Improvement of Voltage Stability of Radial 28 Bus System using L-Index Sensitivity Matrix

G Rajendar, Basavaraja Banakara

Abstract: The goal is to offer a new technique for ascertaining the optimal location along with the quantity of reactive power (RP) to be injected to ameliorate the voltage stability (VS) of Radial 28 bus system that is susceptible to voltage instability. A new sensitivity matrix termed L-Index sensitivity matrix is proposed and the same is pondered for recognizing the buses, at which the RP is to be injected. The proposed work is tested for a practical instance of a Radial 28 bus system. Test outcomes illustrate the developed algorithm's efficiency.

Inex terms: L-index matrix, Jacobian matrix, voltage stability, sensitivity

I. INTRODUCTION

Voltage stability (VS) involves with the power system's ability to retain acceptable voltages on every buses on the normal setting. Once linked chiefly with weak systems along with longer lines, voltage issues are a root of concern in extremely developed networks due to heavier loadings. The paper by Ajjarapu and Lee [8] offers an extensive listing of work performed in the VS field until 1998.

The phenomenon that contributes to the VS is illustrated, the numerous counter-measures to prevent are listed and also the different computer analysis techniques utilized or suggested hitherto is presented in a reasonable manner.

II.MOTIVATION

A voltage instability issue on a distribution system that extends to an equivalent transmission system rooted a chief blackout on the S/SE Brazilians system in the time of 1997. Thus, over time, VS of distribution system attained great interest with a requirement for examination and also amelioration of the operating setting. The VS issue of Radial 28 distribution system as of its single line equivalent was examined along with the voltage stability index (VSI) intended for distinguishing the node which is more responsive to voltage collapse was constructed. The determination of the sizes, location, and number along with the capacitors' type to be used is of immense importance, since it lessens the power along with energy losses, augments the feeders' capacity and also enhances the feeder voltages profile. An association betwixt loss minimizations and VS has been generated. Algorithms for ameliorating the VS of distribution network via network re-configuration that changes the topological constitution of the distribution feeders via reorganizing the switches' status has been propounded in reference. Nonetheless, there were no effort till now to ameliorate the system's stability overall or to ameliorate specific buses' stability.

Numerous indices were suggested to point out the VS of power systems. The L-Index technique suggested in [3] offers a gauge of the stability of load buses to a system via ranking them as per L-Index. The power flow jacobians' eigenvectors and eigenvalues were utilized to typify the stability margin. In this work, L-Index [3] along with Jacobin matrix [7] is employed to derive the L-Index sensitivity matrix signified as (L_q) that is employed to work out the capacitors' optimal location. The result of setting a capacitor at a bus aimed at Radial 28 and also meshed systems is studied. L-Index Sensitivities (L_q) matrix that provides the information about the change in L-Index [3] value with the change in RP injection on any bus is proposed. A technique is generated to ameliorate the

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system's stability utilizing the L-Index sensitivities (L_q) that is relevant to ameliorate the stability of Radial 28 bus system. Linear programming optimizations technique is employed to attain location and quantity of RP to be injected.

III .ITERATURE REVIEW

A.L Index

This technique is suggested [3] to discover the buses that are more vulnerable to voltage instability. Here, the Y_{bus} matrix is bifurcated into rows in addition to columns of generators as well as load buses.

$$\begin{bmatrix} I_G \\ I_L \end{bmatrix} = \begin{pmatrix} Y_{GG} & Y_{GL} \\ Y_{LG} & Y_{LL} \end{pmatrix} \begin{bmatrix} V_G \\ V_L \end{bmatrix} \tag{1}$$

$$\begin{bmatrix} V_L \\ I_G \end{bmatrix} = \begin{pmatrix} Z_{LL} & F_{LG} \\ K_{GL} & Y_{GG} \end{pmatrix} \begin{bmatrix} I_L \\ V_G \end{bmatrix} \tag{2}$$

$$F_{LG} = -[Y_{LL}]^{-1}[Y_{LG}]$$

$$L_j = \left| 1 - \sum_{i=1}^{i=g} F_{ji} \frac{V_i}{V_j} \right| \tag{3}$$

(4)

Wherein the subscript

G : signifies the generator buses

L : signifies the load buses

An L-index value away as of one and near to zero points to big VS margins. The maximum of L-indices (L_{max}) of the buses to which it fits is the utmost serious bus. In addition, the summation of the squares of the L-indices of the individual buses ($\sum L^2$) is utilized as a relative index of the general VS at disparate operating setting [4].

IV. DERIVATION OF L-INDEX SENSITIVITIES

As mentioned in the above section, L-Index would compute VS.

To derive L-Index sensitivities, the number of generator nodes {1,2,3..........g} and also the number of load nodes {g+1,g+2,g+3..........n}are considered.

From the precedent equation, L_j becomes,

$$L_j = \left| 1 - \sum_{i=1}^{i=g} F_{ji} \frac{V_i}{V_j} \right| \tag{5}$$

By squaring the equ (5),

$$L_j^2 = \left(\left| 1 - \sum_{i=1}^{i=g} F_{ji} \frac{V_i}{V_j} \right| \right)^2 = \left(1 - \sum_{i=1}^{i=g} F_{ji} \frac{V_i}{V_j} \right)^2 \tag{6}$$

Let $K_j = L_j^2$

$$K_j = \left(1 - \sum_{i=1}^{i=g} F_{ji} \frac{V_i}{V_j} \right)^2 \tag{7}$$

As previously discussed,

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{pmatrix} H & N \\ M & L \end{pmatrix} \begin{bmatrix} \Delta \theta \\ \Delta V \end{bmatrix} \tag{8}$$

$$\Delta L_j = -\frac{1}{L_j} \left(1 - \sum_{i=1}^{i=g} F_{ji} \frac{V_i}{V_j} \right) \left(\sum_{i=1}^{i=g} F_{ji} \frac{V_i}{V_j^2} \right) \sum_{i=1}^{i=g} a_{ji} \Delta Q_i \tag{9}$$

Therefore, the L-Index sensitivity matrix is,

$$-\left| \left\{ \frac{1}{L_j} \left(1 - \sum_{i=1}^{i=g} F_{ji} \frac{V_i}{V_j} \right) \left(\sum_{i=1}^{i=g} F_{ji} \frac{V_i}{V_j^2} \right) \sum_{i=1}^{i=g} a_{ji} \right\} \right| = L_q$$

New Algorithm for Capacitor Placement

1. Calculate the L index for all the available load buses
2. Calculate the sensitivity matrix
3. Fix (L_{limit}) as a limit for the calculated L-Index,
4. Find the buses with L-Index > L_{limit}, let those buses are [B_2 B_5 B_7].
5. Determine ΔL_{red}, where, ΔL_{red} is considered only for the buses with exceeding L_{limit}.
6. Determine the reduced

sensitivity matrix (L_{rq}),

7. $\Delta L_{red} = \Delta L_{rq}\ \Delta Q_{red}$

8. Take $\sum \Delta Q_{red}$ as the objective function

9. Now execute optimization minimizing objective function fulfilling the constraints $\Delta L_{min} \leq \Delta L \leq \Delta L_{max}$

10. From the above algorithm, the value of capacitors to be placed is attained.

V .EXPERIMENTAL RESULTS

To delineate the above algorithm's effectiveness, the proposed work is implemented on the 28 bus system with its loads increased four times of the base case as proffered in Table 1.

Case study: Radial 28 bus system

Table: L-index Values

Bus no	L-Index
2	0.0521
3	0.1133
4	0.1493
5	0.1736
6	0.2739
7	0.3481
8	0.3879
9	0.4622
10	0.5635
11	0.6347
12	0.6678
13	0.7595
14	0.8373
15	0.8870
16	0.9244
17	0.9575
18	0.9694
19	0.0604
20	0.0626
21	0.0654
22	0.0677
23	0.1209
24	0.1253
25	0.1298
26	0.2804
27	0.2826
28	0.2837

L-index Graph: Before Placing capacitor

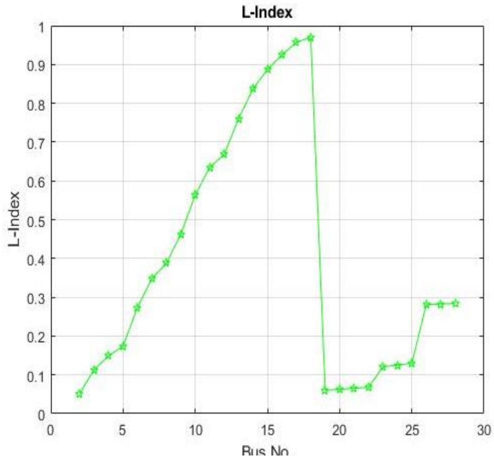


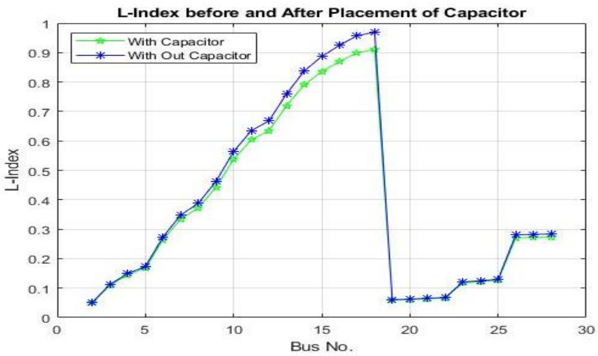
Table 2: Optimum values of the capacitor to be placed in the Radial 28 bus system

Bus no	Value of Capacitor
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0.14346

Table 3: L index values after placing capacitor

Bus no	L-Index
2	0.05212
3	0.11329
4	0.14935
5	0.17362
6	0.2739
7	0.34807
8	0.38792
9	0.46217
10	0.5635
11	0.63469

12	0.66785
13	0.75951
14	0.83728
15	0.88696
16	0.92438
17	0.95754
18	0.96936
19	0.060351
20	0.06257
21	0.06543
22	0.0677
23	0.12087
24	0.12529
25	0.12977
26	0.28041
27	0.2826
28	0.2837



Remarks and Future Scope

A new and effectual approach is developed for the placement capacitor to make the system voltage stable. A new L-Index real power sensitivities matrix is proposed to see the influence of real power on the VS of the system.

VI.CONCLUSIONS

This work is essentially concerned with the VS improvement in Radial 28 power systems. Most of the proposed indices that evaluate the VS are examined. The new algorithm delineated above is found to optimally place the capacitors to ameliorate the VS to the needed level. The impact of RP injections at a bus on the whole power system under consideration is examined. Buses at which the capacitors are to be placed for improving the VS are identified.

In the Radial 28 power systems, the proposed algorithms can be properly modified and then implemented to the meshed systems. The impact of real power on the L index has to be further studied in detail. An index can be developed which can predict the maximum column element in a given row of L index sensitivity matrix (L_q) without looking at thmatrix.

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