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Placement of FACTS Device Using Soft Computing Technique: A Review

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Abstract **- In recent year, power demand has increased substantially and hence expansion of power generation and transmission system has been severally limited due to limited resources and environmental restriction. From the secure operation point of view, power system stability has been recognized as an important role. After physical disturbances, the system regains a state of operating equilibrium is called as steady state stability. This problem can overcome by use of Flexible AC Transmission System (FACTS) device. Thyristor Controlled Series Capacitor (TCSC) and Static VAR Compensator (SVC) FACTS device will be used here. But proper placement of FACTS device is a big challenge, this challenge can be overcome by use of sensitivity indices analysis method and the priority is decided with the help of soft computing technique. The soft computing technique use here is Fuzzy logic to decide priority. All the study will be carried out on electrical IEEE-14 bus system and software used is MATLAB.**

Index Terms— soft computing technique, TCSC, SVC, FACTS, Power system, sensitivity indices, and fuzzy logic.

I. INTRODUCTION

In power system planning electric power network is playing an essential role. On other hand, as power transfer grows, the power system becomes increasingly more complex to operate and the system can become less secure for riding through the major outages [1][2]. As a result large power flow with necessary control and large reactive power will be in different part of the system [3]. The power systems of today, by and large, are mechanically controlled, but problem with mechanical devices is that control cannot be initiated frequently, because these mechanical devices tend to wear out very quickly [4].

The traditional utility grid is also called as Vertically Integrated Utility (VIU) in which Generation, transmission and distribution are come under one umbrella. There is large increase in demand of electrical energy which cannot be stored in large quantity due to of industrialization and urbanization [5]. Continuity of supply is more important in this case. Electric power utilities are currently undergoing major competition.

This competition promises that it will increase the efficiency of the industrial sector and reduce the cost of electrical energy of all customers [6]. The goal of changing the way of operation is called deregulation i.e. the separation of Generation, transmission and distribution functions. Power system, all over the world, due to increase in load demand, transmission systems are being pushed to operate closer to their stability limits. If the power flow were not controlled, some lines of transmission line on particular paths may become overloaded, this phenomenon is called congestion. Congestion can occur in power systems because of transmission line outages, generator outages, sudden change in demand and uncoordinated transactions. Hence, Congestion Management (CM) is necessary in order to make the system secured. Congestion management can be defined as the actions taken to avoid or relieve congestion [7][8][9].

The issue of transmission congestion is more common in deregulated and competitive markets and it needs to be Addressed [10]. To relieve the congestion in this deregulated power system independent system operator (ISO) has, so that the system is operated in secure state [11]. The FACTS devices are more useful to relieve congestion. Main function of transmission system is to serve distributed customer loads along a feeder line and also it should provide reliable, stable and high quality of electric power. To achieve above said objective existing transmission line structure can be optimized through proper location of FACTS devices. The optimal location of TCSC and SVC is decided with the help of sensitivity indices analysis method and the priority of placing device is decided with the help of soft computing technique i.e. with the help of fuzzy logic

II. SYSTEM OPERATING STATE

The system operation is governed by three sets of generic equations – one differential and two algebraic (generally non-linear). Out of two sets of algebraic sets, one set comprises equality constraints (E) which express balance between the generation and load demand. The other set consists of inequality constraints (I) which express limitation of the physical equipment (such as current and voltages must not exceed maximum limits) [12]. The classification of the system states is based on the fulfillment or violation of one or both sets of these constraints, Fig.1 shows the system operating state [5].

- ***A.Normal State:*** - Here all equality (E) and Inequality (I) constraints are satisfied.
- ***B.Alert State:*** - This implies that there is a danger of violating some of the inequality (I) constraints.
- ***C.Emergency State:*** - Here inequality (I) constraints are violated.
- ***D.In-Extremis State:*** - Here both equality (E) and inequality (I) constraints are violated.
- ***E. Restorative State:***- This is a transitional state in which inequality (I) constraints are met from the emergency control actions taken but the equality(E) constraints are yet to be satisfied. [13].

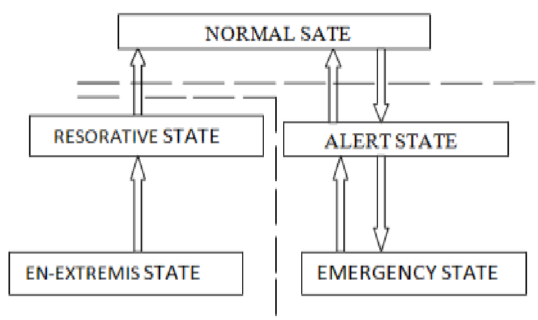

Figure 1. Power System Operating State

III. SENSITIVITY INDICES ANALYSIS METHOD

Reduction of Total System Reactive Power Loss and Real Power Flow Performance Index Sensitivity Indices These are the two method of sensitivity indices method for optimal location of TCSC and SVC. This can be calculating by following two formulas [14] [16].

$$a_{ij} = \frac{\delta Q_L}{\delta X_{ij}} = [V_i^2 + V_j^2 - 2V_iV_j \cos\delta_{ij}]\,\frac{(r_{ij}^2 - X_{ij}^2)}{(r_{ij}^2 + X_{ij}^2)^2}$$

$$PI = \sum_{m=1}^{N_L} \frac{W_m}{2n}\left(\frac{P_{Lm}}{P_{Lm}^{max}}\right)^{2n}$$

Where,

P is the real power flow,
P is the thermal limit of line m,
n is an exponent used to adjust the index value to avoid the masking effect in the contingency,
W_m is the weighting coefficient used to reflect the importance of line

IV. SOFT COMPUTING TECHNIQUE

Powerful representation, modeling paradigms and optimization mechanism for solving power system issues, rapid growth in soft computing technologies play an important role. Sophisticated methodology is provided by soft computing. Fuzzy logic, neurons, genetic algorithm, evolutionary computing and probabilistic reasoning is included in soft computing techniques. Soft computing technique is considered as attractive alternatives to the well-established hard computing paradigms. Crystallization is first step of soft computing. To provide practice and reasonable solution, soft computing has become a well-known tool. In so many cases problem can be solved by using Fuzzy logic method FLM), Genetic Computing (GC), Neural Computing (NC) in combination rather than exclusively. From last three decades, Fuzzy techniques have acquired much popularity because of knowledge based algorithm, good non-linearity handling features and reduction in computation. so that Fuzzy logic has become more important in the power system as it is providing complex nonlinear control to even the uncertain nonlinear system[15].

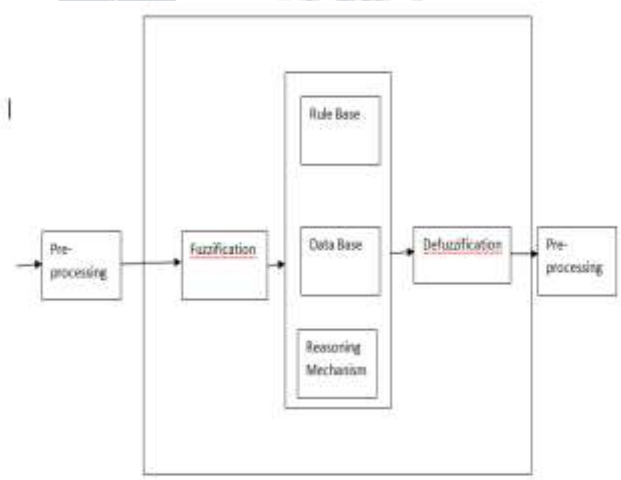

Figure 2. Fuzzy Method Structures

V. SYSTEM DESCRIPTION

With the help of sensitivity indices method study of power system stability is done here. In this paper, idea about, line which is most sensitive is explained here. The analysis is done on IEEE-14 bus system. The single line diagram for IEEE-14 bus standard test system is shown in Fig.3, which

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consists of two generators, including five synchronous machine, located at bus 1 and 2 as well as three synchronous compensators used only for reactive power support, located at bus 3, 6 and 8. Bus 1 is a slack/ reference bus while bus 2, 3, 6 and 8 are PV bus and other all are PQ bus [16].

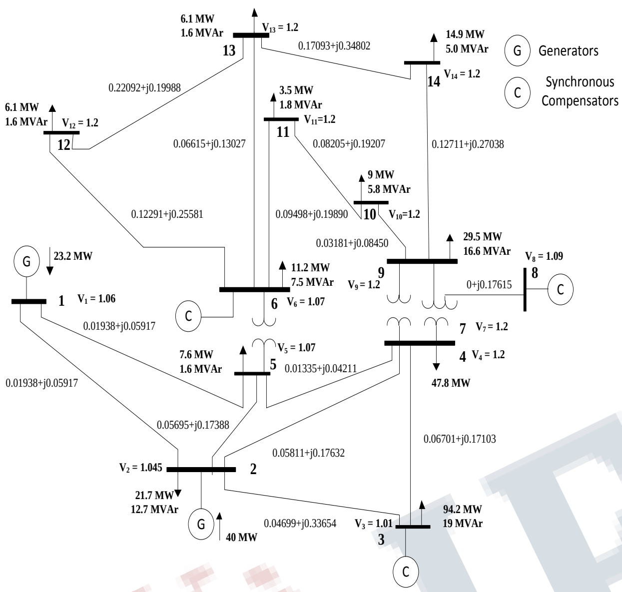

Figure 3. IEEE-14 Bus

CONCLUSION

As per expected goal, first step is nothing but the finding of the sensitive line. The proposed approach is composed of soft computing technique. Introducing sensitivity indices analysis method and fuzzy logic method as a soft computing technique the analysis approach has been utilized to find the most sensitive line and to decide priority of FACTS device respectively.

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