*International Journal For Technological Research In Engineering*
*Volume 8, Issue 7, March-2021* *(Online): 2347 - 4718*

# SIMULATION OF DVR USING APC TRACKING CONTROL FOR VOLTAGE SAG AND SWELL MITIGATION

[1]Parth Sharma, [2]Dr. R .A. Patel
[1]Assistant Professor, [2]HOD
Department of Electrical Engineering
UVPCE, Ganpat University Campus, Kherva, Mehsana, Gujarat, India

***Abstract: Nowadays, the fast developments in power electronics increases use of sensitive and nonlinear load in power system. The fast developments in power electronic technology have made it possible to mitigate voltage disturbances in power system. Power Quality problem in a system leads to various disturbances such as voltage fluctuations, transients and waveform distortions those results in a mis operation or a failure of end user equipment. Voltage disturbances challenging the industry are Voltage sag and Swell, among them voltage sags are considered the most significant problem to sensitive loads. To solve this type of short duration voltage variation problem, power electronics controller based custom power devices are used. In this paper usefulness of including DVR in distribution system for purpose of voltage sag and swell mitigation by using PI Controller with SRF theory is used. SVPWM pulse generation technique is utilized in this paper for generating required gate pulses. Appropriate results are presented to assess the performance of DVR as a potential custom power solution. To verify the performance of the proposed method simulation results carried out by MATLAB with its Simulink and Sim Power System toolboxes.***

***Keywords: DVR, Power Quality, Sag, Swell, THD***

## 1. INTRODUCTION

The Generally we can define power quality as any power problem manifested in voltage, current, or frequency deviations that results in failure or disoperation of customer equipment [1]. Presently, most of the industries use power electronics conversion and switching for manufacturing and processing. One of the major concerns in electricity industry today is power quality problems to sensitive loads. This is due to the advent of a large numbers of sophisticated electrical and electronic equipment, such as computers, programmable logic controllers, variable speed drives, and so forth.

Power distribution systems, ideally, should provide their customers with an uninterrupted flow of energy at smooth sinusoidal voltage at the ideal magnitude level and frequency. Good quality of electric power is necessary for right functioning of industrial processes as well as protection to the industrial machines and its long usage

Among various power quality problem voltage sag and swell are most significant short duration variation problem. Voltage sag and swell [1] can cause sensitive equipment to fail, shutdown and create a large current unbalance. A sag is a decrease to between 0.1 and 0.9 pu in rms voltage or current at the power frequency for durations from 0.5 cycle to 1 min [2]. Faults on electrical power system like short circuit due to insulation breakdown at heavy load conditions can cause voltage sag. Voltage swell, in contrast can be defined an increase to between 1.1 and 1.8 pu in RMS voltage or current at the power frequency for durations from 0.5 cycle to 1 min [2]. Switching off of large loads, Energization of capacitor banks etc. can be considered as the common causes of voltage swell. Among various custom power devices to mitigate voltage sag and swell series connected device called DVR is commonly used.

In this paper, the performance of the DVR used for the load bus voltage control have been analyzed and compared when Voltage sag & swell occur in the distribution system across the load bus. In this paper, Synchronous reference frame theory is used for generating reference voltages and Space Vector Pulse Width Modulation technique is used to generate the switching pulses for Voltage source Inverter. Simulation studies have been performed to check the results in a three-phase distribution system.

*Dynamic Voltage Restorer*

DVR is a series connected solid state device that injects voltage into the system in order to regulate the load side voltage. It is normally installed in a distribution system between the supply and critical load feeder as shown in Figure-1. Usually the connection is made via a transformer, but configurations like DVR with no storage and supply-side-connected shunt converter also exist. The resulting voltage at the load bus bar equals to the sum of the grid voltage and the injected voltage from the DVR.

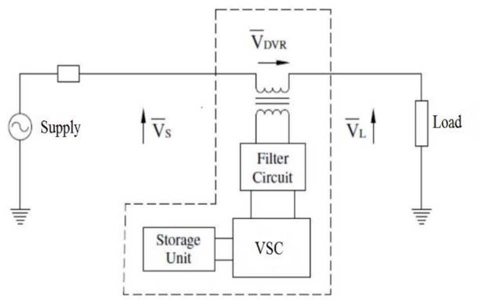


Figure 1. DVR Configuration

The converter generates the reactive power needed while the active power is taken from the energy storage. The compensation for voltage sags and Swells using a DVR can be performed by injecting/absorbing reactive power or real Power.

*Fundamental Components of DVR*
1) Series Injection Transformer
2) Voltage Source Converter (VSC)
3) Filter
4) Control System
5) DC Energy Storage Device

*Control Strategy*
In Figure-2 shows the control block diagram of the DVR in which the synchronous reference frame (SRF) theory is used for the control of self-supported DVR [4]. The voltages at PCC (Vt) are converted to the rotating reference frame using the abc-dqo conversion. The harmonics and the oscillatory components of voltages are eliminated using low pass filters.

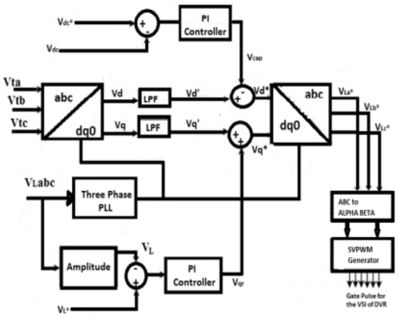


Figure-2 Block Diagram of DVR control strategy with SRF theory

Three-phase reference supply voltages (VLa*,VLb*,VLc*) are derived using the sensed load voltages, terminal voltages and dc bus voltage of the DVR as feedback signals. The SRF theory based method is used to obtain the direct axis (Vd) and quadrature axis (Vq) components of the load voltage. The load voltages are converted into the d-q-0 frame using the Park's transformation [4]. The resultant voltages (Vd*, Vq*, Vo) are again converted into the reference supply Voltages using the reverse Park's transformation. Reference supply voltages (VLa*,VLb*,VLc*) are then converted into alpha beta component with the help of alpha beta conversion. Then the SVPWM generator generates required gating pulses for switches of VSI.

## 2. PROPOSED WORK

The goal of zero active power tracking for enhancing DVR-based compensation is to make the most of the utilizable energy (ΔWDC) that is stored in the DC-link capacitor. This limited energy can be calculated as in fig.3; due to technical limitations, not all the stored energy can be utilized. The minimum DC-side voltage (VDCmin) must be at a level that can still provide the converter with proper operation. Anything lower than this level will result in the converter not producing the demanded AC voltage, which shows that more utilizable energy yields longer active compensation for the DVR to address sags. Obviously, less real power utilized by the DC-link capacitor means that the DVR can also last for a considerable period and overcome more of the voltage sag.

$$\Delta W_{DC} = \frac{1}{2} C\left(V_{DCmax}^2 - V_{DCmin}^2\right) \quad (7)$$

$$V_{DCmin} \geq \sqrt{2} V_{DVR} \quad (8)$$

$$T_C = \frac{\Delta W_{DC}}{P_{DVR}} \quad (9)$$

Therefore, in order to gain more from the DVR, the idea proposed here is to achieve a condition where the compensation process requires the least real power from the DC-link capacitor.

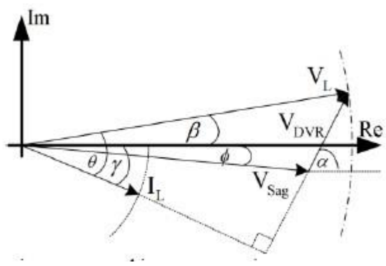


Fig. 3 Zero active power tracking compensation

*Zero Active Power Tracking*
As mentioned earlier, varying both the magnitude and phase of the DVR voltage plays a major role in reaching better compensation for the sag voltage. This voltage is involved in the calculation of energy stored in the DC-link capacitor that would be utilized each moment, considering these equations, to achieve the best performance, the displacement of the corresponding DVR's voltage and load current complex phasor must be maintained at an angle of approximately 90 degrees, as illustrated in Fig.3. The illustration in Fig. 3 also shows that the DVR voltage phasor is a stretchable one, as required, representing the compensation voltage added to the sag voltage. Its magnitude is adjusted related to the calculation of (10), and its displacement angle α is set according to (11). An angular displacement ϒ indicates the load characteristic, which can be determined directly using (12), relating to the load real power.
Similar to the angle θ displacement, it is also tied to the resulting voltage. Therefore, adjusting the DVR voltage will result in both θ and ϒ being changed. By this technique, the resulting load voltage phasor may or may not be returned to the pre-sag level; some β degrees displacement must be observed

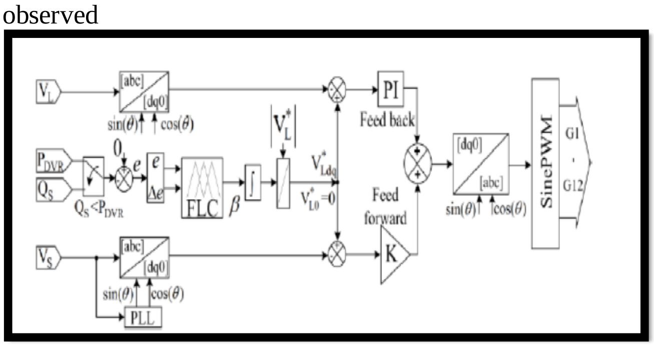


Fig. 4 The proposed control system.

  

The tracking process starts with the control of the converter output to provide the corresponding voltage, which must be varied to meet the targets. The magnitude and phase are increased progressively until reaching a value that results in a relatively acceptable power. Two possible targets are set as the preferred tracking boundaries. In case 1, the ideal zero active power (PDVR=0) is achieved, while the load is still supported by some of the system reactive power. In this case, the load current lags behind the grid voltage (the sag voltage, VSag). In case 2, the minimum active power is achieved (as it cannot achieve zero active power), whenever all of the load reactive power is completely supported by the DVR and no longer supported by the system. At that point the load current appears to advance in leading the voltage sag, which indicates that the DVR not only supplies to the load side but also begins supplying reactive power back to the grid side. The increase in the phase angle α should be stopped immediately. If not, high power loss will degrade the DVR performance.

## Matlab Simulation of Voltage Sag mitigation with Proposed Controlling

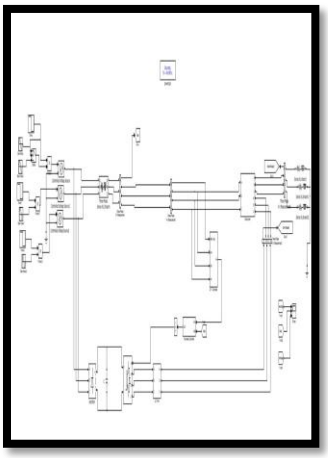

Fig 5 Voltage Sag Control using DVR

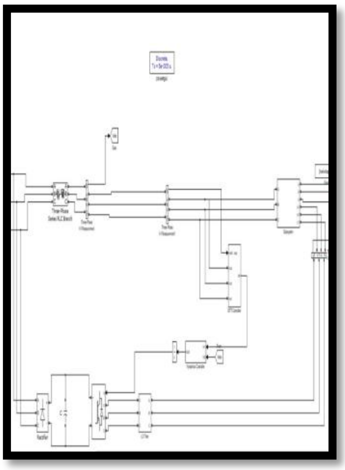

Fig 6- DVR Control Subsystem

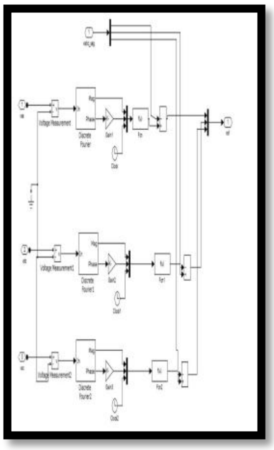

Fig 7- DFT Controlling Block subsystem

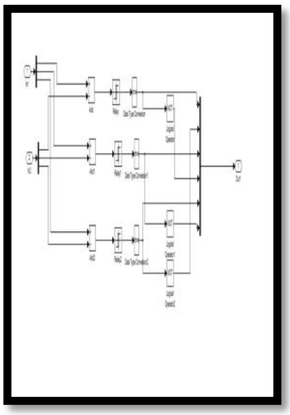

Fig 8- Hysteresis Control block subsystem

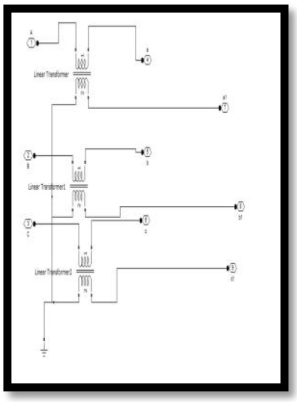

Fig 9- Injecting transformer subsystem

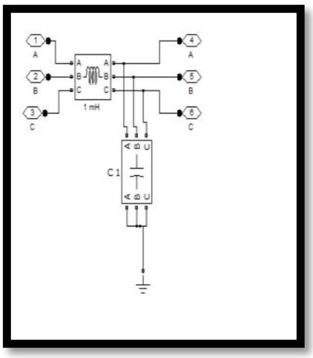


Fig 10- L-C Filter Subsystem

  

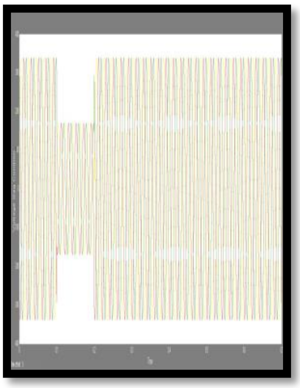

Fig 11- Voltage Sag condition waveform

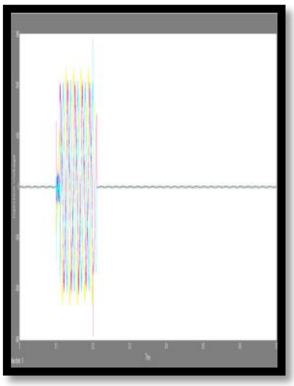

Fig 12- Injecting voltage waveform

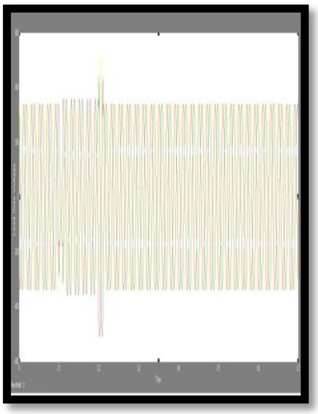

Fig 13- Load Voltage waveform

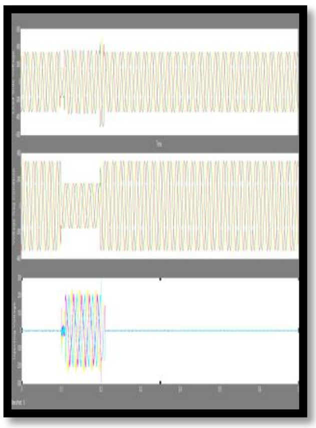

Fig 14- Sag condition all parameters

## Matlab Simulation of Voltage Swell mitigation with Proposed Controlling

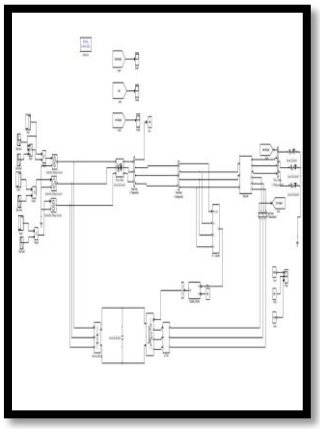

Fig 15 Voltage Sag Control using DVR

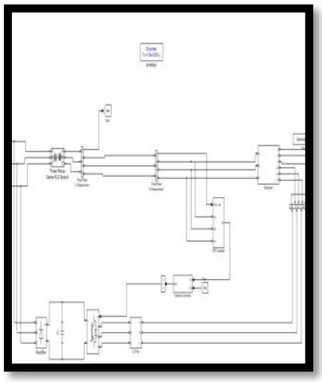

Fig 16- DVR Control Subsystem

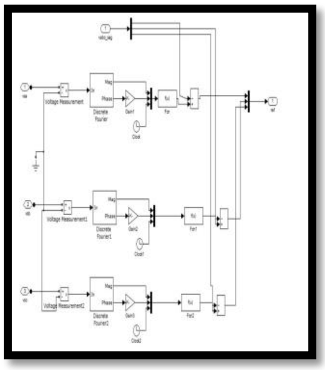

Fig 17- DFT Controlling Block subsystem

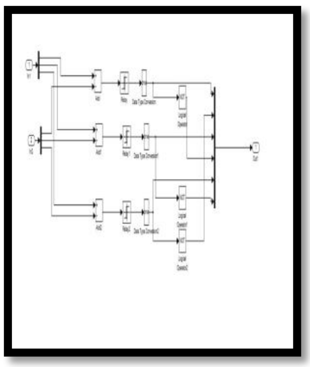

Fig 18- Hysteresis Control block subsystem

  

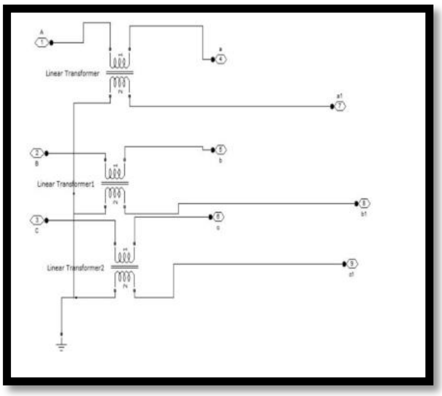


Fig 19- Injecting transformer subsystem

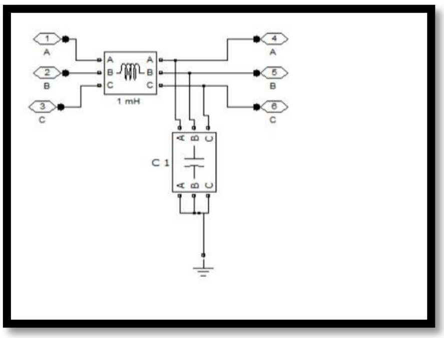


Fig 20- L-C Filter Subsystem

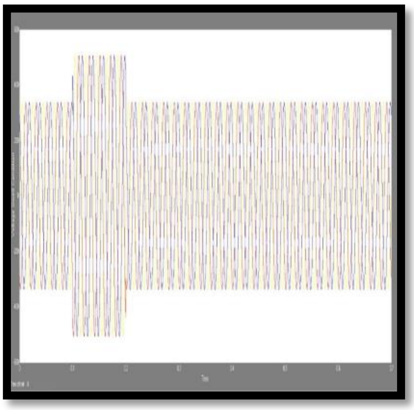

Fig 21- Voltage swell condition waveform

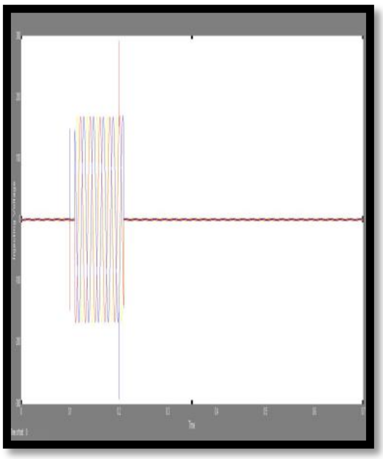

Fig 22- Voltage swell condition injecting voltage

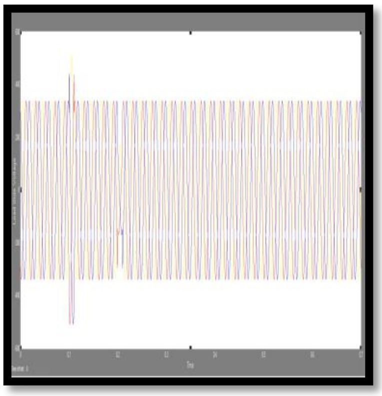

Fig.23- load side controlled output voltage waveform

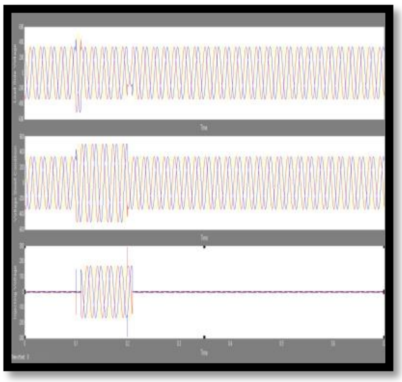

Fig 24- Swell condition all parameters

## 3. CONCLUSION

The power quality enhancement of the power transmission systems is a vital issue in power industry. In this study, the application of DVR 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 sag & swell is analysed by implementing three phase fault and a three-phase external signal directed from the source. Simulation results in this proposed scheme is represent the voltage sag & swell mitigation using DVR effectively. The proposed zero active power tracking system with DFT has control phase shifting and using hysteresis control had the DVR had succefully done the voltage sag and swell problem mitigation.

## REFERENCES

[1] IEEE Recommended Practice for Monitoring Electric Power Quality," IEEE Std 1159-1995,

[2] Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H. Wayne Beaty, "Electrical Power Systems Quality", Tata McGraw Hills publications, 3rd Edition 2012.

[3] Bollen, M. H. J., "Understanding power quality problems" Vol. 3. New York: IEEE press, 2000.

[4] Hingorani, N.G., "Introducing custom power," Spectrum, IEEE , vol.32, no.6, pp.41,48, June 1995.

[5] Pakharia, A., Gupta, M, "Dynamic Voltage Restorer for Compensation of Voltage Sag and Swell: A Literature

  

Review", International Journal of Advance in Engineering & Technology, vol 4, issue 1,pp. 347-355, july 2012.

[6] C. Fitzer V.K. Ramachandaramurthy, A. Arulampalam, C. Zhan, M. Barnes and N.Jenkins, "Supervisory Control of Dynamic Voltage Restorers", IEE Proceedings Generation, Transmission and Distribution, Vol. 151, Issue: 4, Page(s): 509 – 516, July 2004.

[7] G.-M. Lee, D.-C.Lee, and J.-K. Seok, "Control of series active power filters compensating for source voltage unbalance and current harmonics," IEEE Trans. Ind. Electron., vol. 51, no. 1, pp. 132–139, Feb. 2004

[8] 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.

[9] 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

[10] Mahmoud, A., El-Gammal, Amr Y. Abou-Ghazala and Tarek I. El-Shennawy,," Dynamic Voltage Restorer (DVR) for Voltage Sag Mitigation",International Journal on Electrical Engineering and Informatics, vol.3, no.1, pp.1-11, march 2011

[11] H Mahesh Singh, Vaibhav Tiwari, "Modeling analysis and solution of Power Quality Problems", .student of IEEE.

[12] G. Uppunoori Venkata reddy , paduchuri.chandra babu, "space vector pulse width modulation based dvr to mitigate voltage sag and swell",International Conference om Computer Communication and Informatics(ICCCI-201)

  