Different Indices for Voltage Collapse Prediction in Power Systems

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Abstract: This thesis proposes an indicator to estimate the voltage balance margin in electrical energy systems, described as L index which can supply an correct indication to strength gadget voltage instability. From the indicator, it is allowed to predict the voltage instability or the proximity of a voltage collapse. The proposed index has been evaluated on IEEE 6 bus, IEEE 14 bus and IEEE 30 bus system, thinking about a number of running prerequisites and contingencies as line outages.

INTRODUCTION

In recent years, cost effective and environmental reasons have pressured the transmission systems to be operated toward their protection limits. Traditionally, their limits are associated with thermal and transient stability barriers. However, the transient stability barriers have come to be less restrictive as these days most of the electric utilities use quicker relays to reduce the fault clearing time, fast reaction excitation structures and Flexible ac Transmission System (FACTS) gadgets to reduce the amplitude of the oscillation.

Voltage stability troubles are regularly associated with contingencies like unexpected line and generator outages, insufficient local reactive energy deliver and elevated loading of the transmission lines. A strength gadget at a modern operation factor is voltage strong if, following any disturbance voltages near masses are close to the pre-disturbance values; and a device is voltage risky if it's far incapable in preserving pre-disturbance values of voltage after any disturbance.

Bruno Leonardi et al. proposed a man-in-loop technique to increase reactive strength reserves whilst retaining a minimal quantity of voltage steadiness margin bus voltage limits. In this paper, the manipulate motion is primarily based on convex quadratic optimization.

The energy structures voltage instability is taking phase in growing the losses in energy systems,which is no longer proper and with amplify in losses the price of strength structures is turning into more.Various voltage steadiness indices are mentioned in literature that are used to decide the proximity of the electricity gadget to the voltage cave in i.e. how a device is shut to the voltage collapse. For instance, some voltage balance indices are primarily based on electricity drift Jacobian matrix such as the minimal eigenvalue, take a look at function, tangent vector and bus voltage rating index V/Vo. There are many different indices which use the factors of the admittance matrix and some gadget variables such as bus voltages and electricity glide thru strains such as VCPI, L index, prolonged L-index, LCPI, Lmn, LQP, FVSI. “One of these indices is L index as mentioned in

[3]. Its fee lies between zero (no load) to 1 (voltage collapse). In [3], L index is carried out on 6 bus system. This thesis proposes L index and its overall performance is evaluated on 6 bus system, IEEE 14 bus machine and IEEE 30 bus gadget and that too with exceptional simulation instances additionally effects are in contrast with modal analysis.

The solution of the V is represented as PV or QV curves. Fig.3.3 shows PV curve for different power factors.

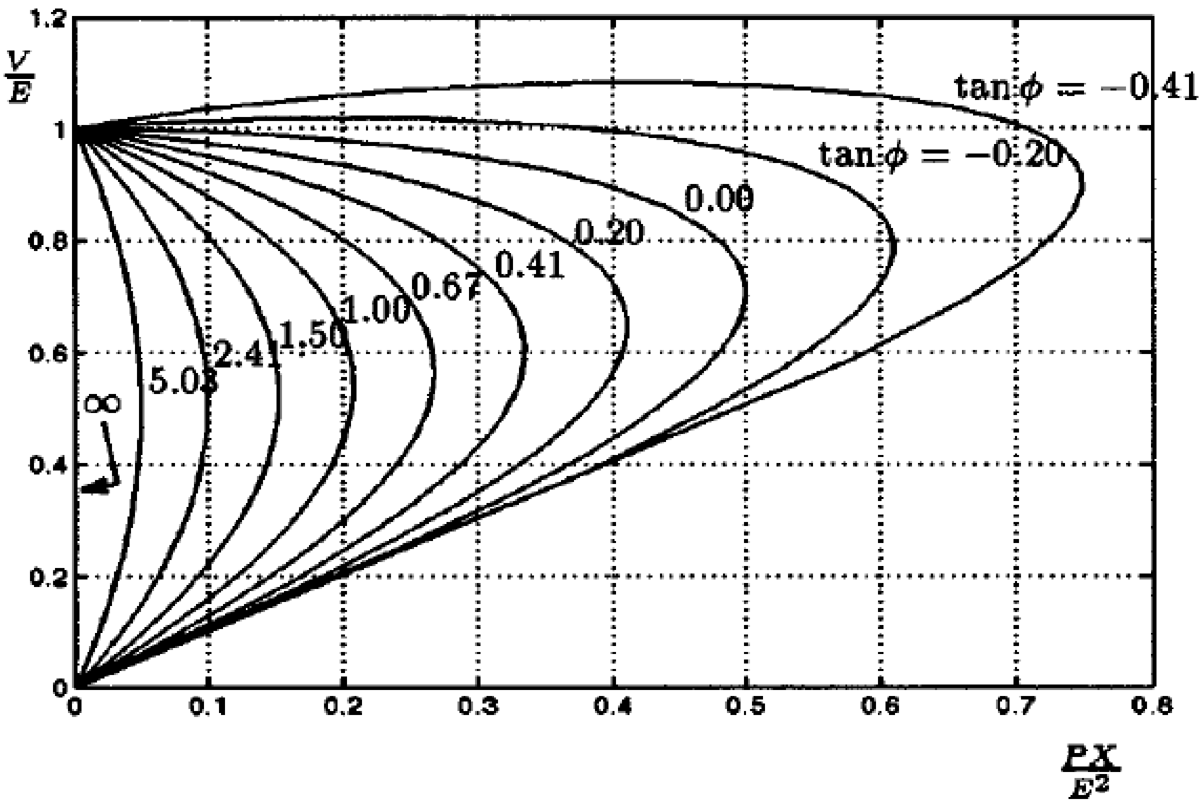

Fig.1 PV curves

From Fig.3.3, it is clear that there is a most energy that can be transmitted for every load strength component and for any loading, there are two specific values of V. Normal operation of the electricity device is alongside the top section of the curve the place the receiving cease voltage is almost 1.0 p.u. i.e. the top section of the curve is secure which corresponds to the fine signal in eq.(3.3) whilst the decrease phase is unstable. The load is expanded by way of lowering the wonderful resistance of the load upto the most power, the product of load voltage and modern-day will increase and device is stable. As the most strength factor is reached, a in addition discount in high quality load resistance, reduces the voltage a great deal greater than the enlarge in modern and, therefore, there is an superb discount in strength transmission.

Voltage Collapse Proximity Indicator (VCPI)

The voltage give way proximity indicator is proposed with the aid of M. Moghavvemi. It investigates the steadiness of every line of the machine and it is primarily based on the thought of most electricity transferred thru a line [6].

The indices of the line i-j are described as,

$$VCPI(Power) = \frac{P_R}{P_{R(max)}} \tag{4.8}$$

$$VCPI(Losses) = \frac{P_{losses}}{P_{losses(max)}} \tag{4.9}$$

As the energy go with the flow transmitted by using transmission line increases, the values of VCPI (Power) and VCPI (Losses) will amplify and when they attain 1, the voltage give way occurs. The VCPI indices fluctuate from zero (no load condition) to 1 (voltage collapse).

V/V0 index

According to [6], if the bus voltage can be recognized from load go with the flow or kingdom estimation studies, new bus voltage (V0) is acquired through fixing a load drift for the machine at an same nation bus with all hundreds set to zero.

The ratio V/V0 at every node offers the voltage balance map of the machine and permits for immediately detection of vulnerable bus.

RESULTS

L index results since according to the results of L index, bus 14 is the most critical bus. Fig 6.9 shows the bus participation factor for 30 bus test system in the least stable mode for critical operating point. As we can see, the bus that presents the highest participation factor is bus 30. So, this is the bus that contributes more to the voltage collapse. This also resembles with the results of L index. Thus, the proposed index gives accurate information regarding the critical bus of the system and therefore, this can be used as promising tool for voltage stability analysis.

For 6 bus system

(All calculations are on 100 MVA base)

Table 6.1 L index at different loading conditions (6 bus system)

Bus no.	Voltage stability L index					
	base load	140%	180%	220%	260%	peak load
3	0.1245	0.1821	0.2477	0.3264	0.4299	0.6643
5	0.1031	0.1497	0.2018	0.2618	0.3347	0.4847
6	0.0995	0.1426	0.1922	0.2511	0.3259	0.4809
4	0.0912	0.1335	0.1816	0.239	0.3136	0.4761

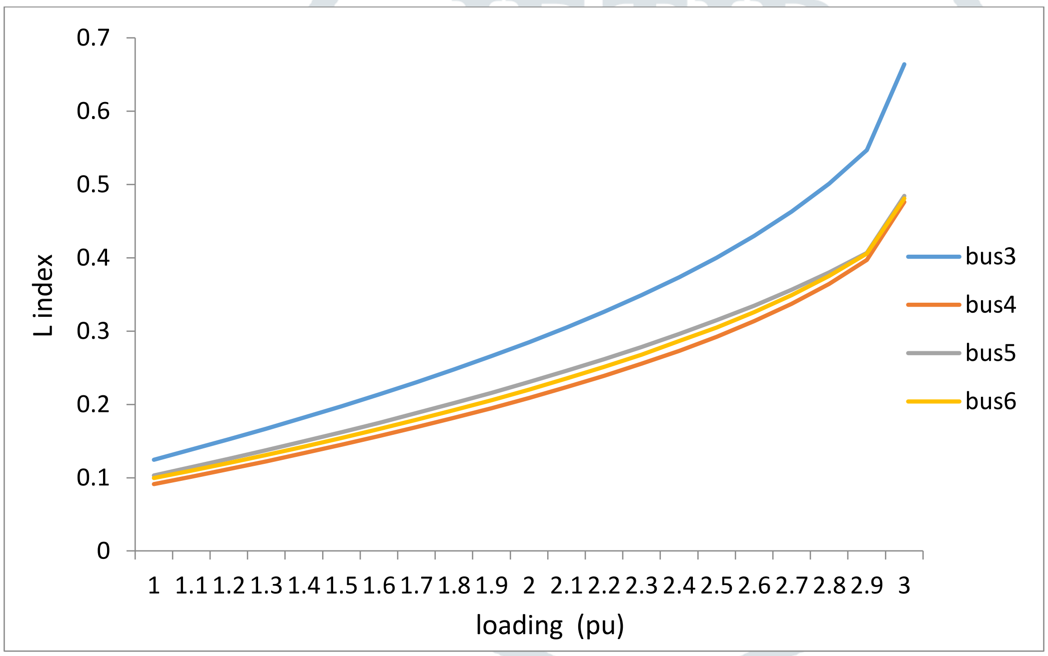

Fig.2 L index curve (6 bus system)

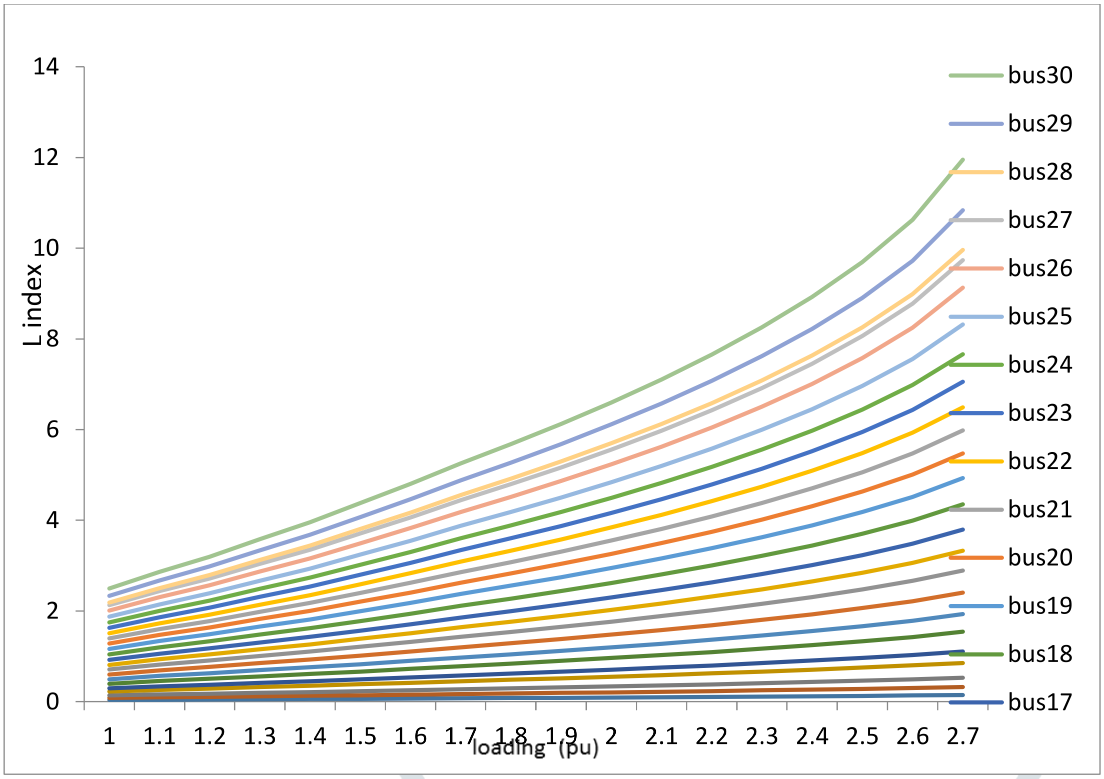

Fig 3 L-index curve (30 bus system)

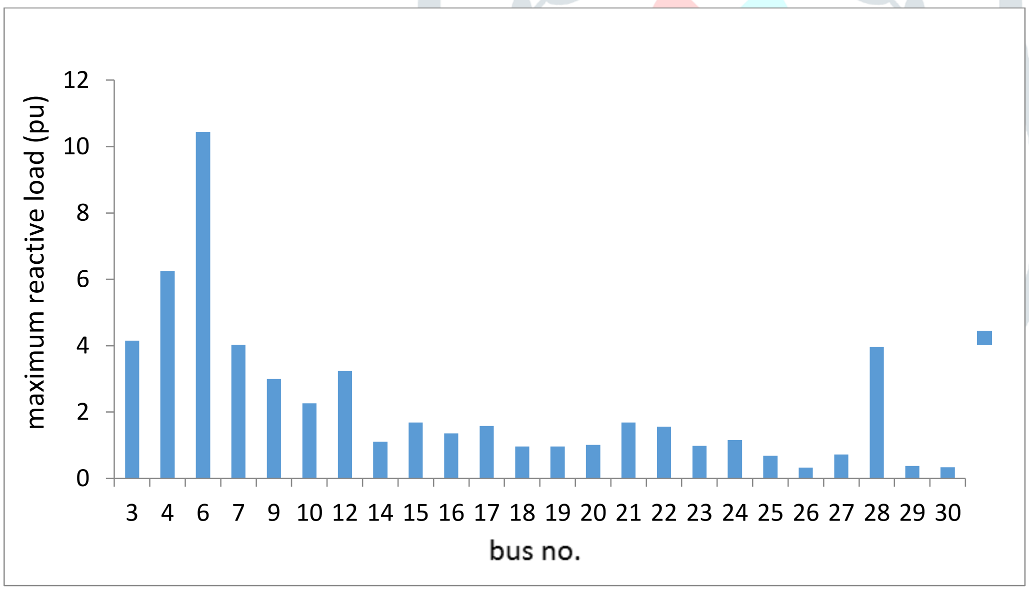

Fig 4 Maximum permissible reactive loading (p.u.) of load buses in IEEE 30 bus system.

The permissible reactive load of each bus within the IEEE 30-bus machine is illustrated by means of bar chart as shown in Fig. 4. On the idea of this chart the voltage-weak nodes and areas can be identified. Nodes 25, 26, 27, 29, and 30 are located to be the voltage-susceptible nodes of the device as these nodes have smaller permissible reactive loading. Therefore, region containing those buses is taken into consideration because the weakest area of the system.

Conclusion

This thesis compares the overall performance of voltage balance indices together with L index and the conventional Jacobian index based on the minimal eigenvalue of the reduced Jacobian matrix. The indices have been examined on IEEE 6, IEEE 14 and IEEE 30 buses test gadget. In terms of widespread overall performance, the L index is coherent with their theoretical background. When the device is stable, the index presents value near zero and go 1 on the voltage fall apart point.

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