UPFC AND DPFC COMPARISON STUDY FOR LOW HARMONIC DISTORTION USING MATLAB

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Abstract
The complete automation of the power transmission and distribution system as well as the automatic control of commercial and residential loads are both results of technological advancements in power electronic components and circuits, which in turn results in an increase in nonlinear load currents drawn from the supply system. These nonlinear currents can lead to additional heating losses, low power factor, low efficiency, greater temperature, etc. To lower the overall harmonic distortion in the transmission system close to load locations, a novel D-FACTS device is suggested. Also, a comparison with the current FACTS device and UPFC will be done.

Keywords: Non linear loads, total harmonic distortion, UPFC, DPFC.

1. INTRODUCTION

The examination of harmonics present in the power system's currents and voltages is the focus of today's power system engineers. This is because for a typical industry, non-linear loads represent a steadily growing portion of the overall load. Because to the rising percentage of non-linear demand, utilities have set harsher limitations and IEEE Std. 519 has been updated with more restrictive requirements. To improve the dependability of the electrical supply, harmonic concerns must be made more widely known.

The effects of these harmonics include distortions in voltage, current, increased power losses, thermal stress, etc. The time varying impedance characteristics of diodes, silicon controlled rectifiers, thyristors, PWM systems, and induction and arc furnaces for various applications, mainly causes the distortions in voltage waveforms.

The spikes at constant intervals as multiples of the fundamental frequency are known as Harmonics. If 50 Hz is the fundamental frequency, then the 3rd harmonic is five times that frequency 50, i.e. 150 Hz. Likewise, the 5th harmonic is five times the fundamental, i.e. 250 Hz, and so on. Harmonics can be discussed in terms of current or voltage.

The amount of harmonics present in the original wave can be determined by the formula of Total Harmonic Distortion (THD). The following is the formula for calculating the THD for voltage:

$$V_{THD} = \sqrt{\frac{\sum_1^n V_n^2}{V_1}}$$

Where n represents the harmonic order

V_1 is the voltage with fundamental frequency

There are several methods available to reduce this harmonics which includes passive filter design, shunt compensators, UPFC etc. Here in this paper first an UPFC is modeled in MATLAB/SIMULINK for reducing total harmonic distortion. A new D-FACTS based device, Distributed Power Flow Controller is then proposed for the reduction of total harmonic distortion and its output being compared with the results of UPFC.

MATLAB/SIMULINK model of a 4 bus system shown in figure 1 is modeled first, and its behavior without any controller is observed under the events of Voltage Sag and Voltage Swell.

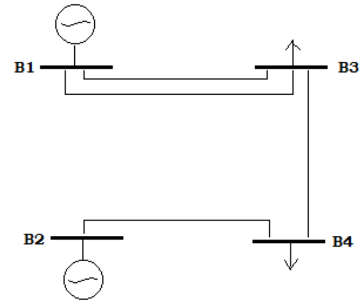

Figure 1: Proposed 4 Bus Transmission System

2. UNIFIED POWER FLOW CONTROLLER

FACTS-devices provide a better adaptation to varying operational conditions and improve the usage of existing installations. Worldwide for various applications FACTS-devices have been introduced. One of such application is mitigation of power quality disturbance, mainly harmonic distortion.

An UPFC is a static device which controls the voltage, current, real power and reactive power simultaneously. It consists of a shunt converter and series converter connected through a DC link. It acts simultaneously as a phase shifting and a shunt compensating device.

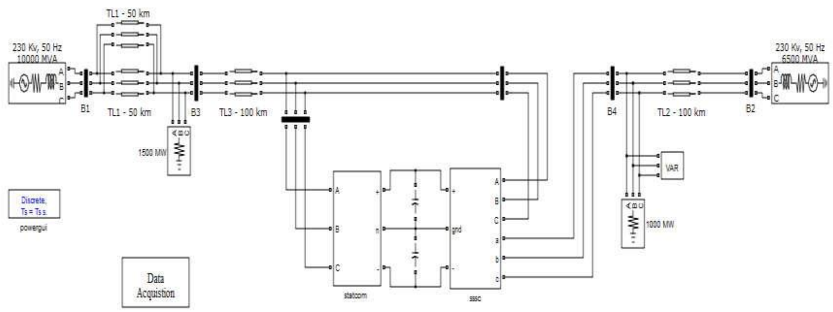

Figure 2: UPFC connected to the load bus of the transmission system for reducing THD

Harmonic analysis is done with the modeled UPFC for the four bus system in the process of mitigation of Voltage Sag and Swell using FFT analysis. And it is observed that higher order harmonics present in the output were more. Also the coordinated controlling of shunt and series converter is typical to model. Also it is observed from the literature survey that the common DC link used in the UPFC increasing its cost. Hence a new controller is proposed in this paper namely DPFC.

3. DISTRIBUTED POWER FLOW CONTROLLER

The common DC link between shunt and series converter has been removed to obtain flexible control of the converter. Also the concept of D-FACTS is introduced in the design of series compensation. To improve the reliability instead of using one single series converter multiple series converters have been used for the series compensation as the length of transmission line is considerably long it is better to use more series compensators of low rating in order to improve the reliability.

The proposed DPFC consists of STATCOM as a shunt controller and SSSC as Series controller. Active power exchange between the shunt and series controllers has been done through the common connection of the AC terminals, which is the transmission line.

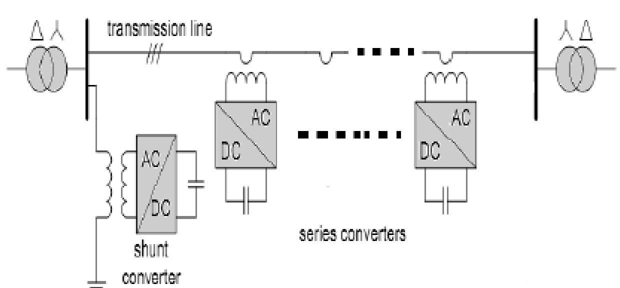

Figure 3: Structure of DPFC

A conventional PI control logic is developed for the operation of the shunt and series controllers of the proposed DPFC.

A MATLAB/SIMULINK model is developed with the new controlling device. Harmonic analysis is carried out with this new controller in the process of mitigation of Voltage Sag and Swell. The results of both were tabulated and compared.

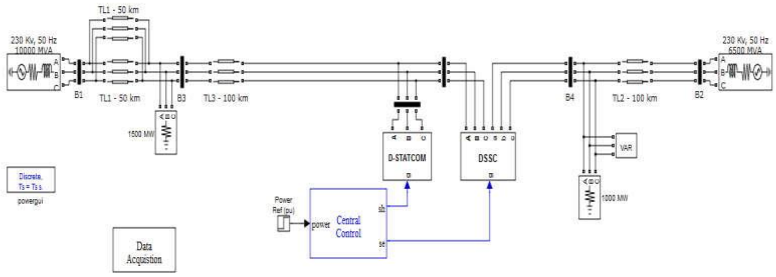

Figure 4: DPFC connected to the load bus of the transmission system for reducing THD

4. Simulation Results

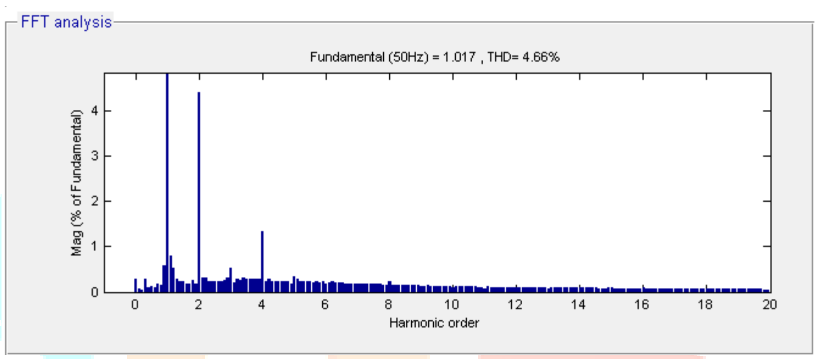

Figure 5: THD resulted during mitigation of Voltage Swell with UPFC

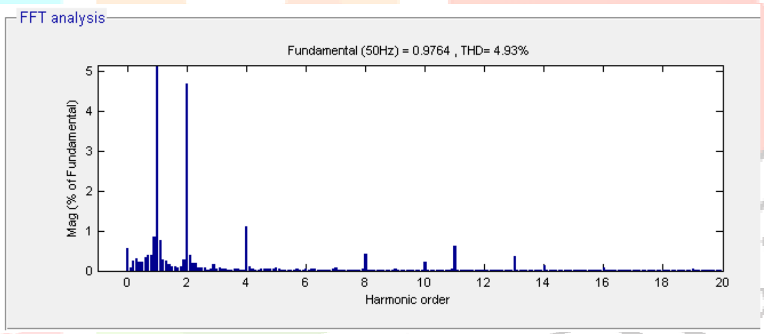

Figure 6: THD resulted during mitigation of Voltage Sag with UPFC

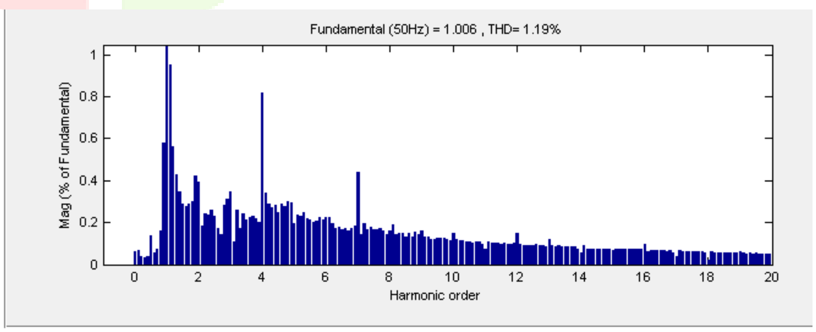

Figure 7: THD resulted during mitigation of Voltage Swell with DPFC

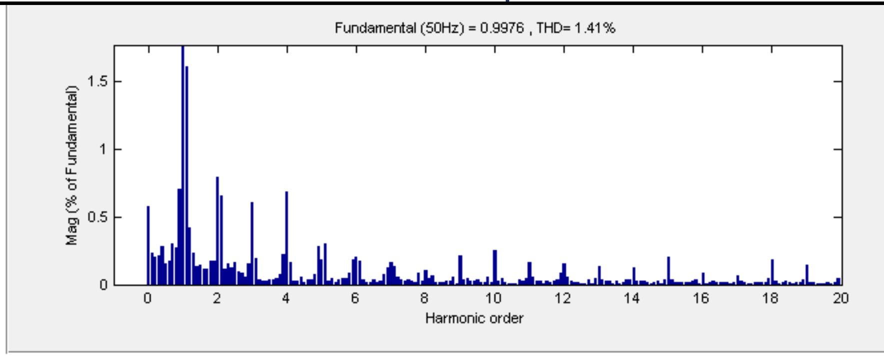

Figure 8: THD resulted during mitigation of Voltage Sag with DPFC

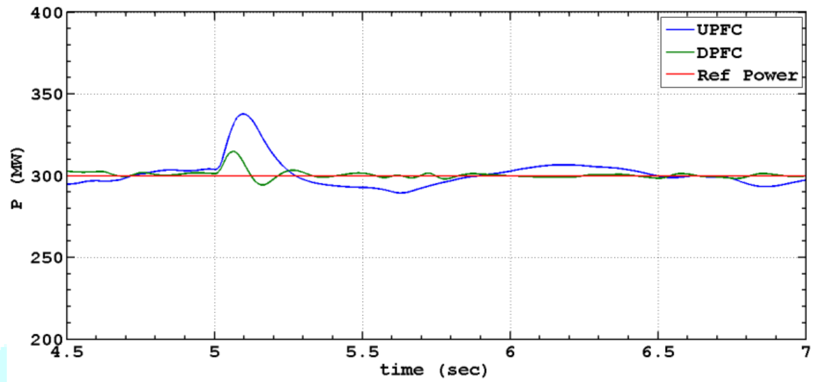

Figure 9: Control of power during mitigation of Voltage Swell

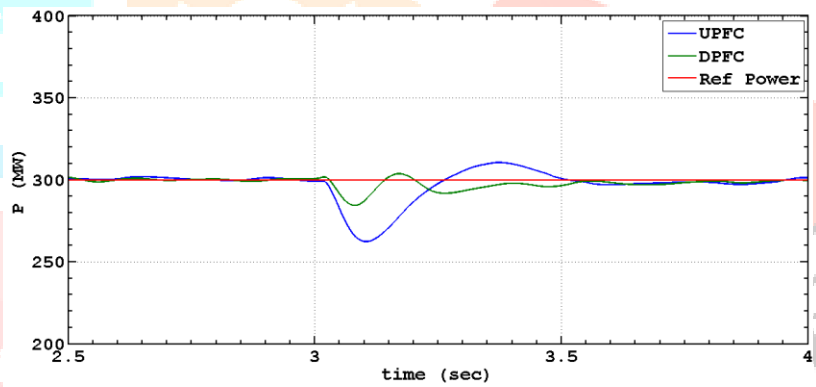

Figure 10: Control of power during mitigation of Voltage Sag

Conclusion

The decrease of total harmonic distortion utilizing the two controllers, UPFC and DPFC, is compared in this research. From the simulation findings, it can be seen that using DPFC instead of UPFC significantly reduces THD. Both the Voltage Sag and Voltage Swell mitigation techniques have a sizably high decrease. Additionally it is noted that DPFC is leading in quick convergence in the mitigation procedure.

References

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