Dynamic Voltage Restorer to Maintain Constant Voltage at Load

K Sravan Kumar¹, Ram Deshmukh², K Sanjay³ & K.Ravikiran⁴

¹Department of EEE, Sumathi Reddy Institute of Technology for Women, Warangal, India.
²Department of EEE, SR Engineering College, Warangal, India.
³Department of EEE, Sumathi Reddy Institute of Technology for Women, Warangal, India.
⁴Department of ECE, Sumathi Reddy Institute of Technology for Women, Warangal, India.

Corresponding Mail: sravankumar219@gmail.com

Abstract. This paper is used for decrease the power quality problems in electrical distribution. Sometimes potential is not stable so it causes potential disturbances in power system then it produces harmonics in the system. Therefore, this gained with a concept called DVR. This controls the potential increase and decrease the distribution. Because of these problems, there is a possibility to draw more power and reduction in the devices. DVR saves the power with potential injections which cause effect phase and also the shapes of the input waveform. In this project, we are using a lead acid battery device as energy storage element and also PWM process useful for trigger the circuits. It will be operated in unsymmetrical potential conditions and remains ideal in normal conditions. It will set the potential into system at a rated value of the quantity and cycles per second. So that it is regained the receiving side potential to accurate range. This process is used to compare the decrease in potential, increase in potential and power frequencies in the system. To decreases economic problems this project is helpful. If the potential is highly changes, the machine will get destroy it can have a severe economic problem on residential areas and industries. Which is help to improve quality of powering issues in the future power system operations.

Keywords: Power quality, DVR, Potential increase sags and decreases, PWM, Power devices

1. Introduction

In current circumstance the Power quality locates a crucial place. The Power quality problems are high trouble in electricity inject to sensitive burden [5]. These are shown as changes in signals of potential, current and frequency in a power system. If there is any changes in potential and frequency at where the power being send, then the feature of power is changes. The manufactures used in the process become contrived which decreases their effectiveness and period of life. It mentions to a huge diversity of electromagnetic method that distinguish the potential and current at a specified time and at a specified place in the power system. The two of them, electric benefits and customers of electrical power are setoff growingly covers about the quality of electric power. Delicate loads such as computers, plc, variable speed drives etc. need more standard supplies. Power quality is a sunshade process for quantity of separate ways of power system problems. Standard of input may be differentiated in three parts as reliability, power quality and custom service. Power distribution systems, should completely dispense their consumers with a consistent movement of energy with a
calm varying according to a sine curve potential [5] at the narrow value pitch and cycles per second. Although over real power systems particularly in distribution systems have several irregular burdens [5] such outstandingly change the grade of the power supply. As a subsequent of these irregular loads, the clarity of the input wave shape is lost in many positions. This turns build-up many power quality issues. The main cause that we are focused in power quality is profitable worth. There are profitable influence on befits, their consumers and providers of load apparatus. Crucial amount of all power quality issues are of the potential-quality method where the divergence of the potential wave shapes from its original shape occurrence. The familiar known issues of the potential wave shape are potential increase and decrease, deviate from sinusoidal waveforms, inter harmonics and potential imbalances.

2. Dynamic Potential Regulator

**Dynamic Potential Restorer:**
Using this DVR principle, the DVR triggers the potential of the magnitude and frequency needed to compensate for the potential changes so that it reduces the potential sag and swell, then it maintain stable potential even though potential alterations are there. Typically, the equipment uses the thyristors gate for DVR and solid state power electronic switches in the construction of a pulse-width modulated inverter. The DVR can generate or take in real and reactive power, which can be controlled independently of the load. The source of instable potential is the process of modifying the energy sources for reactive power and actual power demand. The supply is usually connected to the DVR through its DC input terminal.

![Figure1. Without DVR energy arcade & supply side change](image)

*Potential Source Inverter (VSI)*
A potential source inverter is a power electronic device that includes an energy conservation device such as a switching device and battery. VSI produces sinusoidal potential at any required magnitude, phase and frequency. Here inverter makes use of DC capacitors as a supply & it can change on a large frequency to produces the wave, reduces the potential sag and swells across the burden. IGBT is a sophisticated covenant switching device used with a potential source inverter for dynamic potential restorer operation.
Injection/Boost transformer

It has two sides potential one is high potential side and low potential side. In injected transformer is usually connected at high potential in series connection with distribution system, while the low potential side is connected to DVR of the power circuit. The DVR transfers the required potential from the DC side of the inverter to the distribution network via the injection transformer. The transformer also helps to separate the line from the DVR system. It is connected in series with the load to be protected by the DVR. If the potential is high or low from VSI is by passed by the filtration.

Passive/LC Filters

The filtering scheme is to eliminating the potential sag and potential swelling harmonics. In filtration the injection transformer is connected in series to potential swell or VSI side DVR . The foremost advantage of the inverter-side filter is that it's on the low-potential side of the series transformer and is closer to the harmonic source. Using this scheme, the high-order harmonic currents are prevented from getting through the series transformer, thereby reducing the potential pressure on the transformer.

3. Power topologies of DVR

The assignment of a dvr is continuing potential provide at the receiving end to its official quantity. The researchers have suggested such a lot of topologies for DVR's. The DVR usually injects an appropriate potential during disruptions in an exceeding network to redeem potential at receiving end. During this time dvr must contain real and reactive power exchanges along the encircling Network.

There are two topologies which are focused on energy storage.
- Topology with no energy arcade
- Topology with energy arcade

Topology that doesn't have energy device are often split into two that's structure-1 and structure-2 configurations. In dvr layout of networks with no energy arcade, the excellence between structure-1 and structure-2 is that in structure-1 the energy origin is from the incoming supply 'via', a positive shunt converter attached to the provision edge. While in structure-2 energy from the connected side of the grid is take all over a passive shunt converter attached to the load side.

Topology with energy arcade

The stored energy storage provides the system's real power requirements while DVR used for the cycle of compensation when there's a interference within the distribution system. Fly wheels, lead acid batteries, super conductive magnetic energy storage and super condenser will be used as devices for energy storage. Mitigation of potential fluctuations like potential decrease, may improve the accuracy of the DVR by using energy storage, although retaining electricity is expensive.

4. Potential Introduction Process:

Potential introduction process using of a dynamic potential restorer rely on the bounding components like dvr power values, different factors of load, and differing classification of potential sags. The various process of dvr potential introduction which are
Pre-sag/dip compares process

The pre-sag process trace the input potential constantly as well as if it sense any problems in input potential introduce variation potential between the sag or potential at pcc and prefault position. Therefore the receiving end potential is regained past to pre-fault position. Compares of potential sags inside one on the other phase angle and magnitude delicate burdens will be gained by pre-sag compares process.

Meanwhile in present process introduced real power notable to supervise also it's resolved by outer situations as class of faults and burden situations.

\[ V_{DVR} = V_{prefault} - V_{sag} \]

In-phase compares process

This is supreme simple procedure. During this process the introduce potential is same phase with the input potential in any case of the load current and pre-fault potential. The phase degrees of the pre-sag and load potential are not same but the very main norm for power quality that's the same value of load potential is convinced. The advantage of this process is that the value of DVR booster potential is low for specific potential sag as balance with other procedures.

In-phase leading compares process

Present process true power driven by dvr is reduced by makes little of the load angle between the sag potential and load at current. Just in case of pre-sag and in-phase compares process the real power is introduced into the system during distraction. Present process the quantities of I_L and potentials same inside arrangement. So we are tried to modify hardly the period of the sag at potential. IPLC process
utilizes only reactive power and unluckily, unlike every sag is frequently diminished lack of active power, as a substance, present process purely acceptable as a restricted span of sags.

![Figure 4](image.png)

**Figure 4.** In-phase leading compares process

Potential forbearance process with least energy introduction

A low fall in potential and slight change in phase degree may be forbearance by the load virtually. If the potential estimates lie down in a range between (90-110)% of nominal potential and (5-10)% of formal position which will not change the functioning features of loads. The two of them amplitude and phase are command specification for present process might be gained by low power introduction.

![Figure 5](image.png)

**Figure 5.** Potential forbearance process with least energy injection

5. Matlab Simulations:

So far lot of techniques to mitigate the potential sag/swell and to reduce the loading of power system transmission line. Among them the most effective way is to use a tool at the purpose of interest to manage the potential. These control strategies are simulated in MATLAB SIMULINK

MATLAB Modeling of DVR

![Figure 6](image.png)

**Figure 6.** One wire diagram of the test system for dvr
One wire diagram of the test system for dvr consists by a 13 kV, 50 Hz producing arrangement, sustain two transmission lines[6] through a three winding transformer connected in delta/Star/Star, 13/115/115 kV. Like transmission lines suckle two distribution networks through two transformers attached in Star / delta , 115/11 kV. The dvr is imitate to be operational just for the time of the problem.

6. Simulation Results
When fault occurs within the system then potential sag and swell creates in the system. To check the process of dvr for potential compare, a problem with the fault resistance 0.66 ohm is applied at 11kV line of T/F-2 for time duration of 200 ms. The waveforms of potential sag and swell of the system without DVR is shown in Figure7.

The first replicate show of three phase potential sag is replicate. The simulation started with the supply potential 20% sagging as shown in figure.7 (a). In figure7 (a) indicates a 20% potential sag initiated at 0.2s and it’s kept until 0.4s, with total potential sag duration of 0.2s. Similarly, the simulation started with the supply potential 20% swell as shown in figure 7(b). In figure 7(b) also shows a 20% potential swell initiated at 0.2s and its kept until 0.4s, with total potential sag duration of 0.2s.

(a) potential sag

(b) potential swell.

Figure 7. The waveforms of load potential of the system without DVR

For Potential Sag
Figure8 (a) and (b) show the corresponding load potential with sag compensation and also the potential injected by the DVR. As a result of DVR, the load potential is kept at 1 p.u. Its corresponding load
potentials are shown in figure 8 (a) where it’s possible to determine that the compensation process is keeping the load potentials constant at 1 p.u. Figure 8 (c) shows the FFT analysis after the compensation where THD of the load potential is 0.59%.

(a) Load potential

(b) Injected potential

(c) FFT Analysis

Figure 8. Waveforms of during Potential sag with DVR

7. Conclusion
To keep the standard of power the issues influence the power quality should handle effectively. Among the various power quality issues, potential sag and swell are one amongst the most important one influence the characteristics of the customer devices. By using Dynamic potential restorer (DVR), it’s possible to scale back power quality problems. DVR is series compensation devices which are injected potential into the system to maintain a relentless potential at load side. From the results, it shows the FFT analysis after the compensation where THD of the load potential is 0.59%.
8. References

[1] S. A. Dahat, M. S. Isasare, R. P. Argelwar and T. Shanu, "Co-ordinated tuning of PSS with TCSC damping controller in single machine power system using PSO," 2018 2nd International Conference on Inventive Systems and Control (ICISC), Coimbatore, 2018, pp. 301-306.

[2] Supriya R. Hangargekar, Suraj Ankush Dahat, "Development of Storage Less Single Phase Dynamic Voltage Regulator for Mitigation of Voltage Sag and Swell", International Conference on Science and Engineering for Sustainable Development (ICSESD-2017), International Journal of Advanced Engineering, Management and Science (IJAEMS), Special Issue 1, pp.96-102, 27-May-2017.

[3] Suraj Ankush Dahat, Nikhil Bodele and Sumit Bagde, "Compensation of Voltage Fluctuation by using Dynamic Voltage Restorer (DVR) with the Different Control Techniques", International Conference on Science and Engineering for Sustainable Development (ICSESD-Special Issue 1), pp.38-44, 27-May-2017.

[4] S. A. Dahat, A. Chowdhury, P. Kundu and G. S. K. Viranchi, "Mitigation of voltage fluctuation in the transmission line by using SEN transformer," 2016 IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES), Delhi, 2016, pp. 1-6.

[5] Rajababu, D. & Raghu Ram, K. 2019, "Load current observer and adaptive voltage controller for standalone wind energy system with linear and non-linear loads", International Journal of Engineering and Advanced Technology, vol. 9, no. 1, pp. 5491-5496.

[6] Sai Kumar M., Rajender B., Kothapalli B., Rajeshwar Reddy K. 2019 Instability evaluation of the temperature tracking and transmission corridors International Journal of Engineering and Advanced Technology