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A New PWM Generation Scheme for Multi Level Inverter

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Abstract

This paper proposes new SVPWM technique has been presented for multilevel inverters. It is a generalized method for the generation of space vector pulse width modulation (SVPWM) signals for multilevel inverters. The switching vectors and optimum switching sequence are automatically generated by the principle of mapping. In the proposed method, the actual sector containing the tip of the reference space vector need not be identified. A method is presented to identify the center of a sub hexagon that contains the tip of the reference space vector. Using the center of the sub hexagon, the reference space vector is mapped to the inner sub hexagon, determination of the duration of switching vectors and optimum switching sequence corresponding to a two-level inverter is determined. The two-level vectors are translated to the vectors of the multilevel inverter by the principle of reverse mapping proposed in this paper. Switching vectors of the multilevel inverter by adding the center of the Sub hexagon to the two-level vectors. The proposed method can be extended to any multilevel inverter. The scheme is explained for three -level and results are presented for three level with and without load conditions.

***Key words*—Multilevel inverter, reverse mapping, space vector pulse width modulation (SVPWM),Switching sequence, Candidate vector.**

1.Introduction

The most widely used techniques for implementing the pulse width modulation (PWM) strategy for multilevel inverters are sine-triangle and space vector PWM (SVPWM).In the SVPWM [1]-[2] scheme reference space vector is rotated ,tip of the voltage

Proposed method uses sec-tor identification only at the two-level. In the proposed method, the actual sector (where the tip of the instantaneous reference space vector lies) in the space vector diagram of a multilevel inverter [9] is not required to be identified. A method using the principle of mapping is proposed for generating the switching vectors corresponding to the actual sector and the optimum switching sequence of a multilevel inverter from that of the two-level inverter. An algorithm is proposed for generating SVPWM for any multilevel inverter. The proposed method can be used for an inverter with an even number of levels also. The scheme is explained with a three-level inverter, and simulation results for three-level and the current wave forms of three level under load condition are presented.

II. Principle Of The Proposed Method

Fig. 1shows the space vector diagram of three level inverter. The small triangles formed by the adjacent voltage space vectors are called sectors. Such six sectors around a voltage space vector forms a hexagon called sub hexagon [3]. Fig.1 consist of two subhexagons. The are represented as "subhexagonI"(referred as inner sub hexagon) having the vector 000 as the center and "subhexagonII" having the vector 110 as center The inner sub hexagon can be viewed as a space vector diagram of a two- level inverter whose inverter voltage vectors switch between the lower most levels.
Subhexagon1 can be also viewed as a space vector diagram of a two-level inverter [3]-[5],[7], whose voltage vectors involve higher levels. The shifting of subhexagon11 in the space vector diagram of multilevel inverter towards zero vectors 000 involves

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the mapping of the sectors of sub hexagon II to the sectors of the inner sub hexagon. This is done by subtracting the vector at the center of subhexagonII from its other vectors .Consider voltage space vectors 000, 001, 101, and 111 associated with sector 5 of inner sub hexagon and voltage space vector 010 which is the vector at sub hexagonal. Adding 010 to the voltage space vector associated with sector5 of the inner sub hexagon gives the vectors 010 (000+010), 011(001+010), 111(101+010) which are the vectors associated with sector 5 of sub hexagon II. The mapping of the inner sub hexagon to any other sub hexagon is used to generate the vectors associated with any sector in the space vector diagram of the three-level inverter.

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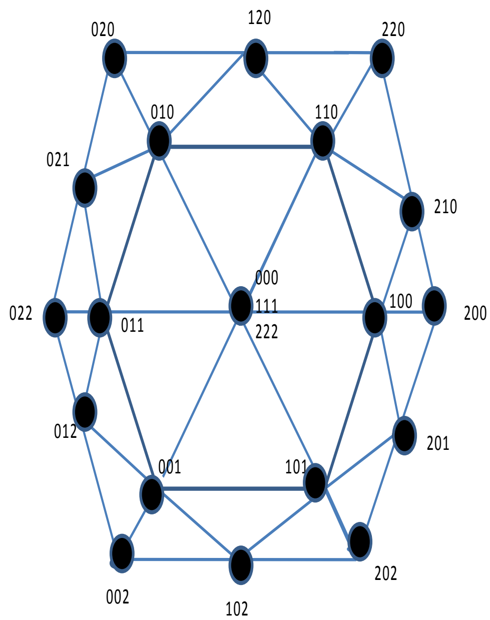

Fig. 1. Space vector diagram of Three-level inverter

Fig. 2 shows the instantaneous space vector OT. The tip of the reference space vector OT lies in the sector I of the sub hexagon II which contains the tip of the reference space vector. The vector 110 at the center of the sub hexagon III which contain the tip of the reference space vector. The vectors 000,100, and110 are associated with sector I of the inner sub hexagon. Subtracting the center of the sub hexagon II to the inner sub hexagon, by adding these vectors with the vector located at the center of the sub hexagon, the actual switching vectors 220,210,200 for the reference space vector can be generated

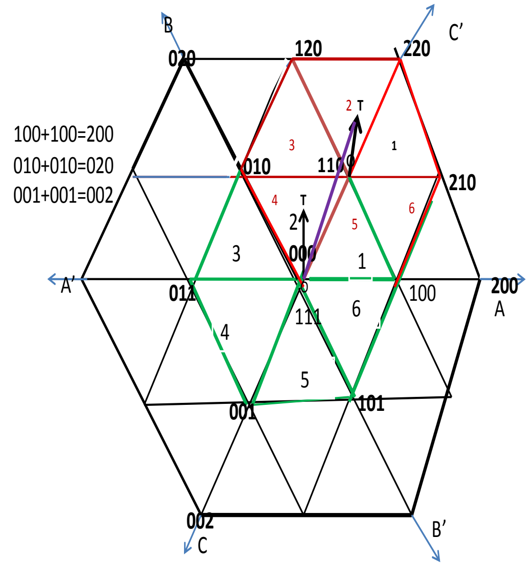

Fig.2. Generating switching vectors through reverse mapping

III. Identifying The Center Of Subhexagon

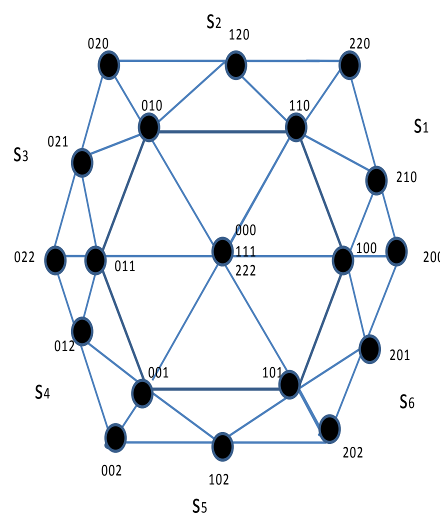

Fig. 3.: Layers in the space vector diagram of three-level inverter

Fig.3.also shows the six 60◦ regions S_1, S_2, S_3, S_4, S_5, and S_6.In this paper, these candidate vectors are automatically generated from the vectors of the inner subhexagon, and the candidate vector which is closest to the tip of the reference space vector is chosen as the center of the sub hexagon.

A.Identifying the layer of operation

The instantaneous reference space vector can be resolved into the axes, ja, jb, and jc. Where va,vb, and vc are the instantaneous amplitudes of the three reference phase voltages

$$Vja=\sqrt{3}/2(Va-Vc) \quad (1)$$

$$Vjb=\sqrt{3}/2(Vb-Va) \quad (2)$$

$$Vjc=\sqrt{3}/2(Vc-Vb) \quad (3)$$

Let **V**jmax be the maximum magnitude among the three resolved components. It may be noted that the width of each layer in the case of an *n*-level inverter is ($(\sqrt{3}/2)$ (V_{dc}/(n-1)). Therefore, the layer number can be easily obtained as in Fig.4

$$m=1+int(Vjmax/(\sqrt{3}/2Vdc/(n-1))) \quad (4)$$

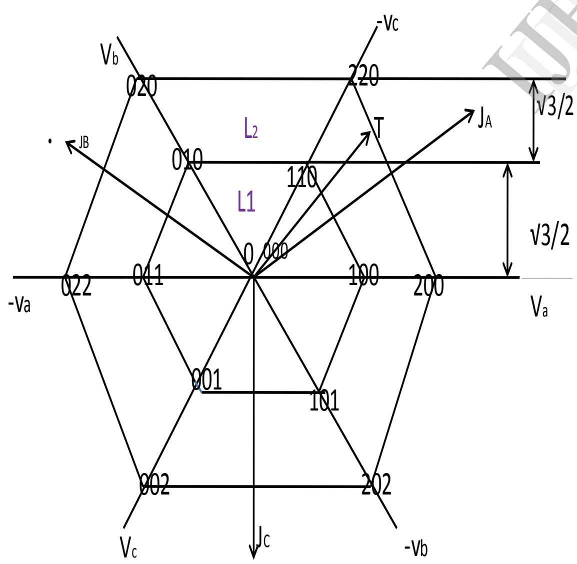

Fig.4. ja,jb and jc axis and width of each layer for three-level inverter

B.Generating Candidate Vectors for the Sub hexagon Center

Let the vectors on the inner side of layer 2 for any 60◦ region be (a1, b1, c1) and (a2, b2, c2) and the end vectors on the inner side of layer m be (am1, bm1, cm1) and (am2, bm2, cm2). Then, the end vectors on the inner side of layer m can be generated as

$$(a_{m1}, b_{m1}, c_{m1}) = (m-1) \times (a_1, b_1, c_1)$$

$$(a_{m2}, b_{m2}, c_{m2}) = (m-1) \times (a_2, b_2, c_2) \quad (5)$$

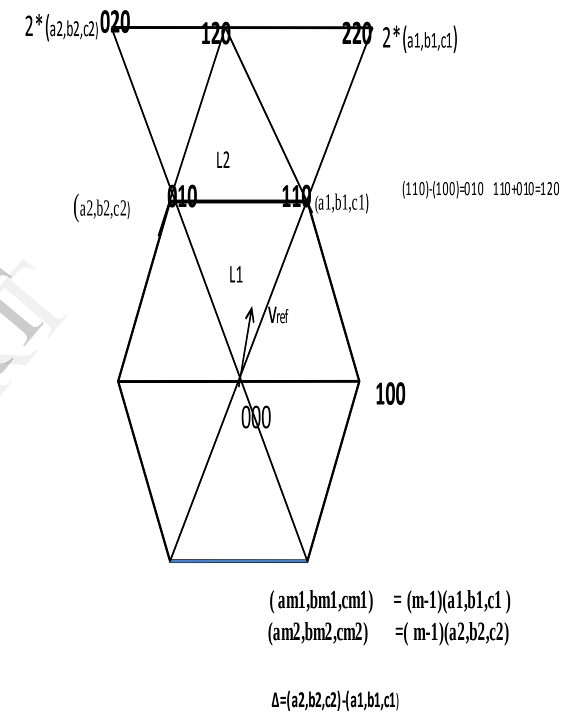

Fig.5. : Generating candidate vectors for the center of the sub hexagon

If (a_0, b_0, c_0) is the instantaneous switching vector corresponding to the two-level inverter and (a_c, b_c, c_c) is the vector at the center of the sub hexagon, then the actual switching vector of the multilevel inverter is explained in Fig 6

$$(a_m, b_m, c_m) =(a_0, b_0, c_0) +(a_c, b_c, c_c) \quad (6)$$

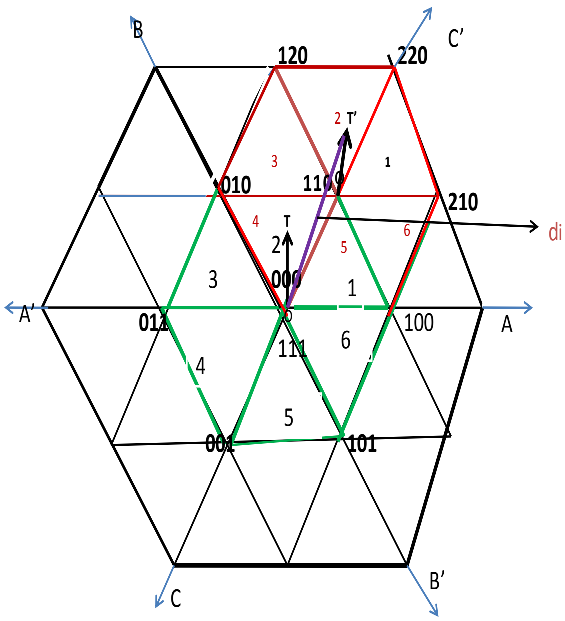

Fig 6: reverse mapping

IV.Control Of Induction Motor

The speed control of the induction motor has evolved over the years from the simple stator voltage control where in the stator voltage is varied to achieve a small speed range. How ever the stator voltage control is very inefficient as the flux decrease with decrease in voltage. The generated torque is the product of the flux and the stator current. If the flux decreases with reduction in stator voltage, the generated torque reduces. Next in the evolution of the induction motor control is the flux control. Depending on the type of the flux control , where based on the steady-state flux control, the scalar(v/f) control and the vector control strategies has evolved.

V.Results And Discussion

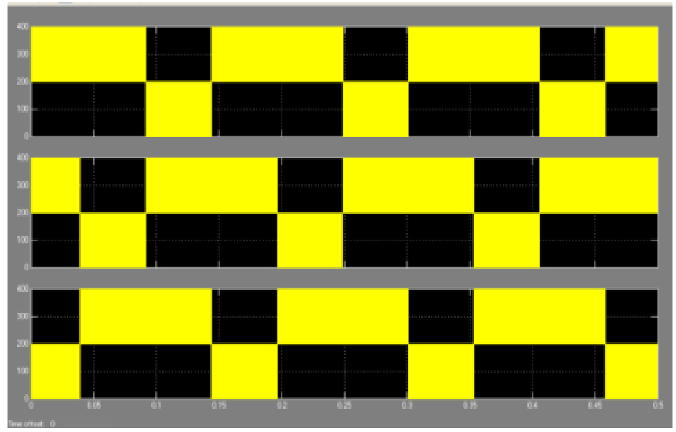

Fig 7: Pole voltage waveforms of three level inverter

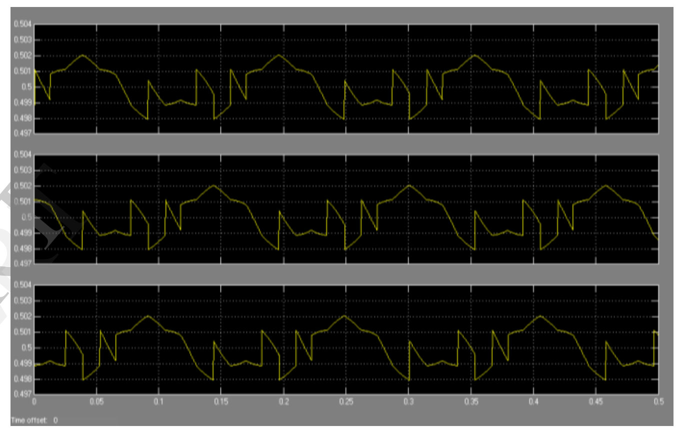

Fig. 8: Instantaneous duty ratio three level inverter for modulation index .5

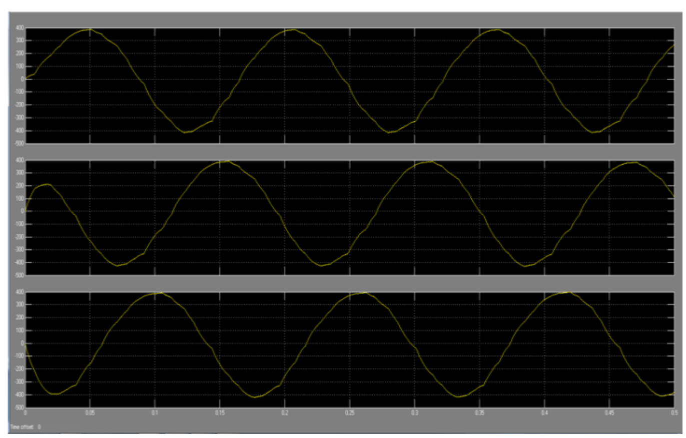

Fig 9: Three phase current Va,Vb,Vc

Fig 9. Shows the three phase voltages obtained by the application of current control scheme.

CONCLUSION

The work brings out direct and simple approach to generate space vector PWM (SVPWM) for multilevel inverter. The switching vectors and switching sequence are automatically generated by the principle of mapping. The vector at the center of the sub hexagon containing reference space vector was directly identified, The reference space vector is mapped to the innermost sub hexagon and switching vectors for the two level inverters are generated. The two level inverter vectors are translated to multilevel inverter vectors by the principle of reverse mapping. The algorithm does not require any lookup table nor any complex mapping technique to generate a SVPWM. The algorithm can be extended to any general multilevel inverter without any complexity. The algorithm has been simulated in a MATLAB/SIMULINK for three-level, and validate the performance of the algorithm driven under load condition. Current wave form of the given load condition is presented here.

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