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Simulation and Modelling of Custom Power Device using MATLAB

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Abstract – Now -a-days the power demanded by different consumers is much higher than the past days. This demand is due to the increased usage of electric power for different types of loads in balanced and unbalanced conditions. When the load on the consumer side is unbalanced, the current will flow through the neutral wire. Hence due to I^2R losses voltage drop will occur in neutral. As a result the quality of distribution of power gets decreases. This paper present the modelling and simulation of DPFC. Each part of series and shunt converter's modelling done. The DPFC is consequent from the unified power flow controller (UPFC) with excluded common dc link between shunt and series converter.

Keywords- Modelling of series and shunt converter, Third harmonic frequency, Power exchange,

I. INTRODUCTION

For the last decade, the power quality problems has been the major concern of the power companies. Power quality is defined as both the delivery and consumption of electric power affect on the performance of electrical apparatus. From a customer point of view, power quality problem can be defined as any problem I manifested on voltage, current, or frequency deviation that results in power failure. The power electronics progressive, especially in flexible alternating-current transmission system (FACTS) and custom power devices, affects power quality improvement.

Generally, custom power devices, e.g., dynamic voltage restorer (DVR), are used in medium-to-low voltage levels to improve customer power quality. Most serious threats for sensitive equipment in electrical grids are voltage sags (voltage dip) and swells (over voltage). These disturbances occur due to some events, *e.g.*, short circuit in the grid, inrush currents involved with the starting of large machines, or switching operations in the grid.

The FACTS devices, such as unified power flow controller (UPFC) and synchronous static compensator (STATCOM), are used to alleviate the disturbance and improve the power system quality and reliability. In this paper, a distributed power flow controller, introduced in as a new FACTS device, is used to mitigate voltage and current waveform deviation and improve power quality in a matter of seconds. The DPFC structure is derived from the UPFC structure that is included one shunt converter and several small independent series converters. The DPFC has same capability as UPFC to balance the line parameters, i.e., line impedance, transmission angle, and bus voltage magnitude.

II. DPFC CONSTRUCTION

By introducing the two approaches outlined in the previous section (elimination of the common DC link and distribution of the series converter) into the UPFC, the DPFC is achieved. Similar as the UPFC, the DPFC consists of shunt and series connected converters. The shunt converter is similar as a STATCOM, while the series converter employs the DSSC concept, which is to use multiple single-phase converters instead of one three phase converter. Each converter within the DPFC is independent and has its own DC capacitor to provide the required DC voltage. The configuration of the DPFC is Shown in below Figure

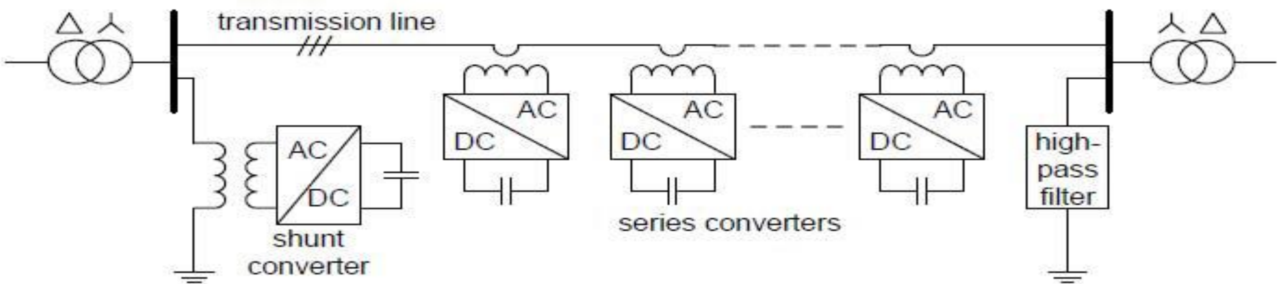

Fig 1.DPFC configuration

Within the DPFC, the transmission line presents a common connection between the AC ports of the shunt and the series converters. Therefore, it is possible to exchange active power through the AC ports. The method is based on power theory of non-sinusoidal Distributed Power Flow Controller (DPFC) components [4].

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According to the Fourier analysis, non-sinusoidal voltage and current can be expressed as the sum of sinusoidal functions in different frequencies with different amplitudes. The active power resulting from this non-sinusoidal voltage and current is defined as the mean value of the product of voltage and current. Since the integrals of all the cross product of terms with different frequencies are zero, the active power can be expressed by

$$P = \sum_{i=1}^{\infty} ViIi\ COS\ \varphi i \qquad (1)$$

Where Vi and Ii are the voltage and current at the ith harmonic frequency respectively, and φi is the corresponding angle between the voltage and current [4]. Equation shows that the active powers at different frequencies are independent from each other and the voltage or current at one frequency has no influence on the active power at other frequencies.

The independence of the active power at different frequencies gives the possibility that a converter without a power source can generate active power at one frequency and absorb this power from other frequencies. By applying this method to the DPFC, the shunt converter can absorb active power from the grid at the fundamental frequency and inject the power back at a harmonic frequency.

This harmonic active power flows through a transmission line equipped with series converters. According to the amount of required active power at the fundamental frequency, the DPFC series converters generate a voltage at the harmonic frequency, thereby absorbing the active power from harmonic components. Neglecting losses, the active power generated at the fundamental frequency is equal to the power absorbed at the harmonic frequency.

III. DPFC CONTROL

To control multiple converters, a DPFC has a three types of controllers: central control, shunt control and series control, as shown in Figure.

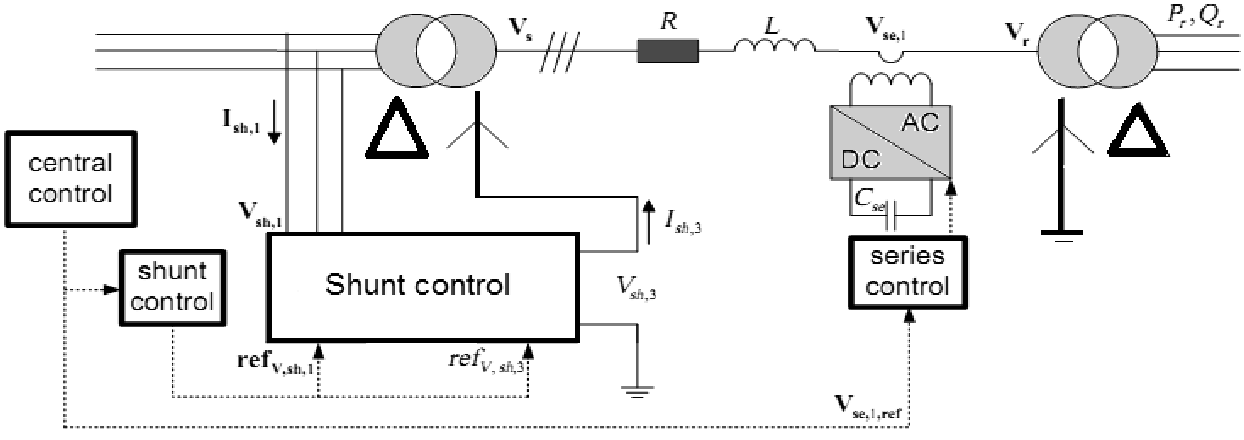

Fig 2. DPFC control block diagram

A. Central control of DPFC

This controller manages all the series and shunt controllers and sends reference signals to both of them.

B. Series control of DPFC

Each single-phase converter has its own series control through the line. The controller inputs are series capacitor voltages, line current, and series voltage reference in the dq frame.

Any series controller has a low-pass and a 3rd-pass filter to create fundamental and third harmonic current, respectively. Two single-phase phase lock loop (PLL) are used to take frequency and phase information from network. The PWM-Generator block manages Switching processes [4].

C. Shunt control of DPFC

The shunt converter includes a three-phase converter connected back-to-back to a single-phase converter. The three-phase converter absorbs active power from grid at fundamental frequency and controls the dc voltage of capacitor between this converter and single-phase one.

Other task of the shunt converter is to inject constant third-harmonic current into lines through the neutral cable of Δ-Y transformer[4].

VI. MODELLING AND SIMULATION OF DPFC

The whole model of system under study is shown in Fig. 5. The system contains a three-phase source connected to a three phase RLC load through transmission lines.

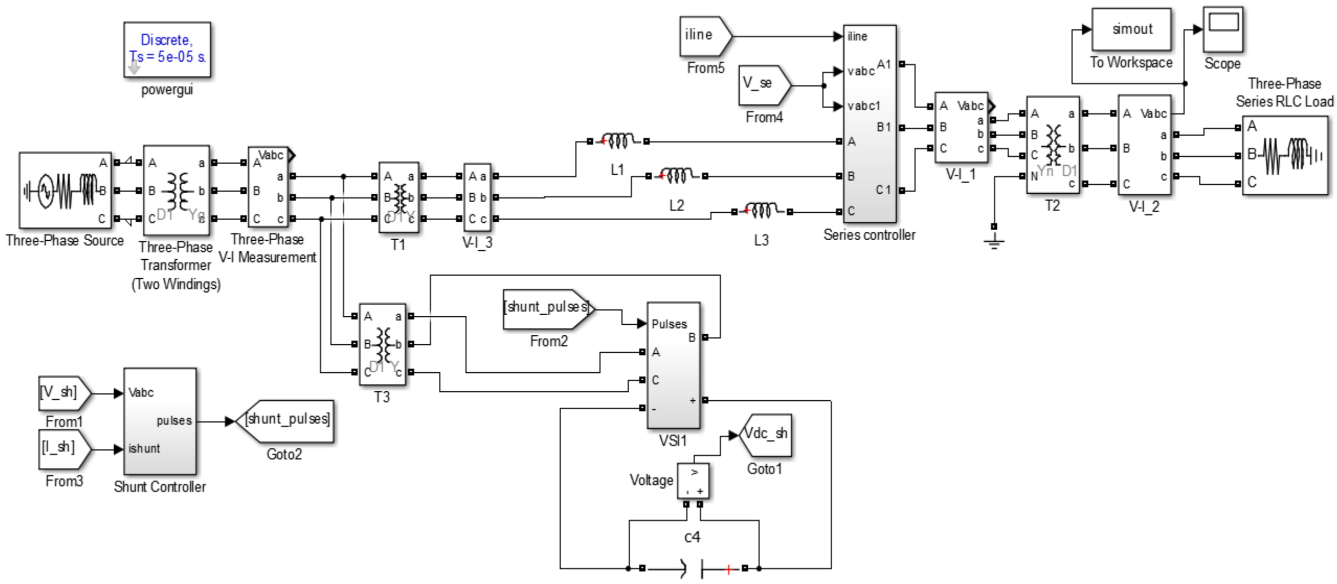

Fig. 5 Simulation of DPFC at Power System

Shunt Converter Subsystem: In a three Phase shunt converter dc-link capacitor, bank gives the voltage to system using PWM and VSI when the voltage deviation is occur.

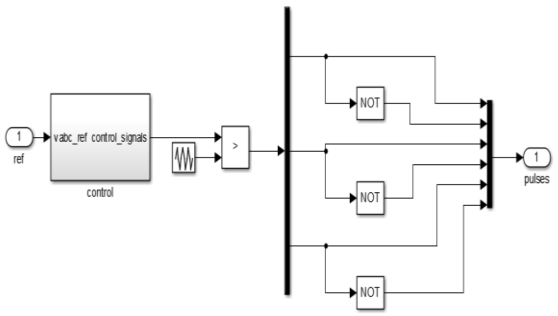

Fig 6 PWM of Shunt Converter

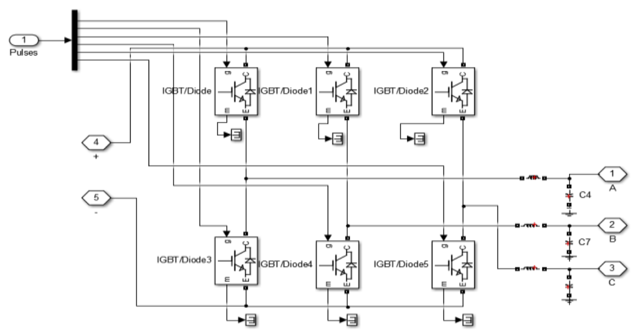

Fig 7 VSI of Shunt Converter

Series Converter Subsystem: In a three single Phase series converter, dc-link capacitor bank gives the voltage to system using PWM and VSI when the voltage deviation is occur.

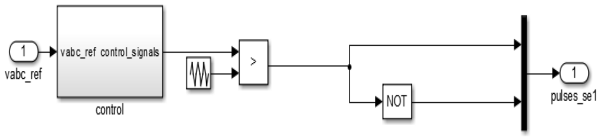

Fig 8 PWM of Single Phase series Converter

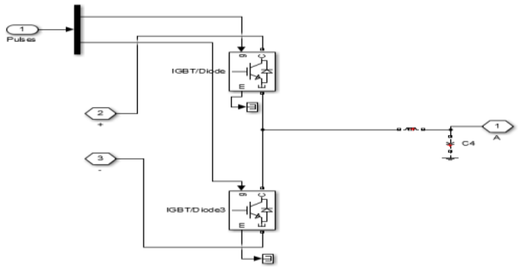

Fig 9 VSI of Single Phase series Converter

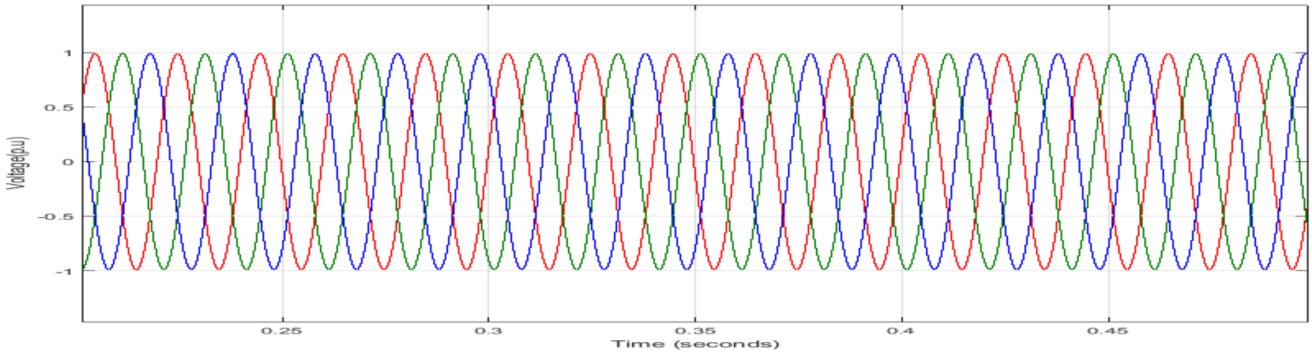

Fig. 10 Normal three phase voltage waveform of DPFC

Waveform of fig 10 shows that the modelling of series and shunt converter of DPFC is perfectly done.

V CONCLUSION

In the transmission system so many methods are there to improve power quality. But in this paper, mitigating the voltage sag and swell by using a new FACTS device called distributed power flow controller (DPFC) is presented.. The main advantages of DPFC compared with the UPFC are low cost, high control capability and high reliability. The DPFC has contains the modeled and three control loops, i.e., series control, central controller and shunt control are design..

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