INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Transient Stability Enhancement of 110/11kv Substation using ETAP

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Abstract:
Transient stability is the ability of a power system to maintain synchronism subjected to large disturbances such as three phase fault, short circuit etc.. Present time power systems are being operated nearer to their stability limits due to economic and environmental reasons. Maintaining a stable and secure operation of a power system is therefore a very important and challenging issue. In this paper power flow and hence transient stability of a multi machine practical power system under northern side of Kerala is investigated. Actual data are collected from K.S.E.B is used for simulation. Also comparison of transient stability with and without SVC is done in this paper.

Key words: *Transient stability, ETAP, SVC*

1. Introduction

Analysis and study of power system has a significant role in power systems engineering. Power systems are continuously subjected to various types of disturbances which causes the instability problem. Power system stability is defined as the ability of power system to preserve its steady condition or recover the initial steady state after any deviation of the system's operation. Present time power systems are being operated nearer to their stability limits due to economic and environmental reasons. Maintaining a stable and secure operation of a power system is therefore a very important and challenging issue.

Transient stability has been given much attention by power system researchers and planners in recent years, and is being regarded as one of the major sources of power system insecurity. Shunt FACTS devices play an important role in improving the transient stability, increasing transmission capacity and damping low frequency oscillations. In this paper shunt FACTS device-SVC is used for improving the transient stability. As the problem of transient stability is a crucial issue, the tools for mitigating such a sensitive problem have an important significance. Static VAR Compensator (SVC) can control reactive power and therefore is used to improve transient stability as well as the voltage profile.

Rapid development of power systems especially with the increased use of transmission facilities has necessitated new ways of maximizing power transfer in existing transmission facilities while at the same time maintaining the same level of stability. To enhance the power system's stability and improve the quality of the transmission of electric power, it is necessary to provide reactive power and stable voltage for the power system. As a main reactive power compensation device especially for the distribution system, shunt capacitor reactive power compensation has gotten a wide range of applications Long .Recent development of power electronics has introduced the use of Flexible Alternating Current Transmission Systems (FACTS) devices in electric power systems, FACTS devices are capable of controlling the network conditions in a very fast manner and are recognized as viable solution for controlling transmission voltage, power flow, and dynamic response. As a result FACTS represent a new era for the transmission of electric power.

The innovative FACTS have been proposed during the last three decades for improving transient stability of a power system. There are various forms of FACTS devices namely Static VAR Compensator SVC, Static Synchronous Series Compensator (SSSC), Thyristor Controlled Series Compensator (TCSC), Static Synchronous Compensator (STATCOM), Unified Power Flow controller (UPFC) SVC based on Thyristor Control Reactor (TCR) is one of the shunt FACTS devices that are used for voltage regulation by controlling the production, absorption, and power flow of reactive power through the network. Power flow solution of the network that contains such devices is a fundamental requirement, many research works have been carried out in the literature for developing load flow algorithms for such devices. Even though the primary purpose of shunt FACTS devices is to support bus voltage by injecting (or absorbing) reactive power, they are also capable of improving transient stability by increasing (or decreasing) the power transfer when the machine angle increases (or decreases) which is achieved by operating the shunt FACTS devices in a capacitive (or inductive) mode .

2. Transient Stability

Power system stability is the ability of an electric power system, for a given initial operating condition, to regain a state of operating equilibrium after being subjected to a physical disturbance, with most system variables bounded so that practically the entire system remains intact. Angular stability is subcategorised into Small-Disturbance Angle Stability and Transient Stability. Small disturbances can be for example when changing the operation point of generators or small voltage dips. Transient stability may be an issue in case of larger disturbances such as disconnection of a line or faults where the voltage drops close to zero at the fault location.
Consider two generators connected by a lossless line,
The active power generated between two generators is given by,

$$P = \frac{|V_1||V_2|}{X} \sin \delta_{12} \qquad (1)$$

The power transferred between the two generators depends mainly on the angle difference between them as seen in (1). If (1) is plotted as a function of angle it can be seen how the maximum power transfer between the two generators occurs .when the angle difference is 90^0.
Although the maximum power interchange is at 90^0 a power system is rarely operated atthat point. The main reason is that the power system in general is dynamic and quantities are constantly varying. Small disturbances could then lead to a system collapse, since small angle variations would reduce the air gap power of the generators and the initial angle could not be restored. As stated before Rotor Angle Stability is classified into two categories depending on the significance of the fault, Small-Disturbance Angular Stability or Transient stability.

3. Description of Single Line Diagram

Power systems are basically composed of a set of generating plants, a distribution network and a combination of industrial, commercial and residential loads. The study system consists of a complex power system connected to the 110/11kV substation. It consists of three generating stations having 12 generators and seven substations having step down transformers. The system under study is one of the 110kV substations under Kerala state electricity board. It consists of four power transformers, Circuit breakers, Current transformers, potential transformers, Lightning arresters ,Isolators, Many feeders etc. This substation is a step down as well as distribution substation.

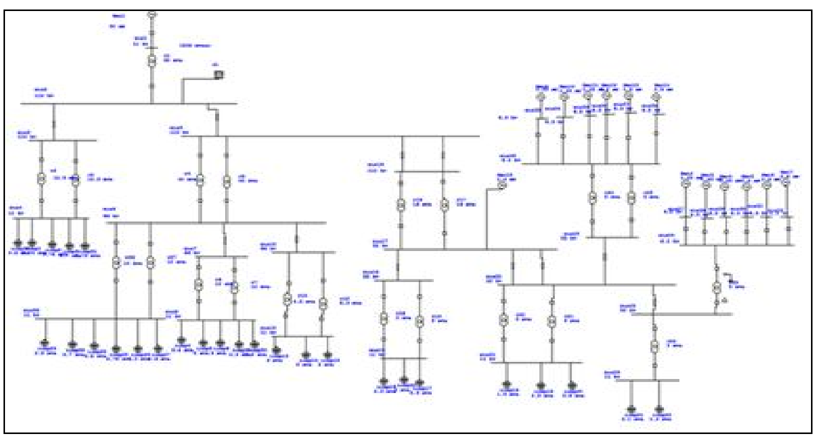

Figure 1

There are four 110kV feeders. There are two 40MVA 110/66kV transformers these transformers are normally operated in parallel. Two 10 MVA transformer are used to step down 66kV to 11kV.There are two numbers of 20MVAr shunt capacitor bank and are used to improve the power factor. All 110kV circuit breakers are SF_6 and motor operated. All 66kV circuit breakers are SF_6 type out of these three are pneumatically operated mechanism. The sub transmission voltage 66kV line can serve as a source to distribution substation. Distribution substation is located near to the end user. Distribution substation transformer changes the transmission or sub transmission voltage to lower level for use by end user. The distribution voltage is 11kV.

4. Transient Stability Analysis of System

Transient stability is the ability of a power system to maintain synchronism under large disturbance conditions like severe three phase faults, line switching etc. For analysing the transient stability there are many software are available. Out of these one of very efficient and user friendly ETAP(Electrical Transient Analyser Programme).The simulation diagram for the study system is shown in fig 1.First we will conduct the load flow analysis of the whole system.

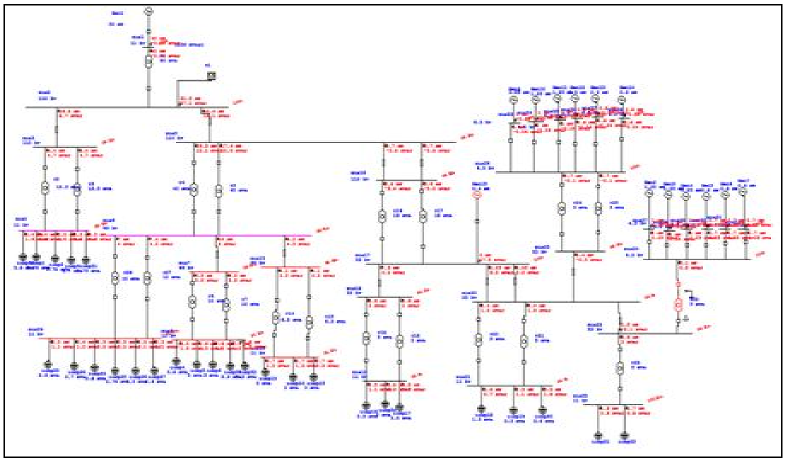

Figure 2: Load flow analysis of system

While conducting load flow using ETAP, we can see that all the buses are regulated and no buses are under voltage or overvoltage problems. Similarly no generators are overloaded and also other protecting instruments. The minimum voltage occurred is only at 11kV buses that are about 92%.So we can go for the transient stability analysis.

Transient stability analysis is analysing whether the system is stable under severe disturbances or it loses synchronism or not during faulty conditions. First we are applying a three phase fault at bus number 4 at 3sec and clearing the fault at 3.3sec.This continuous till it becomes unstable. And we will get the critical clearing time as 0.7 sec. This is simulation results are shown in fig without connecting SVC.

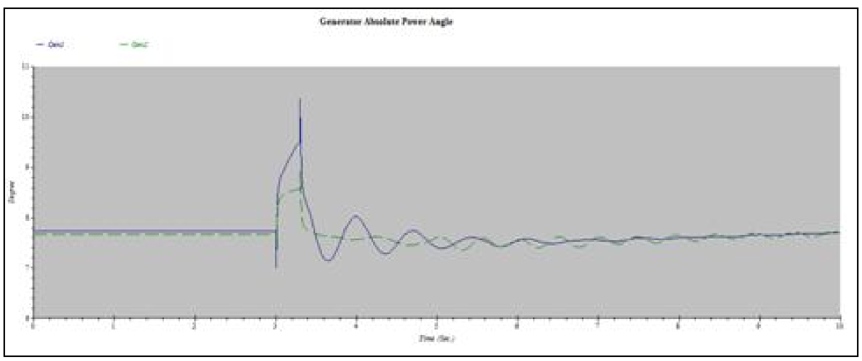

Figure 3: power angle

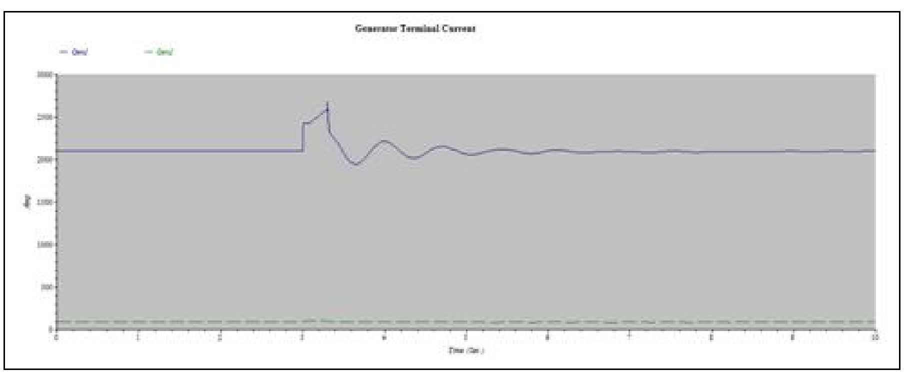

Figure 4: generator terminal current

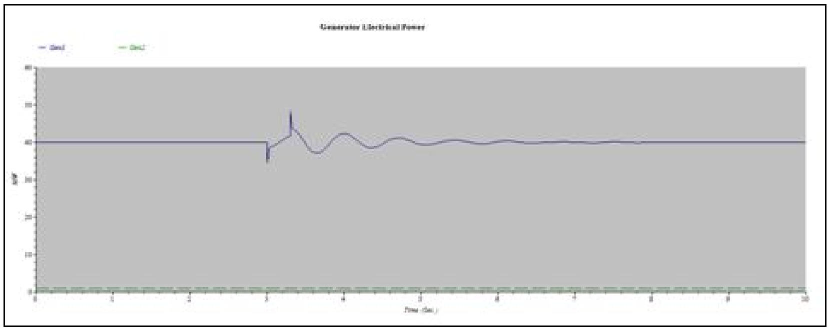

Figure 5: generated electrical power

Static Var systems are applied by utilities in transmission applications for several use. The primary purpose is usually for rapid control of voltage at weak points in a net work. Installations may be at the midpoint of transmission interconnections or at the line ends. Static Var Compensators are shunt connected static generators and or absorbers whose outputs are varied so as to control voltage of the electric power systems. The SVC is connected to a coupling transformer that is connected directly to the ac bus whose voltage is to be regulated. The effective reactance of the FC-TCR is varied by firing angle control of the anti parallel thyristors. The firing angle can be controlled through a PI controller in such a way that the voltage bus where the SVC is connected is maintained at the reference value. This improves the dynamic performance of the power system. The improved transient performance of the system is shown in the fig 3 to 5.

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