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A THREE-LEVEL DIODE-CLAMP INVERTER WITH A PULSE GENERATOR AND PULSE WIDTH MODULATION AS A CASE STUDY

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Keywords: diode clamp inverters; three-level inverter; multi-level inverter; pulse generator.

Abstract: To demonstrate the efficiency of the logic control approach, three-level diode clamp inverters (DCI), employing two different switching scheme technologies, namely pulse generator (PG) and pulse width modulation (PWM), using MATLAB Simulink, are designed and constructed. The PG is believed to send out a square pulse signal that is exact, consistent, and accurate. The current state of PG innovation is far too vast to be properly encapsulated. The most appropriate dominance and modification methods for these converters are PG and PWM, which are used to drive the MOSFET switching device and produce consistent high voltage pulses with a pulse electric range of up to high intensity.

Introduction

Many industrial appliances work on variable power (medium or low power), and some sectors demand high power. The multi-level inverter (**MLI**) was first proposed in 1975 as an option in high-power and medium-voltage circumstances [1]. It uses multiple switches, diodes, and capacitors to convert medium-voltage sources (solar cells, batteries, and megacapacitors) into high power output [2]. With MLI you can provide output voltages with minimal distortion, reduce *dv*/*dt* stresses and input current draw with minimal distortion, and reduce stress in motor bearings by producing a lower voltage in common mode. It can also function at both low and high pulse width modulation (**PWM**) switching frequencies. (Because of the reduced conversion frequency, there is less conversion loss and more efficiency.) [3, 4]. Here's a rundown of some of MLI's advantages; the biggest disadvantage is that it necessitates a large number of semiconductor switches [5]. Whereas each drive circuit switch necessitates a relevant gate, each kind has its own set of benefits, which may cause the overall system overhead to rise. Figure 1 and Table 1 show how MLI is separated into three primary kinds, each with its own set of benefits and drawbacks.

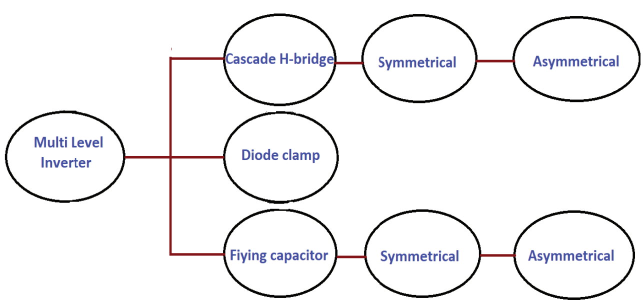

Fig. 1. Types of MLI

Table 1

Applications, Benefits, and drawbacks of MLI types

Names	Advantages	Disadvantages	Applications
Diode Clamped Multilevel Inverter	Capacitance is low Back to back inverterscan beused Capacitors are pre changed Efficiency is high at fundamental frequency	The number of clamping diodes increases with the increase in each level DC level will be disc-harge when control and monitoring are not precise	Static varcompensation Variable speed motor drives High voltage system interconnections High voltage DC and AC transmission lines
Flying Capacitor Multilevel Inverter	Staticvar For balancing capacitors voltage levels, phase redundancies are available We can control reactive and real power flow	Voltage regulation is difficult for all capacitors Difficult startup Switching efficiency is low Capacitors are more expansive than diodes	Introduction to motor control Static variable generation. AC-DC and DC-AC conversion applications. Harmonic distortion converters. Sinusoidal current rectifiers are used
Cascade H Bridge Multilevel Inverters	Output voltage levels are doubled to double the number of sources Easy and quick production Packaging and layout is modularized We can control it easily with a transformer Inexpensive	Every H bridge needs a separate DC source Due to the large number of DC sources, applications are limited	Active Filters Electric vehicle drives DC power source utilization Power factor frequency link system Interfacing with renewable energy resources

Diode clamp (DCMLI)

This inverter employs diodes to deliver amplified voltage levels from various phases to the capacitor banks in the chain [1, 6]. A diode only transfers a small amount of electricity, lessening the load on other electrical components. The main disadvantage is that the maximum output voltage is only half that of the input DC voltage. However, this can be overcome by increasing the number of switches, diodes, and capacitors. This inverter has a high efficiency and is a simple technique for back-to-back power transmission systems [7] because it uses fundamental frequency for all switching components.

The voltage across each capacitor is Vdc/2. In Table 2, the switching modes are plotted versus the magnitude of the o/p voltage. For each mode, two switches are turned on, while the other two are turned off with varying degrees of o/p. Two capacitors, C1 and C2, connected in series, divide the DC bus voltage into three-levels [6, 8, 9].

The purpose of the switching modes is to ensure that switches operate in the proper manner. Van's o/p voltage has three situations (Vdc/2), (Zero), and (–Vdc/2), as shown in Fig. 2. All three of these scenarios are possible when using newer logic states.

Upper switches (IGBT and IGBT1) are ON and all lower switches (IGBT2 and IGBT3) are OFF to get (Vdc/2).

Switches (IGBT 1 and IGBT 2) be ON, IGBT and IGBT3 be Off to get Zero.

Switches (IGBT 2 and IGBT 3) be ON, IGBT and IGBT1 be Off to get (–Vdc /2).

Table 2

Switches modes against the magnitude of o/p voltage

Switch Number	Output Voltage		
	+Vdc/2	Zero	–Vdc/2
IGBT	1	0	0
IGBT-1	1	1	0
IGBT-2	0	1	1
IGBT-3	0	0	1

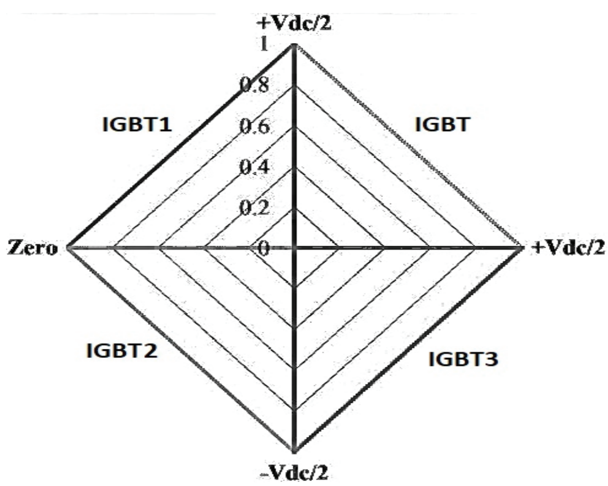

Fig. 2. Sector divisions of three-level DCI

Pulse Generators PG

Pulse generators are control techniques in the MATLAB program that issue a square wave at fixed intervals utilizing the parameters in the source block of each switch (amplitude, period, pulse width, and phase delay) in Fig. 3. The amplitudes are the same for all switches with a period of 1/f, but the phase delay and pulse width vary according to table 2. Switch 1, for example, is ON for one-time Vdc/2 o/p and OFF the rest of the time, accounting for 10 % of the life cycle.

The phase delay is zero because Switch 1 has no delay, and the pulse width is 12.5 % of the period. Because Switch 2 operates without a delay, the phase delay is also zero. Switch 2 is ON twice in Vdc/2 and 0 the rest of the time, so the pulse width is equal to 25 % of the period, and so on for the remaining switches, as shown in Figs. 4, 5.

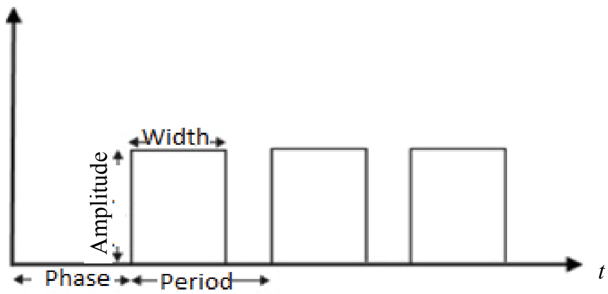

Fig. 3. Explanation of wave measurements

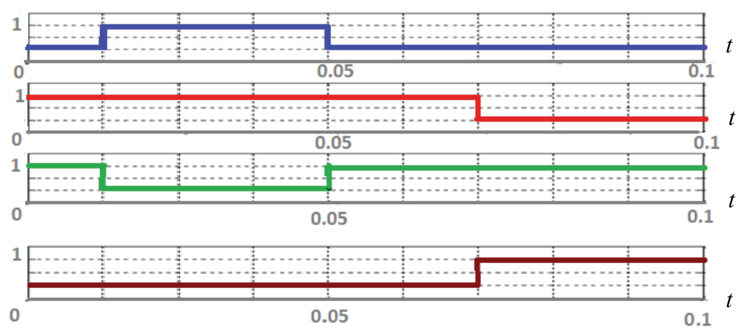

Fig. 4. Switching Sequence

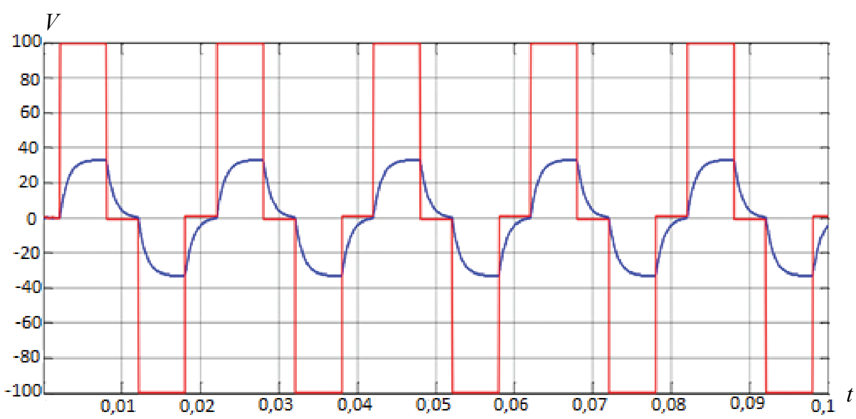

Fig. 5. Three-level output waveform (PG)

Pulse Width Modulation PWM

The converter output is controlled by varying the phase delay, period, and pulse width (as shown in Figs. 3, 4), and the third order harmonic is the easiest to filter out [9 – 12].

Every half cycle, switches are switched. The output voltage i*s* regulated by adjusting the width of the pulses, which is referred to as a PWM control in Figs. 6, 7 shows the gateway signals produced by combining a DC signal with a triangle wave. By adjusting the number of pulses, lower order harmonics can be eliminated. As a result, increasing the number of pulses should increase the number of higher-order harmonics, making filtering simpler. In comparison to inverters built with other technologies, inverters built using PWM technology are outstanding in many factories. A PWM is a way of adjusting the pulse chain's pulse width at a direct rate to a modest control signal. PWM creates a way of reducing overall harmonic distortion in the load current [14, 15]. The THD requirement is generally met by a PWM inverter output (together with several filters, which are more readily available from the quadrate wave switching planner). The THD of the unfiltered PWM output is relatively high, making fabrication filtering easier (the harmonics are higher frequencies in proportion to a square wave). The output voltage amplitude can be changed together with the modifying waveforms in PWM. Two distinct benefits of PWM are the elimination of filter concerns for harmonic reduction and output voltage amplitude control [11]. PWM has a number of drawbacks, including difficult control and frequent switching losses. A reference signal, which is a triangular wave that observes the switching frequency, is required for the switches to control the sinusoidal PWM output (a sinusoidal and a carrier signal in this case). These inverters are made according to the following instructions:

– Input voltage Vdc = 100 volt;
– Capacitors 100 μF;
– Switching frequency fsw = 50 KHZ;
– O/P voltage 100-volt peak-peak;
– Vdc = Vc1 + Vc2 × Vci = Vc2 = Vdc/2;
– Period time = 1/fsw.

In the Fourier series, the fundamental frequency of the PWM output voltage is the same as the reference signal. Multiples of harmonic frequencies exist at and around switching frequencies. A natural low-pass filter could be effective in ejecting some harmonics due to their high frequencies, because their bulk is perfectly significant. The ratio of carrier frequencies to reference signals is known as the frequency modulation ratio mf [13].

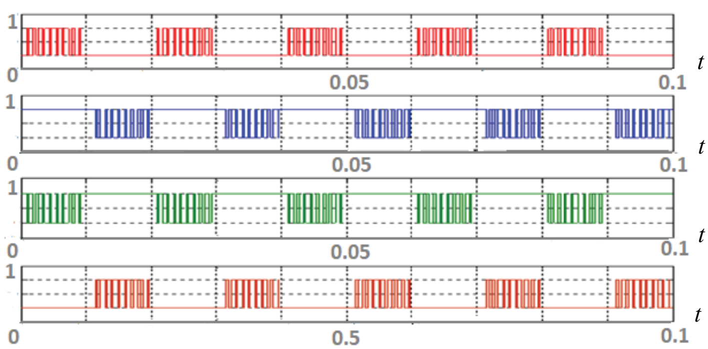

Fig. 6. Switching sequence (PWM)

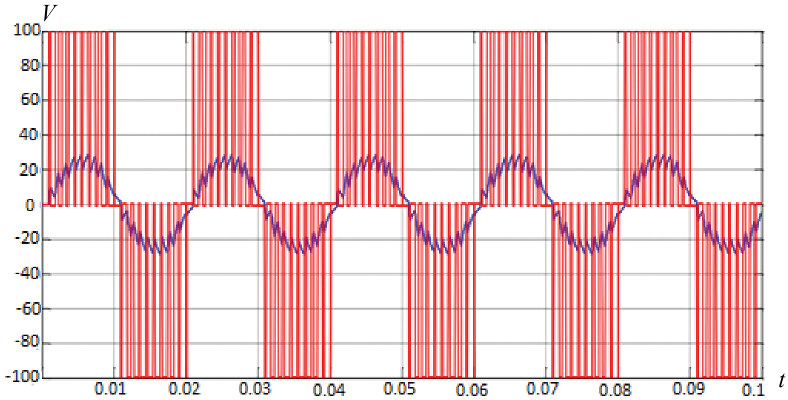

Fig. 7. Level output waveform (PWM)

When the carrier frequency rises, the frequencies at which the harmonics occur rise as well (mf rises). High switching frequencies have the disadvantage of causing additional losses at the inverter switches. The amplitude modulation ratio "ma" is used to assign reference signal amplitudes to carrier signals.

The PWM output will then be controlled by ma (amplitude of the essential frequency). This is significant for an unorganized DC supply voltage since the value of ma could be modified to compensate for the changes in the DC supply voltage, resulting in a fixed amplitude output [14]. Because of the different ma, the output amplitude can change. If ma is greater than one, the output of amplitude grows in lockstep with ma (rather than linearly). For PWM, the switches must be capable of carrying current in all directions (full-bridge circuit), just as they were for square-wave operation. The physical switches are not immediately turned on or off. As a result, much like with a square wave inverter, switching control times must be factored in. The sinusoidal reference voltage should come from an incoming reference or be generated by the inverter control circuit. A sinusoidal voltage must exist before the bridge can provide a sinusoidal output (so it seems the function of the inverter bridge is needless). The inverter's purpose is to provide load power from a DC power source.

Conclusion

Both PG and PWM are switching scheme methods. In a PG, there is just one pulse every half cycle, whereas in PWM, the switches are turned on and off repeatedly during the same time period. The output voltage of a PG converter is controlled by altering the phase delay, period, and pulse width, whereas the output voltage of a PWM converter is controlled by adjusting the pulse width. Lower order harmonics can be decreased in PWM by adjusting the number of pulses per half cycle. As a result, increasing the number of pulses should increase the number of higher-order harmonics (which primarily corresponds to THD demand), making filtering easier. The third harmonic is the lowest order harmonic in a PG (and it's difficult to filter out). PWM has a number of drawbacks, including difficult control and frequent switching losses.

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Трехуровневый диодно-зажимный инвертор с генератором импульсов и широтно-импульсной модуляцией

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Ключевые слова: инверторы с диодным зажимом; инвертор трехуровневый; многоуровневый инвертор; генератор импульсов.

Аннотация: Для демонстрации эффективного логического управления сконструированы и построены трехуровневые диодные зажимные инверторы (DCI), использующие две различные технологии схемных переключений, генератор импульсов (PG) и широтно-импульсную модуляцию (PWM) с применением для расчетов программный пакет MATLAB Simulink. Считается, что PG посылает прямоугольный импульсный сигнал, который отличается последовательностью и высоким качеством. Наиболее подходящими методами модификации таких электрических преобразователей являются использование PG и PWM, которые применяются для устройств коммутации MOSFET с высокой интенсивностью.

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Der dreistufige Dioden-Klemme-Gleichwechsler mit einem Impulsgenerator und Pulsweitenmodulation

Zusammenfassung: Um eine effiziente Logiksteuerung zu demonstrieren, sind dreistufige Dioden-Klemm-Wechselrichter (DCI) unter Verwendung von zwei verschiedenen Schalttechnologien, Pulsgeneratoren (PG) und Pulsweitenmodulation (PWM) unter Verwendung des MATLAB Simulink-Softwarepakets für Berechnungen entworfen und gebaut. Es ist angenommen, dass das PG ein Rechteckimpulssignal sendet, das sich durch die Sequenz und Hochwertigkeit auszeichnet. Die am besten geeigneten Modifikationsverfahren für solche elektrischen Wandler sind die Verwendung von PG und PWM, die für hochintensive MOSFET-Schaltvorrichtungen verwendet werden.

Onduleur à diode à trois niveaux avec un générateur d'impulsions et modulation de largeur d'impulsion

Résumé: Pour démontrer un contrôle logique efficace, sont conçus et construits des onduleurs à diodes à trois niveaux (DTR) utilisant deux technologies de commutation de circuits différentes, le générateur d'impulsions (GI) et la modulation de largeur d'impulsion (PLI), avec le logiciel MATLAB Simulink. On pense que GI envoie un signal d'impulsion rectangulaire qui se distingue par une séquence et une haute qualité. Les méthodes les plus appropriées pour modifier de tels transducteurs électriques sont l'utilisation de GI et PLI, qui sont appliquées aux dispositifs de commutation MOSFET à haute intensité.

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