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Significance of Five Level B inverter for improving power quality of Microgrid

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ABSTRACT: ***Multilevel inverter (MLI) is a breed of voltage source inverter (VSI), which can synthesize a high quality ac output voltage of required frequency from multiple separate/isolated dc sources (SDCs) [1]. The MLIs strikingly outperform the conventional three level inverters (TLIs) with the apparent merits such as lower dv/dt and device stresses, a diminished output voltage distortion, a minimal switching loss and a reduced electro-magnetic interference (EMI). Now a days MLI has become an amenable solution to prevailing issues of the TLI, through which the integration of SDCs like batteries, super capacitors and solar panels has become doable. The MLIs, an improved the class in the VSI family, can establish a closer (staircase) shape to the sinusoidal wave and there by minimizes the total harmonic distortion (THD). MLI structures actualize a higher system voltage, which is typically quite a few times more than the individual switch's blocking voltage. MLIs can synthesize an ac voltage of desired magnitude and frequency at a lower distortion level with a multiple control degrees of freedom. This unique characteristics is not available in the classical TLI. The evolution of MLI family started when its first pristine structure was introduced by R.H.Baker, which is a simple series connection/addition of H-bridges and called as cascaded H-bridge multilevel inverter (CHBMLI). This paper presents the thorough study and analysis of various such technologies.***

1. INTRODUCTION

Families of power converters of various kinds have been created. One of the most important converters for converting direct current to high-grade alternating current is an inverter. Two-level inverters and MLIs are the two primary categories into which the inverter families are divided. Conventional two-level inverters were the standard in the industry until the late 1980s. Research on MLI designs has intensified due to breakthroughs in power electronic switches, such as MOSFET and IGBT, and the corresponding cost reductions. in order to link these sources to local loads or the distribution grid. Fundamental use of the suggested work as depicted in Figure 1. Families of power converters of various kinds have been created. One of the most important converters for converting direct current to high-grade alternating current is an inverter. Two-level inverters and MLIs are the two primary categories into which the inverter families are divided. Conventional two-level inverters were the standard in the industry until the late 1980s. Research on MLI designs has intensified due to breakthroughs in power electronic switches, such as MOSFET and IGBT, and the corresponding cost reductions.

2. LITERATURE REVIEW

Abderezak Lashab et al. [1], when maintaining maximum power point tracking (MPPT), the different irradiances of the power cells in cascaded multilevel converters result in different duty cycles for those cells.

W. Peng et al. [2], a seven-level inverter based on switched capacitors is proposed. It has eight transistors, two diodes, and two capacitors. **M. Saeedian et al. [13],** a novel step-up dc to ac converter with only one power supply is presented in this paper. With low input dc sources, these kinds of converters are ideal for applications requiring renewable and sustainable energy. **J. Liu et al. [4],** have present a brand-new nine-level switched capacitor inverter with quadruple boost capability and fewer parts as the 9LSCI. **W. Peng et al. [5],** in this work, a seven-level inverter based on switched capacitors is proposed. It has eight transistors, two diodes, and two capacitors. Because the eight transistors form two H-bridges, the structure is straightforward and gate drivers are simple to design. **Y. Q. Wang et al. [1],** a novel switched-capacitor-based T-type multilevel inverter (MLI) is proposed in this paper. In addition to achieving a lower maximum voltage stress on the switches than the input voltage, the proposed inverter also has the ability to boost voltage, making it suitable for high-voltage applications.

Ruijie Sun et al. [2], have proposes a novel single-phase boosting five-level inverter with fewer parts and simple control for use with electric vehicles (EVs) and renewable energy systems. The inverter has one diode, one capacitor, nine power transistors, and supplies power from a dc voltage source.

Y. Q. Wang et al. [3], the large number of devices and complicated expansion of conventional multilevel inverters cause issues. A modular expanded multilevel inverter that can effectively simplify expansion and reduce the number of devices is proposed in this paper.

S. Habib et al. [4], in order to develop dependable and effective charging solutions for electric vehicles (EVs), the transportation sector needs new options for power electronics converters.

3. NEED OF MIL

In the last few decades, industries have started to insist higher power capabilities, and the load demand has reached the megawatt level, very recently. Today, in the industrial milieu, modern ac drives of megawatt (MW) range are required to connect to the medium voltage distribution network. The power electronic switches of such a high voltage are either not available or not economical. This emphasizes the importance of MLI structures, where synthesis of medium voltages just by involving the low voltage devices are possible. The synthesize of the higher output voltage demands more number output levels, but not the voltage rating of an individual device. That is the power electronic switches with a lesser voltage specification can be utilized in a MLI structure designed for the higher voltage. The dv/dt rating required for the switches of MLI is much lesser than the switches employed in the TLI. MLIs could be successful in the renewable energy, electric vehicles and similar applications due to their minimal output distortion. Besides all the above advantages, the scope for the performance enhanced PWM strategies and component count reduction options in MLI are still open. Multilevel inversion is a voltage synthesising technique wherein near sinusoidal shape is engraved through staircase kind of wave through several input dc sources. This staircase waveform minimizes the THD. As the number of steps (stair) increases the THD deceases. To actualize such an ac waveform with multiple steps, a complicated circuit topology is required which may involves several dc sources, array of power switches, diodes to clamp the node voltages, etc. The higher number of steps increases the component count and also controls complexity. Every application decides an optimal number of levels by considering the compromise between complexity and distortion.

4. POWER QUALITY PROBLEMS

Poor PQ issues eventually bring about monetary loss of the power system network. PQ chiefly concerns to keep up voltage and current profile i.e. any deviation in these parameters can make extreme harm the electrical utility and end shoppers. A diagram of numerous PQ issues alongside their causes and results are introduced.

Voltage sag/dip: - The voltage droop or plunge can be expressed as reduction in ostensible voltage level by 10-90% for brief term for half cycle to one moment as appeared in Fig.1. At some point, voltage list keep going for long length such delayed low voltage profile alluded as 'under-voltage'. Voltage hang is additionally partitioned in three classifications: quick, fleeting and brief lists separately. Voltage droop are predominantly caused because of event of faults in power system, overloading of the electrical network and beginning current drawn by substantial electrical loads like engines and refrigerators. Voltage sag in power system network results in failure of relays and contactor, dim light and fluctuating power.

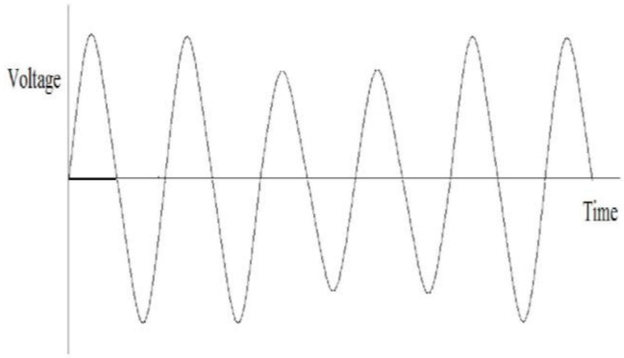

Figure 1 Voltage Sag/Dip

Voltage Swell: - Voltage swell can be expressed as voltage rise by 10-80% of typical incentive for length of half cycle to one moment as appeared in Fig.2.

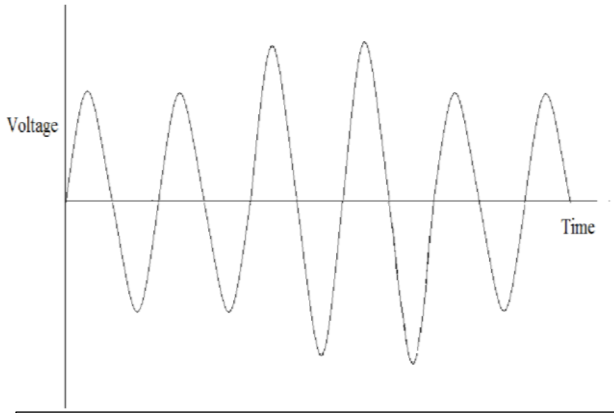

Figure 2: Voltage Swell

Likewise voltage droop, delayed high voltage profile is eluded as 'finished voltage'. Voltage swell is subdivided as:

- Instantaneous swell
- Momentary swell
- Temporary swell

Voltage swell is for the most part caused by separation of substantial load, Single Line to Ground fault (SLG) brings about voltage ascend in undaunted phases and free association of impartial wire. Voltage swells brings about breakdown of protection, overheating of electrical hardware and harm to electronic gear.

Voltage Interruption: - Voltage intrusion can be expressed as diminishment in rms voltage by beneath 0.1 pu of ostensible or complete disappointment of supply voltage. It can be additionally partitioned into two classes in view of interruption time period:

1 Short interruption

If the intrusion span happens for few milli-seconds then it is named as short interference. This is because of breaking down of switching devices which may influence the information stored in sensitive devices like PLCs.

2 Long interruption

If the interruption duration occurs for range between few milli-seconds to several seconds then it is termed as long interruption as shown in Fig. 3.

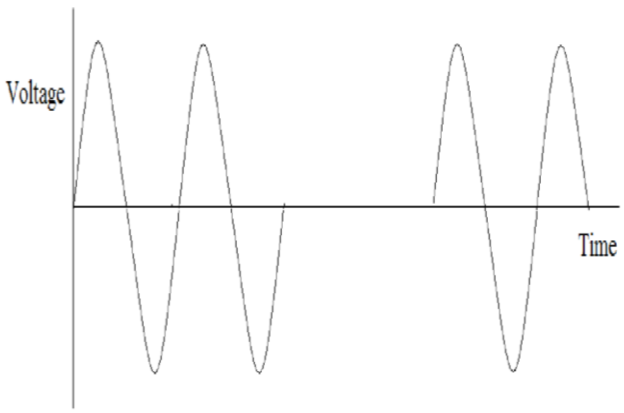

Figure 3: Voltage Signal with long Interruption

The primary driver is detachment of electrical power system for support and faults in electrical network which may bring about total stoppage of supply.

Waveform distortion:- Distortion implies change in original waveform shape as shown in fig.1.4. In a power system network, the voltage and current waveform ought to be sinusoidal in nature. Waveform distortions are due to:

5. MULTILEVEL INVERTERS

The Multilevel Inverters (MLIs) concept is derived by Baker in 1975. Due to the advantages of MLIs, they are exceptionally matched with DC-AC applications (PV and electrical drives). The Neutral-Point Clamped MLI is the supremely used in MLI and offered by Nabae et al. in1981 (Baker & Bannister 1975) The MLIs structure has a unique topology, which permits them to extent high-voltage and high-power without transformers. MLIs are well-matched for high-voltage electrical drives and PV converters, where it is provide lower voltage and current THD. The common characters of the MLIs are to produce a stare-case (multilevel) desired voltage as it uses number of levels of DC voltage sources. When the number of levels increases in the MLIs, can be extend over through joining power electronics.

Three basic MLI topologies namely Diode-Clamped, NeutralClamped, and Capacitor- Clamped or flying capacitors and cascaded multicell bridge with separate DC-sources have been used broadly used in numerous applications. Even though Capacitor- Clamped and cascaded bridge MLIs has it won advantages, the Neutral-Clamped MLIs are become extensive in drives applications and it has unlimited benefits (Gupta &Khambadkone 2006; Bharatiraja et al. 2014) In recent times, a number of MLIs have developed, for example mixed combination MLIs, hybrid-MLIs and soft-switch MLIs. Current era power electronics researchers are motivated to progress the various MLI topologies and its contribution to the electrical systems. The new researches on MLIs are getting the following interests;

- Design and development of novel MLI topologies for PV power generation systems and demands.
- Evolution of different modulation approaches for decrease of voltage and harmonics. • Reduction of DC-link current ripples.
- DC-link utilization of PV applications.
- Solving power quality related problems: engaging of MLIs for STATCOM, decrease of common-mode voltage (CMV) and active filters.

The main applications of MLI in electrical drive application are briefed as follows;

- Facilitate the low switching frequency harmonics filtering and switching and conduction losses reductions.
- Lesser device dv/dt.• Lesser CMV and common –mode current.
- lesser Electro Magnetics Interference (EMI)
- Minimization of output voltage distortion (THD) and enhancement of fundamental component.
- Enhanced fundamental voltage, reduced voltage THD, which eased output filtering requirement.

- The MLI modularity structure makes the simple maintenance and high reliability.

Table 2: Simulation parameters

Parameter	Specification
DC source (VDC)	100V
Output frequency	50Hz
switching frequency	10kHz
Capacitor	4200uF
R load	50 Ω
RL-Load	R=50Ω,L=100mH

Figure 4 shows the load voltage and load current with resistive load of 50 Ohm. It archives five-voltage level at the output terminal and generates boost output voltage with levels of +200V, +100V, 0, -100V and -200V.

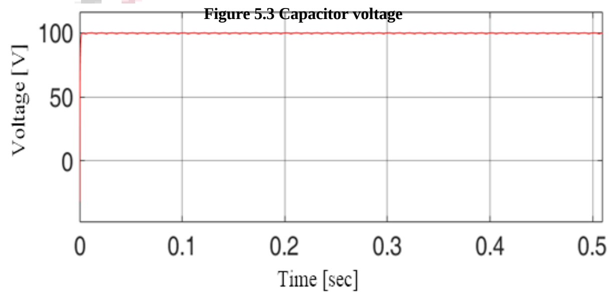

Figure 5: Capacitor voltage

Figure 5 shows the capacitor voltage with very less ripple voltage. Proposed five level inverter operates with boosting capabilities and balance the capacitor voltage at the input DC voltage 100V. Figure 6 shows the dynamic response of the proposed multilevel inverter. In this intense the resistive load change from 100 Ohm to 50 Ohm at the time of 0.5 sec. It can be clearly seen that the output voltage has not change at this time but output current has been doubled at this point. Its changes from 2A to the 4 A after doing half of the resistive load.

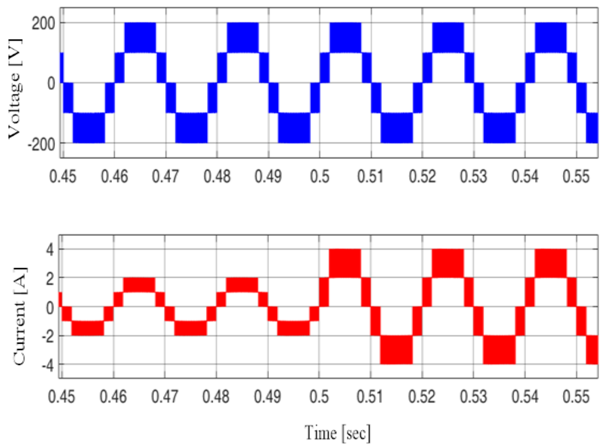

Figure 6: Output voltage and current

6. CONCLUSION

High voltages and power are used in the operation of compressors, conveyors, crushers, furnace blowers, grinding mills, pumps, rolling mills, mining hoists, and other contemporary industrial loads. Conventional VSIs are no longer the recommended option for high power applications because to their disadvantages, which include the requirement for a higher number of power switches at higher di/dt and dv/dt ratings. Many power electronic experts have acknowledged the many benefits of MLI, such as decreased switching device strains, EMI, and THD. The conversion of solar and wind energy, fuel cell and electric vehicles, uninterrupted power supply (UPS), flexible AC transmission systems (FACTS), and other items are among the growing list of uses for MLI.

Throughout the previous forty years, a number of MLI topologies that are

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