POWER QUALITY IMPROVEMENT OF DISTRIBUTED GENERATION POWER SYSTEM

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Abstarct: *The aim of this project is to improve the power quality for Distributed Generation (DG) with Active power filter. Power quality is the combination of voltage quality and current quality. Power quality is the set of limits of electrical properties that allows electrical systems to function in their intended manner without significant loss of performance or life. The electrical power quality is most concerned issue. The main problems are stationery and transient distortions in the line voltage such as harmonics, flicker, swells, sags and voltage asymmetries. Distributed Generation (DG) also called as site generation, dispersed generation, embedded generation, decentralized generation, decentralized energy or distributed energy, generates electricity from the many small energy sources. In recent years, micro electric power systems such as photovoltaic generation systems, wind generators and micro gas turbines, etc., have increased with the deregulation and liberalization of the power market. Under such circumstances the environment surrounding the electric power industry has become ever more complicated and provides high-quality power in a stable manner which becomes an important topic. This project deals with the performance of Shunt Active Power Filter (SAPF) for the power quality improvement based on the distributed generation. The real power supply is given by Distributed Generation for the compensation of the voltage related problems. The SAPF has the better performance in the elimination of the harmonics related problems in the distribution side. Here DG is assumed to include Wind power Generation and photovoltaic generation systems. Advantages of this system are constant power supply, constant voltage magnitude, absence of harmonics in supply voltage, un-interrupted power supply. The model system used in this Project work is composed of a Wind Turbine and PV Array. The performance of SAPF is modeled and simulated using MATLAB / SIMULINK.*

Index Terms: Power quality, Distributed Generation, Shunt Active Power Filter

I: INTRODUCTION

Distributed Generation is a back-up electric power generating unit that is used in many industrial facilities, hospitals, campuses, commercial buildings and department stores. Most of these back-up units are used primarily by customers to provide emergency power during times when grid-connected power is unavailable and they are installed within the consumer premises where the electric demand is needed.. Shunt passive filters, consist of tuned LC filters and/or high passive filters are used to suppress the harmonics and power capacitors are employed to improve the power factor. But they have the limitations of fixed compensation, large size and can also exile resonance conditions. The objective of the active filtering is to solve these problems by combining with a much-reduced rating of the necessary passive components. There are many FACTS devices which are being used in the modern electrical network, some of them are Static Synchronous Compensator (STATCOM), Static Synchronous Series Compensator (SSSC), Interline Power Flow Controller (IPFC), Unified Power Flow Controller(UPFC), etc. Some of the widely used custom power devices are Distribution Static Synchronous Compensator (DSTATCOM), Dynamic Voltage Restorer (DVR), Active Filter (AF), and Unified Power Quality Conditioner (UPQC). There are many power quality problems in distribution system such as sag, swell, harmonics, transients etc., but voltage sag is the most severe disturbance which is generally caused by the faults. Voltage Sag and swell can be instantaneous, momentary or temporary. In order to mitigate voltage sag and swell in distribution system DVR is one of the efficient and effective custom power devices. DVR is connected in series with the line and injects or absorbs voltage in order to compensate the voltage sag or swell in the load side and remains the flat voltage profile at the load end.

II: POWER QUALITY ISSUES: The Power Quality issue is defined as "any occurrence manifested in voltage, current, or frequency deviations that results in damage, upset, failure, or disoperation of end-use equipment." Almost all PQ issues are closely related with PE in almost every aspect of commercial, domestic, and industrial application. The most common types of Power Quality problems are Voltage sag (or dip), Very short interruptions, Long interruptions, Voltage spike, Voltage swell, Harmonic distortion, Voltage fluctuation, Noise, Voltage unbalance.

2.1: Mitigation methods for power quality issues

There are two approaches to the mitigation of power quality problems. The first approach is called load conditioning, which ensures that the equipment is made less sensitive to power disturbances, allowing the operation even under significant voltage distortion. Passive filters have been most commonly used to limit the flow of harmonic currents in distribution systems. They are usually custom designed for the application. Active power filters are becoming a viable alternative to passive filters and are gaining market share speedily as their cost becomes competitive with the passive variety. Through power electronics, the active filter introduces current or voltage components, which cancel the harmonic components of the nonlinear loads or supply lines, respectively.

2.2: Power quality improvement methods

Depending on the particular application or electrical problem to be solved, active power filters can be implemented as shunt type, series type, or a combination of shunt and series active filters (shunt-series type).

- The shunt-connected active power filter, with a self-controlled dc bus, has a topology similar to that of a static compensator

(STATCOM) used for reactive power compensation in power transmission systems. Shunt active power filters compensate load current harmonics by injecting equal-but opposite harmonic compensating current.

- Series active power filters operate mainly as a voltage regulator and as a harmonic isolator between the nonlinear load and the utility system. The series-connected filter protects the consumer from an inadequate supply voltage quality. Series active filters work as hybrid topologies with passive LC filters. If passive LC filters are connected in parallel to the load, the series active power filter operates as a harmonic isolator, forcing the load current harmonics to circulate mainly through the passive filter rather than the power distribution system.
- The series-shunt active filter is a combination of the series active filter and the shunt active filter. The shunt active filter is located at the load side and can be used to compensate for the load harmonics. On the other hand, the series portion is at the source side and can act as a harmonic blocking filter. This topology has been called the Unified Power Quality Conditioner (UPQC).
- Hybrid power filters are a combination of active and passive filters. With this topology the passive filters have dynamic low impedance for current harmonics at the load side, increasing their bandwidth operation and improving their performance.
- The advantage of multilevel converters is that they can reduce the harmonic content generated by the active filter because they can produce more levels of voltage than conventional converters (more than two levels).

III: DISTRIBUTED GENERATION SYSTEMS

Distributed Generation (DG) also called as site generation, dispersed generation, embedded generation, decentralized generation, decentralized energy or distributed **e**nergy is electrical generation and storage performed by a variety of small, grid connected or distribution system connected devices referred to as distributed energy resources (DER). Distributed generation may serve a single structure, such as a home or business, or it may be part of a micro grid, a smaller grid that is also tied into the larger electricity delivery system. When connected to the electric utility's lower voltage distribution lines, distributed generation can help support delivery of clean, reliable power to additional customers and reduce electricity losses along transmission and distribution lines.

3.1: Advantages of DG systems:

- On-site power supply avoids transmission and distribution losses.
- Increasing the efficiency compared with central power generation.
- Diversification of power sources.
- A possible solution to constraints on new transmission lines.
- Provides cleaner power by using renewable sources such as wind and sun.
- Better quality of power.
- Hedge against uncertain load growth and high market.
- distributed generation systems with their comparatively small size and short lead times as well as their different technologies, allow players in electricity market to respond in a flexible way to changing market conditions.
- To sell ancillary services (such as reactive power and stand by capacity etc.)

3.2: Challenges of Distributed Generation

- Impact on protection systems.
- Dynamic interaction between generators.
- Conflict in voltage control for generators in proximity.
- Sustained interruptions.
- Harmonics.
- Voltage sags.
- Intermittent in nature
- Free but not always usable.
- Deteriorate system stability.

IV: DEVELOPMENT PLATFORM

The block diagram of proposed model system is shown below in Figure 4.1. In this the electric power qualities in two cases will be compared. Case I: With the SAPF and DVR when it is introduced. Case II: Without the SAPF and DVR. It will be found that the electric power quality will be improved, when SAPF and DVR is introduced. The proposed model system used in this work is composed of a Wind Turbine and a PV array. A miniature Wind Power Generator is represented by WG.

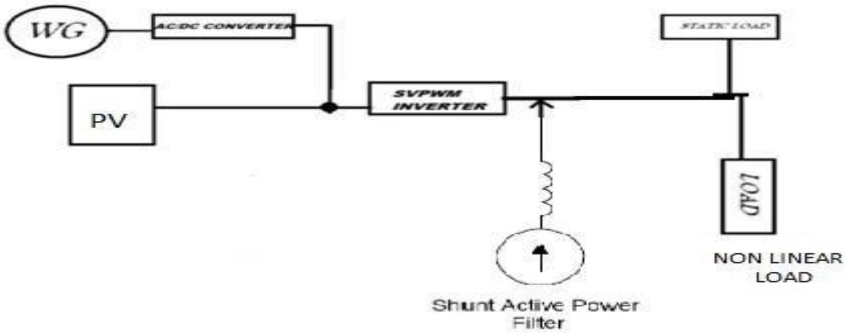

Fig: 4.1 Power Quality Improvement in Distributed Generation System

Dynamic Voltage Restorer is a power electronic switching device which major parts are: Storage Unit, DC link, Filter Circuit, Control Unit, Series Injection Transformer and Voltage Source Inverter as shown in the figure 4.2. DVR is connected in series with the line between the supply and load. The main function of the DVR is to boost up the voltage at the load side so that equipment connected at the load end is free from any power disruption. In addition to voltage sag compensation DVR also carry out other functions such as line voltage harmonic compensation, reduction of transient voltage and fault current.

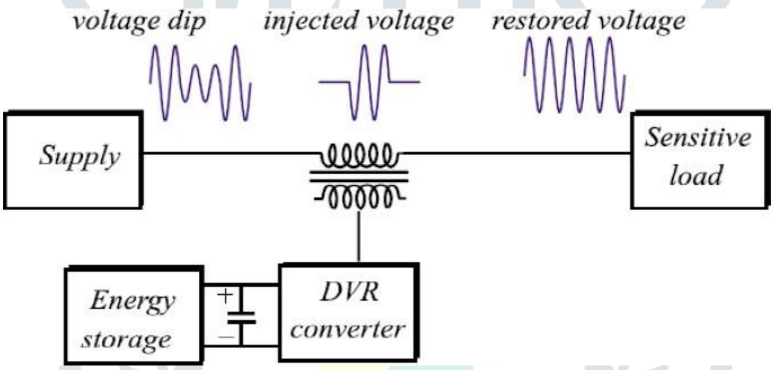

Fig: 4.2 ***Block Diagram of Dynamic Voltage Restorer (DVR)***

V: ACTIVE POWER FILTERS

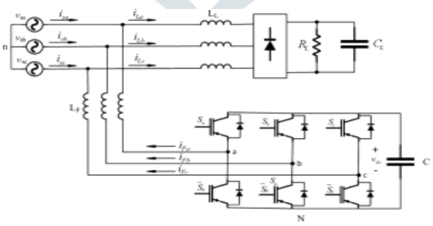

Fig: 5.1: Three phase active power filter

Active power filters are superior to passive filters and can suppress supply current harmonics and also reactive power components. Active power filters consist of power electronic devices and can generate specific current components to mitigate the harmonic currents caused by nonlinear loads. Active power filters can be connected in series as well as in shunt to the nonlinear loads. Here a three-phase shunt active power filter is used. The cost of shunt active filters is relatively high, and they are not preferable for a large-scale system because the power rating of the shunt active filter is directly proportional to the load current to be compensated.

VI: MATLAB MODELLING & SIMULATION RESULTS

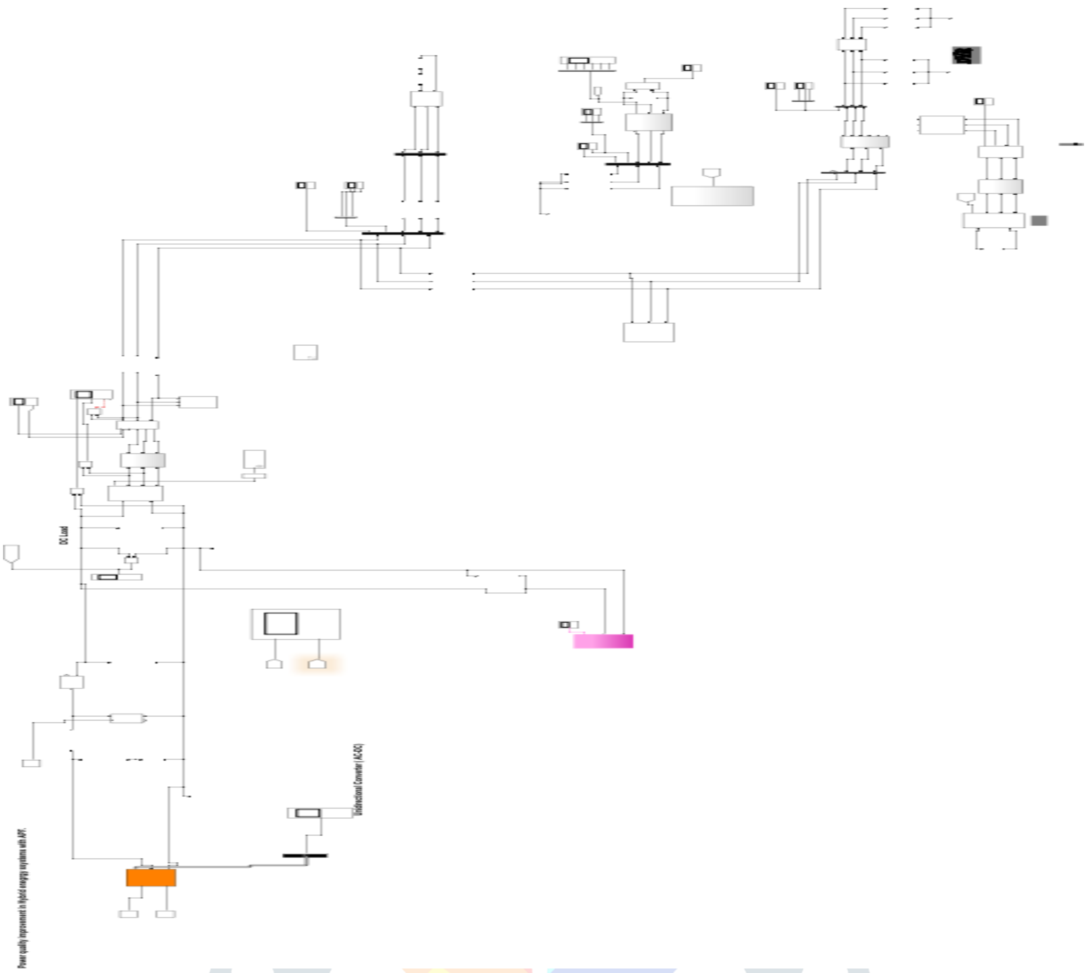

Fig 6.1.Hybrid Distribution Generation System.

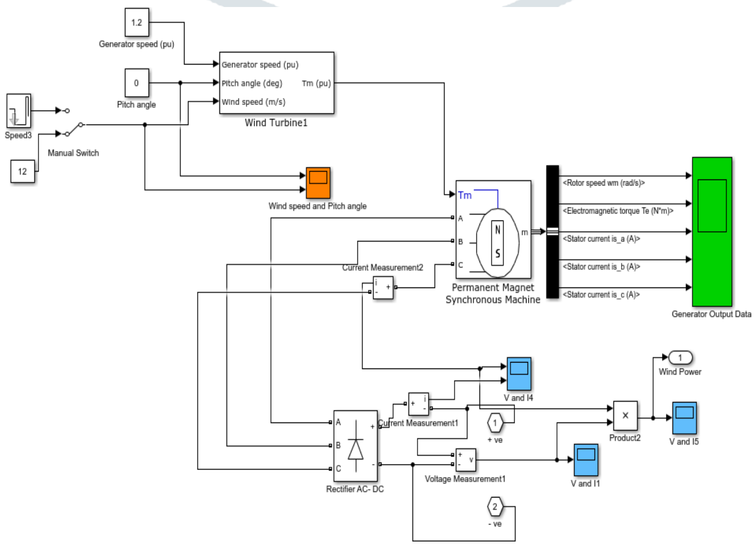

Fig 6.2 Wind Generator

VII: RESULTS AND DISCUSSION:

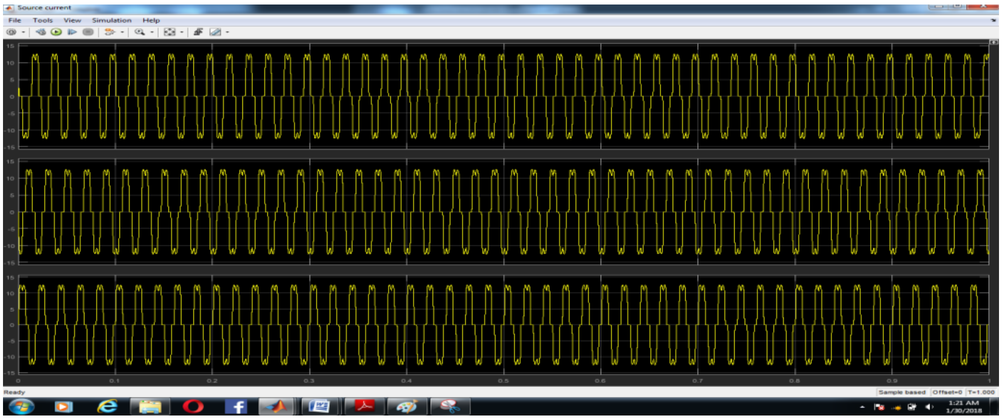

Fig 7.1 Output waveform without APF

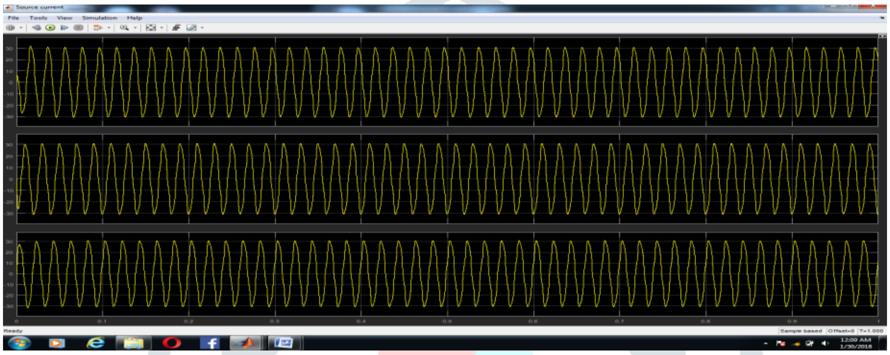

Fig 7.2 Output waveform with APF

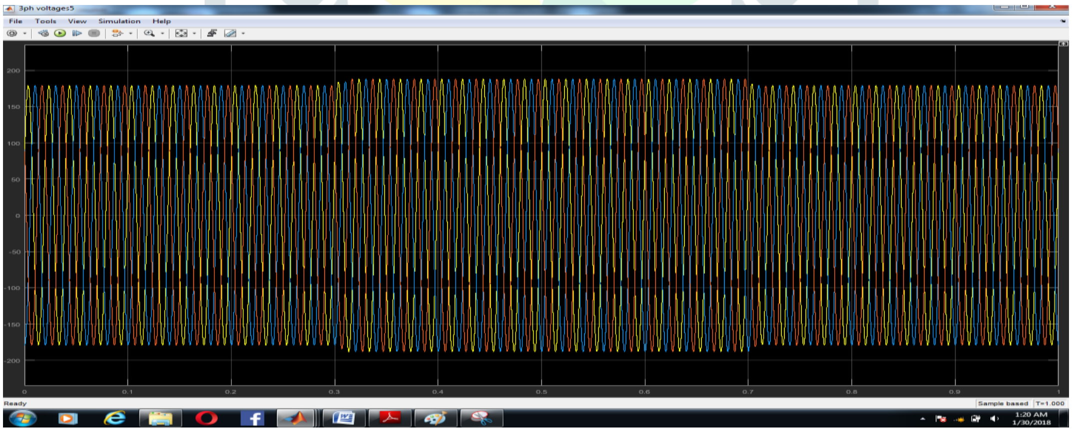

Fig7.3 Voltage swell without DVR

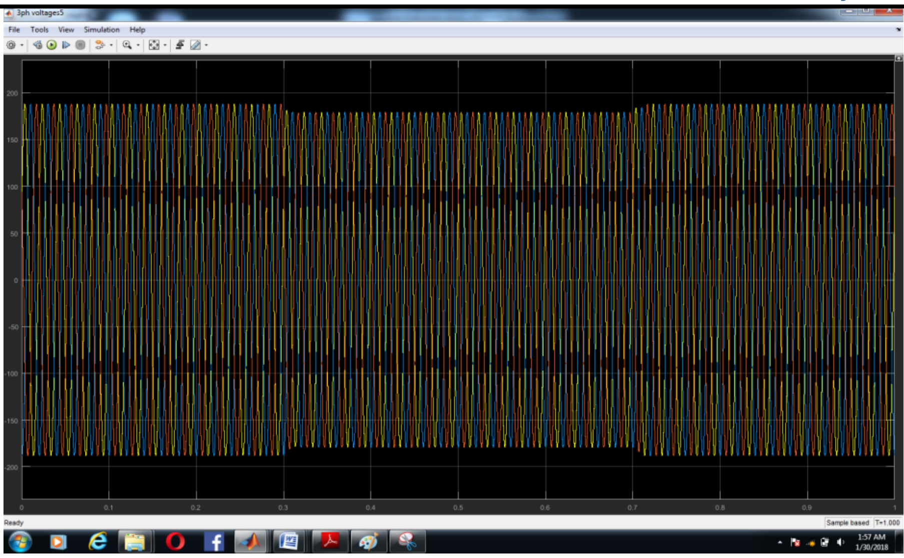

Fig 7.4 Voltage sag and swell mitigation due to DVR

VIII: CONCLUSION

A shunt active power filter has been investigated for power quality improvement. Various simulations are carried out to analyze the performance of the system. PI controller based shunt active power filter is implemented for harmonic and reactive power compensation of the non- linear load. The proposed APF system is more robust, efficient and stable to improve the feasibility and harmonic propagation of the power distribution system. Active power filter which has been used here monitors the load current constantly and continuously adapt to the changes in load harmonics. Shunt Active Filter (SAF) accommodate itself to compensate for variation in non-linear currents. A model has been developed in MATLAB SIMULINK. Simulated to verify the results and total harmonic distortion is calculated using FFT analysis. It is found from simulation results that shunt active power filter improves power quality of the power system by eliminating harmonics and reactive current of the load current, which makes the load current sinusoidal and in phase with the source voltage. It shows that the device is capable of mitigating the sag and swell. Simulation and experimental results proved the viability of using active power filters to compensate active power filters.

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