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Performance Comparison of DSTATCOM and Shunt Active Filter for Voltage Sag Improvement in Distribution System

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Abstract Electrical energy is very convenient form of energy to change into various forms of energy for different purposes as lighting, heating, cooling and for number of applications. Therefore, the consumption of electricity is increasing day by day throughout the world, hence now a days, there is a need to focus on power quality issues to solve the economic challenges faced by power system throughout the world. The term power quality describes by the magnitude and waveforms of the voltage and current in power system. increasing number of distorting loads may leads to an increased awareness of power quality both by customers and utilities. The most common power quality problems today are voltage sags, harmonic distortion and low power factor. This paper presents the improvement of voltage sags using Distribution Static Compensator (D-STATCOM) and Shunt Active Filter in power distribution network. The model is based on the Voltage Source Converter (VSC) principle. The D-STATCOM injects a current into the system to mitigate the voltage sags A shunt active power filter can realize the appropriate solution for all the aforesaid problems. In [3] have discussed power quality problems in distribution systems and their solutions using power electronics equipments. The performances of the APF in distribution line under fault have also discussed. simulations were performed using MATLAB SIMULINK version R2009b.

Key words:- Introduction, DSTATCOM, VSC,Shunt Active Filter .

1. INTRODUCTION:

Electrical energy is very convenient form of energy to change into various forms of energy for different purposes as lighting, heating, cooling and for number of applications. Therefore, the consumption of electricity is increasing day by day throughout the world, hence now a days, there is a need to focus on power quality issues to solve the economic challenges faced by power system throughout the world. The term power quality describes by the magnitude and waveforms of the voltage and

current in power system To overcome the problem related to the power quality custom power device is introduced. A number of power quality problem solutions are provided by custom devices. DSTATCOM is one of the custom power devices, used for supplying reactive, harmonic currents of load demand in distribution system. The fast response of D-STATCOM makes it efficient solution for improving the power quality in distribution system. Here the D-STATCOM used with different controller such as PI to improve the power quality under different abnormal condition, which causes the power quality related problem. Voltage sags are one of the most occurring power quality problems. For an industry voltage sags occur more often and cause severe problems and economical losses. Utilities often focus on disturbances from end-user equipment as the main power quality problems. Harmonic currents in distribution system can cause harmonic distortion, low power factor and additional losses as well as heating in the electrical equipment. It also can cause vibration and noise in machines and malfunction of the sensitive equipment. Active power filters are simply power electronics converter, which have been designed ,improved and commercialized in last three decades. They are applicable to compensate current based distortion such as current harmonics, reactive power. They are also used for voltage based distortions such as voltage harmonics, voltage flickers, voltage sags and swells, and voltage imbalances and load unbalancing.

2. DISTRIBUTION STATIC COMPENSATOR

The generation system is not portable and cannot be placed or established where ever we want as there are so many economical and environmental issues. So, generation can be done at selected places. But the utility systems are widely spread all over the world to transmit power over long distances which is

accomplished by the transmission system or transmission lines. Active power and reactive power are correlated with each other. In order to utilize the active power efficiently, firstly, we should control the reactive power in the line. For this purpose, the FACTS devices like SSSC, STATCOM, etc are being used. The main purpose of these controlled devices is to maintain the reactive power within limits in order to have constant voltage profile. Constant voltage profile at the utility terminals makes the power efficient at those terminals so that there is no reverse flow of power from that point to the source point i.e., the active power is used efficiently. DSTATCOM in the sense differs from the point of connection compared to the other controlled devices. DSTATCOM is connected at the distribution side which makes the system efficient and which is essential. In the electric supply system, to utilize the electric power, distribution substations are provided where the tapings are provided for the extraction of power. When the tapings are provided, a voltage imbalance occurs. As the consumers are taking power from the terminals through the distributor, the distribution system should be in such a way that the voltage imbalance should be rectified. For this purpose the use of DSTATCOM is wise as compared to the other compensation devices to provide smooth voltage profile. When the STATCOM is used to apply in distribution system it is called D-STACOM (Distribution-STATCOM) and its design is the same, or with small changes, oriented to a feasible future amplification of its possibilities in the distribution network at low and medium voltage, implementing the function so that we can explain as flicker damping, harmonic filtering and whole and short interruption compensation. Distribution STATCOM (DSTATCOM) exhibit high speed control of reactive power to offer voltage stabilization, flicker reduction, and other types of system control. It utilizes a design consisting of a GTO- or IGBT-based voltage sourced converter coupled to the power system by means of a multi-stage converter transformer.

It protects the utility distribution system from voltage sags and/or flicker caused by rapidly variation in reactive current demand. In utility applications, it provides leading or lagging reactive power to achieve system stability during transient conditions.

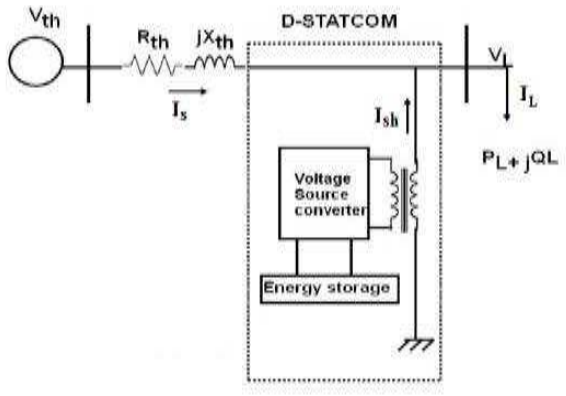


Fig1:Schematic diagram of a DSTATCOM

2.1 VOLTAGE SOURCE CONVERETR:

A voltage source converter is a power electronics device which consists of a storage device and switching device, which can generate an ac voltage with any magnitude, frequency and phase angle. Voltage source converters are used in adjustable speed drives and also can be used to moderate the voltage dip & voltage sag. Voltage source converter is either used to replace the complete voltage or to inject the lost voltage. The lost voltage is the difference between the nominal voltage and the actual voltage. the converter is normally based on the concept of energy saving, which will supply the converter with a DC voltage. Solid state electronics in the converter is then switched to get the require output voltage. VSC is also used for other power quality issues like flicker, harmonics etc.

2.2CONTTROLLER

The controller input is an error signal obtained from the reference voltage and the R.M.S. value of the terminal voltage measured. Such error is passed through the PI controller the output is the angle δ. The output of PI controller is provided to the PWM signal generator. It is important to note that in this case, there is active and reactive power exchange with the network simultaneously. An error signal is obtained by comparing the reference voltage with the R.M.S. value of voltage measured at the load point. The PI controller process the error signal generates the required angle to drive the error to zero. The R.M.S. load voltage is brought back to the reference voltage.

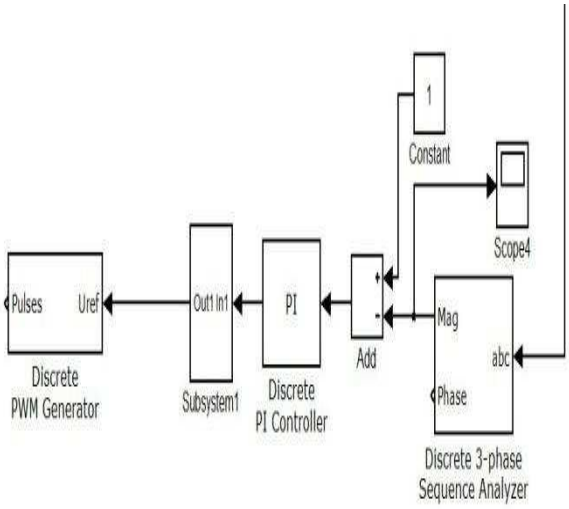


Fig2. Block Diagram of Controller System

2.3 ENERGY STORAGE CIRCUIT

DC source is connected in parallel with the DC capacitor. It carries the input ripple current of the current harmonics, reactive power. They are also used for voltage based distortions such as voltage harmonics, voltage flickers, voltage sags and swells, and voltage in balances and load unbalancing. Moreover unlike passive filters, they do not cause harmful resonances with power distribution systems. Consequently, AHFs performances are independent of the power distribution system properties. APF's can be categorized based on converter type, topology and number of phases. The converter type is mainly two types Voltage source inverter and current source inverters. The topology of active power filter is categorized in to three types. Series active power converter and it is the main reactive energy storage element. This DC capacitor could be charged by a battery source or could be recharged by the converter itself.

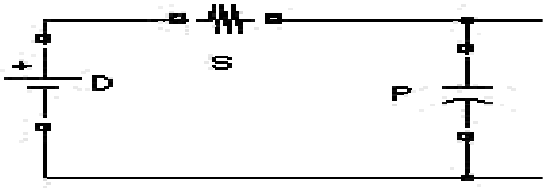


Fig3 Circuit Diagram of DC-STORAGE

3. ACTIVE FILTER

Active power filters are simply power electronics converter, which have been designed, improved and commercialized in last three decades. They are applicable to compensate current based distortion such as

filters, Shunt active power filters, Hybrid active power filters

3.1 SHUNT ACTIVE FILTERS

The active filter concept uses power electronic equipment to produce harmonic current components that cancel the harmonic current from the nonlinear loads.. In this configuration, the filter is connected in parallel with the load being compensated .Therefore the configuration is often referred to as an active parallel or shunt filter.

4. RESULT & DISCUSSION

To create distortion in the distribution system, different types of fault such as Line to Line Fault(LL), Single Line to ground (SLG), Double Line to Ground(DLG), Three Line to Ground(TLG) are injected.

4.1 Without insertion of DSTATCOM

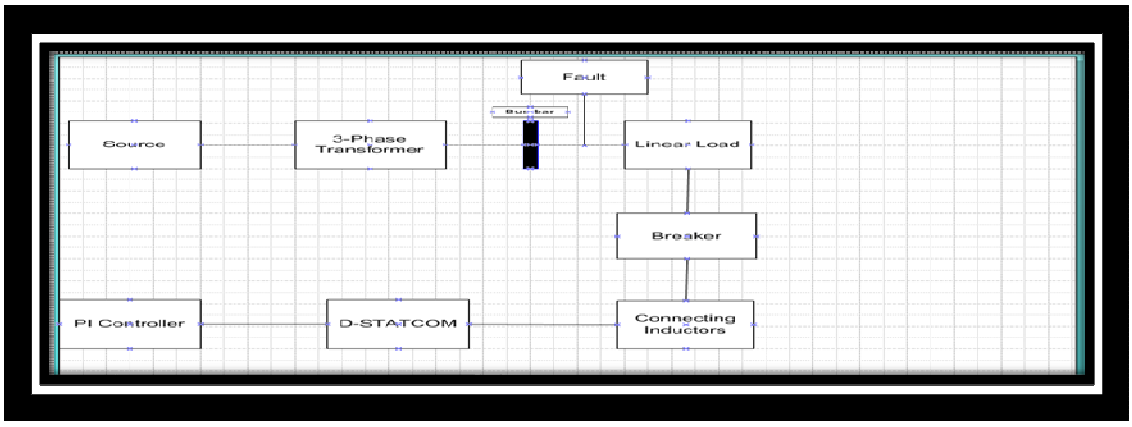


Fig 4: Block Diagram of Simulink Model

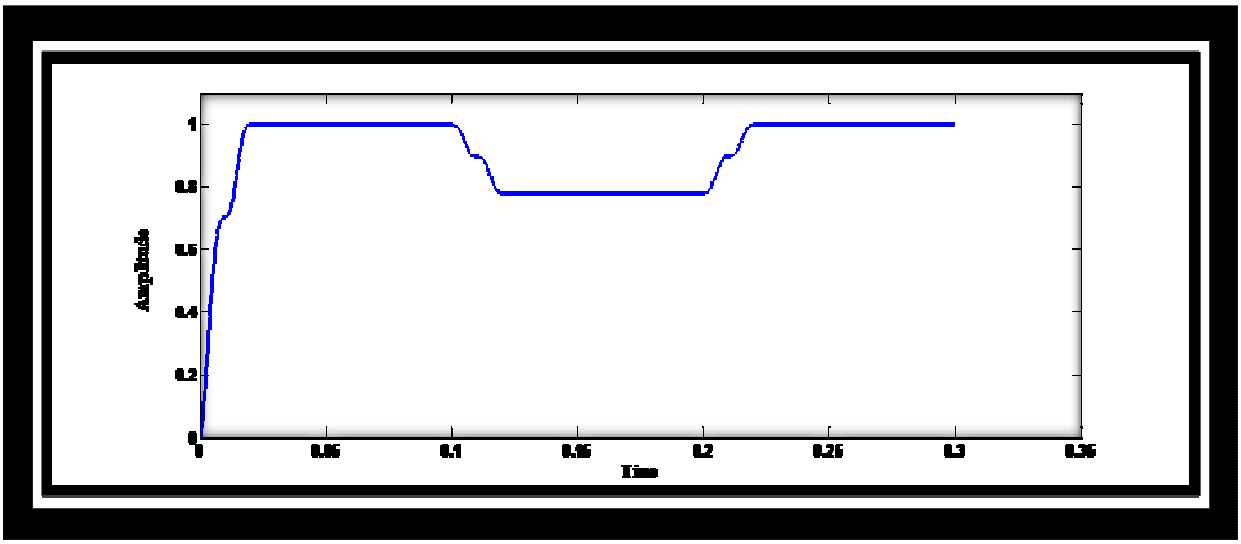


Table 4.1 Results of Voltage Sags for different types of Fault

Fig 4.1(a) Voltage Sag (LL) Fault without inserting DSTATCOM

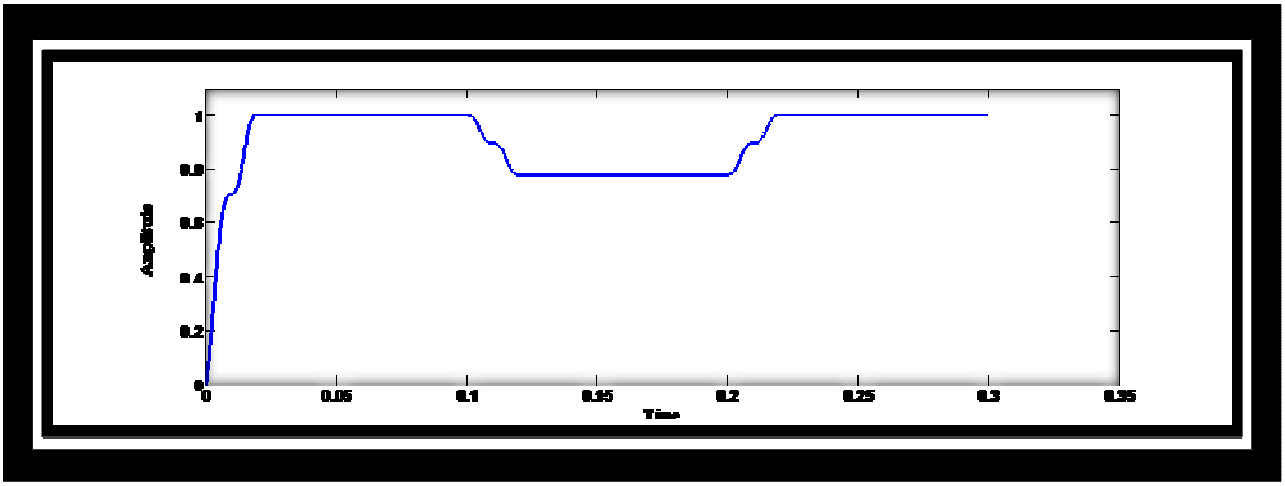


Fig 4.1(b) Voltage Sag (SLG) without insertion of DSTATCOM

MATLAB SIMULINK MODEL	Voltage Sags for **LL** fault (p.u)	Voltage Sags for **SLG** fault (p.u)	Voltage Sags for **DLG** fault (p.u)	Voltage Sags for **TLG** fault (p.u)
Without D-STATCOM	0.7833	0.8679	0.7833	0.7515

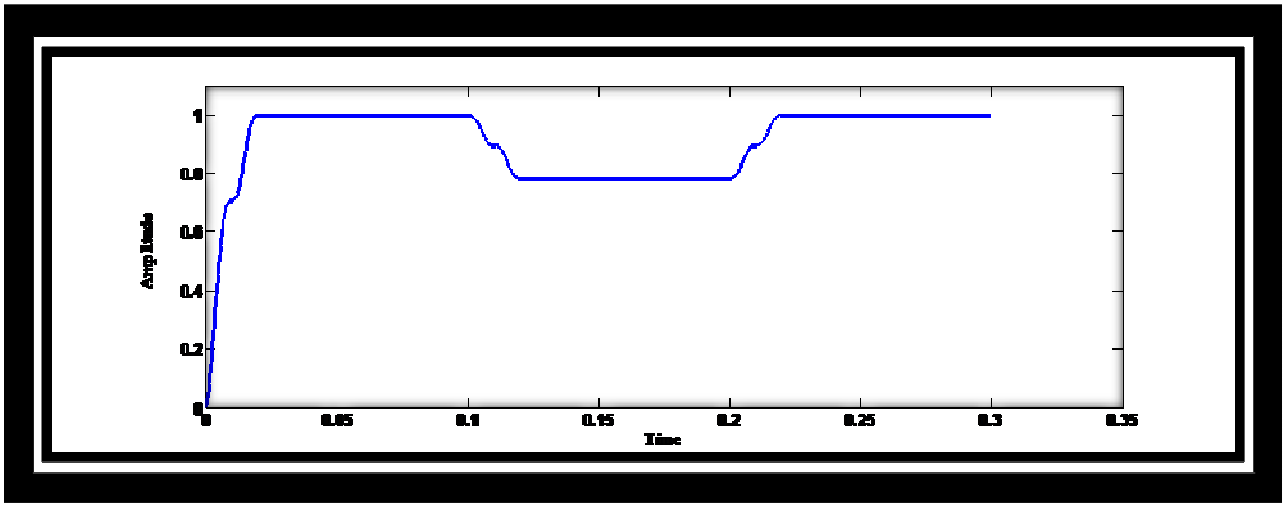


Fig 4.1(c) Voltage Sag (DLG) without insertion of DSTATCOM

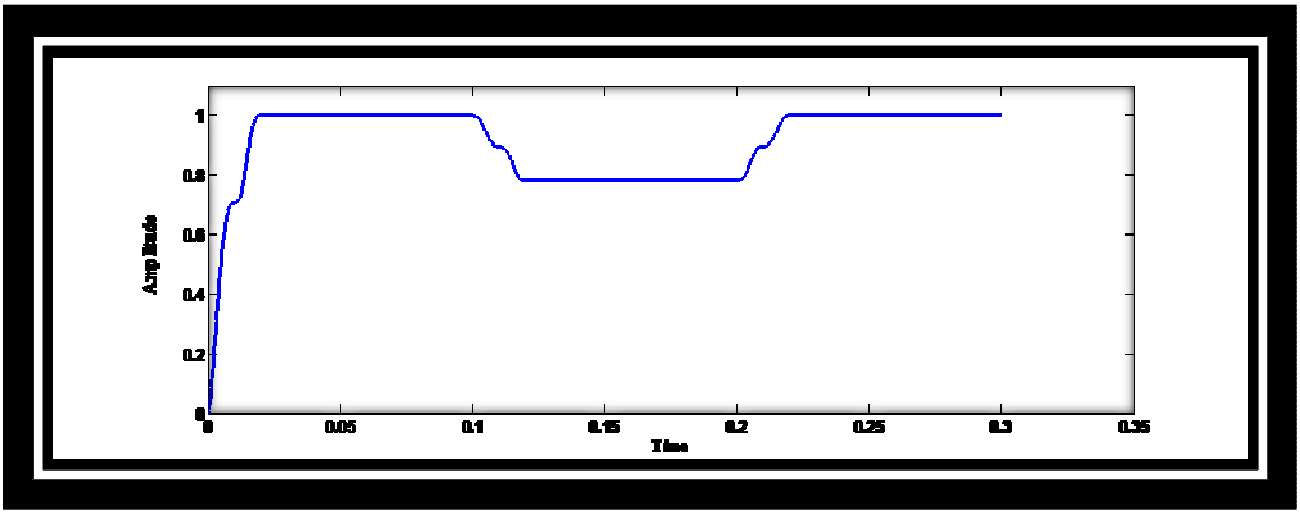


Fig 4.1(d) Voltage Sag (TLG) without insertion of DSTATCOM

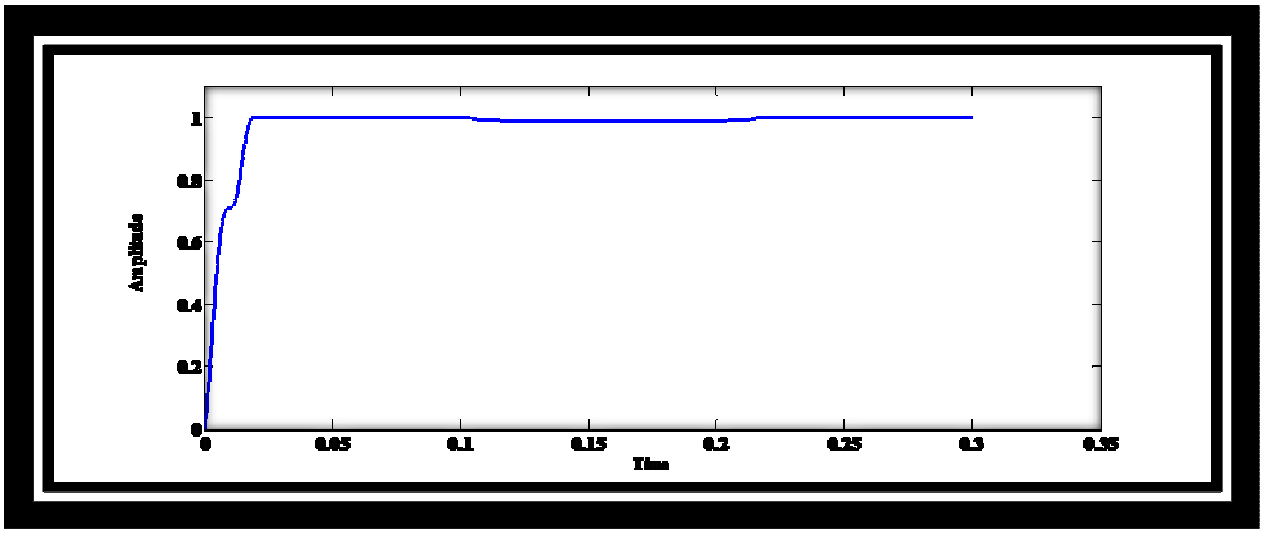
4.2 With insertion of D-STATCOM

Table 4.2 Results of Voltage Sags for different types of Fault

MATLAB SIMULINK MODEL	Voltage Sags for **LL** fault (p.u)	Voltage Sags for **SLG** fault (p.u)	Voltage Sags for **DLG** fault (p.u)	Voltage Sags for **TLG** fault (p.u)
With D-STATCOM	0.9858	0.9863	0.9858	0.9543

Fig 4.2(a) Voltage Sag (LL fault) by inserting D-STATCOM

Fig 4.2(b) Voltage Sag (SLG fault) by inserting D-STATCOM



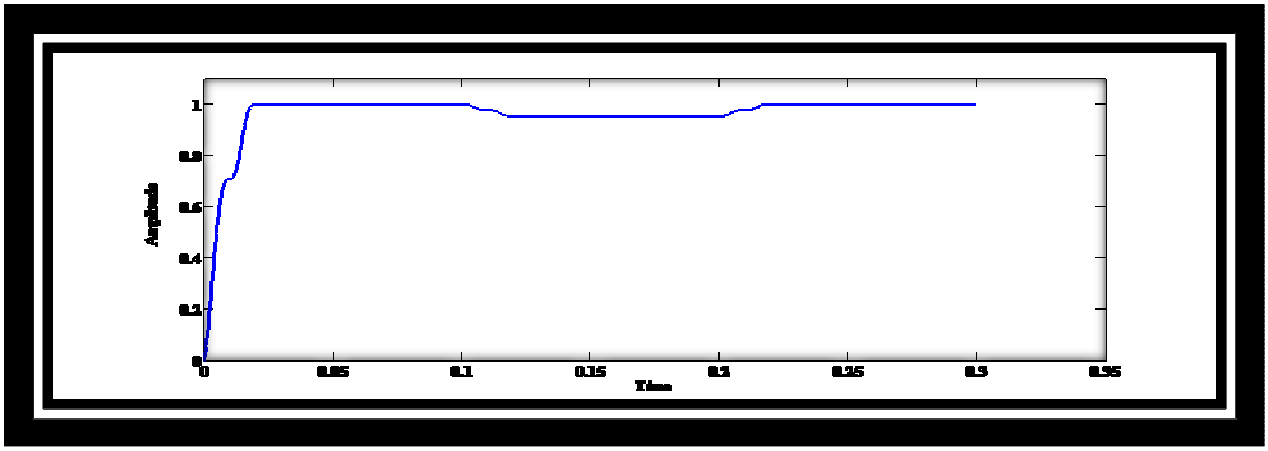


Fig 4.2(c) Voltage Sag (DLG fault) by inserting D-STATCOM

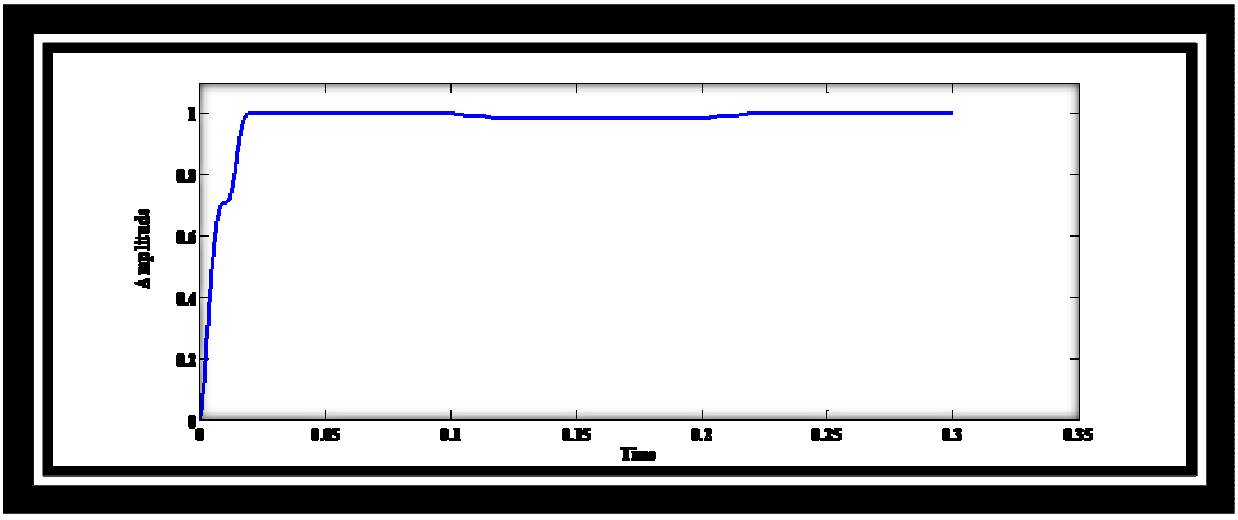


Fig 4.2(d) Voltage Sag (TLG Fault) by inserting D-STATCOM

4.3 With insertion of Active Shunt Filter

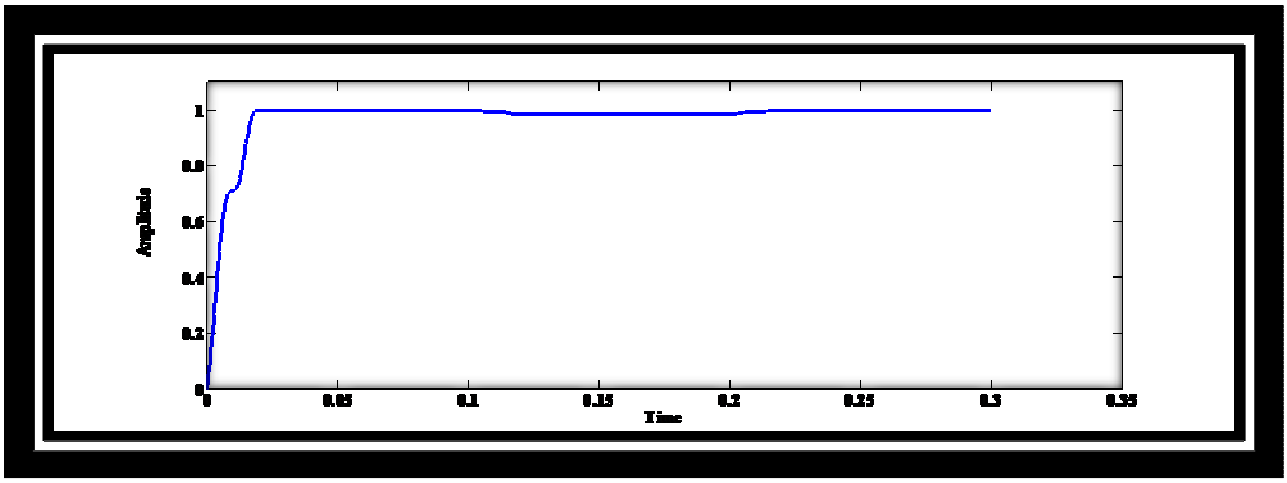


Table 4.3 Results with insertion of active filter

MATLAB SIMULINK MODEL	Voltage sag for LL fault (p.u)	Voltage sag for SLG fault (p.u)	Voltage sag for DLG fault (p.u)	Voltage sag for TLG fault (p.u)
With filter	0.6831	0.6823	0.6341	0.6831

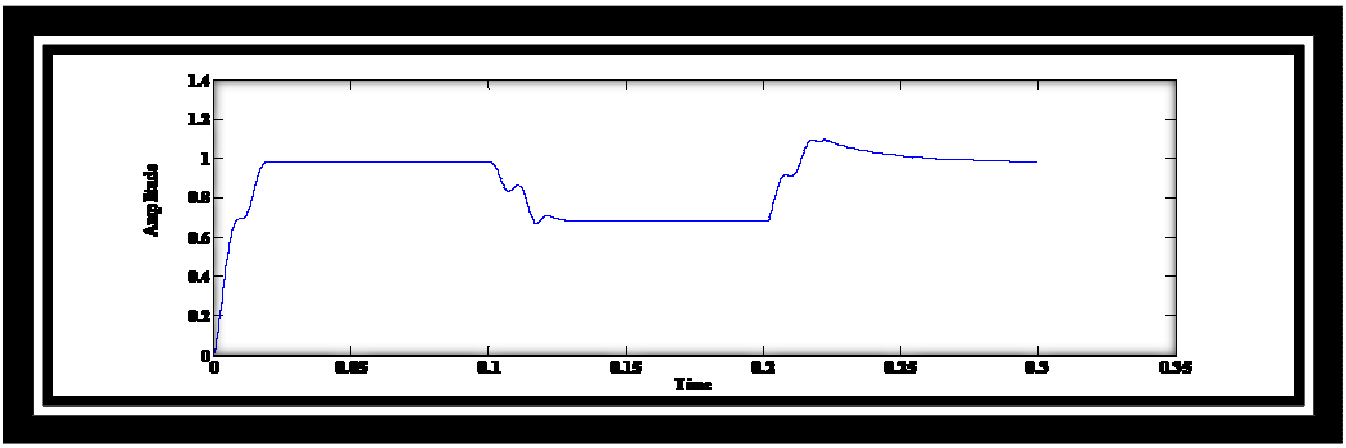


Fig 4.3(a) Voltage Sag (LL fault) by inserting Active Filter

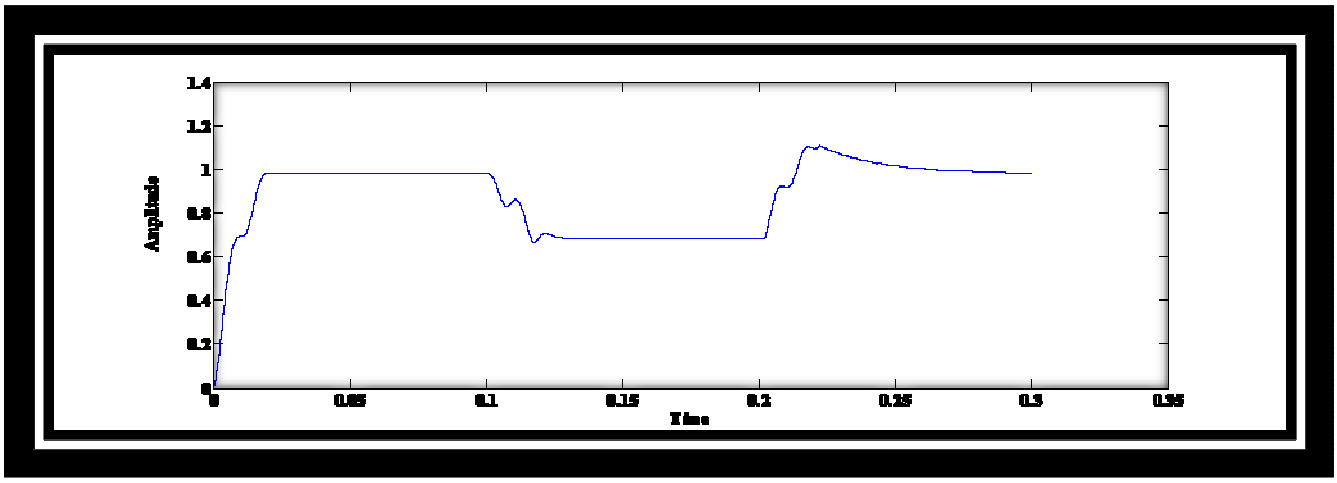


Fig 4.3(b) Voltage Sag (SLG fault) by inserting Active Filter

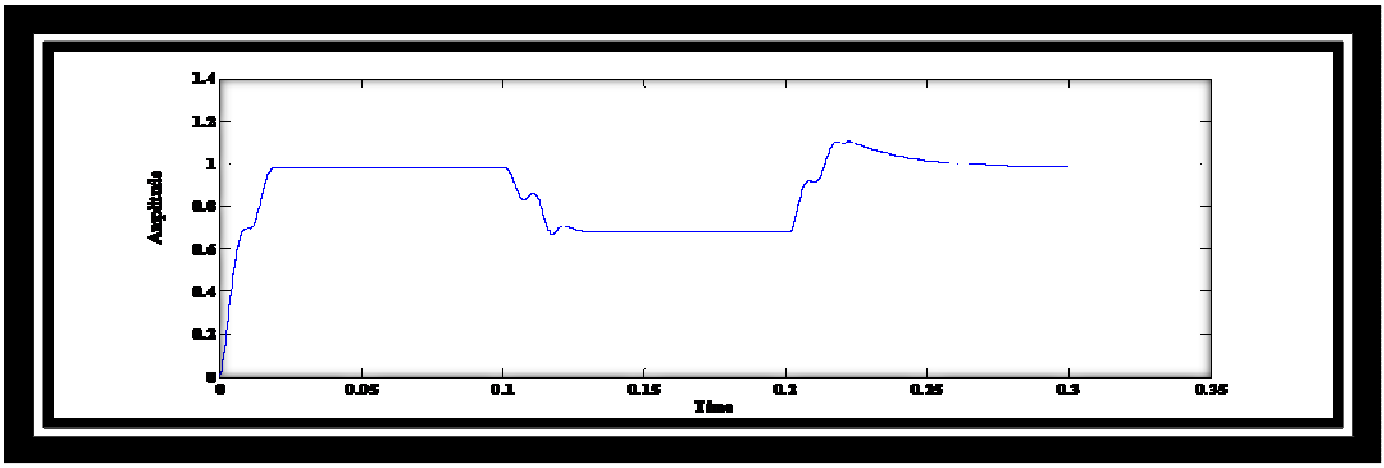


Fig 4.3(c) Voltage Sag (DLG Fault) by using Active Filter

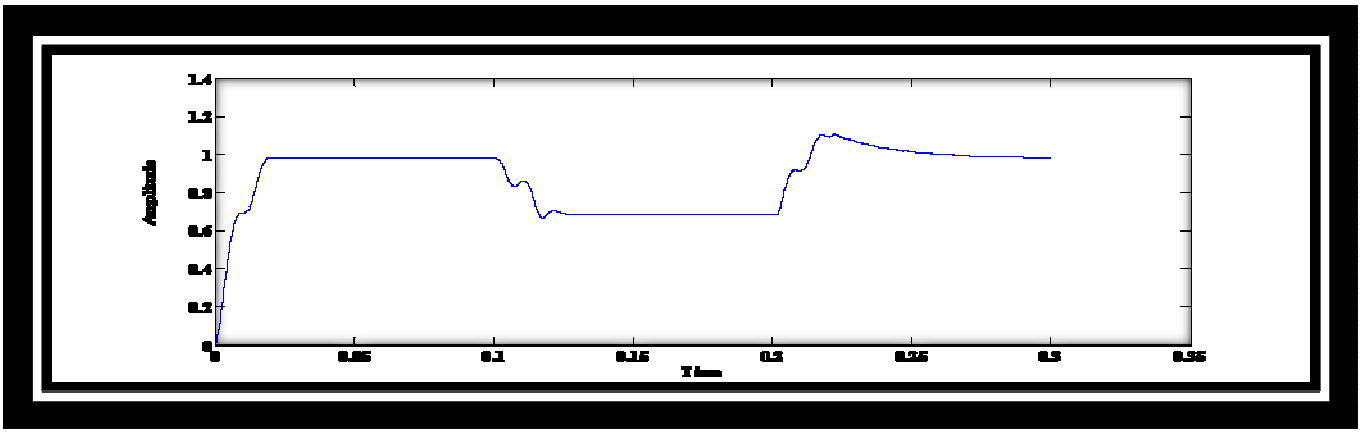


Fig 4.3(d) Voltage Sag(TLG Fault) by using Active Filter

Fig 4.1(a) to Fig4.1(d), Fig4.2(a) to Fig 4.2(d), & Fig4.3(a) to Fig 4.3(d) shows the results of test system for different types Faults .

Table 4: Comparison chart of Voltage Sags by with and without DSTATCOM & with Active Filter

MATLAB SIMULINK MODEL	Voltage sag for LL fault (p.u)	Voltage sag for SLG fault (p.u)	Voltage sag for DLG fault (p.u)	Voltage sag for TLG fault (p.u)
Without DSTATCOM	0.7833	0.8679	0.7833	0.7515
With DSTATCOM	0.9858	09863	0.9858	0.9543
With Active Filter	0.6831	0.6823	0.6349	0.6831

5. CONCLUSION

This paper has presented the power quality problems such as voltage Sags. The objective of this work is to study the performance of D-STATCOM for mitigating voltage sag (dip) and to improve the power quality in distribution network. The investigation is made on different fault conditions in a distribution network.. In this work the investigation is composed of power system distribution network with and without D-STATCOM and with Active Filters. So it can be concluded that D-STATCOM effectively improves the power quality in distribution network than the Active Filters.

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