ISSN: 2321-2152

IJMECE

International Journal of modern electronics and communication engineering

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editor@ijmece.com

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MITIGATION OF VOLTAGE SAG WITH TRANSFORMER LESS DVR BASED REDUCED SWITCH COUNT MULTILEVEL INVERTER

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ABSTRACT:

Multilevel inverters (MLIs) are becoming commonly increasing in high- and medium-power applications. This is because MLI has various intrinsic advantages over conventional two-level inverters, including reduced device ratings, high-quality output, and so on. Although MLIs have a promising future in industry-oriented applications, their commercial acceptance has been constrained by their size cost, excessive device count, and switch complexity. To convey the drawbacks of MLIs, academics are continually developing next-generation topologies known as reduced switch count (RSC) MLIs. Now-a-day's power quality issues are become extremely important as sensitive loads are becoming more severe daily in power systems. Severe power quality issues including voltage sag, voltage swell, harmonics, flicker, etc. are to be notable. In power systems voltage sag is the most severe power quality problem. MLIs have stood up to be a mature technology for many custom and commercial products for an extensive variety of power applications particularly flexible alternating current transmission systems (FACTS). For the protection of sensitive loads from the power quality problems, one of the FACTS devices DVR is most effective solution. This paper explains Transfomerless DVR based on a T-type multilevel inverter. By eliminating the injection transformer, we can achieve the cost reduction, reliability and high efficiency. The controller of DVR is implemented by d-q transformation. The simulation results are generated using MATLAB/Simulink Software.

Keywords: DVR, FACTS, RSC, Voltage sag, swells, MLI.

I INTRODUCTION

In order to maintain a constant flow of power to sensitive loads, modern power electronics have developed dynamic voltage restorers (DVRs) to shield electrical transmission lines from spikes and dips in voltage. These gadgets detect when the voltage is off from what's considered normal and then inject or absorb compensatory voltage on the fly to get it back to where it should be. A DVR system's essential parts include an injection transformer, filters, an energy storage unit, a voltage source converter (VSC), and a complex control system. In order to neutralize voltage disturbances, the VSC injects AC voltage into the transmission line via the injection transformer, after converting stored DC energy into DC voltage. Preventing interruptions and possible damage to vital equipment, this real-time adjustment helps keep voltage within permissible ranges.

The control system of a DVR starts the operation by continuously checking the voltage of the transmission line. The DVR rapidly determines the size of the necessary compensating voltage upon detecting a voltage sag or swell. In order to restore a voltage that has dropped below the specified level, the DVR injects supplementary voltage that is in phase with the line voltage. On the other side, when the voltage spikes, the DVR takes it all in and brings it down to normal levels. In order to provide a clean sinusoidal output, the VSC must first generate the appropriate compensating voltage, which must then be filtered to remove harmonics. By injecting the compensating voltage into the transmission line via the injection transformer, the disturbance is successfully neutralized and voltage levels are maintained consistently.

A number of control mechanisms, including feedforward, feedback, and hybrid control, are used by DVRs to maximize performance. Feedforward control provides fast but less flexible responses by reacting to pre-defined patterns of disturbances. Conversely, feedback control might provide slower responses but more adaptability by continually adjusting the compensating voltage in response to real-time data. To achieve a happy medium between responsiveness and speed, hybrid control uses elements of both approaches. Power quality, equipment uptime, and system dependability are all greatly improved by using DVRs. Protecting vital infrastructure and sensitive industrial processes from the harmful effects of voltage fluctuations, DVRs quickly reduce spikes and dips.

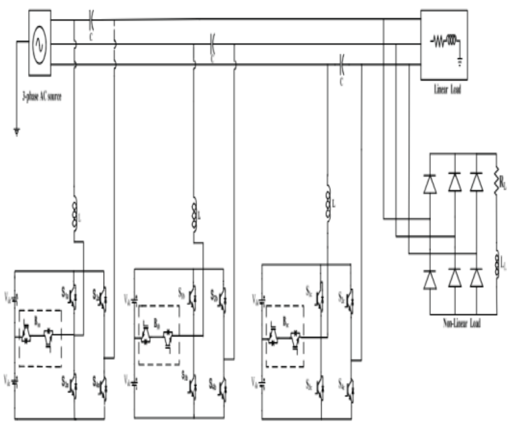


Fig.1. Block diagram.

II LITERATURE SURVEY

[1] M. Bollen, understanding power quality problems.Piscataway, NJ USA, IEEE press 2000: In this paper proposed the expected and possible adverse consequences for power quality of introducing several smart distribution-grid technologies and applications. The power quality issues occurring in AC microgrids during islanded operation and in DC microgrids should be minimized. The research shows that the system may reduce power quality issues by using DVR based multilevel inverter .

[2] Soleiman, Galeshi, Hossein Iman-Eini "Dynamic Voltage restorer employing multilevel cascaded-H bridge Inverter", IET Power Electronics, 2016 pp.2196-2204

In this paper presented design and performance assessment of a DVR based on the voltage sag data collected from MWPI..This estimation method is able to recognise voltage sags in approximately half a cycle. A voltage control scheme, comprised of three separate controllers, was proposed in this paper for keeping voltage balance among the DC link capacitors within nominal range.

[3] Kavita Kiran Prasad, Hareesh Myneni, Ganjikunta Siva Kumar, "Power Quality Improvement and PV Power Injection by DSTATCOM with Variable DC Link Voltage Control from RSC-MLC,"

The study proposes a method to optimize dc-link voltage of distribution static compensator based on load compensation requirement using reduced switch count multilevel converter (RSC-MLC) integrated with photovoltaic (PV) system. The proposed method is capable of compensating reactive power, unbalance, and harmonics demanded by three-phase unbalanced and nonlinear loads connected to the distribution side, leading to improvement of power quality. During off-peak loads, the dc-link voltage can be brought down to a lower value, which will reduce the voltagestress across switches of inverter and minimizes the switching losses.

[4] Z Li, Jayesh Motwani, Zhiyong Zeng, Srdjan M. Lukic, Angel V. Peterchev, and Stefan M. Goetz, "Reduced Series/Parallel Module for Cascade Multilevel Static Compensators Supporting Sensorless Balancing." A reduced series/parallel module (RSPM) is proposed and optimized for cascaded multilevel STATCOMs. Compared to the conventional H-bridge modules, the additional switch in RSPM allows parallel interconnection, and cycling the parallel state throughout the arm guarantees sensorless balancing. It does not interfere with other control loops. Upgrading Hbridge modules to RSPMs is simple. It requires less components than similar series/parallel modules while achieving the same semiconductor utilization ratio as the H-bridge.

[5] Gupta, K.K.; Ranjan, A.; Bhatnagar, P.; Sahu, L.K.; Jain, S. Multilevel Inverter Topologies with Reduced Device Count: In this paper, some of the recently proposed multilevel inverter topologies with reduced power switch count are reviewed and analyzed. The paper will serve as an introduction and an update to these topologies, both in terms of the qualitative and quantitative parameters. Also, it takes into account the challenges which arise when an attempt is made to reduce the device count. Based on a detailed comparison of these topologies as presented in this paper, appropriate multilevel solution can be arrived at for a given application.

Proposed system:

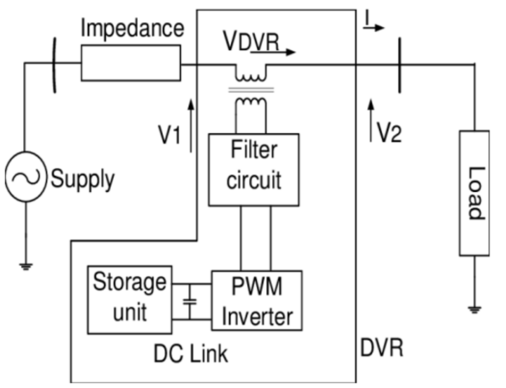
The proposed system for mitigating voltage sag employs a transformer-less Dynamic Voltage Restorer (DVR) integrated with a reduced switch count multilevel inverter. This configuration enhances the efficiency and reliability of voltage sag compensation by eliminating the bulky and expensive transformer, thereby reducing the overall system cost and size. The multilevel inverter, with its reduced switch count, simplifies the circuitry and minimizes switching losses, while still achieving the desired voltage levels to counteract sags. By directly connecting to the distribution network, the DVR swiftly injects the necessary compensating voltage during sag events, maintaining the quality and continuity of power supplied to sensitive loads. This innovative approach leverages the advantages of multilevel inverters in providing smoother voltage waveforms and improved harmonic performance,

ISSN2321-2152
www.ijmece .com
Vol 12, Issue 2, 2024

ensuring a robust solution for voltage sag mitigation in power systems.

WORKING METHODOLOGY

The Dynamic Voltage Restorer (DVR) is a power electronic converter-based device that has been designed to protect the critical loads from all supply side disturbances other than the outages. It is connected in series with a distribution feeder and is capable of generating or absorbing real and reactive power at its terminals. The basic operating principle behind the DVR is to inject a voltage of the required magnitude and frequency in series with the incoming supply voltage so as to restore the load voltage to the pre sag state. It is basically consisting of power circuit and control circuit.



The power circuit of the DVR has four main parts; Voltage Source Inverter(VSI), voltage injection transformer, DC energy storage device and low pass filter, as shown in Fig.1. The most common custom power devices used to compensate for the voltage sags and swells are the UPSs, and the DVR with voltage sag compensation facility. Among those the UPSs are the well-known. The DVRs are less popular due to the fact that they are still in the developing stage, even though they are highly efficient and cost effective than UPSs. But as a result of the rapid development in the power electronic industry and low cost power electronic devices will make the DVRs much popular among the industries in the near future.

UPS and DVR can be considered as the devices that inject a voltage waveform to the distribution line. When comparing the UPS and DVR; the UPS is always supplying the full voltage to the load irrespective of whether the wave form is distorted or not. Consequently, the UPS is always operating at its full power.

Voltage injection transformer

Three single phase transformers are connected in series with the distribution feeder to couple the VSI (at the lower voltage level) to the higher distribution voltage level. The three single phase transformers can be connected with star/open star winding or delta/open star winding. The latter does not permit the injection of the zero-sequence voltage. The choice of the injection transformer winding depends on the connections of the main step-down transformer that feeds the load. If a Δ-Y connected transformer is used, during an unbalance fault or an earth fault in the high voltage side, there will not be any zero sequence currents flow in to the secondary so, there is no need to compensate the zero sequence voltages (the DVR needs to compensate only the positive and negative sequence components only). So, the delta /open star configuration (Figure3.8-a) should be used. Further this winding configuration allows the maximum utilization of the DC link voltage.

SIMULATION RESULTS

Simulation is an effective tool by which we can experience the practical results through the software. There are a number of simulation software available, and the most efficient tool is the MATLAB. Here we have a number of parts of MATLAB. We employ the Simulink part of the MATLAB. Transformer less DVR based on T-type multilevel inverter is proposed in this project. Proposed DVR has less number of switches, high efficiency and THD is better than the other topologies. The proposed DVR is controlled by d-q rotating reference frame. The DVR model, switching strategy and control techniques are explained in detail. Compensation of the load voltage under sag conditions is done for the regulation of the load voltage to maintain the desired load voltage by proposed DVR and alidated through MATLAB/SIMULINK Software.

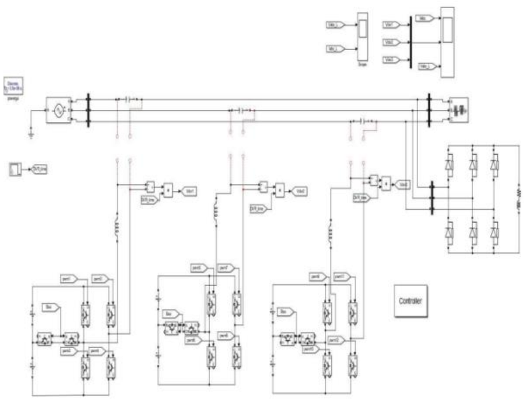


Fig:6.1 The modulation circuit without DVR

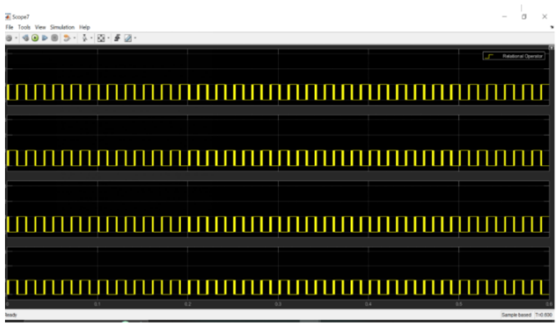


Fig:6.2 Switching pulses generated by reduced carrier PWM technique method

ISSN2321-2152
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Vol 12, Issue 2, 2024

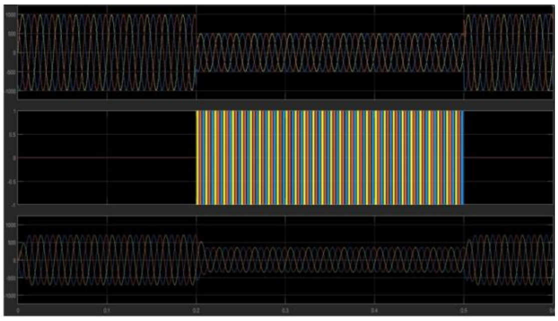

Fig:6.3 Output voltage without DVR at 0.2sec sag is created then the difference in the switching can be observed.

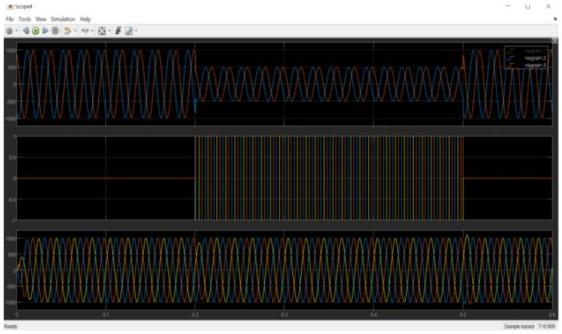

Fig:6.6 Compensated Output voltage with DVR at 0.2sec sag is created then the difference in the switching can be observed.

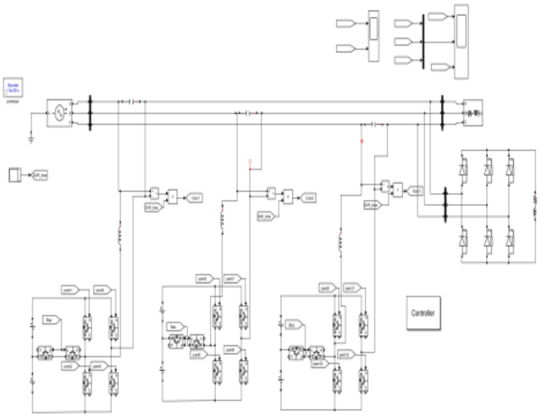

Fig:6.4 Simulation of T-Type Multilevel inverter as DVR

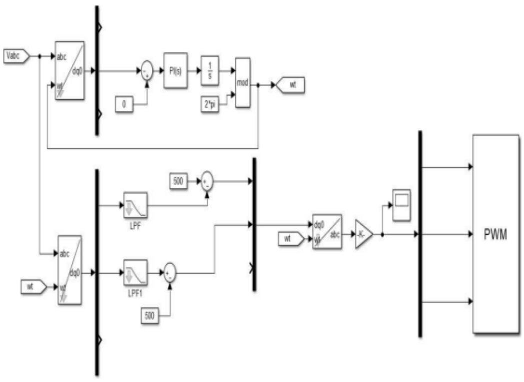

Fig:6.5 The circuit of PI controller by using PWM technique

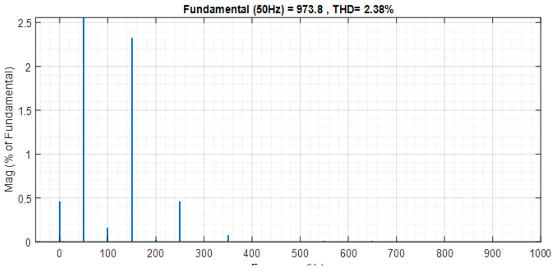

Fig: 6.7 Harmonic analysis of output volage without DVR

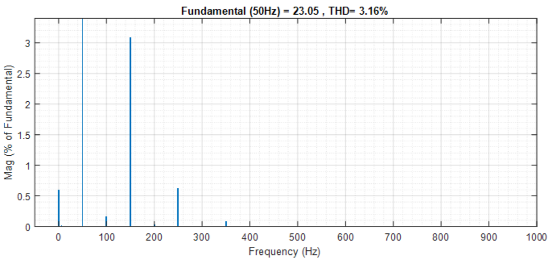

Fig: 6.8Harmonic analysis of output current without DVR

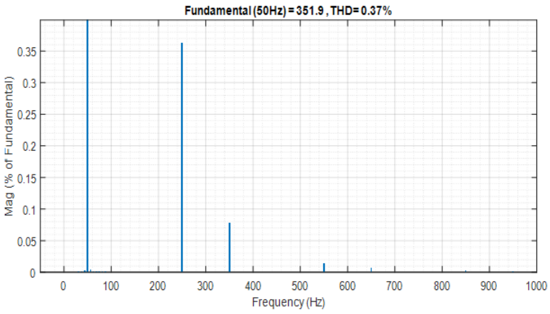

Fig: 6.9Harmonic analysis of output Voltage with DVR

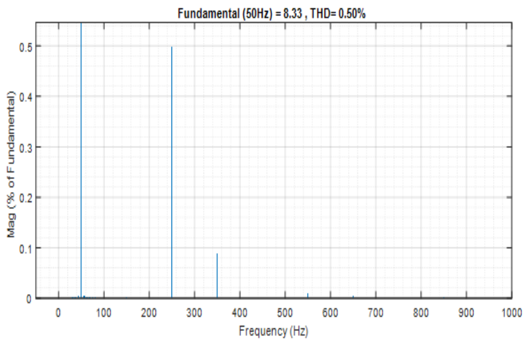

Fig: 6.10Harmonic analysis of output Current with DVR

CONCULSION

Transformer less DVR based on T-type multilevel inverter is proposed in this paper. Proposed DVR has less number of switches, high efficiency and THD is better than the other topologies. The proposed DVR is controlled by d-q rotating reference frame. The DVR model, switching strategy and control techniques are explained in detail. Compensation of the load voltage under sag conditions is done for the regulation of the load voltage to maintain the desired load voltage by proposed DVR and validated through MATLAB/SIMULINK Software. Furthermore, the proposed DVR model will be verified with hardware prototype.

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