



## IMPROVING POWER QUALITY ENHANCEMENT USING DYNAMIC VOLTAGE RESTORER(DVR) SYSTEM

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### ABSTRACT—

Power quality has become one of the most significant parameters in today's power world. Power quality is mainly related with the quality of voltage, current and frequency. As now-a-days due to open access, the competition in generation, transmission and distribution sector has increased. So it is become necessary to maintain power quality standards, so as to fulfil the needs of consumers. Generally, most of the power quality problems constitute of voltage sags and voltage swells. Problems like voltage sags occurs mainly due to the line faults or starting of electrical motors or due to the saturation of magnetic circuits or due to non-linear utility loads. So here we are mainly dealing with problems of voltage sags due to line faults. In order to overcome this problem, we are using Dynamic Voltage Restorer (DVR) with Photovoltaic (PV) and Battery storage, Multilevel Inverter (MLI), PI Controller with SPWM. As DVR injects the voltage in series with the line and maintains the load voltage constant. Here simulation for the system has to be carried out using MATLAB Software and hence it has to show that voltage sag/swell is compensated.

**Keywords—** Power Quality, Problem Identification, Proposed System Objective.

### 1. INTRODUCTION

Power quality is of great importance in all modern environments where electricity is involved, power quality can be essentially influenced by an important factor like quality service. One of the major concerns in electricity industry today is power quality problems. Presently, most of the power quality problems are due to different fault conditions. These conditions cause voltage sag, voltage swell, transients, voltage interruption and harmonics. These problems may cause the apparatus tripping, shutdown commercial, domestic and industrial equipment, and miss process of drive system. Dynamic voltage restorer (DVR) can provide the lucrative solution to mitigate voltage sag by establishing the appropriate voltage quality level, necessary. It is recently being used as the active solution for mitigation of power quality problems.

### LITERATURE SURVERY

1. Abdul Mannan Rauf and Vinod Khadkikar, " Integrated Photovoltaic and Dynamic Voltage Restorer System Configuration ", IEEE Transactions on Sustainable Energy, Volume: 6 , Issue: 2 , April 2015.

This paper presents a new system configuration for integrating a grid-connected photovoltaic (PV)

system together with a self-supported dynamic voltage restorer (DVR). The proposed system termed as a “six-port converter,” consists of nine semiconductor switches in total. The proposed configuration retains all the essential features of normal PV and DVR systems while reducing the overall switch count from twelve to nine. In addition, the dual functionality feature significantly enhances the system robustness against severe symmetrical/asymmetrical grid faults and voltage dips. A detailed study on all the possible operational modes of six-port converter is presented. An appropriate control algorithm is developed and the validity of the proposed configuration is verified through extensive simulation as well as experimental studies under different operating conditions.

**2. Ravi.Dharavath, I. Jacob Raglend and Atul Manmohan, “ Implementation of Solar PV - Battery Storage with DVR for Power Quality Improvement ”, International Conference on Innovations in Power and Advanced Computing Technologies [i-PACT 2017].**

This paper is focusing on the novel integration of solar PV-Battery based Dynamic Voltage Restorer is implementing in the distribution system to meet the necessary power and for power quality improvement. Solar photovoltaic with boost converter is implemented by incremental conductance method to track the Maximum power. The performance of solar photovoltaic, Battery with Dynamic Voltage restorer is simulated under dynamic conditions of the load in MATLAB-SIMULINK software.

**3. Sanghun Kim, Heung-Geun Kim and Honnyong Cha, “ Dynamic Voltage Restorer Using Switching Cell Structured Multilevel AC–AC Converter ”, IEEE Transactions on Power Electronics, Vol. 32, No. 11, November 2017 .**

This paper presents a new DVR topology using a cascaded multilevel direct PWM ac–ac converter. In the proposed scheme, the unit cell of the multilevel converter consists of a single-phase PWM ac-ac converter using switching cell structure with coupled inductors. Therefore, the multilevel converter can be short- and open-circuited without damaging the switching devices. Neither lossy RC snubber nor a dedicated soft commutation strategy is required in the proposed DVR. This improves the reliability of the DVR system. The output voltage levels of the multilevel converter increase with the number of cascaded unit cells, and a high ac output voltage is obtained by using low-voltage-rating switching devices. Furthermore, a phase shifted

PWM technique is applied to significantly reduce the size of the output filter inductor. A 1-kW prototype of single-phase DVR is developed, and its performance is experimentally verified.

**3. Masoud Shahabadini and Hossein Iman-Eini, “Improving the Performance of a Cascaded H-Bridge-Based Interline Dynamic Voltage Restorer”, IEEE Transactions on Power Delivery, Vol. 31, No. 3, June 2016**

This paper presents an interline dynamic voltage restorer (IDVR) is a new device for sag mitigation which is made of several dynamic voltage restorers (DVRs) with a common dc link, where each DVR is connected in series with a distribution feeder. During the sag period, active power can be transferred from a feeder to another one and voltage sags with long durations can be mitigated. IDVR compensation capacity, however, depends greatly on the load power factor, and a higher load power factor causes lower performance of IDVR. To overcome this limitation, a new idea is presented in this paper which enables reducing the load power factor under sag conditions and,

therefore, the compensation capacity is increased. The proposed IDVR employs two cascaded H-bridge multilevel converters to inject ac voltage with lower total harmonic distortion and eliminates the necessity to low-frequency isolation transformers in one side. The validity of the proposed configuration is verified by simulations in the PSCAD/EMTDC environment. Then, experimental results on a scaled-down IDVR are presented to confirm the theoretical and simulation results.

4. **Peng Li, Lili Xie, Jiawei Han, Shilin Pang and Peihao Li, "A New Voltage Compensation Philosophy for Dynamic Voltage Restorer to Mitigate Voltage Sags Using Three-Phase Voltage Ellipse Parameters"**, IEEE Transactions on Power Electronics, Vol. 33, No. 2, February 2018 This paper introduces a series compensation philosophy to improve the voltage property of loads using three-phase voltage ellipse parameters intended for optimal utilization of a dynamic voltage restorer. The proposed approach relies on the instantaneous magnitude of voltage signals and functions by inserting a virtual equivalent impedance in series with the distribution feeder during voltage sags, compensating for the difference between faulty and nominal voltages. In addition, the definite mathematical derivations using iterative processes are properly used as an identification mark of the resultant rotating vector tracing an ellipse. The ellipse parameters including major axis, minor axis, and inclination angle are utilized to develop the proposed algorithm and hence, a set of generalized VA loading formulations calculating an optimal sizing with the minimum possible rating are presented. The uniqueness of dual VSCs connected with common dc-side is an attempt to formalize the topological structure keeping a

higher level of compensation accuracy. A novel design and the corresponding algorithm are proposed and all possible scenarios concerning sag depth and phase jump are taken into consideration. MATLAB-based simulation results are discussed in detail to support the concept and the test is also performed to verify the effectiveness through real-time experimental laboratory.

5. **Sze Sing Lee, "Single-Stage Switched-Capacitor Module (S3CM) Topology for Cascaded Multilevel Inverter"**, IEEE Transactions on Power Electronics, Vol. 33, No.10, October 2018

In this paper, a two-stage switched-capacitor based multilevel inverter possesses a drawback such that switches in the second stage (i.e., H-bridge) endure higher voltage stress. To resolve this problem, this letter proposes a single-stage switched-capacitor module (S3CM) topology for cascaded multilevel inverter, which ensures the peak inverse voltage across all the switches within the dc source voltage. A total of nine voltage levels can be generated with only one dc source and two incorporated capacitors. Hence, the number of isolated dc sources is significantly reduced compared to a cascaded H-bridge. In addition, voltage boosting gain of two is achieved. A comparative analysis of the recent topology reveals that the proposed S3CM topology achieves switch count reduction. The operation of the proposed topology is validated through circuit analysis followed by simulation and experimental results of a single-module (9-level) prototype.

### 3. Problem identification

Due to rapid developments in the industry, power quality plays a crucial role. Power quality is a measure of how well a source of electrical power

meets the energy-supply needs of the connected load. If the load does not experience any operational problems, then by this measure, power quality is adequate. The term power quality refers to maintaining a near sinusoidal power distribution bus voltage at rated magnitude and frequency. When power quality becomes poor, it affects almost all consumers. Any variation in the supply voltage for duration not exceeding one minute is called a short duration variation. Short duration voltage variations are usually caused by faults in the power system.

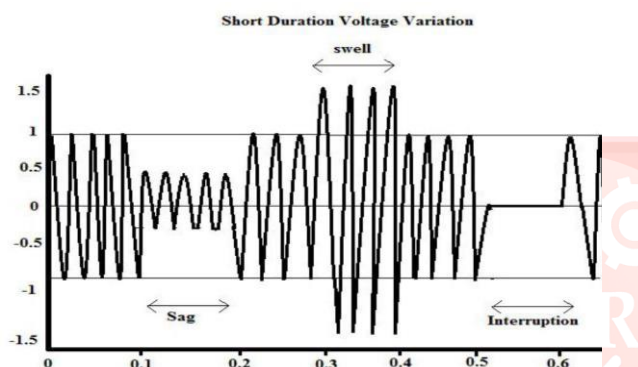


Figure 1.1 Short duration voltage distortion

The following are the major power quality issues:

### 1. Voltage Sag

Decrease in fundamental frequency in the supply voltage for a short duration. The voltage magnitude of 10% to 90%. The duration of voltage sag varies between 5 cycles to a minute. This is caused by faults on the transmission or distribution network (most of the times on parallel feeders), Connection of heavy loads and start-up of large motors. This fault causes malfunction of information technology equipment and loss of efficiency in electric rotating machines.

### 2. Voltage Swell

It is defined by IEEE 1159 as the increase in the RMS voltage level to 110% - 180% of nominal, at the power frequency for durations of ½ cycle to one

minute. This voltage swell is caused due to start/stop of heavy loads, badly dimensioned power sources and badly regulated transformers (mainly during off-peak hours).

### 3. Harmonics

One on the major power quality problem is harmonics, which is caused by the non-linearity of customer loads. Harmonics distorts the waveform shape of voltage and current, and increase the current level, which results in many disturbances as shown in the Figure.

The voltage reduction standard of IEEE std.1159-1995 is shown in Figure

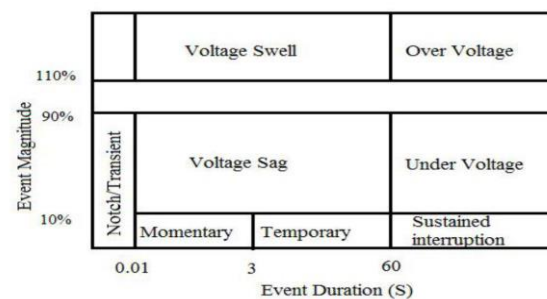


Figure 1.2 Voltage reduction standard of IEEE Std. 1159-1995

### 4. OBJECTIVES OF THE PROJECT

The objectives of this project are as follows :

1. To develop a model and simulate the Dynamic Voltage Restorer in MATLAB/Simulink to compensate the voltage sag/swell.
2. To integrate the Dynamic Voltage Restorer with Photovoltaic(PV) and Battery to mitigate the voltage sag/swell and harmonics
3. To use 5 Level Diode Clamped Inverter with SPWM technique for generating Grid Voltages.

## 5. Implementation

### Tools/Software Used

#### 1. MATLAB / Simulink

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

Typical uses include

1. Math and computation
2. Algorithm development
3. Modeling, simulation, and prototyping
4. Data analysis, exploration, and visualization
5. Scientific and engineering graphics
6. Application development, including
7. Graphical User Interface building

### The MATLAB System

The MATLAB system consists of five main parts

#### a. The MATLAB language.

This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create complete large and complex application programs.

#### b. The MATLAB working environment

This is the set of tools and facilities that you work with as the MATLAB user or programmer. It includes facilities for managing the variables in your workspace and importing and exporting data. It also includes tools for developing, managing, debugging, and profiling M-files, MATLAB's applications

#### c. Handle Graphics

This is the MATLAB graphics system. It includes high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level commands that allow you to fully customize the appearance of graphics as well as to build complete Graphical User Interfaces on your MATLAB applications.

#### d. The MATLAB mathematical function library

This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigenvalues, Bessel functions, and fast Fourier transforms.

#### e. The MATLAB Application Program Interface (API).

**This is a library that allows you to write C and Fortran programs that interact with MATLAB. It include facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.**

## 6. Proposed schedule of work

Month	Proposed work
June - July	Literature survey
August - September	Study of the system
October - December	Simulation work
January - February	Paper submission
March - April	Conclusion and result
May - June	Thesis submission

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