Simulation Of Power Quality Event And Their Mitigation Using DVR

Jatin Kumar[1] , Navneet Das[2], Ratnesh Kumar[3]

[1]Student, Department of Electrical Engineering, Delhi Technological University, India
[2] Student, Department of Electrical Engineering, Delhi Technological University, India
[3]Student, Department of Electrical Engineering, Delhi Technological University, India

Abstract. *Now a days, a major problem which distribution system faces is power quality due to wide application of power electronic equipments. Voltage sag contribute majorly in power quality issues. In voltage sag, RMS voltage decrease between 10% to 90% of rated voltage. Voltage sag increases the losses which ultimately decrease the efficiency of equipment. To simplify these problems, we use DVR to compensate the decrease in voltage level. In this paper we have made two simulation models line fault model and capacitor bank model. A comparison has been made of these two models before and after compensating of these models with DVR.*

Keywords: *power quality, DVR, fault, line fault, capacitor bank model*

1. INTRODUCTION

The most simple and easy form of energy for human uses is electric energy. Electric energy is easy to use and can be moved from one place to another, but it is almost impossible to store any large amounts. It has been recognized as everyday consumer need. In the recent years, due to the modernization of technology, the electric energy has become most important commodity in day-to-day life. Banking, railway networks, telecommunication and computer networks, post offices, medical system and every industry in today's time cannot operate in absence of electric energy.

Power system is the chain of transferring electrical power starting from the generating unit to the load unit. Power grid is the example of power system which supply electrical energy to industries, residence, etc. Electric grid can be mainly divided in three parts first is generating unit, where power is generated, second is transmission where power is transferred from generating end to load end and the last is distribution where power is fed to the load. Power system supply energy to the load to work and to give desired output. The load can vary from a small machine which consume small watt of power, to the very large machine which can consume kilo watts of power. These systems mainly work on AC three phase supply which have been standardized for large scale power system.

2. DYNAMIC VOLTAGE RESTORER

The problems like sag, swell, harmonics and unbalanced voltage compensated by DVR. Both balanced and unbalanced situation can be handled by the DVR without any difficulties. DVR injects the appropriate voltage component in order to maintain constant voltage. DVR is mainly used in devices which are easily affected due to fluctuation in voltage. The main components of DVR are voltage source inverter, filter circuits, series connected Transformer, DC source control and protection system.

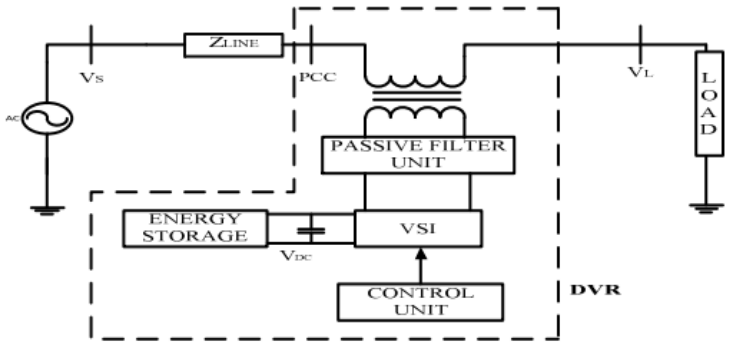

Fig. 1. Structure of DVR

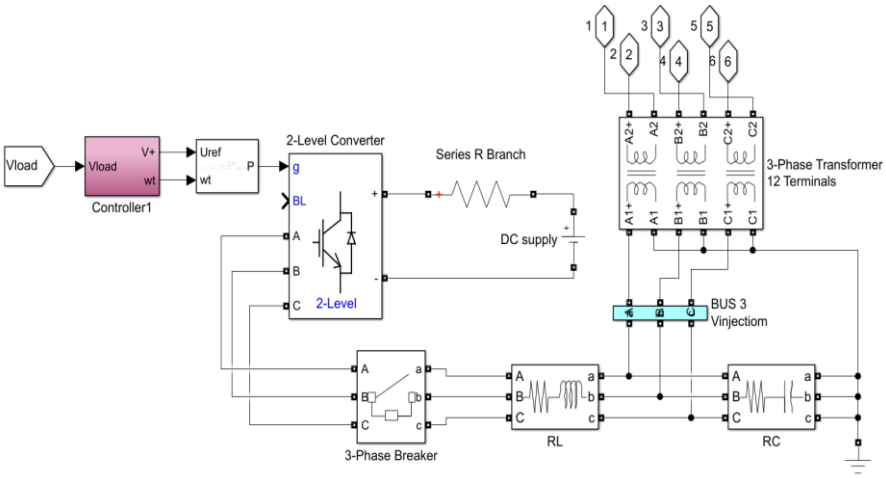

Fig. 2. Simulink model of DVR

2.1 VSI

IGBT or GTO switches are used in DVR, so that it can convert DC input voltage to the ac voltage output in order to inject the voltage into the system to maintain constant voltage. PWM method is used to operate the switches which generate required level of voltage.

2.2 Filter circuit

At the output of voltage source inverter, there is presence of harmonics. In order to eliminate the generated harmonics at the output of VSI, we connect the filter.

2.3 Series Transformer

A series transformer is used to connect DVR with distribution feeder.

2.4 Control unit

The voltage error generated is detected by control unit of DVR which compare it with reference voltage. If error is present, then it sent error to PWM generator which give pulses to the switches of the VSI and required voltage is obtained.

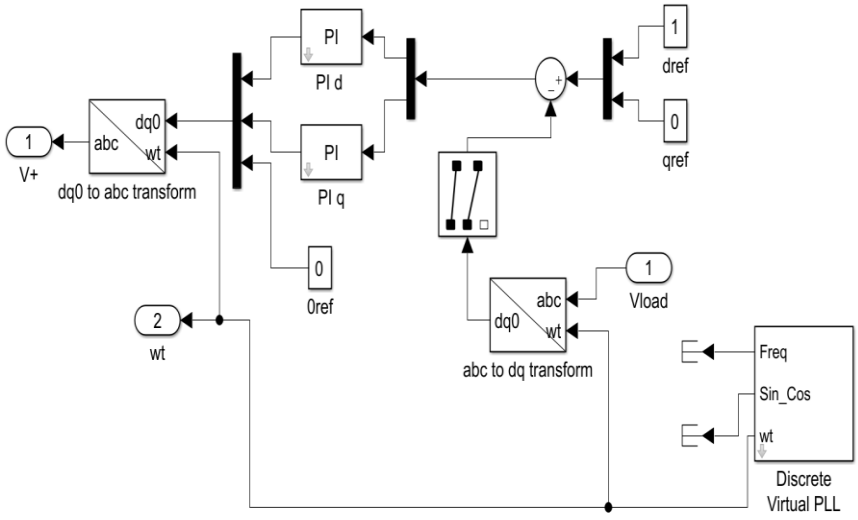

Fig. 3. Control unit of DVR

3. Mitigation

3.1 Mitigation of line fault using DVR:

A 440V three phase voltage source is used for the supplying a three phase RL load connected through a three-phase delta-star connected11KV/415V, 1 MW transformer. A multistage fault take place on load side of the transformer. The fault starts at 0.1 second and end at 0.168 second and then the second fault start at 0.168 second and end at 0.3 second. The DVR is connected to load side of line fault model. In this model, two faults are simulated at load side of the transformer. Due to fault, two phase experiences voltage sag and the remaining phase experiences a slight voltage swell as seen in the Fig. 5.

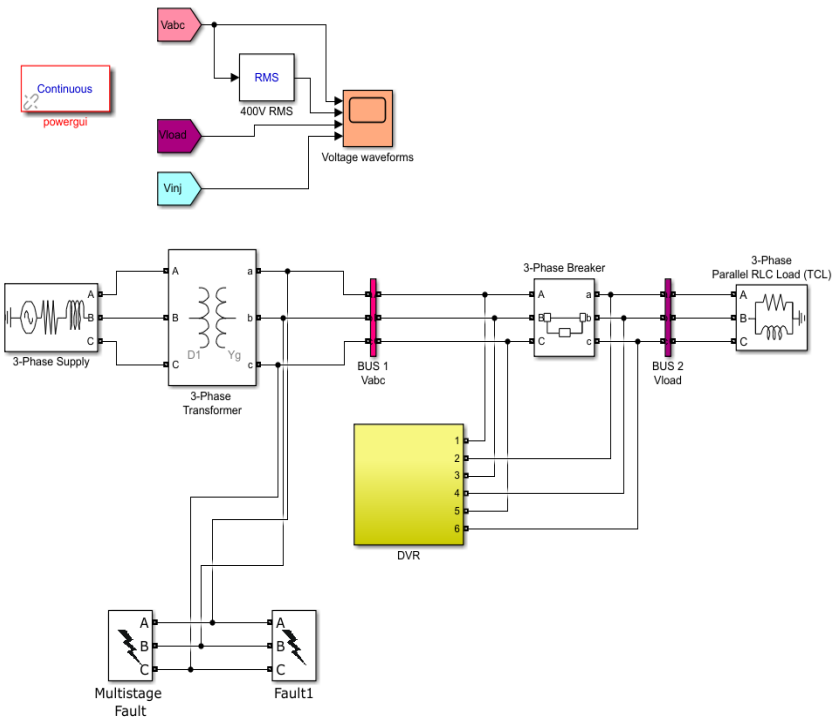

Fig. 4. line fault model with DVR

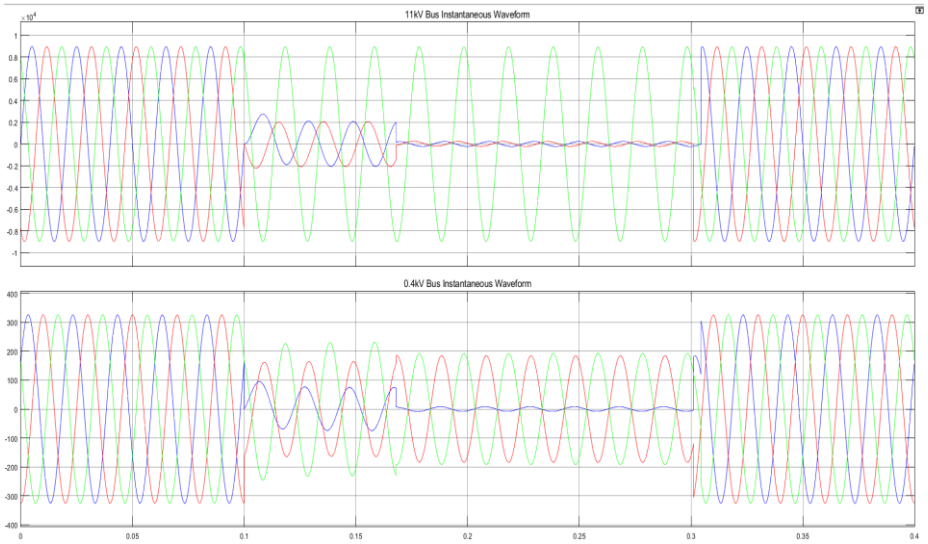

Fig. 5. Output of Line Fault Model Without DVR

In Fig. 6 when the voltage sag occur in phase a and b (represented by red and blue), the DVR start to inject voltage into the load through circuit breaker. The DVR converts stored DC voltage into AC with the help of a three phase inverter. The magnitude of voltage injected can be easily measured in Simulink. The load voltage is therefore maintained constant and the load is protected from sudden variations in supply voltage.

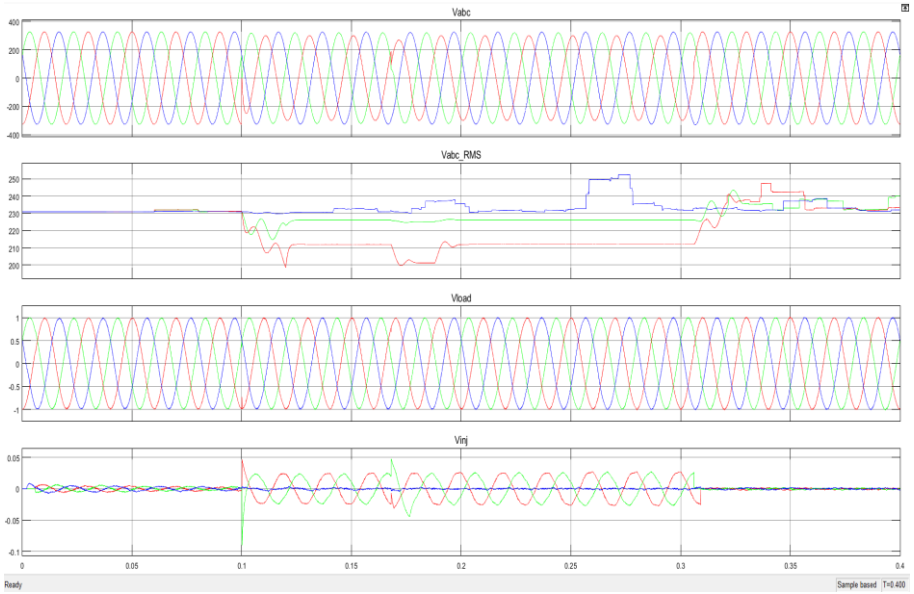

Fig. 6. output of line fault model with DVR

3.2 Mitigation of Capacitor bank energizing model using DVR:

400V three stage voltage is being provided to the RL load from source to the Delta-Star transformer of 11KV/400V (rms), 1MW rating and transformer to the circuit breaker which is initially closed and finally to the RL load. Two capacitor bank models are connected through the circuit breaker which is initially open. One capacitor bank is connected on the source side and other at the load side of transformer to simulate the voltage transient. In Fig. 7 it can be seen that the voltage transient take place, whenever the three phase circuit breaker is closed at capacitor bank.

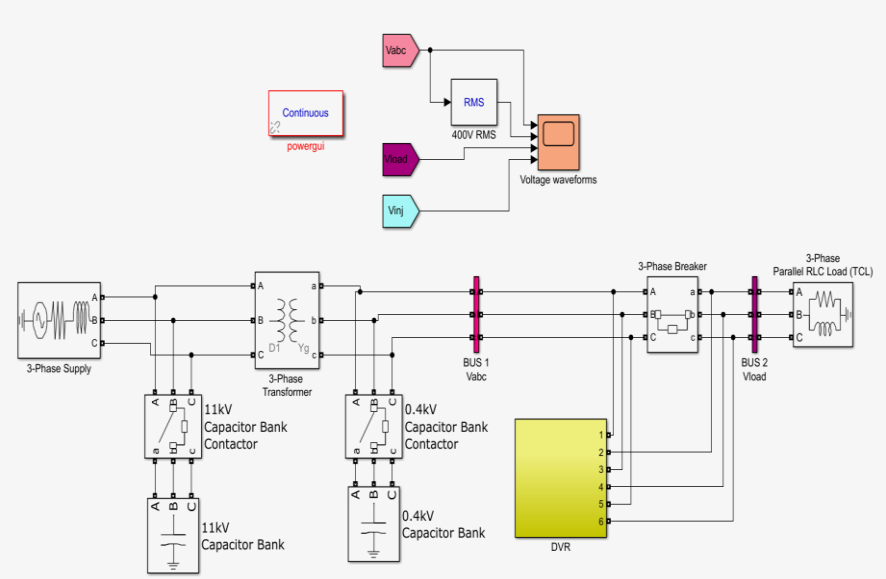

Fig. 7. Capacitor bank model with DVR

Table 1. Ratings of Blocks Used in Capacitor Bank Model

Blocks used in capacitor bank model with DVR	Rating of Block
Three phase supply	11KV
Capacitor Bank Contractor	Open initially Switching Time:0.23s
Capacitor Bank	11 KV
Three phase Transformer	11KV/415V, 1 MVA
3 phase Breakers	Closed initially Switching Time:0s
Load	RL Load Active Power:4.42KW Reactive Power:100var

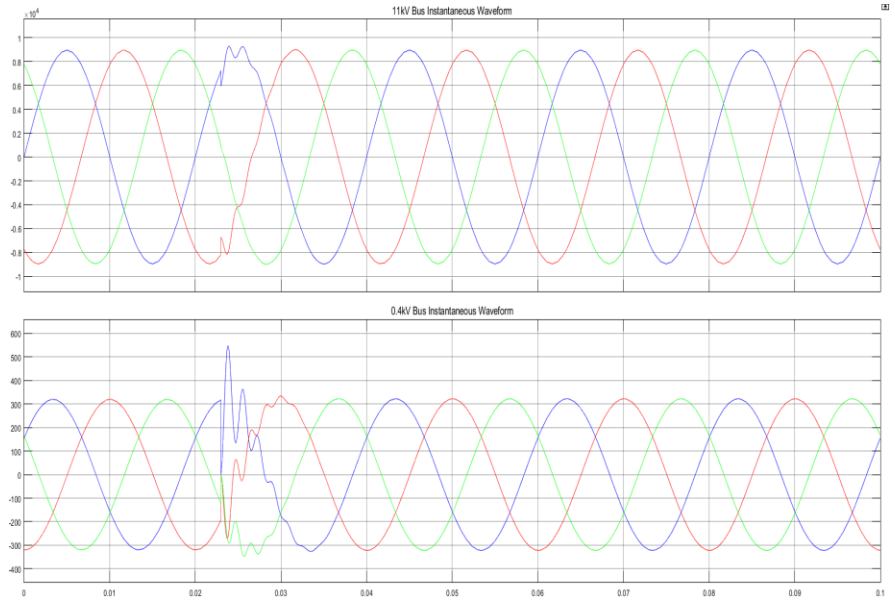

Fig. 8. Output of capacitor bank model without DVR

Fig. 9 shows that whenever the voltage transient occurs on closing of three phase breaker, the Dynamic Voltage Restorer supply the voltage to improve the power quality of system. The magnitude of voltage transient reduces as it moves along 11KV bus feeder, the injecting voltage from DVR also decreases hence overall the power quality of the system remain good. The voltage stored in DVR is in form of DC and get converted into ac by the inverter. The voltage injected by DVR can be measured in Simulink. Therefore, load experience constant voltage.

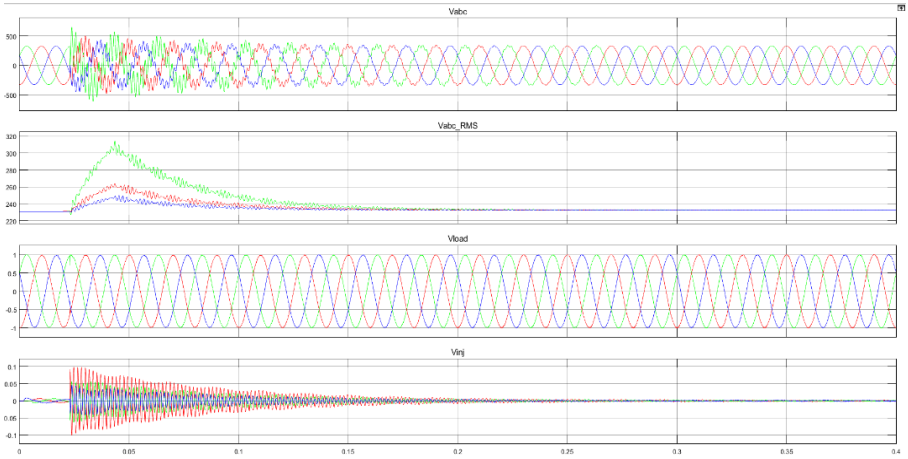

Fig. 9. Output of capacitor bank model without DVR

4. Load voltage THD Comparison

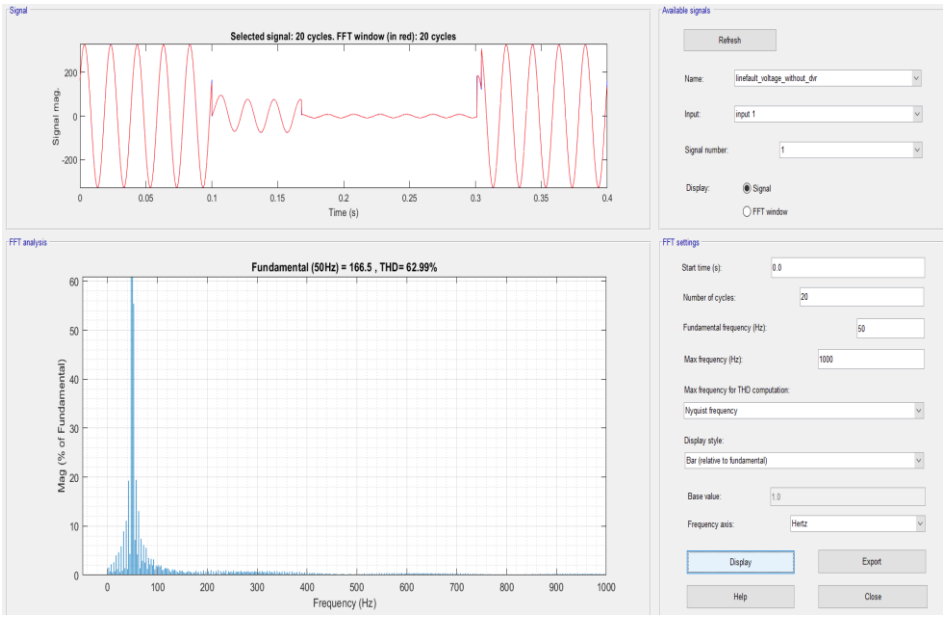

Fig. 10. Load Voltage THD of line fault model without DVR

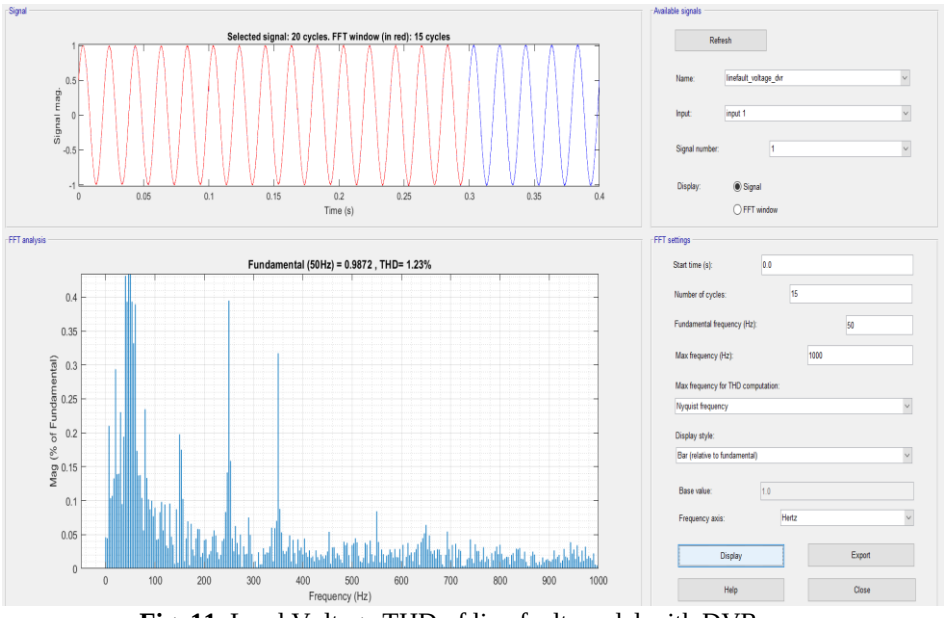

Fig. 11. Load Voltage THD of line fault model with DVR

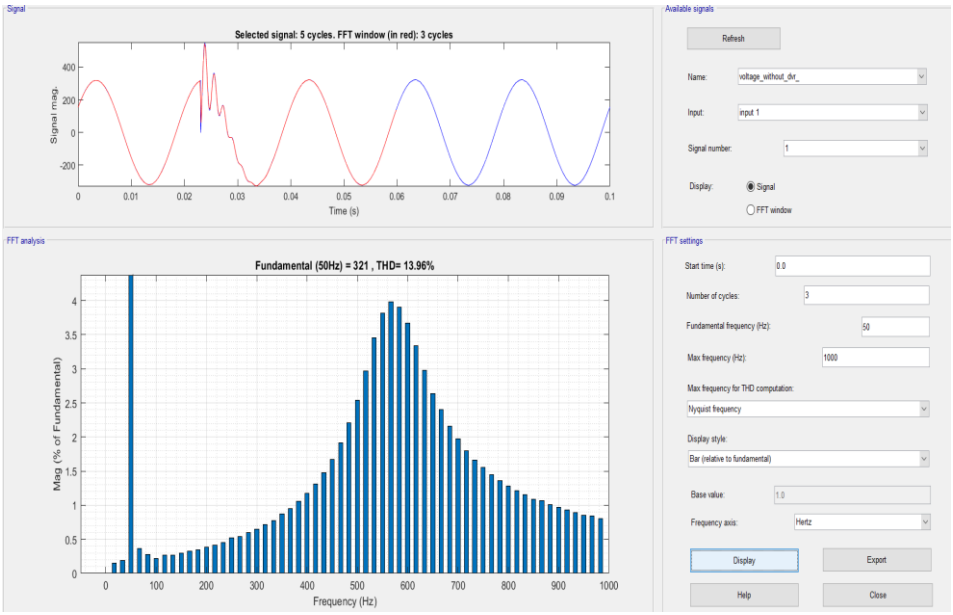

Fig. 12. Load Voltage THD of Capacitor energizing model without DVR

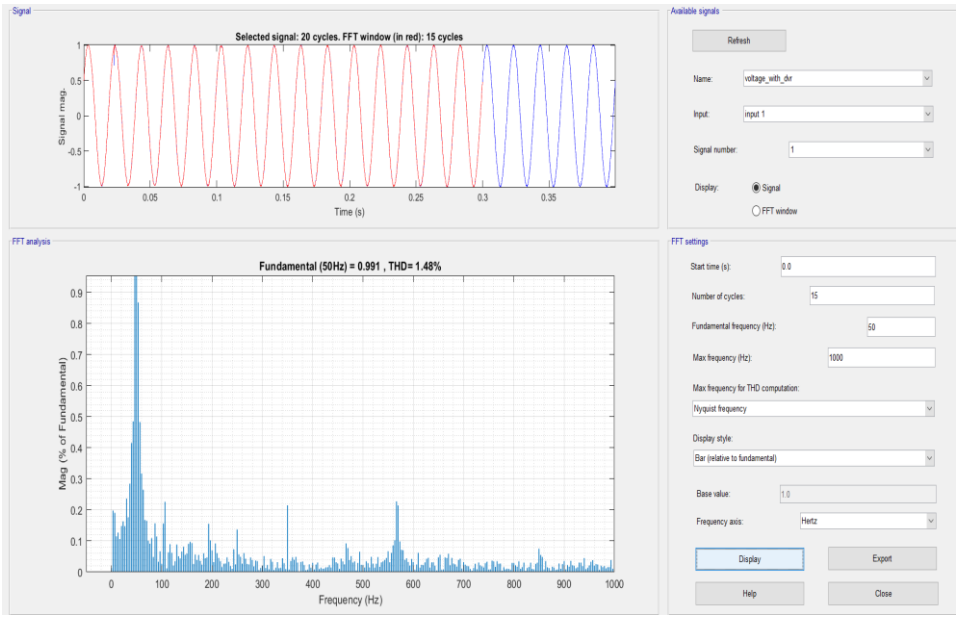

Fig. 13. Load Voltage THD of Capacitor energizing model without DVR

Table 2. Voltage THD with and without DVR

	THD Without DVR	THD With DVR
Line Fault Model	62.99%	1.23%
Capacitor Bank Energizing	13.96%	1.48%

5. CONCLUSION

This works simulates power quality issue of voltage sag and swell in a power system. The effect of line faults on voltages of different load. These issues if not corrected before feeding voltage to load can severely damage the load side equipment. The DVR used is an excellent equipment for this purpose as it injects the desired voltage and compensates the voltage sag. The DVR is recommended for industrial use as it is a costly equipment. From the load voltage THD comparison it is clear that as we apply DVR to the system, the Load Voltage THD decreases as compared to when DVR is not connected to the system.

6. REFRENCES

[I] J. A. Martinez and J. M. Arnedo, "Voltage sag studies in distribution networks-part T: System modeling," iEEE Trans. Power Del., vol. 21, no. 3, pp. 338-345, Jul. 2012.

[2] M. I. Marei, E. F. EI-Saadany, and M. M. A. Salama, "A new approach to control DVR based on symmetrical components estimation," iEEE Trans. Power Del., vol. 22, no. 4, pp. 2017-2024, Oct. 2012.

[3] A Transformer Inrush Mitigation Method for Series Voltage Sag Compensators Po-Tai Cheng, Wei-Ting Chen, Yu-Hsing Chen, Chia-Long Ni, and Jarsun Lin, IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 22, NO. 5, SEPTEMBER 2007

[4] Tejashree G. More et al. Int. Journal of Engineering Research and Applications ISSN : 2248-9622, Vol. 4, Issue 4(Version 4), April 2014, pp.170-177

[5] Reducing the Voltage Sag and Swell Problem in Distribution System using Dynamic Voltage Restorer with PI Controller Raunak Jangid, Kapil Parkh, Pradeep Anjana , International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-3 Issue-6, January 2014