International Journal of Research in Engineering, Science and Management
Volume-1, Issue-5, May 2018
www.ijresm.com

New Topology of an Efficient Five Level DC/AC Traction Multilevel Inverter for Railway Transportation Electrification

S. Sripriya
Assistant Professor, Department of EEE, Roever Engg. College, Perambalur, India

***Abstract*— In our project is transportation industry to adopt the multilevel inverter-based propulsion systems and gives the design procedure of a dc/ac 1-phase 5-level inverter for powering the rail metro cars. The proposed inverter is based on the multilevel converter as it possesses much lower component voltage stress compared with the pulse width modulated topologies. Pulse width modulation with flying capacitor voltage modulation operation is used to achieve voltage regulation and high efficiency at any loading condition. This system operation is achieved without using an auxiliary circuit, which leads to minimum switching losses. The proposed inverter within the proposed control methodology, which uses a new switching pattern that a PWM to eliminate the unwanted harmonics from the output voltage. As a result, a higher operating efficiency at full-load is achieved as compared to previous efficiency. The simulation and experimental results of a converter are presented. The converter provides real estate savings for the train under floor layout, higher operating efficiency as well as better cost price than the conventional two level pulse width modulated (PWM) hard switched converters.**

Index Terms— Electric vehicles, power electronics, traction motors, transportation, vehicles

I. Introduction

The use of renewable energy sources is increasing to supply the increasing demand of electricity due to urbanization. Solar energy produces dc power which needs to be converted into ac for further applications. Conversion of dc power to ac is done multilevel inverter with less THD. The high power multilevel inverter should be analysed with respect to its output active power, reactive power and THD in output voltage. This study will help the design engineer in selecting the appropriate multilevel inverter for required application. Multilevel inverters are classified as current source inverter and voltage source inverter.

In case of multilevel current source inverter, it was observed that if there is short circuit in the circuit, the fault current will be very high further damaging the other equipment's connected in the circuit. Therefore multilevel voltage source inverters are more commonly used. Multilevel voltage source inverters are classified into three main categories as (i) cascaded H-bridge multilevel inverter, (ii) Neutral point clamped multilevel inverter and (iii) Flying capacitor multilevel inverter. Flying capacitor multilevel inverter is more commonly used because it gives high output voltage, reliability, power levels and simplicity of control.

This document is IJRESM template. Any queries on paper preparation & guidelines, please contact us via e-mail.

II. Experimental Circuit Design

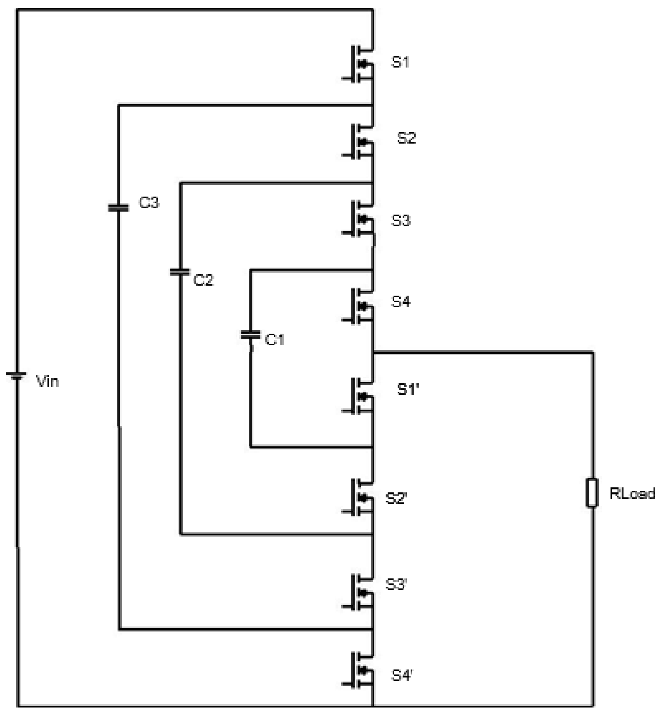

Fig. 1. Proposed circuit diagram

The multilevel inverters have some gained much attention in the due to the medium voltage and high power application because of their some advantages, such as low harmonics, low voltage stress on power switches and EMI output. The advantages of using multilevel inverter are: Harmonics distortion is very low. Reduced switching losses. Efficiency is increased. High voltage capability with voltage limited devices.

III. Proposed System Analysis

Single phase inverters present similarities with the application and control, power decoupling strategies as well as topologies from have been adapted to PV inverters. Thus working as a current source, as in the boost converter applications, if the buck converter is operated in the boundary between continuous and discontinuous conduction mode the injected current to the grid is proportional to the grid voltage. By analyzing the average current value in a switching cycle, it can be concluded that this is possible if the off-time is kept constant.

Two possible implementations are proposed for the single stage forward micro inverter, a) with unfolding stage and b) with secondary side switches. In both cases, the primary transistors are high-frequency switched to operate the micro inverter in the boundary mode. Implementation b) integrates the unfolding stage in the micro inverter power stage, i.e., the secondary side bidirectional switches are line frequency switched according to the grid voltage polarity. Thus, two sub circuits are generated as depicted. Therefore, the two primary windings are used either for energy transfer or transformer reset during the corresponding grid half-cycle and the primary to tertiary turns ratio is forced to be the same. Furthermore, both primary windings are designed for the same current stress; hence, a bigger core is needed.

The parallelization in the primary side reduces the current stress in both switches and primary windings of the transformer. The current sharing is guaranteed because of the secondary series connection, although affected by the coupling of the individual transformers. The current stress is also decreased in the secondary side diodes due to the common cathode configuration and the synchronized driving of the primary switches. As a result, SMD devices can be used, a low-profile implementation is feasible and the thermal management is improved, although more devices are needed. The secondary series connection allows achieving the grid voltage using transformers of lower turn's ratio. Therefore, the primary to secondary coupling at each transformer can be significantly improved, i.e., primary side current sharing is improved and parameters such as leakage inductance can be reduced, thus improving the off transition of the primary transistors.

IV. Multilevel Inverter

Numerous industrial applications have begun to use high power apparatus in recent years. Some medium voltage motor drives and utility applications require medium voltage and megawatt power levels. For a medium voltage grid, it is troublesome to connect only one power semiconductor switch directly.

As a result, a multilevel inverter structure has been introduced as an alternative in medium and high power applications. With this type of inverters, improvements in the harmonic quality of the output voltage can be achieved. Multilevel inverter not only achieves high power ratings, but also enables the use of renewable energy sources.

Renewable energy sources such as photovoltaic, wind and fuel cells can be easily interfaced to a multilevel inverter system for medium and high power applications. Multilevel inverter produces a desired AC voltage waveform from several levels of DC voltages. These DC voltages may be or may not be equal. AC voltage produced from these DC voltages is of stepped waveform. One drawback of using multilevel inverter is to approximate sinusoidal waveforms from stepped waveform. The staircase waveform produced by the multilevel inverter contains sharp transitions. Fourier series theory makes clear that this phenomenon results in harmonics, in addition to the fundamental frequency of the sinusoidal waveform. The power quality of the power system is affected by the harmonics generated on the AC side. The power quality of the multilevel inverter is improved by performing the power conversion in small voltage steps.

Multilevel inverter widely replaces the conventional two level three phase Voltage Source Inverter (VSI) by its performance such as lower switching stress (dv/dt) and lower THD on output voltage. The multilevel inverters start from three levels. As the number of levels reach infinity, the output THD approaches zero. The number of the achievable voltage levels is limited by voltage unbalance problems, voltage clamping requirement, circuit layout and packaging constraints.

A multilevel inverter has several advantages over a conventional two level inverter that uses high switching frequency PWM. The attractive features of a multilevel converter can be briefly summarized as follows: Multilevel inverters not only can generate the output voltages with very low distortion, but also can reduce the dv/dt stresses. Therefore electromagnetic compatibility problems can be reduced. Multilevel inverters produce smaller CM voltage; Therefore, the stress in the bearings of a motor connected to a multilevel inverter drive can be reduced. Furthermore, CM voltage can be eliminated by using advanced modulation techniques. Multilevel inverters will draw input current with low distortion.

Multilevel inverters can operate at both fundamental switching frequency and high switching frequency PWM. It should be noted that lower switching frequency usually means lower switching loss and higher efficiency. The main drawback of multilevel inverters is that the number of switches increases with the number of levels. In early stages of multilevel inverters, development of control circuitry for large number of power switches was a significant problem.

But continuous evolution of CPLD, DSP and FPGA devices easily solved this inconvenience. Other drawback of this inverter is the requirement of multiple numbers of DC voltage sources, mainly provided by capacitors. Balancing the voltage sources during operation under different load conditions is an important challenge. In spite of these drawbacks, introducing multilevel inverters will decrease switching losses occurred in the power device. By comparing with two level inverters, smaller size filter is required for the elimination of harmonics. This reduces the inverter weight, dimension and cost.

Many multilevel inverter topologies have been proposed during the last two decades. Contemporary research has evolved novel inverter topologies and unique modulation schemes. Moreover, three different major multilevel inverter structures have been reported in the literature.

They are, Diode clamped /Neutral clamped Multilevel Inverter Flying capacitors /Capacitor clamped Multilevel Inverter Cascaded H-bridge Multilevel Inverter Abundant modulation techniques and control paradigms have been developed for multilevel inverters such as Sinusoidal Pulse Width Modulation (SPWM), Selective Harmonic Elimination (SHE-PWM), Space Vector Modulation (SVM) and others.

Multilevel inverters replace the existing two level inverters from the applications such as power supplies, traction drive systems, industrial medium-voltage motor drives, utility interface for renewable energy systems and Flexible Alternating Current Transmission System (FACT).

V. Simulation Output

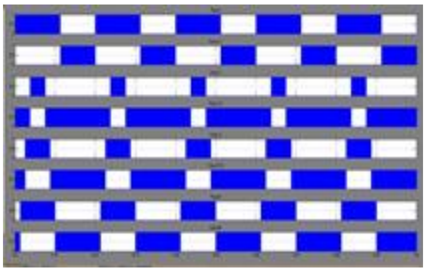

Fig. 2. Simulation Output: Gate pulse waveform (X-axis: Time)

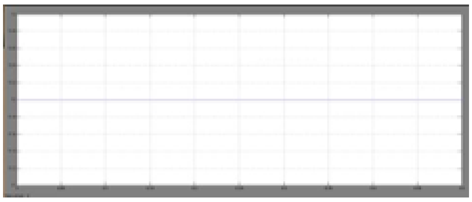

Fig. 3. Input waveform (Current in mA)

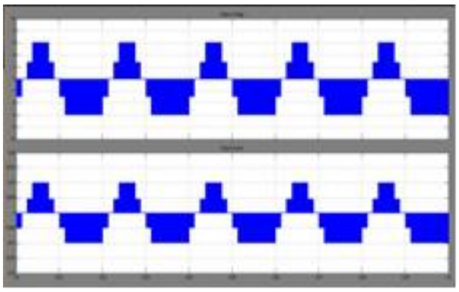

Fig. 4. Output waveform (Time in µsec)

VI. Conclusion

In this project, a new topology for the multilevel inverter. This multilevel topology has been presented for industrial application. The main concept of this inverter is to use capacitors to limit the power devices voltage stress. The multilevel inverters have become an effective and practical solution for largest output levels and the smallest Total Harmonics Distortion percentage. The simulation result, the output voltage waveform presents better harmonics profile.

References

[1] S. Mariethoz, "Systematic Design of High-Performance Hybrid Cascaded Multilevel Inverters With Active Voltage Balance and Minimum Switching Losses," in *IEEE Transactions on Power Electronics*, vol. 28, no. 7, pp. 3100-3113, July 2013.

[2] D. Ahmadi, K. Zou, C. Li, Y. Huang and J. Wang, "A Universal Selective Harmonic Elimination Method for High-Power Inverters," in *IEEE Transactions on Power Electronics*, vol. 26, no. 10, pp. 2743-2752, Oct. 2011.

[3] T. Kjellqvist, S. Ostlund and S. Norrga, "Active Snubber Circuit for Source Commutated Converters Utilizing the IGBT in the Linear Region," in *IEEE Transactions on Power Electronics*, vol. 23, no. 5, pp. 2595-2601, Sept. 2008.

[4] K. Fujii, P. Koellensperger and R. W. De Doncker, "Characterization and Comparison of High Blocking Voltage IGBTs and IEGTs Under Hard- and Soft-Switching Conditions," in *IEEE Transactions on Power Electronics*, vol. 23, no. 1, pp. 172-179, Jan. 2008.

[5] E. S. Kim and Y. H. Kim, "A ZVZCS PWM FB DC/DC converter using a modified energy-recovery snubber," in *IEEE Transactions on Industrial Electronics*, vol. 49, no. 5, pp. 1120-1127, Oct 2002.