# Simulation of Three Phase Svpwm & Spwm Inverters Using Simulink

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***Abstract***- *The most widely Used PWM schemes for three-phase voltage source inverters are sinusoidal PWM and space vector PWM. There is an increasing trend of using space vector PWM because of their easier digital realization and Better dc bus utilization. A new technique called the Space Vector Modulation (SVM) is an alternative method to the conventional, sinusoidal PWM for control of high power converters. Sinusoidal pulse width modulation (SPWM) and space vector pulse width modulation (SVPWM) are the most popular modulation strategies for Multi level inverters. This paper provides the theoretical analysis and simulation results of Three level SPWM inverter and SVPWM for Two level and three level inverter. Also this paper gives comparison between three level SVPWM & two level SVPWM & also gives comparison between three level SVPWM & SPWM inverter. This paper concludes that SVPWM can produce about 15% higher output voltage and also it utilizes DC bus voltage more efficiently and generates less harmonic distortion when compared with SPWM technique.*

***Keywords***- SVPWM THREE & TWO LEVEL, SPWM THREE LEVEL, THD, NPC.

## I. INTRODUCTION

Three phase voltage-fed PWM inverters are recently growing popularity for multi-Megawatt industrial drive applications. The main reasons for this popularity are easy Sharing of large voltage between the series devices and the improvement of the harmonic quality at the output as compared to a two level inverter. Multilevel inverters are used in high voltage and high power applications with less harmonic contents. Multilevel inverters are recognized due to the limitation of the two level inverters. To control multilevel converters, various pulse width modulation (PWM) techniques are used; SPWM and SVPWM techniques are widely used. In Sinusoidal Pulse width modulation (SPWM) we generate the gating signals by comparing sinusoidal reference signal with a triangular carrier wave. SVPWM technique was originally developed as a vector approach to PWM for three phase inverters. It is an advanced and computation method and it is quite different from reaming methods. SPWM inverter output voltage maintains good performance of the drive in the entire range of operation between zero and 78 % of the value that would reached by square wave operation with less control on each switching instant and produces lager THD. The Space Vector PWM of a three level inverter provides the additional advantage of superior harmonic quality. Increasing the number of voltage levels in the inverter without requiring higher ratings on individual devices can increase the power rating. As the number of voltage levels increases, the harmonic content of the output voltage waveform decreases significantly. As the number of levels is increased, the amount of switching devices and other component are also increased, making the inverter becoming more complex and costly .In case of the conventional two level inverter configurations, the harmonic contains reduction of an inverter output is achieved mainly by raising the switching frequency. However in the field of high voltage, high power applications, and the switching frequency of the power device has to be restricted below 1 KHz due to the increased switching losses. So the harmonic reduction by raised switching frequency of a two-level inverter becomes more difficult in high power applications.

## II. THEORETICAL ANALYSIS OF SINUSOIDAL PULSE WIDTH MODULATION

In this method of modulation, several pulses per half cycle are used as in the case of multiple pulse width modulation. Instead of maintaining the width of all pulses the same as in the case of multiple pulse width modulation, the width of each pulse is varied proportional to the amplitude of a sine wave evaluated at the center of the same pulse. By comparing a sinusoidal reference signal with a triangular carrier wave of frequency Fc, gating signals are generated. The frequency of reference signal, Fr, determines the inverter output frequency Fo and its peak amplitude Er, controls the modulation index M and then in turn the RMS output voltage. SPWM technique has been extensively used, because it improves the harmonic spectrum of the inverter by moving the harmonic components to higher frequencies. Inverter output voltage has the following features by using SPWM technique

1) PWM frequency is same as the frequency of trigging voltage Vtri.

2) Amplitude is controlled by the peak value of control voltage Vcntr.
3) Fundamental frequency is controlled by the frequency of control voltage Vcntr.The generation of gating signals with sinusoidal PWM is shown in below figure. There are three sinusoidal reference waves (Vra, Vrb, and Vrc) each shifted by 1200 .A carrier wave is compared with the reference signal corresponding to a phase to generate the gating signals for that phase. Comparing the carrier signal Vcr with the reference phases Vra, Vrb, and Vrc produces g1,g3 and g5.the instantaneous line to line output voltages is Vab = Vs(g1-g3). The output voltage as shown in below figure(1) is generated by eliminating the condition that the two switching devices in the same arm cannot conduct at the same time.

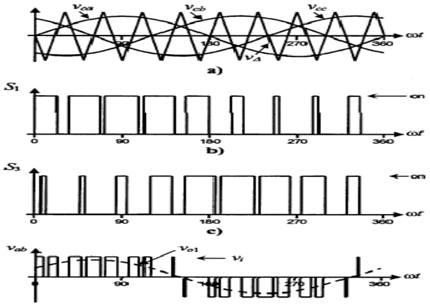


Figure 1. waveforms of SPWM

## III. THEORETICAL ANALYSIS OF TWO LEVEL SVPWM INVERTER

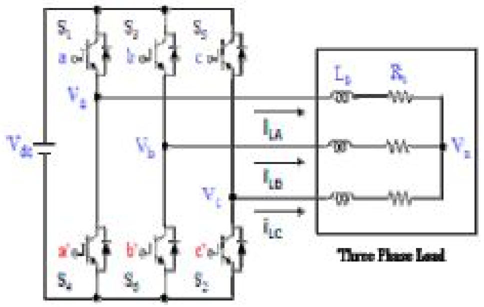


Figure 2. block diagram of three phase two level inverter

The circuit model of a typical three-phase two level voltage source PWM inverter is shown in “Figure.2”. S1 to S6 are the six power switches that shape the output, which are controlled by the switching variable a, a’, b, b’, c and c’. When an upper transistor is switched on, i.e., when a, b or c is 1, the corresponding lower transistor is switched on, i.e., the corresponding a’, b’ or c’ is zero .Therefore, the on and off states of the transistors can be used to determine the output voltage. In this PWM technique1800 conduction is used for generating the gating signals. If two switches, one upper and one lower switch conduct at the same time such that the output voltage is ± Vs. the switch state is 1.If these two switches are off at the same time, the switch state is 0.

## SPACE VECTOR PWM TWO LEVEL INVERTER ALGORITHM

- No of switching states & selection of switching states.
- No of space vectors.
- Determination of location of space vectors.
- Sector identification.
- Calculation of active vectors switching time periods.
- Generation of gating signals for the individual power devices.
- Determination of switching sequence for the individual sectors.

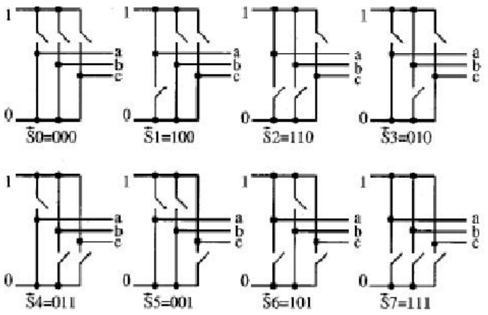


Figure 3. Switching states of two level inverter

Table 1. Functioning of switches

| STATE | ON | OFF |
|---|---|---|
| 0 | S4,S6,S2 | S1,S3,S5 |
| 1 | S1,S2,S6 | S4,S5,S3 |
| 2 | S2,S3,S1 | S5,S6,S4 |
| 3 | S3,S4,S2 | S6,S1,S5 |
| 4 | S4,S5,S3 | S1,S2,S6 |
| 5 | S5,S6,S4 | S2,S3,S1 |
| 6 | S6,S1,S5 | S3,S4,S2 |
| 7 | S1,S3,S5 | S4,S6,S2 |

## SPACE VECTOR DIAGRAM OF TWO-LEVEL INVERTER

Space vector diagram is divided into six sectors. The duration of each sector is 600. V1, V2, V3, V4, V5, V6 are active voltage vectors and V0 & V7 are zero voltage vectors. Zero vectors are placed at origin. The lengths of vectors V1 to V6 are unity and lengths of V0 and V7 are zero.

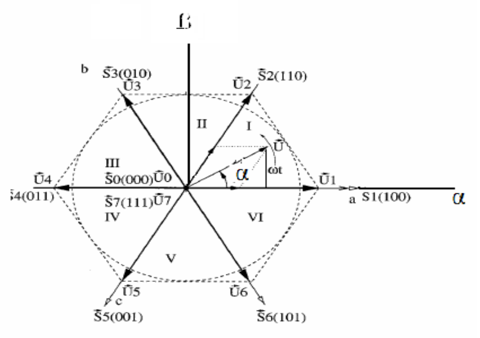


Figure 4. Space vector diagram of two level inverter

The space vector Vs constituted by the pole voltage Vao, Vbo, and Vco is defined as [4]

Vs = Vao + Vbo e j (2π/3) + Vco e j (4 Π/3)
Vao=Van + Vno , Vbo=Vbn + Vno and Vco=Vcn+ Vno
Van+Vbn+Vcn=0
Vno= (Vao+Vbo+Vco) /3
Vab = Vao – Vbo , Vbc = Vbo – Vco , Vca = Vco – Vao
FOR example voltage vector V1 that is 100
Vao=Vdc, Vbo=0and Vco=0, then Vn= (Vdc+0+0)/3=Vdc/3)
Van=Vao-Vno = (2/3) Vdc, Vbn=Vbo-Vno= (-1/3) Vdc,
Vcn=Vco-Vno= (-1/3) Vdc
Vab=Vao-Vbo=Vdc , Vbc=Vbo-Vco=0
Vca=Vco-Vao=-Vdc

## SPACE VECTOR TRANSFORMATION

Let the three phase voltage component be
V a = Vm cos wt
V b = Vm cos (wt-2π/3)
V c = Vm cos (wt-4π/3)

In this modulation technique three phase quantities can be transformed to their equivalent 2-phase quantity. From this 2-phase component the reference vector magnitude can be found and used for modulating the inverter output.To implement the space vector PWM, the voltage equations in the abc reference frame Can be transformed into the α β reference frame that consists of the horizontal (α) and Vertical (β) axes as depicted in below Fig 3.10

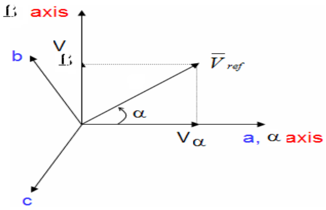


Figure 5. The relationship between ABC reference frame and α β reference frame

Along α axis
V α=V a cos 0 +Vb cos 120 +VC cos 240
V α =V a +V b cos (180-60) +VC cos (180+60)
V α =V a -V b cos60 -VC cos 60
V α =Va-1/2Vb-1/2Vc

Along β axis
V β = V a cos 90+Vb cos 30 +VC cos 150
V β = 0 + V b cos 30 + VC cos (180-30)
V β = 0 + V b cos 30 - VC cos 30
V β =√3/2 V b - √3/2 VC

$$\begin{bmatrix} V\alpha \\ V_\beta \end{bmatrix} = \frac{2}{3}\begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix}\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}$$

2/3 is a scaling factor.
V α = 2/3 (Va – 1/2 Vb – 1/2 Vc)
V β =1/√3 V b – 1/√3 VC

Table 2 switching vectors, phase voltages and output line to line voltages

| Voltage Vectors | Switching Vectors | | | Line to neutral voltage | | | Line to line voltage | | |
|---|---|---|---|---|---|---|---|---|---|
| | a | b | c | $V_{an}$ | $V_{bn}$ | $V_{cn}$ | $V_{ab}$ | $V_{bc}$ | $V_{ca}$ |
| $V_0$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| $V_1$ | 1 | 0 | 0 | 2/3 | -1/3 | -1/3 | 1 | 0 | -1 |
| $V_2$ | 1 | 1 | 0 | 1/3 | 1/3 | -2/3 | 0 | 1 | -1 |
| $V_3$ | 0 | 1 | 0 | -1/3 | 2/3 | -1/3 | -1 | 1 | 0 |
| $V_4$ | 0 | 1 | 1 | -2/3 | 1/3 | 1/3 | -1 | 0 | 1 |
| $V_5$ | 0 | 0 | 1 | -1/3 | -1/3 | 2/3 | 0 | -1 | 1 |
| $V_6$ | 1 | 0 | 1 | 1/3 | -2/3 | 1/3 | 1 | -1 | 0 |
| $V_7$ | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

## CALCULATION OF ACTIVE VECTOR SWITCHINGTIME PERODS

In a two level inverter, on time calculation is based on the location of reference vector with in a sector.In one sampling interval, the output voltage vector V can be written as

V=T0/TS + V0 +T1 /TS V1 +-----+T7 /TS V7

The Output voltage Vector V is split into the two nearest adjacent voltage vectors and zero vectors.

For example for Sector 1
V=T0/TS*V0+T1/TS*V1+T2/TS*V2+T7/TS*V7 (1)
Lengths of vectors V0 & V7 are zero.

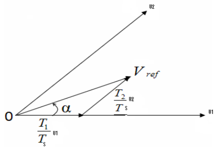


Figure 6. Reference vector as a combination of adjacent vectors at sector 1

Along the α axis

V = V ref cos α
V1 = V dc cos 0 & V2 = V dc cos 60
Along the β axis
V = V ref sin α
V1 = V dc cos 90 & V2 = V dc cos (90-60) = V dc sin 60

V ref cos α = V dc ××T1/Ts + (V dc cos 60) *T2 / TS - (2)
V ref sin α = (V dc sin60) × T2 / TS - (3)
T1 = (2/√3) (Ts/ Vdc) V ref sin (Π/3- α)
T2= (2/√3) (Ts/ Vdc) V ref sinα

## IV. THEROTICAL ANALYSIS OF THREE LEVEL SVPWM INVERTER

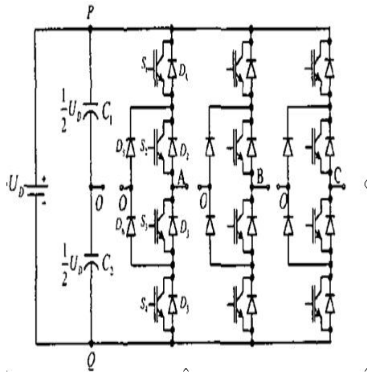


Figure 7. block diagram of three phase three level inverter

This figure shows the popular topology of diode – clamped three phase three level inverter and consists of a three level voltage inverter based on IGBTs. . The circuit employs 12 power switching devices and 6 clamping diodes. Each arm contains four IGBTs, four anti parallel diodes and two neutral clamping diodes. And the dc bus voltage is split into three levels by two series connected bulk capacitors C1, C2 two capacitors have been used to divide the DC link voltage into three voltage levels, thus the name of 3-level.The middle point of the two capacitors can be defined as the neutral point 0. As the result of diode clamped, the switch voltage is limited to half the level of the dc bus voltage Vdc/2.Thus , the voltage stress of switching device is greatly reduced. The output voltage Vao has three different states: Vdc/2, 0, - Vdc/2 .here takes phase A as an example.

For phase A, For voltage level +Vdc/2, switches S1 & S2 need to be turned on. For voltage level 0, switches S2 & S3 need to be turned on and voltage level -Vdc/2 switches S3 & S4 need to be turned on. We can define these states as 2 , 1, and 0.

## THE SWITCHING VARIABLE OF PHASE A

The switching states of the inverter are summarized in table 3.4, where “a” represents the output phase A. Using switching variable Sa and dc bus voltage Vdc, the output phase voltage Vao is obtained as follows:

Vao = (Sa-1)/2 × Vdc
For example Sa = 2
Vao = (2-1)/2 × Vdc
Vao = Vdc/2
Vab = Vao- Vbo = ½ × Vdc × (Sa-Sb)
Vbc = Vbo- Vco = ½ ×Vdc × (Sb-Sc)
Vca = Vco- Vao = ½ ×Vdc × (Sc-Sa)

Table 3. switching variable

| Vao | Sa1 | Sa2 | Sa3 | Sa4 | Sa |
|---|---|---|---|---|---|
| +Vdc/2 | 1 | 1 | 0 | 0 | 2 |
| 0 | 0 | 1 | 1 | 0 | 1 |
| -Vdc/2 | 0 | 0 | 1 | 1 | 0 |

## SPACE VECTOR PWM THREE LEVEL INVERTER ALGORITHM

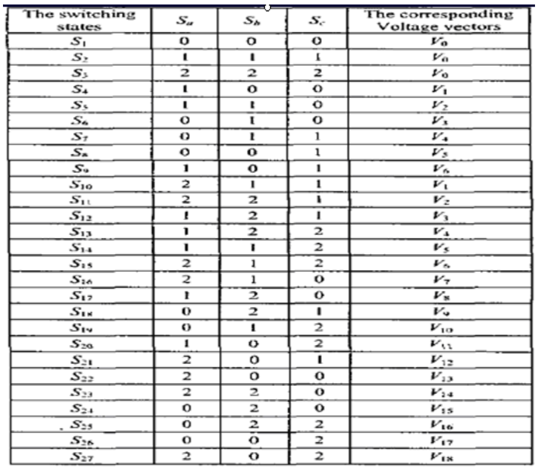
- No of switching states
- No of voltage vectors and corresponding voltages.
- Sector identification.
- Determining the region in the sector.
- Calculating the active vectors switching time periods.
- Generation of gating signals for the individual power 9idevices.
- Determination of switching sequence for the individual sectors.

## SWITCHING STATES

There are 27 (that is “33) switching states in diode clamped three level inverter.24 states are active states and 3 zero states. They correspond to 19 voltage vectors (V0 to V18) whose positions are fixed. These space voltage vectors can be classified into 4 groups: they are

1. large voltage vectors
2. medium voltage vectors
3. small voltage vectors
4. Zero voltage vector

Table 4. Switching states of three level inverter



| The switching states | $S_a$ | $S_b$ | $S_c$ | The corresponding Voltage vectors |
|---|---|---|---|---|
| $S_1$ | 0 | 0 | 0 | $V_0$ |
| $S_2$ | 1 | 1 | 1 | $V_0$ |
| $S_3$ | 2 | 2 | 2 | $V_0$ |
| $S_4$ | 1 | 0 | 0 | $V_1$ |
| $S_5$ | 1 | 1 | 0 | $V_2$ |
| $S_6$ | 0 | 1 | 0 | $V_3$ |
| $S_7$ | 0 | 1 | 1 | $V_4$ |
| $S_8$ | 0 | 0 | 1 | $V_5$ |
| $S_9$ | 1 | 0 | 1 | $V_6$ |
| $S_{10}$ | 2 | 1 | 1 | $V_1$ |
| $S_{11}$ | 2 | 2 | 1 | $V_2$ |
| $S_{12}$ | 1 | 2 | 1 | $V_3$ |
| $S_{13}$ | 1 | 2 | 2 | $V_4$ |
| $S_{14}$ | 1 | 1 | 2 | $V_5$ |
| $S_{15}$ | 2 | 1 | 2 | $V_6$ |
| $S_{16}$ | 2 | 1 | 0 | $V_7$ |
| $S_{17}$ | 1 | 2 | 0 | $V_8$ |
| $S_{18}$ | 0 | 2 | 1 | $V_9$ |
| $S_{19}$ | 0 | 1 | 2 | $V_{10}$ |
| $S_{20}$ | 1 | 0 | 2 | $V_{11}$ |
| $S_{21}$ | 2 | 0 | 1 | $V_{12}$ |
| $S_{22}$ | 2 | 0 | 0 | $V_{13}$ |
| $S_{23}$ | 2 | 2 | 0 | $V_{14}$ |
| $S_{24}$ | 0 | 2 | 0 | $V_{15}$ |
| $S_{25}$ | 0 | 2 | 2 | $V_{16}$ |
| $S_{26}$ | 0 | 0 | 2 | $V_{17}$ |
| $S_{27}$ | 2 | 0 | 2 | $V_{18}$ |

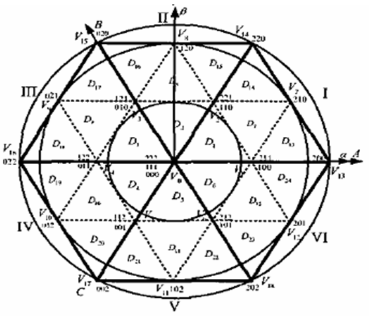


Figure 8. Space vector diagram of three level inverter

## DETERMINATION OF REGION IN A PARTICULAR SECTOR:

For example we are taking the space vector diagram of sector 1 for determining the particular region in a sector 1. In sector I contains 4 minor triangular sectors.D1, D7, D13 and D14 are 4 minor triangular sectors. If the triangular sector is defined by vector Vx, Vy, Vz, then V* can be synthesized by Vx, Vy, Vz. The duration of these vectors are Tx, Ty, and Tz.

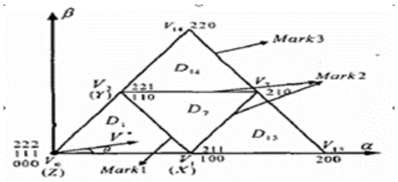


Figure 9. Selection of region of three level inverter

Vref = V* = Vx (Tx/ Ts) + Vy (Ty/ Ts) + Vz (Tz/ Ts)
Tx / Ts + Ty/ Ts + Tz/ Ts = 1
Tx / Ts = X, Ty/ Ts = Y, Tz/ Ts = Z
Tx + Ty + Tz = Ts & X + Y + Z = 1
Vx X + Vy Y + Vz Z = V*

Modulation ratio M = (V* / 2/3 Vdc) = (3 V* /2 Vdc)
We can suppose that the rotating voltage V* falls into sector I (0<θ<600). Note that there are 4 minor sectors, then X, Y, and Z can be calculated with the following four cases, respectively

A. When the modulation ratio M < Mark1, then the rotating voltage vector V* will be in sector D1 (Region
B. When the modulation ratio Mark1 < M < Mark2, then V* will be in sector D7 (Region 2).
C. When the modulation ratio Mark2 < M < Mark3 and 0 <θ < 30 deg, then V* will be in sector D1 (Region 3).
D. When the modulation ratio Mark2 < M < Mark3 and 30 <θ < 60 deg, then V* will be in sector D14 (Region 4).

## CALCULATION OF ACTIVE VECTOR SWITCHING TIME PERIOD

a) When the modulation ratio M < Mark1, then the IIrotating voltage vector V* will be in sector D1 (Region 1).

$$\begin{cases} X = 2m \cdot \left[ \cos(\theta) - \dfrac{\sin(\theta)}{\sqrt{3}} \right] \\ Y = m \cdot \dfrac{4\sin(\theta)}{\sqrt{3}} \\ Z = 1 - 2m \cdot \left[ \cos(\theta) + \dfrac{\sin(\theta)}{\sqrt{3}} \right] \end{cases}$$

b) Similarly when the modulation ratio Mark1<M< Mark2, then V* will be in sector D7 (Region 2). V* can be synthesized by V1, V2, and V7.

$$\begin{cases} X = 1 - m \cdot \dfrac{4\sin(\theta)}{\sqrt{3}} \\ Y = 1 - 2m \cdot \left[ \cos(\theta) - \dfrac{\sin(\theta)}{\sqrt{3}} \right] \\ Z = -1 + 2m \cdot \left[ \cos(\theta) + \dfrac{\sin(\theta)}{\sqrt{3}} \right] \end{cases}$$

c) When the modulation ratio Mark2 < M < Mark3 and 0 <θ < 30 deg, then V* will be in sector D13 (Region 3). V1, V13 and V7 are selected to synthesize V*.

$$\begin{cases} X = -1 + 2m \cdot \left[ \cos(\theta) - \dfrac{\sin(\theta)}{\sqrt{3}} \right] \\ Y = m \cdot \dfrac{4\sin(\theta)}{\sqrt{3}} \\ Z = 2 - 2m \cdot \left[ \cos(\theta) + \dfrac{\sin(\theta)}{\sqrt{3}} \right] \end{cases}$$

d) When the modulation ratio Mark2 < M < Mark3 and 0 <θ < 30 deg, then V* will be in sector D13 (Region 3). V2, V7 and V14 are selected to synthesize V*.

$$\begin{cases} X = 2m \cdot \left[ \cos(\theta) - \dfrac{\sin(\theta)}{\sqrt{3}} \right] \\ Y = -1 + m \cdot \dfrac{4\sin(\theta)}{\sqrt{3}} \\ Z = 2 - 2m \cdot \left[ \cos(\theta) + \dfrac{\sin(\theta)}{\sqrt{3}} \right] \end{cases}$$

When the reference vector falls into the other major sectors, similar arguments can be applied. Suppose that the reference vector falls into II major sector, replacing θ by θ-600.Reference vector falls into III major sector, replacing θ by θ-120.Reference vector falls into IV major sector, replacing θ by θ-1800.Reference vector falls into V major sector, replacing θ by θ-240.Reference vector falls into VI major sector, replacing θ by θ-3000.

## V. SIMULATION STEPS FOR TWO LEVEL SVPWM INVERTER

1) Initialize simulation parameters using Mat lab
2) Build Simulink Model

- Simulink model of SVPWM control block.
- Generating three phase voltages.
- 3-phase to 2-phase transformation.
- Finding space vector angle & Determine sector.
- Determine time duration T1, T2, T0.
- Determine the switching time (Ta, Tb, and Tc) of each transistor (S1 to S6)
- Generate the triggering pulses.
- Send data to Workspace & .Plot simulation results using Mat lab

## SIMULINK MODEL OF TWOLEVEL SVPWM INVERTER

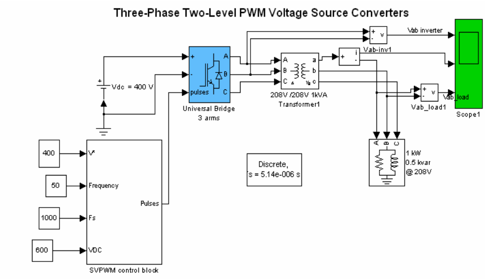


Figure 10. SIimulink model of three phase two level SVPWM inverter

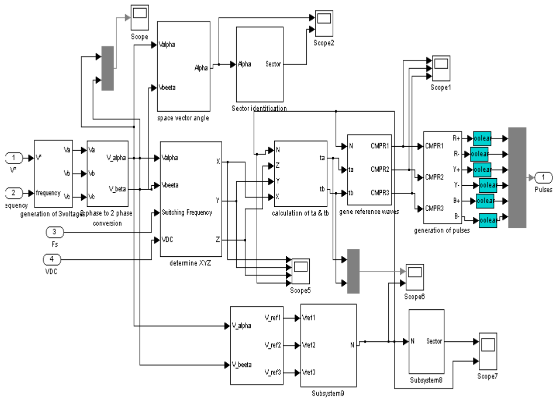


Figure 11. Internal diagram of two level SVPWM control block

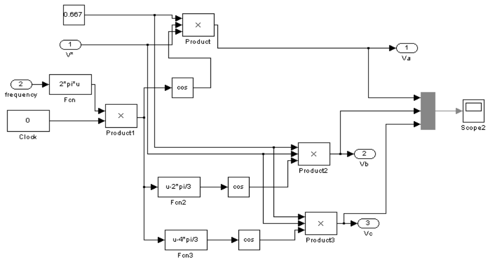


Figure 12. Representations of three phase voltages

This block generates balanced three phase voltages by using input voltage V* and fundamental frequency F. For simulation of the theoretical studies, Vref was determined by a system of balanced three phase voltages given by

Va = 2/3 V* cos t = 0.667 V* cos t

Vb = 2/3 V* cos ( t-2pi/3) = 0.667 V* cos ( t-2pi/3)

Vc = 2/3 V* cos ( t-4pi/3) = 0.667 V* cos ( t-4pi/3)

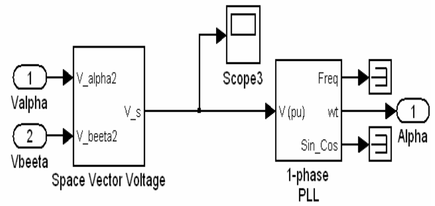


Figure 13. representation of space vector angle

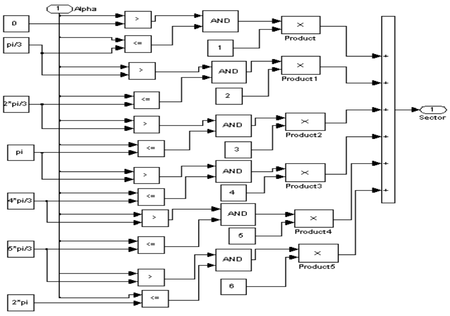


Figure 14. representation of particular sector

## VI. SIMULINK MODEL OF THREE LEVEL SVPWM INVERTER

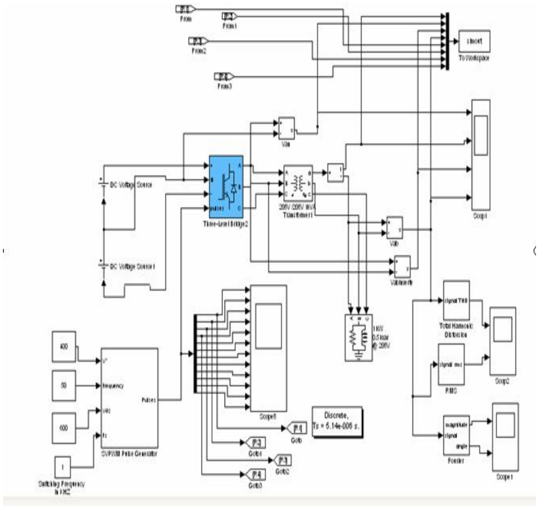


Figure 15. simulink model of three phase three level svpwm inverter

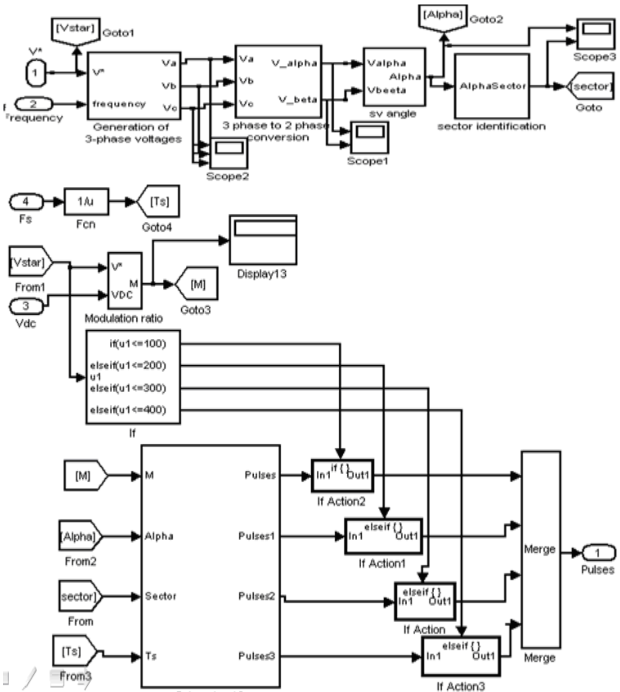


Figure 16. representation of internal diagram of SVPWM control block

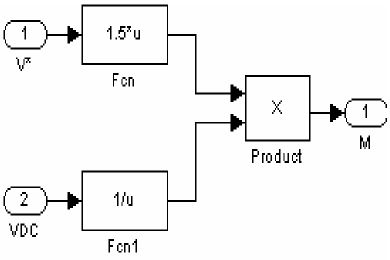


Figure 17. modulation ratio

## VII. SIMULATION STEPS FOR THREE LEVEL SPWM INVERTER

1. Initialize simulation parameters using Mat lab
2. Build Simulink Model

- Simulink model of SPWM control block.
- Generating three phase voltages.
- Generate the triggering pulses.

3. Plot simulation results using Mat lab

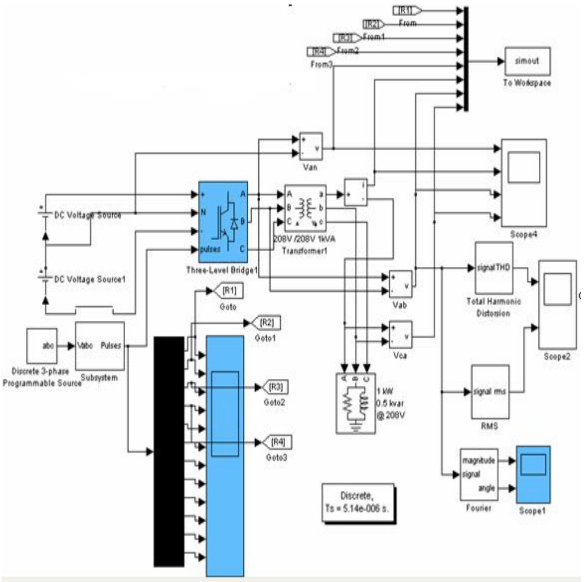


Figure 18. simulink model of three phase three level SPWM inverter

## VIII. SIMULATION RESULTS OF THREE PHASE TWO-LEVEL SVPWM INVERTER

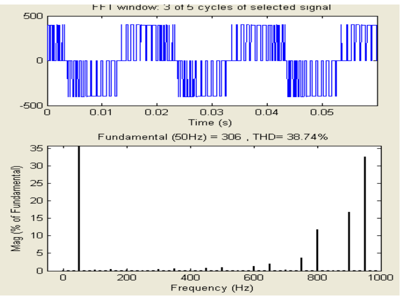


Figure 19. THD waveforms of two level SVPWM inverter voltage

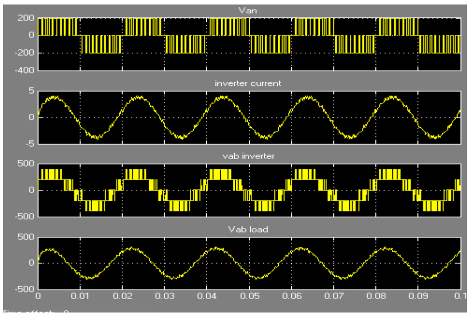


Figure 20. waveforms of two level SVPWM inverter voltage, inverter current & inverter

## IX. SIMULATION RESULTS OF THREE PHASE THREE-LEVEL SVPWM INVERTER

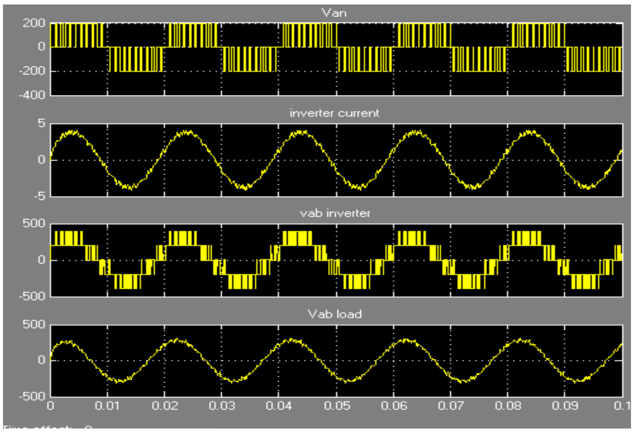


Figure 21. waveforms of three level SVPWM inverter pole and line voltage, inverter current & inverter load voltage

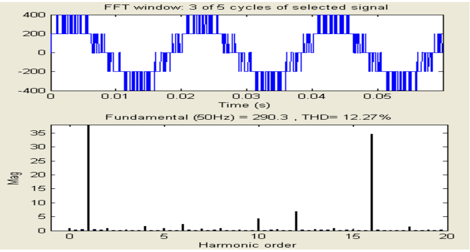


Figure 22. THD of three level SVPWM inverter line voltage

## X. SIMULATION RESULTS OF THREE PHASE THREE-LEVEL SPWM INVERTER

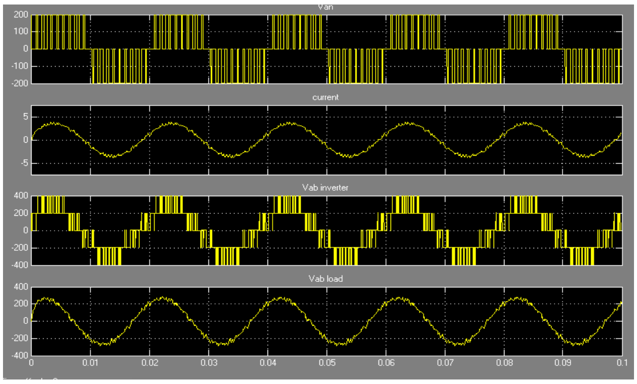


Figure 23. waveforms of three level SPWM inverter pole and line voltage, inverter current & inverter load voltage

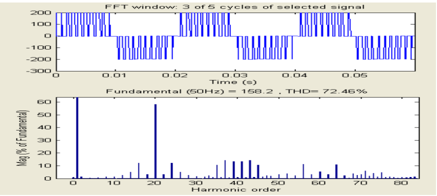


Figure 24. THD of three level SPWM inverter pole volta

Table 5. THD values of SVPWM two level & three level inverters

| Type | Vab Inverter | Vab load | Inverter current |
|---|---|---|---|
| SVPWM TWO LEVEL INVERTER | 38.74% | 13.12% | 11.80% |
| SVPWM THREE LEVEL INVERTER | 12.27% | 6.19% | 4.86% |

Table 6. THD values of SVPWM & SPWM three level inverters

| Type | Vab inverter | Vab load | Inverter current | Van(inverter pole voltage) |
|---|---|---|---|---|
| SPWM THREE LEVEL INVERTER | 35.89% | 8.58% | 6.56% | 72.46% |
| SVPWM THREE LEVEL INVERTER | 12.27% | 6.19% | 4.86% | 13.66% |

The simulation results suggest that three-level SVPWM can achieve less harmonic distortion compared to SPWM. And also these results shows that when the number of levels increasing, harmonics are reduced.

## XI. CONCLUSION

In this paper, SVPWM technique is used to reduce the harmonics. 3-level NPC inverter simulation model has been successfully developed with RL load in this paper. Sinusoidal PWM method has intermediate switching losses, but its THD is significantly higher compared to other techniques of PWM. It is concluded that harmonic content is very less in case of SPACE VECTOR technique. The voltage THD values of the SVPWM inverter are lower than SPWM. The proposed scheme has been successfully implemented by using Simulink MATLAB. It is used for the further research in high voltage and high power application. This paper work provides successful attempt to analysis & comparison of SVPWM & SPWM inverters. In this paper, SVPWM strategy for two level & three level inverters and SPWM strategy for three level inverters is reported. From this paper SVPWM strategy concludes that, it generates less THD compared to SPWM strategy and also this paper concludes that when the number of levels increasing, harmonics are reduced for same technique as well as for different techniques. Simulation results have been given for R-L load in this paper. This software implementation used in this paper can be extended further to three phase Induction Motor load which will be a future enhancement. The proposed scheme is used for future works with high levels that is more than three level inverters. The basic implementation is used for future works with high levels that is more than three level inverters.

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