AN APPLICATION OF TLBO ALGORITHM FOR THE VOLTAGE STABILITY IMPROVEMENT BY MW-GENERATION RESCHEDULING.

Prof V R Patel, Prof H N Raval

[1]Associate Professor Electrical Engineering Department L.D.College of Engineering Ahmedabad, Gujarat, India
2Assistant Professor Electrical Engineering Department L.D.College of Engineering Ahmedabad, Gujarat, India

ABSTRACT

This paper presents Georschgorin's theorem a new approach method of accessing voltage stability and an application of TLBO optimization method for voltage stabilty improvement by MW-generation rescheduling. TLBO-teaching learning based optimization method is used for the parameters optimization of load flow Jacobean matrix. This method is based on the Teacher's influence on the learners.Optimal solution based generator rescheduling is performed for energy management during congestion by applying TLBO method for optimization process.Optimal energy transmission and its consumption is big issue in electric power systems as large amount of electricity cannot be stored in its electrical form. In deregulated power system, the transmission lines are overloaded. Congestion is not acceptable as it increases the energy price and threatens system reliability and security. The Georgeoschrin's theorem is presented to trace the eigen values for power system voltage stability analysis. The theorem will gives the information regarding inclusion of matrix eigen values. Numerical analysis of IEEE 30-bus system is presented to provide evidence of the performance of the power system under critical loading.The presented algorithm takes less computational time to achieve their optimal MW rescheduling when compared with JAYA optimization method.

Keywords: *TLBO, Teacher-Learner, Eigen Value, Inclusion, MW-Rescheduling, Voltage Stability.*

---

1. Introduction

The voltage stability refers to the ability that all the bus voltages was sustained in an acceptable range by power system when it runs in normal or disturbance circumstances. Voltage instability stems from the unbalance between power requirements of load and supply of the system.[1]. Voltage instability is a slow process, means the simulation would frequently last a few minutes, sometimes even tens of minutes.

With current trends in decreasing fossial fuels , increasing pollution levels, and uncontrolled increase in population , power system optimization is the need of the hour. Various parameters in the power system like voltage, frequency, active and reactive power , harmonic distortion and power factor requires control. [2] With the advent of generator rescheduling , it has become possible to multiple power system parameters.

Direct applications of conventional methods for power system eigenvalue problems is computationally not feasible or insufficient [3] . The selective model analysis approach uses a reduced order model to compute the desired critical eigenvalues relevant to the selected modes [4].

All of the above mentioned critical eigenvalue solvers are normally applied to calculate critical eigenvalues under a given system operating scenario. As the system equilibrium point often vary with respect to any control and load conditions.[5] In such case the best eigenvalues with respect to any control and load conditions are recalculated. In such case eigenvalues and study of voltage stability are understand using inclusion og Jacobean Matrix usin Gerschgorin's theorem. Improvement in voltage stability is observed by generator rescheduling and it is optimized by proposed TLBO method.

Group of learners are considered as population and different subjects offered to the learners are considered as different design parameters. Learner's result is analogous to the fitness value of the optimization problem. The best solution in the entire population is considered as the teacher. The working of TLBO is divided into two parts.(1) Teacher Phase (2) Learner Phase.

2. BRIEF DESCRIPTION OF GERSCHGORIN'S THEOREM AND TLBO METHOD

Gerschgorin"s Theorem will gives the information regarding inclusion of Matrix Eigen values. The meaning of "inclusion"is the determination of approximate values of eigenvalues and corresponding error bounds. Let λ be an eigenvalue of an arbitrary n×n matrix A=[a_{jk}]. Then for some integer j(1≤j≤n) we have,

(1) $|a_{jj}-\lambda| \le |a_{j1}|+|a_{j2}|+|a_{j,j+1}|\_\_\_\_\_\_\_\_\_\_\_\_+|a_{jn}|$

Let X be an eigenvector corresponding to an eigenvalue λ of A. Then (2) $A_x = \lambda x, (A-\lambda I)X = 0$

Let x_j be a component of x that is largest in absolute value. Then we have $\left|\frac{x_m}{x_j}\right| \le 1$ for m= 1,…..,n. The vector equation (2) is equivalent to a system of n equations for the n components of the vectors on both sides. The j[th] of these n equations for the n equations is $a_{j1}x_1 + a_{j,j-1}x_{j-1} + (a_{jj}-\lambda)x_j + a_{j,j-1}x_{j+1} + a_{jm}x_n = 0$ Division x_j by and reshuffling terms gives

$$a_{jj}-\lambda = -a_{j1}\frac{x_1}{x_j} - \_\_\_\_\_\_\_\_\_\_\_\_\_\_ a_{j,j-1}\frac{x_{j-1}}{x_j} - \_\_\_\_\_\_\_\_\_\_\_\_\_ a_{jn}\frac{x_n}{x_j}$$

By taking absolute values on both sides of this equation, applying the triangle inequality.

$|a+b| \le |a|+|b|$ (Where a and b are any complex numbers), and observing that because of the choice of j We obtain (1), and the theorem is proved. Suppose for the eigenvalues of the matrix

$$\begin{pmatrix} 0 & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & 5 & 1 \\ \frac{1}{2} & 1 & 1 \end{pmatrix}$$

D1: Center 0, radius 1, D2: Center 5, radius 1.5, D3: Center 1, radius 1.5. Since A is symmetric, and the spectrum of A must actually lie in the intervals [-1,2.5] and [3.5,6.5]on the real axis. It is interesting that here the Gerschgorin disks form two disjoint sets, namely, $D_1 \cup D_3$ which contains two eigenvalues, and D_2 which contains one eigenvalue. [6]

- Suppose one function described as follows is to minimize by this method .
- $$f(x_i) = \sum_{i=1}^{D} x_i^2$$

$$f(x) = x_1^2 + x_2^2$$

- Assume No. Of students=5, and No of subjects=No. Of variables=2
- Assume limit for x as $-100 \le x_i \le 100$

Find best students among 5 as our objective function is minimum value among the group. [8]

- Now updates the value of x1 and x2 using following formula.

$$x_{1new} = x_{old} + rand(x_{best} - TF(MeanValue))$$
$$x_{2new} = x_{old} + rand(x_{best} - TF(MeanValue))$$

Application of TLBO method as follows:

- Obtain Load flow Jacobian at heavy loading condition where VSM is in adequate.
- Objective function is to maximize.Max {Min Jii }--------(1)_ Where Jii is diagonal element of Jacobian.
- Objective function (1) is to be maximized subject to following constraints.
-

$$(1) V_n \le V_n \le V_n$$
$$(2) Q_p \le Q \le Q_p$$
$$(3) V_p \le V_p \le V_p$$
$$(4) t_p \le t_p \le t_p$$

- Generate populations containing reactive power control variables as decision variables.
- Run AC power flow and obtain solution one varying Highest [Min Jii] and obtain worst solution which has lowest [Min Jii]
- Modify solution using TLBO till convergence is obtain.

III Implementation of TLBO Method-

The system comprises of six buses. Out of which two buses are with generator and other are load buses. This is one of the smallest system used for power system studies. We have tested the analysis using Matlab programming for this system with basic parameters as per the standards.

The necessary input data required for the implementation of Gerschgorin's theorem is as per given below.

Data File System **:**(A) Input Data :

The system data is presented in the form of following matrix files : (1)Line Data

– describes R, X, 1/2B, tap setting

- Bus Data – describes bus type, voltages, generation, reactive power limits, injected MVAr (3)Rated Bus Voltage Data

IV -Results-

Table 2.1 : Results for IEEE-14 and IEEE-30 Bus Test system

Sr. No	% Load and % Generator MW	Corresponding Minimum EigenValues	Ratio of Eigenvalue to Summation of Eigenvalues	Objective value to be Maximize	TLBO method Based maximize value	Updated Value	No Of iteration
1	0.3 Pd	0.0261	0.0003389				
2	0.4 Pd	0.0292	0.0003792				
3	0.5 Pd	0.0386	0.0005013				
4	0.6 Pd	0.0423	0.0005493				
5	0.8 Pd	0.0721	0.0009364				
6	0.95 Pd	0.1615	0.002097				
7	1.0 Pd	0.2815	0.003656				
8	1.05 Pd	0.4618	0.005997				
9	1.08 Pd	0.5920	0.007688				
10	1.15 Pd	5.618	0.07296				
11	1.25 Pd	12.163	0.1579	0.0003389	0.02618	0.02618	17
12	1.30 Pd	12.178	0.1582				
13	1.40 Pd	14.135	0.1835				
14	0.7 Pg	1.263	0.01640				
15	0.8 Pg	2.189	0.0284				
16	0.9 Pg	4.168	0.05413				
17	0.95 Pg	4.232	0.05496				
18	1.0 Pg	4.985	0.06474				
19	1.05 Pg	6.125	0.07954				
20	1.20 Pg	8.235	0.1069				

Table 2.2: Results for IEEE-30 Bus Test system

Sr. No	% Load and % Generator MW	Corresponding Minimum EigenValues	Ratio of Eigenvalue to Summation of Eigenvalues	Objective value to be Maximize	TLBO method Based maximize value	Updated Value	No Of iteration
1	0.3 Pd	0.0935	0.001127				
2	0.4 Pd	0.1096	0.001321				
3	0.5 Pd	0.1218	0.001468				
4	0.6 Pd	0.1236	0.001490				
5	0.8 Pd	0.1563	0.001884				
6	0.95 Pd	0.1865	0.002248				
7	1.0 Pd	0.3615	0.004358				
8	1.05 Pd	0.7542	0.009093				
9	1.08 Pd	0.8124	0.009795				
10	1.15 Pd	7.230	0.08717				
11	1.25 Pd	7.260	0.08753	0.001127	0.09648	0.09648	23
12	1.30 Pd	16.120	0.1943				
13	1.40 Pd	18.126	0.2185				
14	0.7 Pg	1.249	0.01505				
15	0.8 Pg	2.321	0.02798				
16	0.9 Pg	2.456	0.02961				
17	0.95 Pg	2.964	0.03573				
18	1.0 Pg	3.249	0.03917				
19	1.05 Pg	8.1230	0.09793				
20	1.20 Pg	11.1218	0.13409				

3. Results and Conclusion

- A methodology of TLBO has been developed and implemented on the IEEE-14 and IEEE-30 bus test system to obtain approximate values of eigenvalues and corresponding error bounds to voltage collapse point using one of the best theorem which is Gerschgorin's theorem. One of the advantages of this technique is that better chance of obtaining optimal solution. The significance of Gerschgorin's circle with a shortest radius and a centre which is very close to zero is a realistic proximity indicator for the voltage collapse point. Generator Rescheduling is observed by changing the generator MW rating. It is observed that by increasing the Generator MW Rescheduling upto 1.20 of Base Generator MW rating, all the constraits are within limit. This type of theorem and Optimization method is used for voltage stability assessment and enhancement. It gives better result compared to JAYA Optimization method.

4. REFERENCES-

[1] Yuyan Chen, Yanping Zhang, Jian Zhang, Yanjun Zhang, Lixin Song ," A full dynamic voltage stability research based on time-domain simulation" Scientific Research , Energy and Power Engineering,2013,5,769-773

[2] Ärchana Naganathan, Vidhyapriya Ranganathan," Ïmproving voltage stability of power system by optimal location of FACTS devices using Bio-Inspired Algorithms" "Scientific Research Publishing, Circuits and Systems,2016,7,805-813

[3] Shao Hong Tsai, Yuan Kang Wu, Ching Yin Lee," A critical eigenvalues tracing method for the small signal stability analysis of power systems, Scientific Research , " Energy and Power Engineering,2013,5,677-682

[4] Carson W. Taylor," Power system voltage stability, TMH publicationsinternational edition 1994.

[5] D.P. Kothari and J.S.Dhillon," Power System Optimization", PHIpublications, 2nd edition-2006.

[6] Erwin Kreyszig, " Advanced Engineering Mathematics" John Willey & sons, INC.8th edition.

[7]Yamille del Valle," Particle Swarm Optimization: Basic Concepts, Variants, and Applications in Power Systems". ,IEEE Vol 12 No 2 April 2008

[8] R. Venkata Rao "Parameters optimization of selected casting processes using teaching- learning based optimization algorithm.
