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An Optimized Code for Space Vector PWM for A Two Level Voltage Source Inverter

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Abstract*—a Space Vector Pulse Width Modulation Method (SVPWM) is an advanced intense computational modulation method with several advantages such as less harmonic content relative to other PWM modulations, effective utilization of dc bus, and complete digital implementation by a single chip microprocessor. Due to the advantages SVM has increasing applications in power converters and motor control. 2-level inverter is the first model developed using this technique. In this paper, we implement SVPWM technique for 2-level inverters in the simplest way possible and optimized memory usage by processor using programmable pulse generator.

***Index Terms*— Programmable Pulse Generator, SIMULINK, SVPWM, Two-level inverter**

I. INTRODUCTION

Conventionally in general Space vector Pulse Width Modulation Technique is implemented using look up tables by processor to retrieve the data and process to generate gate signals for gate switching which is tedious for the processor as it require considerably high amount of memory. And even in few situations the data saved is not at all useful to compute or process in order to generate gate signal. This burden on processor may lead to ineffective performance by the system. As such if the burden on processor is minimized the performance can be improved yielding high reliability. In this paper the processor instead of retrieving data from look up tables for processing SVPWM algorithm, a code is designed which helps processor from using excessive memory.

In this paper the code that provides a unique functional block called programmable pulse generator helps processor generate waveforms of specified pulse width in specified period with specified delay without the necessity of lookup tables.

II. PRINCIPLES OF SVPWM

Space vector modulation (SVM) is one of the preferred real-time modulation techniques and is widely used for voltage source inverters

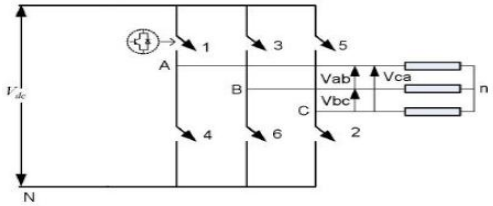

Fig 1 Circuit Diagram for 2-Level Inverter

The operating status of the switches in the two-level inverter in Fig 1 can be represented by switching states.

Space Vector		Switching State (Three Phases)	On-State Switch	Vector Definition
Zero Vector	$\vec{V}_0$	[1 1 1]	S1, S3, S5	0
		[0 0 0]	S4, S6, S2	
Active Vector	$\vec{V}_1$	[1 0 0]	S1, S6, S2	$\vec{V}_1 = \frac{2}{3} Vd\ e^{j0}$
	$\vec{V}_2$	[1 1 0]	S1, S3, S2	$\vec{V}_1 = \frac{2}{3} Vd\ e^{j\frac{\pi}{3}}$
	$\vec{V}_3$	[0 1 0]	S4, S3, S2	$\vec{V}_1 = \frac{2}{3} Vd\ e^{j\frac{2\pi}{3}}$
	$\vec{V}_4$	[0 1 1]	S4, S3 ,S5	$\vec{V}_1 = \frac{2}{3} Vd\ e^{j\frac{3\pi}{3}}$
	$\vec{V}_5$	[0 0 1]	S4, S6, S5	$\vec{V}_1 = \frac{2}{3} Vd\ e^{j\frac{4\pi}{3}}$
	$\vec{V}_6$	[1 0 1]	S1, S6, S5	$\vec{V}_1 = \frac{2}{3} Vd\ e^{j\frac{5\pi}{3}}$

Table 1: Switching States of SVPWM

As indicated in Table 1, switching state '1' denotes that the upper switch in an inverter leg is on and the inverter terminal voltage (V_{an}, V_{bn}, V_{cn}) is positive ($+V_d$) while '0' indicates that the inverter terminal voltage is zero due to the conduction of the lower switch. There are eight possible combinations of switching states in the two-level inverter as listed in Table 1. The switching state [100], for example, corresponds to the conduction of *S*1, *S*6, and *S*2 in the inverter legs *A*, *B*, and *C*, respectively. Among the eight switching states, [111] and [000] are zero states and the others are active states.

Space vector concept

The concept of space vectors is derived from the rotating field of AC modulating the inverter output voltage. In this modulation technique the three phase quantities can be transformed to their equivalent 2-phase quantity either in synchronously rotating frame or stationary frame. From this 2-phase component the reference vector magnitude can be found and used for modulating the inverter output.

The active and zero switching states can be represented by active and zero space vectors, respectively. A typical space vector diagram for the two-level inverter is shown in Fig. 2, where the six active vectors V1toV6 form a regular hexagon with six equal sectors (I to VI). The zero vector V0 lies on the center of the hexagon.

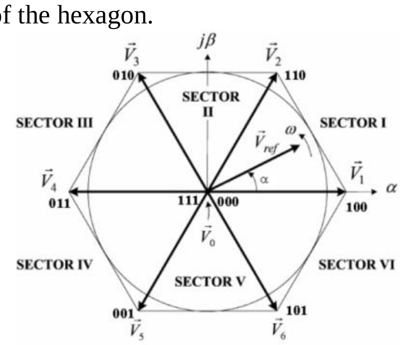

Fig 2 Space Vector Diagram For A Two Level Inverter

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In order to obtain the output of inverter supported by SVPWM as sinusoidal the reference vector locus with respect to time should be a circle instead of hexagon as locus of the vector sum of three voltages gives a circle. To achieve the above scenario, the vector in each sector is sampled for a specific duration using active and zero vectors and hence we can obtain required vector of corresponding instant. The sampling duration for active and zero vectors to realize the vector at corresponding instant can be obtained using volt second balance equation. Fig 3 shows timing diagrams or switching pattern for sector I.

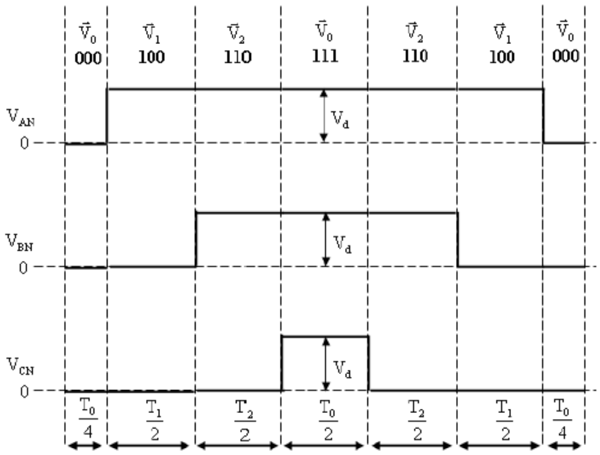

Fig. Svpwm Switching Patterns For Sector-1

The switching pattern for remaining vectors is determined similarly.

III. SIMULATIONS USING PROGRAMMABLE PULSE GENERATOR

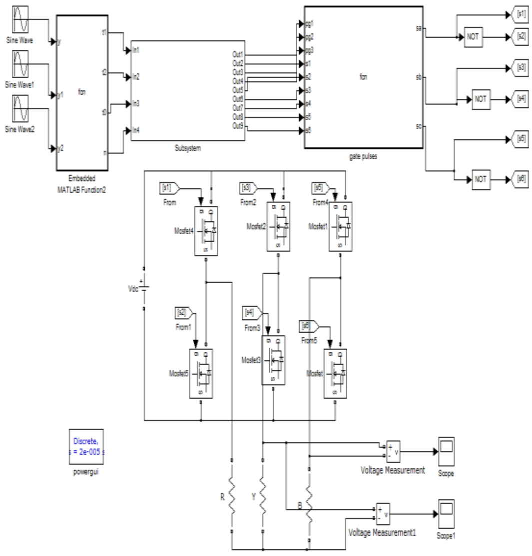

Fig 3 Circuit diagram for MATLAB 2-level SVM

Program for T_0, T_1, T_2 calculation: (written in embedded matlab function block)

```
function [t1,t2, t0, n] = fcn(y, y1, y2)
y3= (3/2)*y;
y4= (sqrt(3)/2)*(y1-y2);
th= 0;
if y3>0&&y4>0
 th= atan(y4/y3);
 end
if y3<0&&y4<0
th= pi+atan(y4/y3);
end
if y3<0&&y4>0
   th= pi+atan(y4/y3);
end
if y3>0&&y4<0
   th=(2*pi)+atan(y4/y3);
end
n=fix((th*3)/pi);
vd=2.5;
ts=1/(63*50);
vr=sqrt((y3)^2+(y4)^2);
alpha=(th-(n*(pi/3)));
t1=ts*vr/vd*2/sqrt(3)*sin((pi/3)-alpha);
t2=ts*vr/vd*2/sqrt(3)*sin(alpha);
t0=ts-(t1+t2);
```

Program for sector determination:

```
 function [s1,s2,s3,s4,s5,s6] = fcn(n)
if n==0
   s1=1;
else s1=0;
end
if n==1
   s2=1;
   else s2=0;
end
if n==2
   s3=1;
   else s3=0;
end
if n==3
   s4=1;
else s4=0;
end
if n==4
   s5=1;
else s5=0;
end
if n==5
   s6=1;
else s6=0;
end
```

In sub system there is a functional block (programmable pulse generator) which can provide waveform of specified pulse width in specified period with specified delay.

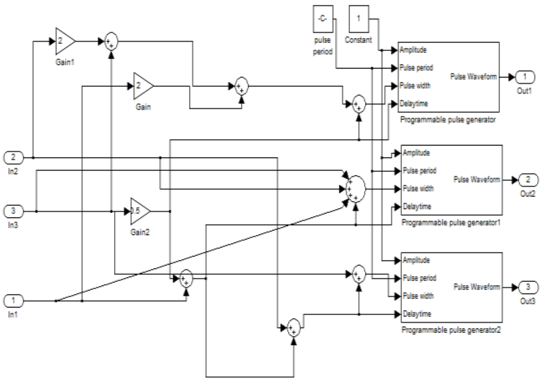

Fig 4 Circuit for wave form generation: (sub system)

Program for sector change over: (output of subsystem is given to matlab function as input)

```
function [sa, sb, sc] = fcn(pg1, pg2, pg3, s1, s2, s3, s4, s5, s6)
 sa=0;
 sb=0;
 sc=0;
 if s1==1
    sa=pg1;
    sb=pg2;
    sc=pg3;
 end
  if s2==1
    sa=pg2;
    sb=pg1;
    sc=pg3;
  end
 if s3==1
    sa=pg3;
    sb=pg1;
    sc=pg2;
 end
 if s4==1
    sa=pg3;
    sb=pg2;
    sc=pg1;
 end
 if s5==1
    sa=pg2;
    sb=pg3;
    sc=pg1;
 end
 if s6==1
    sa=pg1;
    sb=pg3;
    sc=pg2;
 end
```

IV. RESULTS

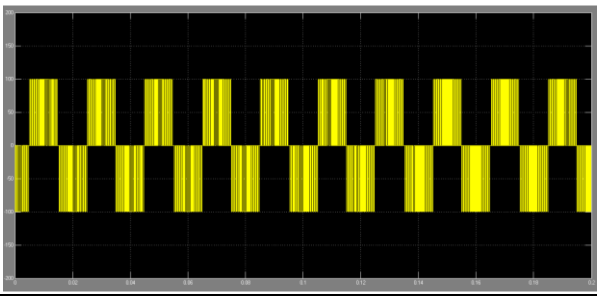

Fig 5 Response of output line-line voltage

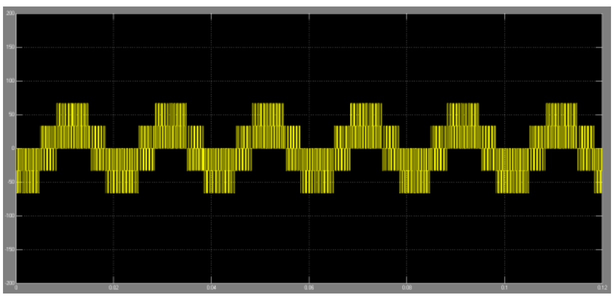

Fig 6 Mat lab circuit Response for output Phase voltage

Harmonic profile of output:

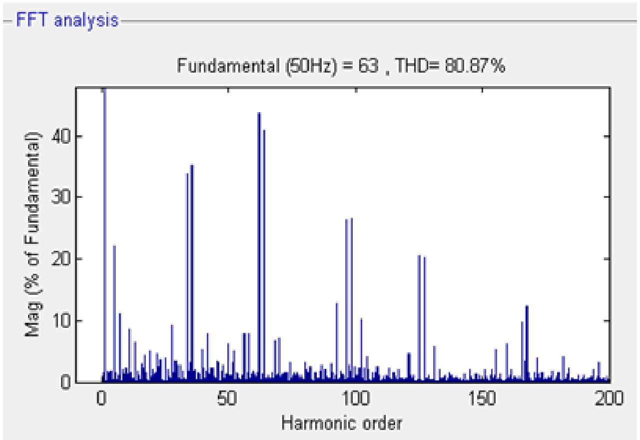

Fig 7 FFT analysis of output

V. CONCLUSION

Without using lookup tables implementation of SVPWM can be achieved and hence effective memory management of the controller is obtained.

REFERENCES

1. Simulation and implementation of 2-level & 3-level inverters by Mat lab By "ABD ALMULA G.M. GEREEL"
2. A Novel Voltage Modulation Technique of the Space Vector PWM By "JOOHN-SHEOK KIM & SEUNG-KI SUL"
3. Programmable Laboratory Inverter And Space Vector PWM By "ING PAVEL GAJDUSEK"
4. A PWM Scheme for a 3-level inverter cascading two 2-level inverters By "V.T SOMASEKHAR, GOPAKUMAR, M.R.BAUU, K.K MOHAPATRA & L.UMANAND"
5. Space Vector Pulse Width Modulation of 3-level Inverter Extending Operation Into Over modulated Region By " SUBRATA K.MONDAL,BIMAL K.BOSE,VALENTIN OLESCHUK "
6. Power electronics By "P.S BIMBRA" Power electronics By" RASHID