REVIEW ON ROLE OF UPFC AND DPFC FACTS DEVICES IN POWER SYSTEM

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Abstract: The electricity is considered as the backbone for industrial revolution. Today the demand and consumption of electrical energy has increased steadily. To meet this increasing demand very complex interconnected power systems are built. These complex networks are subjected to power oscillations. Power oscillations can be defined as the change in machine rotor angle around its steady state value at the natural frequency of the total electromechanical system due to disturbance. There are different types of oscillations occurring in power system, they are: local oscillations, inter-area oscillations, inter-plant oscillations and global oscillations. Damping of these oscillations is important so as to maintain the system stability. The main function of Unified Power Flow Controller (UPFC) and Dynamic Power Flow Controller (DPFC) is to independent control of active and reactive power of transmission line and regulation of bus voltage by injection or absorption of reactive power. These devise are used to improve transient stability margin or to damp low frequency oscillations. In recent years many researches are focused on the modeling of UPFC and DPFC and their interactions with the power system. But most of these researches use a steady state model of the electrical network and disregard network dynamics. This paper presents a concept of a distributed power flow controller (DPFC) and Unified Power Flow Controller (UPFC) for damping oscillation in Power System. The DPFC is derived from the unified power flow controller (UPFC). The DPFC can be seen as a UPFC with an eliminated common DC link.

I. INTRODUCTION

Now recent years, the power system design, high efficiency operation and reliability of the power systems have been considered more than before. The electricity is considered as the backbone for industrial revolution. Today the demand and consumption of electrical energy has increased steadily. To meet this increasing demand very complex interconnected power systems are built. These complex networks are subjected to power oscillations. Power oscillations can be defined as the change in machine rotor angle around its steady state value at the natural frequency of the total electromechanical system due to disturbance. There are different types of oscillations occurring in power system, they are: local oscillations, inter-area oscillations, inter-plant oscillations and global oscillations. Damping of these oscillations is important so as to maintain the system stability. Due to the growth in consuming electrical energy, the maximum capacity of the transmission lines should be increased. Therefore in a normal condition also the stability as well as the security is the major part of discussion. Several years the power system stabilizer act as a common control approach to damp the system oscillations. However, in some operating conditions, the PSS may fail to stabilize the power system, especially in low frequency oscillations. As a result, other alternatives have been suggested to stabilize the system accurately. It is proved that the FACTS devices are very much effective in power flow control as well as damping out the swing of the system during fault. The main function of Unified Power Flow Controller (UPFC) and Dynamic Power Flow Controller (DPFC) is to independent control of active and reactive power of transmission line and regulation of bus voltage by injection or absorption of reactive power. These devise are used to improve transient stability margin or to damp low frequency oscillations. In recent years many researches are focused on the modeling of UPFC and DPFC and their interactions with the power system. But most of these researches use a steady state model of the electrical network and disregard network dynamics. This project presents a concept of a distributed power flow controller (DPFC) and Unified Power Flow Controller (UPFC) for damping oscillation in Power System. The DPFC is derived from the unified power flow controller (UPFC). The DPFC can be seen as a UPFC with an eliminated common DC link. The cost of the DPFC is also much lower than the UPFC because no high-voltage isolation is required at the series converter part and the rating of the components of is low. The DPFC works the distributed FACTS (D-FACTS) concept, which is to use multi small-size single phase converters instead of the one large-size the three-phase series converter in the UPFC. A large number of series converters provide redundancy, thereby increasing the system reliability. The DPFC has the similar control capability as the UPFC, which involves the adjustment of the line impedance, the transmission angle, and the bus voltage.

Recent years lots of control devices are implemented under the FACTS technology. By implementing the FACTS devices gives the flexibility for voltage stability and regulation also the stability of the system by getting proper control signal. The FACTS devices are not a single but also collection of controllers which are efficiently not only work under the rated power, voltage, impedance, phase angle frequency but also under below the rated frequency. Among all FACTS devices the UPFC and DPFC most popular controller due to its wide area control over power both active and reactive, it also gives the system to be used for its maximum thermal limit. It’s primarily duty to control both the powers independently. It has been shown that all three parameters that can affect the real power and reactive power in the power system can be simultaneously and independently controlled just by changing the control schemes from one type to other in UPFC.

II. METHODS FOR DAMPING POWER SYSTEM OSCILLATIONS

Several methods are used to damp the power oscillations.

One of the traditional methods is to use power system stabilizer (PSS). PSS proves to be robust and effective in damping the oscillations in the power system. But as the system size increases especially in large interconnected power systems, PSS does not provide sufficient damping. Also it affects the voltage profile of the large system. Another method is to use HVDC links to damp the power oscillations. It uses active power on parallel ac lines or other signals in the HVDC control system to add damping to the system. With the advancement in technology, today FACTS devices are used for this purpose. The concept of FACTS i.e. flexible a.c. transmission system was introduced by Dr. N. Hingorani in 1988. FACTS devices are power electronics based controllers for a bulk power system. These devices not only improve the power flow in the transmission lines but can effectively damp the power oscillations. Several FACTS devices like SSSC, STATCOM, TCSC, UPFC, SVC etc. are used to damp the oscillations. This project concentrates on UPFC and DPFC devices for damping the oscillations.

Unified Power flow controller (UPFC)

Unified power flow controller (UPFC) is a series shunt FACTS device. It consists of a combination of SSSC in series and STATCOM in shunt with the transmission line. These two voltage source converters are connected by a common d.c. link capacitor. Fig.1 shows the schematic diagram of UPFC. The series part injects the voltage of controllable magnitude in the transmission line to control the real and reactive power of the power system. The shunt part is used to maintain the voltage across the d.c. link capacitor and the bus voltage where it is connected by injecting the current of controllable magnitude in the system. Each voltage source converter can control the magnitude and phase angle of the output voltages of series and shunt converters by controlling the amplitude of modulation index(Mb ,Me) and phase-angle(δb,δe) of series and shunt respectively.

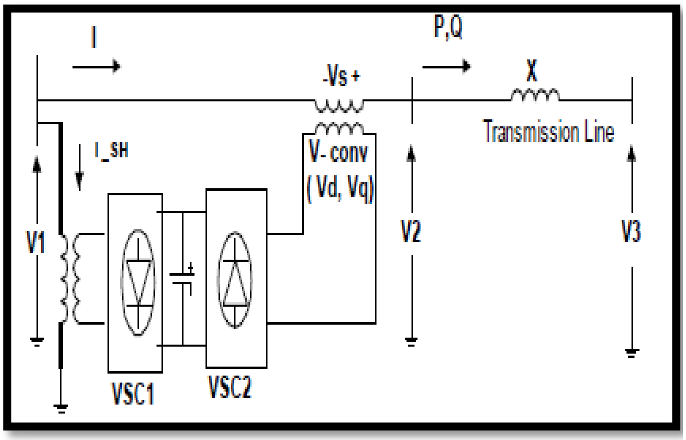

Fig.1 Schematic diagram of UPFC

UPFC for Damping Power Oscillations

UPFC main control consists of series and shunt controller. These controllers do not provide adequate damping. Hence, an additional damping controller known as power oscillations damping (PID) controller is used in conjunction with the main controller of UPFC for this purpose. The construction of PID controller is similar to PSS. Fig.2 shows the block diagram of POD controller. It consists of a gain block, washout block and two lead-lag blocks.

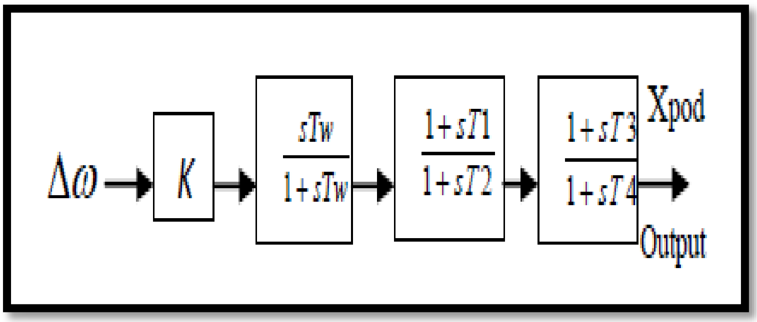

Fig.2 Block diagram of PID controller

III. DISTRIBUTED POWER FLOW CONTROLLER (DPFC)

By introducing removal of the common DC link and distribution of the series converter into the UPFC, the DPFC is accomplished. Similar as the UPFC, the DPFC consists of shunt and series connected converters. The shunt converter is similar as an STATCOM while the series converter employs the DSSC concept, which is to use multiple single-phase converters as a replacement for one three-phase converter. Each converter within the DPFC is independent and delivers its DC capacitor to supply the required DC voltage. The form of the DPFC is shown in Fig.3.

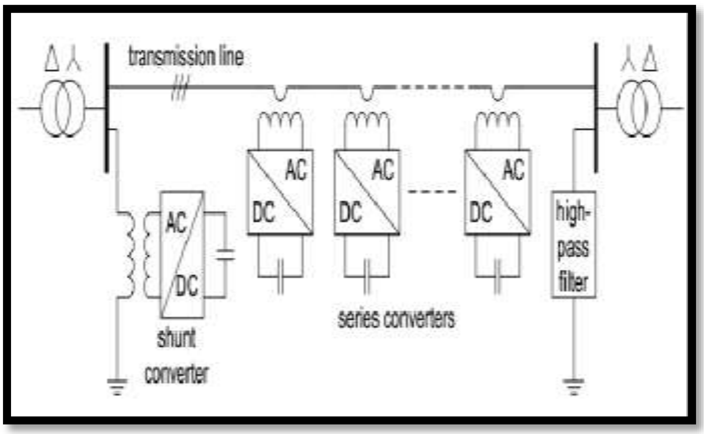

Fig. 3 DPFC configuration

The exclusive control capability of the UPFC is given by the back-to-back construction between the shunt and series converters, which allows the active power to easily exchange. To ensure the DPFC has the same control capability as the UPFC, a method that allows active power exchange between converters with an eliminated DC link be needed.

Control of DPFC

To control multiple converters, a DPFC contains three types of controllers: central control, shunt control, and series control, as exhibited in Fig. 4. The shunt and series control are localized controllers and are in authority for maintaining their converters and its parameters. The central control takes care of the DPFC functions at the power system level.

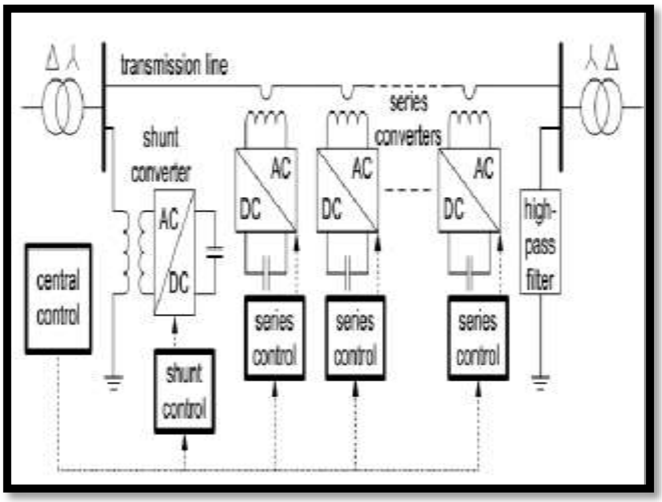

Fig. 4 DPFC control blocks diagram

Central control

The central control produces the reference signals for both the shunt and series converters of the DPFC. Its control function depends on the specifics of the DPFC application at the power system level, such as power flow control, low-frequency power oscillation damping, and balancing of asymmetrical components. According to the system desires, the central control gives corresponding voltage reference signals for the series converters and reactive current signal for the shunt converter. All the reference signals produced by the central control concern the fundamental frequency components.

Series control

Each series converter has its series control. The controller is used to maintain the capacitor DC voltage of its converter, by using third harmonic frequency components, in addition to generating a series voltage at the fundamental frequency is necessary by the central control.

Shunt control

The aim of the shunt control is to inject a constant third harmonic current into the line to supply active power for the series converters. At the same time, it prevents the capacitor DC voltage of the shunt converter at a constant value by taking up active power from the electrical system at the fundamental frequency and injecting the required reactive current at the fundamental frequency into the power system. The shunt controls involves injecting a constant third harmonic current into the communication channel to supply active power for series converters, retain the capacitor DC voltage of the shunt converter by absorbing active power from the grid at the central frequency and inject a reactive voltage at the central frequency of the power system as prescribed by the central command.

IV. MODELING AND SIMULATION

The Three phase unbalanced system which is connected with non linear R-L load and D.C load is shown in the fig below. The simulation results of Distorted voltage and Current waveform is shown in the results and the unbalanced condition active and reactive power also shown.

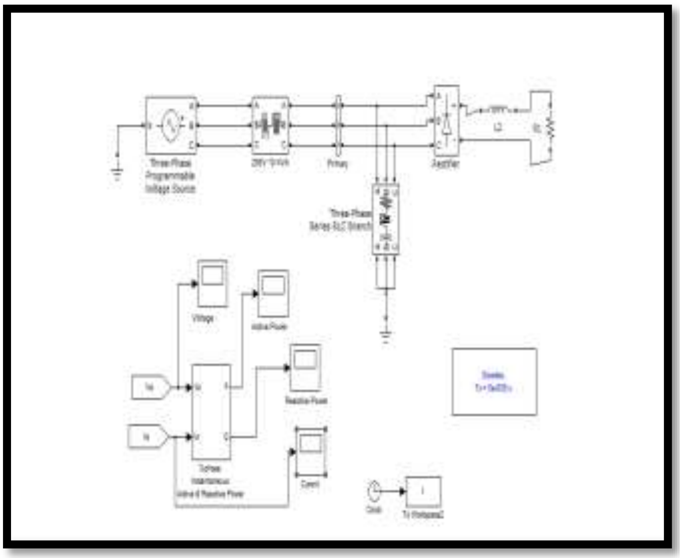
Fig- Three phase unbalanced system with D.C and Non linear Load

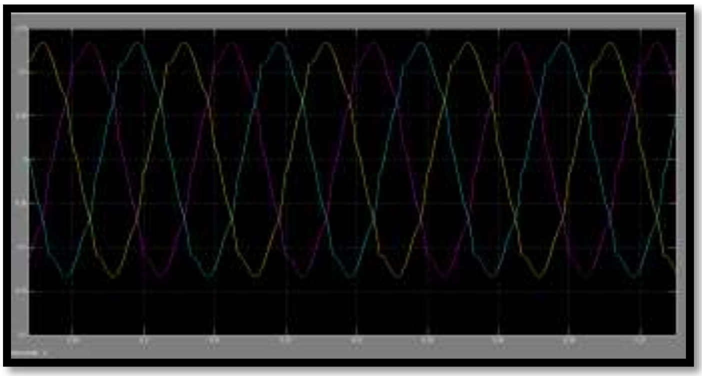
fig- Current distorted Waveform

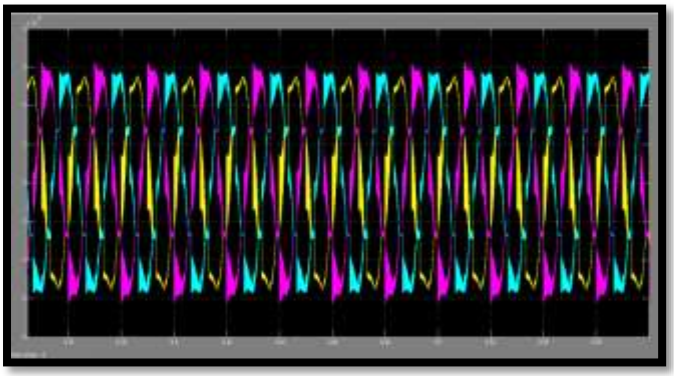
Fig-Voltage Distorted Waveform

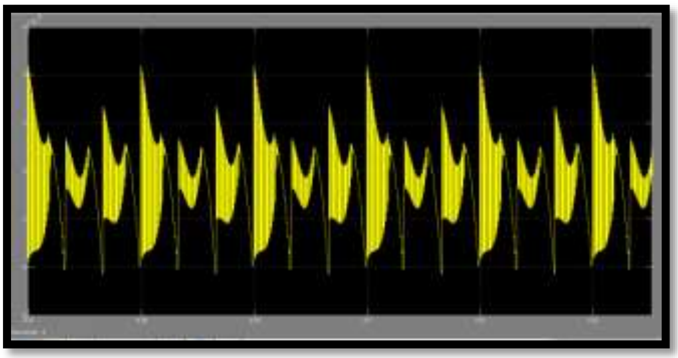
Fig-Reactive Power

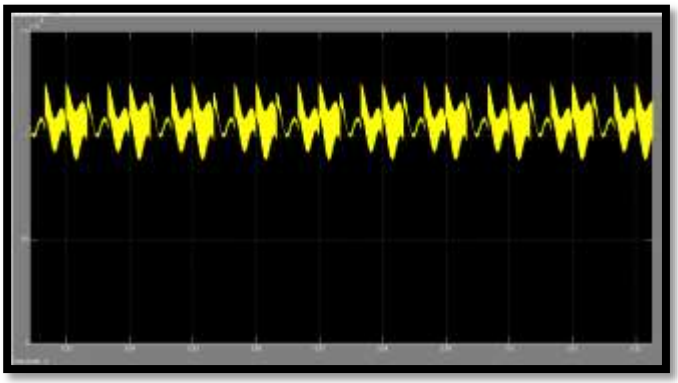

Fig-Active Power

V. CONCLUSION

This is a review paper showcasing the application of UPFC and DPFC for damping power system oscillations. The two area power system was used to analyze the role of UPFC for damping the oscillations. The study shows that the DPFC is derived from the unified power flow controller (UPFC). The DPFC can be seen as a UPFC with an eliminated common DC link. It was observed that the results of three phase unbalanced condition system with non linear and D.C load have the distorted waveform of voltage and current and at other side the active and reactive power also unstable.

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