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TO IDENTIFY WEAKEST BUS IN A SYSTEM FOR IMPROVING VOLTAGE STABILITY USING VOLTAGE RATIO PROXIMITY INDICATOR

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Abstract

This paper is concerned with the problem of voltage stability. The paper analyses the usefulness of voltage ratio proximity indicator to identify weakest bus in a system for improving voltage stability. The results are carried out over a wide range of load. Test results for the IEEE 14 bus 20 line System are presented. Result obtained from this technique shows that suggested indicator can provide useful information at any operating point and it is reliable and capable to identify weakest bus and facts controller device used for improving voltage stability.

To analyses the effect of facts device voltage stability shunt capacitor is connected to weakest bus. And result will be obtained for it.

Keywords: Voltage Ratio indicator(VRI), Voltage stability, Mat lab.

1. Introduction

Electricity is one of the vital and basic inputs necessary for the economic development of a country. The rapid economic development and industrialization of our country has created a spectacular growth in power demand for electrical power. With the increased loading and exploitation of the power transmission system, the problem of voltage stability and voltage collapse attracts more and more attention. A voltage collapse can take place in systems or subsystems, and can appear quite abruptly. Continuous monitoring of the system state is therefore required.

Voltage stability is concerned with the ability of a power system to maintain acceptable voltages at all buses in the system under normal condition and after being subjected to a disturbance.

Voltage collapse proximity index (name VRI) has been calculated to detect the closeness of present operating state of the system to the critical loading condition. The VRI has been evaluated for standard IEEE 14 bus power system and results show that the proposed index value

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approaches to one when critical loading condition has been achieved.

P.V Curve is useful for conceptual analysis of Voltage stability of a system. The method is also used for large meshed network where P is the total load in area and the voltage at a critical or representative bus. P can also be the power transfer across a transition interface or interconnection.

The reliability of the Voltage ratio indicator (VRI) is tested on the IEEE 14 bus 20 line power systems. Diagram of IEEE 14 bus 20 lines power system is as shown in Figure 1.

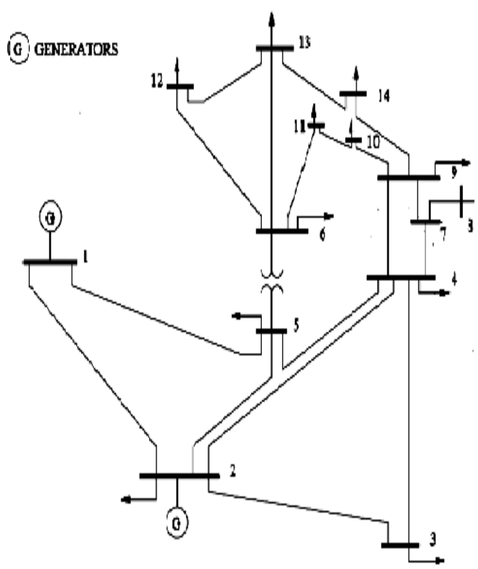


Figure No. 1 IEEE 14 bus 20 line power system

N-R method based algorithm is programmed using MATLAB to simulate the results.

2. Methodology

In this study, development of a voltage collapse proximity index have presented which indicates how far current operating conditions are from the critical point and which buses are more vulnerable from the voltage instability new point. The proposed index will help in monitoring the system at load dispatch centers (LDCs) against voltage collapse and in taking proper correcting actions to mitigate from the critical conditions.

Problem formulation in detail is given below. Let us consider a simple two bus system –

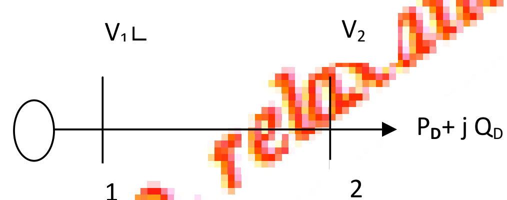


Figure No.2 Simple two bus power system

The governing power flow equations are:

$$P_D = \frac{V_1 V_2}{X} Sin\ \delta \ \text{...............Equation(1)}$$

$$Q_D = \frac{V_1 V_2}{X} Cos\ \delta - \frac{V_2^{\ 2}}{X} \ \text{........Equation (2)}$$

By Squaring and adding equations 1 and 2, we get

$$V_2^{\ 4} - (V_1^{\ 2} - 2XQ_D)\, V_2^{\ 2} + X^2 (P_D^{\ 2} + Q_D^{\ 2}) = 0$$

………………..Equation (3)

$$V_2^2 = \frac{(V_1^2 - 2XQ_D) \pm \sqrt{(V_1^2 - 2\,X\,Q_D)^2 - 4X^2(P_D^2 + Q_D^2)}}{2}$$

…………………Equation.(4)

For each load demand (P_D, Q_D), there will be two solutions for the load bus voltage.

$$V_{2H}{}^2 = \frac{(V_1^2 - 2XQ_D) + \sqrt{(V_1^2 - 2\times Q_D)^2 - 4X^2(P_D{}^2 + Q_D{}^2)}}{2}$$

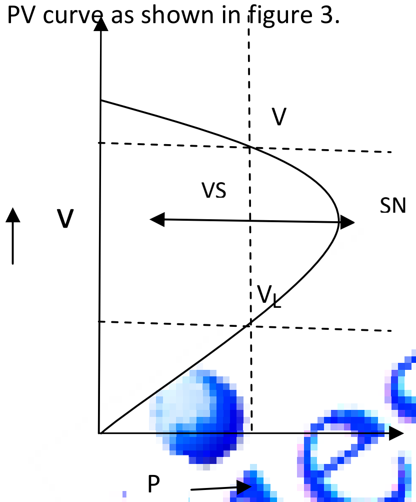
……………… Equation(5)

and

$$V_{2L}{}^2 = \frac{(V_1^2 - 2\times Q_D) - \sqrt{(V_1^2 - 2\times Q_D)^2 - 4X^2(P_D{}^2 + Q_D{}^2)}}{2}$$

…………… Equation (6)

Where V_H is called upper voltage solution and V_L is called lower voltage solution. These are illustrated in PV curve as shown in figure 3.



Where SNBP is the Saddle Node Bifurcation Point and VSM is the Voltage Stability Margin

Let us define $Q_D = \beta.P_D$…. Equation (7)

Where, $\beta = \tan\phi$

ϕ = Power factor angle at the load bus,

By using the relation of equation 7, the equation 5 and 6 can be rewritten as:

$$V_H{}^2 = \left\{\frac{(V_1^2 - 2\times\beta P_D + \sqrt{(V_1^2 - 2\times\beta P_D)^2 - 4X^2(1+\beta^2)P_D{}^2}}{2}\right\}……….$$

Equation (8)

$$V_L^2 = \left\{\frac{(V_1^2 - 2\times\beta P_D) - \sqrt{(V_1^2 - 2\times\beta P_D)^2 - 4X^2(1+\beta^2)P_D{}^2}}{2}\right\}$$

………..Equation (9)

The new proximity indicator is proposed as:

Voltage ratio Index (VRI) = VH / VL

Using Relations 8 and 9, we have

$$VRI = \sqrt{(V_1{}^2 - 2X\beta P_D)^2 - 4X^2 P_D{}^2(1+\beta^2)}$$

…………………..Equation (10)

The VRI will become one at the critical demand P_D.

The critical P_D for making VRI equals to one can be deduced using eq. no. 10

The proposed VRI at any load buscan be calculated with the following information (i)Real power demand PD at the load bus(ii) Line data of connecting line (iii)Load Power Factor (iv) Sending end bus voltage magnitude.

For the determination of VRI at different load buses for a multibus system, following algorithm has been proposed. The variation in VRI at different loadings can be observed. This variation can help in identification of weak buses of the system. The algorithm used is as described below:

1. Read System Data
2. Set β = tanϕ at load buses.
3. Set system load.
4. Run the load flow.
5. Evaluate VRI at load buses.
6. Increase load
7. Go to step 3
8. If the value of VRI is near 1 at any bus then it is the weak.
9. END

Block Diagram of the process adopted is given in the figure no. 4

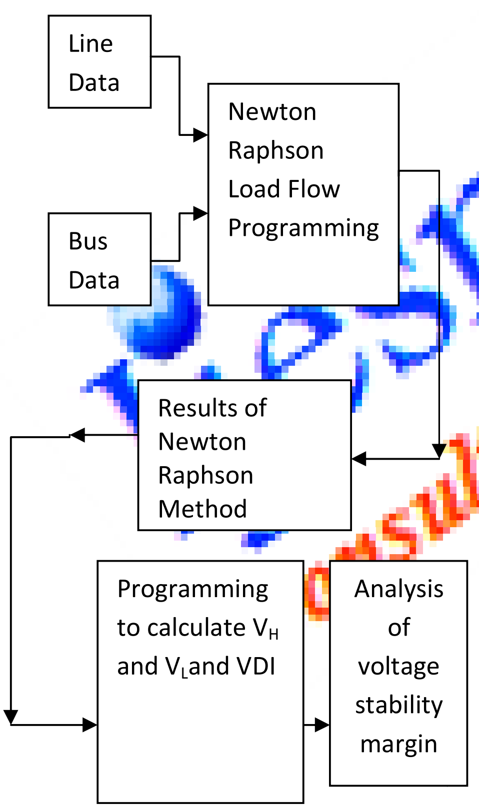


Figure 4 Block diagram of the method adopted

3. Implementation and Results

In this paper value of β = tanφ is taken as 0.5. Value of ratio $V_H/V_L$is calculated at different load from 100% to 180% for different lines. That line at which ratio V_H and $V_L$is nearer to unity is tabulated as given in table 1 below at different load.

Result shows that value of suggested Voltage Ratio Index is near to one mostly at 4 number bus. It indicates that 4 number bus is weakest. Also from the result we can conclude that at higher load value of VRI is getting closer to one in most of the buses. So at high load the voltage stability is low

Results at value of bita β = 0.5

Bus No	value of ratio index nearest to 1 at 100%	value of ratio index nearest to 1 at 120%	value of ratio index nearest to 1 at 140%	value of ratio index nearest to 1 at 160%	value of ratio index nearest to 1 at 180%
1	4.818	4.8189	4.8189	4.518	4.818
2	7.732	4.7929	5.067	4.441	3.995
3	7.52	8.55	10.43	16.89	13.75
4	**2.91**	**1.00**	**1.00**	**1.00**	**1.00**
5	18.50	8.62	6.22	4.97	4.06
6	6.48	4.99	3.89	3.28	2.722
7	14.18	12.36	8.17	5.63	4.23
8	14.18	14.18	8.17	9.95	5.25
9	3.19	2.71	2.33	1.97	1.62
10	14.18	6.07	4.68	2.24	3.11
11	14.18	6.07	4.68	2.24	3.11
12	7.24	5.32	4.15	3.47	2.84
13	4.99	4.03	3.34	3.47	2.84
14	4.99	4.03	3.34	3.47	2.38

Table 1 Value of voltage ratio index at different load for different buses

Results can be evaluated for different values of beta.

4. Conclusions

The proposed Index is easy to evaluate and involve less computational time. This index can be evaluated centrally at load dispatch centers (LDCs) and can be helpful for offline monitoring of stressed power systems against voltage collapse.

In this work weakest bus found out is 4 number bus for the given 14 bus 20 lines power system. It can be concluded from the work that comparatively weaker bus can find by this suggested VRI. One more conclusion that we get from this work is that voltage stability of the system decreases with increase in load.

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