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Modeling of Distributed Interline Power Flow Controller for Reduces the Oscillations by using Particle Swarm Optimization

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Abstract: The purpose of the work reported in this paper is to design an oscillation damping controller for DIPFC to damp low frequency electromechanical oscillations. The optimal design problem is formulated as an optimization problem, and particle swarm optimization (PSO) is employed to search for the damping controller parameters. Results demonstrate that DIPFC with the proposed model can more effectively improve the dynamic stability and enhance the transient stability of power system compared to the genetic algorithm based damping controllers. The r and **λ** are relative magnitude and phase angle of DIPFC controller. Moreover, the results show that the **λ** based controller is superior to the r based controller.

Keywords: FACTS Controllers,UPFC,DIPFC.

1. INTRODUCTION

During the last twenty years, the operation of power systems has changed due to growing consumption, the development of new technology, the behavior of the electricity market and the development of renewable energies. In addition to existing changes, in the future, new devices, such as electrical vehicles, distributed generation and smart grid concepts, will be employed in the power system, making the system extremely complex. Power flow is controlled by adjusting the parameters of a system, such as voltage magnitude, line impedance and transmission angle. The device that attempts to vary system parameters to control the power flow can be described as a Power Flow Controlling Device (PFCD).Depending on how devices are connected in systems, PFCDs can be divided into shunt devices, series devices, and combined devices (both in shunt and series with the system). In power systems the utilization of electricity varies frequently, so due to this reason we have to control the power flow in the system. Here we use a device called Power Flow Controlling (PFC) used to adjust the parameters such as bus voltage , transmission angle and impedance of the line. The combined characteristics of Flexible AC Transmission System (FACTS) and PE PFCDs are the most appropriate devices which are used to control the power flow. One of the series compensated FACTS controller known as Unified Power Flow Controller (UPFC) which is treated as the most commanding PFCD which is used to correct all the above mentioned system parameters. The development of the UPFC into a new FACTS device called the Distributed Interline Power Flow Controller (DIPFC) is done by excluding the common DC link and series converter distribution as shown in Fig. 1.

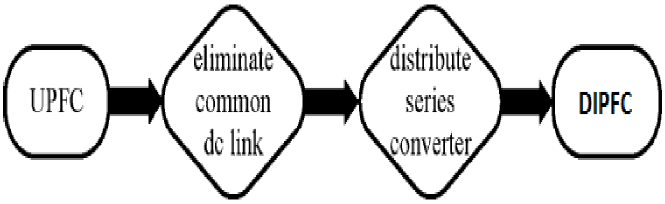

Figure 1. Flowchart from UPFC to DIPFC

The reactive power which is swapped at the dc-terminals is produced internally. At the dc link, the VSC1 is used to engender or take up active power which is requisited by converter2. Voltage sourced converter-1 be able to function at the UPF mode. Perceptibly, nearby no reactive-power will flow throughout the Unified-PFC dc-link. In UPFC there is presence of common dc-link connecting the shunt in addition to the series-converters, so if the dc-link failure occurs in the system it damages the whole system and hence there will be an interruption in the power supply and the cost of the

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components that are used in UPFC is very expensive. Both the devices are coupled with dc-link, if a dc link failure occurs it damages the whole system, so that the reliability of the system gets reduced. Hence so as to eliminate the 2 disadvantages a new power flow controlling device so called DIPFC is presented in this paper.

II. PRINCIPLE OF DIPFC

The DIPFC consists of one shunt and several series connected converters. The shunt converter is similar as a STATCOM, while the series converters employ the D-FACTS concept. Each converter within the DIPFC is independent and has a separate DC link capacitor to provide the required DC voltage. Fig. 2 shows the structure of DIPFC that is used in a transformation system with two parallel lines. The control capability of the UPFC is given by the back-to-back connection between the shunt and the series converters with DC link, which allows the active power to exchange freely. To ensure that the DIPFC has the same control capability as the UPFC device, a method that allows the exchange of active power between converters without DC link is the prerequisite. In the DIPFC, there is a common connection between the AC terminals of the shunt and the series converters, which is the transmission line as shown fig.2.

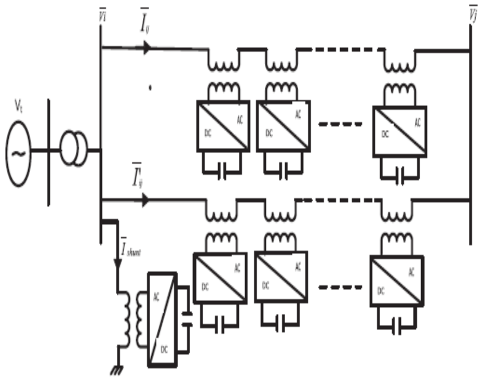

Figure 2.Schematic representation of DIPFC

III. CONTROLLING OF DIPFC

There are three types of controllers that control the multiple converters; they are central control, shunt control and series control. The parameters of shunt and series control are maintained by themselves, they are also called as local controllers. At the power-system level the central control regulates the DIPFC functions. Each controller’s function is discussed.

IV. MODELLING OF DIPFC

From the conceptual viewpoint, each converter can be replaced by a controllable voltage source in series with impedance. Hence each converter generates voltage at 2 different frequencies each converter can be represented by two series connected controllable voltage sources, one at fundamental frequency and the other at 3rd harmonic frequency. The total active power generated by the two frequency voltage source will be zero, if the converter is lossless. The conceptual representation of DIPFC is shown in Fig.3, where *Vse*,1 equals to the sum of the fundamental voltages for all series converters, and *Vse*,3 is the sum of the 3rd harmonic voltages. The shunt converter generates voltage at 3rd harmonic frequency. As a result, a third harmonic current will flow in the section of the transmission line to feed the active power to series converters.

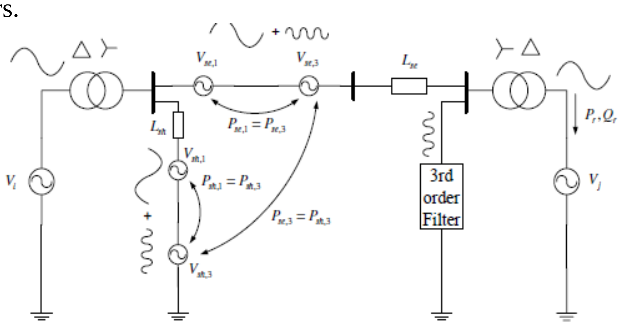

Figure.3. Theoretical representation of DIPFC in two bus system

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The capacitor dc voltage of shunt converter is compensated by the absorbing active power at fundamental frequency. The series converters inject a fundamental voltage which is controllable in both magnitude and phase. It absorbs the active power from 3rd harmonic frequency to balance their dc voltages. Base on the superposition theorem, the circuit can be split into two circuits at different frequencies. The two circuits are isolated from each other, and the link between two circuits is the active power balance of each converter, see in Fig.4. As shown in Fig.4, the circuit of a DIPFC at fundamental frequency is the same as a UPFC, therefore the DIPFC have the same characteristic as UPFC.

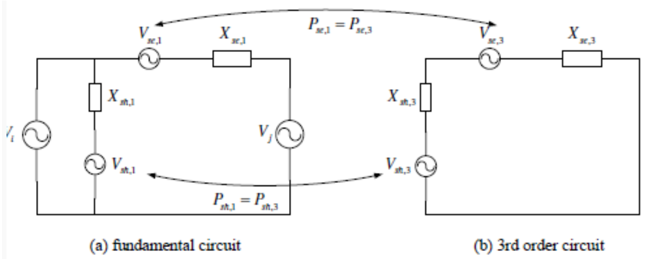


Figure.4. Electrical circuits in fundamental and 3rd frequency

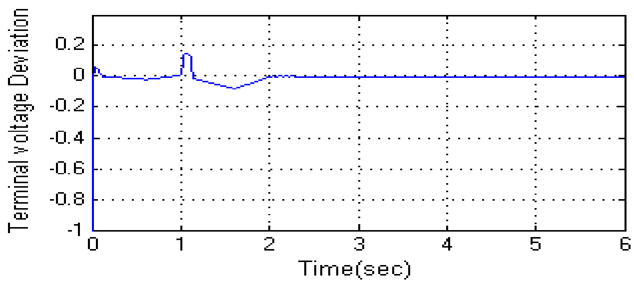
V. RESULT

The optimization of DPFC controller parameters is carried out by evaluating the objective cost function as given in Eq. which considers a multiple of operating conditions. The operating conditions are considered as:

Base case: P =0.75 pu and Q =+0.17 pu (Nominal loading)
Case 1: P = 0.6 pu and Q= +0.2025 pu (Light loading)
Case 2: P = 0.95 pu and Q= +0.07 pu (Heavy loading)

In our implementation, in order to acquire better performance, number of particle, particle size, number of iteration, c1 and c2 are chosen as 30, 5, 50, and 2, respectively. Also, the inertia weight, w, is linearly decreasing from 0.9 to 0.4.
The proposed control scheme for DIPFC is evaluated by computer simulation in MATLAB/ Simulink. In this conditions, a 6-cycle 3-phase fault is measured and this fault take place at t=0.9 sec(900 msec), at the middle of the transmission line is cleared with the everlasting tripping of the faulted section. The speed-deviation curves of generator under nominal, light, and under the heavy-loading conditions are represented in Fig.5.

Case 1:
In this scenario, it is considered a 6-cycle three-phase fault occurred at t= 1 s at the middle of the one transmission line cleared by permanent tripping of the faulted line. The speed deviation of generator at nominal, light, and heavy loading conditions due to designed controller for k and r by PSO algorithm are shown in Fig. 5. Also, Fig. 6 shows the generator output power, internal voltage variations, and excitation voltage deviation with λ and r based controllers for nominal loading conditions, respectively. These figures obviously show the good damping effect of the supplementary controller.



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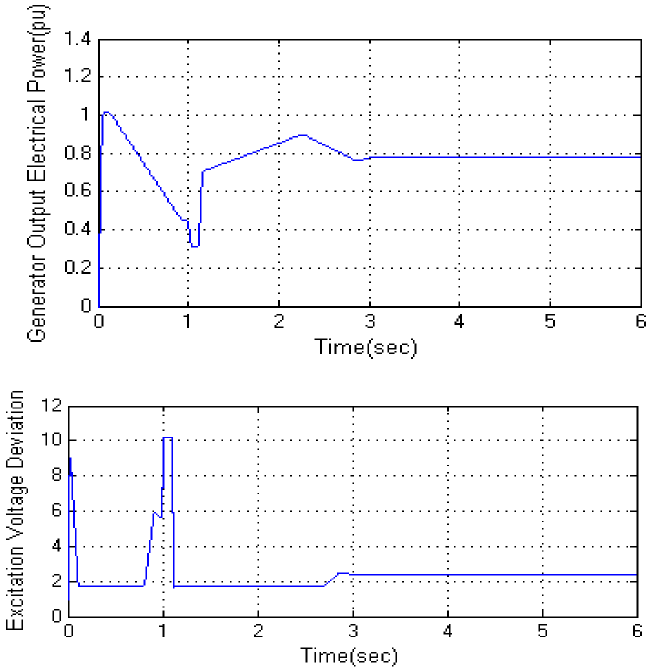
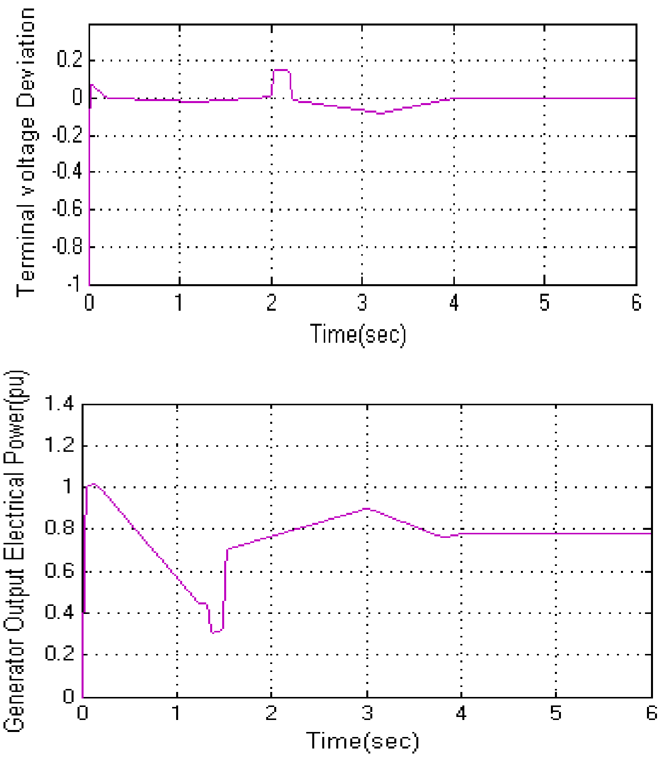


Figure5.1 DIPFC case1 r controller nominal loading



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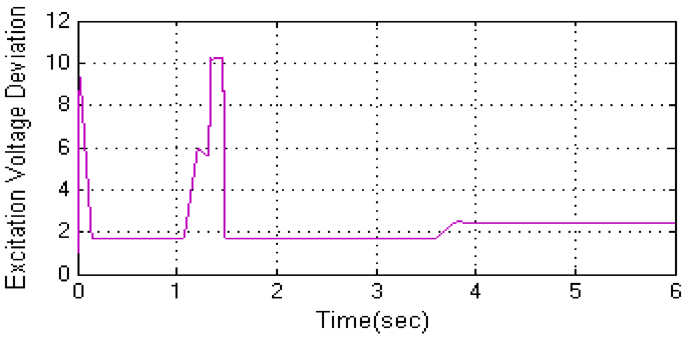

Figure5.2 DIPFC case1 r controller light loading

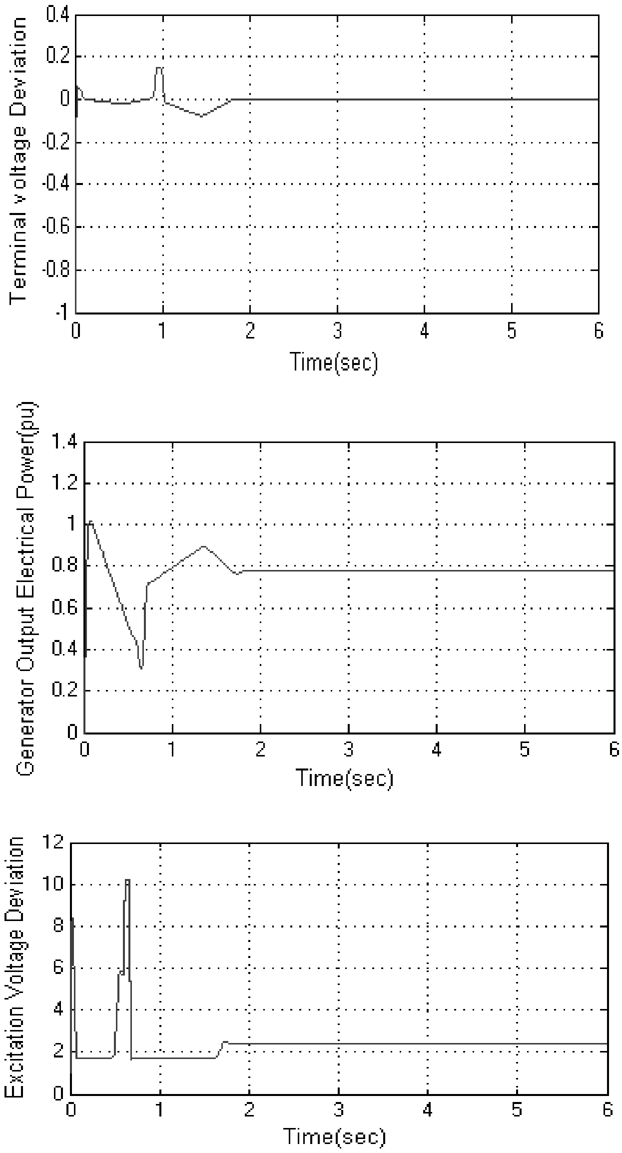

Figure5.3 DIPFC case1 r controller Heavy loading

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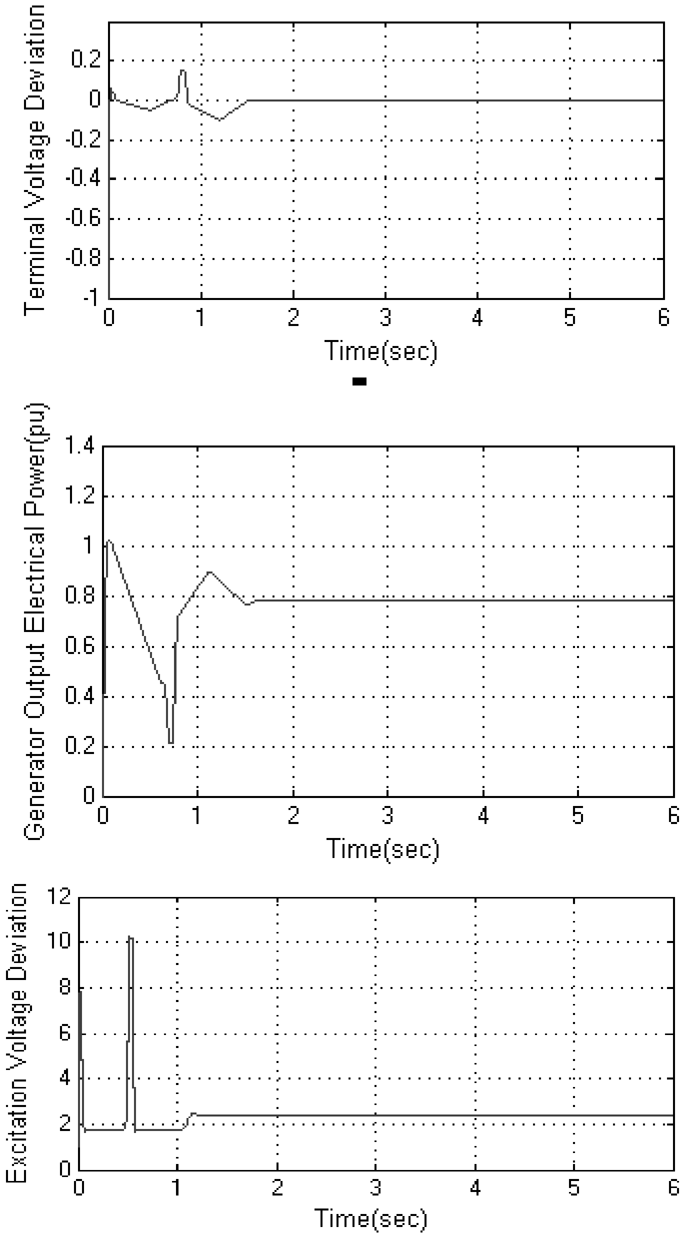
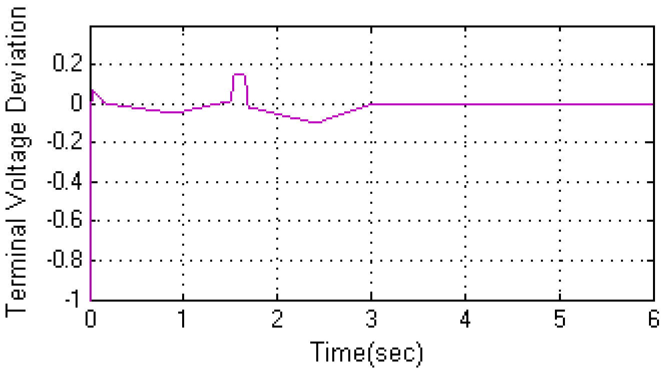


Figure6.1 DIPFC case1 λ controller Heavy loading



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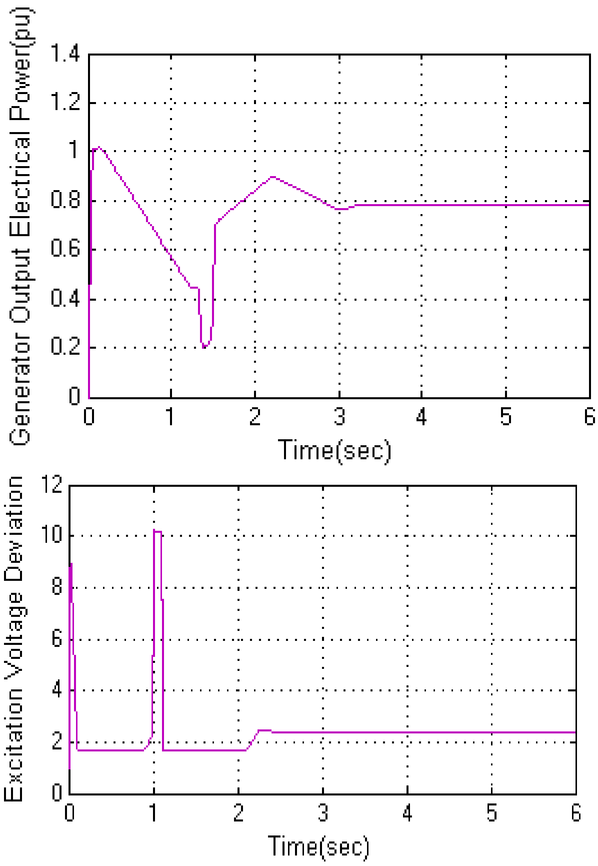
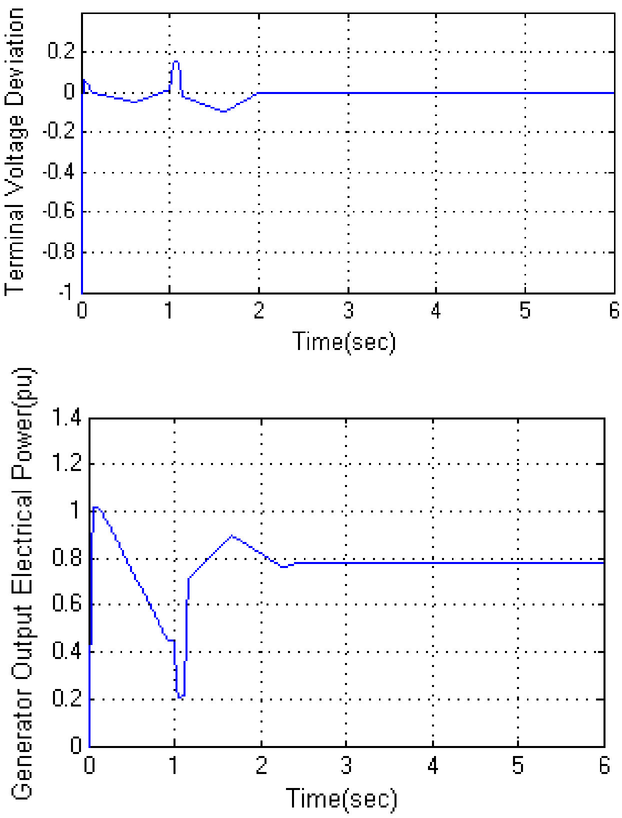


Figure6.2 DIPFC case1 λ controller Light loading



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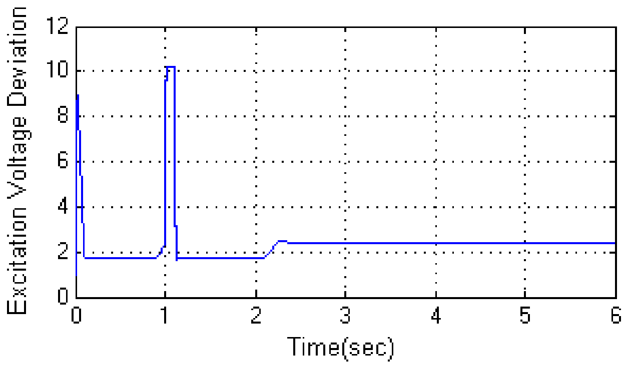

Figure6.3 DIPFC case1 λ controller Nominal loading

VI. CONCLUSION

This paper presents the new concept of DIPFC system and the method of transmitting active power through the same line at different frequency. The distributed converters bring the following benefits: reduce cost for both equipment and maintenance; increase the reliability of the whole system, even when the shunt converter breaks, series converters can also work as variable conductor; break the location constrain, the converters are physical separated without losing control capability and also damp the voltage, speed deviations in transmission system.

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BIOGRAPHIES

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