Journal of Next Generation Technology (JNxtGenTech)
Vol. 1, Issue 1, June 2021

# The Effect of DPFC on Power Quality Improvement Using Hysteresis Band Pulse Width Modulation

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*Article Received: 1 Jan 2021* *Article Accepted: 14 May 2021* *Article Published: 29 Jun 2021*

Citation
Veeramuthulingam, N.,Rajan, V.R.(2021), The effect of DPFC on Power Quality Improvement Using Hysteresis Band Pulse width Modulation. Journal of Next Generation Technology, 1(1), 29-36.

## Abstract

Hysteresis Band pulse width modulation (HB-PWM), this research provides a DPFC for increasing quality of power. The primary goal of in this study is to advanced a power flow control system that has low cost and the capacity as same in the UPFC controller but at higher reliability. The UPFC Controller is resultant model from the DPFC Controller, and the DPFC Controller has the same control ability as the UPFC Controller formation. The UPFC Controller formation is used to mitigate a power quality issue like voltage sag, swell. The series converters connect to many single-phase converters side finished line in the peculiar UPFC, the typical dc-link in DPFC Controller. The HB-PWM performance is proposed, which detects voltage sags and adjusts voltage of three single-phase reference DPFC. This paper suggested the structure is demonstrated by simulating the application of a DPFC controller in improving power quality in a Mat Lab environment.

***Keywords: DPFC, HB-PWM, Power quality***

## I. Introduction

The power system has become a particularly demanding subject in recent years due to increased load demand for power and the development of power system. There is a respectful commitment to keep power flowing in transmission lines while maintaining authenticity and speed [1]. The governance of power flow in the transmission system is handled by all flexible ac transmission devices. UPFC Controller is a FACTS system power flow controller that can manage transmission angle, bus voltage and line impedance [2]. For a bidirectional power flow system, the UPFC Controller is employed, which has both a converter like shunt and a series with a common DC link. Between the transmission line and the series converter, this converter series side injects voltage into the bus, causing by injection and absorption of real and reactive power. The current and voltage ratings of the devices utilised in Controller.

The DPFC Controller, which is derived from the UPFC, is one of the FACTS family's most significant devices. The DPFC Controller, like the UPFC Controller, has the ability to control all of the limits inside the transmission bus network. The DC link between series and shunt, which is usually connected, is removed in the case of a DPFC Controller, and the DFACTS[3] theory is applied to the series converter depicted in Figure (a). The third order harmonic frequency of the real energy shift between the both converter like shunt and series converters. The Distributed FACTS concepts not only lower the ratings, but they also improve the system's authenticity and lower the cost of high voltage isolation.
The following is the layout of the paper: The DPFC working principle is described in zone II. Zone III proposes a DPFC control discipline constructed on a hysteresis band pulse width modulation

method. In zone IV, the effect of the Distributed Power Flow Controller on power quality enrichment is examined. Certainly, the simulation findings are evaluated in the final section of this paper.

## II. Structure of the DPFC

The elimination of DC-links and the use of 3rd-current harmonic to active power exchange are the fundamental problems in the DPFC principle. The operating principle of the DPFC is presented in the following subsections.

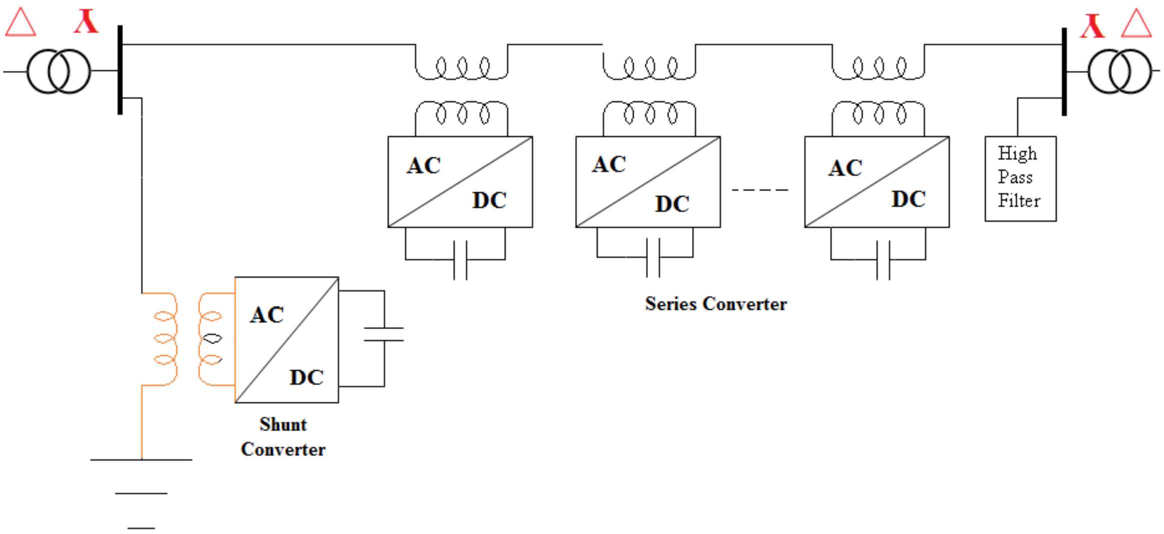

Figure 1. shows the structure of a DPFC.

### A. DC-Link Elimination and Power Exchange

Rather than using DC-link for power switching between converters, output and AC port of shunt and series converters in the DPFC connect transmission line. The power swaps notion in DPFC is based on the power concept of a non-sin component [9]. The sum of sin components at various frequencies can be used to calculate non-sinusoidal component like voltage and current. It is the most significant outcome of Fourier analysis. The active power is generated by the product of the current and voltage mechanisms. The active power equation is as follows: Since the integral of some terms with different frequencies is active power and zero, equation is as follows:

$$P = \sum_{i=1}^{\infty} V_i I_i \cos \varphi_i$$

The current and voltage harmonic frequency, respectively, are Ii and Vi, and at the same frequency, the angle formed by the foundation component of voltage and current. As seen in Equation 1, the active powers at various frequencies are varied. As a result, the converter can exercise active power while producing power at a different frequency. If the DPFC is used in a system with two bus transmission lines; as a result, the power supply delivers true power and the shunt converter consumes current at an elementary frequency. The Y-transformer is currently stuck at the third order harmonic component.

The third order harmonic current is inserted into the -Y transformer's neutral via the output terminal of the shunt converter. As a result, the harmonic current is increased in transmission line. This harmonic current regulates the voltage of series capacitors. In the DPFC, active power is transported between the two converter like shunt and series converters, as shown in Figure 2.

### B. The Merits of the DPFC

In comparison to the UPFC, the DPFC has a few merits: 1) High control capacity, The DPFC Controller can coordinate all of the transmission network's line impedance, bus magnitude voltage and parameters angle. 2) High reliability Series converter redundancy improves DPFC authenticity throughout converter operation [10]. One of the series converters fails, the other will continue to function. 3) It is a low-cost option. Single-phase converters have a very low rating when compared to three-phase converters.

Furthermore, there is no requirement to link in line with the series converters in this composition due to any voltage isolation. Series converters can be suspended using single-turn transformers. A case study of using DPFC to reinstate UPFC of the KEPCO is explored to determine the applicability of the DPFC. To attain the control capabilities as the UPFC, the DPFC structure employs less material using same type of controller [9].

## III. HB Pulse Width Modulation method for DPFC Control

As shown in Figure 3, the DPFC Controller has three regulator categories: shunt, central and series control.
A: Central Control: This controller is in charge of all of the controllers, as well as the reference signals that are sent to both shunt and series converter.
B: Series Control: The line's single-phase converters each have their own series control. The controller inputs are the capacitor voltages, series voltage, and dq line current reference. A filter are incorporated in every series controller to accurately represent fundamental and third harmonic current. To catch frequency and phase data from the network, two single-phase phase lock loops (PLLs) are worn [11]. Figure 4
C: illustrates a series controller's imagined schematic. Controlling Shunts: A three-phase converter is coupled with a single-phase converter in a shunt converter.

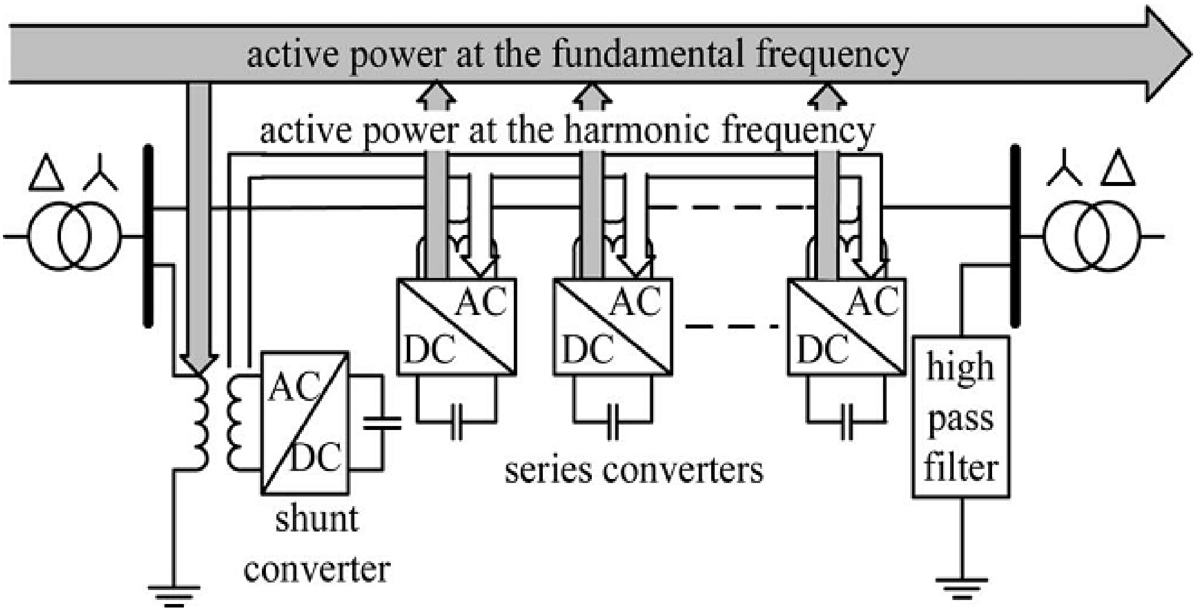

Fig. 2. Power exchange between converters (DPFC).

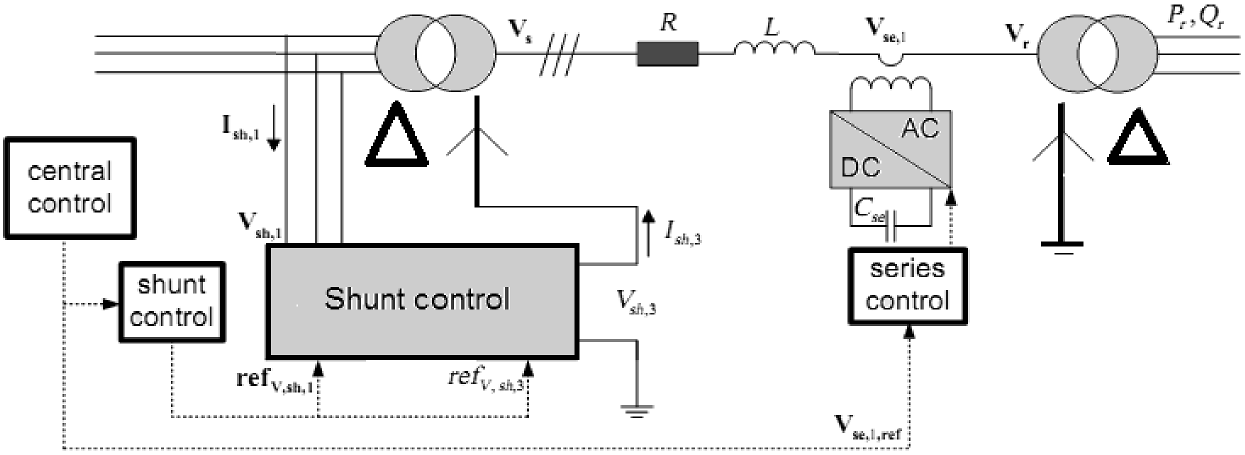

Figure 3: DPFC structure.

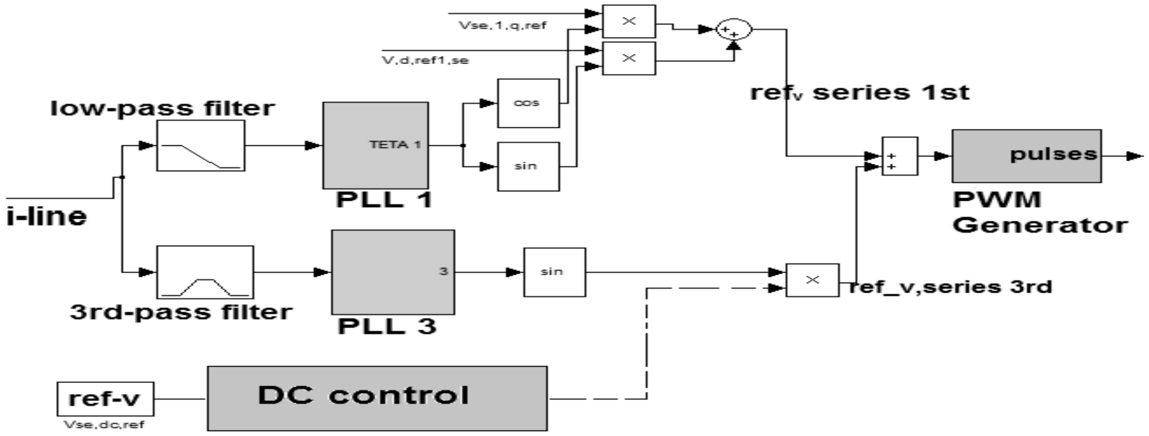

Figure 4: control structure with Series

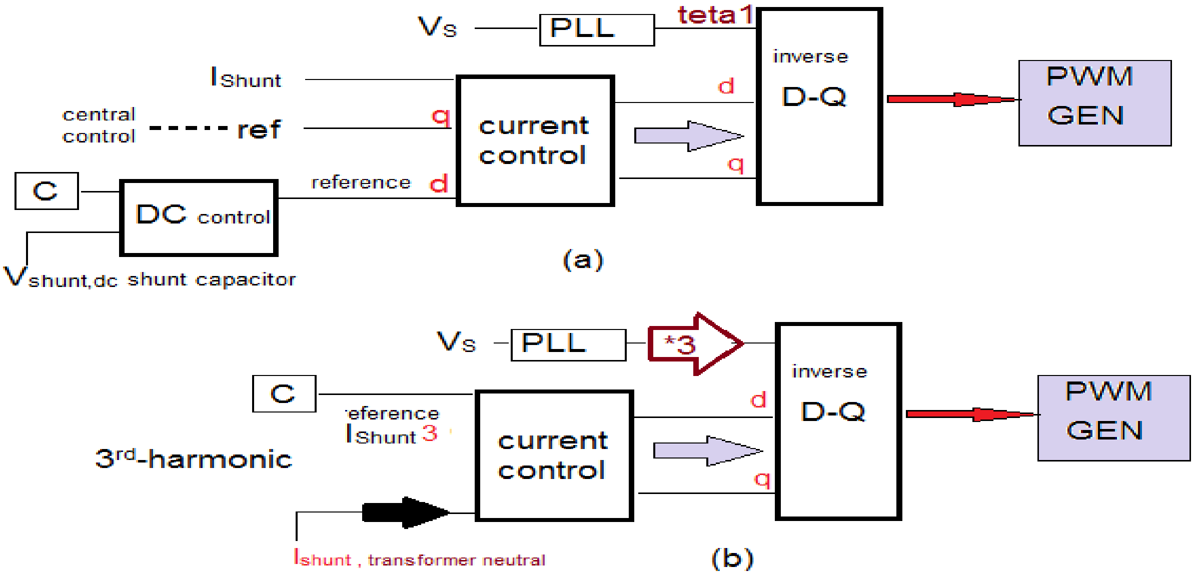

Figure :5 (a) frequency shunt control (b) third-harmonic shunt control

By drawing actual electricity at fundamental frequency from the grid, the three-phase converter adjusts the capacitor's dc voltage between it and the single-phase converter. Figure 5 shows a block diagram of the shunt control structure.

### D. Proposed Determination and Detection Techniques

The HB Pulse Width Modulation methodology is presented as an identify and resolve tool to classify voltage sags and regulate voltages of the DPFC. In the pre-sag state, the grid's line-to-neutral voltages are

$$V_{dpfc,d}^{ref} = V_{grid,d}^{ref} - V_{grid,d} \rightarrow (2)$$

$$V_{dpfc,q}^{ref} = V_{grid,q}^{ref} - V_{grid,q} \rightarrow (3)$$

Where $V_{dpfc,d}^{ref}$ and $V_{dpfc,q}^{ref}$ are the reference component of DPFC desired interject voltages in the HPWM, appropriately

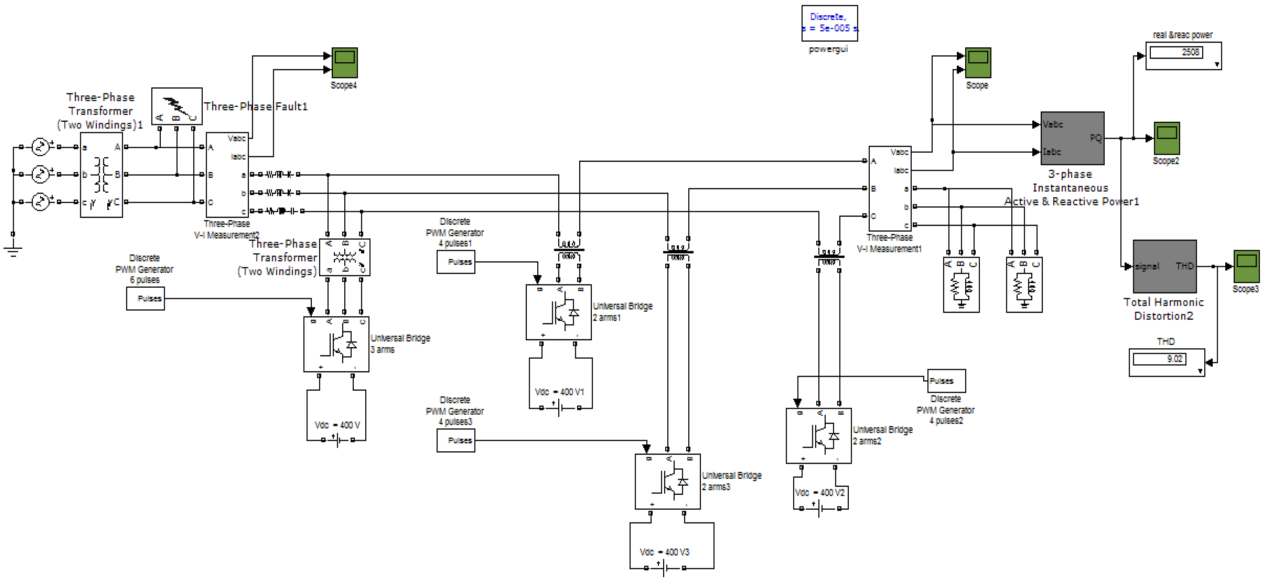

Figure 6. DPFC Simulation model

As the first step in this methodology, I was converted from an abc correlative system to an SRF (dq0). After that, the actual and reference line-neutral grid voltages' dq0 values are compared, and the presence of a discrepancy indicates voltage sag, and the DPFC desired target voltages' dq0 values are evaluated.

## Iv. Power Quality Improvement

As shown in Fig. 6, this design was created in the Matlab/Simulink environment. A supply voltage is coupled to a non-linear in this system simulation. Table 1 contains the simulation parameters. This supply is connected to the load via the transmission lines system 1 and 2 as well as the correlative transmission lines. The length of the correlating transmission lines is the same. Transmission line 2 has a built-in DPFC. The different loads are coupled to analysis good performance. To do a transient analysis, the fault system must be connected to the load. A Y-three-phase transformer connects the shunt converter three phase system to transmission line 2 in parallel, and series converters connect series with are distributed throughout the line.

## V. Simulation

The conclusions of this case study, which considers swell/ sag state in a the following are the components of a single infinite bus system. As seen in Figure 6, there is a failure near the system load, is created to assess voltage drop. This problem has a duration of 0.5 seconds (500-1000 ms). As seen in Figure 7, a three-phase fault causes measurable voltage to drop. The voltage per unit is around 0.5. The DPFC is capable of successfully compensating for load voltage sag. Figure 8 depicts the reduction of voltage sag using a DPFC Controller. Figure 9 shows the 1.1 per unit swell after the three-phase fault is introduced.

The issue lasts for about 0.5 seconds. In this example, the load current magnitude has decreased as a result of the DPFC deployment. Figure 10 depicts the current state of swell mitigation in this example. Figure 11 shows a load voltage harmonic analysis utilising Simulink's FFT window. It can be shown that when a DPFC Controller is installed in a system, the harmonics are decreased to acceptable levels, and the THD of the load voltage is lowered.

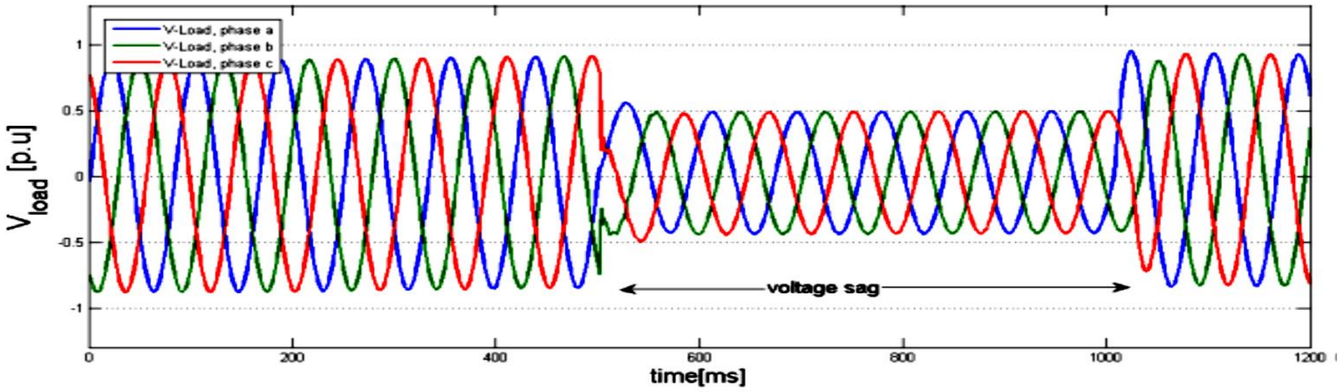

Figure: 7 Voltage sag waveform

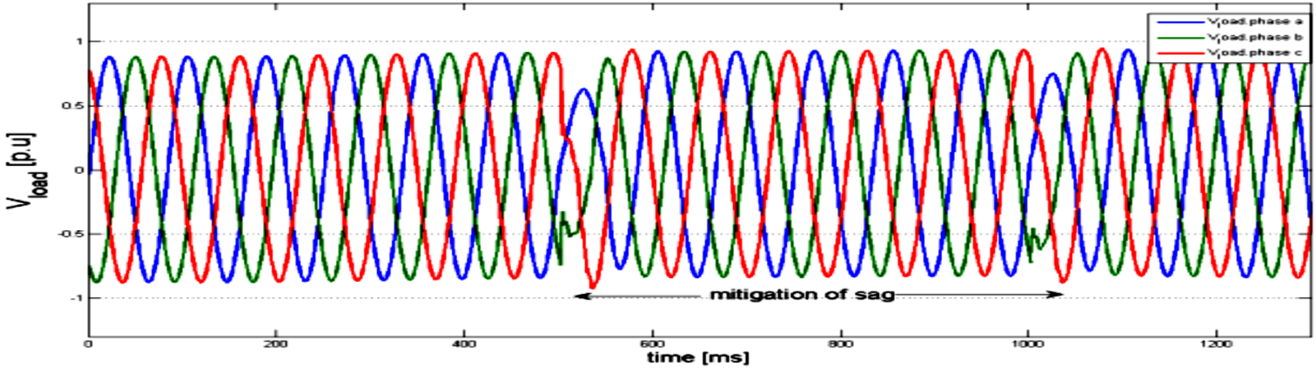

Figure: 8 Mitigation of load voltage sag with DPFC.

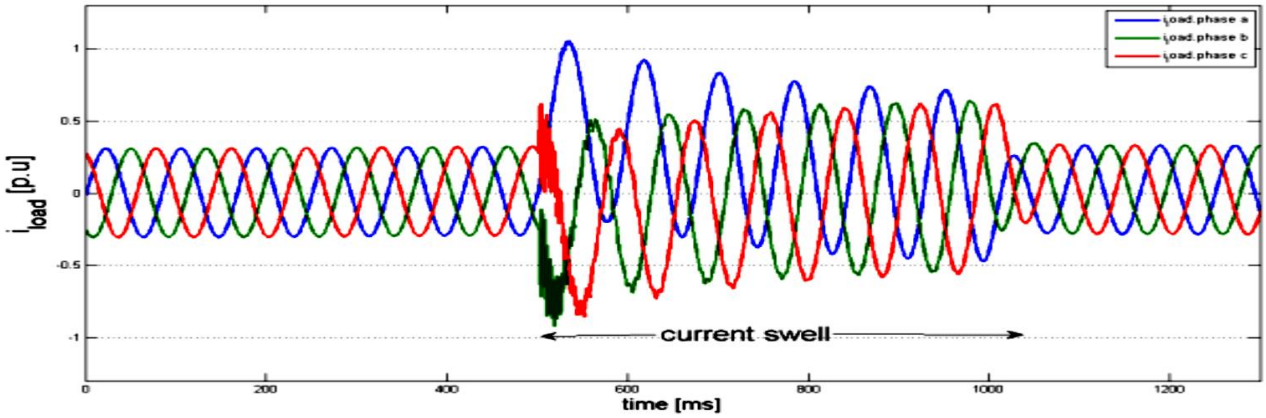

Figure: 9 swell waveform (Load current)

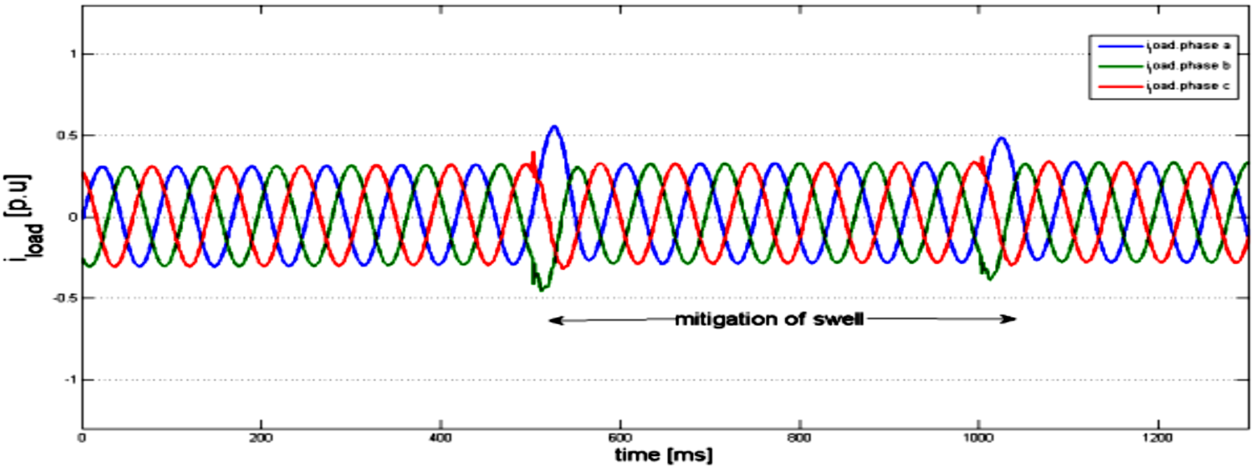

Figure: 10 swell with DPFC (load current)

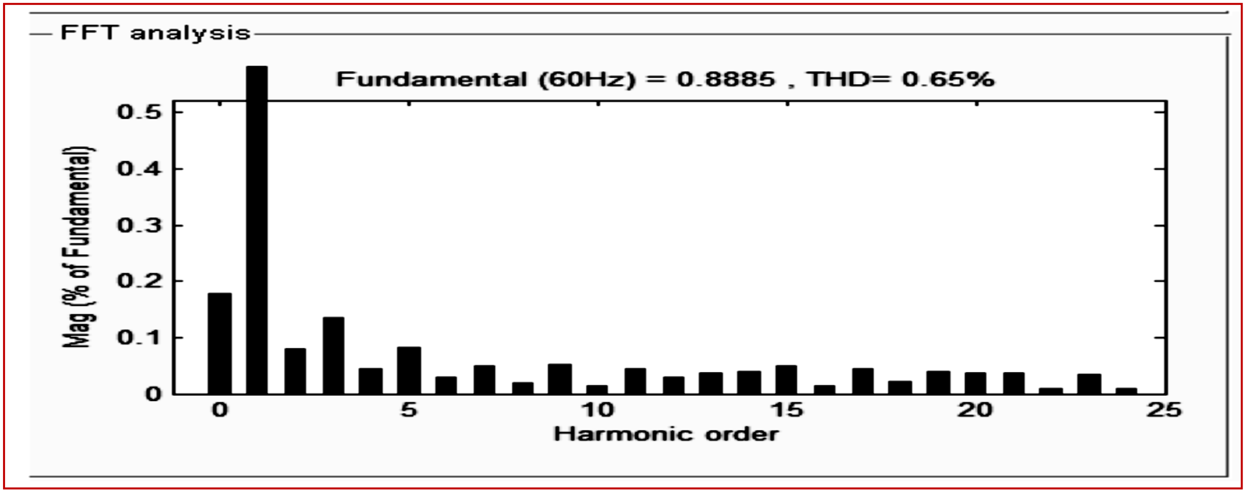

Figure: 11 THD (The load voltage)

**Table I: Parameter**

| **Parameters** | **Values** |
|---|---|
| **Voltage** | 230kv |
| **Power** | 100mw |
| **/ Frequency** | 50hz |
| **X /R** | 3 |
| **Inductance/Capacitance Reactance** | 0.12/0.12 Pu/Km |
| **Length of Transmission Line** | 100 Km |
| **Short Circuit Capacity** | 11000 Mw |
| **Resistance** | 0.012 Pu/Km |

## VI. Conclusion

In the power industry, improving the power quality of transmission line is a critical problem. In this study, the usage of DPFC controller as a new flexible ac transmission systems device is simulated in the Matlab/Simulink environment to improve the voltage Swell and Sag of a structure composed of a source coupled to a non-linear load through nearby transmission lines. The voltage dip is investigated using a three-phase failure close to the system load. The Hysteresis Band pulse width modulation approach is utilised as an exposure and resolved approach to notice the Sags and Swells and establish the reference voltages of the DPFC Controller. The achieved simulation results demonstrate the performance of the DPFC Controller in totally mitigating swell and sag and improving power quality system.

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