A Review on Power Quality Improvement Using DVR

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Abstract- *The occurrence of faults upstream of a power network can propagate downstream and affect industrial and utility consumers. And the power equipment of industrial and commercial consumers is affected by these power system faults. Therefore fault detection and mitigation study are essential to maintain the system's reliability. In this project, an approach is adopted to detect the faults, and then, with the help of a Dynamic Voltage Restorer (DVR), the Power Quality (PQ) issues (i.e. mainly Voltage sag and swell) have been mitigated. This project will help the end-user adopt DVR to protect their respective equipment from power system faults. The work in this project is modelled using the MATLAB Simulink environment. Also, in this project, four different types of faults are detected, and their impact has been mitigated using DVR.*

Keywords- Dynamic Voltage Restorer (DVR), Transmission Line, Power Quality (PQ)

I. INTRODUCTION

The power system faults are unpredictable and affect mainly the industrial equipment. In a structured power system, industrial customers fed power directly from a sub transmission or distribution system. Therefore, whenever there is a fault in the transmission system, it needs to be clear as soon as possible; otherwise, the system's reliability will decrease. The poor power quality due to faults leads to voltage sag, swell, under-voltage, overvoltage and interruptions. Therefore these poor power quality issues will malfunction or stop various sensitive equipment. The occurrence of voltage sag due to power system faults leads to huge financial losses in the industry. Industrial sensitive equipment such as adjustable drives, variable speed drives, personal computers, electronics chips, contactors and motor stators are affected mainly by the power system faults. As power system faults are random, its detection and mitigation are essential concerns for industrial customers. . The detection of power system faults is a very complex task. To develop a mitigation stage, a utility engineer should know the when, how, and where the power system faults have occurred. Therefore, Discrete Wavelet Transform (DWT) and Discrete Fourier Transform (DFT) has been used to identify the fault in the transmission network, and with the help of Unified Power Flow Controller (UPFC), the impact of faults has been mitigated.

II. DVR

A DVR is a solid-state power electronics switching device consisting of either GTO or IGBT, a capacitor bank as an energy storage device and injection transformers. A DC to AC inverter regulates this voltage by the sinusoidal PWM technique. All through the normal operating condition, the DVR injects only a small voltage to compensate for the voltage drop of the injection transformer and device losses. However, when voltage sag occurs in the distribution system, the DVR control system calculates and synthesizes the voltage required to preserve output voltage to the load by injecting a controlled voltage with a certain magnitude and phase angle into the distribution system to the critical load.

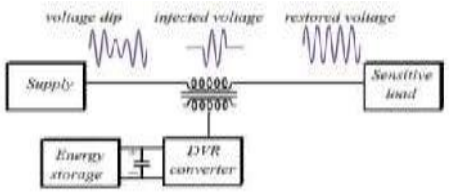

Fig 1. Basic structure of DVR

III. LITERATURE REVIEW

In 2019 Ch. Sandhya [et.al] presented a paper for show the issue which is getting by Voltage Sags and Swells. Voltage Sags and Swells give the effects on linear loads and sensitive loads. DVR (Dynamic Voltage Restorer) is a best coast effective solution for remove the problem for Voltage Sags and Swells for the protection of sensitive loads. The control of compensation voltage is based upon the DQO algorithm. The general configuration of the DVR consists of an injection or a booster transformer, a harmonic filter, a voltage source converter, DC charging circuit, a control and protection system.

In 2020 S. Ganesh [et.al] presented a paper for the distribution system, in which Sags are creating so much disturbances. Voltage Sags are occur due to the fault in the electrical network and it is also occur due to a large induction motor.

This problem can be solved by dynamic voltage restorer (DVR). In this paper, they show the solution for remove Voltage Sags from the Voltage waveform. The DVR consists of VSC, injection transformers, passive filters and energy storage (lead acid battery). By injecting an appropriate voltage, the DVR restores a voltage waveform and ensures constant load voltage.

In 2021 Shazly A. Mohammed [et.al] presented a paper for show the problem of Voltage Sags and also that how much impact it is showing in sensitive loads. DVR (Dynamic Voltage Restorer) is an important device for reduce the problem of voltage Sags. The Dynamic Voltage Restorer (DVR) is fast, flexible and efficient solution to voltage sag problem. The DVR is a series compensator used to mitigate voltage sags and to restore load voltage to its rated value. In this paper, an overview of the DVR, its functions, configurations, components, operating modes, voltage injection methods and closed-loop control of the DVR output voltage are reviewed along with the device capabilities and limitations.

In 2021 Anita Pakharia [et.al] presented a paper for requirement of power quality. It is important issue for the customer of the distributed power. In the power transmission Voltage Sags and swells, notch, spike and transients get occur so we have to remove that for project transmission. The voltage sag and swell is very severe problem for an industrial customer which needs urgent attention for its compensation. There are various methods for the compensation of voltage sag and swell. One of the most popular methods of sag and swell compensation is Dynamic Voltage Restorer (DVR), which is used in both low voltage and medium voltage applications. In this paper, the comprehensive reviews of various articles, the advantages and disadvantages of each possible configuration and control techniques pertaining to DVR are presented. The compensation strategies and controllers have been presented in literature, aiming at fast response, accurate compensation and low costs. This review will help the researchers to select the optimum control strategy and power circuit configuration for DVR applications. This will also very helpful in finalizing the method of analysis and recommendations relating to the power quality problems.

In 2020 Md. Riyasat Azim [et.al] presented a paper for power quality issue. This issue is growing rapidly in the industries and residence electricity users. In the modern and recent technology sensitive power electronic equipment, control device and nonlinear loads are using to increase the efficiency of the distributed network. Voltage disturbances are the most common power quality problem due to this increased use of a large numbers of sophisticated and sensitive electronic equipment in industrial systems. The Dynamic Voltage Restorer (DVR) has recently been introduced to protect the sensitive industrial loads from the detrimental effects of voltage sags/swells and other voltage disturbances. Configurations and control schemes for the DVR vary depending upon the nature and characteristics of the load to be protected. Industries with induction motors loads require a completely different approach for the design and control of a suitable DVR owing to the inherent inertia of the induction motors and their capability to withstand short-duration, shallow sags/swells, in addition to its tolerance to phase angle jumps. In this paper, a DVR with fast response, simple and efficient controller is proposed for fulfilling the voltage restoration requirements for industrial induction motor loads. The proposed DVR employs the classical Fourier Transform (FT) for sag/swell detection and quantification and a Fuzzy Logic based feedback controller which utilizes the error signal (difference between the reference voltage and actual measured load voltage) to control the triggering of the switches of an inverter using a Sinusoidal Pulse Width Modulation (SPWM) scheme. The proposed DVR utilizes the energy from available supply line feeders through a rectifier to feed the inverter.

In 2021 S.F. Torabi [et.al] presented a paper to show the working of the Dynamic Voltage Restorer (DVR). DVR is used to protect the distribution network from the voltage Sags and swells. In the Distribution system it will protect sensitive loads from the voltage Sags and Swells. The DVR can be implemented to protect a group of medium voltage or low voltage consumers. The new configuration of DVR has been proposed using improved d-q-0 controller technique. This study presents compensation of sags and swells voltage during single line to ground (SLG) fault and three-phase fault. The control system is based on DQO technique which is a scaled error, between the source side of the DVR and its reference for compensating sags and swells. The simulation shows that the DVR performance is efficient in mitigation of voltage sags and swells. ***In 2019 Priyanka Kumari [et.al]*** presented a paper for the power quality which is an important issue in the present time. In this paper, a sophisticated device is introduced so that the power quality performance can be improved. The major problem occurs in the system that is Voltage Sags. To solve this problem, custom power devices are used. One of those devices is the Dynamic Voltage Restorer (DVR), which is the most efficient and effective modern custom power device used in power distribution networks. Its appeal includes

lower cost, smaller size, and its fast dynamic response to the disturbance. It can provide the most commercial solution to mitigation voltage sag by injecting voltage as well as power into the system. This paper presents modelling, analysis and simulation of a Dynamic Voltage Restorer (DVR) using MATLAB. The efficiency of the DVR depends on the performance of the efficiency control technique involved in switching the inverters. In this model a PI controller and Discrete PWM pulse generator is used.

In 2020 Mahmoud A. El-Gammal [et.al] presented a paper for the solution of voltage Sags. For remove the problem of Voltage Sags they are giving the DVR (Dynamic Voltage Restorer). DVR is a power electronic based device. It is providing a three phase based controlled voltage source. DVR voltage vector magnitude and angle are added for the voltage of source when voltage sags occur. It is doing so that voltage drop can be resolved and voltage stability gets stable. The DVR is designed for protecting the whole plant with loads in the range of some MVA. The DVR can restore the load voltage within a few milliseconds. Several configurations and control methods are proposed for the DVR. In this paper, an overview of the DVR, its functions, configurations, components, compensating strategies and control methods are reviewed along with the device capabilities and limitations.

In 2021 Ch. Srisailam [et.al] presented a paper to reduce the problem of voltage Sags and Swells by DVR (Dynamic Voltage Restorer). DVR is able to provide the proper voltage quality level which is requested by the customers. DVR will connect along with the feeder in series at the medium voltage. The PI controller is very common in the control of DVRs. However, one disadvantage of this conventional controller is the fact that by using fixed gains, the controller may not provide the required control performance, when there are variations in the system parameters. To overcome this problem the fuzzy logic controller is proposed. And the simulation results have proved that the proposed control method greatly improves the performance of the DVR compared to the conventional PI controller.

In 2020 Mayank Paliwal [et.al] presented a paper for simulation results of mitigation voltage sags and swells. They are using DVR for reduce the problem of Voltage Sags and Swells in electrical power network. The dynamic voltage restorer with its excellent dynamic capabilities, when installed between the supply and a critical load feeder, can compensate for voltage sags/swells, restoring line voltage to its nominal value within few milliseconds and hence avoiding any power disruption to the load. In this paper the technical aspect feasibility related to the use dynamic voltage restorer (DVR) of traditional DC storage systems are evaluated. This topology would ensure a constant DC voltage across the DC link during the process of voltage compensation. The modelling of dynamic voltage restorers is carried out component wise and their performances are analysed using MATLAB software.

In 2019 Tarek I. El-Shennawy [et.al] presented a paper for give the solution from the problem of voltage Sags and Swells for the industries by DVR. DVR is solving the issue of voltage Sags along with all other losses of the distribution network. Existing configurations and control techniques for the DVR aim at protecting industries of high-tech, loads with adjustable speed drives and other power-electronic based loads. Industries with induction motors loads require a complete different approach for the design and control of a suitable DVR. Owing to the inherit inertia of the induction motors and their capability to withstand short-duration, shallow sags, in addition to its tolerance to phase jumps, a DVR with low cost, fast response and simple controller could be configured to fulfil the voltage restoration requirements.

IV. METHODOLOGY

DVR System

Rectifier, inverter, filter and coupling transformer comprises DVR structure, to control variable voltage pulse width modulation technique is used besides. Harmonics can be eliminated by filter due to high switching frequency. Typically the DVR system is connected in series with a distribution feeder which supplies sensitive load in the power system network.

Basic configuration

1. An Injection transformer
2. A Harmonic filter
3. Storage Devices
4. A Voltage Source Converter (VSC)
5. DC charging circuit

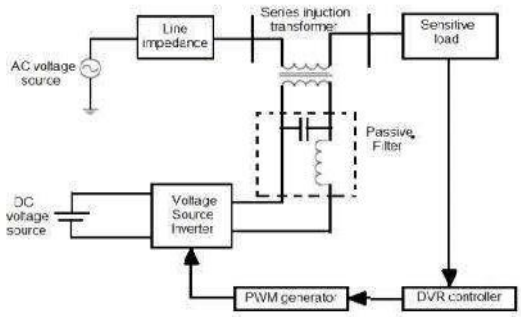

Fig. 2 Basic configuration of DVR

1. **Injection transformer**- Three single phase transformers are connected in series with the distribution feeder to couple the VSC (at the lower voltage level) to the higher distribution voltage level. It links the DVR system to the distribution network via the HV-windings and transforms and couples the injected compensating voltages generated by the voltage source converters to the incoming supply voltage. In addition, the Injection transformer also serves the purpose of isolating the load from the DVR system (VSC and control mechanism).
2. **Ripple Filter**- The output of the inverter contains high frequency switching harmonics. To remove these switching harmonics, a three-phase ripple filter (Electro-Magnetic Interference-EMI) filter is used.
3. **Voltage Source Converter (VSC)** - A VSC is a power electronic device consisting of a storage device and switching devices which can generate a sinusoidal voltage at any required frequency, magnitude, and phase angle. In the DVR application, the VSC is used to inject the voltage or part of the voltage into the system to maintain load voltage balanced.

DC Charging Circuit The dc charging circuit has two main tasks.

1. The first task is to charge the energy source after sag /swell Injection.
2. The second task is to maintain the dc link voltage at the nominal dc link voltage.

SYSTEM REQUIREMENT

Hardware requirement

- Processor: Intel Core i7- 8th Gen
- Installed memory (RAM): 4.00GB
- System Type: 64-bit Operating System

Software Requirement MATLAB Software

MATLAB is a software package for high-performance mathematical computation, visualization, and programming environments. It provides an interactive environment with hundreds of built-in functions for technical computing, graphics, and animations.MATLAB stands for Matrix Laboratory. MATLAB was written initially to implement a simple approach to matrix software developed by the LINPACK (Linear system package) and EISPACK (Eigen system package) projects.

MATLAB is a modern programming language environment, and it has refined data structures, includes built-in editing and debugging tools, and supports object-oriented programming.

V. CONCLUSION

In this project an enhanced sag compensation scheme is proposed for capacitor-supported DVR. The proposed strategy improves the voltage quality of sensitive loads by protecting them against the grid voltage sags involving the phase jump. The effectiveness of the proposed method is evaluated through simulations in MATLAB/Simulink. The scheme can be easily realized by implementing the discrete-time model of the system. The simulation and experimental results confirm the usefulness of this scheme.

VI. FUTURE SCOPE

The presented DVR system considered as an appropriate techno-economical solution, particularly using energy optimization technique. This technique will lead to minimize energy storage component, compared to other compensation methods for DVR, thus having cheap, efficient and reliable system.

The result of inverter were presented and the operation principles were addressed to validate the proposed voltage control scheme DVR. Practical implementation of detection techniques of voltage sag with minimum energy optimization will be addressed in ELEC499.

The DVR system to be implemented for Qatar Petroleum is to overcome voltage sag events, hence secure the power supply to the facility.

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