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Simulation of Distributed Power Flow Controller for Voltage Sag Compensation

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Abstract

In this paper, we introduced a new series-shunt type FACTS controller called as distributed power flow controller to improve and maintain the power quality of an electrical power system. This DPFC method is same as the UPFC used to compensate the voltage sag and the current swell these are voltage based power quality problems. As compared to UPFC the common dc link capacitor is removed and three individual single phase converters are used instead of a three phase series converter. Series referral voltages, branch currents are used in this paper for designing control circuit. The evaluated values are obtained by using MATLAB/SIMULINK.

Keywords: DPFC, Power Quality, Voltage Sag, Voltage Swell

1. Introduction

Load is increasing in present days so proportionally power quality issues are also increasing. Main Power Quality issues are voltage sags/swells and interruptions[1].

Because of these voltage distortions devices may fail or shut down or else a Large current unbalance is happened that could trip breakers or blow fuses. Some sort of compensation is necessary to meet PQ standard limits[2]. In order to maintain active power filtering and rectification a new concept called shunt active power filter is suitable and also it helps for reduction of negative load influence on the supply. But for filtering the supply voltage imperfections a series active power filter is proposed.

When compared to many other methods to compensate voltage sags and swells, using a custom Power device is the most efficient method. Energizing a large capacitor bank, Switching off a large inductive load is a typical system event that causes swells. So a new method is implemented in this paper i.e. DPFC[3].

2. Working Principle of DPFC

A little change in DPFC that compared to UPFC is dc link capacitor is removed.

Like unified power flow controller, the distributed power flow controller is also a combination of series and shunt controllers. Unlike UPFC, in DPFC the series converter is spitted into three individual single phase series converters as shown in Figure 1[4]. The controlling capacity of the UPFC is back-to-back connection of series and the shunt converters with a DC link, which is used for exchanging the power. In this distributed power flow controller the common dc-link capacitor is eliminated. So, in distributed power flow controller the active power is starts exchanged through the transmission line[5].

2.1 Better Qualities of DPFC

The Distributed Power Flow Controller is better than previous devices because of these[6]

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2.1.1 High Controlling Reliability

The distributed power flow controller controls the transmission line parameters such as impedance of the line, load angle and voltage deviations.

2.1.2 More Efficiency

DPFC is having three series converters which are connected in series so any one of the series converters is fails to work, the total work could not be stopped.

2.1.3 Economically Reliable

2.2 Control Circuit for DPFC

As per the control diagram of DPFC which is shown in Figure 2 it is clear that the DPFC is as it divided in to

- Central controller,
- Series controller and
- Shunt controller[7].

2.2.1 Main Controller for DPFC

For controlling series and shunt controllers all the reference signals are generating in this central controller.

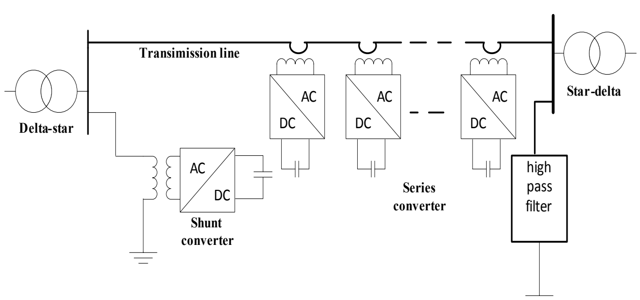

Figure 1. Schematic diagram for DPFC.

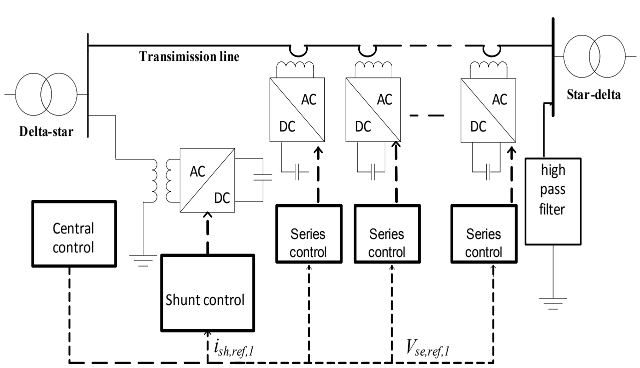

Figure 2. Closed loop control diagram of DPFC.

2.2.2 Series Controller

By maintaining the capacitor voltage to a rated value series controller controls the voltage issues. Capacitor voltages in both quadrature and direct frame generates the reference signals generated and that reference signals are used to operation of this controller. Basically, natural and 3rd order harmonic currents in these series controllers[8] are created by first order low pass and third order band pass filters. Figure 3 shows the control structure of series controller.

2.2.3 Parallel Controller

Figure 4 shows the control diagram of shunt converter. For generating suitable active power to DVR converter a 3rd order harmonic current[9] is inserting into the transmission line it is the basic theme to use this control. The static converter is basically a3ϕ converter and it is connected back to back with another 1ϕ converter.

2.3 Fuzzy Logic Controller

Fuzzy control system is a mathematical system and it completely depends on fuzzy logic. Fuzzy controllers

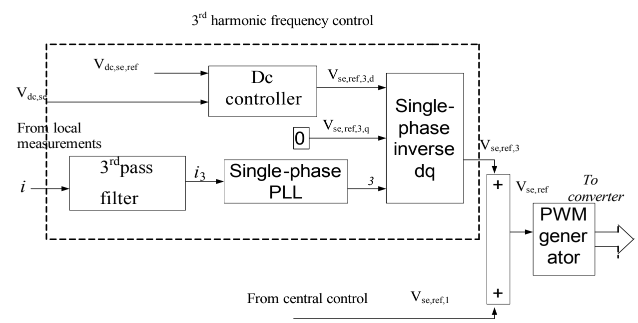

Figure 3. PFC series control structure.

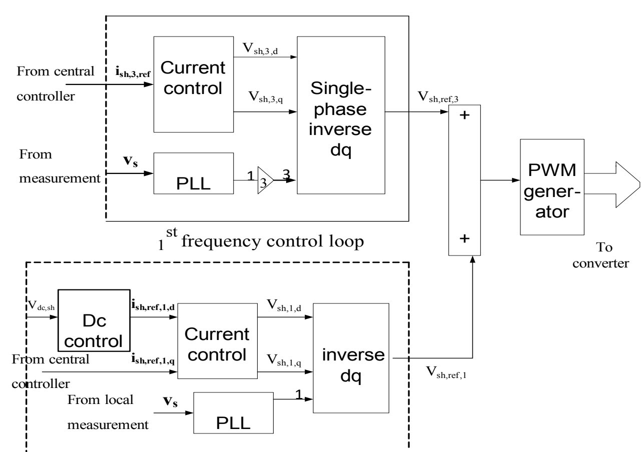

Figure 4. DPFC shunt control structure.

which are directly use the fuzzy rules. Fuzzy rules are conditional statements, gives the relationship among all fuzzy variables[10]. The logic involved in the fuzzy controller can deal with concepts that cannot be expressed as true or false. In below Figure 5 basic diagram for fuzzy Logic Controller is shown.

For two area system in Load Frequency control fuzzy Logic Controller is used, variable Fuzzy rules used for analysis.

2.4 Experimental Verification

In this experiment we are creating a condition that a system is having voltage sag by connecting a three phase fault to the system and observation analysis is shown below. The experimental diagram is implemented by basic diagram which is shown in Figure 6.

Simulation diagram for this system with DPFC is shown in the Figure 7. The fault occurring time in this system is 500ms to 1500ms. When fault occurred in the system then sag will appear in output voltage shown in Figure 8. The magnitude of voltage is reduced by 0.65 percent of its nominal value during this fault time.

Figure 8 shows the simulation result of three phase output voltage. In this system the fault occurs from 0.05 sec to 0.15 sec. During this period there is sag occurs in load voltage with difference magnitude of 0.8%.

During this period of fault the load current raises its magnitude around 1.2% per unit as shown in Figure 9.

The voltage sag and current swell obtained by fault condition between time 0.5 sec to 1.5 sec is compensated using Distributed Power Flow Controller. The compensated voltage and current waveforms for the system is as shown in Figure 10 and Figure 11.

Figure 12 shows the simulation results of active and reactive power variation with variations in fault condition timings.

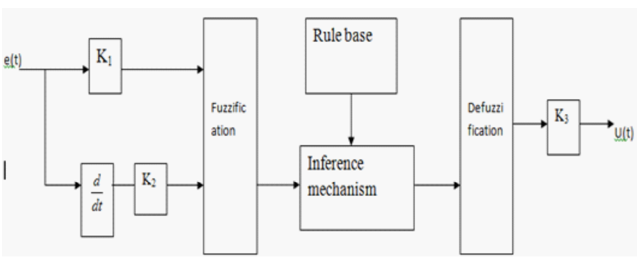

Figure 5. Structure of fuzzy inference system.

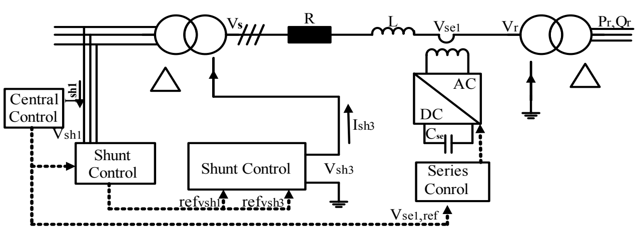

Figure 6. DPFC control structure.

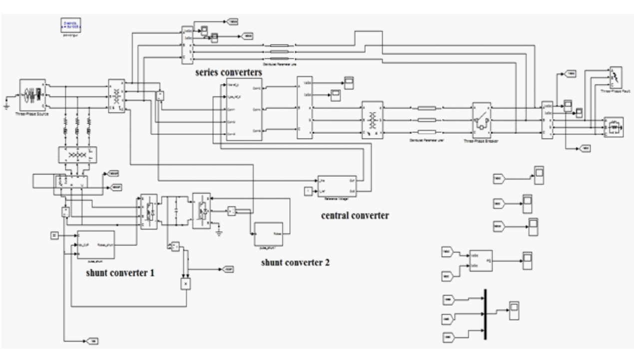

Figure 7. Simulink diagram for system with DPFC.

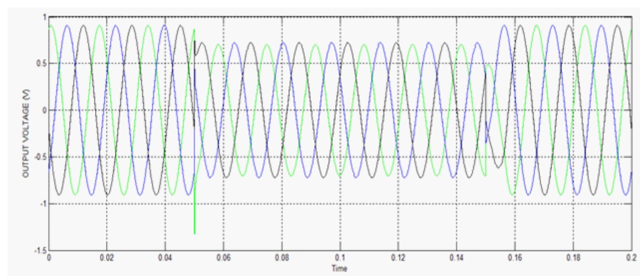

Figure 8. Output voltage during fault condition.

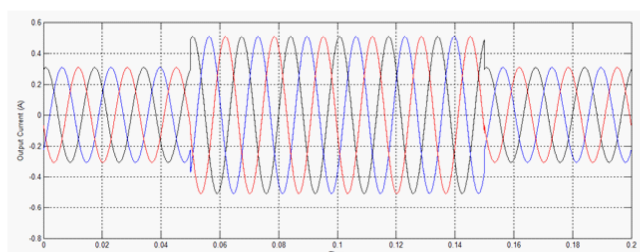

Figure 9. Output current during fault condition.

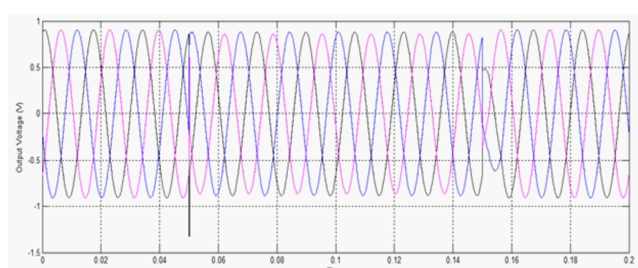

Figure 10. Output voltage compensated by DPFC controller.

A system which is having 12.36% of THD value is shown Figure 13 and it is decreased by using DPFC controller.

THD value for that system using DPFC controller based on PI controller is reduced to 3.88% and it is shown in Figure 14.

Now instead of PI controller, fuzzy controller is used then the THD value is reduced to 3.65% it is shown in Figure 15.

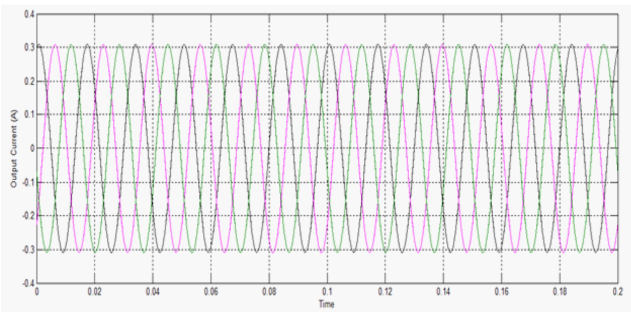

Figure 11. Compensated output current by DPFC controller.

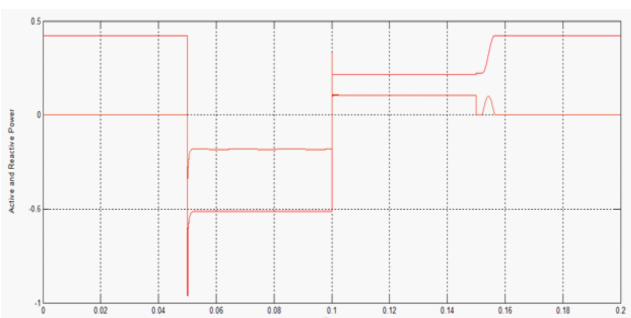

Figure 12. Active and reactive power.

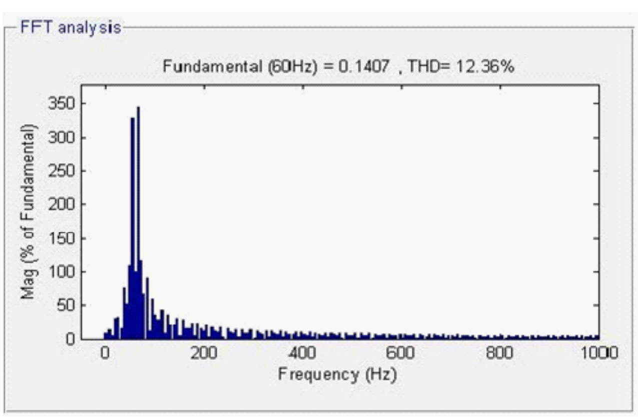

Figure 13. THD value of system output voltage without DPFC.

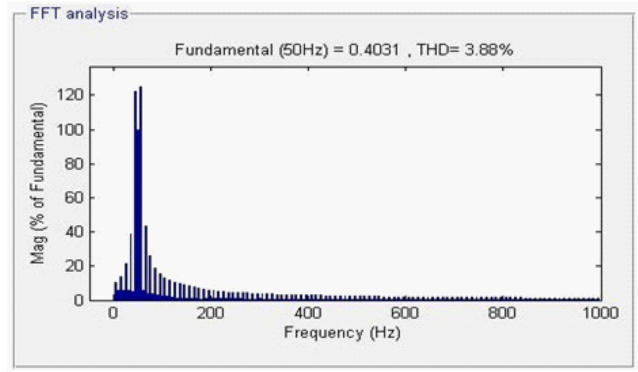

Figure 14. THD value of DPFC (pi controller) load voltage.

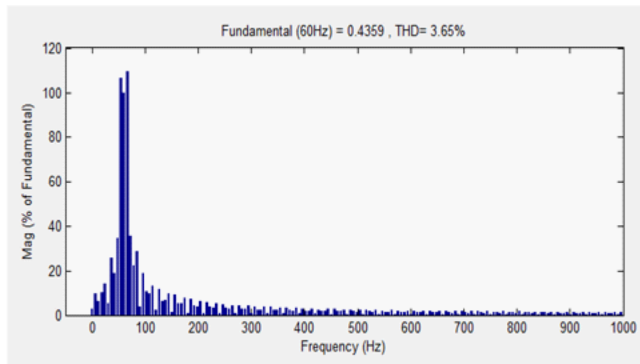

Figure 15. THD value of fuzzy controller output voltage.

3. Conclusion

In this paper we implemented a concept to controlling the power quality issues i.e DPFC. The proposed theory of this device is mathematical formulation and analysis of voltage dips and their mitigations for a three phase source with linear load. In this paper we also proposed a concept of fuzzy logic controller for better controlling action. As compared to all other facts devices the DPFC based Fuzzy has effectively control all power quality problems and with this technique we get the THD as 3.65% and finally the simulation results are shown above.

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