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ORIGNAL ARTICLE

Implementation of a pulse generator and pulse width modulation to a three-level diode-clamp inverter as a case study

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Abstract

Three-level diode clamp inverters (DCI) are designed and implemented in this paper using two different switching scheme technologies namely (PG) pulse generator and (PWM) pulse width modulation using Matlab Simulink to make certain the efficiency of this logic control method. The PG is assumed to transmit a precise, stable and accurate square pulse signal. The current PG innovation is too big to be fully encapsulated. Comparative study between the most fitting domination and modification methods sophisticated for these converters PG and PWM are implemented to drive the MOSFET switching device, to make constant high voltage pulses which give a pulse electric range of up to high intensity.

1. Introduction

Many industrial appliances require variable power (medium or low) to operate, and some industries require high power. In recent years, 1975 multi-level inverter (MLI) was introduced as an alternative in high power and medium voltage situations [1]. It converts medium voltage sources (solar cells, batteries, mega capacitors) into high power output; these transformers consist of several switches, diodes, and capacitors [2]. MLI can generate output voltages with significantly low distortion; it can reduce dv/dt stresses and input current draw with low distortion; it can reduce stress in motor bearings because it produces a smaller voltage in Common Mode. It can also operate within the base and the high frequencies of PWM switching. (The lower conversion frequency results in less conversion loss in addition to higher efficiency) [3,4]. Here is a summary of some of the benefits of MLI; as for its drawbacks, the main one is its requirement for many semiconductor switches [5].

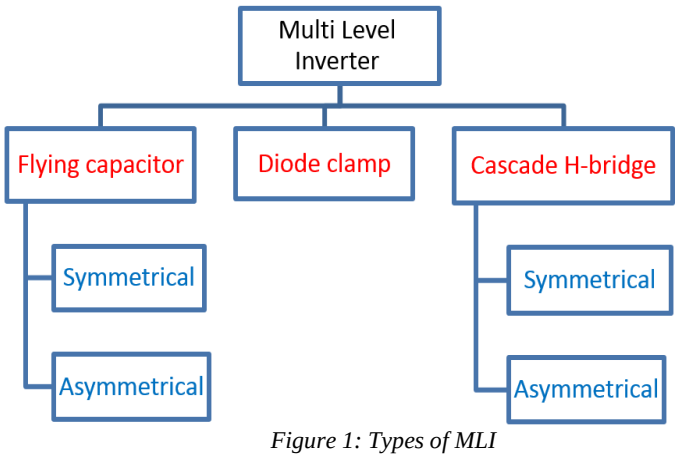

Figure 1: Types of MLI

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Whereas each drive circuit switch requires a relevant gate which may cause the overall system overhead to increase. MLI is divided into three main types, and each type has some benefits and DE benefits, table 1 and fig. 1.

Table 1: Applications, Benefits, and De Benefits of MLI types

Names	Advantages	Disadvantages	Applications
Diode Clamped Multilevel Inverter	• Capacitance is low • Back to back inverters can be used. • Capacitors are pre changed. • Efficiency is high at fundamental frequency	• Number of clamping diodes increases with the increase of each level. • DC level will be discharge when control and monitoring are not precise.	• Static var compensation • Variable speed motor drives. • High voltage system interconnections • High voltage DC and AC transmission lines
Flying Capacitors Multilevel Inverter	• Static var • For balancing capacitors' voltage level, phase redundancies are available. • We can control reactive and real power flow.	• Voltage control is difficult for all the capacitors. • Complex startup • Poor Switching efficiency • Capacitors are expansive than diodes.	• Introduction motor control. • Static var generation. • Both AC-DC and DC-AC conversion applications. • Converters with harmonic distortion capability. • Sinusoidal current rectifiers.
Cascade H Bridge Multilevel Inverters	• Output voltage levels are doubled the number of sources. • Easy and quick manufacturing. • Packaging and layout is modularized. • We can control it easily with a transformer. • Inexpensive.	• Every H bridge need a separate DC source • Due to large number of DC source, applications are limited.	• Active Filters • Electric vehicle drives • DC power source utilization • Power factor frequency link system • Interfacing with renewable energy resources

2. Diode clamp (DCMLI)

This inverter uses diodes and supplies multiplied voltage levels out of the various phases to the capacitor banks who are in chain [1,6]. A diode transmits a limited quantity of voltage, that way reducing the strain on other electrical equipment's. The main drawback is the maximum output voltage is half of the input DC voltage, it can be solved by increasing the number of switches, diodes, capacitors. because of using fundamental frequency for all the switching devices this inverter provides high efficiency and it is a simple method of the back-to-back power transfer systems [7].

The voltage across each switch is Vdc/2 ((Vdc /2) is the voltage of each capacitor). Table 2 shows the switches modes against the magnitude of o/p voltage. Two switches are On for each mode and the other two switches are Off with different o/p. Dc bus voltage share into three levels by Two capacitors C1 and C2 which are connected in series [6,8].

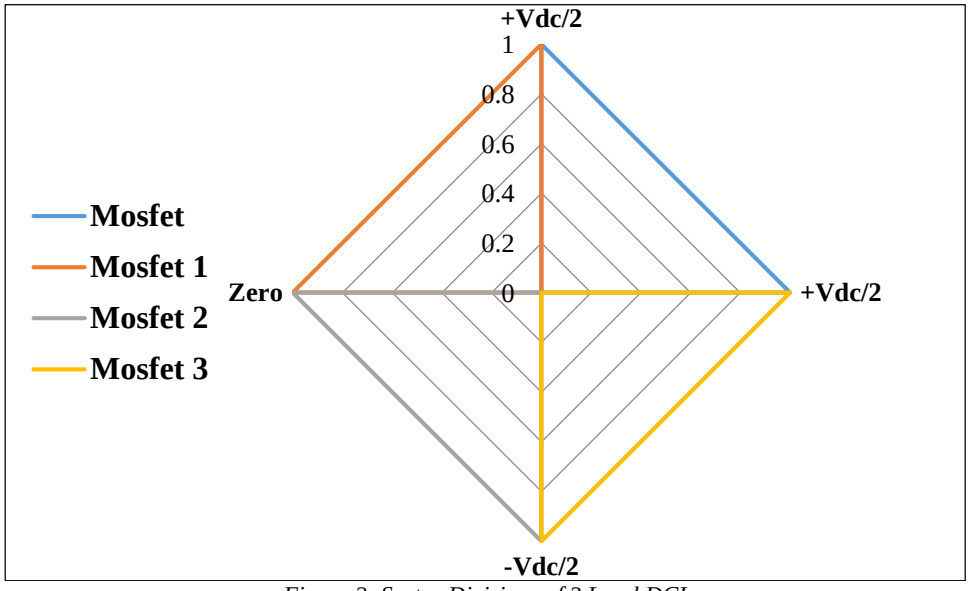

Figure 2: Sector Divisions of 3 Level DCI

Table 2: Switches modes against the magnitude of o/p voltage

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

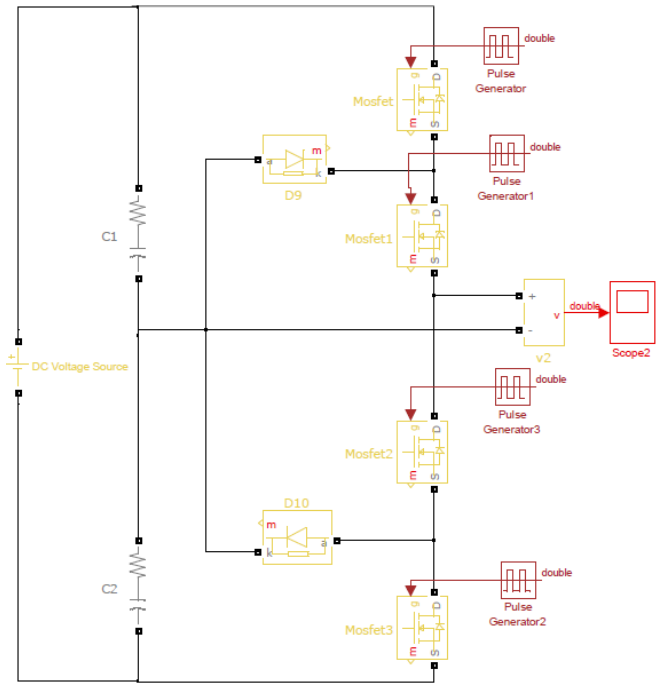

Figure 3: 3 Level DCI (PG)

The switching modes is to guarantee that switches action in tangent style. O/p voltage Van has three cases (Vdc/2), (Zero), (-Vdc/2), Fig. 7. These three cases are achieved when depending on the newer logic states.

- Upper switches (Mosfet and Mosfet1) are ON and all lower switches (Mosfet2 and Mosfet3) be Off to get (Vdc/2).
- Switches (Mosfet1 and Mosfet2) be ON, Mosfet and Mosfet3 be Off to get Zero.
- Switches (Mosfet2 and Mosfet3) be ON, Mosfet and Mosfet1 be Off to get (-Vdc /2).

2.1 Pulse Generators PG

Control strategies in the Matlab program by using the parameters in the source block of each switch (amplitude, period, pulse width, and phase delay) by issuing a square wave at fixed intervals are called pulse generators [8].
Amplitudes are one for all switches with period 1/f, phase delay and pulse width are changing depending on table 2. As an example switch 1, is ON in one time Vdc/2 o/p, and at whole else time is OFF, works of 10% from the life cycle.

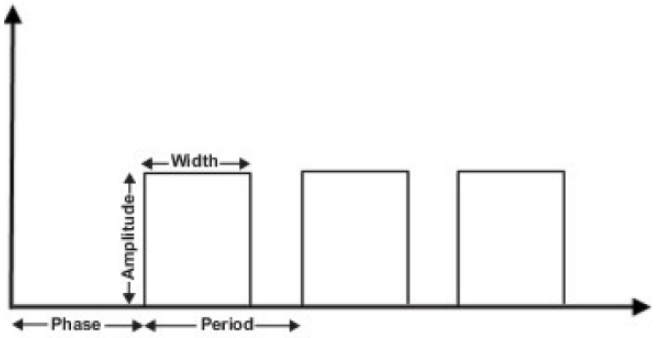

Figure 4: Explanation of wave measurements

Switch 1 works without delay, so phase delay is equal to zero, and pulse width is equal to 12.5% of the period. Switch 2 works without delay, so phase delay is equal to zero also. Switch 2 is two times ON in Vdc/2 and Zero, off for all other times, so pulse width is equal to 25% of the period and so on for other switches, Fig. 5&6.

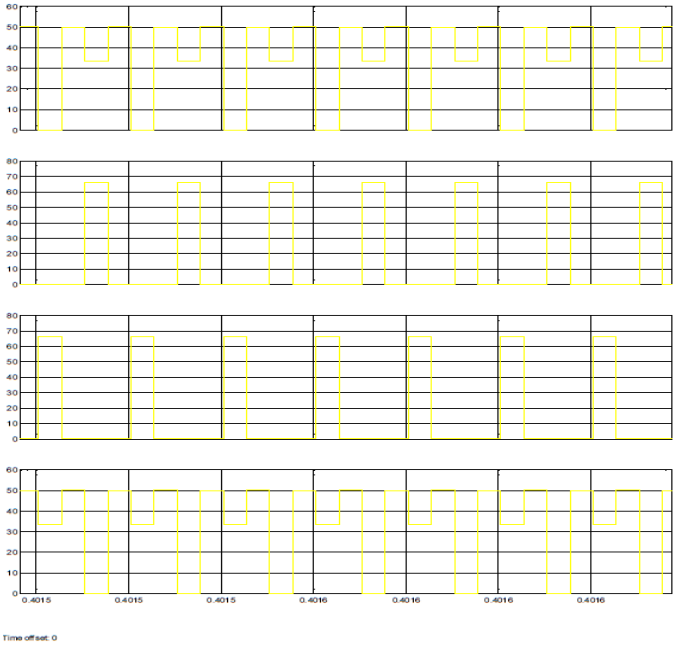

Fig. 5. Switching Sequence

2.2 Pulse Width Modulation PWM

In a pulse generator, there is only one pulse per half-cycle, Fig. 7 (the converter output is controlled by changing the phase delay, period, and pulse width, Fig. 4&6), then the minimal order harmonic is the third (It's tricky to filter out) [9-11].

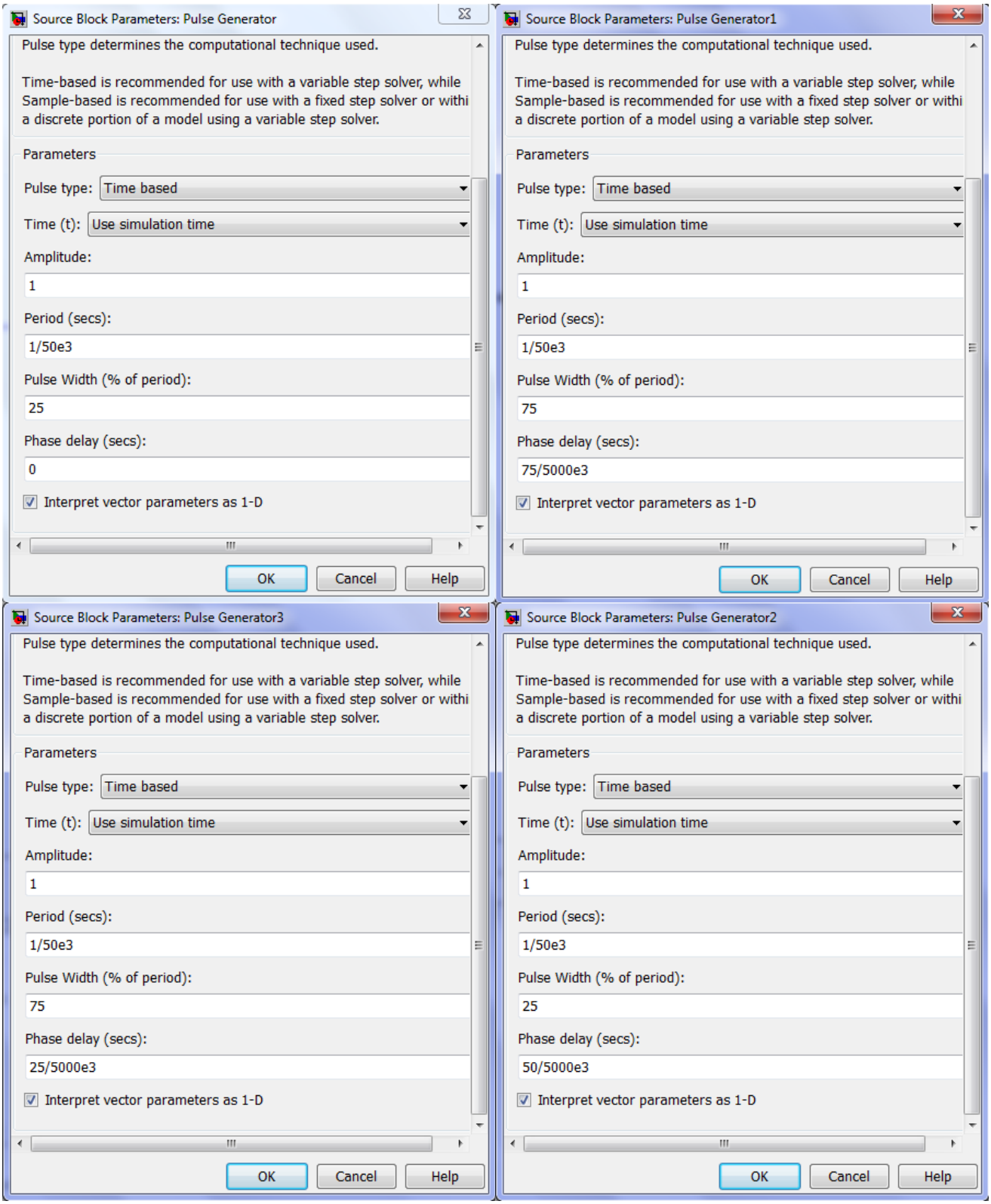

Figure 6: Switches Source Block Parameters

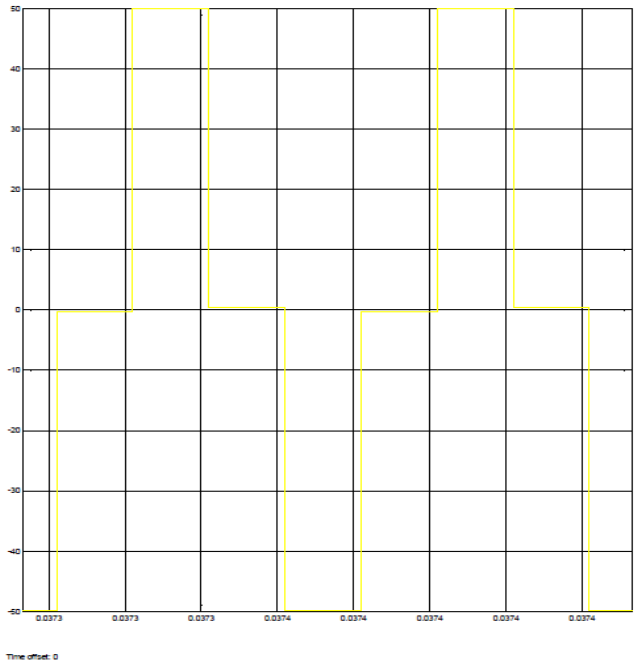

Figure 7: 3 Level Output Waveform (PG)

In each half cycle, Switches are transitioned On\Off much times, and the output voltage is controlled by changing width of the pulses, these are called a PWM control. Fig. 10. The gateway signals produced by matching a dc signal with a triangular wave [12], Fig. 8. The lower order harmonics can be eliminated by selecting the number of pulses. as a result, growing the number of pulses should also grow the amount of the higher-order harmonics, then it's easy to be filtered.

Inverters established with a PWM technology, are excellent in many factories in proportion to others established with other technologies. PWM is the modifying method to the pulses width in the pulse chain at a direct rate to a small control signal. PWM produces a path to lessening the load current total harmonic distortion [13,14].

A PWM inverter output mostly meets THD demand (together with several filtering which is more readily from the quadrate wave switching planner). The unfiltered PWM output has a comparatively high THD, fabricate filtering is easier (the harmonics so higher frequencies proportion to a square wave).

In PWM, the amplitude of the output voltage can be streaked together with the modifying waveforms. eliminated filter matters to harmonics reduction and the output voltage amplitude control are two distinguished benefits of PWM [10].

Switches circuits complicated control, and frequent switching losses are the disadvantages of PWM. a reference signal is needed to the switches control for the sinusoidal PWM output (a sinusoidal and a carrier signal in this case) that is a triangular wave who observations the switching frequency. These inverters are prepared as stated by:

- Input voltage Vdc = 440 volt
- Capacitors 100 µF
- Switching frequency fsw = 50 KHZ
- O/P voltage 440-volt peak-peak
- $V_{dc} = V_{c1} + V_{c2}$
- $V_{ci} = V_{c2} = V_{dc}/2$
- Period time = $1/f_{sw}$

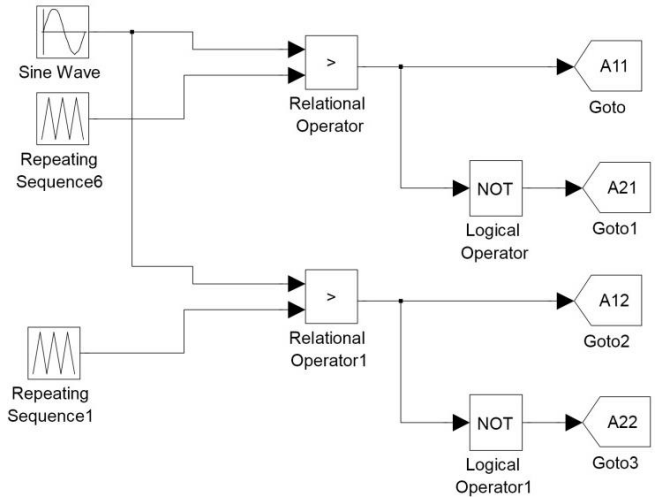

Figure 8: PWM Scheme

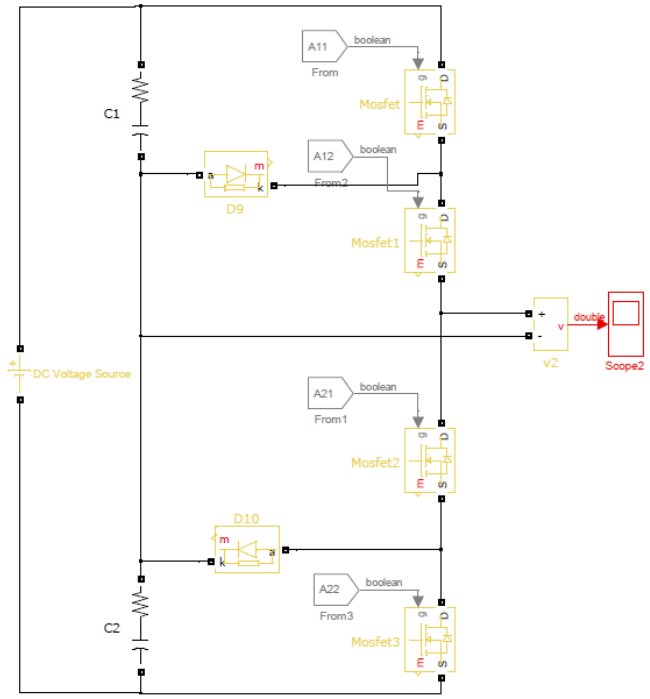

Figure 9: 3 Level DCI (PWM)

The PWM output voltage has a fundamental frequency in the Fourier series that is identical to the reference signal. Multiples of switching frequency have Harmonic frequencies at and concerning of it. The bulk of some harmonics are perfectly considerable, so because of these high frequencies harmonics, a

natural low-pass filter could be functional in ejecting them. The ratio of the carrier frequencies to reference signals is defined as the frequency modulation ratio mf [11].
mf = F. carrier/ F. reference = F. tri./ F. sine

when the carrier frequency growing, (rising mf) growing the frequencies at whose the harmonics take place. High switching frequencies have a disadvantage of more losses at the switches utilized to perform the inverter.

The attribution of the amplitudes of the reference to carrier signals is defined as amplitude modulation ratio ma:

ma= V_m. reference/ V_m . Carrier = V_m. sine/ V_m. Tri.

whether ma is >= to1, then capacity of the output voltage essential frequency V1 is linearly proportionate to ma. Then V1= ma Vdc

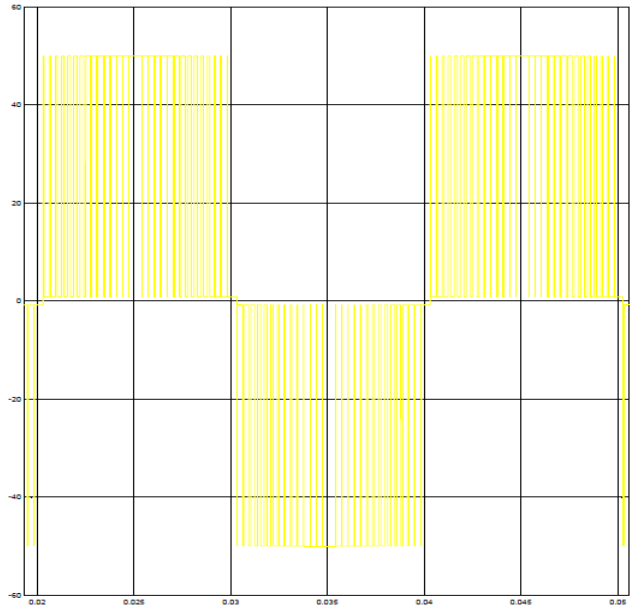

Figure 10: Level Output Waveform (PWM)

Then ma will control the PWM output (amplitude of the essential frequency). Now, this is considerable for an un organized dc supply voltage, and this is because the value of ma could be changed to recompense for the dc supply voltage variations, introducing a fixed amplitude output [13].
the output amplitude could be changed due to varied of ma. If ma is > to1, output of amplitude growing up (not linearly) together with the ma.
The switches have to be eligible of carrying current in every direction (full-bridge circuit) for PWM same as they did before for the square-wave operation [18]. The real switches are not turned on\off right away. So, it's requisite to allow for switching control times, same as for square wave inverter.
The sinusoidal reference voltage should be possessed from an outgoing reference or created with the inverter control circuit. a sinusoidal voltage should be existent prior to the bridge working to make a sinusoidal output (so it seems the function of the inverter bridge is needless). The intentional objective of the inverter is to providing the load power from the dc power source.

3. Conclusions

PG and PWM both are a switching scheme technique. In a PG, there is only one pulse per the half cycle, In PWM, the switches are turned On\Off many times through the same period.
In a PG the converter output is controlled by changing the phase delay, period, and pulse width, In PWM, the output voltage is controlled by changing the width of pulses.
In PWM, the lower order harmonics could be reduced by selecting the number of pulses per the half cycle. as a result, growing the number of pulses should also grow the amount of the higher-order harmonics (mostly meets THD demand), then it's easy to be filtered. In a PG, the minimal order harmonic is the third (It's tricky to filter out).
Switches circuits complicated control, and frequent switching losses are the disadvantages of PWM.

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