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Solar PV - Battery Storage with DVR for Power Quality Enhancement

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***Abstract* - The consumption of electric power is very high due to high invention and more number of non-linear loads. The most of the loads are nonlinear loads, causes the harmonic electric currents in the system. These harmonic currents in turn create system resonance, capacitor overloading, decrease in efficiency, voltage magnitude changes. Power quality has become an increasing concern to utilities and consumers. The power transmitting in a distribution line is needed to be of very high quality. One of the major power quality issues is considered in the distribution system called Voltage sag and it can mitigate with the help of dynamic voltage restorer (DVR). In this paper, Focusing on the new integration of solar PV-Battery based Dynamic Voltage Restorer is implementing in the distribution system to meet the required power and for power quality enhancement. 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.**

Keywords – Solar Photovoltaic (PV) Array, Power Quality, DCDC Boost converter, Battery Storage System, Dynamic Voltage Restorer (DVR), Maximum power point Tracking(MPPT).

I. INTRODUCTION

This article describes a solar photovoltaic (SPV) Boost Converter based Dynamic Voltage Restorer (DVR) for the minimization of voltage and current quality problems namely sags and harmonics under nonlinear load condition. To generate reference voltage waveforms UVT control technique is used. This control technique, control the operation of SPV DVR. This work also describes the hybrid system for optimum maximum power point tracking (MPPT). This is the integration of perturbation and observation (P&O) system and incremental conductance (INC) system. The obtained MATLAB/Simulink based results are investigated.

In any country, Energy is the essential source to implement economically. Energy utilization is growing day by day due to new modern technology; population growth and Energy consumption are becoming major part in agriculture, domestic as well as in industrial sectors. Now a day's, power system most of the power supply is supported by the coal generated based plant and still in India most of the people suffering from shortage of power during the peak load. The shortage of peak power is reduced every year due to invention of renewable energy sources like solar, wind, hydro in the power system. But the usage of power is increasing each and every year due to population, growth in technology, industry, Educational institutions, and high invention of non-linear load. This non-linear load causes power quality problem such as harmonics, power fluctuation, imbalance the voltage and sudden switching these load causes voltage sag, swell, spikes, transient will occur in the existing power system. The low voltage Distribution system suffers from the voltage sag and swell. This voltage problem can be mitigated with the help of one of the distributed FACTS (Flexible AC Transmission system) device, is called Dynamic Voltage Restorer (DVR).

II. EXISTING SYSTEM

There are different kind of power quality problem such as transients, voltage sags, voltage swells, Voltage interruption and harmonics. Also explain the causes, effect of power quality problems in the distribution system and basic model of DVR is implemented to mitigate the voltage sag. When the load is suddenly switched on, then the necessary power in the utilities required is more. The

necessary peak demand is achieved with the help of solar photovoltaic (PV) system.

The solar PV is playing a vital role in generating the electricity and reduces the dependency on fossil fuel. The solar PV technology is reliable, simple to design, clean and efficient for grid connected mode, Off-grid system [3].

M.Ramaswamy and S.Thangavel are studied experimental verification for power quality improvement in low voltage distribution systems using solar PV-DVR [4]. The solar PV is implemented with fuzzy logic based perturb and observation, maximum power tracking method is to track maximum power from solar PV and they compared the results with conventional technique. This Experimental study is only for single phase system. The Authors in [5] has explained dynamic voltage restorer with PI controller, and separate storage devices integrated with DVR to enhance the load performance under faulty condition in three phase distribution system. Anthony M.Gee et.al [6] has considered the battery and super conducting magnetic storage system (SMES) based DVR. This hybrid storage system is to mitigate the grid fluctuation in the short interval. The SMES has reduces the peak demand of battery, but no longer to support during the voltage fluctuation. This separate storage device leads to again a cost expend in the distribution system.

III. PROPOSED SYSTEM

In this paper, solar PV, Battery based DVR is integrated with the utility grid. Here, the novelty is the Battery and Solar PV are used for supplying the necessary power and also it will support the DVR to maintain the smoothening power at the utility. The following section deals with in detail the modules of solar PV, Battery based DVR and implementing this proposed system in MATLAB-SIMULINK software. The SIMULINK model and results are presented under dynamic conditions of the loads.

COMPONENTS OF HYBRID SYSTEM

1. Solar Photovoltaic (PV) System Solar photovoltaic system generates the electricity due to the photoelectric effect. Basically, solar PV cells are non-linear devices, which are arranged in series-parallel to form a PV array. The basic diagram of solar PV is shown in Figure.1.

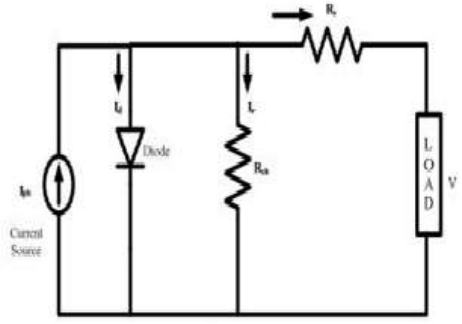

Fig. 1 Solar PV Equivalent circuit [7].

In the proposed system, solar PV system produces the electricity and it is integrated with the utility grid to meet the peak power. The solar PV is also integrated with DVR and battery through DC-DC boost converter to provide required DC bus voltage at DC link.

2. DC-DC Boost Converter

DC-DC Boost converter is connected among the solar PV and inverter to step-up the voltage. This boost converter used for stepping up the natural voltage of solar PV. The basic diagram of boost converter is shown in Fig.2 [8].

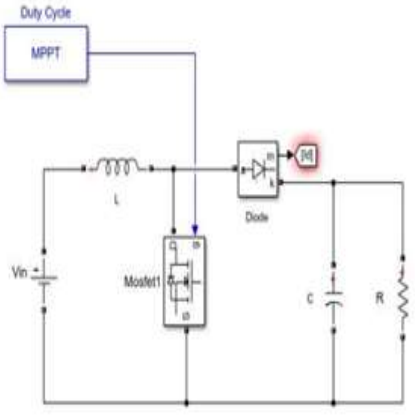

Fig. 2 Block diagram of Dc-Dc Boost converter [8]..

Switching operation of boost converter is optimized with incremental conductance based maximum power point tracking controller and it is used to track the maximum power from the solar PV.

3. Dynamic Voltage Restorer

Dynamic voltage restorer is the one of the distributed FACTS devices, which is connected in series with the line through the transformer and voltage source converter with a common DC link capacitor. The basic model DVR is shown in Figure.2[9].

The main goal of the DVR is maintaining the appropriate voltage at sensitive load under dynamic voltage fluctuation. DVR restores the voltage in the distribution system under dynamic variations in the load as well as during the voltage sag. Hence it has become one of the consumer, familiar device is called customer power device.

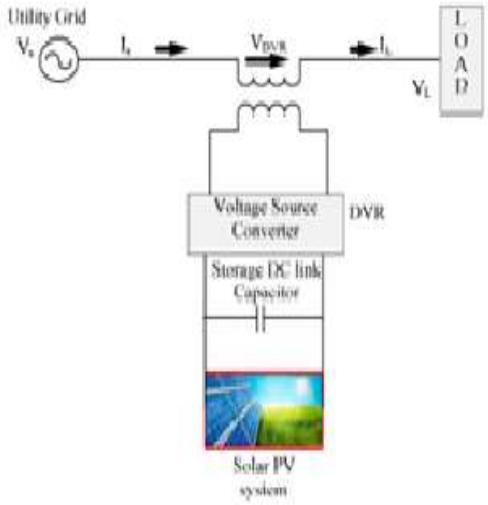

Fig. 3 Basic block diagram of Dynamic Voltage Restorer [9].

DVR operation performs in two modes. The primary one is to restore or compensate the voltage in the distribution line during the disturbance such as voltage sag, swells, harmonic, transient, and fault current. The second one is the normal operating mode. In this mode injection voltage by the DVR is zero [10]. The injected voltage must satisfy the load demand.

IV IMPLEMENTATION OF SOLAR PV-BATTERY STORAGE WITH DYNAMIC VOLTAGE RESTORER (DVR)

The proposed hybrid system is simulated in MATLABSIMULINK software, which is shown in Fig.3. A Grid of 25kV is integrated with the 100kW of solar PV array trough a DC-DC boost converter and a three leg voltage source converter.

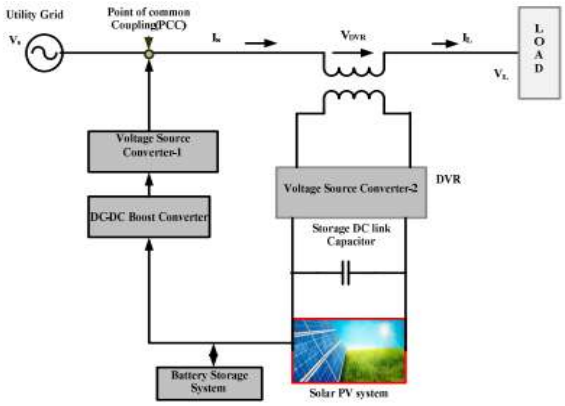

Fig.4.Basic block Diagram of Solar PV, Battery with DVR

Solar PV arrays are framed with 96 numbers of series connected cells with open circuit voltage of 64.2V at short circuit current of 5.96A. In this hybrid system incremental conductance based integral regulator control maximum power point tracking technique is proposed to track the maximum power from the solar PV panels. At maximum power voltage and currents are 54.7V, 5.58A respectively. Capacitor bank is used for filtering the harmonics which are produced by a voltage source converter. Three phase transformer rating of 260V/25kV is connected in series with the line for injecting the DVR voltage.

Solar PV and Battery is integrated in the system and it is supported to the DC link capacitor. The DC link capacitor is connected to support the grid as well as DVR to maintain the necessary smoothening power to the load.

V. SIMULATION RESULTS OF SOLAR PV-BATTERY STORAGE WITH DVR

The simulation of Solar PV, Battery with DVR is simulated under standard test conditions at 25deg.C, 1000W/m2 . Up to t=0.05sec DC link capacitor and the batteries are charged. The boost converter and inverter are not operated due to blocking the pulses to the both the converters.

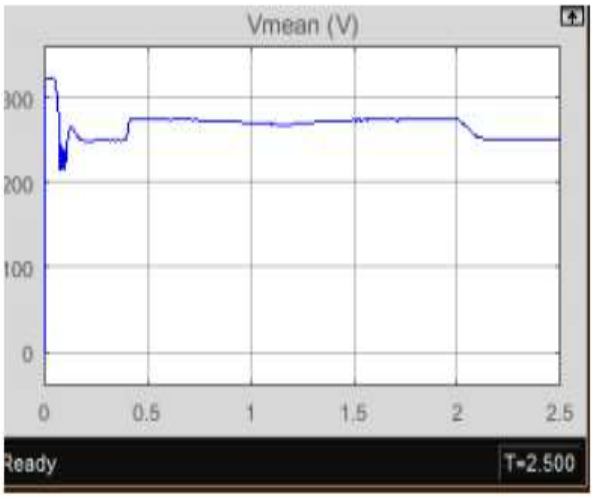

Fig.5.Solar PV Voltage

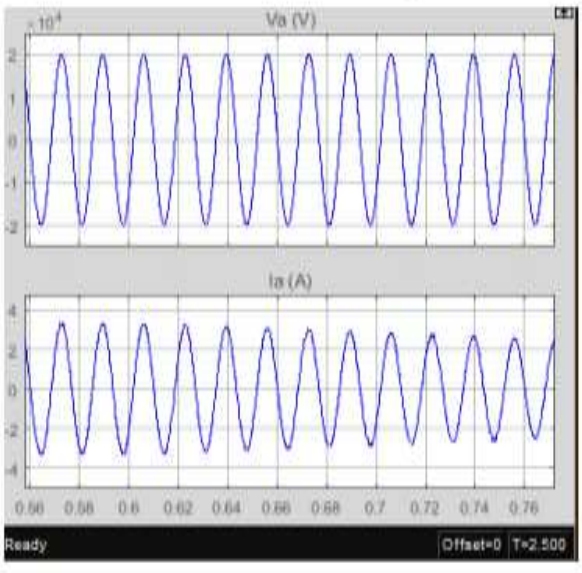

Fig.6.Utility Grid Voltage and Current of phase

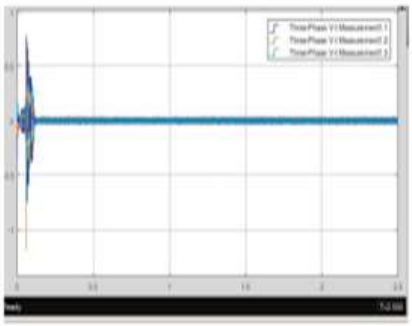

Fig.7. Utility Grid Voltage under fault without dynamic voltage Restorer.

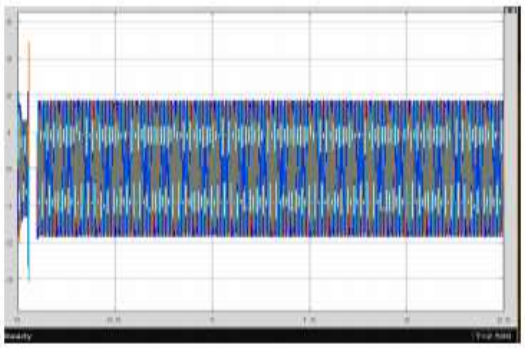

Fig. 8. Load Voltage under Fault conditions.

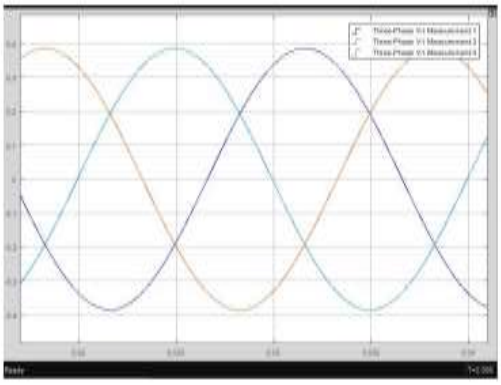

Fig. 9. Load voltage with Dynamic voltage Restorer during one cycle.

The fault is created at the load end from at t= 0.01 to 0.06Sec. The utility grid and load voltage under fault condition Without DVR is shown in Figure.9 and Figure.10. A DVR is protecting the grid fault condition. The battery is supported under the abnormal radiance to meet the load demand and during the voltage sag; it has

maintained the necessary power The grid voltages and load voltage with DVR.

VI. CONCLUSION

Utility grid connected Solar PV, Battery based DVR is simulated under dynamic fault conditions. This paper has discussed the novel integration of solar PV supported in two ways, one is to meet the load demand and the other one is maintaining the DC link voltage of DVR at voltage source converter. The sensitive load voltages and grid voltage are balanced by injecting the voltage in series with distribution line the line.

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