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Modeling and Simulation of Unified Series Shunt Compensator for Power Quality Improvement

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ABSTRACT

Power Quality in the distribution system is the important issue for industrial, commercial and residential applications. An increasing demond for high quality, reliable electrical power and an increasing number of distorting loads have led an increased awareness of power quality both by customer and utilities. This paper deals with the simulation of a Unified series shunt compensator, which is aimed at mitigating most of the Power Quality problems such as- Voltage sag compensation, Voltage swell compensation, Voltage Flicker reduction, Voltage Unbalance mitigation, UPS mode operation. The modeling and simulation of the USSC has been carried out by using Facts controller. The USSC simulation model comprises of two 6- pulse inverters which are connected in series and in shunt to the system. The USSC is designed by using MATLAB/SIMULINK based simulation for the working of the USSC. The USSC has mitigated several Power Quality problems giving better performance.

Keywords: *6- pulse inverter, Power Quality, Unified series shunt compensator*

I. INTRODUCTION

The increasing Industrialization, urbanization of life style has lead to increasing dependency on the electrical energy. This has resulted into rapid growth of power systems. This rapid growth has resulted into few uncertainties. In contrast to the rapid changes in technologies and the power required by these technologies, transmission systems are being pushed to operate closer to their stability limits and at the same time reaching their thermal limits due to the fact that the delivery of power have been increasing.

The major problems faced by power industries in establishing the match between supply and demand are:

- Transmission & Distribution supply the electric demand without exceeding the thermal limit.
- In large power system, stability problems causing power disruption and blackouts leading to hugs losses.

These constraints can be suppressed by enhancing the power system control. One of the best methods for reducing these constraints are FACTS devices.

FACTS devices can be utilized to control power flow and enhance system stability. Particularly with the deregulation of the electricity market, there is an increasing interest in using FACTS devices in the operation and control of power systems. A better utilization of the existing power systems to increase their capabilities and controllability by installing FACTS devices becomes imperative.

Reactive power compensation is provided to minimize power transmission losses, to maintain power transmission capability and to maintain the supply voltage. Series compensation is control of line impedance of a transmission line with the change of impedance of a line either inductive or capacitive compensation can be obtained thus facilitating active power transfer or control. Thyristor Controlled Series Capacitor (TCSC) is a variable impedance type series compensator and is connected in series with the transmission line to increase the power transfer capability, improve transient stability, reduce transmission losses and dampen power system oscillations Shunt compensation is used to incresse the steady – state transmttable power and to control the voltage profile along the line. USSC is a shunt compensator and one of the important members of FACTS family that are increasingly being applied to long transmission line by the utility in modern power systems.

II. BASIC DESIGN OF USSC

The unified series shunt compensator is a voltage source inverter based series –shunt connected custom power device that is used for the voltage regulation, reactive power compensation, and flicker reduction. The USSC includes the function of both series and shunt connected inverter which generates or absorbs reactive power to regulate voltage magnitude and current flow at the ac terminal.

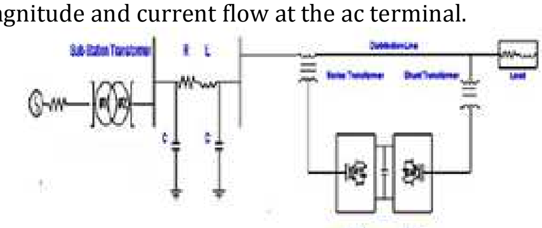

Fig 1- Structure of USSC

Power system consists of 3 kind of power active, reactive, and apparent power. Active power is the useful or true power that performs a useful work in the system. Reactive power is caused entirely by energy storage component. The apparent power is the combination of active power & reactive power. Power system consists of 3 principle components they are generation, transmission, and distribution system. Fig 1 shows the basic components used in the simulation model. The capacitor plays an important role in the USSC operation by acting as a dc source to provide reactive power to the load and to regulate the DC voltage.

III. MODELING OF USSC

The static compensator is one of the most prominent members in the family of FACTS devices, which is connected in shunt to the transmission grid. It is usually used to control transmission voltage by reactive power compensation. In ideal steady state analysis, it can be assumed that active power exchange between the AC system and the USSC can be neglected, and only the reactive power can exchanged between them.

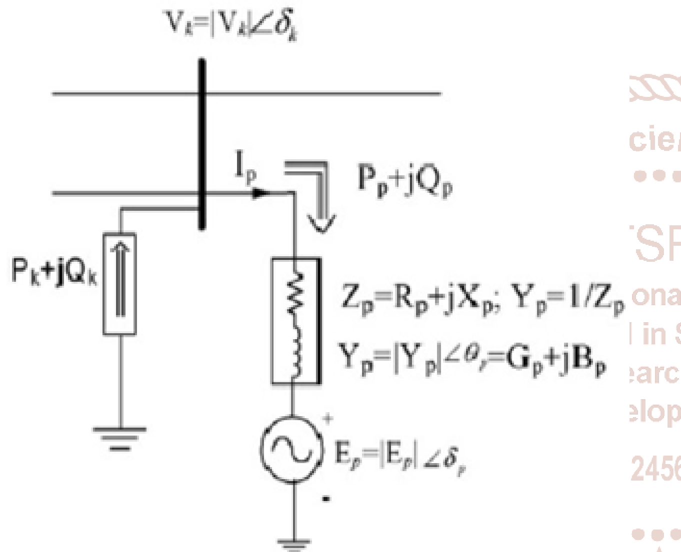

Fig 2 – MODEL OF USSC

The presence of FACTS controllers is accommodated and accounted for by adding new equation to the set of the power flow equation and modifying some of the existing power flow equation as needed. The Jacobian equation is modified accordingly. Fig 2 shows the circuit model of a USSC connected to Bus k of an N- Bus power system, the subscript 'p' means the USSC is connected in parallel with the power system. The USSC is modelled as a controllable voltage source (E_p) in series with impedance. The power flow equation for a bus i of the power system with no FACTS controlleris given by :

$$P_i = \sum_{j=1}^{n} |V_i||V_j||Y_{ij}| \cos(\delta_i - \delta_j - \theta_{ij}) \qquad (1)$$

$$Q_i = \sum_{j=1}^{n} |V_i||V_j||Y_{ij}| \sin(\delta_i - \delta_j - \theta_{ij}) \qquad (2)$$

Where Vi represents complex voltage of a bus i and Yij represent (i,j) entry of the Y matrix . With the addition of USSC connected at bus k the power flow equation of the system remain same as the power flow equation of the system without USSC for all buses given by eq. 1,2.

IV. Evolutionary Algorithm For load Flow with USSC

Evolutionary algorithms are search methods that take their inspiration from natural selection and survival of the fittest in the biological world. Genetic Algorithm is one of the evolutionary Algorithms search technique. The method was developed by John Holland Genetic Algorithms are global search techniques based on the mechanism of natural selection and genetics. They can search several possible solutions simultaneously and produces high quality solutions. The goal of FIG Fig 3 = Flow chart for Genetic Algorithm optimization is to find out the best optimal location of TCSC and USSC in power system using genetic algorithum. The genetic algorithm follows the following steps:

Step 1: Genetic an initial population of binary string.
Step 2: Calculation fitness value of each member of population based on the problem type.
Step 3: Generate off spring string through reproduction, crossover and mutation and evalution.
Step 4: Calculate fitness value for each string.
Step 5: Terminate the process if required solution is obtained or number of generation is attained. The above process is represented in flow chart as shown in fig 3.

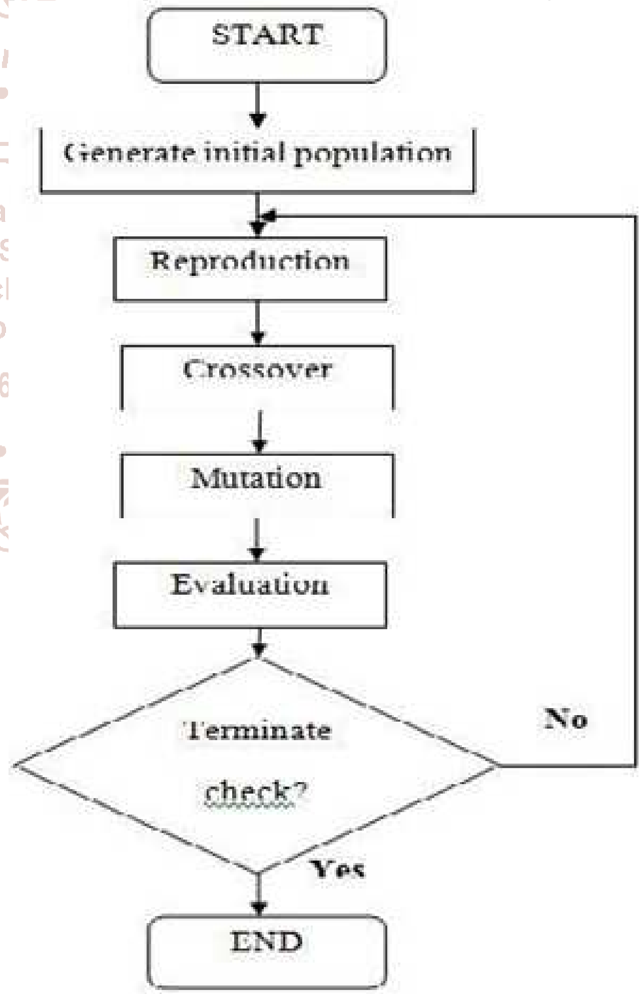

Fig 3 = Flow chart for genetic algorithm

V. SIMULATION MODEL OF USSC

The concept of custom power is the employment of power electronic controllers in medium voltage distribution systems aiming to supply a reliable and higher quality power that are needed by sensitive users. The main aim of the present simulation is to explore the capabilities of a USSC in mitigating power quality problems.

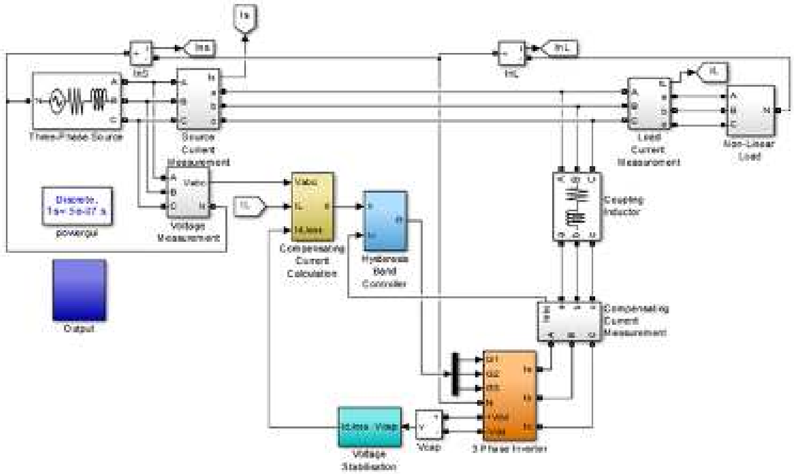

Fig 4 = Simulation Mdel of USSC

VI. SIMULATION RESULT OF USSC

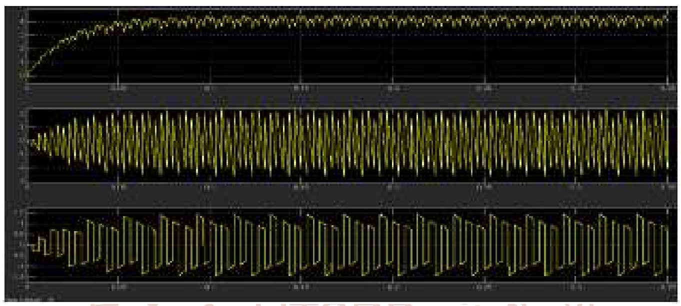

Fig a = Result of Load Current

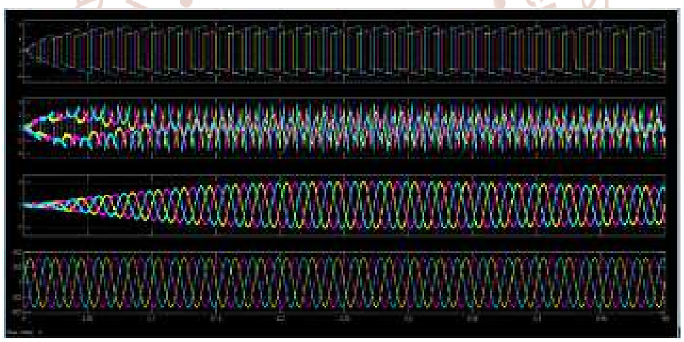

Fig b = RESULT OF SOURCE CURRENT

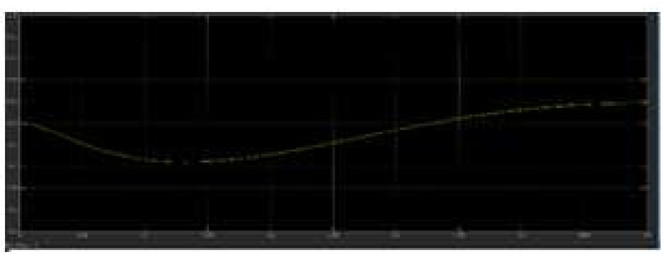

Fig c = RESULT OF CAPACITOR VOLTAGE

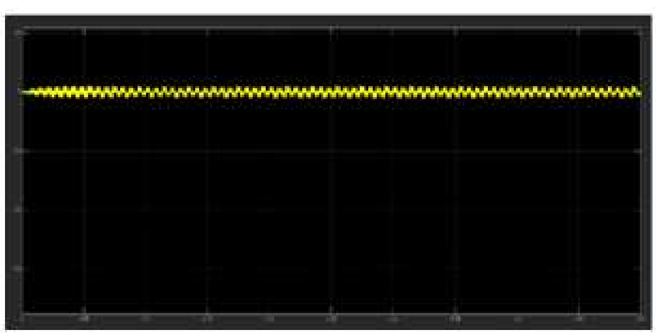

Fig d = RESULT OF CAPACITOR CURRENT

VII. CONCLUSION

The work on Evolutionary Algorithm assisted Optimal Placement of FACTS Controllers in powe system has been carried out to find optimai location of TCSC and USSC to improve the losses and voltage profile of the system . The optimal placement of FACTS controllers has been attemped using genetic algorithm. The developed algorithm is effictive in deciding the placement of FACTS device. USSC helps in diverting flow from heavily loaded lines and results in reduction in active power losses. USSC helps in improving voltage profile of the system and also results in reduced active power losses.

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