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A Comparative Investigation of Reduce Device Count in Inverter Topologies

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Abstract: ***Industrialization plays an important role for the Economic growth of the country. In industries various convertors are used for the controlling and conversion of power in convertor Circuit. The no. of semiconductor devices are used along with its auxiliary circuit, which makes the system complex. Hence in order to reduce the complexity of converter system, various researchers are suggested different circuit topologies in order to reduce the complexity of the of the converter system with reduce device count. , and claimed the better performance. This paper is response note of the various work in the subject area .which has been already done previously.***

Key words: switch count, switch leg structure.

I. INTRODUCTION

Power Electronics is the viable solution to control the power and got more and more importance during the years due to the benefits they brought into electrical engineering fields. There are lots of advantages which Power Electronics brought, but the most meaningful is the possibility to control electrical machine and to manage the flows of electromagnetic power. Due to Power Electronics it was possible to build drives, active filters, static Var compensators, etc.

In present trends the approach to fulfilling the demand for independently supplying a number of ac loads in several applications is using separate inverters for each of them. But, this may result in undesirable increase in system cost, size and weight. Number of devices use in convertors makes structure complex to control and in switching. There is a growing trend in power electronics for reduced switch count power converters with the aim of sustaining high power quality and enhancing the system reliability. Dual-terminal converters provide the researches with an extra degree of freedom in realizing switch reduction of power converters resulting in system cost, size and weight optimization. Implementing low cost power inverters is a recent trend towards cost reduction in power electronics based systems especially induction motor drive systems. In many sensitive applications such as robotic systems, in addition to cost reduction, reducing the system size and weight as well as providing a high degree of reliability is of utmost importance. Thus, the study of topologies with a reduced number of power switches constitutes an important topic in power electronics these objectives could be achieved by reducing the number of active switches in power inverters. The resultant configurations are called reduced switch count inverters. Various topologies have been proposed so far for switch reduction in the literature.

Reduced switch-count inverters fall into two broad categories of single-output and multi-output inverters.

II. REVIEW

The static power converters are used to change the amplitude, frequency, and phase from one level to other one. There are four basic conversion functions that can be implemented, namely ac to ac, ac to dc, dc to ac, and dc to dc. Inverter converts dc to ac. In several industrial applications it serves to supply ac loads. Based on the application inverters are categorized as single output and multi output. Some work in the field of such inverter configuration has been done by researchers. This chapter reviews the various topologies on reduced device count in multilevel inverter.

Vander *et al.* [1] suggested the **B4** type single output inverter with less number of devices in comparison to B6 inverter. In a three-phase system voltage and frequency control of a three-phase load is possible by PWM of the output of a simplified bridge inverter with only four switches (B4). The operational region of phase asymmetrical PWM control is investigated theoretically in the frequency plane, compared to PWM control of a six-element bridge, and shown to have application possibilities. PAPWM applies asymmetric PWM voltages to all phases and uses four switches. Floating neutral eliminates zero sequence components. The approach indicated that this method may be applied to control of three-phase loads and machines instead of the standard PWM/B6 combination, however, two control strategies for this type of three-phase inverter bridge, i.e., current source operation (two-level current control) and voltage source operation (PWM). The second option are also investigated .Method of implementing pulse width modulation in the B4 circuit is suggested.

Jacobina *et al.* [2], proposed a three-phase VSI-PWM rectifier and inverter structure with eight switches with wave shaping feature. The proposed concept uses two identical inverters with four power switches, for rectifier and inverter, by which bidirectional power flow is possible. Two split-capacitor dc high voltage links are introduced. Inverter with the split capacitors in the dc link gives balanced three-phase output to ac motor at adjustable voltage and frequency. Here two reduced-switch-count ac drive systems are presented.

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One operates with a two-phase motor and the other with a three-phase motor. Pulse width modulation techniques for the converter control are discussed. The performance of this topology is superior to the six-switch converter because low THD, control over input output voltage of convertor, and no ac fundamental current flows through the dc-bus capacitor.

Lipo *et al.* [3], proposed a new concept of three-phase to three-phase converter for ac motor drives .The proposed converter employs only eight switches with two split capacitor and has the capability of delivering sinusoidal input currents with unity power factor and bidirectional power flow. A current-controlled VSI-PWM rectifier and inverter with capacitor dc link is most important structure for three-phase to three-phase power conversion. This type of converter normally requires twelve switches for a rectifier and inverter composed of self turnoff switch such as a bipolar transistor or an IGBT with an anti-parallel diode.

Compared with a conventional thyristor converter, the advantages of proposed structure are Capability of unity or even leading power factor, sinusoidal input current waveforms reducing harmonic pollution and bidirectional power flow.

Park *et al.* [4], presented single-phase voltage regulator by using the concept of common arm between the rectifier and inverter. The proposed structure employs six switches. Regulator is able to deliver sinusoidal input current with unity power factor, good output voltage regulation, and bidirectional power flow with less no. of switches.

Choi *et al.* [5], discussed the application of three-leg-type converter in High-Performance Online UPS. The first leg of convertor charge the battery and the third leg make the output voltage. The common leg control line frequency. The inverter regulates output voltage and limits current under a fluctuating load. Feedback concept is used to determine the charger voltage. Power losses can be decreased by using a common leg for both PWM rectifier and inverter. The disturbance of the input voltage, such as overvoltage and under voltage which cause a system trip and hardware equipment failure can be resolve by fast detection of input voltage disturbances and a fast output voltage.

Freitas *et al.* [6], discussed a reduced switch count dc-link five-leg converter for three-phase power conversion. To maximizing the utilization of the dc-link voltage a control method is proposed. A hysteresis current controller is developed which operate by sharing one leg between load and grid. The converter is compared to those of the six-leg and four-leg converters. The overall performance of this topology is superior to the topologies based on the four-leg converter due to a smaller THD and no ac fundamental current flowing through the dc-link capacitors.

Silva *et al.* [7], investigated two reduced-switch-count ac/ac dc-link six-leg converters. The proposed topologies allow for three-phase-to-three-phase power conversion to supply a three-phase four-wire load without any capacitor dc-link midpoint connection. A control strategy to obtain the maximum utilization of the dc-link voltage is proposed. Configuration obtained with a half-bridge converter at the grid side denoted as configuration Fl (i.e., a six-leg half-bridge/full-bridge converter), or at the load side denoted as configuration Fg (i.e., six-leg full-bridge/half-bridge converter). These converters use 12 power switches and the capacitor dclink- midpoint connection. Other possible configurations using input full-bridge and output half-bridge converters can be derived from configuration Fg. by the connecting the neutral of the load to one of the inverter legs and the load phase is connected to the dc-link midpoint. The configuration shares a leg between one of the grid phase and the load neutral, and is denoted here as configuration Sn (i.e., a six-leg converter with shared load neutral) and other configuration shares a leg between one of the grid phases and one of the load phases denoted here as configuration Sp (i.e., a six-leg converter with shared load phase). Both configurations allow for bidirectional power flow between the grid and the load as well as the active control of the input power factor.

From the comparative study of the configurations, the following conclusions may be drawn.

• As compared to configurations Fg and Fl, proposed configurations Sn and Sp do not use the capacitor dc-link midpoint connection and present smaller total harmonic distortion.

• As compared to configuration F, configurations Sn and Sp have smaller cost and size, and may be used for fault tolerant purposes and with loss reduction. For several operation conditions, the dc-link voltage, switch currents, and total harmonic distortion of configurations Sn and Sp are close to those of configuration F

Lima *et al.* [8], introduced the new concept of two reduced-switch-count dc-link three-phase-to-three-phase four-leg converters. The applications of proposed configuration is in the area where input-current (power factor and harmonic content) and load-voltage amplitude must be controlled, and at the same time, the grid and load frequencies are equal (e.g., UPS and ac/dc distributed-power-system applications).Generally 12 power switches are used for full-bridge topology but this increase cost and reduced reliability of system. Using the two reduced switch count topology are introduced by using the concept of capacitor midpoint connection denoted as Configurations 4Lg and 4Ll. Configuration 4Lg is connected to the grid by the filtering reactance *X*g and has a power converter with four legs and a capacitor bank at the dc link for supplying a three-phase load. Configuration 4Ll also uses four legs as Configuration 4Lg. However, in this case, the phase *g*2 is connected to the capacitor midpoint. For applications in which the load frequency is equal to the grid frequency, a synchronization technique is proposed and the converters may provide more voltage capability than the conventional half-bridge solutions**.** Objective of control strategy is to synchronize vl_{123} (load side voltage) with vg_{123} (grid side voltage) provided that both sides of the converter have the same frequency.

Enjeti *et al.* [9], proposed a new single-phase to three-phase converter for low-cost ac motor drive. The proposed converter is capable of powering a three-phase adjustable-speed ac motor drive from a single phase ac main and maintaining sinusoidal input current at near unity power factor**[9]**. The present topology for adjustable-speed HVAC systems employs a diode bridge rectifier and a regular six-switch PWM inverter to power a three-phase induction motor from a single-phase ac mains .disadvantage of this configuration is poor input current quality and lack of bidirectional power flow capability.

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Author suggested, a new single-phase to three-phase converter that employs only six transistor or IGBT-type switches. In proposed configuration the front-end half-bridge active rectifier structure provides the dc link with an active input current shaping feature. Since transistors and IGBT switches can operate at high frequency, advanced PWM techniques known for inverter control can be used. Low cost, less harmonic content, bidirectional power flow, compact size and high frequency output are the advantages of this configuration.

Jakkli *et al.* [10], proposed two new circuit topologies for single-phase to three-phase conversion which use less switches. In first topology a half-bridge converter with two active semiconductor devices and two diodes are employed. One disadvantage of this approach is that switches are subjected to twice the peak voltage of the single-phase mains. Also, the VA rating of the capacitors in the dc link is higher. In second topology circuit employing four active switches *Tl-T4* with two diodes *D1* and ***D2***. Active input current shaping feature is achieved by operates switches in PWM pattern and synchronized to the ac mains.

Kominami *et al.* [11], introduced the concept of Nine-Switch Inverter to control two three phase loads in the field of dual output inverter. *Configuration* consists of two three-phase inverters combined with three common switches; however, there is some ripple amplitude, and slight interference between *Inv1* and *Inv2*.

Liu *et al.* [12], proposed a novel three-phase nine-switch AC/AC converter topology. Converter operation is analyzed with two mode of operation i.e. constant frequency and variable frequency mode. The CF mode of operation is particularly suitable for applications in uninterruptible power supplies whereas the VF mode can be applied to variable-speed drives.

Dehghan *et al.* [13], developed Uni and Bi-directional single-input dual- output matrix converters using a Uni- or Bi-directional current-source rectifier (CSR) and dual-output inverter (nine switch or Five-Leg inverter). Single input- dual-output matrix converters (SIDO-MCs) are direct ac/ac converters that can produce two set of balanced three phase voltage in output terminals from single balanced three phase input voltage without any intermediate electrolyte capacitor. power loss, output voltage and current of proposed convertor is analyzed.

Khalegi *et al.* [14], investigated a new single input single phase to dual-output three phase AC/ AC converter using zeta DCIDC converter and dual-output nine switch inverter. this configuration can be used in HEV s to charge the low voltage battery and drive the electric motor of them simultaneously. Optimized career-based PWM modulation is introduced. a comparison with Z-source nine switch inverter (ZS-NSI) has been accomplished.

Rossiter *et al.* [15], proposed two ac–ac reduced-switch-count drive configurations for single- to three-phase applications. Configurations use three legs and the dc-link capacitor midpoint connection. Control strategy is introduced to reduce dc link voltage for converter in which dc-link voltage *Vc* is adjusted to reference value by using the controller. Controller gives reference current $I*g$, generated as the instantaneous reference current $i*g$ synchronized with *eg*.

Grath *et al.* [16], proposed voltage-source inverter based on multiple two-phase PWM inverters. It is a dual ac-drive system with reduced switch count. By using eight switches inverter produce two sets of three-phase or two-phase sinusoidal output currents that can be used to feed three-phase or two-phase induction motors. The proposed drive system uses two four-switch inverters connected back to back which share a single split dc-link capacitor. The system eliminate single phase circulation current through dc link capacitor by control the phase angle of current of each inverter

Zhang *et al.* [17] proposed an alternative to the 12-switch dual-bridge inverter to eliminate common mode voltages and reduce conducted EMI .This dual B4 inverter has the ability of common-mode voltage cancellation. This eliminates the motor shaft voltage and the resulting bearing current which can cause premature bearing failure. Proposed inverter also eliminates the single-phase current through the dc-link capacitors and enables to use much smaller dc link capacitor compare to conventional B4 inverter.

Jacobina *et al.* [18], investigated different ac drive systems employing a common dc-link and converter topologies with a minimized number of power switching devices. Configuration H (half-bridge topology), uses multiple two-leg converter topologies in which all the inverters share the midpoint of a split capacitor bank in the dc-link. Configuration S (shared-leg topology), also uses multiple two-leg converter topologies but shares a connection with an extra-leg. Some features which makes configuration S superior than H are: smaller THD, machine voltages do not depend on the individual capacitor voltages, no ac fundamental current flowing through the dc-link capacitors.

Dehghan *et al.* [19], proposed a novel bidirectional z-source nine switch inverter to use in electric vehicle. In BZS–NSI, converter has two ac and one dc bidirectional terminals that can be used in hybrid electric vehicle. However, using BZS–NSI increases the rating of semiconductor switches and decreases efficiency.

Xiong Liu *et al.* [20], presented matrix converter with one ac input and two ac outputs. By using Conventional indirect matrix converter with only three extra switches added, the proposed converter is able to produce two sets of three-phase ac outputs, whose amplitudes, frequencies, and phases can appropriately be regulated. System analyzes for both constant frequency and variable frequency modes.

Heydari1 *et al.* [21], proposed a reduced switch count multi-output inverter in this paper. The inverter has two legs with three power switches in each. Three sources are placed in series at the dc link. Two phases of each three-phase ac load are connected to the two inverter legs and the other phase is connected to one of the joints of the dc link sources. Modulation scheme was developed and two modes of operation (CF & VF) were defined.

Green *et al.* [22], described voltage-sourced reversible rectifier using current-forced control. This is AC/DC convertor has bidirectional power-flow capability, with, sinusoidal line current. A current-forced control strategy is used to switch two power transistors. The configuration is useful to deal between single phase **AC** supply and a **DC** busbar voltage to drive induction motor.

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Covic *et al.* [23], presented single phase to three phase convertor with six switches. Configuration provides bidirectional power flow, sinusoidal current. Single phase reversible rectifier produces two PWM waveforms using Space Vector Modulation strategy.

Correa *et al.* [24], investigated voltage source inverter for supplying two-phase induction motors under unbalanced power flow. To described unbalanced of two phase motor a quasi time-invariant model is used.

Ribeiro *et al.* [25], proposed three phase ac-ac convertor with reduce device count. Configuration used four leg structures at line side as rectifier and load side as inverter. Space vector modulation is used to control the voltage and current of convertors. Author suggested that voltage at the out of the converter A must be greater than the grid voltage ($V_2 > Ve$). The difference between V, and V, results as the filter reactance increases and more current is drawn from the grid.

Chiang *et al.* [26], presented a single phase three legs rectifier inverter system to supply ac load with reduced device count concept. Switching control strategy for the common arm is proposed to control the rectifier inverter arm. VSC controller, an instantaneous power feedback controller for inverter and rectifier are designed.

Ojo *et al.* [27], proposed modulation strategies for voltage source inverter for the generation of three-phase voltages which may be balanced or unbalanced. Continuous and discontinuous pulse width modulation, space vector modulation are discussed and performances are evaluated.

Cursino *et al.* [28], presented vector modeling strategies to describe unbalanced three-phase four-wire system. These are useful to analyze three-phase electrical systems having power converters and unbalanced loads.

Park *et al.* [29], presented a topology to reduce switch count in convertor. Configuration has six switches with a common arm between the rectifier and inverter, and adopts an appropriate switching strategy to develop single-phase voltage regulator. A new concept of low-cost ac capacitor using two dc capacitors was also implemented.

Jacobina *et al.* [30], investigated controlling of a single-phase ac/ac reversible converter. Proposed convertor shares a leg between both the grid and the load side. The concept of local and general apportioning factor has also been proposed, with space and vector pulse width modulation.

Kim *et al.* [31], developed model of the dc link voltage control for three-phase to three-phase VSI-PWM convertor system having eight switches. Transient model voltages of split capacitor are also developed.

III. CONCLUSION

Different topologies suggested by various authors to reduce the device count in inverters to achieve high degree of reliability are successfully investigated. With their advantages and limitation these topologies results in reduce cost and improve performance. Reduced device count can be achieved by sharing a switch leg between rectifier and inverter or by replacing switch leg by split capacitor. Two configurations of inverter, single output and dual output are suggested. Dual-terminal invertors provide to the researches new area to work in the field of single phase inverter to supply different loads with reduce switch legs.

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