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Power Quality Restoration in a Distribution System Using a Dynamic Voltage Restorer: An Overview

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ABSTRACT

This research looks at the dynamic voltage restorer and how it may be used to enhance the power quality in electrical distribution networks. Over the last half-century, problems associated with poor power quality have only worsened. In response to these difficulties, several pieces of hardware, such as a distribution static compensator (D-STATCOM), solid-state transformer (SST), uninterruptible power supply (UPS), and dynamic voltage restorer (DVR), have been put in place. Using a digital voltage regulator (DVR) may be an inexpensive solution to voltage problems including harmonics and voltage sag/swell. It is widely used to mitigate voltage fluctuations in the power grid, especially in medium and low voltage distribution systems. This article's goal is to take a closer look at the renewable energy system's DVR implementation.

1. INTRODUCTION

The power quality cannot be compromised between consumers and power utility corporations since it defines the benefits in the extremely competitive trade market. The utility sector benefits from the superior quality of the supplied energy. Voltage fluctuations and other power quality issues may damage electrical and electronic equipment. As a result, several precautions have been taken to ensure that the voltage and frequency supplied are of sufficient quality for practical use [1]. Power quality issues such as voltage spikes, dips, harmonic distortion, and outages are plaguing the system. The most harmful kind of interruption is voltage sag and swell.

issues with voltage due There are several overview articles on power quality improvement methods in the published literature. In [5], the authors primarily concentrate on the uninterruptible power supply (UPS) circuit, topologies, setup, and associated control algorithm to deliver energy during power outages. However, in [6] there is a review of D-STATCOM's use in power system operation. Many different types of control strategies and circuit topologies and architectures are discussed. This research also compares and contrasts the many applications of D-STATCOM in the real world, with an eye on the ways in which this technology may be utilized to improve power quality, especially in the areas of harmonic filtering and power factor correction. The author then provides a comprehensive review on the development of SST for use in electrical distribution networks in [7].

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Here we present
In order to enhance power quality in the electrical distribution system, this research examines the use of dynamic voltage restorers (DVRs) in systems that include renewable energy sources. Since renewable energy is the industry's future, this is very important [12]. DVR's involvement in decreasing disruptions in the system caused by changes in voltage stability is important, making study of its use in such systems crucial. This article covers not only the latest developments in DVR technology but also the standard components, controllers, compensation methods, and applications of DVR systems.

2. THE DYNAMIC VOLTAGE RESTORER

The standard design of the DVR used in practice is covered in this section. In order to correct for voltage sagging, swelling, and harmonic in the distribution network, the DVR is a specialized power device utilized in practice [13]. It is essential to the proper functioning of the delicate load [14]. A DVR's main job is to identify voltage disturbances in the system and inject the appropriate voltage to restore the voltage to the system's typical operating level. To ensure high-quality voltage for appliances, voltage is injected into irregular input [15].

3. THE DVR POWER CIRCUIT

A voltage injection transformer, VSI, low-pass filters, and a device to store DC energy [16] are the four fundamental components of a DVR power circuit, as seen in Figure 1. Table 1 lists the descriptions of each DVR component.

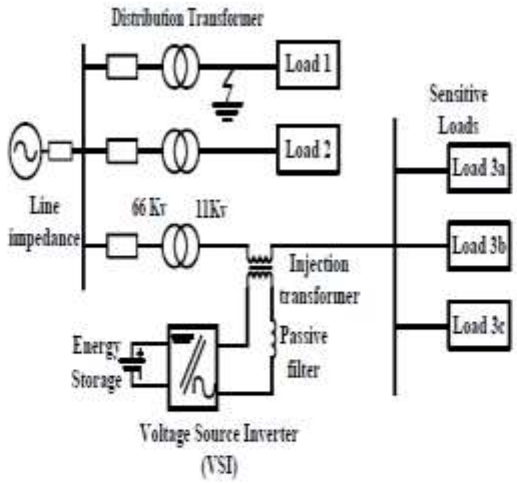

Figure 1. The typical power circuit of a DVR

4. DVR COMPENSATION METHODS

Managing a DVR for voltage injection requires attention to both phase angle and magnitude. There are three possible methods of compensation that might be employed to generate the required voltage. Some of the most basic methods of control include in-phase, pre-sag, and minimum energy compensation [20].

4.1 Compensation before the sag

Figure 2 depicts the pre-sag compensation strategy used in the DVR application. This method equalizes the sinking voltage variance with the pre-sag voltage variation [21] by restoring the magnitude and phase of the voltage before the commencement of the voltage sag. Vpresag represents the system voltage just before the disruption. Vsag and sag are the new voltage and phase angle after the voltage disturbance. This method will correct the sag in the structure.

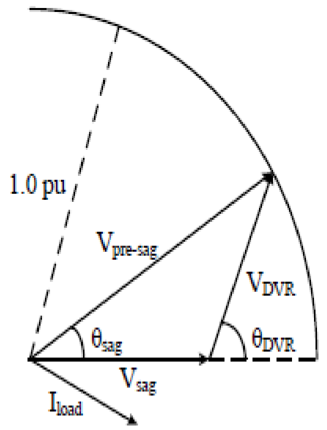

Figure 2. The pre-sag compensation technique

4.3. Minimum Energy Compensation

The minimal energy compensation approach of a DVR is represented by the magnitude and angle representation in Figure 4. The approach injects the required voltage magnitude VDVR with a 90° phase angle to the load [16] based on the diagram. Following a voltage disturbance in the system, the system voltage Vpre-sag-pre-sag falls to the Vsag-0° level. When the DVR notices a voltage disturbance, it elevates the voltage to Vcomp and injects the required VDVR90° into the system. Despite the fact that the method does not involve actively injecting power into the system, the injected voltage may necessitate the use of a transformer and inverter with a greater rating in order to balance out the voltage disturbance in the system. The figure shows that the VDVR exhibited in Figure 4 is considerably greater than the VDVR necessary for the

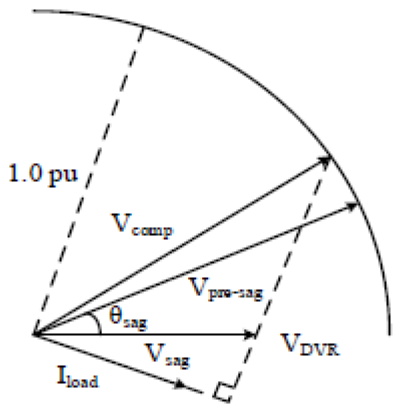

Figure 4. Minimum energy compensation

5. TYPES OF DVR CONTROL STRATEGIES

For a DVR to function, it must be able to effectively manage active and reactive power to protect against potential power quality problems [22]. As mentioned in Section 2 [23, 24], the DVR's control strategies center on adjusting the VSI. Therefore, the control techniques of the VSI are the focus of this section's study. The literature discusses a wide variety of VSI control methods. This study differentiates between two classes of DVR control strategies: linear and non-linear. DVR control strategies are considered in light of the system's load type and sensitivity.

Standardized Regulation

It is possible to classify the conventional control approach into three distinct categories: feedforward, feedback, and hybrid. In DVR, feedforward control is the norm. The approach improves power quality [25] by comparing pre-sage and real-time voltages in the system utilizing an open-loop system. The approach is popular because it is simple, cheap, and fast, even if it is not as precise as other ways of control. Therefore, less complicated load mitigation techniques are preferred over more sensitive and crucial ones. The feedback method uses a closed-loop control scheme [26] by measuring the load voltage against the reference voltage. The technique outperforms the feedforward method in terms of accuracy in power quality mitigation. However,

Management by Means of Artificial Intelligence (AI)

It is well knowledge that the power system does not behave linearly in practice.

Consequently, linear control is only applicable within a narrow operating window. Only a subset of DVR uses have traditionally been met by a single kind of controller. The DVR's linear control is inadequate for dealing with the dynamic nature of operations at the distribution network's upper tiers. Therefore, this issue is believed to be resolved by the nonlinear control. Therefore, many non-linear control techniques for the DVR using ANN, fuzzy logic, and space vector pulse width modulation (SVPWM) are presented in the published literature. Currently, ANN may be used to address complicated engineering problems in any engineering discipline. Its

SIXTH IMPROVEMENTS IN DVR 6.1. Traditional Resources

The use of interline dynamic voltage restoration 6.1.1

However, there are situations when it is not desired to replace the energy storage system owing to the expenses involved, even if it has been shown that the DVR may minimize voltage fluctuations in the system. The interline DVR is mentioned in [30-32] as a solution to this issue. Figure 5 depicts the typical configuration of an interline DVR. In order to provide voltage correction to two separate distribution lines, the graphic shows that two nearby DVRs use the same energy storage technology. Power system specialists and engineers are now investigating the potential of Interline DVR because to its efficacy. Rapid development of the control system is detailed in [34], and the analysis that led to the optimal design is given in [33]..

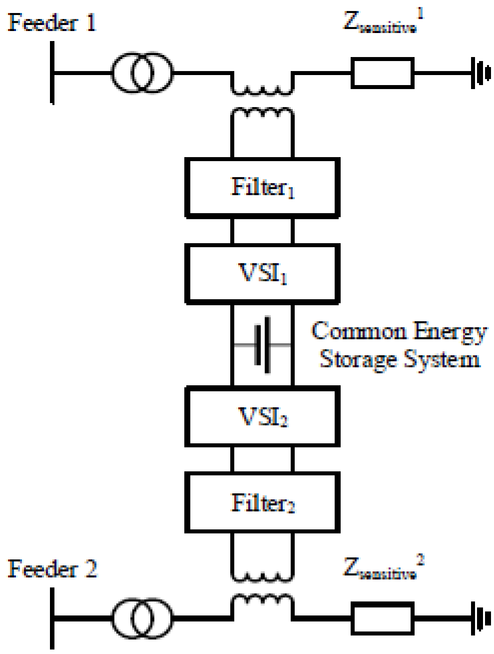

Figure 5. The typical configuration of an interline DVR

6.1.2. Development based on SOGI-PLL

A control strategy for generating the reference voltage and current for the DVR application is presented in [35]. The approach is based on the second-order generalized integrator (SOGI), which is implemented in each distribution line phase. The DVR is used in conjunction with the D-STATCOM method as the shunt and series active compensator to rectify harmonics, sag, and swell in the system voltage and current. The research claims that the SOGI-based algorithm can generate the required reference voltage and current utilizing the distorted signals as input. In [36], the authors investigate the shortcomings of the conventional DVR under voltage sag situations. The approach employs a dual SOGI (DSOGI) algorithm to remove the double frequency interference and isolate the symmetrical parts of the observed data.

6.1.3 Variable Control Units

According to the published works, the DVR is still in the research and development phase. To address these power quality issues, a plethora of state-of-the-art controllers have been proposed. In [38], a positive and negative sequence extractor (PNSE) is designed to address the shortcomings of the conventional SRF-PLL in filtering out negative sequence voltage and harmonics in the power system. This technique simplifies the algorithm used for voltage restoration following a system failure. However, in [39], the authors present a soft-switching single-phase three-arm DVR that increases the DVR power circuit's dependability by decreasing the number of switches used during the voltage adjustment method. In [33], researchers describe a DVR method that uses a moving average filter (MAF) to isolate the desired positive sequence.

6.2. Renewable Energy Integration

When developing new technologies and investigating power systems, scientists and engineers will undoubtedly factor in renewable energy sources. Considering renewable energy sources presents serious integration challenges for the power system community. The advent of DVR technology is not prohibited by this tendency. Researchers in [41] use a feedforward vector control technique to produce the firing angle for the VSI, which in turn reduces voltage disturbances. Measured data from a wind farm at India's Chinnaputhur substation during a voltage dip and rise event are used to demonstrate the effectiveness of the proposed approach. In [42], it is said that a PV-based DVR improves power quality after a system interruption. The role of PV is dual.

7. CONCLUSION

As a conclusion, we talk about how the DVR deployment in the power grid has been evaluated. Normal power circuit layout is shown. The whole of the digital video recorder is dissected. This leads to a discussion of and reference to the real DVR compensation methods. This is a detailed description of the pre-sag, in-phase, and minimum energy compensation strategies. The paper goes on to address the topic of control strategy variation. Both the conventional controller and the AI-based controller are discussed, both in terms of how they work and how they are evaluated critically. Finally, traditional energy sources are assessed after several DVR control strategies have been discussed. Recent advancements in renewable energy sources are also discussed.

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