International Journal For Technological Research In Engineering
Volume 3, Issue 8, April-2016 *ISSN (Online): 2347 - 4718*

MODELLING AND SIMULATION FOR FAULT MITIGATION USING DVR AND DSTATCOM

Vinit .H. Solanki[1], Prof. Ankit Gajjar[2]
[1]PG Scholar, [2]Assistant Professor, Electrical Department, Kalol Institute of Technology & Research Centre, Kalol, Gujarat, India

Abstract: The electrical energy is one of the easily used forms of energy. It can be easily converted to other forms of energy. With the advancement of technology, the dependency on the electrical energy has been increased greatly. Computer and telecommunication networks, railway network banking, post office, life support system are few application that just cannot function without electricity. At the same time these applications demand qualitative energy. However, the quality of power supplied is affected by various internal and external factors of the power system. The presence of harmonics, voltage and frequency variations deteriorate the performance of the system. In this paper the frequently occurring power quality problem- voltage variation is discussed. The voltage sag/dip is the most frequently occurring problem. There are many methods to overcome this problem. Among them the use of FACT devices is an efficient one. This paper presents an overview of the FACT devices like- DVR, D-STATCOM for fault mitigating like single line to ground fault . Each one of the above device is studied and analyzed. And also the control strategies to control these devices are presented in this project. The proposed control strategies are simulated in MATLABSIMULINK environment and the results are presented in this paper. A comparative study based on the performance of these devices in mitigating voltage sag is also presented.

I. INTRODUCTION

Overview:-

Power quality is one of the major concerns in modern power system. It has become important especially with the introduction of sophisticated devices, whose performance is very sensitive to the power quality problems. In modern industries, load equipment uses electronic controllers which are sensitive to poor voltage quality and will shut down if the supply voltage is depressed and may mal-operate in other ways if harmonic distortion of the supply voltage is excessive. Power quality problems is an occurrence manifested as non-standard voltage, current or frequency, the result in failure or miss operation of end user equipment. Much of this modern load equipment itself uses electronic switching devices which then can contribute to poor network voltage quality. The introduction of competition into electrical energy supply has created greater commercial awareness of the issues of power quality while equipment is now readily available to measure the quality of the voltage waveform and so quantify the problem.

The quality of the power is affected if there is any deviation in the voltage and frequency values at which the power is being supplied. This affects the performance and life time of the end user equipment. Whereas, the continuity of the power supplied is affected by the faults which occur in the power system. So to maintain the continuity of the power being supplied, the faults should be cleared at a faster rate and for this the power system switchgear should be designed to operate without any time lag. The power quality is affected many problems which occur in transmission system and distribution system. Some of them are like- harmonics, transients, sudden switching operations, voltage fluctuations, frequency variations etc. These problems are also responsible in deteriorating the consumer appliances. In order to enhance the behaviour of the power system, these all problems should be eliminated. To full fill consumer requirement many efforts have been taken by utilities, some consumers require a level of power quality higher than the level provided by modern electric networks. This implies that some Measures must be taken in order to achieve higher levels of power quality. The FACTS devices and Custom power devices are introduced to electrical system to improve the power quality of the electrical power. DVR, STATCOM/DSTATCOM, ACTIVE FILTERs, AUTOTRANSFORMER, UPQC etc are some of the devices used to improve the power quality of the voltage and current. With the help of these devices we are capable to reduce the problems related to power quality. The power quality is affected many problems which occur in transmission system and distribution system. Some of them are like- harmonics, transients, sudden switching operations, voltage fluctuations, frequency variations etc. These problems are also responsible in deteriorating the consumer appliances. In order to enhance the behaviour of the power system, these all problems should be eliminated.

II. STUDY OF DVR AND DSTATCOM FOR VOLTAGE SAG MITIGATION

A. Dynamic Voltage Restorer (DVR)

The DVR is a power quality device, which can protect these industries against the bulk of these disturbances, i.e. voltage sags and swells related to remote system faults. A DVR compensates for these voltage excursions, provided that the supply grid does not get disconnected entirely through breaker trips. Modern pulse-width modulated (PWM) inverters capable of generating accurate high quality voltage waveforms form the power electronic heart of the new Custom Power devices like DVR. Because the performance of the overall control system largely depends on the quality of the applied control strategy, a high performance controller with fast transient response and good steady state characteristics is required. The main considerations for the control system of a DVR include: sag detection, voltage reference generation and transient and steady-state control of the injected voltage.

The typical power quality disturbances are voltage sags, voltage swells, interruptions, phase shifts, harmonics and transients. Among the disturbances, voltage sag is considered the most severe since the sensitive loads are very susceptible to temporary changes in the voltage.

B. Operating principle of DVR:-

The basic principle of operation of the DVR is that by injecting a voltage of required magnitude and frequency in the system restored the load side voltage to desired amplitude frequency as shown in figure.2.1 DVR injects a controlled voltage generated by a forced commuted converter in a series to the bus voltage by means of an injecting transformer. A DC to AC inverter regulates this voltage by sinusoidal PWM technique. All through normal operating condition, the DVR injects only a small voltage to compensate for the voltage drop of the injection transformer and device losses. However, when voltage sag occurs in the distribution system, the DVR control system calculates and synthesizes the voltage required to preserve output voltage to the load by injecting a controlled voltage with a certain magnitude and phase angle into the distribution system. Figure 4.3a shows the phasor diagram in which DVR injects the missing voltage between sag voltage and pre-sag voltage.

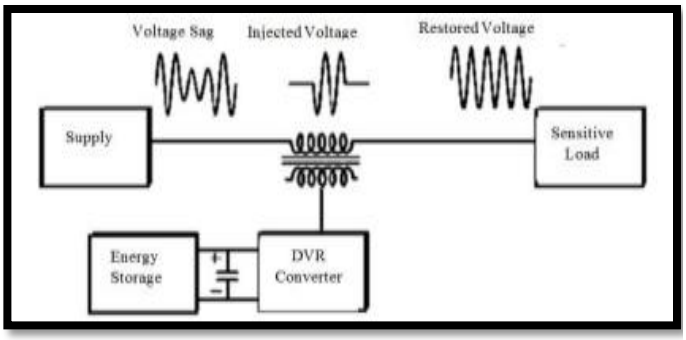


Fig-2.1 Principle of Operation of DVR System

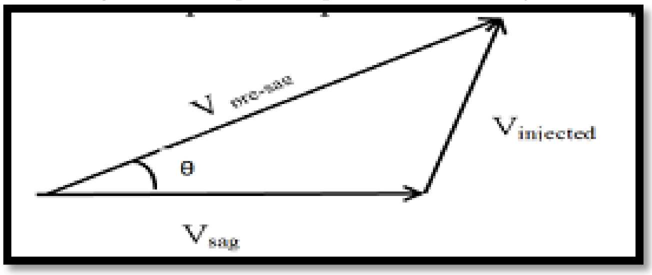


Fig-2.1 (a) Vector Diagram of Operating Principle of DVR

C. Control Strategy:

Control theory introduces feedback loop to overcome the limitations of the open-loop controller. A closed-loop controller uses feedback loop to control outputs of dynamic system. Closed-loop controllers have the following advantages over open-loop controllers:-

- Provides disturbance rejection.
- When the model structure does not match perfectly the real process and the model parameters are not exact, guaranteed performance can be obtained even with model uncertainties.
- Sensitivity will be reduced to parameter variations.
- Unstable processes can be able to stabilize.

Suppose there is an interconnected power system with two or more independently controlled areas and any disturbance may cause a change in frequency of power system which results in instability. In addition the power interchange between the control areas cannot be constant. PI controller design has been implemented to maintain constant voltage at the sensitive load in this report. The PI controller design demand to find out the characteristic equation of the simulation model. It proves to be an effective and efficient method to control the settling time and maintain the stability of the system.

In the simulation model, the two feeder line had been taken to demonstrate the operation of the Dynamic voltage restorer. Dynamic voltage restorer is successful in compensating voltage sag and voltage swell type of power quality problems. For maintaining constant magnitude at the sensitive load end, the PI controller is designed Precisely. In the designing of PI controller, the stability and the step response is checked firstly to ensure about the stability. But the transfer function of the model shows the stability of the system and as its denominator term does not contain any sign change. If there is any sign change then the system will be unstable according to the number of sign changes i.e. if sign changes two times then there will be two roots on the R.H.P of S-plan. If there is no any sign change then the system is having all the roots on L.H.P of S-plan. Thus the characteristic equation of the model plays a very significant role in designing the PI controller.

D. Introduction of DSTATCOM:

Voltage sags is the most important power quality problems faced by many industries and utilities. It contributes more than 80% of power quality (PQ) problems that exist in power systems. Various methods have been applied to reduce or mitigate voltage sags. The conventional methods are by using capacitor banks, introduction of new parallel feeders and by installing uninterruptible power supplies (UPS). However, the PQ problems are not solved completely due to uncontrollable reactive power compensation and high costs of new feeders and UPS.

The D-STATCOM has emerged as a promising device to provide not only for voltage sags mitigation but a host of other power quality solutions such as voltage stabilization, flicker suppression, power factor correction and harmonic control. The D-STATCOM has additional capability to sustain reactive current at low voltage reduce land use and can be developed as a voltage and frequency support by replacing capacitors with batteries as energy storage. Distribution Static Compensator is in short known as D-STATCOM. It is a power electronic converter based device used to protect the distribution bus from voltage unbalances. It is connected in shunt to the distribution bus generally at the PCC.

4.14.1Basic Structure:

D-STATCOM is a three-phase and shunt connected power electronics based device. It is connected near the load at the distribution systems. The major components of a D-STATCOM are shown in Fig. 2.2. It consists of a dc capacitor, three-phase inverter, ac filter, coupling transformer and a control strategy. The basic electronics block of the D STATCOM is the voltage-sourced inverter that converts an input dc voltage into a three-phase output voltage at fundamental frequency.

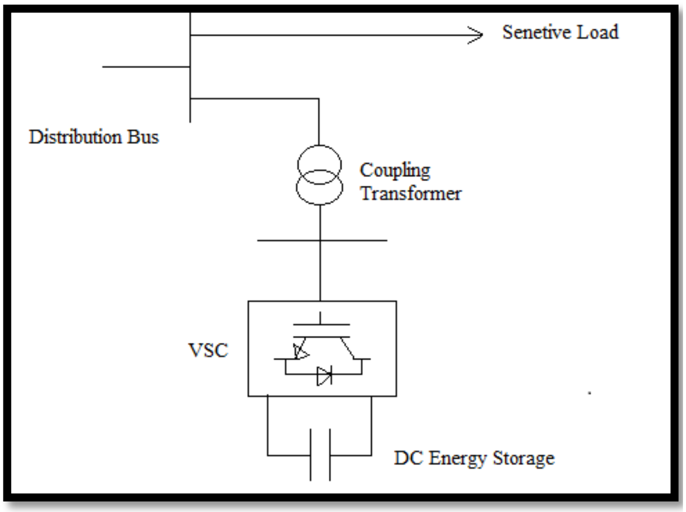


Fig-2.2 DSTATCOM

Voltage Source Converters (VSC)

Converter used here is a voltage source inverter (VSI). It is a power electronic device consisting of IGBTs and a DC storage unit. VSI is used to generate three phase AC voltage at any required magnitude, phase and frequency to compensate the load voltage at the required value.

LC Filter

An LC filter is used for decreasing harmonics and matching inverter output impedance to enable multiple parallel inverters to share current. The LC filter is selected as per the type of the system and the harmonics present at the output of the inverter.

DC-Energy storage:

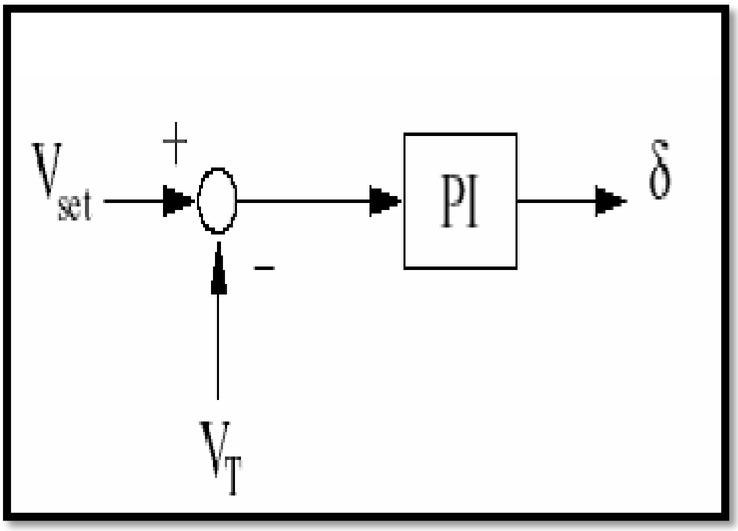
The function of this part is to supply the necessary energy to the VSC for converting DC to AC signal. Batteries are most widely used DC storage unit. The amount of voltage which has to be compensated determines the capacity of the battery.

Coupling Transformer:

It is used to couple the VSC to the distribution line. The high voltage side is normally connected in shunt with the distribution network while the power circuit of the DSTATCOM is connected to the low voltage side [13]. The DSTATCOM inject the current which is required for the compensation from DC side of the inverter to the distribution network through the injection transformer. It also isolates the line from the VSC.

Control Strategy:

The aim of the control scheme is to maintain constant voltage magnitude at the point where a sensitive load is connected, under system disturbances. The control system only measures the r.m.s voltage at the load point, i.e., no reactive power measurements are required. The VSC switching strategy is based on a sinusoidal PWM technique which offers simplicity and good response. Since custom power is a relatively low-power application, PWM methods offer a more flexible option than the Fundamental Frequency Switching (FFS) methods favoured in FACTS applications. Besides, high switching frequencies can be used to improve on the efficiency of the converter, without incurring significant switching losses. The controller input is an error signal obtained from the reference voltage and the value rms of the terminal voltage measured. Such error is processed by a PI controller the output is the angle δ, which is provided to the PWM signal generator. It is important to note that in this case, indirectly controlled converter, there is active and reactive power exchange with the network simultaneously: an error signal is obtained by comparing the reference voltage with the rms voltage measured at the load point. The PI controller process the error signal generates the required angle to drive the error to zero, i.e., the load rms voltage is brought back to the reference voltage.



Equivalent circuit of DSTATCOM

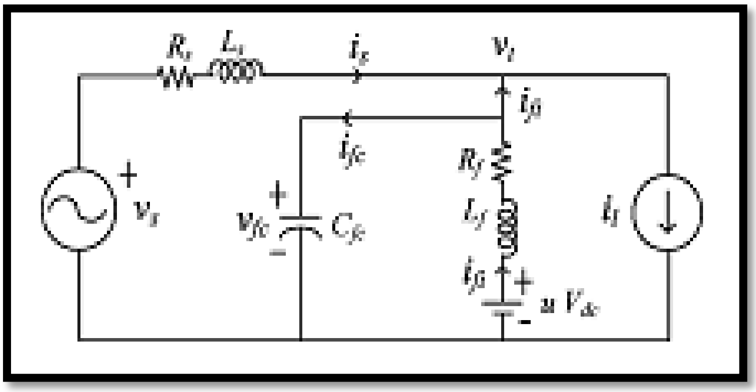


Fig. 2.3 Single-phase equivalent circuit of DSTATCOM

Fig. 2 shows the single-phase equivalent circuit. Variable u is a switching function, and can be either+1 or -1 depending upon switching state. Filter inductance and resistance are L_f and R_f, respectively. Shunt capacitor C_{fc} eliminates high-switching frequency components

Operating Principle of DSTATCOM

A D-STATCOM is capable of compensating either bus voltage or line current. It can operate in two modes based on the parameter which it regulates [4]. They are-

Voltage Mode Operation:

In this mode, it can make the bus voltage to which it is connected a sinusoid. This can be achieved irrespective of the unbalance or distortion in the supply voltage.

III. MODELLING AND SIMULATION

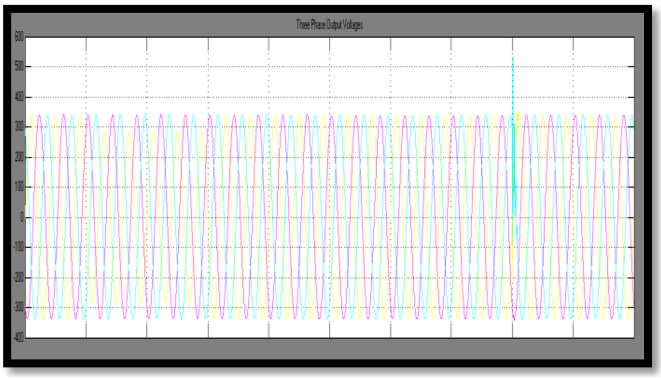
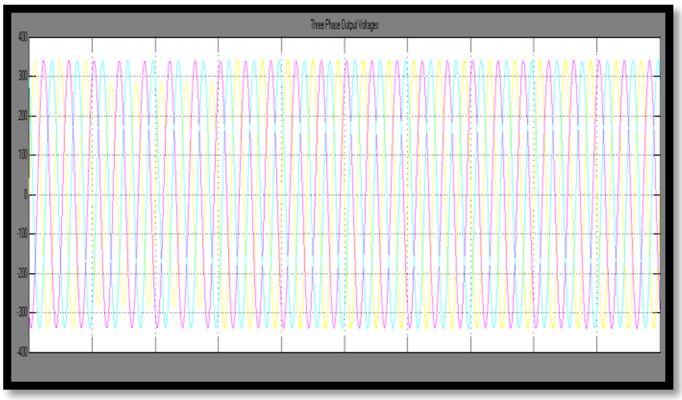


Fig-4.1simulation result for single line to ground fault without DVR and DSTATCOM



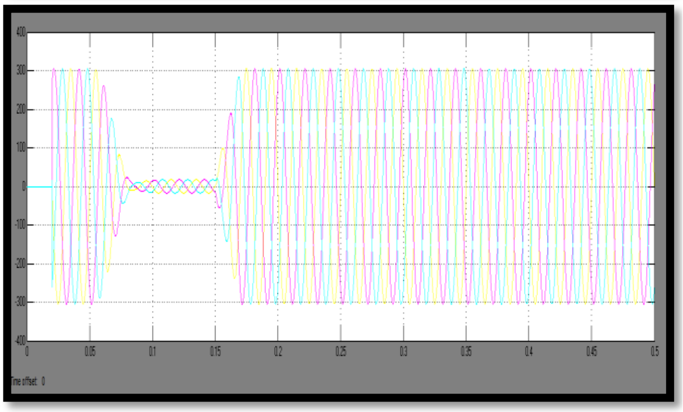


Fig-4.2 simulation result for single line to ground fault when connected DVR

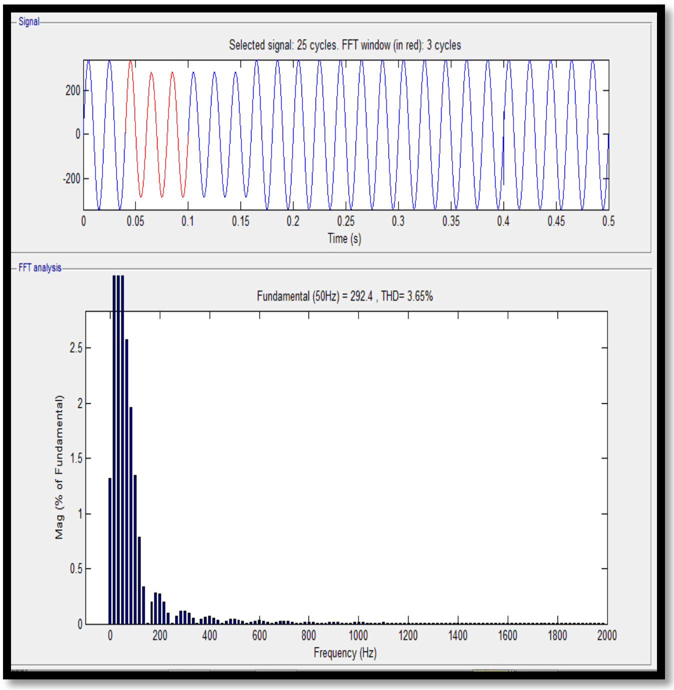


Fig-4.3 FFT analysis for single line to ground fault condition without DVR

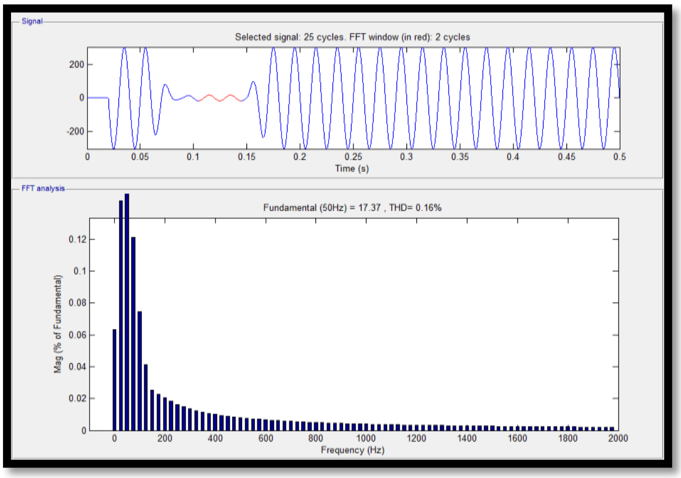
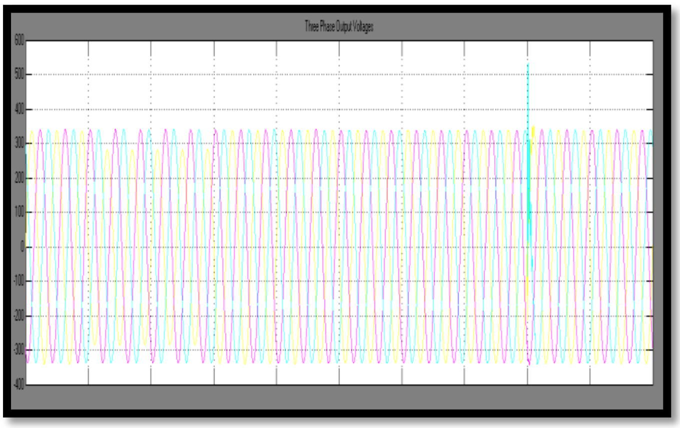


Fig-4.4FFT analysis for single line to ground fault condition with DVR



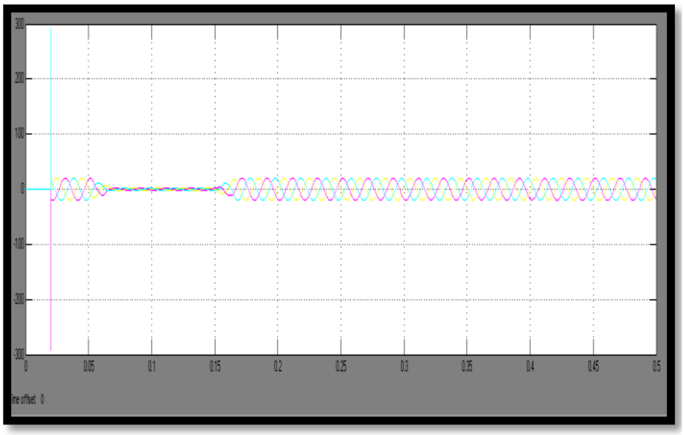


Fig-4.5 simulation result for single line to ground fault when connected DSTATCOM

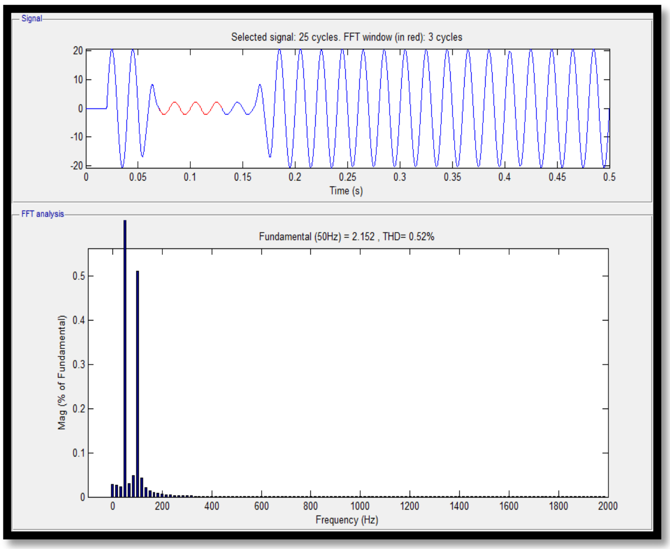


Fig-4.6 FFT analysis for single line to ground fault condition with DSTATCOM

(a) THD comparison

Sr. No.	Condition	THD (%) without any Device	THD (%) using D-STATCOM	THD (%) using DVR
1	Sag	10.43	1.17	0.45
2	Swell	9.95	2.48	0.87
3	Single line to ground fault	3.65	0.52	0.16

Table-4.1-Comparision of DVR and DSTATCOM

IV. CONCLUSION

In this paper the main objectives for the utilization of the studied equipment to mitigate the single line to ground fault using DVR and DSTSTCOM and there is also their comparison is shown. In order to protect critical loads from more sever fault in distribution network. The facility available in MATLAB/SIMULINK is used to carry out extensive simulation study.

By simulating DVR and FFT analysis of Voltage, it can be concluded that, it can give better performance than D-STATCOM because it's dynamic response against voltage sag and swell.

REFERENCES

[1] Rosli Omar and NasrudinAbd Rahim Faculty of Electrical Engineering, University Teknikal Malaysia Melaka, Malaysia Department of Electrical Engineering , Faculty of Engineering , University of Malaya, Kuala Lumpur, Malaysia "Mitigation of Voltage Sags/Swells Using Dynamic Volt Age Restorer (DVR)" in ARPN Journal of Engineering and Applied Sciences VO L.4,NO. 4, JUNE 2009

[2] Christoph Meyer , Student Member, IEEE , Rik W. De Doncker , Fellow, IEEE , Yun Wei Li , Member, IEEE , and FredeBlaabjerg, Fellow, IEEE "Optimized Control Strategy for a Medium-Voltage DVR—Theoretical Investigations and Experimental Results" in IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 23, NO. 6, NOVEMBER 2008

[3] Chris Fitzer, Mike Barnes, Member, IEEE, and Peter Green," Voltage Sag Detection Technique for a Dynamic Voltage Restorer" in IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 40, NO. 1, JANUARY/FEBRUARY 2004

[4] Firouz Badrkhani Ajaei, Saeed Afsharnia, Alireza Kahrobaeian, and Shahrokh Farhangi "A Fast and Effective Control Scheme for the Dynamic Voltage Restorer" in IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 26, NO. 4, OCTOBER 2011

[5] [5]. Michael John Newman,Member, IEEE , Donald Grahame Holmes, Senior Member, IEEE , John Godsk Nielsen, Member, IEEE , and FredeBlaabjerg, Fellow, IEEE "A Dynamic Voltage Restorer (DVR) With Selective Harmonic Compensation at Medium Voltage Level" in IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 41, NO. 6,NOVEMBER/DECEMBER 2005.

[6] H. Ezoji Electrical & Computer Engineering Department, Babol University of Technology, A. Sheikholeslami, Electrical & Computer Engineering Department, Babol University of Technology, M. Tabasi Electrical & Computer Engineering Department, Babol University of Technology, M.M. Saeednia Electrical & Computer Engineering Department, Babol University of Technology "Simulation of Dynamic Voltage Restorer Using Hysteresis Voltage Control " in European Journal of Scientific Research ISSN 1450-216X Vol.27 No.1

(2009), pp.152-166

[7] Mahmoud A. El-Gammal Dean of the Faculty of Engineering, Pharos University in Alexandria, Egypt, Amr Y. Abou-Ghazala, Electrical Engineering Dept., Faculty of Engineering, Alexandria University, Egypt, Tarek I. El-Shennawy, Alexandria National Refining and Petrochemicals Co. (ANRPC), Alexandria, Egypt "Dynamic Voltage Restorer (DVR) for Voltage Sag Mitigation" in International Journal on Electrical Engineering and Informatics - Volume 3, Number 1, 2011

[8] Poh Chiang Loh , Member, IEEE , D Mahinda Vilathgamuwa, Senior Member, IEEE , SengKhai Tang, and HianLih Long "Multilevel Dynamic Voltage Restorer" in IEEE POWER ELECTRONICS LETTERS, VOL. 2, NO. 4, DECEMBER 2004

[9] R.S Pote,SumitA.Borakhde ."Mitigation Voltage Sag Using Dynamic Voltage Restorer Iosr journal of Electrical and Engineering.

[10] sumayya ,shahewar,ravimalothatra,"power quality issues and their mitigation techniques"International Journal of Industrial Electronics and Electrical Engineering, ISSN: 2347-6982

[11] Rupal Singh,Dushyant Kumar Singh."Simulation of D-STATCOM for Voltage Fluctuation.2012 Second International Conference on Advanced Computing & Communication Technologies978-0-7695-4640-7/12 $26.00 © 2012 IEEE

[12] IIendti Masdi; Nornian Mariun; Senan Ma1imud;AzahMohamcd and SaIlehIiudinYusuf.""Design of a Prototype D-Statcom for Voltage Sag Mitigation0-7803-8724-4/04/$20.00 02004 IEEE.

[13] Gabriel R. F. Q. Mafra, Wadaed Uturbey and Braz J. Cardoso Filho, Member, IEEE"Analysis of the Operation of a D-STATCOM in Unbalanced Distribution Systems Under Voltage Disturbances" 2010 IEEE/PES Transmission and Distribution Conference and Exposition: Latin America

