

Simulation and Analysis of ZSI in UPFC for Power Flow Improvement

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Abstract

The operation of an ac power transmission line is generally constrained by limitations of one or more network parameters. The FACTS (Flexible ac transmission systems) technology has a principle role to enhance the controllability and power transfer capability in an ac system. The unified power-flow controller (UPFC) is a member of the FACTS family with very attractive features. The real and reactive power can be controlled using UPFC. This paper deals with the application of Z Source Inverter (ZSI) in UPFC for power flow improvement. The circuit model is developed in MATLAB using rectifier and ZSI. The MATLAB simulation results show active and reactive power improvement with ZSI in UPFC.

Keywords: Power flow improvement, Simulation, UPFC, Z Source Inverter.

1. Introduction

In today's high complex and interconnected power systems, there is a great need to improve utilization while still maintaining reliability and security. Reducing the effective reactance of lines by series compensation is a direct approach to increase transmission capability. However, a power transfer capability of long transmission line is limited by stability consideration [1]. Fast progression in the field of power electronics has already started to influence the power industry. This is one direct outcome of the concept of flexible ac transmission systems (FACTS) aspects, which has become feasible due to the improvement realized in power-electronic devices. In principle, the FACTS devices could provide fast control of active and reactive power through a transmission line. The unified power-flow controller (UPFC) is a member of

the FACTS family with very attractive features. This device can independently control many parameter, since it has the combined properties of a static synchronous compensator (STATCOM) and static synchronous series compensator (SSSC) [2]. Among the FACTS components UPFC is one of the most efficient. It possesses a great aptitude to achieve an independent and simultaneous control of both active and reactive power flow, in the line [3]. In this paper the modelling and control of active and reactive power using Z-Source inverter based UPFC are simulated using MATLAB software. The simulation results are presented to show the effectiveness of ZSI in UPFC for improvement of power flow.

2. Operating Principle of UPFC

The unified power flow controller consists of two switching converters. These converters are operated from a common dclink provided by a dc storage capacitor (Fig. 1) [4].

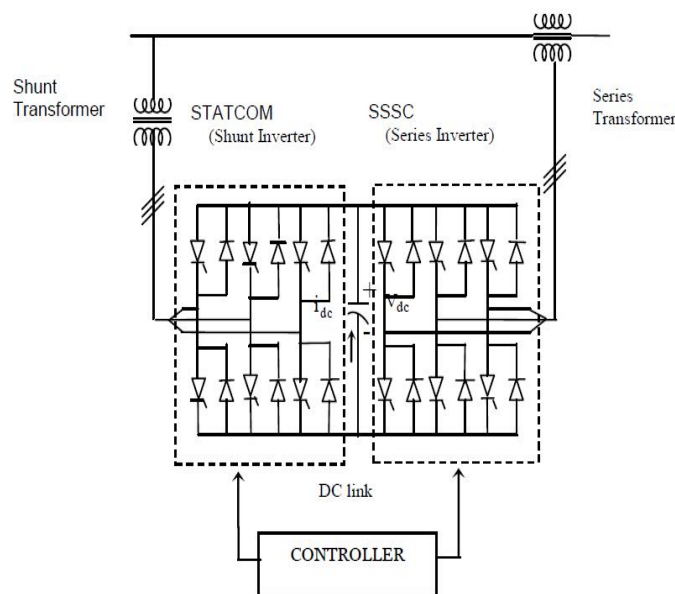


Fig. 1: Basic circuit arrangement of UPFC

Converter 2 (SSSC) provides the main function of the UPFC by injecting an ac voltage with controllable magnitude and phase angle in series with the transmission line via a series transformer. The basic function of converter 1 is to supply or absorb the real power demand by converter 2 at the common dc link. It can also generate or absorb controllable reactive power and provide independent shunt reactive compensation for the line. Converter 2 (STATCOM) supplies or absorbs locally the required reactive power and exchanges the active power as a result of the series injection voltage [5].

3. Z Source Inverter

The main objective of static power converters is to produce an AC output waveform from a dc power supply. Impedance source inverter is an inverter which employs a unique impedance network coupled with the inverter main circuit to the power source. This inverter has unique features in terms of voltage (both buck & boost) compared with the traditional inverters. Z-source inverter overcomes output voltage limitation of traditional voltage source inverter [6]. A two-port network that consists of a split-inductor and capacitor that are connected in X shape is employed to provide an impedance source (Z-source) coupling the inverter to the dc source, or another converter. The DC source/load can be either a voltage or a current source/load. Therefore, the DC source can be a battery, diode rectifier, thyristor converter, fuel cell, PV cell, an inductor, a capacitor, or a combination of those [1]. Switches used in the converter can be a combination of switching devices and anti-parallel diode as shown in Fig. 2 [7].

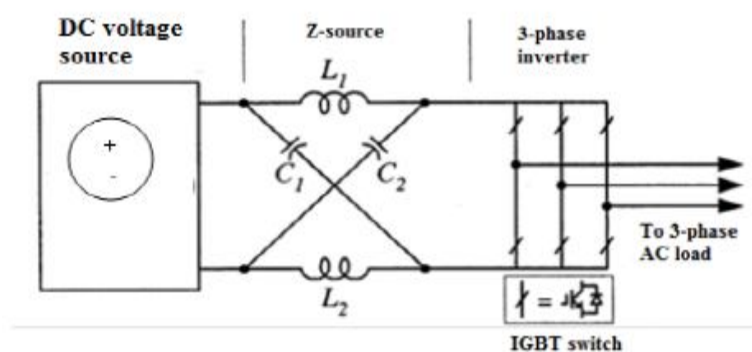


Fig. 2: ZSI

4. Matlab Modeling and Simulation Results

A comprehensive comparison of the UPFC and UPFC with Z-source inverter systems has been performed using simulation. Here Simulation is carried out in different cases.

CASE I. Simulation Model without UPFC

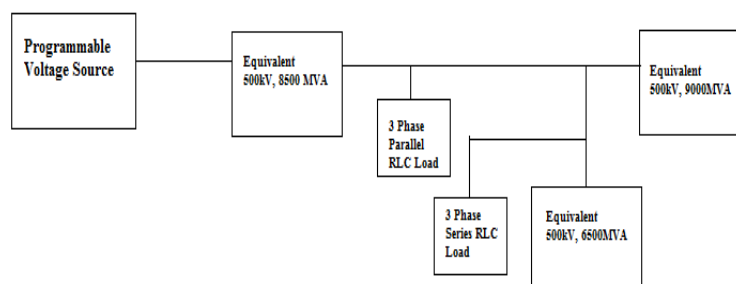


Fig. 3: Block diagram of model without using UPFC

Fig. 3 shows simulation model of power system without using UPFC. The real power value is 917.14 MW and reactive power value is -57.37MVAR as shown in Fig. 4.

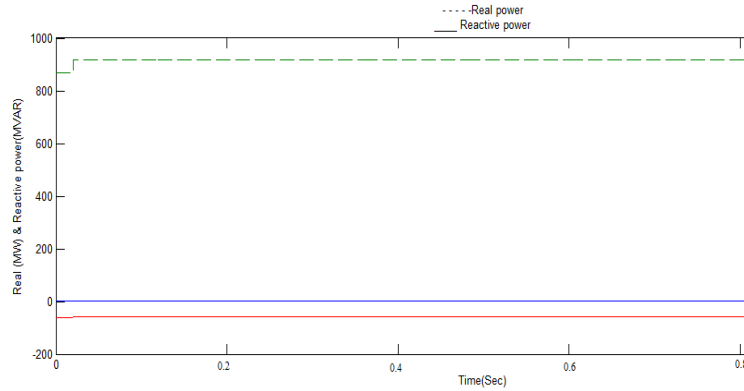


Fig. 4: Real and Reactive power.

CASE II. Simulation Model using UPFC

Fig. 5 shows simulation model of power system using UPFC. The real power value is 1000.06 MW and reactive power value is 70.1 MVAR as shown in Fig. 6.

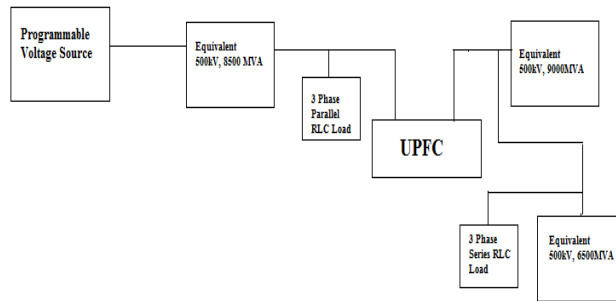


Fig. 5: Block diagram of model using VSI based UPFC

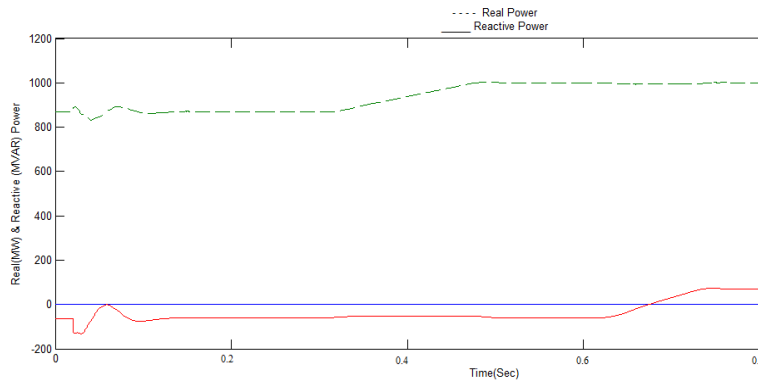


Fig. 6: Real and Reactive Power.

CASE III. Simulation Model With UPFC implementing Z Source Inverter

Fig. 7 presents the simulation model of power system using ZSI in UPFC. The real power value is 1008.07 MW and reactive power value is 72.71 MVAR as shown in Fig. 8.

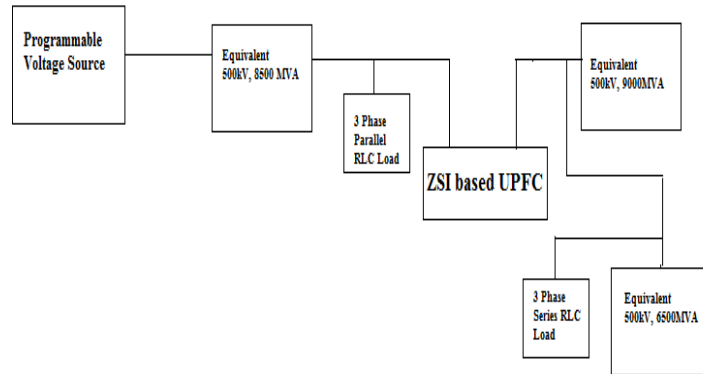


Fig. 7: Block diagram of model using ZSI based UPFC

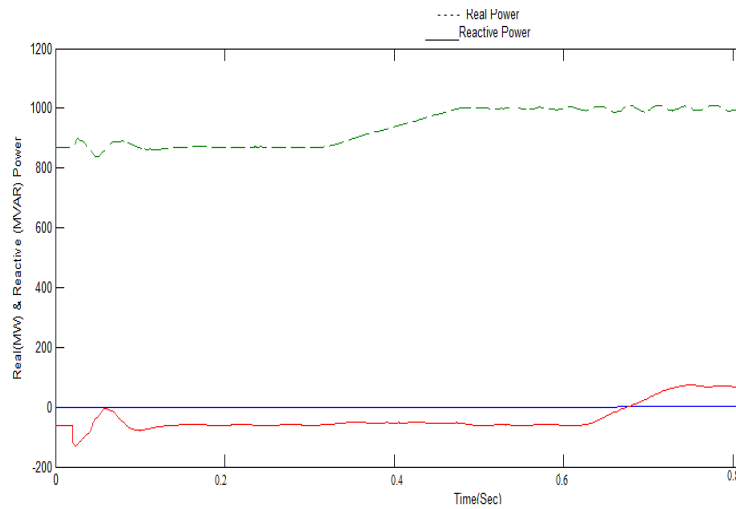


Fig. 8: Real and Reactive Power.

Table 1 shows the comparison of above simulation models. It is observed that the Real and reactive power flow has been improved with the use of UPFC in the power system. The power flow is further improved with ZSI in UPFC.

Table 1: Comparison of Power flow.

Power	Without UPFC	With UPFC	With UPFC using ZSI
Real power (MW)	917.14	1000.06	1008.07
Reactive Power (MVar)	-57.37	70.1	72.71

5. Conclusion

Among the FACTS components UPFC is one of the most efficient devices which improve the Real and Reactive power flow in power system. The various simulation models i.e. power system without UPFC, With UPFC and ZSI in UPFC have been studied and results were analyzed. It is observed that the active and reactive power flow has been improved by 82.92MW and 12.73MVAR respectively and with the use of UPFC in the power system. The active and reactive power has been further improved by 90.93MW and 15.343MVAR respectively with the use of ZSI in UPFC.

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