Identification of Weakest Bus with respect to Increasing Loading Effect

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Abstract--- Voltage instability problem increases day by day because of increase demand in power. It is important to analyses the power system with respect to voltage stability. The power system analysis and design is generally done by using power flow analysis. With the help of different stability indices which can give an accurate indication to power system voltage instability with considering the influence of the load model, the stability of the bus is identified. This can identify the efficient bus among all the buses. As an application of identifying efficient bus, approach is to identify voltage stability for buses, and to transfer loads of faulty bus or weak bus to this efficient bus. There are different methodologies can be used to transfer this kind of loads to efficient bus with which stability of the system can be achieved.

Keywords: Transmission System; Power Flow Analysis; Voltage Stability; Voltage Stable Bus; PSAT.

I. INTRODUCTION

Voltage control and voltage stability problems are not new to the electric utility industry but are now receiving special attention. In many systems once associated with long lines and weak systems, voltage stability problems are now also a source of concern in highly developed network as a result of heavier loading with growing size along with economic and environmental pressure, the possible threat of voltage instability is becoming increasingly pronounced in power system networks.

Voltage stability is concerned with the ability of the power system to maintain acceptable voltages at all buses in the system under normal condition and after being subjected to a disturbance. Voltage stability problems normally occur in heavily stressed system. The underlying problem is an inherent weakness in the power system, while the disturbance lead to voltage collapse may be initiated by a variety of causes. In addition to the strength of transmission network and power transfer levels, the principal factors contributing to voltage collapse are the generator reactive power/voltage control limits, load characteristics, characteristics of reactive compensation devices, and the action of voltage control devices. But the main factor causing instability of voltage is the increase in load demand, which causes extra loading on the transmission lines which ultimately becomes the reason of failure of operation of buses at certain point.

The task of the transmission network in the Power System is to deliver the power generated in the power plants to the load centers in the network and the interconnected power systems. The transmission of electric power has to take place in the most resourceful way without the transmission network failure. The transmission systems in the present time are becoming increasingly complex & stressed because of growing demand and because of restrictions on installation of new lines. For transmission network security & failure point of view it is quite important to find out most efficient bus and weakest bus in the system. So, the changeover of the load from weakest bus to most efficient bus can be done under certain critical condition.

II. OBJECTIVE

The present day transmission network is getting more and more stressed due to economic and environmental constraints. The trend is to operate the existing networks optimally close to their lodability limit. Adequate co-ordination should be ensured between equipment protections/controls based on dynamic simulation studies. Tripping of equipment to avoid an overloaded condition should be the last alternative. Controlled system separation and adaptive or intelligent control could also be used.

To improve the power system it is meant to be in stable condition. To gain stable condition the identification method is required which provides the location of most efficient bus and weakest bus, on which we have to apply switching of the load. Because of the overloading and under extensive pressurized condition maximum chances of failure of the weakest bus are there. Therefore by identifying weakest bus all the loads can transferred to the other most efficient bus. With the help of transferring process, achieved by any switching scheme, the load can be transferred to most efficient bus. The basic objective of the dissertation is to identification of most efficient bus and to transfer load of the weakest bus to most efficient bus by use of any switching scheme.

III. VOLTAGE STABILITY

Voltage stability covers a wide range of phenomena. Because of this, voltage stability means different things to different engineers. Voltage stability is sometimes also called load stability. The terms voltage collapse and voltage instability are often used as requirement.

The voltage instability is a dynamic process wherein contrast to rotor angle stability, voltage dynamics mainly involves loads and the means for voltage control. Voltage collapse is also defined as a process by which voltage instability leads to very low voltage profile in a significant part of the system. Voltage instability limit is not directly correlated to the network maximum power transfer limit.

A. Small-disturbance Voltage Stability:

A power system at a given operating state is small-disturbance voltage stable if, following any small disturbance; voltages near loads do not change or remain close to the pre-disturbance values. The concept of small-disturbance voltage stability is related to steady state stability and can be analyzed using small signal (linearized) model of the system.

B. Voltage Stability:

A power system at a given operating state is voltage stable if on being subjected to certain disturbance, the voltages near loads approach the post-disturbance equilibrium values. The concept of voltage stability is related to transient stability of a power system. The analysis of voltage stability normally requires simulation of the system modeled by non-linear differential-algebraic equations.

C. Voltage Collapse:

Following voltage instability, a power system undergoes voltage collapse if the post-disturbance equilibrium voltages near loads are below acceptable limits. Voltage collapse may be total (blackout) or partial.

D. Voltage Stability Indices

Voltage stability index is the value which is calculated by the power flow analysis with the help of load flow study. There are different types of load flow studies like Gauss-sidle method, N-R method R-k method etc. which provides process continuity from generation to consumer is done efficiently and without interruption. With the help of stability indices the stability margin can be found out and weakest point in the power system can be calculated. Different voltage stability indices (VSI) are used to determine the critical bus or stability of the each line connected between the different buses in an interconnected system network. Some of the important indices are Line Stability Index (Lmn), Fast Voltage Stability Index (FVSI), Line Stability Factor (LQP), Voltage Collapse Proximity Index (VCPI), on Line Stability Index (LVSI), Also P-V curve and Q-V curve are used for analysis of voltage stability. With the help of any of the voltage stability indices the stability of the voltage for particular bus of the system can be found out.

IV. TOOLBOX REQUIRED

For the proposed work we are using PSAT. The Power System Analysis Toolbox (PSAT) is an open source Matlab and GNU/Octave-based software package for analysis and design of small to medium size electric power systems. PSAT includes power flow, continuation power flow, optimal power flow, small-signal stability analysis, and time-domain simulation, as well as several static and dynamic models, including nonconventional loads, synchronous and asynchronous machines, regulators, and FACTS.

PSAT has been thought to be portable and open source. At this aim, PSAT has been developed using Matlab, which runs on the commonest operating systems, such as Unix, Linux, Windows, and Mac OS X. Nevertheless, PSAT would not be completely open source if it run only on Matlab, which is a proprietary software. At this aim PSAT can run also on the latest GNU/Octave releases [12], which is basically a free Matlab clone. In the knowledge of the author, PSAT is actually the first free software project in the field of power system analysis. PSAT is also the first power system software which runs on GNU/Octave platforms. The synoptic scheme of PSAT is depicted in Fig. 1.

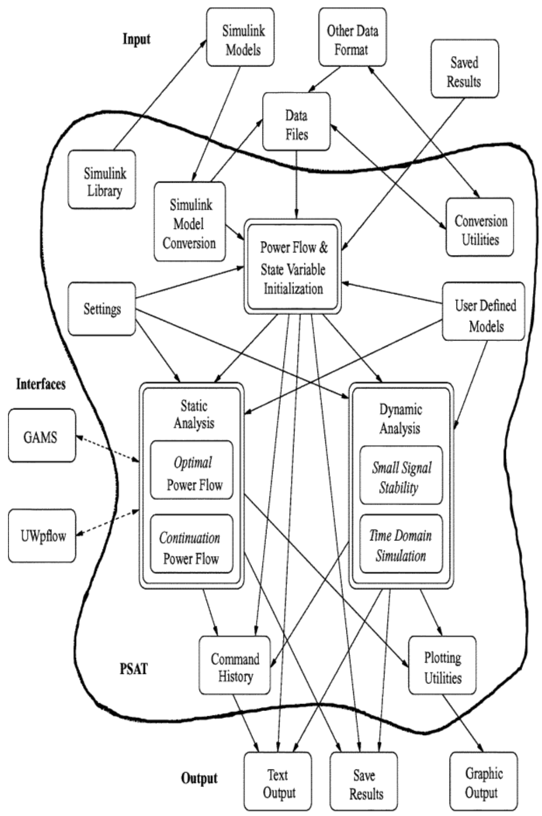

Fig. 1: Synoptic Scheme of PSAT

V. SIMULATION ANALYSIS

In the proposed solution we are experimenting with IEEE-5 bus system. For doing so we are using PSAT a Matlab based Simulink & Simulation tool used for Power System Analysis. Here we have designed a simulink model of IEEE-5 bus system & have used the standard test data for it as shown in figure 2.

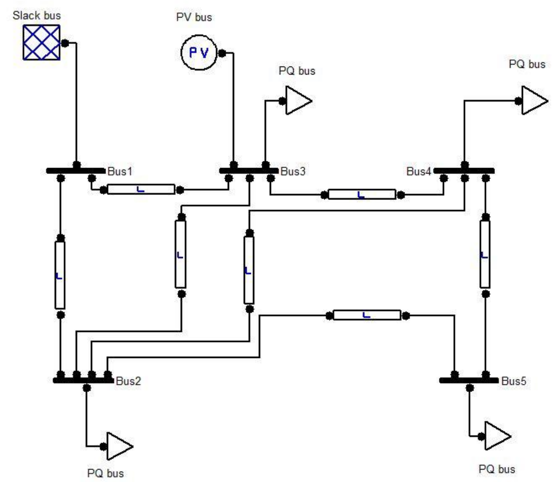

Fig. 2: IEEE – 5 bus system

The input date for the above bus system is given in the table.

Bus Number	Generation		Load		Voltage
	Real	Reactive	Real	Reactive	

1(Slack bus)	0	0	0	0	1.06
2(Load bus)	0.4	0.3	0.2	0.1	1
3(Generator bus)	0	0	0.45	0.15	1
4(Load bus)	0	0	0.4	0.05	1
5(Load bus)	0	0	2.1	0.5	1

Table. 1: Bus Data

Line Number	Resistance R (pu)	Reactance X (pu)	Susceptance Y (pu)
1-2	0.02	0.06	0.03
1-3	0.08	0.24	0.025
2-3	0.06	0.18	0.02
2-4	0.06	0.18	0.02
2-5	0.04	0.12	0.015
3-4	0.01	0.03	0.01
4-5	0.08	0.24	0.025

Table. 2: Line Data

After feeding the above data in the model shown in figure 2, we have obtained power flow result by using Newton-Raphson method. Here we only require the voltage magnitude data from power flow analysis. Now from here onwards we would be changing the load data by 5% repeatedly.

After changing the load values 5% we have performed power flow analysis and have tabulated the results as shown above & have repeated the process for 10% change in load value, then 15% and so on up-to 40% whose power flow result is tabulated below in result (Table 3).

VI. RESULT

After obtaining the power flow analysis result at each percentage change in load, we have tabulated the voltage profile at each change and have taken out average of each change. After obtaining the average we have subtracted the average power flow value to original power flow result. The voltage at bus where the difference is the least is considered as the most efficient bus.

	V1	V2	V3	V4	V5
Original Power flow Result	1.06	0.99515	1	0.98807	0.88603
5% Change	1.06	0.93733	1	0.93403	0.77753
10% Change	1.06	0.89472	1	0.88867	0.69109
15% Change	1.06	0.86307	1	0.85461	0.62354
20% Change	1.06	0.89596	1	0.82759	0.56807
Average after increase in load	1.06	0.88277	1	0.87622	0.66655
Difference	0	0.11238	0	0.11185	0.21948

Table. 3: Voltage magnitude Result

VII. CONSLUSION

As seen in result analysis in table 3, average difference of voltage profile is taken of values of increased loading effect by 5%, 10%, 15% & 20%. There is highest difference in bus number 5 in this bus system which proves that the bus number 5 is the weakest bus among the whole bus system.

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