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Enhancement of Power Flow by Using Distributed Power Flow Controller (DPFC)

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ABSTRACT:

This paper presents a new concept of power flow controlling device (PFCD) that proposes the same control ability as the UPFC, at a reduced the cost and with an growing the reliability of the device. That new device is, so-called as Distributed Power Flow Controller (DPFC). The DPFC is the advanced development of the UPFC. The DPFC eliminates the common DC link within the UPFC, to enable the independent operation of the shunt and the series converter.. In a traditional power system, the electrical energy is generated by centralized power plants and flows to consumers via the transmission and distribution network. The rate of the transported electrical energy within the lines of the power system is referred to as "Power Flow", to be more specific, it is the active and reactive power that flows in the transmission lines. The proposed control methods like PI control, sliding mode control (SMC). The control approach used for the DPFC balances the power flow and regulates the voltage with stable operation. At the end, this paper presents the system level, which includes the DPFC applications to improve power system controllability and stability of the DPFC for real networks.

1.INTRODUCTION:

In a traditional power system, the generated electrical energy by centralized power plants and runs to customers through the transmission and distribution network. Currently greater demands have been located on the transmission network, and these demands will go on to rise, since the increasing number of non utility generators and sensitive competition among utilities themselves. Due to the changing electric power systems create a growing need for flexibility, reliability, fast response and accuracy in the fields of electric power generation, transmission, distribution and

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consumption. FACTS devices never can be over loaded [1][5].

Distributed Power Flow Controller (Dpfc)

To control multiple converters, a DPFC consists of three types of controllers: central control, shunt control and series control, as shown in Fig.1. The shunt and series control are contained controllers and are responsible for preserving their own converters" parameters. The central control takes care of the DPFC functions at the power system level. The central control generates the reference signals for both the shunt and series converters of the DPFC. Its control function depends on the essentials 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 requirements, the central control gives corresponding voltage reference signals for the series converters and reactive current signal for the shunt converter. All the reference signals generated by the central control concern the fundamental frequency components.

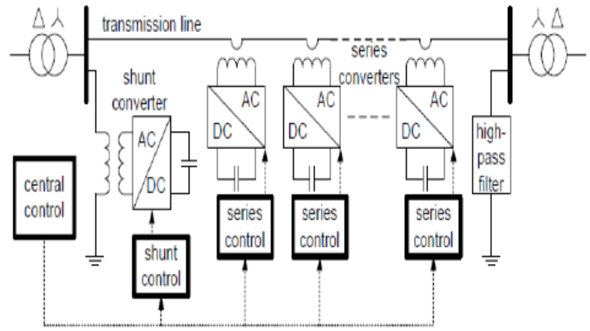


Fig.1. DPFC control block diagram.

2. WORKING PRINCIPLE OF DPFC The DPFC presents a familiar connection between the AC ports of the shunt and the series converters. Hence, it is possible to exchange active power through the AC ports. The method is based on power theory of non-sinusoidal components. According to the Fourier analysis, the integrals of all the cross product of terms with different frequencies are zero, the active power can be expressed by

$$P = \sum_{i=1}^{\infty} V_i I_i \cos\phi \qquad (1)$$

Where V = Vi and I = Ii are the voltage and current at the ith harmonic frequency respectively, and =i is the corresponding angle between the voltage and current as shown in Fig.2.

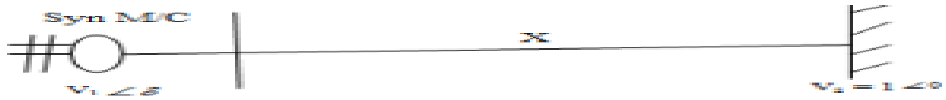


Fig.2. Control System diagram.

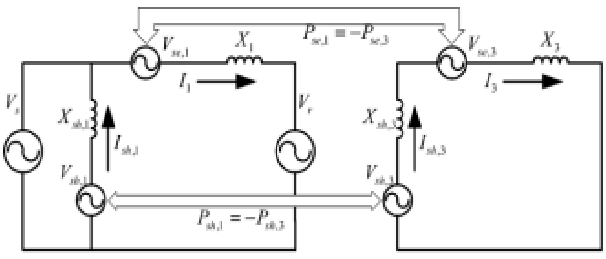
$$P = \frac{V_1 V_2}{X}\sin\delta \qquad (2)$$

$$P = \frac{V^2}{X_l - X_c}\sin\delta \qquad (3)$$

Where $X_c = \frac{V_c}{I_c}$, And $V_1 = V_2$, then the power demand will be increases and we can't any changes in i_c in transmission line at infinite bus bar

3.ANALYSIS OF THE DPFC

In this section, the consistent-state behaviour of the DPFC is analyzed, and the control capability of the DPFC is expressed within the parameters of the community and the DPFC. To simplify the DPFC, the converters are changed by controllable voltage sources in series with impedance. Considering the fact that every converter generates the voltage at two distinct frequencies, it's represented through two series-related controllable voltage sources, one at the predominant frequency and the opposite on the 1/3-harmonic frequency. Assuming that the converters and the transmission line are lossless, the total lively vigor generated by means of the 2 frequency voltage sources will be zero. The more than one sequence converters are simplified as one massive converter with the voltage, which is the same as the sum of the voltages for all sequence converter, as proven, the DPFC is placed in a two-bus system with the sending-end and the receiving-finish voltages Vs and Vr , respectively. The transmission line is represented by using an inductance L with the line current I. The voltage injected through all the DPFC series converters is Vse,1 and Vse,3 at the essential and the 1/3-harmonic frequency, respectively. The shunt converter is attached to the sending bus by way of the inductor Lsh and generates the voltage Vsh,1 and Vsh,three ; the current injected through the shunt converter is Ish . The lively and reactive energy go with the flow at the receiving finish is Pr and Qr , respectively. This illustration consists of each the main and 0.33-harmonic frequency add-ons. Headquartered on the superposition theorem, the circuit in Fig. Eight may also be extra simplified through being break up into two circuits at one of a kind frequencies. The two circuits are remoted from each different, and the hyperlink between these circuits is the lively vigor stability of every converter, as proven in Fig.



(a) (b)

Fig. 9. DPFC equivalent circuit. (a) Fundamental frequency. (b) Third harmonic frequency.

4.Central Control

The central control generates the reference signals for both the shunt and series converters of the DPFC. It is aimed on the DPFC tasks at the power-system level, such as power-flow control, low-frequency power oscillation damping, and balancing of asymmetrical components. According to the system requirement, the central control gives corresponding voltage-reference signals for the series converters and reactive current signal for the shunt converter. All the reference signals generated by the central control are at the fundamental frequency.

4.1. Series Control

Every single series converter has its own series control. The controller is used to maintain the capacitor dc voltage of its own converter by using the thirdharmonic frequency components and to generate series voltage at the fundamental frequency that is given by the central control loop with the DPFC series converter control. The principle of the vector control is used here for the dc-voltage control [7]. The third-harmonic current through the line is selected as the rotation reference frame for the single-phase park transformation, because it is easy to be captured by the phase-locked loop (PLL) [8] in the series converter.

4.2. Shunt Control

The block diagram of the shunt converter control . The objective of the shunt control is to inject a constant third harmonic current into the line to provide active power for the series converters. The third-harmonic current is locked with the bus voltage at the fundamental frequency. A PLL is used to capture the bus-voltage frequency, and the output phase signal of the PLL is multiplied by three to create a virtual rotation reference frame for the third-harmonic component. The control for the fundamental frequency components consists of two cascaded controllers. The current control is the inner control loop, which is to modulate the shunt current at the fundamental frequency. The q-component of the reference signal of the shunt converter is obtained from the central Controller and d-component is generated by the dc control. The shunt converter's fundamental frequency control aims to inject a controllable reactive current to grid and to keep the capacitor dc voltage at a constant level.

5.DPFC Advantages and Applications

The DPFC can be viewed as a UPFC which uses the D-FACTS concept and the concept of exchanging power through harmonic. Therefore, the DPFC inherits all the advantages of the UPFC and the D-FACTS, which are as follows.

5.1 High control capability. The DPFC can simultaneously control all the parameters of the power system: the line impedance, the transmission angle, and the bus voltage. The elimination of the common dc link enables separated installation of the DPFC converters. The shunt and series converters can be placed at the most effectively location. Due to the high control capability, the DPFC can also be used to improve the power quality and system stability, such as low-frequency power oscillation damping [9], voltage sag restoration [10], or balancing asymmetry.

5.2 High reliability. The redundancy of the series converter gives an improved reliability. In addition, the shunt and series converters are independent, and the failure at one place will not influence the other converters. When a failure occurs in the series converter, the converter will be short-circuited by bypass protection, thereby having little influence to the network. In the case of the shunt converter failure, the shunt converter will trip and the series converter will stop providing active compensation and will act as the D-FACTS controller [11].

5.3 Low cost. There is no phase-to-phase voltage isolation required by the series converter. Also, the power rating of each converter is small and can be easily produced in series production lines.

When the DPFC is applied in power systems, the reliability issue is important. The fault tolerance of the DPFC is investigated, including the protection method for different types of failures and the use of supplementary controls, to improve system performance during converter failures. Two control modes are predefined for each series converter, namely full-control mode and limited-control mode. In normal situations, the series converters operate in the fullcontrol mode, which uses the 3rd harmonic component to maintain the DC voltage. When the shunt converter has a failure, the 3rd harmonic current cannot be injected and the series converter will operate in the limited-control mode. In the limited-control mode, the series converter uses the active power at the fundamental frequency to stabilize the DC voltage. It is also capable of controlling the reactive power injection at the fundamental frequency. Due to the over-voltage protection, during a failure, the series converter appears as a short circuit to transmission lines. Accordingly, the network becomes asymmetric during the failure of a series converter because of the asymmetrical voltage injection. To compensate for this asymmetry, a supplementary control is applied to the central controller. The controller monitors the voltages at the sending and receiving ends and the line current, to calculate the total voltage injected by all series converters. By comparing this calculated voltage and the reference voltage generated by the central control, the operation status of the series converters is known. According to the operation status, the controller can automatically adjust the reference for each series converter [12]. The two supplementary controls are verified both in Matlab Simulink and in the experimental setup. This proves that the supplementary controls can improve DPFC performance during converter failures and therefore, the DPFC have relatively high reliability [13]. DPFC can compensate both negative and zero sequence components, consequently the DPFC is more powerful than other FACTS device for compensation of unbalanced currents. Additional controllers are supplemented to existing DPFC controller, and their principle is to monitor the negative and zero sequences of the current through the transmission line, and to force them to be zero by applying an opposing voltage [14].

6. CONCLUSION

In this paper, the essential features of DPFC controller with various applications were discussed. The potential to enhancement of power system stability as well as reliability of power system was explained. In power system transmission, it is required to maintain the voltage magnitude, phase angle and line impedance. Consequently, to control power flow over designated transmission line and enhancement of power system stability FACTS devices are used in modern power system network. In this review paper the role of DPFC device in power system and current status of electric

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power system network are addressed. Therefore, the following results are found, power flow control is achieved by using FACTS (DPFC) devices and transient stability is improved and faster steady state is achieved. Hence congestion is less by improving transient stability and reliability. By using different control strategies, performance of DPFC can be further modified as per the requirement.

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