ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

A Space Vector Pulse Width Modulation (SVPWM) Method Where In Timing Calculation is Reduced in 3 Level Inverters

G. Kishore
M.Tech (Power Elctronics),
Department of EEE,
Balaji Institute Of Engineering Sciences,
Laknepally, Narsampet, Warangal, Telangana.

S.Mallikarjun Reddy
Associate Professor,Head Of Department,
Department of EEE,
Balaji Institute Of Engineering Sciences,
Laknepally, Narsampet, Warangal, Telangana.

Abstract:

Space vector modulation (SVM) is an algorithm for the control of pulse width modulation (PWM). Increase in renewable energy resources like solar , fuel cells had created a need for inverters which can work on higher operating voltages efficiently Advances in power electronics technology allowed the vide investigation of multilevel converters that provide high safety voltages ,less harmonic components ,utilization of more input voltage and flexibility in switching the legs compared to the two-level structures .and digital implementation is also very easy .In multilevel inverters space vector modulation (SVPWM) has become the most popular technique for three phase voltage source converters for the control of ac/dc drives and Flexible ac transmission application(FACT) controllers. In this paper a simplified SVPWM is being implemented . SVPWM for more than two levels is difficult because for them no. Of switching states is very high. In simplified SVPWM timing calculation is required for only one sector and therefore calculations are tremendously reduced and the same could be applied to different types of multilevel inverters like flying capacitor and cascaded h bridge. By using simplified SVPWM a passive RL load and motor load are being simulated in the MATLAB/SIMULINK.

Keywords:
Space vector modulation, Inverters, Power electronics, Statcom

Introduction:

In recent years, there has been great interest in multilevel inverter (MLI) technology including three-level neutral-clamped (NPC) voltage-source inverter (VSIs). This type of inverters of producing five level line-to-line voltages. Therefore, with the same switching frequency, the harmonic content of the three level inverter output is less than that of the conventional two level Inverter. In the three level inverter, required voltage rating of the devices is much lower and equal to half of the DC link voltage. This is the main advantage of the multi-level topology other than better spectral quality. Thus, the three level inverter topology is widely used in heavy power industrial applications due to its high voltage handling and good harmonic rejection capabilities with the currently available power electronic devices. Other than high power/high voltage AC motor drives, the three level topology is increasingly employed in flexible AC transmission (FACTS) System such as, SVC (Static Var Compensator), STATCOM (Static Compensator) etc.To control multilevel inverters the pulse width modulation (PWM) strategies are the most effective, especially the space vector pulse width modulation (SVPWM) one, which has equally divided zero voltage vectors describing a lower harmonic distortion (THD).The space vector modulation technique is an advanced, computations intensive PWM technique and is possibly the best among all the PWM techniques for drive applications. Because of its superior performance characteristics, it is been finding wide spread application in recent years.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

In the technique given in twelve dwell time calculations for four regions of one sector and hence seventy two dwell time calculations of six sectors are required. In not all the dwell times are required but still more computations required and the method is not simple. Here less computations required and stress been given to prove the application to motor load and hence validity of the method is not strongly proved.In this paper, a simple SVPWM method for three-level inverter is proposed. By using this method out of six sectors and twenty four corresponding regions and dwell time calculations for one sector i.e. of four regions is required and same be applied to other regions of remaining sectors just by rotating it by sixty degrees to get in other sector. And the same principal of the method can apply for other types of multilevel inverter like flying capacitor and cascaded. This technique is simulated for passive as well as motor load and open loop v/f speed control of induction motor is also done to enhance the validity of the scheme.

THREE-LEVEL INVERTER ANALYSIS:

A three-level inverter to ascertain the differences between it and a conventional two-level inverter [1]. For a three-phase three-level inverter, a structure similar to that used with 12 electronic devices (IGBT) is needed (Fig. 1). Each phase will switch across three voltage levels (+V dc/2, 0, and -Vdc/2). In a structure such as this the maximum voltage across the IGBT is limited to half the maximum dc link voltage (Vdc/2). This occurs because the IGBTs are connected to the neutral point (MP) by two fast diodes called neutral clamp diodes.

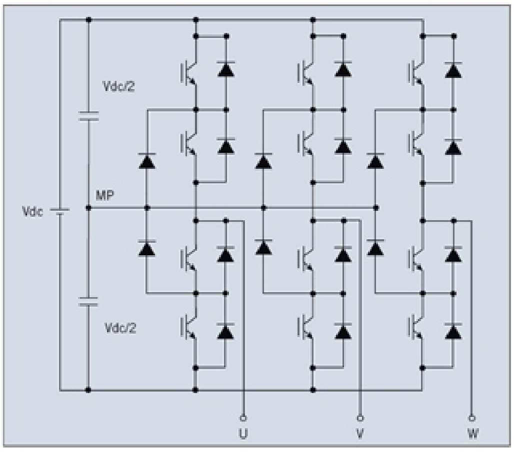


Fig .1. Three-phase three-level inverter topology, in which each phase switches across three voltage levels.

Three-phase two-level-inverter (PWM)-generation algorithms can also be applied to multilevel inverters. The algorithms with a triangular carrier waveform produce the best benefits in terms of harmonic distortion reduction, i.e. a three-level inverter needs both a carrier and a reference. In this case the number of triangular carriers is equal to L-1, where L is the number of voltage levels. For a three-phase three-level inverter this means that two triangular carriers and one sinusoidal reference are needed.

PULSE WIDTH MODULATION:

Pulse Width Modulation (PWM) is the most effective means to achieve constant voltage battery charging by switching the solar system controller's power devices. When in PWM regulation, the current from the solar array tapers according to the battery's condition and recharging needs Consider a waveform such as this: it is a voltage switching between 0v and 12v. It is fairly obvious that, since the voltage is at 12v for exactly as long as it is at 0v, then a 'suitable device' connected to its output will see the average voltage and think it is being fed 6v - exactly half of 12v. So by varying the width of the positive pulse - we can vary the 'average' voltage.

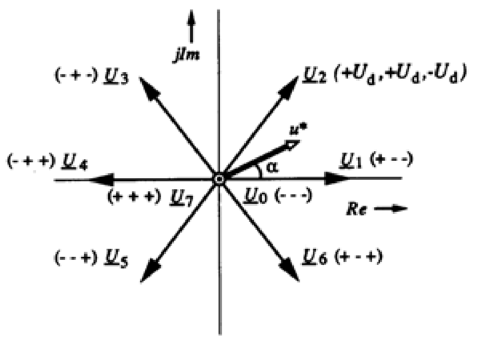
SVM PWM Technique:

The Pulse Width modulation technique permits to obtain three phase system voltages, which can be applied to the controlled output. Space Vector Modulation (SVM) principle differs from other PWM processes in the fact that all three drive signals for the inverter will be created simultaneously. The implementation of SVM process in digital systems necessitates less operation time and also less program memory.

The SVM algorithm is based on the principle of the space vector u*, which describes all three output voltages ua, ub and uc :

$$u^* = 2/3 \cdot (u_a + a \cdot u_b + a^2 \cdot u_c) \ldots\ldots\ldots (5)$$

Where $a = -1/2 + j \cdot \sqrt{3}/2$ We can distinguish six sectors limited by eight discrete vectors u0… u7 (fig:- inverter output voltage space vector), which correspond to the $2^3 = 8$ possible switching states of the power switches of the inverter.

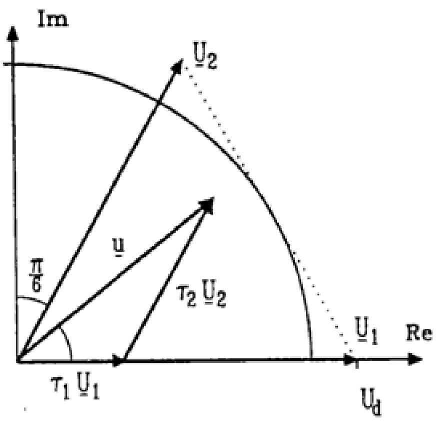


Space vector Modulation

The amplitude of u0 and u7 equals 0. The other vectors u1… u6 have the same amplitude and are 60 degrees shifted.By varying the relative on-switching time Tc of the different vectors, the space vector u* and also the output voltages ua, ub and uc can be varied and is defined as:

ua = Re (u*)
ub = Re (u* . a-1)
uc = Re (u* . a-2) ………… (6)

During a switching period Tc and considering for example the first sector, the vectors u0, u1 and u2 will be switched on alternatively.



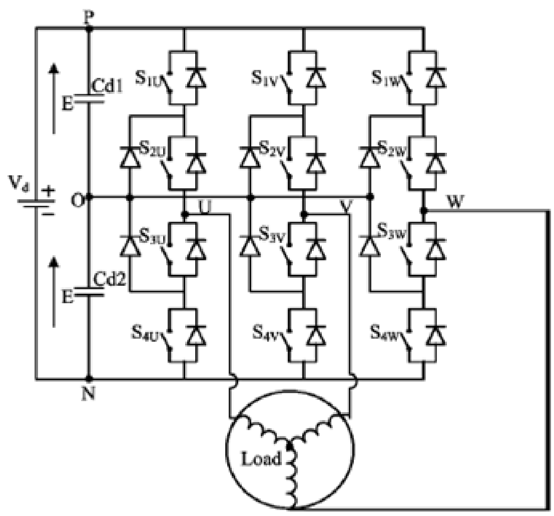
Definition of the Space vector

Depending on the switching times t0, t1 and t2 the space vector u* is defined as:
u* = 1/Tc . (t0 . u0 + t1 . u1 + t2 . u2)
u* = t0 . u0 + t1 . u1 + t2 . u2
u* = t1 . u1 + t2 . u2 ………….. (7)

u* = t1 . u1 + t2 . u2 ………….. (7)
Where
t0 + t1 + t2 = Tc and
t0 + t1 + t2 = 1
t0, t1 and t2 are the relative values of the on switching times.
They are defined as: t1 = m . cos (a + p/6)
t2 = m . sin a
t0 = 1 - t1 - t2

Their values are implemented in a table for a modulation factor m = 1. Then it will be easy to calculate the space vector u* and the output voltages ua, ub and uc. The voltage vector u* can be provided directly by the optimal vector control laws w1, vsa and vsb. In order to generate the phase voltages ua, ub and uc corresponding to the desired voltage vector u* the following SVM strategy is proposed.

THREE LEVEL INVERTER:



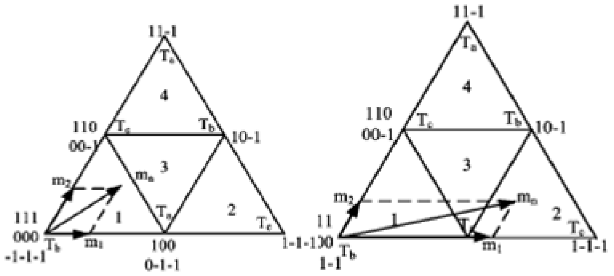
Schematic diagram of a three-level inverter connected to load

Fig. above shows a schematic diagram of a three-level neutral clamped inverter. Each phase of this inverter consists of two clamping diodes, four force commuted switches (MOSFET, GTO, IGBT etc.) .Table I shows the switching states of a three-level inverter. Since three kinds of switching states exist in each phase, a three-level inverter has 27(33) switching states.

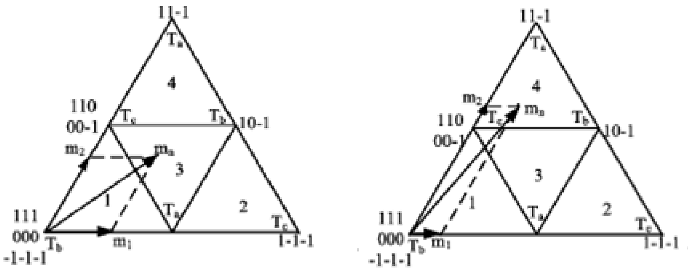
ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

SELECTION OF SWITCHING SEQUENCE AND CORRESPONDING STATES:

Seven segment switching are used and care is taken over of one switching transition i.e. only one device gets on or off. The switching orders for the four regions of sector 1 are as follows Region 1: -1-1-1, 0-1-1, 00-1, 000, 00-1, 0-1-1, -1-1-1
Region 2: 0-1-1, 1-1-1, 10-1, 100, 10-1, 1-1-1, 0-1-1.
Region 3: 0-1-1, 00-1, 10-1, 100, 10-1, 00-1, 0-1-1.
Region 4: 00-1, 10-1, 11-1, 110, 11-1, 10-1, 00-1



(a) Region1of sector1 and (b) Region 2of sector1



(c) Region 3 of sector1 (d) Region 4 of sector1

CONCLUSION:

In this paper effort is done to simplify the space vector PWM method of multi-level inverter. And to prove the validity the method, it is checked for passive as well as motor load. To enhance the validity of the method open loop v/f speed control on induction motor is also carried out and the results are tabulated in which calculated and simulated results are well matched. Another advantage of this method are it can be used for any level and different types of multi-level inverter like flying-capacitor, cascaded and hybrid multi-level inverter.

REFERENCES:

[1] G. Carrara, S. Gardella, M. Marchesoni, R. Salutari and G. Scintto, "A New multilevel PWM method: A theoretical analysis," IEEE Trans.Power Electron. vol.7, July 1992 pp. 497-505.

[2] A. Nabbae, I.Takashi, and H. Akagi, "A New neutral-point clamped PWM inverter," IEEE Trans. Ind. Applicat, vol. 7, Sept./Oct. 1981 pp. 518-523.

[3] K. R. M. N. Rataynake, Y. Murali, T. Watanbe, "Novel PWM scheme to control neutral point voltage variation in three-level voltage source inverter," IEEE Industry Applications Conference,Record.,34thIAS Annual Meeting ,1999,vol.3,3-7 Oct.1999 pp1950-1955 .

[4] Y-H Lee, D-H Kim, D-S Hyun, "Carrier-Based SVPWM method for multi-level system with reduced HDF", IEEE Conference on Industry Applications. Conference Record vol.3, 8-12 October 2000, pp.866-868.

[5] J.–H. Youm and B. –H. Kwon, "An effective software implementation of the space-vector modulation," IEEE Trans. Ind. Elctron., vol.46, Aug. 1999, pp. 866-868.

[6] Zhou and D. Wang, "Relationship between space-vector modulation and three-phase carrier-based PWM: A comprehensive analysis," IEEE Trans. Ind. Elctron., vol. 49, Feb. 2002pp. 186-196.
[7] P. F. Seixas, M. A. Servw Mendes, P. Donos Garcia' "An algebraic PWM method for three-level voltage source inverter," IEEE Conference on Industry Applications, 2000, Conference Record, vol.4, 8-12 October 2000, pp. 2177-2184.

[8] P. Purkait and R. S. Sriranakakavachaam, "A new generalized spacevector modulation algorithm for neutral-point-clamped multi-level converters," In the Progresss In Electromagnectic Research Syposium 2006, Cambridge, USA, March 26-29, 2006.

[9] Ayse Kocalms, and Sedat Sunter, " Simulation of a space vector PWM controller for three-level voltage -fed inverter motor drive," IEEE Coference on Industrial Electronics 2006, IECON 2006-32 Annual Conference Record , 6-10 Nov. 2006,pp. 1915-1920.

[10] M.M. Renge and H. M. Suryawanshi, "Five level diode clamped inverter to eliminate common mode voltage and reduce dv/dt in medium voltage rating induction motor drives," IEEE Trans. Power Electron., July 2008, vol. 23, no. 4, pp. 1598-1607.