International Journal For Technological Research In Engineering *ISSN (Online): 2347 - 4718*
3rd International Conference on Emerging Technologies in Engineering, Biomedical, Medical and Science (ETEBMS - July 17)

SIMULATION OF UPFC AND DPFC FATCS DEVICES FOR OSCILLATION DAMPING IN THE POWER SYSTEM

Amit Patel[1], Prof. Kashyap Patel[2]
[1]PG Scholar, [2]Assistant Professor,
Electrical Department, MEC-Basna, Visnagar, Mehsana, Gujarat, India

Abstract: The electricity is considered as the backbone for industrial revolution. Today the demand and consumption of electrical energy has increased steadily. To meet this increasing demand very complex interconnected power systems are built. These complex networks are subjected to power oscillations. This paper presents a concept of a distributed power flow controller (DPFC) and Unified Power Flow Controller (UPFC) for damping oscillation in Power System. The DPFC is derived from the unified power flow controller (UPFC). The DPFC can be seen as a UPFC with an eliminated common DC link. The cost of the DPFC is also much lower than the UPFC because no high-voltage isolation is required at the series converter part and the rating of the components of is low. This paper proposes a new control scheme to improve the stability of a system by optimal design of distributed power flow controller (DPFC) based stabilizer. The purpose of the work is to design an oscillation damping controller for DPFC to damp low frequency electromechanical oscillations. The shunt and series converters in the DPFC can exchange active power at the third-harmonic frequency, and the series converters are able to inject controllable active and reactive power at the fundamental frequency. The proposed system is simulated by using MATLAB/SIMULINK.

I. INTRODUCTION

There is a high demand for power flow control in power systems of the future, and combined FACTS devices are the most suitable devices. To get a new power flow controlling device that has combined performances of FACTS devices, acceptable cost of electric utilities and reliability of power systems. DPFC is a connected FACTS device, which has taken a UFPC at its beginning phase. The DPFC has control capability as same as that of UPFC, independent adjustment of the line impedance, the transmission angle, and the bus voltage. The DPFC eliminates the common DC link that is used to plug in the shunt and series converter back-to-back within the UPFC. By employing the DFACTS concept as the series converter of the DPFC, the cost is greatly reduced due to the small rating of the components in the series converters. Equally well, the reliability of the DPFC is improved because of the redundancy offered by the multiple series converters. In a power scheme, there is a great desire for a fast and reliable control of the power flow controller because of the growing requirement of energy, the aging of network flow and distributed generations. UPFC is the most powerful device within the FACTS family. It can simultaneously check all the parameters of the system: the line resistance, the transmission angle, and the bus voltage magnitude**.** The Distributed Power Flow Controller (DPFC) recently represented in [3], is a new device within the family of FACTS devices. The DPFC provides a higher reliability than conventional FACTS devices at a lower cost. It is inferred from the UPFC and has the same capability to correct all the parameters of the power system [4] simultaneously. The common DC link between the shunt and series converters is eliminated in DPFC concept, which offers flexibility for independent assignment of series and shunt converter. The DPFC uses the transmission line to exchange active power between converters at the 3rd harmonic frequency [4]. Likewise, series converter distribution reduces cost because no high voltage isolation and high power rating components are required at the series part. By using the two approaches eliminating the common DC link and passing around the series converter, the UPFC is further developed into a new combined FACTS device. Fig.1 shows the Distributed Power Flow Controller (DPFC). This paper introduces a concept of distributed power flow controller (DPFC) that is derived from the UPFC. The same as the UPFC, the DPFC can control all system parameters. The DPFC eliminates the common DC link between the shunt and series converters. The series converter of the DPFC works the distributed FACTS (D-FACTS) concept. Equating with the UPFC, the DPFC have two major benefits:-

- low cost because of the low-voltage isolation and the low component rating of the series converter and
- High reliability because of the redundancy of the series converters.

This paper begins with presenting the principle of the DPFC, followed by its steady-state analysis.

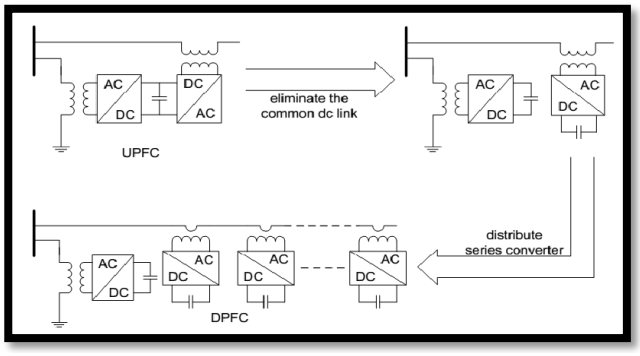

Fig.1: Schematic representation from UPFC to DPFC

 Copyright 2017.All rights reserved.

II. UPFC WORKING

Unified power flow controller (UPFC) is a series shunt FACTS device. It consists of a combination of SSSC in series and STATCOM in shunt with the transmission line. These two voltage source converters are connected by a common d.c. link capacitor. Fig.3.1 shows the schematic diagram of UPFC. The series part injects the voltage of controllable magnitude in the transmission line to control the real and reactive power of the power system. The shunt part is used to maintain the voltage across the d.c. link capacitor and the bus voltage where it is connected by injecting the current of controllable magnitude in the system. Each voltage source converter can control the magnitude and phase angle of the output voltages of series and shunt converters by controlling the amplitude of modulation index (*Mb*,*Me*) and phase-angle ($\delta b, \delta e$) of series and shunt respectively.

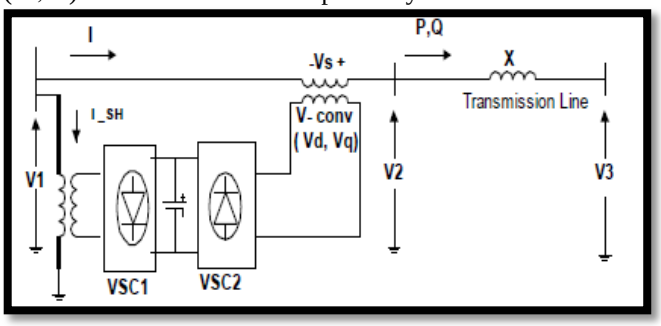

Fig.2-Schematic diagram of UPFC

III. CONTROL CONCEPT OF UPFC

The classical connection of UPFC with transmission line shown on the figure-2. The UPFC uses a two back-to back VSCs, operated from a common dc link. The converter 2 injects the controllable voltage both magnitude and phase angle to the connected line via series transformer. The converter 1 called STATCOM supplies or absorbed the real power demand by the converter 2 via dc link which then support the real power exchange between them. Conceptually the UPFC can automatically control all the system parameter that affect the power flow in a line, namely, voltage, impedance, and phase angle, hence, the name suggested "unified". The UPFC provides complete control over power flow in the line. A circuit equivalent diagram of the UPFC is show in the fig.3.

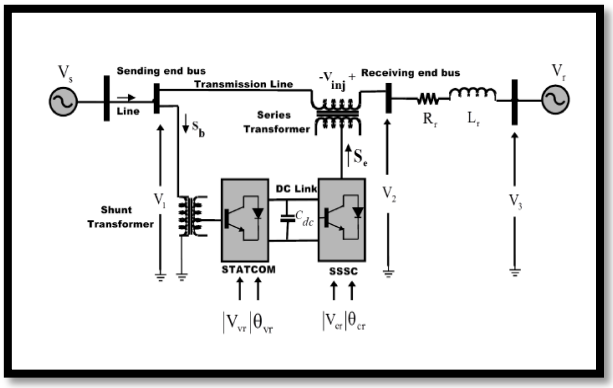

Fig.2. Connection diagram of UPFC with transmission line

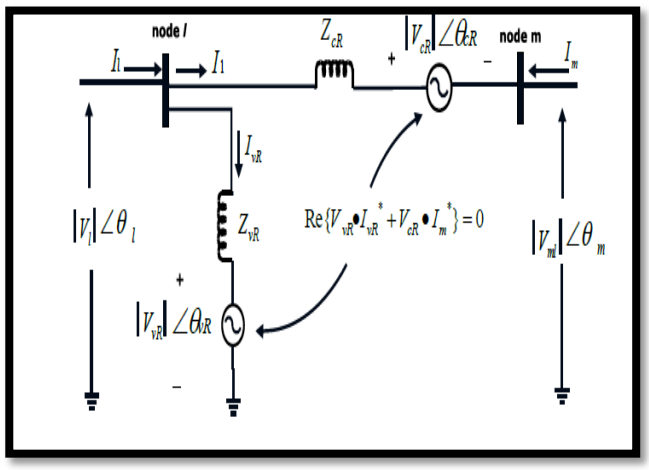

Fig.3 a general circuit equivalent of UPFC

IV. OVERVIEW OF DPFC

By introducing removal of the common DC link and distribution of the series converter into the UPFC, the DPFC is accomplished. Similar as the UPFC, the DPFC consists of shunt and series connected converters. The shunt converter is similar as an STATCOM while the series converter employs the DSSC concept, which is to use multiple single-phase converters as a replacement for one three-phase converter. Each converter within the DPFC is independent and delivers its DC capacitor to supply the required DC voltage. The form of the DPFC is shown in Fig.4.

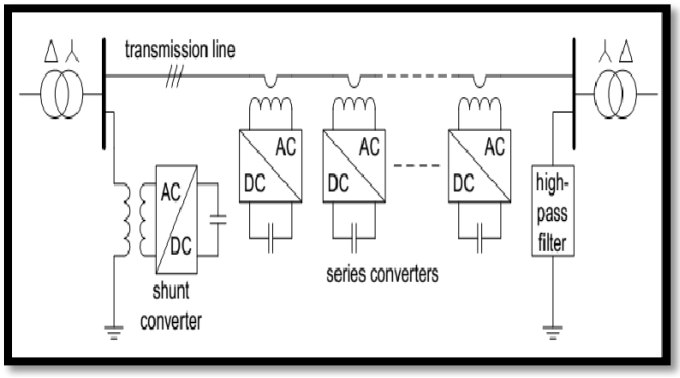

Fig.4- DPFC configuration

The exclusive control capability of the UPFC is given by the back-to-back construction between the shunt and series converters, which allows the active power to easily exchange. To ensure the DPFC has the same control capability as the UPFC, a method that allows active power exchange between converters with an eliminated DC link be needed.

Three-Phase System without UPFC

The 3-Phase system with two areas of economic load dispatch is shown in fig 5. The Non linear load of 3-phase R-L load and also the industrial load is connected in this system. There is 3-phase fault is also created in the system. Due to the non linear load and 3-phase fault there is oscillation and waveform distortion occurs in that system which is shown in the simulation results.

 Copyright 2017.All rights reserved.

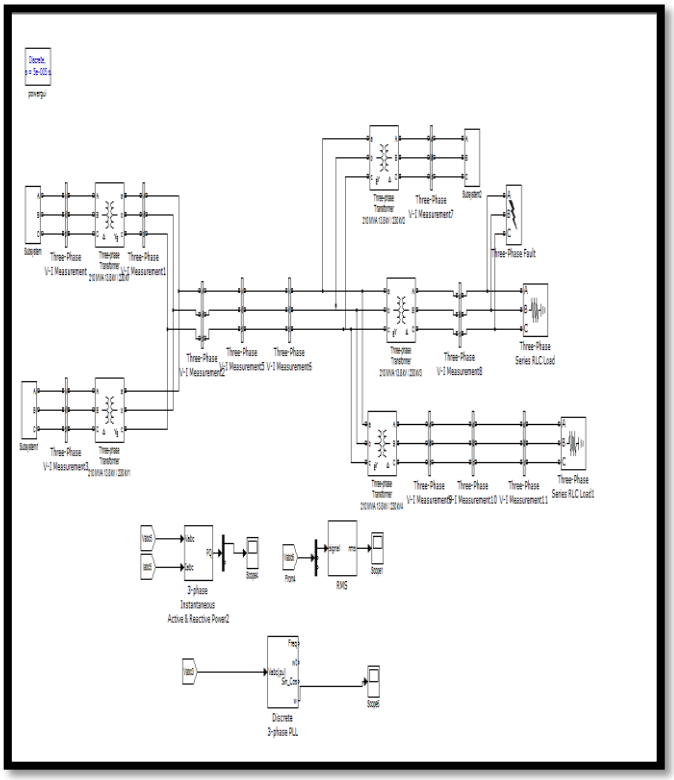

Fig-5 Three-Phase system with Non linear load and 3-phase fault

The simulation results of the above three phase system are shown in the fig below of simulation results. There are voltage value and the active and reactive power also fluctuating and oscillations are produced in the three phase system.

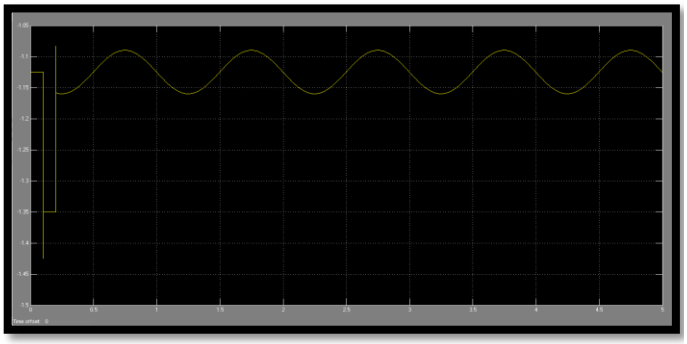

Fig-6 Oscillation occurs in the Active and Reactive power values

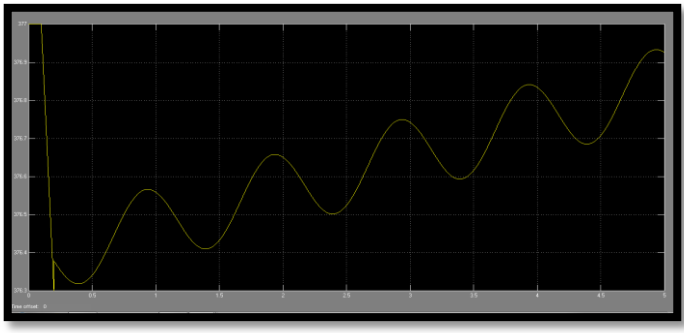

Fig 7- Oscillation occurs in PLL output

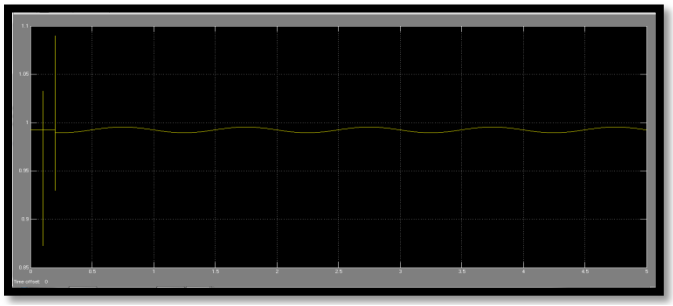

Fig 8-- Oscillation occurs in Output R.M.S value of Voltage Three Phase system with UPFC

The three phase system shows in the above fig 5 is now integrated with UPFC device. Now UPFC subsystem is includes VSC (Voltage source Converter) in series and shunt configuration. There is PLL controller with the individual phase controlling control strategy is provided in this Matlab simulation of below fig with their subsystem and control strategy:-

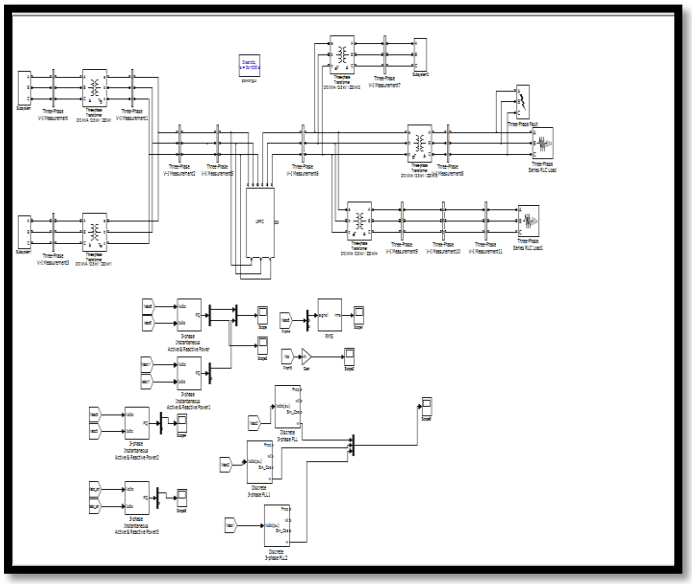

Fig 9-Three Phase system with UPFC device integration in the system

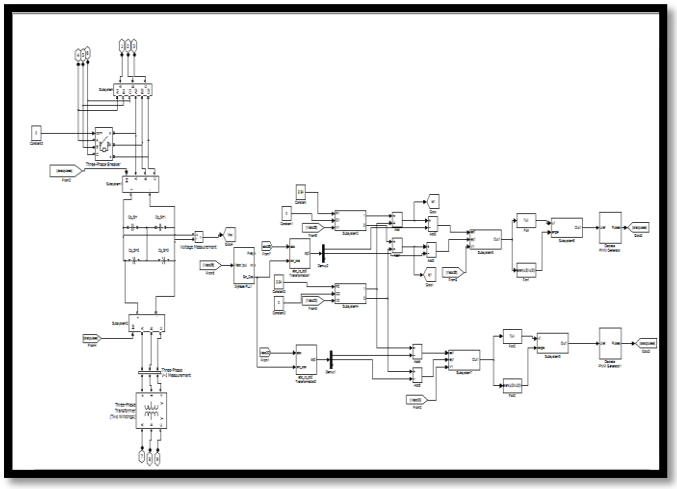

Fig 10-The UPFC device Subsystem

 Copyright 2017.All rights reserved.

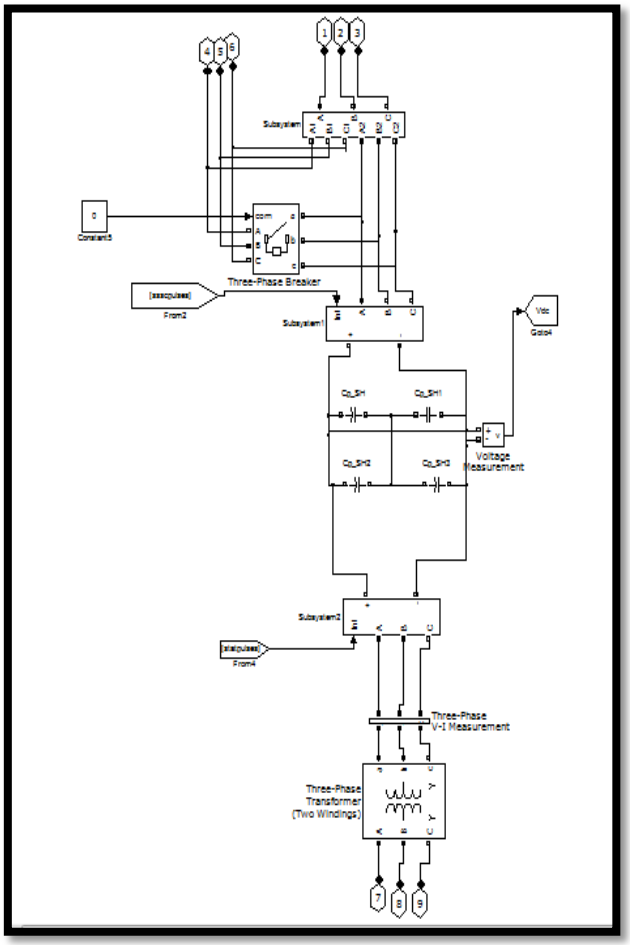

Fig 11-VSC Converter Subsystem in UPFC device Configuration

The VSC Converter in the UPFC subsystem for AC to DC and DC to AC conversion. The Triggering pulses given to this system for continuous and damping oscillation in this system are provided from the control strategy of PLL controller of each individual phase controlling subsystem. The PLL control strategy is shown in the fig below:-

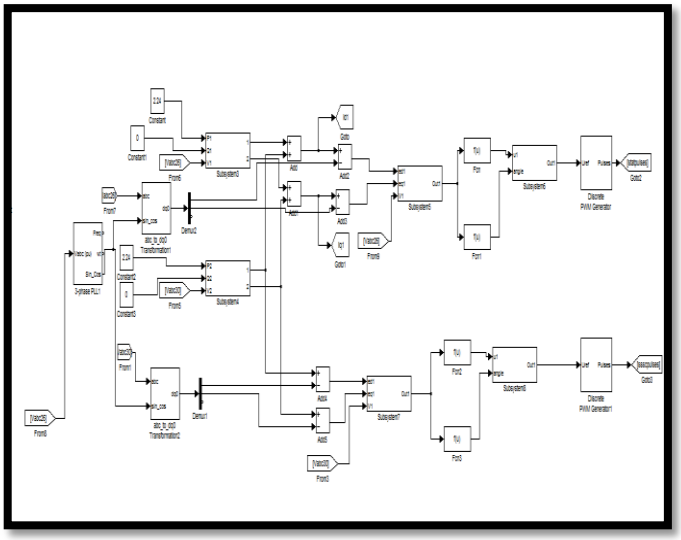

Fig 12-PLL control Strategy in the Subsystem

Now the individual phase control of this proposed control strategy is shown in the fig below. The control strategy and their configuration are shown in the fig 13.

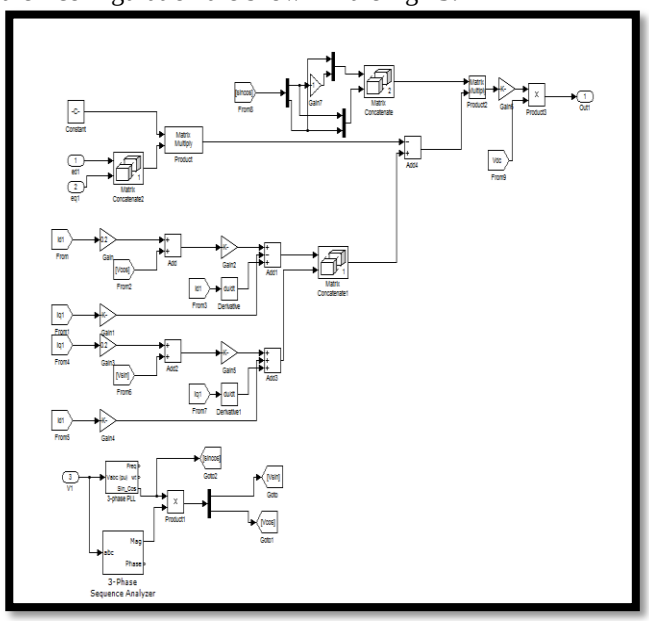

Fig 13-Each and Individual three phase control strategy

Now the simulation results after the connection of UPFC in the proposed system oscillations are damping from the system. The damping simulation results are shown in the fig below:-

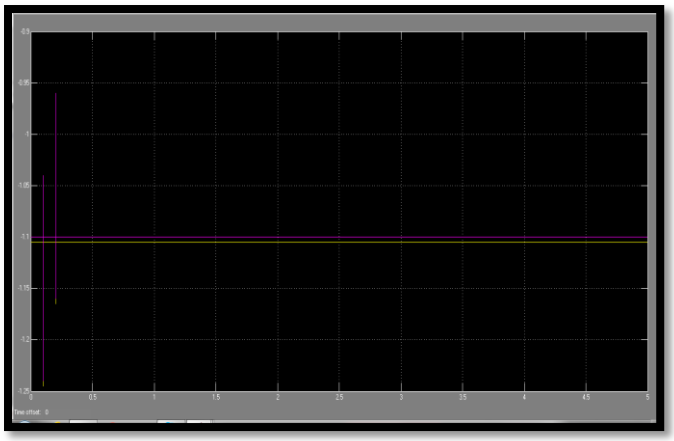

Fig 14-Oscillation damping in Active and Reactive Power

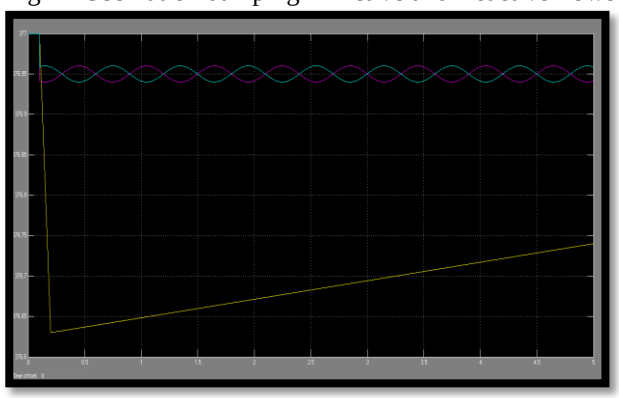

Fig 5.11-Oscillation damping in the PLL output

 Copyright 2017.All rights reserved.

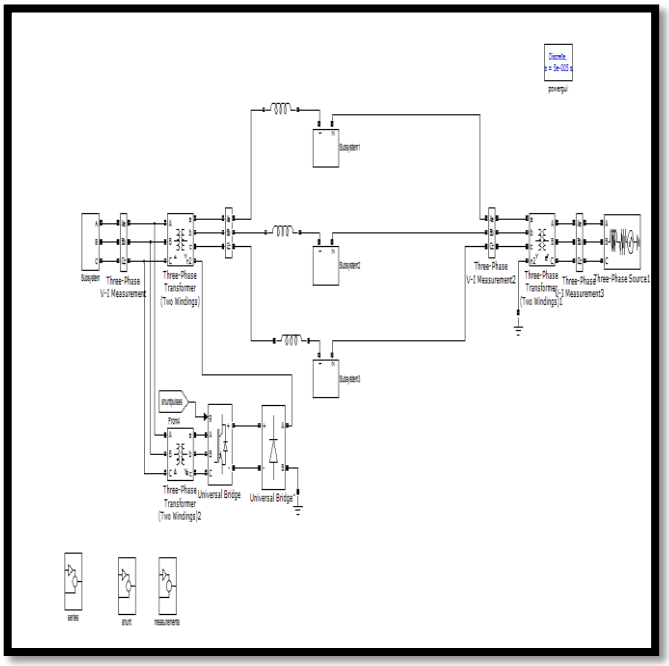

Fig 15-The Simulink model of DPFC device with 3-phase system

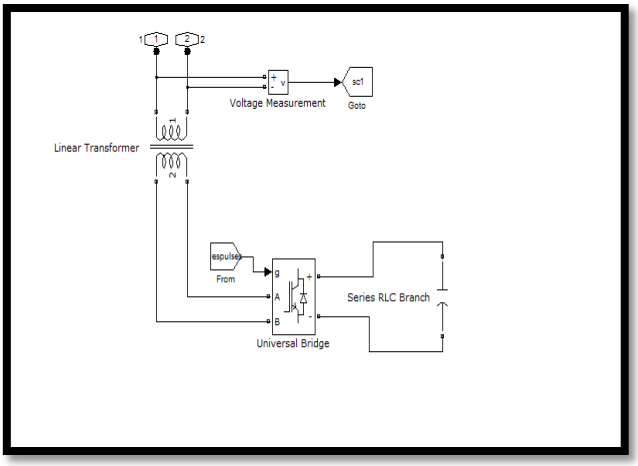

Fig.16 – The subsystem of series converter in the DPFC

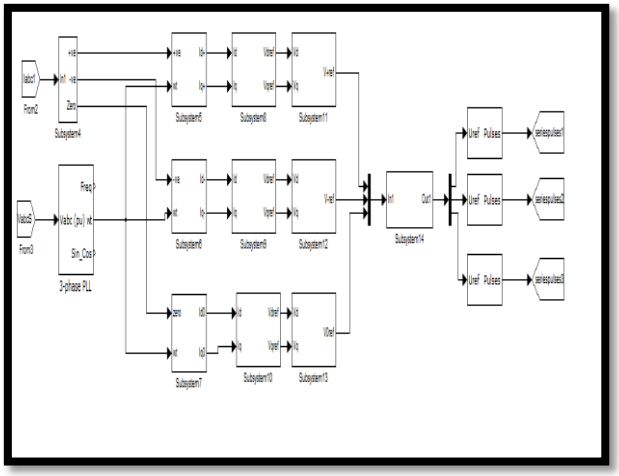

Fig.17- Control strategy for series converter

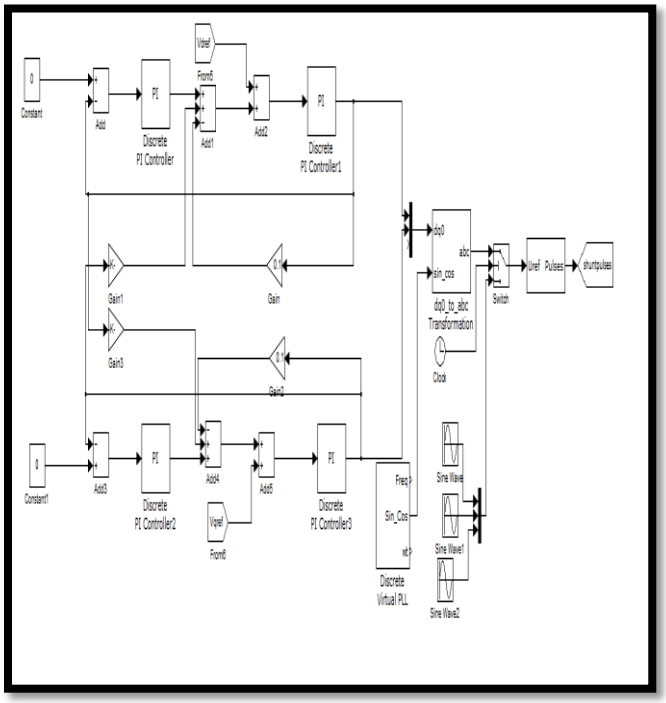

Fig.18- Control strategy for shunt converter at sending end

The control strategy for series and shunt converter of DPFC has shown in the above fig.17 and fig.18 which is working with the PLL and PI controller with triggering pulses for constant voltage and current management in the 3-phase system.

Now the simulation results of DPFC for oscillation damping and mitigation of phase displacement is shown in the below sections.

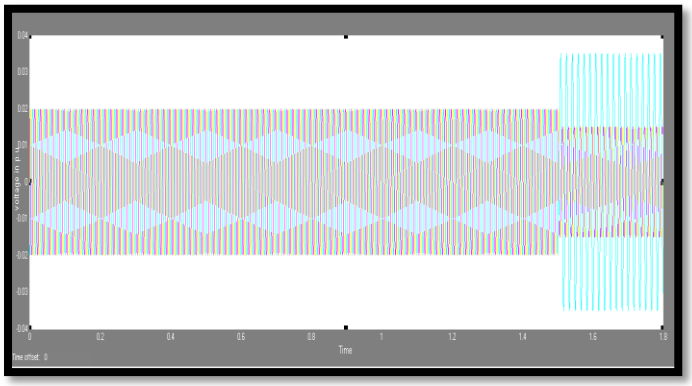

Fig.19- Voltage Unbalancing in three phase system

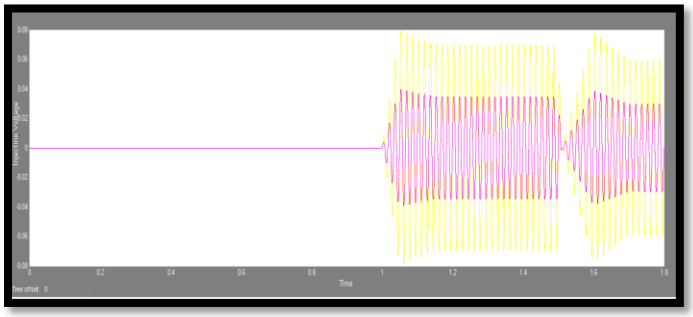

Fig.20- Injecting voltage by DPFC in the system

 Copyright 2017.All rights reserved.

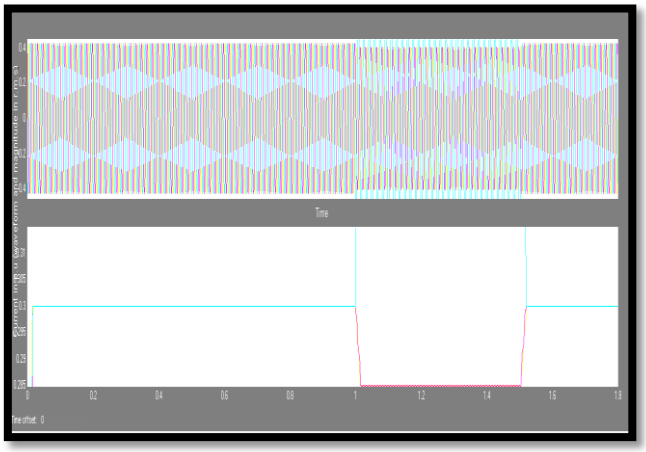

Fig-21-Three phase balanced voltage after DPFC

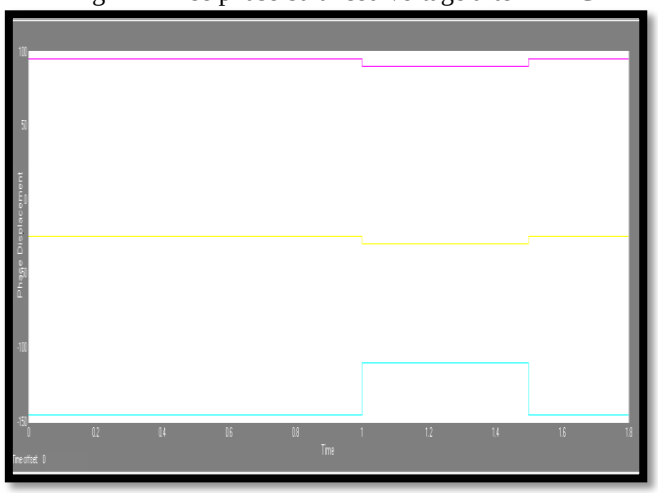

Fig.22- Three phase displacement in the system

V. CONCLUSION

This paper showcasing the application of UPFC and DPFC for damping power system oscillations. The two area power system was used to analyze the role of UPFC for damping the oscillations. The study shows that the DPFC is derived from the unified power flow controller (UPFC). The DPFC can be seen as a UPFC with an eliminated common DC link. It was observed that the results of three phase unbalanced condition system with non linear and D.C load have the distorted waveform of voltage and current and at other side the active and reactive power also unstable. The simulation of UPFC for oscillation damping is shows in Matlab Simulink software. The Matlab simulation of DPFC is also done in this project for voltage balancing and oscillation damping.

REFERENCES

[1] Sudhansu Kumar Samal, Prof. P.C.Panda, "Damping of Power System Oscillations by Using Unified Power Flow Controller with POD and PID Controllers", 2014 International Conference on Circuit, Power and Computing Technologies [ICCPCT], 978-1-4799-2397-7/14/2014 IEEE.

[2] Zhihui Yuan, Sjoerd W.H. de Haan and Braham Ferreira, "Utilizing Distributed Power Flow Controller (DPFC) for Power Oscillation Damping", 978-1-4244-4241-6/09/2009 IEEE.

[3] Mr. R. H. Adware, Prof. P. P. Jagtap and Dr. J. B. Helonde, "POWER SYSTEM OSCILLATIONS DAMPING USING UPFC DAMPING CONTROLLER", Third International Conference on Emerging Trends in Engineering and Technology, 978-0-7695-4246-1/10 / 2010 IEEE.

[4] S. N. Dhurvey, Dr.V. K. Chandrakar, "Optimized POD In Coordination With UPFC For Damping of Power System Oscillations", G.H. Raisoni College of Engineering, Nagpur, India, IEEE Transactions.

[5] M. A. Furini and P. B. de Araujo, "Comparative Study of the Damping Oscillation Function of TCSC and UPFC", Department of Electrical Engineering of Sao Paulo State University - UNESP - FEIS. 15385-000, Solteira, SP, Brazil 978-1-4244-2218-0/08/2008 IEEE.

[6] R. D. Saxena, K. D. Joshi, "Application of Unified Power Flow Controller (UPFC) for Damping Power System Oscillations – A Review", Vol. 1 Issue 4, June – 2012, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181

[7] D. Nazarpour, S. H. Hosseini and and G. B. Gharehpetian, "Damping of Generator Oscillations Using an Adaptive UPFC-based Controller", American Journal of Applied Sciences 3 (1): 1662-1668, 2006, ISSN 1546-9239,2006 Science Publications.

[8] M. Salehi, A. A. Motie Birjandi, F. Namdari, "Unified Power Flow Controller Placement to Improve Damping of Power Oscillations", World Academy of Science, Engineering and Technology International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering Vol:9, No:12, 2015.

[9] [9] Sneha Anand Jamboti , Prof. A. Shravan Kumar, Prasad Pradeep Kulkarni, "DISTRIBUTED POWER FLOW CONTROLLER FOR DAMPING OF POWER SYSTEM OSCILLATIONS",vol-5,issue-5, may-2016,IJSTM,ISSN-2394-1537.

[10] A. D. Parmar , Prof. (Ms.) R. A. Vyas, Prof. A. L. Vaghamshi, "Distributed Power-Flow Controller for Enhancing Power System Stability", Vol. 2 Issue 12, December – 2013, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181.

[11] D. Narasimha Rao, V. Saritha, "Power System Oscillation Damping Using New Facts Device", Vol. 5, No. 2, April 2015, pp. 198~204, International Journal of Electrical and Computer Engineering (IJECE), ISSN: 2088-8708.

 Copyright 2017.All rights reserved.