2nd International Conference on Emerging Technologies in Engineering, Biomedical, Management and Science
[2nd ETEBMS-2016], 5-6 November, 2016

Role of DPFC and DIPFC FACTS devices in voltage SAG and swell mitigation

***Ronak Gandhi*[1], *Gajendra Patel*[2]**
[1]*PG Scholar, Electrical Department, SPCE, Visnagar, Gujarat, India*
[2]*Assistant Professor, Electrical Department, SPCE, Visnagar, Gujarat, India*

Abstract: Now a day's power system facing a power quality problem due to increase in power demand and increase in industrial plants. Good power quality means the power supply which can always available within voltage and frequency tolerance and also these are harmonic free and pure sinusoidal shape. This paper describes the power flow control in transmission line with Flexible AC Transmission System (FACTS) family, called Distributed Power Flow Controller (DPFC) and Distributed Interline Power Flow Controller (DIPFC). The DPFC is derived from the Unified Power Flow Controller (UPFC). The DPFC can be considered as UPFC with an eliminated common DC link, to enable the independent operation of the shunt and the series converters which enhances the effective placement of the series and shunt converters. The active power exchange between the two converters, which is through the common dc link in the UPFC, is now through the transmission lines at the third-harmonic frequency in the DPFC & DIPFC. DPFC & DIPFC is used to mitigate the voltage sag and swell as a power quality issue. The DPFC and DIPFC have the same control capability as the UPFC, which comprises the adjustment of the line impedance, the transmission angle, and the bus voltage. In DPFC three-phase series converter is divided to several single-phase series distributed converters through the transmission line and in DIPFC three single phase series converters are placed in between the two transmission lines.

I. INTRODUCTION

A Power Quality problem can be defined as deviation of magnitude and frequency from the ideal sinusoidal waveform. Good power quality is benefit to the operation of electrical equipment, but poor power quality will produce great harm to the power system. Most of the electronic equipments such as personal computers, telecommunication equipments, microprocessor and micro controller, etc are responsible for power quality problems. A Power Quality problem can be defined as deviation of magnitude and frequency from the ideal sinusoidal wave from. Good power quality is benefit to the operation of electrical equipment, but poor power quality will produce great harm to the power system [1]. Harmonics are defined as sinusoidal wave form having a frequency equal to an integer multiple of the power system fundamental frequency. It is a component of a periodic waveform. If the fundamental frequency multiple is not an integer, then we are dealing with inter harmonics [1]. Most of the electronic equipments such as personal computers, telecommunication equipment, microprocessors, and microcontrollers etc; are generally responsible to Power Quality problems. A poor power quality has become a more important issue for both power suppliers and customers. Poor power quality means there is a deviation in the power supply to cause equipment malfunction or may failure. To solve the power quality problem the power electronic devices such as flexible alternating-current transmission system (FACTS) and custom power devices (DVR) which are used in transmission and distribution control, respectively, should be developed. The impact of transient parameters in majority of transmission lines problems such as sag (voltage dip), swell (over voltage) and interruption, are also considerable [5]. To mitigate the mentioned power quality problems, the utilization of FACTS devices such as power flow controller (UPFC) and synchronous static compensator (STAT-COM) can be helpful. The distributed power flow controller (DPFC) is presented which has a similar configuration to UPFC structure.

II. VOLTAGE SAG

Voltage sags and momentary power interruptions are probably the most important Power Quality problem affecting industrial and large commercial customers. These events are usually associated with a fault at some location in the supplying power system. Interruptions occur when the fault is on the circuit supplying the customer. But voltage sags occur even if the faults happen to be far away from the customer's site. Voltage sags lasting only 4-5 cycles can cause a wide range of sensitive customer equipment to drop out. To industrial customers, voltage sag and a momentary interruption are equivalent if both shut their process down. A typical example of voltage sag is shown in fig.1

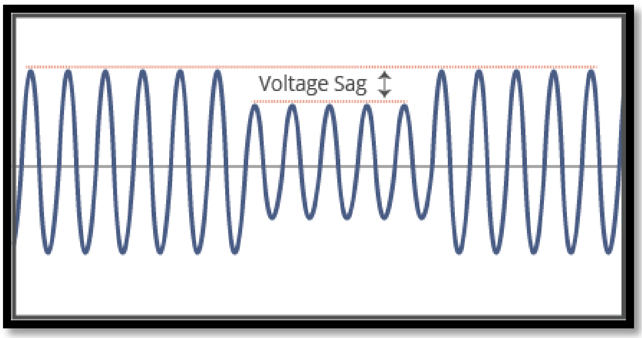

Fig.1- Voltage Sag condition

III. VOLTAGE SWELL

A swell is the reverse form of Sag, having an increase in AC Voltage for duration of 0.5 cycles to 1 minute's time. For swells, high-impedance neutral connections, sudden large load reductions, and a single-phase fault on a three phase system are common sources. Swells can cause data errors, light flickering, electrical contact degradation, and semiconductor damage in electronics causing hard server failures. Our power conditioners and UPS Solutions are common solutions for swells. It is important to note that, much like sags, swells may not be apparent until results are seen. Having your power quality devices monitoring and logging your incoming power will help measure these events.

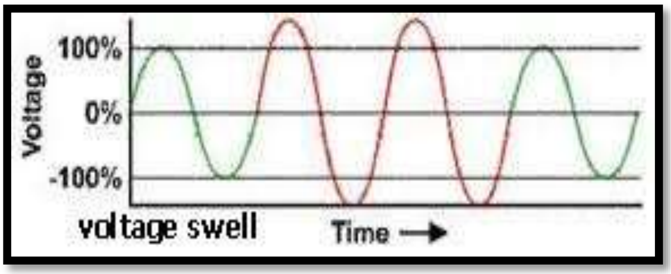

Fig.2-Voltage swell condition

IV. DPFC WORKING

The DPFC is composed of a single shunt converter and multiple independent series converters as shown in Figure 3, which is used to balance the line parameters, such as line impedance, transmission angle and bus voltage magnitude. To detect the voltage sags and determine the three single phase reference voltages of DPFC, the SRF method is also proposed as a detection and determination method.

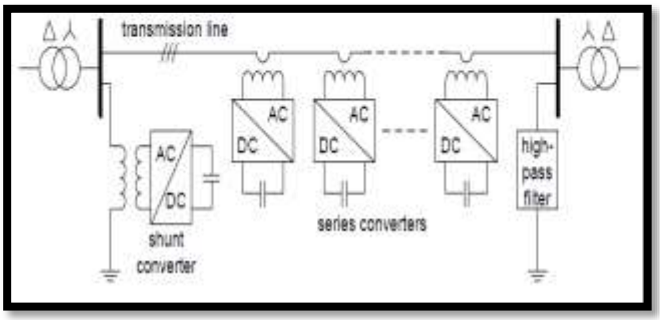

Figure 3: DPFC configuration

To reduce the failure rate of the components by selecting components with higher ratings than necessary or employing redundancy at the component or system levels are also options. Unfortunately, these solutions increase the initial investment necessary, negating any cost-related advantages. Accordingly, new approaches are needed in order to increase reliability and reduce cost of the UPFC and DPFC at the same time. The elimination of the common DC link also allows the DSSC concept to be applied to series converters. In that case, the reliability of the new device is further improved due to the redundancy provided by the distributed series converters. Unlike in UPFC where the active power transfer is through the DC link between the series and shunt converters here in DPFC this power flow is through the transmission lines at the third harmonic frequency which is a zero-sequence component and can be naturally blocked by a Y-Δ transformer. The DPFC makes use of the distributed FACTS (D-FACTS) in the design of the series converter, which is to use multiple single-phase converters instead of one large rated three phase converter while the shunt converter remains as static synchronous compensator (STATCOM) as in UPFC. These large numbers of series converters provides redundancy, thereby increasing the system reliability. As the D-FACTS converters are single phase and floating with respect to the ground, there is no high voltage isolation required between the phases. Accordingly, the cost of the DPFC system is lower than the UPFC. The controllability of the DPFC is same as that of the UPFC which refers to the adjustment of the line impedance, the transmission angle, and the bus voltage. The operation principle, the modelling and control, and experimental demonstrations of the DPFC are presented in this paper.

V. DIPFC WORKING

The Distributed Interline Power Flow Controller (DIPFC) consists of the two (or more) series converters in different transmission lines that are inter-connected via a common DC link, as shown in Figure 4. Unlike other FACTS devices that aim to control the parameter of a single transmission line, the IPFC is conceived for the compensation and control of power flow in a multi-line transmission system. Each converter can provide series reactive compensation of its own line, just as an SSSC can. As the converters can exchange active power through their common DC link, the DIPFC can also provide active compensation.

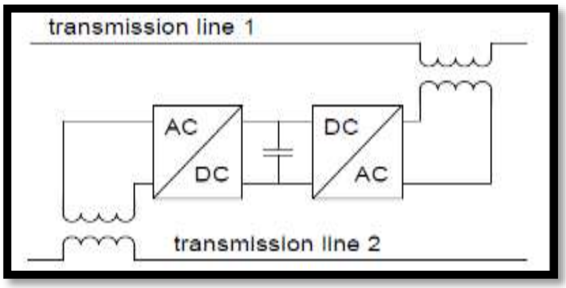

Figure 4: IPFC configuration

Similar to the DPFC, the DIPFC consists of multiple single-phase series converters, which are independent from each other. As the DIPFC is a power flow control solution for multiple transmission lines, the series converters are installed in different lines. The DIPFC can also include shunt converters, but these are not compulsory. The single line diagram of a DIPFC is shown in Figure 5. There is an exchange of active power between the DIPFC converters and this active power is exchanged in the same transmission line at the 3rd harmonic frequency. If the DIPFC is without a shunt converter, the series converters in one transmission line will exchange active power with the converters in the other lines. If there is a shunt converter in the DIPFC, the shunt converter will supply the active power for each series converter.

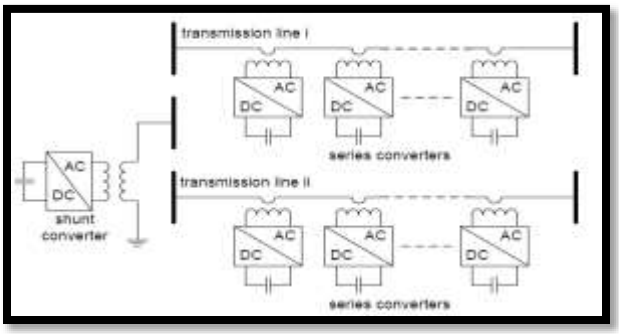

Figure 5- DIPFC configuration

VI. SIMULATION & RESULTS

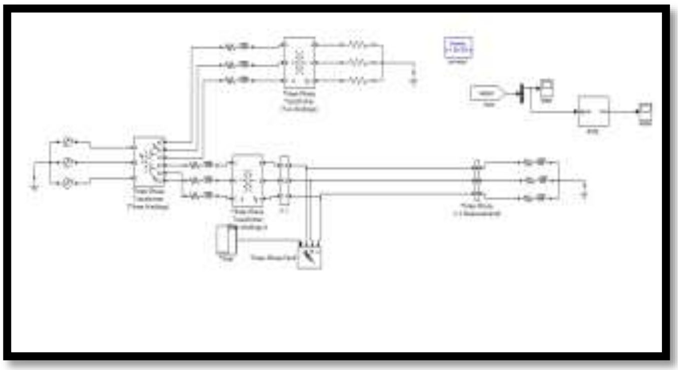

Fig-6 Voltage Sag condition in 3-phase system

As shown above in fig-6 there is 3-phase fault is created in the three phase system which creates voltage sag problem in this system. The three phase fault is operated and controlled through external timer signal which is also shown in the fig. The simulation results of voltage sag condition are shown below:-

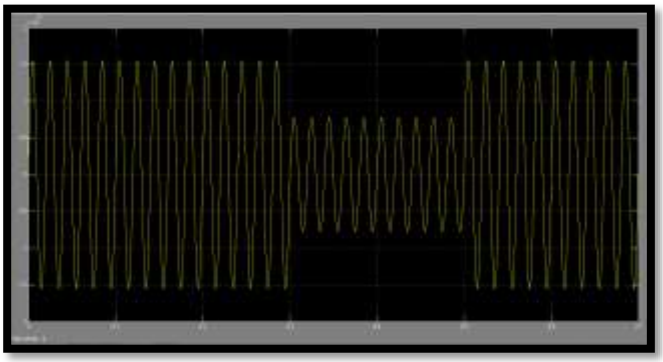

Fig-7 Voltage Sag condition

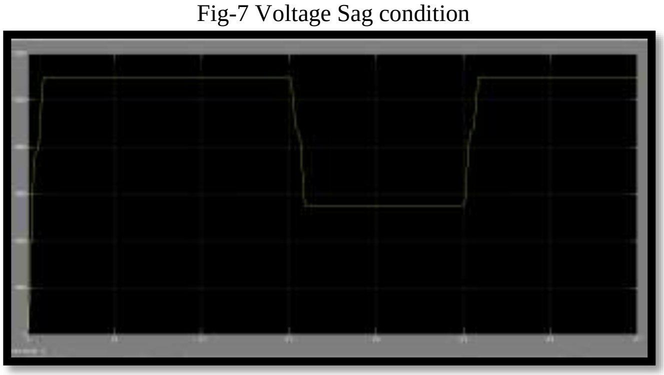

Fig-8 Voltage Sag R.M.S value

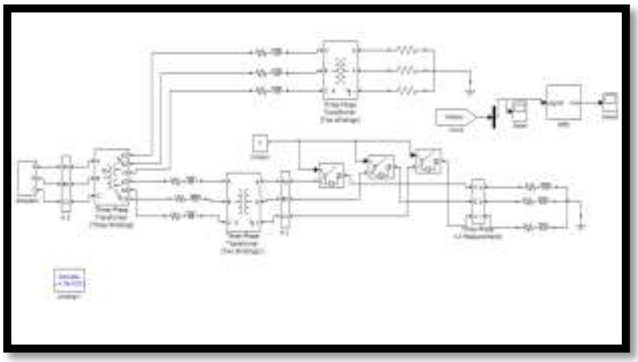

Fig 9- Voltage Sag condition in 3-phase system

Now as shown above in fig-9 there is delay will be provided using external timer signal in the three phase system which creates voltage swell problem in this system. The three phase power supply is operated and controlled through external timer signal which is also shown in the fig. The simulation results of voltage sag condition are shown below:-

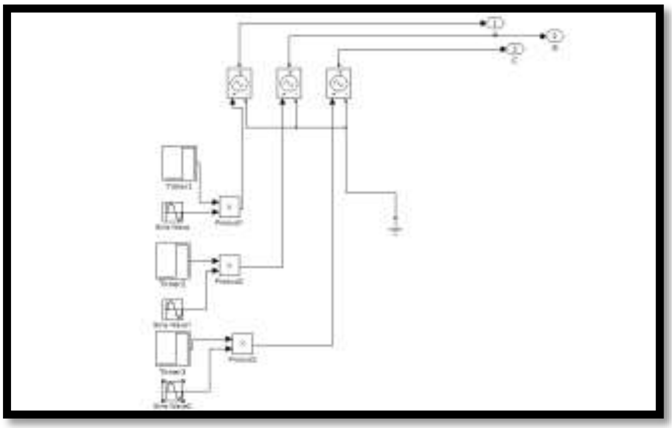

Fig 10- Three phase power supply with external timer signal control

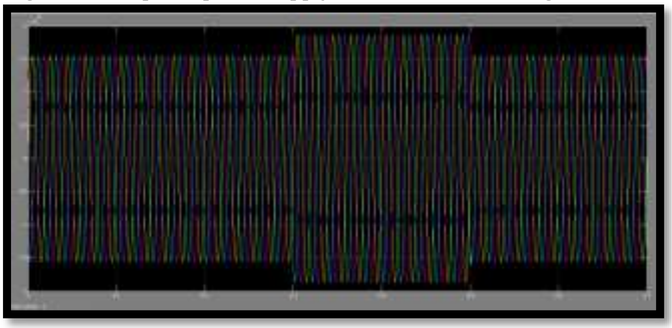

Fig-11 Voltage Swell condition

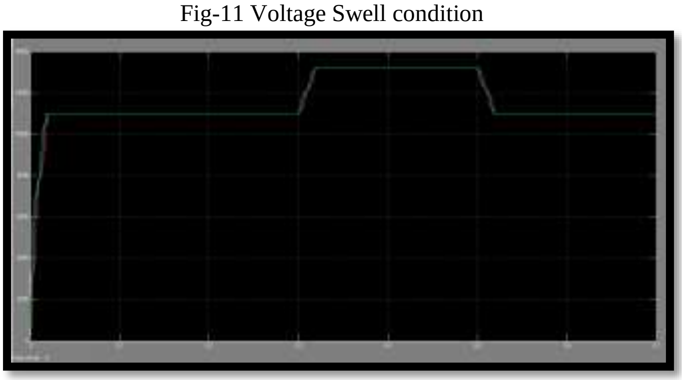

Fig-12 Voltage Sag R.M.S value

VII. CONCLUSION

The power quality enhancement of the power transmission systems is an vital issue in power industry. In this study, the application of DPFC and DIPFC as a new FACTS device in the voltage sag and swell mitigation of a system composed of a three-phase source connected to a non-linear load through the parallel transmission lines is simulated in Matlab/Simulink environment. The voltage dip is analyzed by implementing a three-phase fault close to the system load. To detect the voltage sags and determine the three single phase reference voltages of DIPFC, the SRF method is used as a detection and determination method. The obtained simulation results show the voltage sag and swell condition. We can mitigate the voltage sag and swell problem using DPFC and DIPFC devices.

REFERENCES

[1] Lu Yan: “Wind Power Generation related power quality Issues” 2010.
[2] J. R. Enslin, “Unified approach to power quality mitigation,” in Proc. IEEE Int. Symp. Industrial Electronics (ISIE "98), vol. 1, 1998.
[3] B. Singh, K. Al-Haddad, and A. Chandra, “A review of active filters for power quality improvement,” IEEE Trans. Ind. Electron. vol. 46, no. 5, pp. 960–971, 1999.
[4] M. A. Hannan and A. Mohamed, member IEEE, “PSCAD/EMTDC simulation of unified series-shunt compensator for power quality improvement,” IEEE Transactions on Power Delivery, vol. 20, no. 2, 2005.
[5] J. Faiz, G. H. Shahgholian, and M. Torabian, “Design and simulation of UPFC for enhancement of power quality in transmission lines,” IEEE International Conference on Power System Technology, vol. 24, no. 4, 2010.
[6] A. L. Olimpo and E. Acha, “Modeling and analysis of custom power systems by PSCAD/EMTDC,” IEEE Trans. Power Delivery, vol. 17, no.1, pp. 266–272, 2002.
[7] P. Pohjanheimo and E. Lakervi, “Steady state modeling of custom power components in power distribution networks,” in Proc. IEEE Power Engineering Society Winter Meeting, vol. 4, Jan, pp. 2949–2954, 2000.
[8] Z. H. Yuan, S. W. H de Haan, B. Frreira, and D. Cevoric, “A FACTS device: Distributed power flow controller (DPFC),” IEEE Transaction on Power Electronics, vol.25, no.10, October, 2010.
[9] Z. H. Yuan, S. W. H de Haan, and B. Frreira “DPFC control during shunt converter failure,” IEEE Transaction on Power Electronics 2009.
[10] R. Zhang, M. Cardinal, P. Szczesny, and M. Dame. “A grid simulator with control of single-phase power converters in D.Q rotating frame,” Power Electronics Specialists Conference, IEEE 2002.