ISSN: 0974-2115
www.jchps.com Journal of Chemical and Pharmaceutical Sciences

Voltage sag mitigation using solar fed DVR based on fuzzy logic controller

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ABSTRACT

The Dynamic Voltage Restorer (DVR) is one of the Custom Power devices used in distribution systems to protect sensitive loads from sudden changes in voltage variation. In this paper, a new topology is proposed for the three-phase dynamic voltage restorer (DVR). This topology is used for the voltage sag compensation with a Photo Voltaic voltage fed Boost Converter for the compensation of voltage sag for medium voltage power system. In this topology Boost converter is incorporated as it provides the required high output voltage and possess less EMI noise. Apart from this, voltage generated from conventional sources like PV Panels can be boosted to more ranges of high voltages. Also fuzzy control technique is used for the efficient compensation under the voltage sag condition.

Keywords: DVR, Fuzzy logic, Photo Voltaic, Sag

INTRODUCTION

With increasing quantities of non-linear loads being added to electrical systems, it has become necessary to establish criteria for limiting problems from system voltage degradation. A recent survey of Power Quality indicates that more than 50% of all Power Quality problems are related to sag, swell and harmonics. Electrically operated equipment is affected by Power Quality disturbances which affects both the load as well as the utility. Determining the exact problem requires sophisticated electronic test equipment and its mitigation is performed by custom power devices with control techniques. Some of the symptoms of power quality problems are: automated Systems stops for no apparent reasons, Circuit Breaker trips without being overloaded, Electrical systems failure on a frequent basis, Electrical systems work in one location but not in another location, Equipments failure during a thunderstorm, piece of the equipment dysfunctions at the same time instant.

The commonly used terms those described power quality disturbances are Voltage sags, Voltage Swells, Interruptions, Brownouts, Blackouts, Common mode noise, Harmonics, Sub harmonics, Harmonic resonance, Inter harmonics, Triplen harmonics, Impulse, Notching, Noise, Spikes (Voltage), Ground noise, Electromagnetic interference, frequency variation, Dropout, Fault, Flicker, Ground, Voltage fluctuations, Transient, Momentary interruption, Over voltage, Under voltage, Non- linear load, Voltage dip, Voltage imbalance, voltage and current Distortion, Voltage regulation, Oscillatory transient etc. The issue of electric power quality is gaining importance because of several reasons like the wide spread usage of non-linear power electronic loads, precise operation of sensitive loads, continuous operation of loads using uninterrupted power supplies and electronic equipments making use of switched mode power supplies either generate these disturbances or could get affected because of these disturbances.

Dynamic Voltage Restorer (DVR), which is installed in a distribution system between the supply and critical load feeder, is a custom power device which was first installed in 1996 to inject voltage into the system to regulate the load voltage and to compensate the reactive power. DVR injects active power into the distribution line to compensate sag in load voltage. The capacity of the energy storage elements like battery or capacitor can become a limiting factor during compensation of reactive power to reduce long duration sag.

PROPOSED SYSTEM

In the Proposed System, a new topology is simulated for three-phase dynamic voltage restorers (DVRs). This topology is used for the voltage sag compensation with the PV voltage fed Boost Converter for the compensation of voltage sag for medium voltage power system. In this topology Boost converter is incorporated as it possess less Electro Magnetic Interference (EMI) noise. Apart from the above mentioned advantages the voltage generated from conventional sources like PV Panels can be boosted to various ranges of voltage. Also a fuzzy control technique is used for the efficient compensation under the voltage sag condition.

Now a day, power quality problems become very critical for industries due to the loss of money & time. Due to this, demand of good power quality results in reduction of power quality problems like voltage sag etc. One of the most important power quality problems in the power distribution system is the Voltage sag. Mostly voltage sags are caused by sudden over loading or switching of heavy inductive loads, and faults on the distribution system. Voltage sag is nothing but a slight decrease in voltage for a short duration of time. In definite terms, sag ranges between 0.9 to 0.1 per unit (p.u) in r.m.s voltage or current at power frequency for duration of ½ cycles to 1 minute.

There are many methods to overcome voltage sags. The main goal of DVR is to maintaining a constant voltage of sensitive load bus in the state of disturbance of power system. The control method is based on comparing source and load voltages and their difference determines the dynamic behaviour of the DVR.

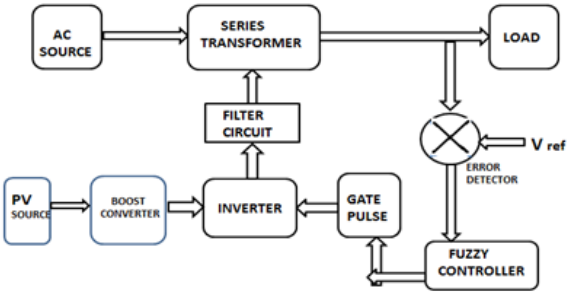

Fig.1.Proposed System Block Diagram

In most sags compensation technique, DVRs are applied to inject active power into distribution line during the disturbance. Therefore, the capacity of energy storage will limit the compensation process, especially for sags with long duration. Typically, DVR consists of three phase inverter, energy storage element, controller and booster transformer. In this paper, fuzzy Mamdani inference method is applied as a controller. Three phase inverter is controlled by Pulse Width Modulation (PWM).

The significant part of the proposed topology is the PV source for the boost converter fed to the 3 phase voltage source inverter. Here the voltage generated from the PV panel is given to the boost converter input which functions to boost up the input voltage with significant magnitude. The boosted voltage is then fed to the 3-phase voltage source inverter to convert the DC voltage to equivalent AC voltage. At last it is injected through injection transformer by passing through LC filter circuit in order to reduce the harmonics.

The main merit of proposed system includes the comparatively faster response as fuzzy controller provides fast & efficient operation. The obtainable output voltage range is wider for the voltage compensation. The presence of proper LC filter circuit additionally decreases the distortions on the output voltage of the load side. It is less vulnerable to EMI noise and the risk of getting damaged is less in either open or short circuit conditions. Scope of power factor correction is high and the total harmonics distortion (THD) is low due to filter circuit.

DC Energy Storage Device: The DC energy storage device provides the requirement of the real power of the DVR during compensation. Basically, there are many storage techniques such as: flywheel energy storage, superconducting magnetic energy storage and Super capacitors. Batteries are not suitable for DVR applications since it takes considerable time to discharge energy from them. Now a days, conventional capacitors and super capacitors are in use.

Filter Circuit: The main function of the filter is to keep the harmonic voltage content by eliminating high frequency switching harmonics. Here the LC filter is used to remover the harmonics from the injected voltage which is connected across the output arms of the boost converter. RL and RC filter circuits are used along the output of inverter circuit for proper reduction & refinement of injected voltage from harmonics & EMI noise. In the proposed model the RL filter is connected in series across the inverter output circuit for the reduction of harmonics or distortions in the injected voltage waveform. Further the RC filter absorbs the by pass harmonics thus acting as the passive harmonics filter for filtering the inverter ac output for suitable & efficient compensation.

Fuzzy logic Controller: The main function of the control system is to maintain voltage magnitude constant at the point where a sensitive load is connected, as the disturbance occurs. The control system mainly consists of a voltage correction method which determines the reference voltage. This voltage is injected by DVR and the VSI control which in this method consist of PWM with PI controller. The controller input is an error signal obtained from the reference voltage and the value of the injected voltage. Fuzzy Logic is an algorithm that allows exploiting linguistic rules in the conditional and iteration format for controlling or modelling different systems without a mathematical description of the system. The linguistic rules work with subjective, non-crisp (aka fuzzy) parameters. As a consequence, the use of fuzzy logic is very helpful when we want to apply human knowledge to a controller mechanism. As technical systems only deliver (and require) crisp values, fuzzy logic controllers need to map crisp parameters into subjective classifications. This is done through fuzzification using membership functions which define overlapping crisp value ranges for the subjective parameters. The overlap areas where a crisp value is a member of two classes allow for smooth transitions between dissimilar behaviours like acceleration under "far" conditions, slow down when "close" and reverse when "very close". A complete fuzzy logic control consists of three main components: fuzzification via membership functions, an inference engine that calculates the fuzzy output based on the inputs and linguistic rules and defuzzification to create the crisp outputs.

Voltage Injection Transformer: The main function of this transformer is to connect the DVR to the distribution network through the HV-windings. The injected voltage may consist of harmonics and dc voltage components i.e. dc offset. If the transformer is not designed properly, the injected voltage may saturate the transformer and result in improper operation of the DVR.

Voltage Source Inverter: A voltage source inverter is a power electronic system consisting of switching devices (IGCTs, IGBTs, and GTOs), which can generate a sinusoidal voltage at any required frequency, magnitude, and phase angle. In the DVR, the voltage source inverter is used to replace the supply voltage or to generate the part of the supply voltage which is missing.

Simulation circuit:

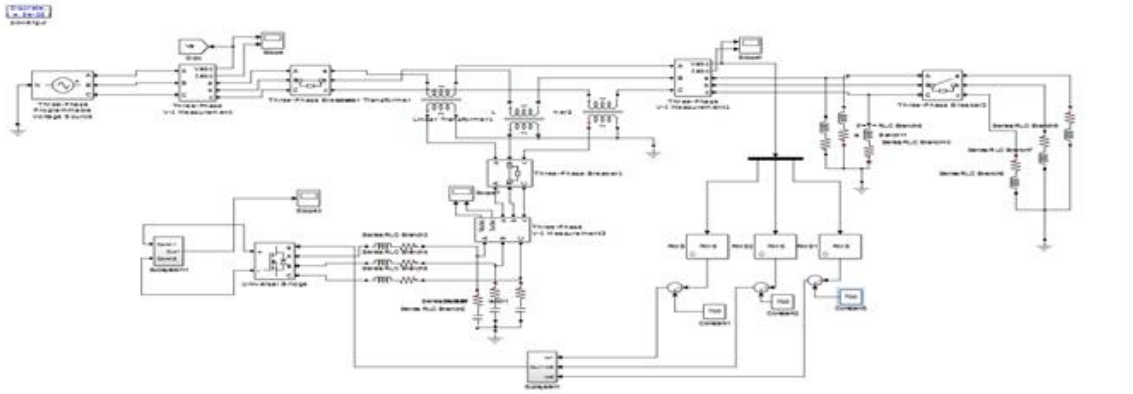

Fig.2.Simulink Model of Proposed System

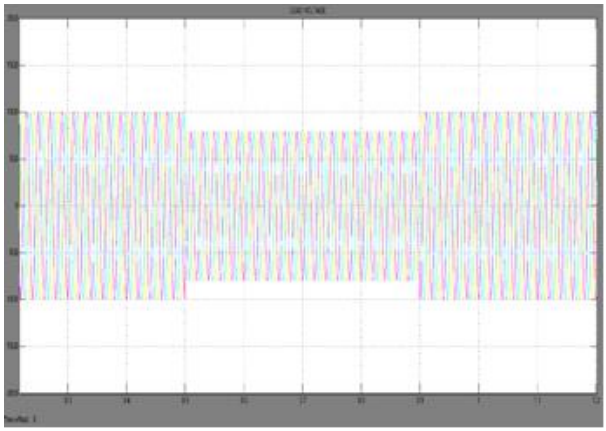

Fig.3.Output voltage without DVR

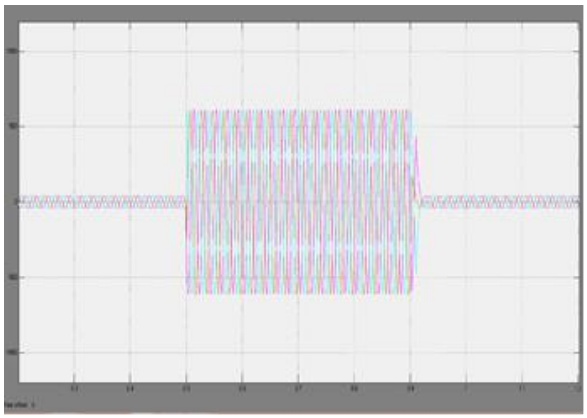

Fig.4.Injected voltage for sag compensation

The instant of time when an external load is applied on the load side of the system with DVR ranges from 0.5sec to 0.9 sec. To create sag the circuit breaker is kept closed in order to connect the external load which in turn causes the sag for a transition time of 0.5sec. to 0.9sec. During this switching period an extra voltage is applied by the DVR to compensate the dip in voltage on the load side of the system which is shown in Fig.4. The actual value of the r.m.s. voltage before the sag condition is 1kv. The circuit is connected to the DVR. The sag compensation which is done during the transitions time of 0.5sec. to 0.9sec creates a uniform voltage magnitude as shown in fig.5. The harmonics which occurs due to the presence of non linear circuit in the system is measured by applying Fast Fourier Transformation (FFT) and is found to be well within the IEEE standard.

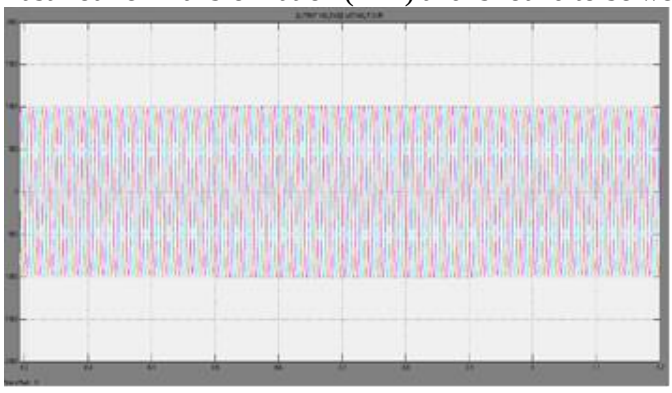

Fig.5.Output load voltage with DVR

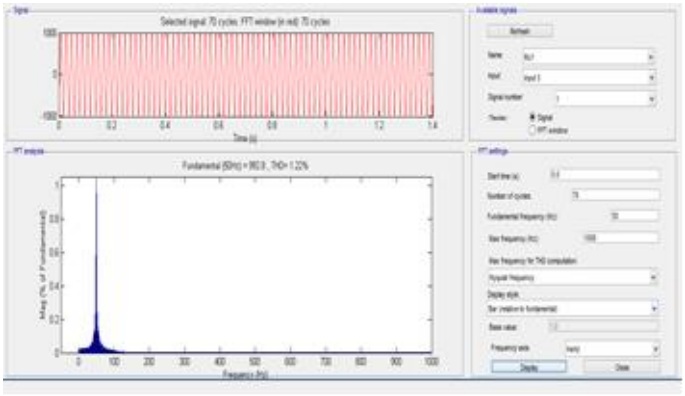

Fig.6.Total Harmonic Distortion

CONCLUSION

This work aims at implementing Voltage quality Improvement by using a Dynamic Voltage Restorer with PV fed boost converter. The proposed system of a dynamic voltage restorer with PV fed boost converter using fuzzy control technique is discussed. Simulation results are done for the proposed system using MATLAB (SIMULINK MODEL). Voltage sag has been compensated as inferred from the simulation results. In this project the DVR with boosted voltage from boost converter has been proposed in order to improve the voltage quality by reducing the total harmonic distortions. This topology aims in extending the scope for utilizing the conventional source generated voltage to overcome the limited range of voltage compensation. Thus from the simulation output of the proposed system it is clearly concluded that the level of the harmonic is comparatively reduced in PV source of Boost converter fed DVR system with THD of 1.12% which is very much with in the IEEE standards.

REFRENCES

E.Babei and S.Murugansami, Voltage quality improvement by DVR for 3 phase converter, IJERA Journal, 3(1), 2013, 1090 – 10.

E.gongial and Serigo, Voltage sag compensation using PI controller, Conference paper in June 2013

F.Z Peng, Z Source Inverter, IEEE Journal, 139, 2003, 504-510.

M.Balamurgan, T.S shivakumaran, Voltage sag/swell compensation using Z-Source inverter DVR based on fuzzy controller, IEEE Conference, 2013

R.M. and Baladhandapani.R, PIC Based 7 Level Cascaded H-Bridge Multilevel Inverter, IJEIT, 2(10), 2013, 84-88.

Voltage sag/swell compensation using current source inverter with fuzzy controller IEEE conference paper by S.Balasubramaniam in March 2014.