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# Enhancement of Voltage Profile in Transmission Line using D-STATCOM and DVR

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***Abstract*—** Now a day, for reliable operation and proper utilization of electrical energy, continuous flow of electrical power between suppliers and consumers is very essential. In this paper we have highlighted the voltage profile as a power quality issue in transmission system. Poor power quality is a result of voltage sags, voltage swells and poor voltage regulation. These factors degrade the power quality by deviating from their standard specifications. It is necessary for modern power engineers to mitigate these power quality issues. So, various techniques have been developed for mitigation of these power quality issues. To mitigate voltage profile disturbances we have shown the application of Dynamic Voltage Restorer (DVR), and D-STATCOM. Voltage related issues sags and swells are by-product of symmetrical as well as unsymmetrical faults of electrical power system. The excessive reactive power demand in the line degrades the voltage magnitude from its specified limit. These entire factors affect the standard of power quality which reduces reliability of electric supply. We have shown MATLAB results to elaborate the operation of D-STATCOM and application of DVR.

***Index Terms*—DVR, D STATCOM, Voltage profile improvement.**

## I. INTRODUCTION

Now a day, for reliable operation and proper utilization of electrical energy, continuous flow of electrical power between suppliers and consumers is very essential. So far various techniques have been developed for mitigation voltage profile issues. To mitigate voltage profile disturbances we have shown the application of D-STATCOM and Dynamic Voltage Restorer (DVR). As we know Voltage related issues sags and swells are by-product of symmetrical as well as unsymmetrical faults of electrical power system. We have shown some MATLAB results to elaborate the operation of D-STATCOM. The other power quality mitigation techniques do not fall into the scope of this paper.

**Voltage sags:** A decrease of the normal voltage level between 10 and 90% of the nominal rms voltage at the power frequency, for durations of 0.5 cycles to 1 minute is called voltage sag. Fig. 2 shows the waveform of 4 cycle voltage sag. Unnecessary tripping of contactors, electromechanical relays, malfunction of information technology equipment and disconnection and loss of efficiency in electrical rotating machines are consequences of voltage sag.

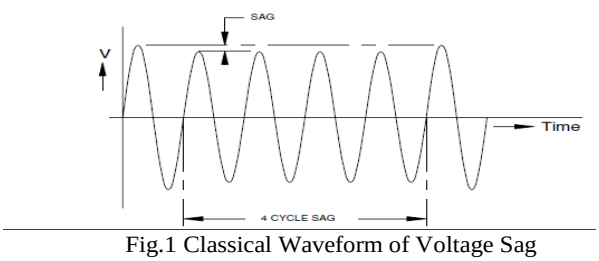


Fig.1 Classical Waveform of Voltage Sag

**Voltage swells:** It is a momentary increase of the voltage, at the power frequency with duration of more than one cycle and typically less than a few seconds. Fig.3 shows the waveform of voltage swell for 2.5 cycles. Flickering and data loss are main cause of voltage swells.

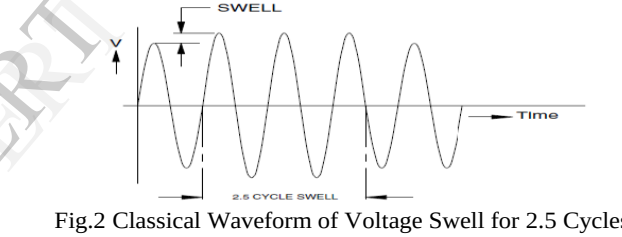


Fig.2 Classical Waveform of Voltage Swell for 2.5 Cycles

## II. D-STATCOM FOR VOLTAGE PROFILE MITIGATION ISSUES

D-STATCOM is a normal static compensator which is used at distribution level. It is a solid state power converter version of SVC. D-STATCOM is a shunt connected reactive power injecting device. This reactive power injection helps in maintaining the voltage magnitude of distribution level. It consists of following parts:

1. Energy source
2. Voltage source inverter
3. Coupling transformer

Generally, capacitor is used as an energy source which is charged with D.C. voltage. Voltage source inverter (VSI) converts D.C. voltage of capacitor into A.C. voltage of proper magnitude and phase. The inverter output terminals are connected to bus through coupling transformer. Fig.3 shows power diagram for D-STATCOM. Such configuration allows the device to absorb or generate active and reactive power. The fast control of the VSC permits the STATCOM to have a rapid rate of response.

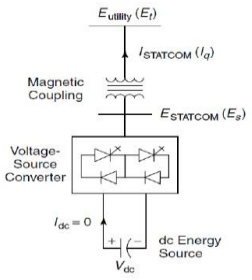


Fig. 3 power diagram for D-STATCOM

## III. TESTING OF D-STATCOM IN MATLAB/SIMULINK

The Test System details for D-STATCOM are mentioned in Table 1.

| **Parameters** | **Values** |
|---|---|
| Input Voltage | 11 kV, 50Hz |
| Source Impedance | 0.968Ω, 0.03H |
| Line Impedance | 0.4 Ω, 0.003H |
| DC Voltage | 3000 V |
| Capacitor | 2000 µF |
| Load 1 | 0.5MW, 0.5MVAr |
| Load 2 | 0.1MW, 0.9MVAr |

Table 1 the test system details of single line diagram used

To verify the performance of the DSTATCOM, Load 1 is connected at bus 2 during the simulation. The sequence of events simulated is explained as follows. Initially, load 1 connected at bus 2. At t=0.1 s, the switch S2 is closed so that load 2 is applied. During these events, the terminal voltage of bus 2 decreases showing the effect of sag. Now the same simulation is simulated with DSTATCOM. The DSTATCOM along with the Distribution System is simulated in MATLAB / SIMULINK Software and the diagram is shown in Fig 4 below.

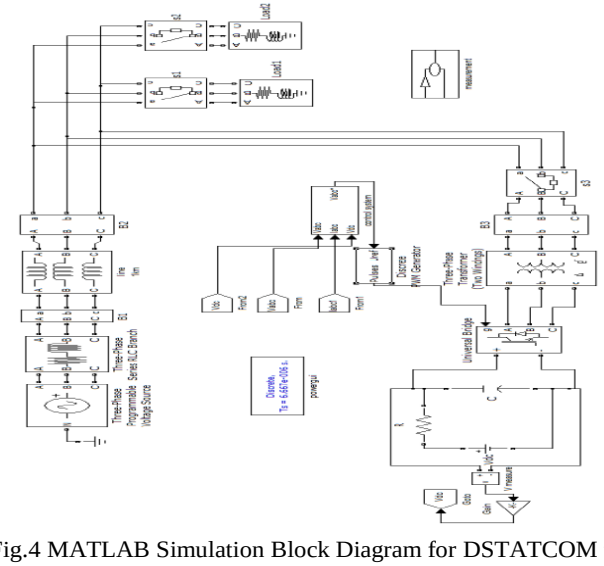

Fig.4 MATLAB Simulation Block Diagram for DSTATCOM test system

Here we have shown MATLAB SIMULATION RESULTS for instantaneous voltage measured at load side without and with D-STATCOM in Fig.5 and Fig.6 respectively.

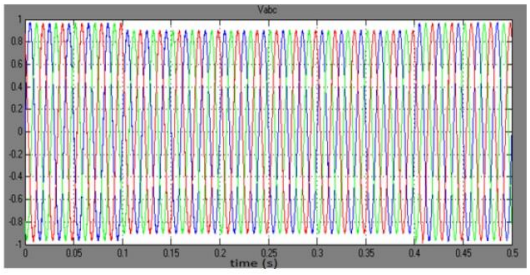


Fig.5 Instantaneous voltage Vabc (pu) measured at load side without D-STATCOM

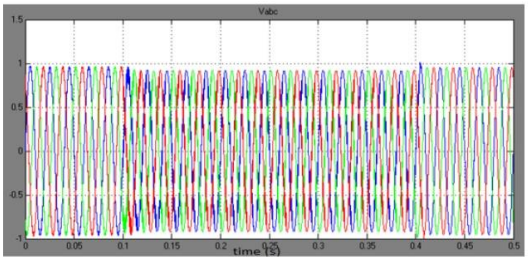


Fig.6 Instantaneous voltage Vabc (pu) measured at load side with D-STATCOM

From these test results in MATLAB we can observe that the voltage profile of transmission line is improved with the use of DSTATCOM.

## IV. ROLE OF DVR IN MITIGATION OF VOLTAGE PROFILE ISSUES

The main power quality issues from voltage point of view are sags, swells and interruptions. These issues are not new for research in power quality field. But with the passage of time and due to innovation of new ideas and technologies the methods of dealing these issues have been changed continuously. Dynamic Voltage Restorer (DVR) is the important tool of power system, which is used for mitigation of PQ issues related to voltage. Dynamic Voltage Restoration (DVR) is a method and apparatus used to sustain, or restore, an operational electric load during sags, or swells, in voltage supply. The Dynamic Voltage Restorer (DVR) is fast, flexible and efficient solution to voltage sag problem. We can consider it as an interfacing between utility and consumer. The voltage level can be maintained near to its specified limit by injecting voltage of proper magnitude, phase angle and frequency in feeder. This can be easily done by DVR. Dynamic Voltage Restorer (DVR) maintains the terminal voltage at end user side within specified range when the source voltage changes from its specified limit.

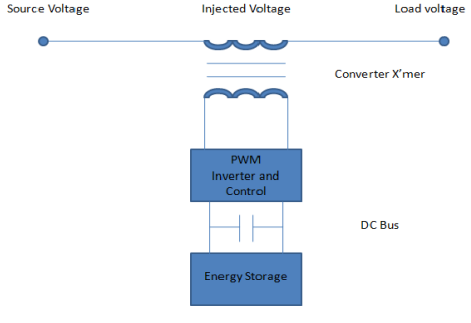


Fig.7 Block Diagram of DVR

It consists of following parts:
1. Energy storage
2. Capacitor
3. Inverter
4. Converter transformer

Fig.7 shows the block diagram for DVR. The reactive power is received by capacitor during normal operation. But when the voltage sag is detected, the capacitor starts injecting power to inverter. The inverter output provides the voltage of proper magnitude, phase angle and frequency to the feeder. Thus it is the controller of DVR tool. The proper injection of voltage nullifies voltage sags and swells from load terminal voltage. The voltage sag detection is done by appropriate algorithms which have real time working criteria. The sag detection algorithm does not fall into the scope of this paper. DVR mitigates sags created by symmetrical as well as unsymmetrical faults. Energy storage system maintains the constant voltage across capacitor terminals. The fault current level can also be reduced to considerable extent by injecting a voltage which opposes source voltage during fault. So DVR is an important tool for mitigation of Power Quality (PQ) issues related to voltage.

## V. CONCLUSION

This paper covers the basic concept of power quality related to voltage profile.. The operation of D-STATCOM and the effect of D-STATCOM are presented with their respective MATLAB SIMULATION RESULTS. The application of DVR for improvement of voltage regulation is also discussed with this research.



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