MJRET
Open Access
Multidisciplinary Journal of Research in Engineering and Technology
Journal homepage: www.mjret.in
ISSN:2348 - 6953

A REVIEW ON CONTROLLABLE PARAMETERS OF UPFC FOR POWER QUALITY METHODS-REALTIME APPLICATION

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Abstract: *As a fact, steady state model of flexible alternating current transmission system (FACTS) devices have been used in many studies to improve power flow capability (PFC) in the transmission lines. Among FACTS devices, UPFC is the most versatile and efficient device. Two important considerations within UPFC are proper placement of FACTS devices is very important for the rapid and successful operation because of high cost and circuit complexities & To obtain damping of sustained oscillation in the power system with the help of Unified Power Flow Controller (UPFC). This research proposal propose an efficient way to optimize the placement of UPFC within distribution system, best location of UPFC (Unified Power Flow Controller) should calculate both for static and transient voltage stability enhancement. Also within the proposed work, the linear model of the UPFC is taken and the tuning of the controllable parameters is done with the help of multi-objective genetic algorithm. Also, splendid improvement in robust damping should observed with proposed implementation by comparing the proposed work with traditional UPFC which we are going to implement in Kanpur grid and Kanpur SVC.*

Keywords: *UPFC, Power Quality, SVC, Facts, Statcom, SSSC*

1. INTRODUCTION

1.1 Overview: Power Generation and Transmission is a complex process, wherever power is to be transferred, the two main components are active and reactive power. In a three stage ac system of power active & reactive power moves from the producing station to the load through different transmission lines and networks buses. The active and reactive power flow in transmission line is known as the power flow / load flow. The studies of power flow provide an organized mathematical method for the determination of numerous voltages of bus, there phase angle, active and reactive power flows through different lines, generators and loads at steady state condition.

The continuing rapid development of high-power semiconductor technology now makes it possible to control electrical the systems of power by means of the devices of power electronic. These devices constitute an emerging technology called FACTS (flexible alternating current transmission systems). The technology of FACTS opens up novel chances for supervisory the both kinds of powers and enhancing the usable capacity of present transmission systems. This opportunity is arises through the ability of FACTS controllers to adjust the power system electrical parameters including series and shunt impedances, current, voltage, phase angle, and the damping oscillations etc. The implementation of such equipment's requires the different power electronics-based compensators and controllers. The FACTS devices use various power electronics devices such as Thyristors , Gate turn offs (GTO), Insulated gate bipolar transistors (IGBT), Insulated Gate Commutated thyristors (IGCT), they can be controlled very fast as well as different control algorithms adapted to various situations. FACTS technology has a lots of benefits, such as greater power flow control ability, increased the loading of existing transmission circuits, damping of power system oscillations, has less bed impact on environmental and , has the less cost than other alternative techniques of transmission system is used.

1.2 Unified Power Flow Controller (UPFC): The UPFC may be considered to be constructed of two VSCs sharing a common capacitor on their DC side and a unified control system. A simplified schematic representation of the UPFC is given in Figure below. The UPFC gives simultaneous control of real and reactive power flow and voltage amplitude at the UPFC terminals. This technique permits with the combined application of controlling the phase angle with controlled series reactive compensations and voltage regulation, but also the real-time change from one mode of compensation into another one to handle the actual system contingencies more effectively. For instance, series reactive compensation may be altered by phase-angle control or vice versa. This can become essentially important at relatively big numbers of FACTS devices will be applied in interconnected power grids, and compatibility and coordination control can own to be save in the face of devices failures and system changes.

The implementation problem of the unrestricted series compensation is simply that of supplying or absorbing the real power that it exchanges with the AC system at its AC terminals, to or from the DC input sides of the inverter applied in the solid-state synchronous voltage source. The implementation in the proposed configuration called unified power flow controller (UPFC) employs two voltage source inverters applied with a common DC connected capacitor; it is shown schematically in Fig.1 below. That arrangement is practically an achievement of an AC to DC power converter with independently controllable input and output parameters.

Inverter 2 in the arrangement shown is used to generate voltage $VB(t) = VB \sin(\omega t - \delta B)$ at the fundamental frequency with variable amplitude ($0 \leq VB \leq VB_{max}$) and phase angle ($0 \leq \delta B \leq 2\pi$), which is added to the AC system terminal voltage by the series connected coupling (or insertion) transformer. With these stipulations, the inverter terminal voltage injected in series way with the line will be applied for direct voltage control, series compensation, and phase-shift.

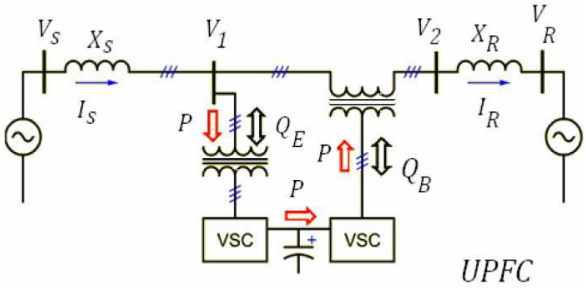

***Fig.1:** Schematic diagram for the UPFC*

The main function of the UPFC is to control the flow of real and reactive power by injecting of voltage in sequence with the line of transmission. Both the magnitude and the phase angle of the voltage can be varied independently. Real and reactive power flow control can allow for the power flow in prescribed routes, loading of transmission lines closer to their thermal limits and can be utilized for improving transient and small signal stability of the power system.

1.3 Characteristics of UPFC: Line outage, congestion, cascading line tripping, power system stability loss are the main matters where ability &the use of the FACTS are observed. The representative of the last generation of the devices of FACTS is known as the Unified Power Flow Controller (UPFC). Device like a UPFC which can switch concurrently all 3 parameters of the line power flow (the line impedance, voltage &the phase angle). Such a "new" device of FACTS syndicates together the topographies of 2 "old" devices of the FACTS they are: the Static Synchronous Compensator (STATCOM) & the Static Synchronous Series Compensator (SSSC). In exercise, these 2 devices are the 2 Voltage Source Inverters (VSI's) associated correspondingly in the shunt with the line of transmission through the transformer of shunt & in the series with line of transmission through the transformer series, associated to each other by the mutual dc link counting the capacitor of storage. The inverter of shunt is used for the voltage directive at the point of assembly inserting an appropriate reactive flow of power into the line & to balance the actual flow of power replaced between the inverter of series & the line of transmission.

1.4 Advantages of UPFC: The UPFC can perform the function of STATCOM and SSSC and phase angle regulator. Besides that the UPFC also provides an additional flexibility by combining some of the function above. UPFC has also a unique capability to control real and reactive power flow simultaneously on a transmission system as well as to regulate the voltage at the bus where it's connected. The UPFC can also increase the capability of the power flow to the load demand until its reach its limit in the short period .At the same time the UPFC also can increase the security system by increases the limit of transient stability, fault and the over load demand .Lastly the UPFC also can reduce the value of the reactive power And will optimum the real power flow through the transmission line.

2. LITERATURE SURVEY

2.1 Overview: The UPFC has been investigated largely& many investigation articles allocating with the modeling of UPFC, control, analysis, &the application have been issued in recent years. The ideas of the Unified Power Flow Controller (UPFC) its presentation & the characteristics of steady state have been broadly stated in the literature [1, 2]. The mathematical models were established for the UPFC to regulate the operational characteristics of steady state using the equations of state space without allowing for the effects of the converters & the dynamics of the generator [3, 4]. The presentation of the UPFC was considered by designing a sequence converter using the conventional &the advanced controllers [5, 6].

The Mathematical Model of the UPFC using common PWM &the approach of space vector was used to achieve the studies of power flow, the examination of Eigen & the passing constancy inquiries [7]. A dynamic nonlinear small model of signal of network with the UPFC was recognized for the studies of transient. The model estimated the recompense effects of the UPFC, enhanced the location of the UPFC & its design of control [8]. A corresponding 2 bus power network was established founded on sets of the equations for system counting the UPFC was proposed. This offered a valuable tool to rate; estimate the presentation of the UPFC on the systems of power [9].

The investigation based on the model of mathematics of the UPFC was basic by including the model of voltage source with the originator equation of o/p power &thus the dynamic examination of system was simplified. The model of UPFC can also be used to characterize the system with the STATCOM /the SSSC [10]. The substituting level model of the UPFC was intended & replicated in the EMTP. The corresponding impedance of the model of voltage source was originated from dynamic responses of the model of UPFC Switching level. The results display that substituting level model was more correct than model of voltage source [11].The harmonic controls are analyzed [12].

The UPFC steady state injection model is derived enabling three parameters to be simultaneously controlled. They are namely the shunt reactive power and the magnitude and angle of the injected series voltage. The injected voltage is added to the shunt side network bus voltage. The UPFC injection model is defined by the constant series branch susceptance, which is included in the system bus admittance matrix, and the bus active and reactive power injections. In the case of a control objective to be achieved the bus power injections are modified through changes of the UPFC parameters [13].

In [14], the authors applied a Continuation Power Flow (CPF) technique to obtain this critical point corresponding to voltage instability. The CPF technique using augmented Jacobian avoids the singularity of the Jacobian and in a single run obtains the continuation of power flow solution until the critical point is reached. In this paper, the CPF technique is used in the proposed algorithm to identify the candidate buses for the UPFC placement.

3. PROPOSED WORK

3.1 Overview: Among FACTS devices, UPFC is the most versatile and efficient device. Two important considerations within UPFC are *proper placement of FACTS devices is very important for the rapid and successful operation because of high cost and circuit complexities & to obtain damping of sustained oscillation in the power system with the help of Unified Power Flow Controller (UPFC).* This research proposal propose an efficient way to optimize the placement of UPFC within distribution system, best location of UPFC (Unified Power Flow Controller) should calculate both for static and transient voltage stability enhancement. Also within the proposed work, the linear model of the UPFC is taken and the tuning of the controllable parameters is done with the help of multi-objective genetic algorithm. Our intention is to prove that, from the time domain simulation that proper placement of UPFC increases the transient performance of the system by damping out the power oscillation under large disturbance conditions. Also, splendid improvement in robust damping should observed with proposed implementation by comparing the proposed work with traditional UPFC which we are going to implement in Kanpur grid and Kanpur SVC.

3.2 Kanpur SVC: Kanpur SVC is composed of 2X + 140 MVAR (280) connected to 400KV Bus. It has been designed & supplied by ABB Sweden and erected, commissioned jointly by POWERGRID & ABB. It is first of its kind in the country. Kanpur switching station is one of the prime stations of northern grid transmitting 2000MW of power on regular basis. SVC is installed at a voltage level of 10.56KV DELTA connected bus through 400/10.56KV coupling transformers.
VAR compensators technology is worldwide recognized due to inherent in-built capabilities. It helps the system in the following ways:

a) Dynamic Mvar Support to the system
b) Enhancing transmission line power carrying capacity
c) Improving Dynamic stability of the Integrated Grid
d) Damping power oscillation on the associated AC lines.
e) Improves & Smoothen Voltage profile of Kanpur Bus i.e. Northern Grid.

3.3 The Overall proposed work is divided into following three parts

Objective 1: Replace SVC in Kanpur grid with UPFC

The SVC is an automatic device of impedance matching, planned to bring the system closer to the factor of unity power factor. The SVCs are used in 2 main conditions:

a) Associated to the system of power, to normalize the voltage of transmission ("Transmission SVC").
b) Associated close great industrial loads, to enhance the quality of power ("Industrial SVC").

Classically, an SVC includes 1 or more banks of secure /the capacitors of switched shunt/ the reactors, of which at smallest 1 bank is switched by the thyristors. The elements which may be used to create an SVC typically contain:

a) The Thyristors controlled reactor (TCR), where the apparatus may be i.e. air- or iron-cored.
b) The Thyristors switched capacitor (TSC).
c) The Harmonic filter(s).
d) Mechanically converted the capacitors /the reactors (switched by the circuit breaker).

Objective 2: Tuning of Controllable Parameters within UPFC

The conventional approach is achieved with the employment of lead lag compensator. The block consists of three blocks namely gain block, washout block and two stage lead - lag compensator. The time constants are varied periodically to achieve effective damping of oscillation. The change in speed deviation is fed as input and the output is fed to the UPFC parameters as input to enhance the stability.

Objective 3: Optimal placement of UPFC within the power system (Kanpur grid)

Whenever a perturbation is there in the system the generators tend to lose synchronism and if they re-maintain to run at the same speed the system. If the oscillations after disturbance are damped and the system comes to new operating point it is said to be stable. If the oscillations after a disturbances are damped and the system comes to new stable operating point hence it is called stable. Due to increased operations which results in making the power system to be highly stressed, the need for dynamic stability is arising. Transient stability assessment is a part of dynamic security assessment of power system which determines the ability of the system to remain in equilibrium when subjected to disturbances.

This research proposal consider following objective functions within optimal placement

a) Continuation Power Flow.
    - Total number of branches.
    - Individual branch current.
    - Individual branch resistance.
    - Real power loss of distribution system.

b) Overall Network Voltage Profile.
    - Number of network buses.
    - Voltage of individual bus.
    - Specified voltage for individual bus.
    - Voltage of individual bus without DG resource.

c) Line Stability Index
    - The value of index should be less than 1 for a stable system.

4. EXPECTED OUTCOME

Within optimal placement of UPFC, the associated validation parameters are
Static Voltage Stability

a) Transient Stability in Time Domain Simulation.
b) Determination of most critical lines.
    - Reactive load at a bus is gradually increased keeping all other loads constant.
    - Load flow is done using PSAT to find out the active and reactive power transmitted at the receiving end for a particular load.
    - Maximum Active and reactive power that can be transferred to a particular bus is calculate.
    - Stability index is calculated at each load knowing power transmitted using load flow.
    - This is repeated for each bus and index is calculated for each line associated with bus.

The line having maximum value of the stability index at maximum load ability point is the most critical line with respect to that bus.

Within tuning of controllable parameters of UPFC, the associated validation parameters are

- Variation of phase angle in UPFC for different experimental conditions.
- Variation of angular frequency in UPFC for different experimental conditions.
- Variation of electrical power in UPFC for different experimental conditions.
- Variation of DC voltage in UPFC for different experimental conditions.

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