ISSN(Online): 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 5, May 2016

Design of Triple Switching Clamping Sequence for BCPWM Technique Using Space Vector Approach

R.N.Uma Mahesh

Assistant Professor, Dept. of Electronics and Communication, ATME College Of Engineering, Mysore, India

ABSTRACT: In Today's Industrial Applications, the pulse width modulation technique plays a vital role in driving the motors. Conventional space vector pulse width modulation technique involves two Zero states and two active states in every sub cycle. The switching energy loss is very high in double switching clamping technique and also the reduction in harmonic distortion is not up to the level Therefore In Proposed work, a new set of Bus clamping pulse width modulation technique called "triple- switching clamping sequence" which uses one Zero state and active vector repeats thrice in a sub-cycle. The proposed work involves Design and simulation of Triple Switching clamping sequence in terms of line current harmonic distortion. Simulation is done on MATLAB/SIMULINK environment.

KEYWORDS: bus clamping,Pulse width modulation,harmonic distortion,Space vector PWM,Switching Sequences,driving motors,switching energy,industry**.**

I. INTRODUCTION

The process of varying the width of each pulse in accordance with amplitude of message signal is called Pulse width modulation. Pulse width modulation plays a major role in controlling the speed of different motors. Harmonic distortion also plays a pivotal role for the smooth operation of motor. Therefore the paper mainly focuses on the different kinds of PWM techniques to control harmonic distortion. Here in this paper, we are describing different kinds of pwm techniques like SPWM, THIPWM, CSVPWM, Double switching bus clamping pulse width modulation, triple switching bus clamping pulse width modulation techniques.

In SPWM and THIPWM techniques, the dc voltage is not utilized completely and harmonic distortion in line current is not reduced. The SPWM technique utilizes 78.5% of DC bias voltage. Since the DC bias voltage is not utilized completely in SPWM the third-harmonic-injection pulse-width modulation (THIPWM) is used. In THIPWM, 15.5% increase in the utilization rate of the DC bias voltage is achieved. In order to increase the output voltage of PWM technique, the Space Vector pulse width modulation technique is used. The goal of each modulation technique is to reduce the Switching losses and maximize DC bias utilization and reduce the harmonic content.

In Conventional space vector pulse width modulation technique, each sequence is designed with two zero states and two active states. In Double switching clamping pulse width modulation technique, the harmonic distortion is not reduced completely and switching energy loss factor is very high. In order to overcome this drawback, Triple switching bus clamping pulse width modulation technique is employed. In Triple switching BCPWM, every active state switches thrice in a sub cycle there by reducing harmonic distortion further. The designed Triple switching BCPWM also results in less line RMS current in harmonic distortion and also fundamental RMS line current is also reduced further over a given sub cycle in a given set of sequences.

II. RELATED WORK

PULSEWIDTH modulation (PWM) techniques have been the subject of intensive research during the last few decades [1] .A classical space-vector pulsewidth modulator (PWM) with equal duration of application of zero-state vectors V0 and V7 was modified. A additional zero vector(proportional to the time of application of vector V7) is introduced. Correlation between existing Double switching clamping sequence and proposed triple switching clamping sequence (with added zero sequence) is introduced [1]. The influence of additional vector on characteristics of the

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PWM is investigated. Salient features of the new clamping sequence are explainedthe developed algorithm is suitable for microprocessor and analog implementation [2] . Here the features of double switching clamping sequence and triple switching clamping sequence is discussed. The harmonic distortion in triple switching clamping sequence of BCPWM is reduced compare to Double switching clamping sequence.

III. SWITCHING SEQUENCES OF INVERTER

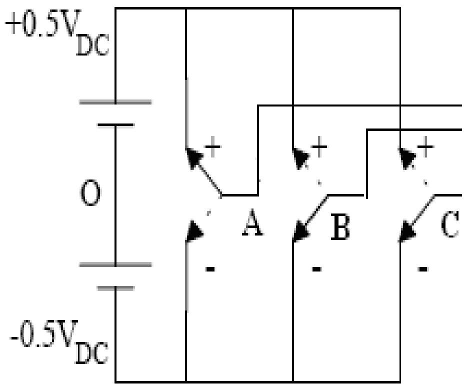

Fig-1 Circuit Diagram Of 3-Phase2- Level Inverter

The 3-Phase 2-level inverter has 8 states in which there are 2 Zero states(--- & +++) and six active states.the two zero states produces of Zero voltage magnitude and six active states produces six active vectors. These six active vectors are placed in hexagonal pattern and angle among each vector is sixty degrees. The magnitudes of active vectors are designed in such way that they satisfy the DC bias volatge.

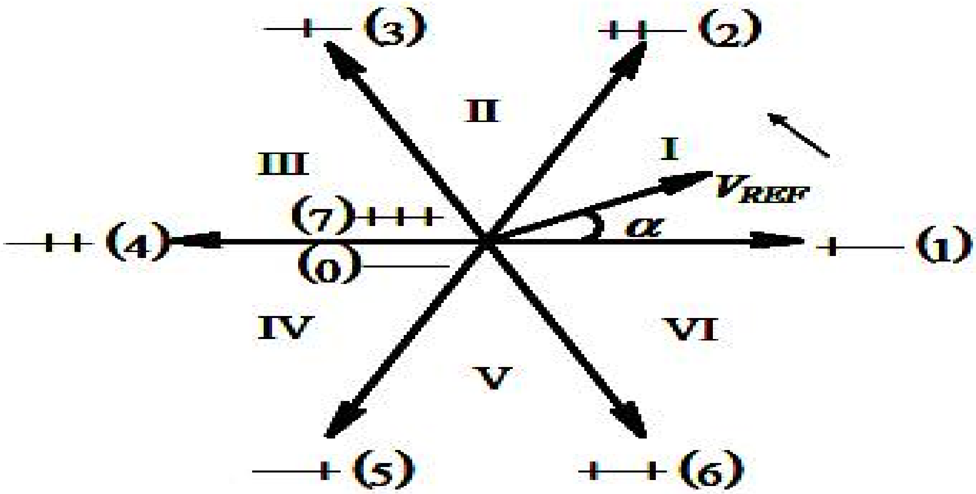

Fig-2 Inverter States and voltage vectors of 3-Phase inverter

ISSN(Online): 2320-9801
ISSN (Print) : 2320-9798

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The six active vectors are represented by the following expression

$$\vec{V}_k \quad \frac{2}{3} V_d e^{j(k-1)\frac{\pi}{3}} \quad \text{with } (k=1,\ldots,6)$$ ………Eqn 1.

In space vector PWM, the reference voltage vector VREF is sampled once in a sub-cycle with time period TS. This reference voltage vector is placed in Sector-1 with an unknown angle α as shown in Fig-2.the time duration of active vector 1 and active vector 2 are represented by T1 and T2 and time duration for Zero State vector is TZ. The expressions for the T1, T2 and TZ are shown in group of equations shown below.

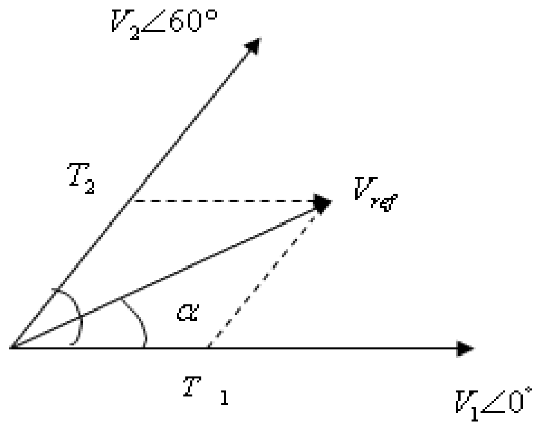

FIG-3 PHASOR DIAGRAM OF SECTOR-1

$$T1 = VREF * TS * \frac{Sin(60-\alpha)}{Sin(60)}$$ …………………………EQN 2

$$T2 = VREF * TS * \frac{Sin(\alpha)}{Sin(60)}$$ ……………………………….EQN 3

TZ=TS-T1-T2………………………………………….EQN 4

In conventional space vector pulse width modulation, the two zero states and two active states are represented in a single sequence. For example the sequence (0-1-2-7) is placed in sector1 which comprises of two zero states (0 and 7) and two active states (1 and 2). In double switching BCPWM, the active vector repeats twice in sub cycle as shown in sequence. For instance, the sequence (0-1-2-1) has active vector 1 repeated twice. By repeating the active vector twice, the double switching BCPWM does not reduce the harmonic distortion to the required level. In Triple switching BCPWM, the active vector repeats thrice in a cycle thereby reducing the harmonic distortion.

The different possible Double switching and Triple Switching Sequences of BCPWM is as shown in above diagram. The sequence (0-1-1-2-1) leads to clamping of Positive Dc voltage .and the Sequence (7-2-2-1-2) leads to clamping of negative Dcvoltage. Hence sequences (0-1-1-2-1) and (7-2-2-1-2) are termed as Triple Switching clamping Sequences. The Sequences in Fig-5 are employed in Sector-1.the sequences of other sectors are as shown in table-1

Sector	Conventional Sequence	Clamping Sequence	Double Switching Clamping Sequences	Triple Switching Clamping Sequences
I	(0127,7210)	(012,210),(721,127)	(0121,2120),(7212,1217)	(01121,21220),(72212,12117)
II	(0237,7320)	(023,320),(732,237)	(0232,3230),(7323,2327)	(02232,32330),(73323,23227)
III	(0347,7430)	(034,430),(743,347)	(0343,4340),(7434,3437)	(03343,43440),(74434,34337)
IV	(0457,7540)	(045,540),(754,457)	(0454,5450),(7545,4547)	(04454,54550),(75545,45447)
V	(0567,7650)	(056,650),(765,567)	(0565,6560),(7656,5657)	(05565,65660),(76656,56557)
VI	(0617,7610)	(061,160),(716,617)	(0616,1610),(7161,6167)	(06616,16110),(71161,61667)

Table-1 Switching Sequences of Six Sectors

 DOI: 10.15680/IJIRCCE.2015. 0405097

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ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

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By using Triple Switching BCPWM, the active vector repeats thrice which helps to reduce the harmonic distortion further. The harmonic distortion of both Double Switching BCPWM and Triple switching BCPWM are as shown below.

IV.SIMULATION RESULTS

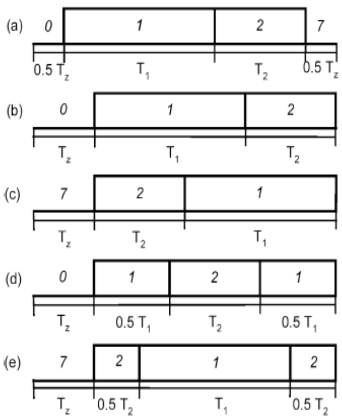

Fig-4 Different Possible Switching Sequences in Double switching clamping sequence output

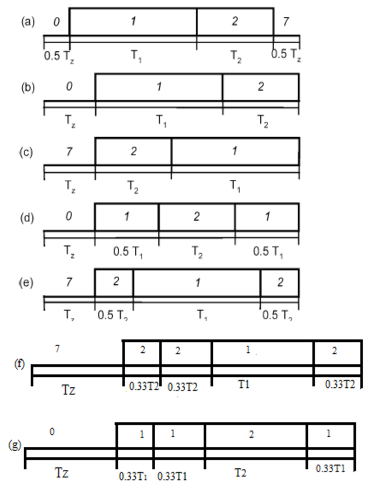

Fig-5 Different Possible switching sequences in double switching clamping sequence and triple switching clamping sequence Output

By using Triple Switching BCPWM, the active vector repeats thrice which helps to reduce the harmonic distortion further. The harmonic distortion of both Double Switching BCPWM and Triple switching BCPWM is shown below.

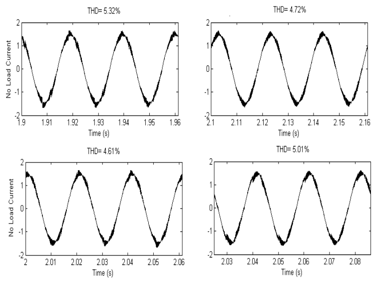

Fig-6 Harmonic distortion waveform of Double Switching BCPWM

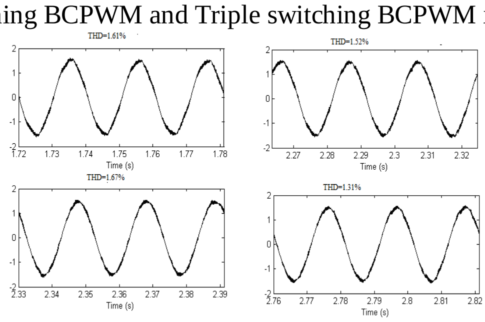

Fig-7 Harmonic distortion waveform of Triple Switching Clamping Sequence

From the above waveforms, It is clear that harmonic distortion is reduced further in Triple Switching BCPWM.

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V. CONCLUSION

A group of Bus Clamping Pulse width modulation techniques which employs both Double Switching Bus clamping PWM and Triple Switching Bus clamping PWM are proposed. The Proposed BCPWM techniques are studied and compared and harmonic distortion in both the techniques are analyzed. The harmonic distortion in Triple Switching BCPWM is reduced compare to Double Switching BCPWM at same switching frequency. The Triple Switching Bus clamping PWM is used in various applications like Speed control of DC Motor, Speed control of induction motor, Electronic Power converter etc.

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