Modular Multilevel Current Source Inverter Using Two-Switch Basic Units

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Extended Abstract

Introduction: Employing power electronic converters in industrial applications has been promoted by the development of semiconductor devices. Voltage Source Inverters (VSIs) and Current Source Inverters (CSIs) are two types of DC/AC converters which can be applied in industrial applications in terms of their features. Moreover, in order to achieve lower Total Harmonic Distortion (THD) and some stress on passive elements and switches in high power applications, multilevel configurations are suggested. In recent years many papers have been published to improve multilevel voltage source Inverters MVSIs in a number of devices, of voltage levels, of power rating, and so on. Consequently, hybrid topologies have been reported. However, little attention has been paid to CSIs and multilevel current source inverters (MCSIs), which provide higher amount of freedom than VSIs and MVSIs. MCSIs are a smart choice to improve the performance and efficiency in industrial applications--such as induction motor drives flexible alternating current transmission system (FACTS) , high-voltage direct-current (HVDC), and grid integration of renewable sources-- where high power or low voltage and high current are required. MCSI drives also show reliable overcurrent and short-circuit protection. In current source inverters, the output current is controlled by switching, which offers advantages such as having high reliability with short circuit, buffering the output current from grid voltage fluctuations, generating a predetermined current to the power grid without AC current feedback loops, and achieving a high power factor operation. Reducing the number of switches and DC current sources and inductors, while improving the switching of the topology, is the main challenge in the designing of multilevel current source inverters. Multilevel current source inverters are divided into two general categories of inductor-based charging inverters and inverters with separated DC sources, each of which offers advantages as outlined in this paper. The most important problem of inductor-based charging inverters is that there are huge intermediate inductors which cause a complex balancing control of the intermediate current level. However, needing more separated DC sources and semiconductors is the main disadvantage of the other category. Thus, the most important concern from the point of design is lowering the number of circuit devices.

Proposed Topology: Recommending new multilevel inverter topologies with higher accomplishment and a lowered number of required components can also considered as a proper opinion. This article recommends a new topology of symmetrical multilevel current source inverter that can be generally comfortable for a plenty number of steps dependent on a reduced number of power devices. In low/medium power applications, this topology, as a good alternative, is highly suggested. In the structure of multilevel converts, important objects are the DC power supplies, switches, and related gate drive circuits. Connection of several

cells in a decent way with the help of six switches and extra two power DC supplies is the source of inspiration for the recommended method. A DC current source and two unidirectional power switches are the elements used for composing each cell. The recommended structure is the series connection of several basic units in a proper connection with an H-bridge and two DC sources with related switches. The plan provides various ways to produce the output current waveform with all processes with both positive and negative polarity in the output waveform.

Results: In the comparison study, the proposed inverter has been compared with traditional inverters in terms of the number of switches, DC sources, inductors, converter losses, and total switch device power (TSDP). The reduced number of DC sources lowered the overall costs because the DC current sources were expensive. That is to say, the main issue which made the inverters expensive was the existence of DC current sources. The number of DC current sources in the suggested CSI in comparison with the traditional inverters was reduced significantly. The number of needed switches was the other leading subject that affected the overall cost of inverters. Also, the needed switches were lower for suggested inverter compared to conventional inverters with the same output levels. The proposed structure and corresponding control systems were simulated using MATLAB/SIMULINK software, and the results were presented in off-grid operation. The archetype of symmetric suggested order included three DC sources and eight switches; this condition generated a staircase waveform with the maximum 30A. Load parameters were a series resistive–inductive parallel with a capacitor with magnitudes 15Ω, 15mH and 100 μF . Also, laboratory prototypes of the proposed inverters were constructed, and the performance of converters was presented in experimental results. Ten BUP314 IGBTs which were driven by HCPL316j were the things that the hardware of inverter contains. DC current sources worth 2A, and series resistive–inductive parallel load worth 20Ω– 15mH and 100 μF .

Conclusion: This article recommends a new configuration and structure for symmetric multilevel current source inverters. The number of devices used in the suggested CSI is lower than the others. In fact, in this method, it required a lower number of DC current sources, switches, and gate driver circuits. Because in this topology for implementing the inverter circuit, a lower number of devices were required; then, the overall cost was considerably reduced. At the same time, the control scheme became simpler. The comparison section illustrates the comparison results between the proposed inverter with CHB and a recently suggested converter. The results obviously have shown the benefits of the recommended structure over the mentioned topologies. In order to show the possibility of the proposed multilevel CSI structure, a prototype of the suggested symmetric topology has been implemented; as a result, all of the experimental resulting waveforms were equal to results drawn from simulation.

Keywords: Multilevel current source inverter, modular multilevel inverter, reduced switch count inverters, switching of current source inverters.

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