# Two Series and One Shunt CMI Bases UPFC System for Harmonic Suppression

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***Abstract - The Unified Power Flow Controller has capability to reduce harmonics present in the power system and maintain the stability of overall system. But the performance of it not as much good which can sustain in every condition. So there is need for better controller which can be implemented with the Cascades Multilevel Inverter (CMI) and gives better stability than the previous configurations. In this work a UPFC is proposed which is based on two series and one shunt cascaded multilevel inverter(CMIs), with the utilization of transformer. The proposed design has lower total harmonic distortion (THD) and faster dynamic response. The system design with the outcomes is explained in the proposed methodology and simulation results sections.***

***Keywords - UPFC, CMI, FACTS, AC Transmission.***

## I. INTRODUCTION

Electrical energy is the back bone for the development of the society. With the industrial growth of a nation there is always an increased requirement of electrical energy. The increased demand for electric energy requires increasing the transmission capabilities. However, the inherent thermal, dielectric and stability limits of power system restrict the power transaction, leading to the under utilization of the existing transmission resources.

Traditionally, fixed or mechanically switched shunt and series capacitors, reactors and synchronous generators were being used. However, wear and tear in the mechanical components, large switching transients and slow response were the problems with these devices.

FACTS controllers provide fast and reliable control over the three main transmission parameters, i.e., voltage magnitude, phase angle and line impedance to facilitate optimal power system performance. FACTS devices are broadly classified into two types namely thyristor based devices and voltage source inverter based devices. Static var compensator, thyristor controlled series capacitor, etc., are the thyristor based FACTS devices.

Among the various FACTS controllers, the devices that use a direct current (dc) - alternating current (ac) inverter are considered superior to those of phase controlled devices in terms of harmonic performance, dynamic response and ease of operation.

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 phase ac power system active and reactive power flows from the generating station to the load through different transmission lines and networks buses. The active and reactive power flow in transmission line is called power flow or load flow. Power flow studies provide a systematic mathematical approach for determination of various bus voltages, there phase angle, active and reactive power flows through different lines, generators and loads at steady state condition. Power flow analysis is also used to determine the steady state operating condition of a power system. For the planning and operation of power distribution system, Power flow analysis is used. It is very important to control the power flow along the transmission line. Thus to control and improve the performance of ac power systems.

## II. UNIFIED POWER FLOW CONTROLLER (UPFC)

It is designed by combining the series compensator (SSSC) and shunt compensator (STATCOM) coupled with a common DC capacitor. It provides the ability to simultaneously control all the transmission parameters of power systems, i.e. voltage, impedance and phase angle. it consists of two converters - one connected in series with the transmission line through a series inserted transformer and the other one connected in shunt with the transmission line through a shunt transformer. The DC terminal of the two converters is connected together with a DC capacitor. The series converter control to inject voltage magnitude and phase angle in series with the line to control the active and reactive power flows on the transmission line. Hence the series converter will exchange active and reactive power with the line.

The unified power flow controller is connected to the power system by two coupling transformers as shown in Fig.2.1. The voltage source inverter (VSI 1) is shunt connected and the VSI 2 is series connected to the power system. These two inverters are operated from a common dc link provided by a dc storage capacitor. Thus the configuration of UPFC can be considered as a compound system of STATCOM and SSSC sharing a common dc link capacitor. It can be operated as a power flow controller, a voltage regulator or a phase shifter depending upon the control strategy adopted.

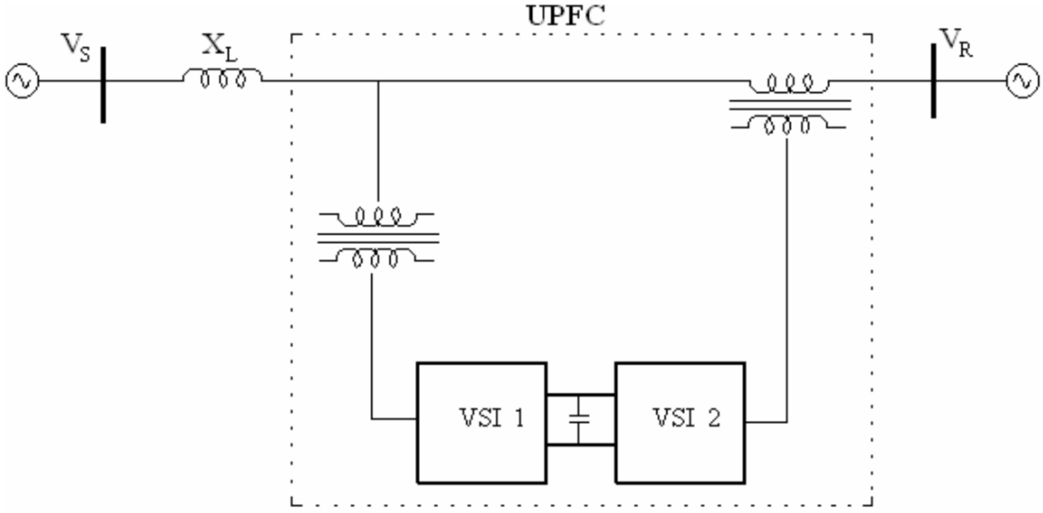


Figure 2.1 Schematic diagram of UPFC.

The application of FACTS in electric power system is intended for reactive power compensation, control of power flow, improvement of stability, voltage profile management, power factor correction and loss minimization. The STATCOM is used for reactive power control and voltage control whereas SSSC helps to enhance the power flow over the line. UPFC has the unique ability of controlling the real and reactive power flow independently.

## III. PROPOSED METHODOLOGY

The proposed work has been implemented and simulated on MATLAB figure 3.1 demonstrate the proposed UPFC control system having 2 machine 2 converters one is a series converter and another is one shunt converter.

A unified power flow controller consists of two voltage source inverters (VSI) connected back to back with a common DC coupling capacitor as shown in Fig.3.1. Such an arrangement allows for ail the three functions namely series, shunt and phase angle compensation to be unified into one unit. Inverter-1 is connected to the power system through a transformer. Figure 3.2 illustrate the UPFC with two Series and one Shunt CMI. Figure 3.3 shows the proposed two series control systems and corresponding proposed one shunt control system has been illustrated in Figure 3.4.

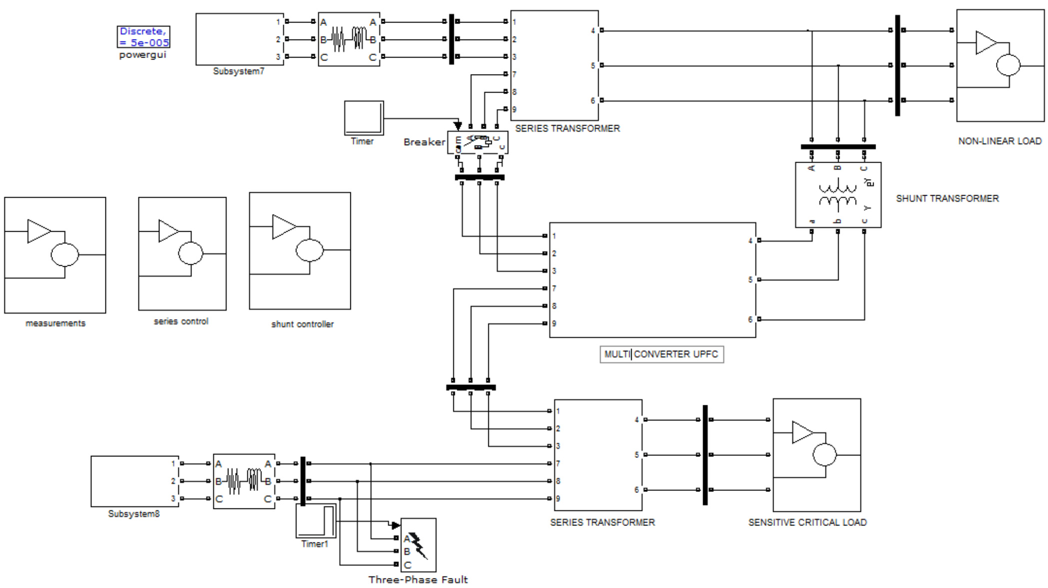


Fig. 3.1 Proposed UPFC has two machine 2 converters (2 series converters & 1 shunt converter).

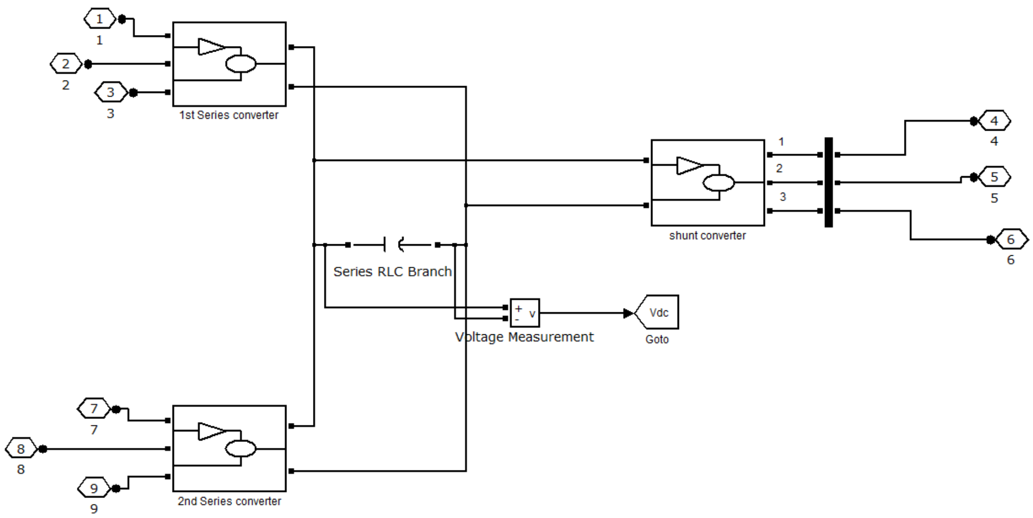


Fig. 3.2 UPFC with two Series and one Shunt CMI

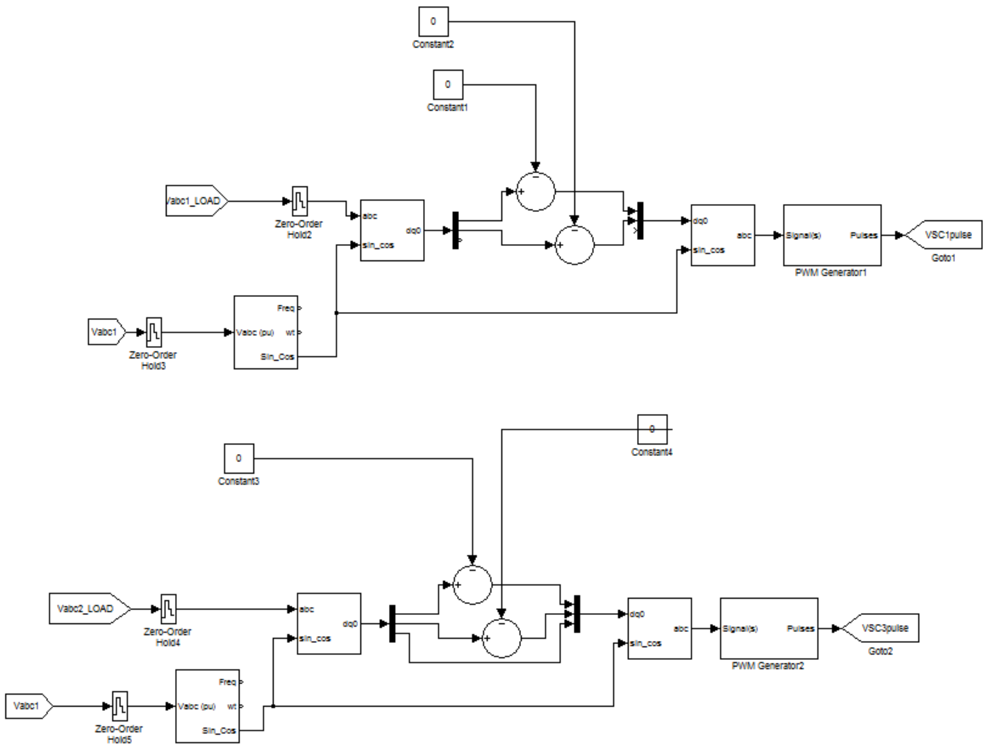


Fig.3.3 proposed two series control systems

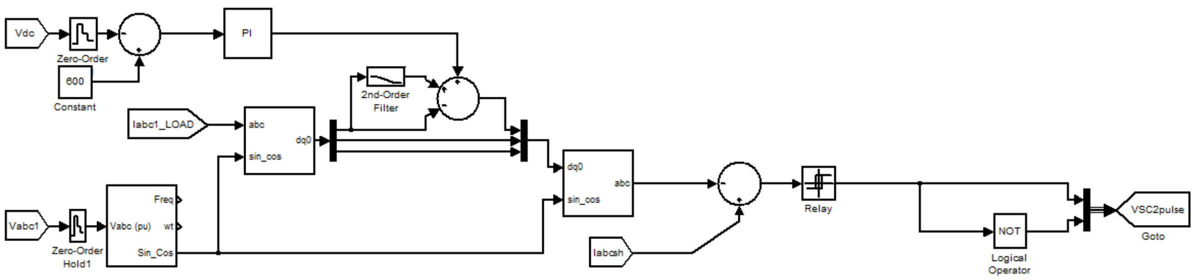


Fig. 3.4 proposed one shunt control system.

## IV. SIMULATION RESULTS

UPFC being a multi-variable controller, it is necessary to look into its overall effect on power system stability.

Frequency domain (small-signal stability) and time domain analysis (transient stability) has been conducted to look into the stability improvement with UPFC. Small-signal stability analysis for power systems with UPFC controlling the real power, reactive power flow in the transmission line/line side bus voltage, DC link capacitor voltage and the UPFC bus voltage simultaneously has been conducted to look into its effect on interconnected power systems. The performance of the proposed system has given with waveform in figure 4.1 DC Capacitor Voltage Waveforms. Fig. 4.2 Shunt Currents in the Proposed System. Fig. 4.3 THD of Proposed System. Fault installed in Figure 4.4 compensated is demonstrated in Fig. 4.5 Compensated Three Phase Waveforms.

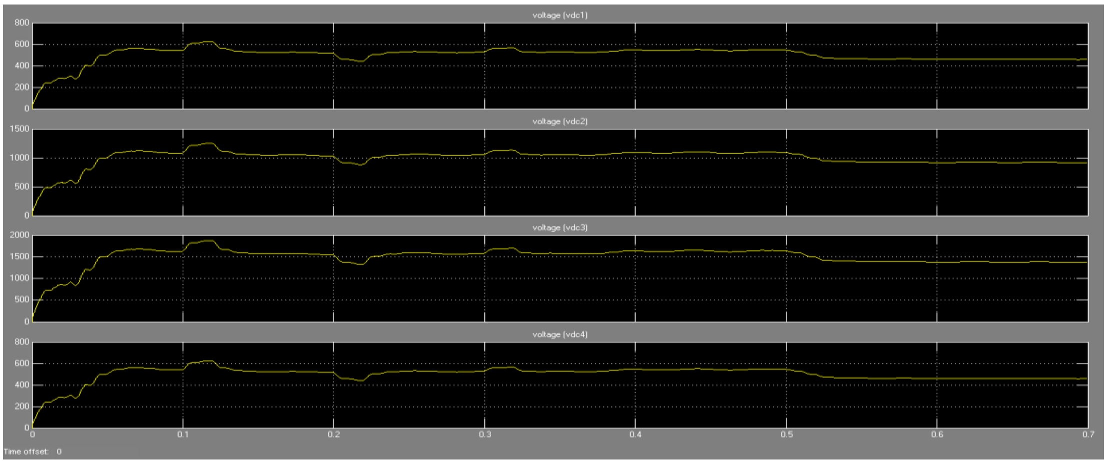


Fig. 4.1 DC Capacitor Voltage Waveforms

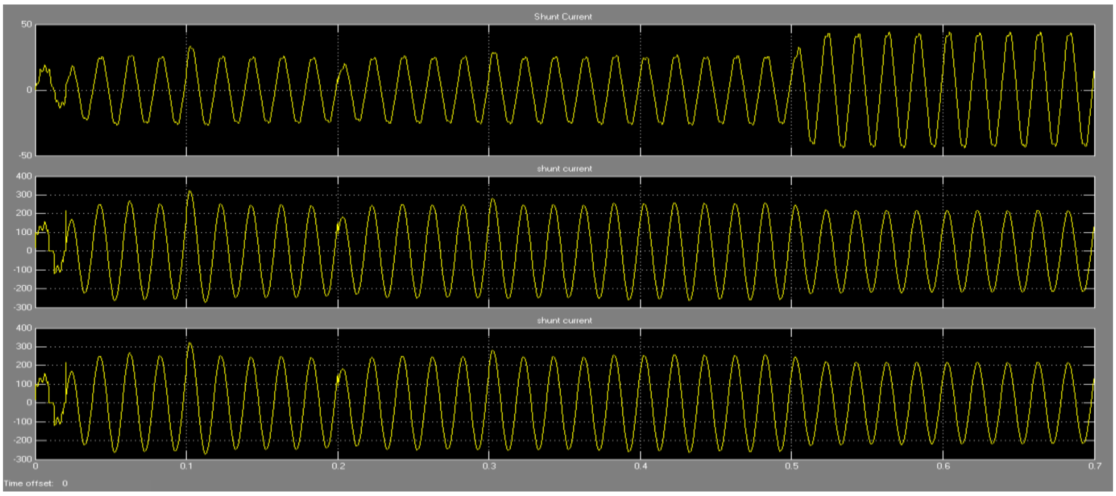


Fig. 4.2 Shunt Currents in the Proposed System. Fig. 4.5 Compensated Three Phase Waveforms

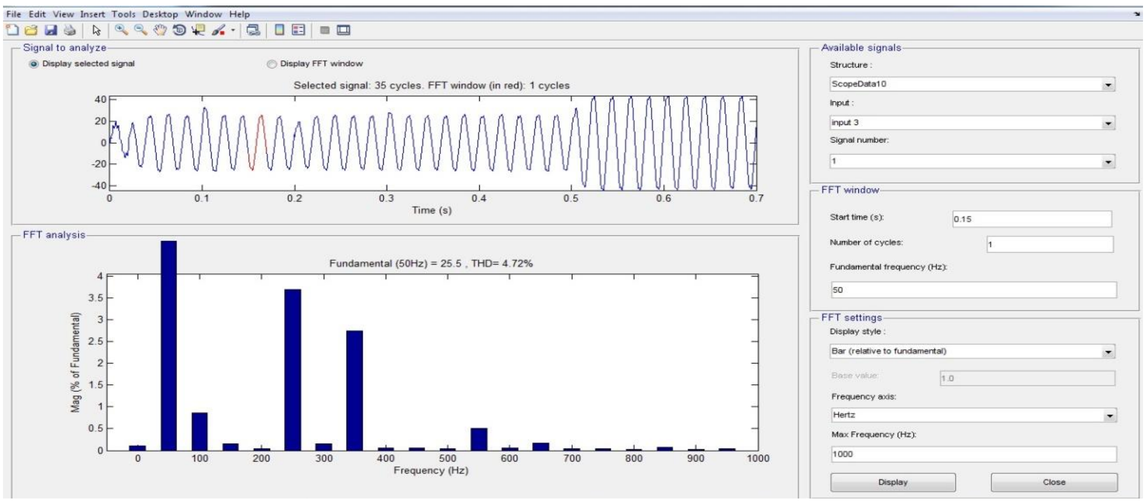


Fig. 4.3 THD of Proposed System

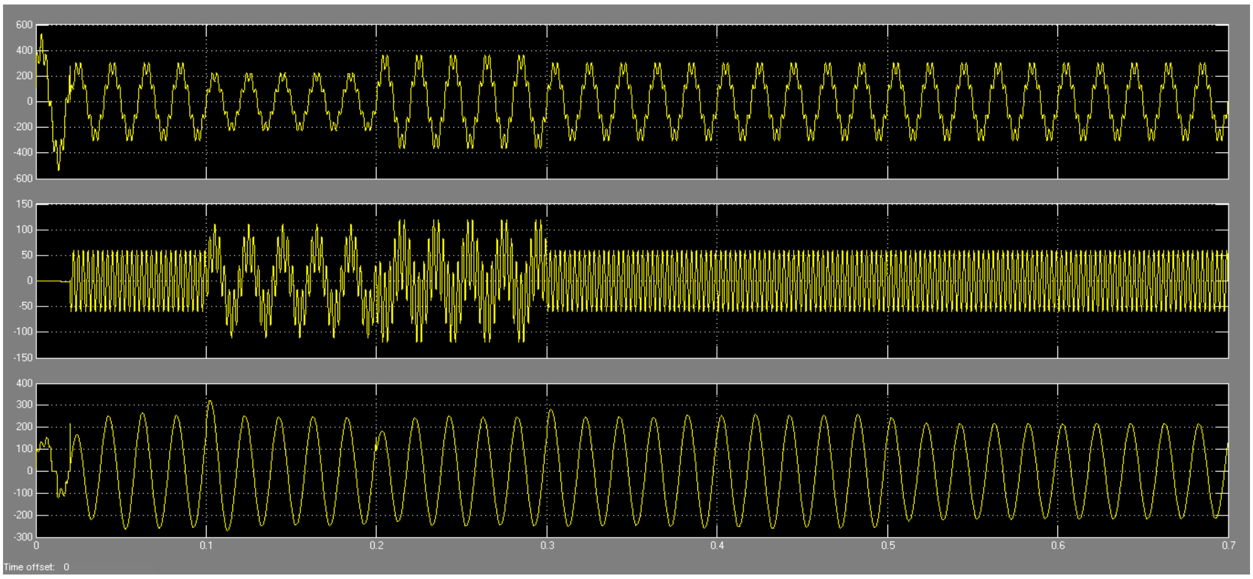

Fig. 4.4 Fault installed but it is compensated

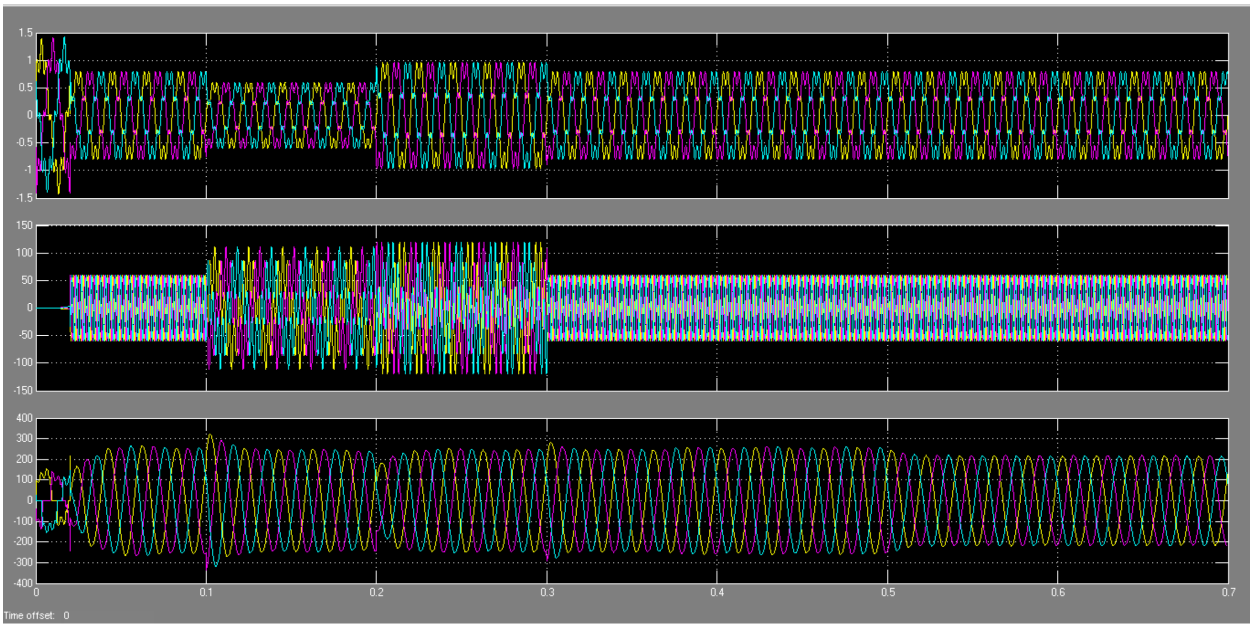

Fig. 4.5 Compensated Three Phase Waveforms

## V. CONCLUSION AND FUTURE SCOPE

Improvement in power oscillation damping has involved the series inverter controlling the real and reactive power flow in the transmission line with the shunt inverter controlling The UPFC bus voltage and the DC link capacitor voltage. With this strategy, it has been mentioned earlier that increase/decrease in the transmission line reactive power achieved by injecting an in-phase voltage by the series inverter is actually supplied by the shunt inverter. Thus the cause and the effect are on two portions of the UPFC. The cause being the injection of in-phase series voltage by the series inverter and the effect is seen as a change in shunt inverter reactive power. This represents an indirect control with respect to transmission line reactive power flow. A new UPFC is based on two series and one shunt cascaded multilevel inverter (CMIs), with the utilization of transformer.

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