An Integrated Dynamic Voltage Restorer- Multilevel H-Bridge Inverter for Improving Power Quality of the Distribution Grid

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Abstract— *In this paper, the problem of voltage sags and swell and it is several impact on sensitive load is well known. To defeat this problem, Dynamic Voltage Restorer (DVR) is a custom power devices Used for mitigating voltage sag and swell in power distribution system. Multilevel H-bridge inverter is used to exchange the real and reactive power to the load from photovoltaic (PV) system. DVR model, PV model, sliding mode controller (SMC) model, neural network and local grids are implemented and the results are shown in the simulation. PV array is directly connected to the DVR with the absent energy storage devices. Neural network controller is used in this system. The proposed system was developed by MATLAB Simulink. The objective of this project is to study the system behavior, which allows the renewable energy sources for mitigating voltage disturbances.*

Keywords— Dynamic Voltage Restorer (DVR), photovoltaic (PV) system, neural network, sliding mode controller (SMC), Multilevel H-bridge inverter

I. INTRODUCTION

The major trouble in power system is voltage sag and engorge, voltage flicker, transient. Dynamic Voltage Restorer (DVR) is a custom power devices Used for mitigating voltage sag and swell in power distribution system [1]. DVR is one of the devices that have a related configuration of series type of FACTS device. The significance of this device is to guard a sensitive load from sag or engorge and deviations in the supply side by quick succession voltage booster to recompense for the fall or grow in the supply voltage. Here we described DVR principles and voltage correction methods for balanced or unbalanced voltages and engorge in a distribution system [9].When there is a distortion in the source voltage, the proposed series device may also have to introduce a distorted voltage to counteract the harmonic voltage

Along with existing control methods of DVR, the SMC technique has its high strength and simplicity. A sliding mode input–output linearization checker for the zero-voltage switching (ZVS) is accessible [5]. The proposed controller broadly improves the transient response and disturbance, dismissal of the converter as preserving the closed-loop stability and SMC utilizes discontinuous control laws to make the system state trajectory onto a specified surface in the state space, so called sliding or switching surface, and to maintain the system state on this assorted for all the subsequent times [1&5].

Photo voltaic systems can create straight current electricity without environmental impact and contamination when exposed to solar radiation [2]. Recently various new methods are proposed for modeling and simulation of photovoltaic arrays (PVA) having higher accuracy and lower assumptions. Being a semiconductor device, the PV system is static, quiet, free of moving parts, and has little operation and maintenance costs. For the effective\ integration of the solar power into the power system, good controlling methods should be developed with power electronics devices [10].

II. DYNAMIC VOLTAGE RESTORER (DVR)

A Dynamic Voltage Restorer (DVR) is newly planned series connected solid state device that injects voltage into the system with the aim of regulate the load side voltage. The DVR was first installed in 1996. It is generally install in distribution system between the supply and critical load feeder. Its primary function is rapidly improving the load-side voltage as it was disturbance in order to avoid any power disruption to that load.

There are various circuit topologies and control schemes with the aim of implement a DVR. In addition to voltage sags and swells compensation, DVR can also added new features such as: line voltage harmonics compensation, reduction of transients in voltage and fault current limitations [9]. The common configuration of the DVR consists of an Injection / Booster transformer, a Voltage Source Converter (VSC), a Harmonic filter, DC charging circuit and a Control and Protection system as shown in Figure 1.

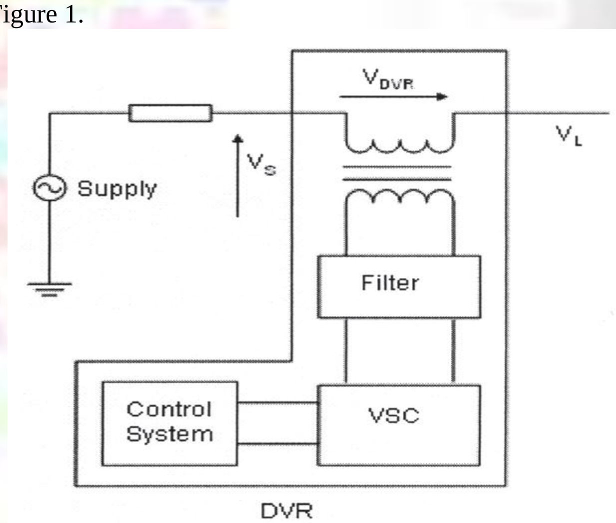


Fig. 1: DVR series connected topology

A. *Operating Principle of DVR:*

The basic role of the DVR is to inject a dynamically controlled voltage VDVR produced by a forced commutated converter in series to the bus voltage by incomes of a booster transformer. The momentary amplitudes of the three injected phase voltages are controlled such as to remove any detrimental effects of a bus fault to the load voltage VL. In that any differential voltages affected by transient disturbances in the ac feeder will be compensated by an equivalent voltage produced by the converter and inserted on the medium voltage level through the booster transformer. The DVR works independently of the type of fault or several events that happens in the system, provided that the whole system remains coupled to the supply grid, i.e. the line breaker does not outing. For most practical cases, a more economical design can be achieved by only compensating the negative and positive sequence components of the voltage disturbance seen at the input of the DVR [8]. This possibility is Reasonable because for a typical distribution bus configuration, the zero sequence part of a disturbance will not permit through the step down transformer because of infinite impedance for this component.

The DVR has two modes of operation which are: boost mode and standby mode. In standby mode (VDVR=0), the booster transformer's small voltage winding is shorted through the converter. No switching of semiconductors occurs in this mode of operation, because the separate converter legs are triggered such as to establish a short-circuit path for the transformer connection. Therefore, only the relatively low conduction losses of the semiconductors in this current loop donate to the losses. The DVR will be most of the period in this mode [8]. In boost mode (VDVR>0), the DVR is inserting a return voltage through the booster transformer due to a finding of a supply voltage disturbance.

III. Proposed Power System Modeling

DVR model, PV model, neural network, DC-DC converter, Multilevel H-bridge inverter and SMC is attached to the power system [1]. DVR is a custom power device Used for mitigating voltage sag and swell in power distribution system [8].Multilevel H-bridge inverter is used to exchange of real and reactive power to the load from photovoltaic (PV) system [7]. PV array is directly connected to the DVR without using any energy storage devices. Fig2 shows the block diagram of proposed system. This method is developed by MATLAB Simulink.

APV cell or solar cell or is a wide area electronic device that exchanges solar energy into electricity by the photovoltaic effect. Photovoltaic is the field of technology and research linked to the application of solar cells as solar energy [10].

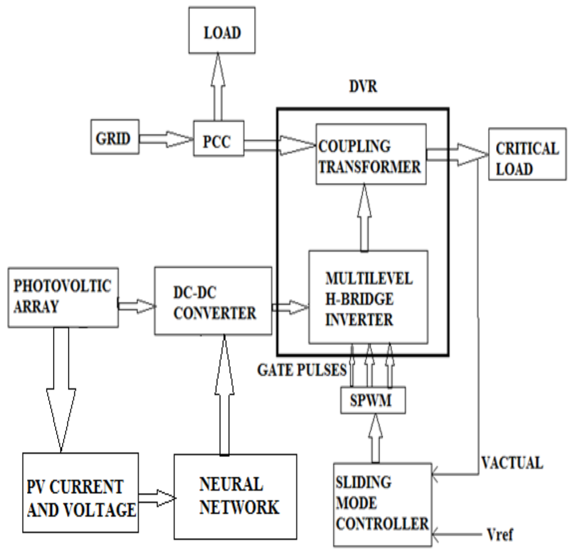


Fig. 2: Block diagram of the proposed system

The artificial neural network is capable of representative both the linear and non-linear relationships. It is having capability to study these relationships directly from the data being modeled. For the innovation and development of better control systems, the design and implementation of intelligent systems has become an essential factor.

Sliding mode control is a nonlinear controller technique introducing remarkable properties of accuracy, robustness, and easy tuning and implementation [5].

IV. Simulation of the Proposed System

The proposed system was implemented with help of MATLAB Simulation and the output waveform was studied. DVR model, PV model, sliding mode controller model and local grids are implemented and the results are shown in simulation. In order to improve the efficiency of the photovoltaic system. PV array is directly connected to the DVR without using any energy storage devices and neural network controller is used. The proposed system Simulink is shown in fig 3.

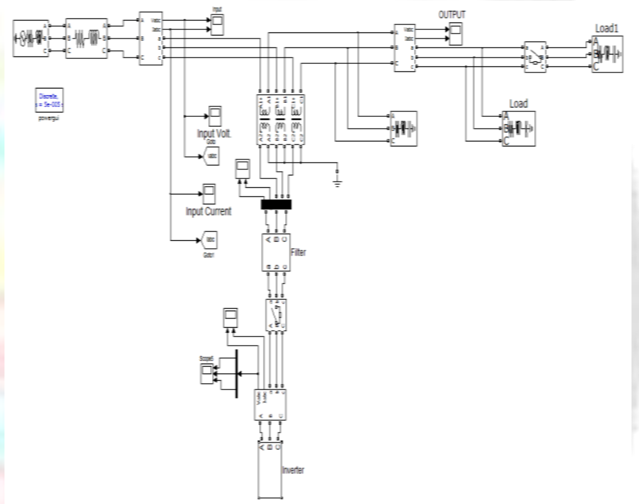


Fig. 3: Simulation of the proposed system

V. Simulation Output of the Proposed System

The proposed system with DVR the voltage waveform after compensation by means of DVR is show fig 4&5. It can be seen that the terms controlling power quality namely voltage and frequency are well within the limits required. In this way, the power supplied to the sensitive load is well inside the limits thereby ensuring efficient operation and long life of equipment. The THD value of before and after compensation as shown in fig 6&7. In fig7 shows that the THD value of load voltage drastically improved.

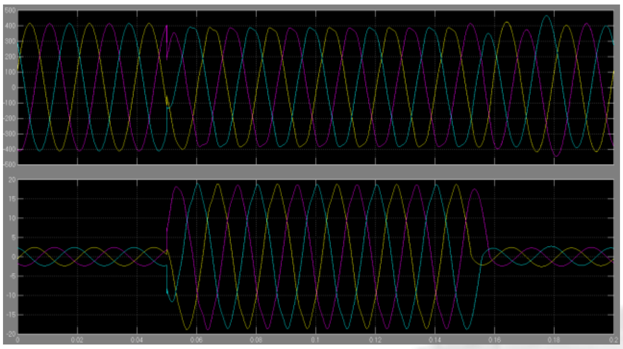


Fig. 4: Load voltage with DVR

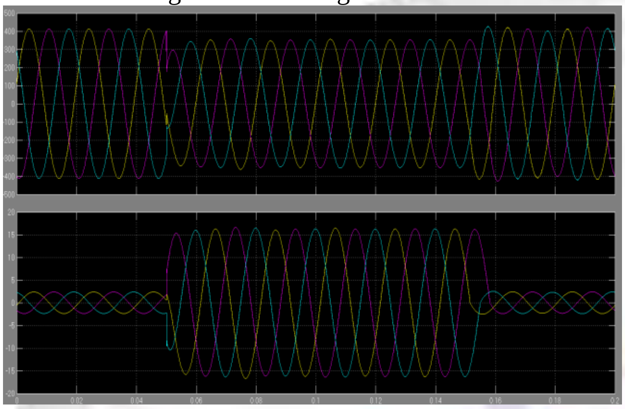


Fig .5: Load voltage without DVR

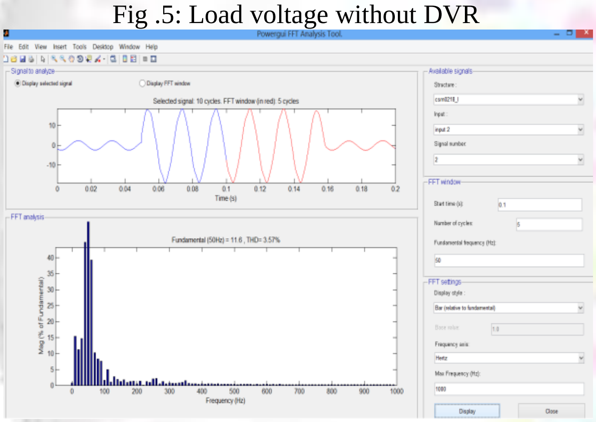


Fig. 6: THD of the proposed system Without DVR

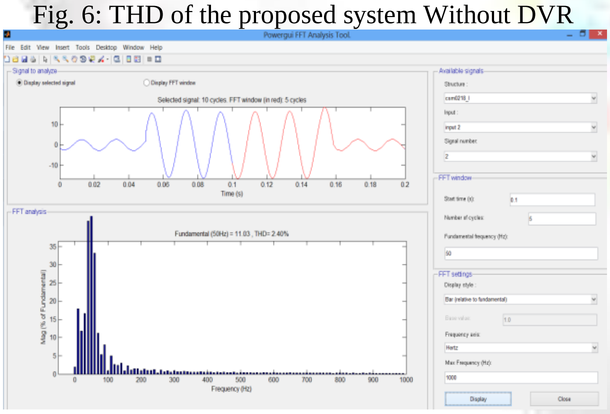


Fig. 7: THD of the proposed system With DVR

VI. SIMULATION OF THE MULTILEVEL H-BRIDGE INVERTER

The traditional three or four levels inverter does not completely remove the unwanted harmonics in the output waveform. So, using the multilevel inverter as an alternative to traditional PWM inverters is studied.

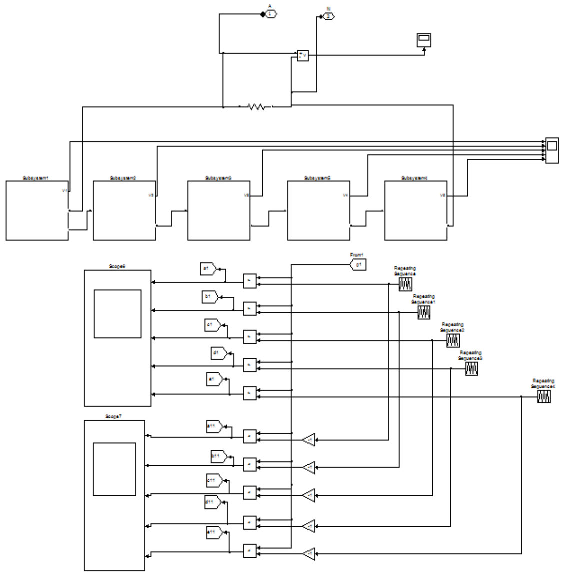
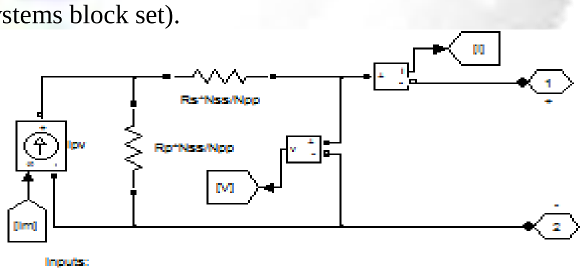


Fig. 8: Simulation of the multilevel h-bridge inverter

In these topologies the number of phase voltage levels at the converter terminals is 2N+1, where N is the dc link voltages or number of cells. In these topologies, each cell has separated dc link capacitor and the voltage across the capacitor might differ between the cells. So, each power circuit needs just one dc voltage source. The number of dc link capacitors is balanced to the number of phase voltage levels. Each H-bridge cell may have positive, negative or zero voltage. Concluding output voltage is the sum of all H-bridge cell voltages and is symmetric with respect to neutral point, therefore the number of voltage levels is odd. Cascaded H-bridge multilevel inverters typically use IGBT switches. These switches have high switching frequency and low block voltage. The MATLAB simulation of the multilevel H-bridge inverter is shown below in fig 8.

VII. SIMULATION OF THE SOLAR PANEL

Fig 9 shows the photovoltaic model circuits implemented with MATLAB/SIMULINK [10]. (Using the Sim Power Systems block set).



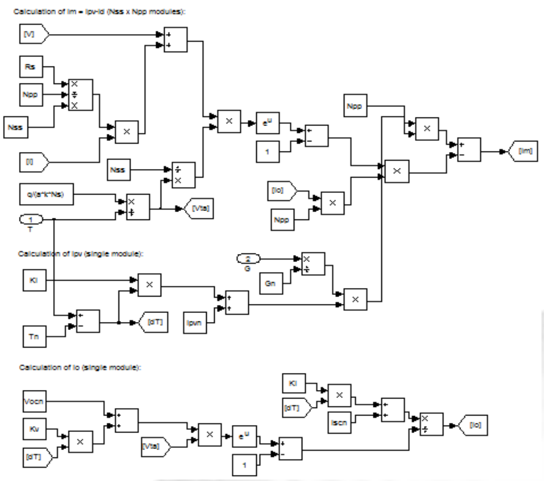


Fig.9 Photovoltaic circuit model built with MATLAB/SIMULINK

VIII. SIMULATION OF THE FUNCTION FITTING NEURAL NETWORK

Function fitting neural network are feed forward neural networks used to fit an input-output relationship. The MATLAB simulation for the neural network as shown in the figure 10.

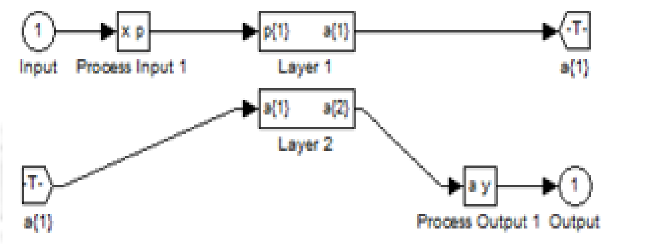


Fig. 10: Simulation of the function fitting neural network

The artificial neural network is capable of representing both the linear and non-linear relationships. It is having ability to learn these relationships directly from the data being modelled.

IX. SIMULATION OF THE SOLAR PANEL CONNECTED WITH NEURAL NETWORK

In the proposed system, solar panels produce the output based on the controller on function fitting neural network. In this system the powers are directly given to the grid with the absence of energy storage devices. The simulation of the solar panel is shown in the below fig 11.

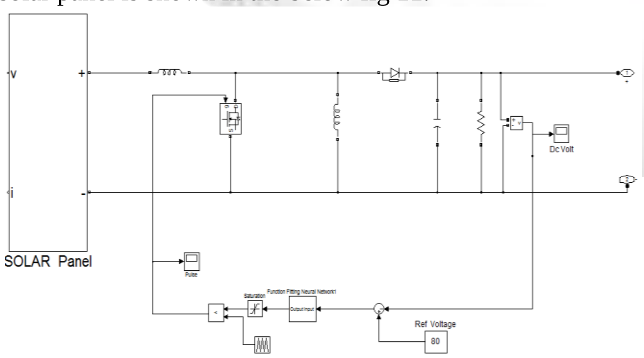


Fig. 11: Simulation of the solar panel connected with neural network

A. *Output waveform for solar panel*

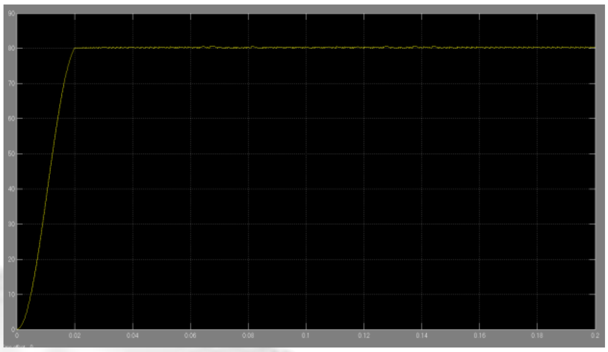


Fig. 12: Output for solar panel

X. RESULTS AND DISCUSSION

A. *Simulation Result without Battery:*

This system, solar panel power is directly connected to the load with the help of DVR to produce constant voltage supply. For the purpose of a DVR is used to reduce the voltage sag/swell. In this project, to neglect the voltage sag/swell in the load side with the absence of energy storage devices (battery). Fig 13 shows that waveforms without using battery.

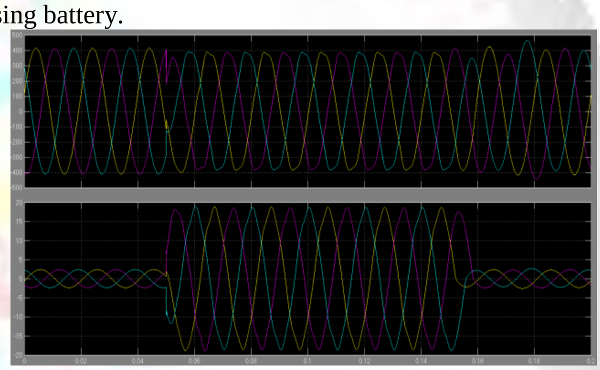


Fig. 13: Output waveform for without battery and with DVR

From the fig .13 shows both the voltage and current waveforms while the DVR is connected tothe load, then we can see the variation in the waveform. If any voltage sags/swell occurs in the voltage at the time current shows the magnitude changes at the changes still voltage sag/swell attack and then it comes to normal. In this project cost are less because absent of energy storage devices. Fig.12&13 shows the concept of using with DVR and without DVR.

The waveforms are formed with the help of a battery .we cannot neglect voltage sag/swell while using battery noise level is high in this condition. Fig.14 shows the waveform for with battery and DVR

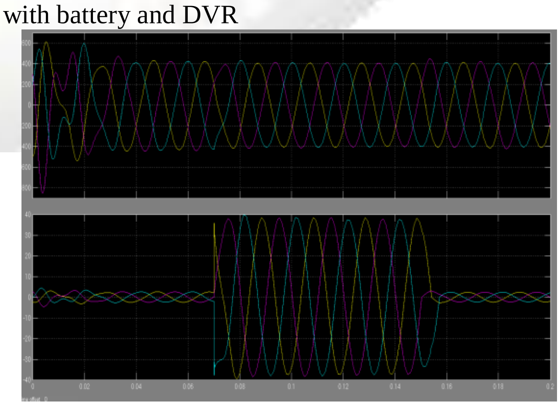


Fig. 14: Output Waveforms for with battery and DVR

XI. Conclusion

In this work, the eminence of voltage on the distribution side was enhanced with the help of a DVR, when the disturbance occurs in the sensitive load feeder. Analysis was carried out to various custom power devices; DVR has excellent compensation aimed at voltage disturbances. Simulation was passed out with a PV interfaced multilevel

To further boosts up the operation of a DVR, we suggest a few techniques. While number of levels in a multilevel inverter increases, we can make sure harmonic free sinusoidal output, but the cost increases as the level increases. However, by means of neural network based controller to drive the power switches in an inverter we can get the preferred results for non-linear loads. Although it is a PV with neural network incorporating this technique into a DVR can very much improve its performance and make sure reliable operation of the sensitive loads.

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