THE COMPENSATATION OF UNBALANCED 3-PHASE CURRENTS IN TRANSMISSION SYSTEMS ON UTILIZE DISTRIBUTED POWER FLOW CONTROLLER

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Abstract

It is self-possessed of the Distributed Power Flow Controller is a new device within the family of FACTS. Power Quality is becoming an important issue for both electric utilities and end users. So the paper concentrate on one of the issue of power quality that is voltage sag compensation. My paper deals with the operation principle of a Practical Design and Implementation Procedure of Utilize Distributed Power Flow Controller (DPFC) to Compensate Unbalanced 3-phase Currents in Transmissions Systems. The series converters of the DPFC are single phase, the DPFC can compensate both active and reactive, zero and negative sequence unbalanced currents. To compensate the unbalance, two additional current controllers are supplemented to control the zero and negative sequence current respectively. FACTS devices can be employed to compensate the unbalanced currents and voltages in transmission systems. Unfortunately, it is found that the capability of most of FACTS devices to compensating unbalance is limited. Series and shunt FACTS device can only provide compensation of unbalanced reactive currents and the most powerful device – the UPFC cannot compensate zero-sequence unbalance current, because of the converter topology. My paper will show that the so-called DPFC can compensate both active and reactive, zero and negative sequence unbalanced currents. My paper consists of both active and reactive variations, using MATLAB/SIMULINK is simulated and its effects on the transmission lines observed. The simulated results are analyzed and validated with the real time results for the system considered

***Index Terms**: AC–DC power conversion, filters, load flow control, power electronics, power-transmission control, power semiconductor devices, Power system control V-I measurements*

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1. INTRODUCTION

It is aimed at obtaining the control is carried out by the Distributed Power Flow Controller (DPFC) recently presented is a powerful device within the family of FACTS devices, which provides much lower cost and higher reliability than conventional FACTS devices. It is derived from the UPFC and has the same capability of simultaneously adjusting all the parameters of the power system: line impedance, transmission angle, and bus voltage magnitude. Within the DPFC, the common dc link between the shunt and series converters is eliminated, which provides flexibility for independent placement of series and shunt converter. The DPFC uses the transmission line to exchange active power between converters at the 3rd harmonic frequency. Instead of one large three-phase converter, the DPFC employs multiple single-phase converters (D-FACTS concept) as the series compensator. This concept not only reduces the rating of the components but also provides a high reliability because of the redundancy. The UPFC is the combination of a static synchronous compensator (STATCOM) and a static synchronous series compensator (SSSC), which are coupled via a common dc link, to allow bidirectional flow of active power between the series output terminals of the SSSC and the shunt output terminals of the STATCOM

1.1 Distributed power flow controller

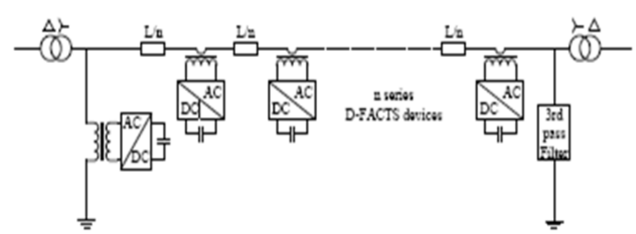


Fig.1. Representation of DPFC

Comparing with the UPFC, the DPFC have two major advantages:
1) Low cost because of the low-voltage isolation and the low component rating of the series Converter and

2) High reliability because of the redundancy of the series converters. [5]

1.2 Advantages of the DPFC over UPFC

The DPFC can be considered as a UPFC that employs the DFACTS concept and the concept of exchanging power through harmonic. Therefore, the DPFC inherits all the advantages of the UPFC and the DFACTS, which are as follows.

(i) High control capability
(ii) High reliability
(iii) Low cost

1.3 DPFC Operating Principle

The DPFC Operating Principle are as follows
(i). Active power exchange with eliminated DC link
The DPFC, 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 components. 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 = □□ □□ cos Ø --------------- (1)

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.[2]

(ii). Using third harmonic components
Due to the unique features of 3rd harmonic frequency components in a three-phase system, the 3rd harmonic is selected for active power exchange in the DPFC. In a three-phase system, the 3rd harmonic in each phase is identical, which means they are „zero-sequence" Components. Because the zero-sequence harmonic can be naturally blocked by star-delta transformers and these are widely incorporated in power systems (as a means of changing voltage), there is no extra filter required to prevent harmonic leakage.

2. DPFC CONTROL

To control multiple converters, a DPFC consists of three types of controllers: central control, shunt control and series control, the shunt and series control are localized controllers and are responsible for maintaining their own converters" parameters. The central control takes care of the DPFC functions at the power system level. The function of each controller is listed:

(i).Central control
The central control generates the reference signals for both the shunt and series converters of the DPFC. Its control function depends on the specifics 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.[4][3]

(ii) Series control
Each series converter has its own series control. The controller is used to maintain the capacitor DC voltage of its own converter, by using 3rd harmonic frequency components, in addition to generating series voltage at the fundamental frequency as required by the central control.

(iii) Shunt control
The objective of the shunt control is to inject a constant 3rd harmonic current into the line to supply active power for the series converters. At the same time, it maintains the capacitor DC voltage of the shunt converter at a constant value by absorbing active power from the grid at the fundamental frequency and injecting the required reactive current at the fundamental frequency into the grid.

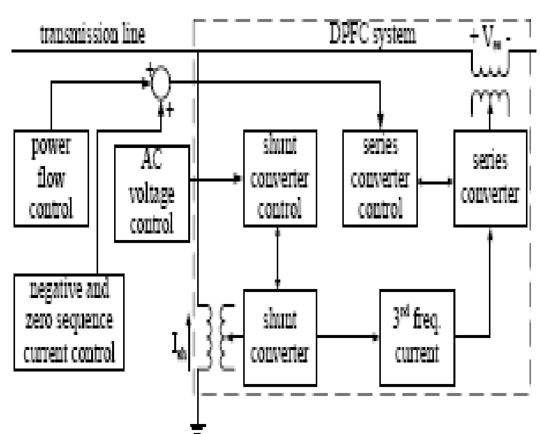


Fig2. Block diagram of the control of a DPFC

2.1. Sequence Network Analysis With The DPFC

In order to compensate the unbalance, the series converters of each phase generate different voltages, and require different active powers consequently. As the DPFC uses 3rd harmonic current to exchange active power between the shunt and series converters, this unbalance compensation will have an influence to the 3rd harmonic current. This section studies the behavior of a simple network with the DPFC under the unbalance situation, by using the method of symmetrical components Fig.3 shows the circuit configuration of the DPFC connected to a simple power system which consists of two power grids with symmetrical voltage vs ,vr and a tie-line. The shunt converter of the DPFC is a back-to-back converter, which absorbs active power from the low voltage side and injects 3rd harmonic current through the neutral point of the Y-Δ transformer. The multiple series converters are represented by three single-phase converters for each phase. An unbalanced voltage vu is added at the grid s.

To simplify the analysis, it is assumed that vu contains the negative and zero sequence component, and v+ u = 0. Without the unbalance compensation, the current through the line can be represented in sequence components:

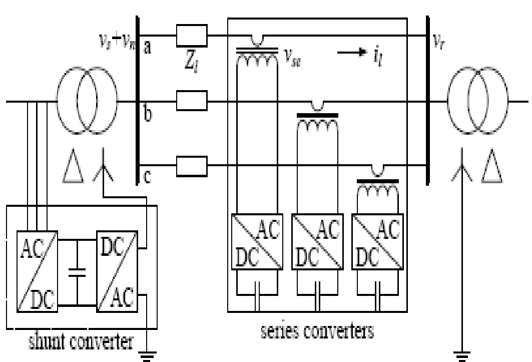


Fig.3. Circuit configuration of the DPFC connected to a simple power system

The 3rd harmonic current is zero sequence components and blocked by the Y-Δ transformers. However, during the unbalance compensation, unsymmetrical active power is required by the series converters, which causes positive and negative sequence current at 3rd harmonic. Since the positive and negative 3rd harmonic current cannot be blocked by the transformers, it is important to find out whether there magnitudes are acceptable for the network from the viewpoint of power quality.[1]

The equivalent network of the DPFC at the 3rd harmonic can be represented as Fig.4. To reduce the magnitude of the 3rd harmonic current through the line, the series converter will not generate any reactive power at the 3rd frequency. Therefore the series converters can be considered as resistances [Ra Rb Rc] at the 3rd frequency, the power consumed by the resistors are [Pse,3]. The shunt converter is controlled

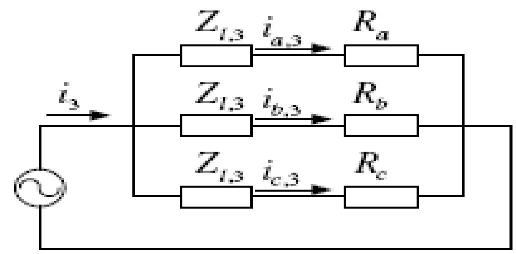


Fig4: The equivalent network of the DPFC at the 3rd harmonic

The solutions for the 3rd harmonic current[ia,3 ib,3 ic,3]. However, by applying a some typical DPFC parameters and solving the equations numerically, it is found that the nonzero sequence 3rd current [ia,3 ib,3 ic,3]+− is less than 10% of nominal line current, typically around 4%.

Table -1: For Voltage, Real and reactive power at different buses without DPFC and With DPFC

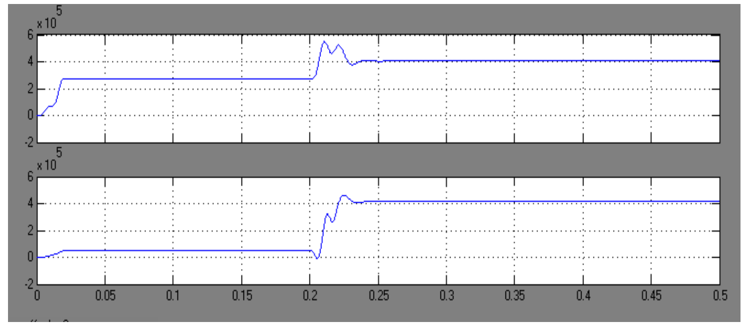
Bus no	P (MW) without DPFC	P (MW) with DPFC	Q (MVAR) without DPFC	Q (MVAR) with DPFC	VOLTAGE (V) without DPFC(RMS)	VOLTAGE (V) with DPFC(RMS)
11	0.418	0.421	0.131	0.132	6783	6798
13	0.338	0.340	1.065	1.067	6069	6075
19	0.341	0.346	0.134	0.136	6868	6876
21	0.286	0.304	0.0934	0.0991	6295	6479
25	0.390	0.394	1.229	1.238	6520	6545
26	0.273	0.283	0.857	0.889	5448	5548

Table -2: Q(MVAR) at buses without DPFC

INJECTED VOLTAGE (KV)	BUS 11 Q(MVAR)	BUS 13 Q(MVAR)	BUS 19 Q(MVAR)	BUS 21 Q(MVAR)	BUS 25 Q(MVAR)	BUS 26 Q(MVAR)
11	0.131	1.065	0.134	0.0934	1.229	0.857
22	0.293	1.67	0.234	0.1729	2.835	1.662
33	0.517	2.418	0.361	0.867	5.08	2.67

Table -3: Voltage injected by DPFC at different buses

INJECTED VOLTAGE (KV)	BUS 11 voltage	BUS 13 voltage	BUS 19 voltage	BUS 21 voltage	BUS 25 voltage	BUS 26 voltage
11	6790	6075	6876	6479	6545	5548
22	10120	7611	9084	8555	9904	7583
33	13450	9147	11290	12650	13260	9617



Graph.2. Real and Reactive Power(Without DPFC)

3. SIMULATION MODEL FOR DPFC USING MATLAB SIMULAB

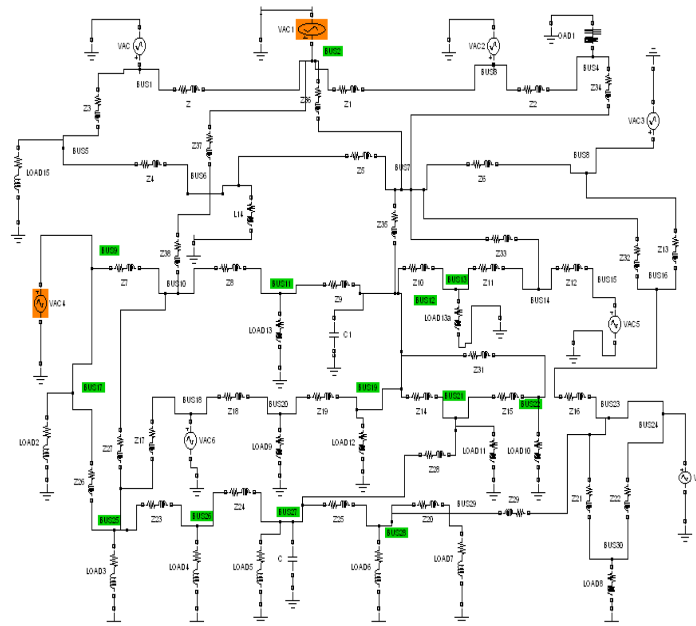


Fig.5 IEEE 30 BUS SYSTEMS WITHOUT DPFC

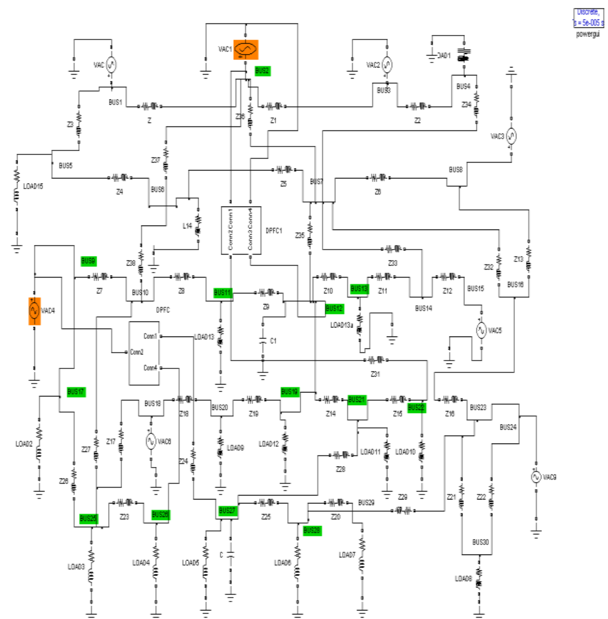
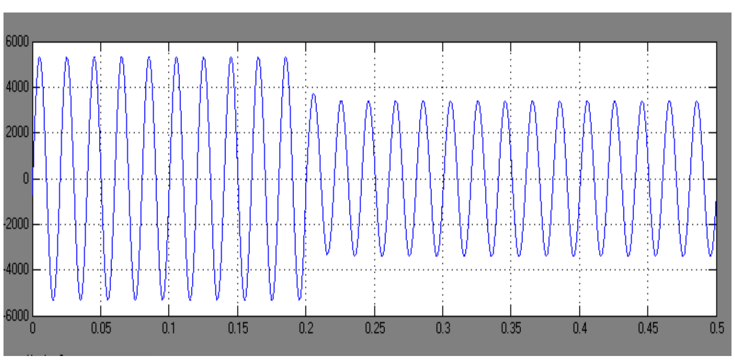
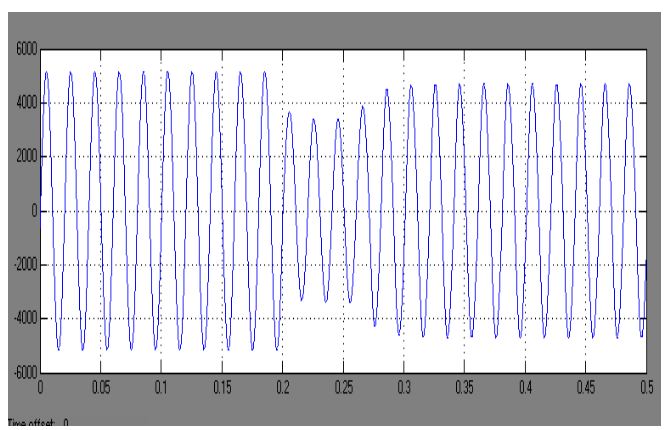


Fig.6. IEEE 30 BUS SYSTEMS WITH DPFC



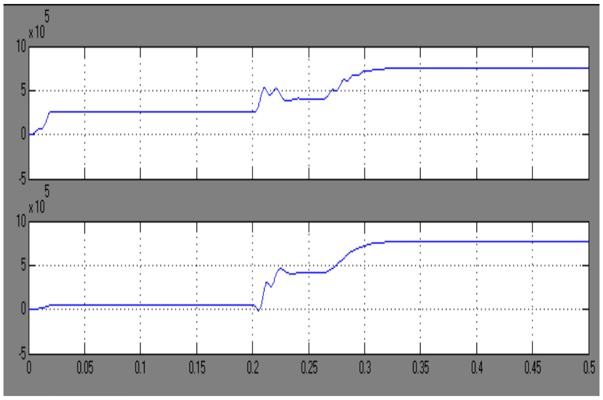
Load on

Graph.1.Voltage Across The Load Side(Without DPFC)



Load on DPFC on

Graph.3. Voltage Across The Load Side(With DPFC)



Graph.4. Real and Reactive Power(With DPFC)

CONCLUSIONS

This paper investigates the capability of the DPFC to balance a network. The Statcom and DVR are separately simulated using the blocks of simulink. DPFC is modeled and successfully simulated. The DPFC is capable of mitigating the sag. The pros of DPFC are the elimination of DC wires between the sending end and receiving end. The simulation results are in line with the theoretical results. Some of the challanges faced in my work are,1.While developing the hardware for three converters ,2. Three driver circuits are require ,3. Frequency is not corrected, only voltage is corrected. Scope for future work, i) 64 bus system can be simulated with multiple FACTS controllers, ii) simulation can also be done with PSCAD or PSIM, iii) lab model for hardware can be done using DSP processor, iv) Closed loop can be done using neutral network or fuzzy controller.

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