of generator bus. Slack bus will be taken as bus 1. 1 to Ng is the number of generator buses. Ng+1 ……….Ng+N are the remaining load buses. L index can be calculated after the evaluation of load flow analysis method.

$$L_k = max[1 - \sum_{i=1}^{g} \frac{F_{ki}V_i}{V_K}] \qquad (1)$$

k- Number of load bus

The load index will provide the quantitative measure for estimation of distance of actual state to stability limit. L index will varies the range from 0 (no load) to 1 (voltage collapse). If the value of L index near to zero the system is in stable condition. If the value of L index reaches near to 1 the system is going to reach unstable condition. So a suitable measure to be taken to prevent the voltage collapses.

4. PARTICLE SWARM OPTIMIZATION

4.1 Problem formation

The problem of multi-objective enhancement is solved by examining the objective functions of L index minimization. The optimization problems are constrained by equality and inequality constraints. Constraints on power flow are treated as an equality constraint. As an equality restriction, the voltage range, generator reactive power capability range, capacitor bank reactive power generation limit, capacitor bank reactive power generation limit, voltage stability range, and transmission line flow limit are used. The fitness value is computed by completing all of the limitation.

4.2 Objective

The main objective function is to minimize L index. It can be represented as$F_0(x) = \min(L\ index)$ (2)
(2)

The L index is the voltage stability indicator at each load bus of the system. This index range is between zero to one (voltage collapse). The L index equation is expressed in equation (3)

$$F_1 = L\ \ index \quad (3) \quad (3)$$

4.3 Constraints

The minimization issue is depend upon the following equality and inequality constraints

1. Power flow constraints:

$$P_k - V_k \sum_{L=1}^{Ng} V_L(G_{KL} \cos \Theta_{kL} + B_{KL} \sin \Theta_{kL}) = 0 \qquad k = 1,2 \dots N-1$$

$$Q_k - V_k \sum_{L=1}^{Ng} V_L(G_{KL} \cos \Theta_{kL} - B_{KL} \sin \Theta_{kL}) = 0 \qquad k = 1,2 \dots N_L$$

2. Voltage range

$$V_k^{min} \leq V_K \leq V_K^{max} K \in N$$

3. Generator reactive power capability range

$$Q_{gk}^{min} \leq Q_{gK} \leq Q_{gK}^{max} K \in N_g$$

4. Reactive power generation limit of a capacitor bank

$$Q_{ck}^{min} \leq Q_{cK} \leq Q_{cK}^{max} K \in N_c$$

5. Voltage stability range

$$VCPI_l^{max} \leq VCPI_l^{min}$$

6. Transmission line flow limit

$$S_l^{min} \leq S_l^{max} l \in N_l$$

5. RESULT AND DISCUSSION

The IEEE - 30 bus systems has six generators, 24 loads, and forty-one transmission lines. For a load condition of base case and 50% load increases, the Newton Raphson method is used to analyse power flow and evaluate L index for all load buses. In terms of voltage stability analysis, the value of L denotes the critical line.

Figure 1 shows L index value for base case and 50% load condition increase for different load bus. The maximum value of L index in corresponding 12th load bus is identified as critical load bus. So, effective measures to be taken in this corresponding load bus. Figure 2 shows when the load increase from base case condition corresponding L index values of load buses are increases.

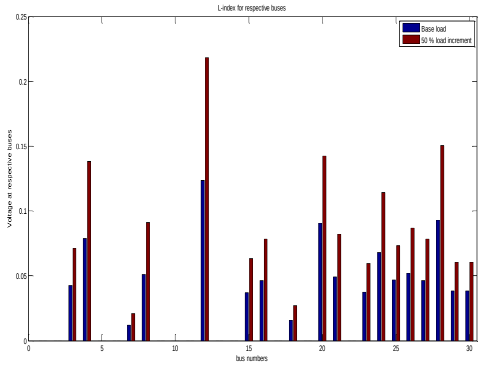

Figure 1 L index for load bus

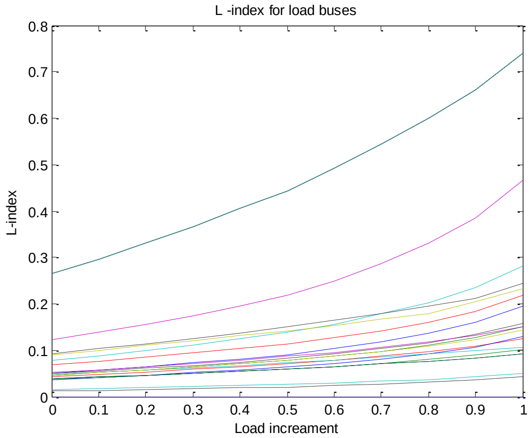

Figure 2 L index value variation for load increases

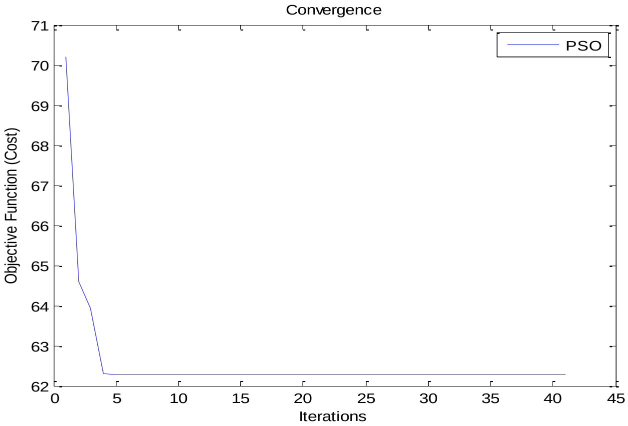

Figure 3 convergence graph of PSO

After the FACTS devices were installed, the L index was reduced, resulting in greater voltage stability during load variations. PSO's convergence characteristic (L index) is shown in Figure 3.

6. CONCLUSION

The main purpose of this study is to find the best location for the TCSC device so that the operator can recognise a threat of voltage instability and aid to improve voltage stability. To solve a multi-objective optimization issue, naturally motivated optimization techniques such as PSO are used. The objective functions of this multiobjective improvement problem are to minimise the L index value while adhering to appropriate constraints. IEEE - 30 is used to test the suggested algorithm. The results are compared to the conventional method using inspired by biological optimization techniques like PSO. When the load is increased gradually, the L index is utilised to locate the critical bus.

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