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Implementation of Svpwm Technique with PI Controller

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ABSTRACT

There is increase in use of power electronics-based loads connected to low and medium voltage power distribution systems in past several years. The loads draws non sinusoidal current from the mains, it decreases the power quality by causing Harmonic distortion. Hence to reduce harmonics and to increase power quality Space vector control strategy is used for three phase inverter system operating under highly nonlinear load. Proportional Integral (PI) controller is used to design SVPWM in closed loop. The controller design generates gating signals which drives inverter and gives high quality output with low distortion for non linear load. MATLAB/SIMULINK is used for designing and development of SVPWM based three phase inverter

Keywords: *Inverter, non linear load, PI controller, Space Vector PWM.*

I. INTRODUCTION

As there is increase in use of rectifiers in critical loads there is a need in improvement in the quality of power obtained from the UPS system. In the years, due to Betterment in the field of power electronics technology, it surface the way for modern fast switching PWM techniques for DC to AC conversion. The Output voltage from an inverter can be accommodated by changing a control within the inverter itself. The most suitable method of doing this is by using pulse-width modulation control within inverter. This is the most popular method to control the output voltage of an inverter and this method is known as Pulse -Width Modulation (PWM) Control.

The popular modulation techniques are SPWM AND SVPWM. In these techniques widths of the voltage pulses, over the output cycle, is varied in a sinusoidal manner in SPWM. This method involves comparison of a high frequency triangular carrier voltage with a sinusoidal modulating signal which then gives the desired component of the voltage waveform. The magnitude of modulating and reference waveform produces the gating pulse which drives the inverter switches

This method is an advanced computation PWM Method and the best PWM techniques for three Phase inverters. The technique uses vectors to be used according to region where the output voltage vector is placed. This technique is more practical for generating sine wave which provides higher voltage to the load with low harmonic distortion. SVPWM is different from PWM modulation. it is placed on space Vector representation of the voltages in the α-β plane. The α-β components are obtained by Clarke's Transformation. Space Vector PWM (SVPWM) uses a specialized switching sequence of the upper three transistors of a three -phase inverter. It increases the capability of the output of Sinusoidal PWM (SPWM) with less distortion in output voltage waveform and also prevents useless switching.

II. SVPWM IMPLEMENTATION

A. Park's transformation

It is the first step is to convert the three Phase quantities into two phase quantities by park's Transformation formulae. These two phase quantities are then utilized to generate the reference vector and its equivalent angle which is rotating in d-q frame which Modulates the inverter output.

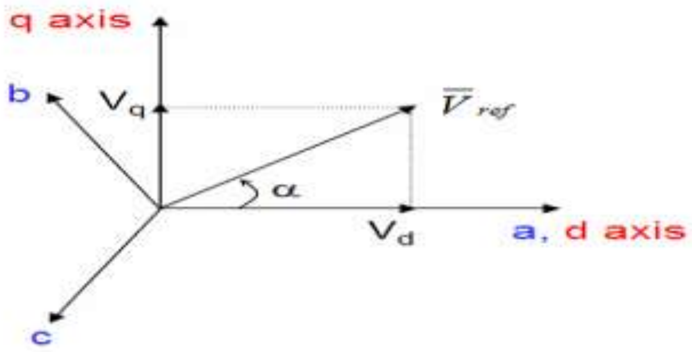

Fig 1 park's transformation

The equations which convert three phase quantities to two phase quantities are given below.

$$V_d = 2/3[V_a \sin(\omega t) + V_b \sin(\omega t - \frac{2\pi}{3}) + V_c \sin(\omega t + \frac{2\pi}{3})]$$

$$V_q = 2/3[V_a \sin(\omega t) + V_b \cos\left(\omega t - \frac{2\pi}{3}\right) + V_c \cos(\omega t + \frac{2\pi}{3})]$$

$$V_0 = 1/3(V_a + V_b + V_c)$$

B. Vref and its equivalent angle

The two phase quantities generated are further used to generate reference vector and equivalent angle as shown .

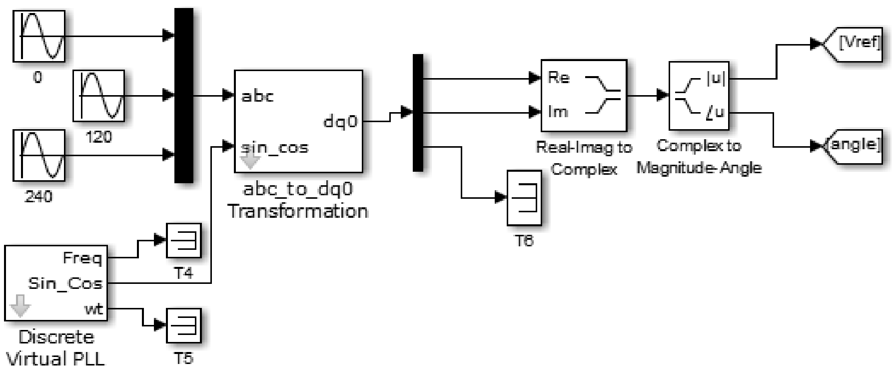

Fig 2. Simulink model for V-reference and angle.

C. Defining sector

The three phase voltage source inverter is shown below. The upper switches are 12,21,31 and the lower switches are 21,22,32 are lower switches. When the upper switches are 1 it turns upper inverter leg ON and if lower switches are 0 it turns lower inverter leg ON.

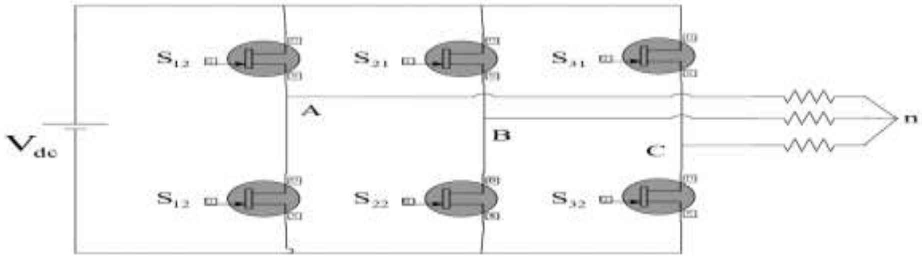

Fig 3. Three phase inverter configuaration.

The lower switches and upper switches complementary to each others ,The possible combination for the switching states are (111,001,010,011,100,101,110,000). There are eight switching states of which six are active states and remaining two states are null states.

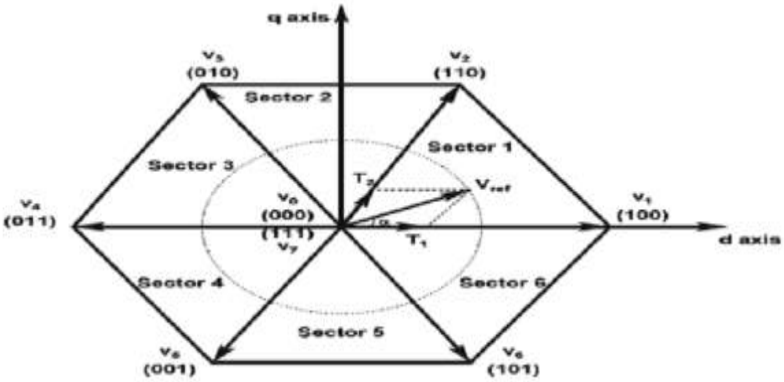

Fig 4. Basic switching vectors.

As shown these vectors gives the shape to the axes of hexagonal and are used to supply power to the loads. Two zero vector V7 and V0 are at the origin and supply zero voltage to the load. The eight vector are known as basic space vectors and are represented as (V0,V1,V2,V3,V4,V5,V6,V7) .The aim of the SVPWM technique is to find the reference vector using eight switching pattern.

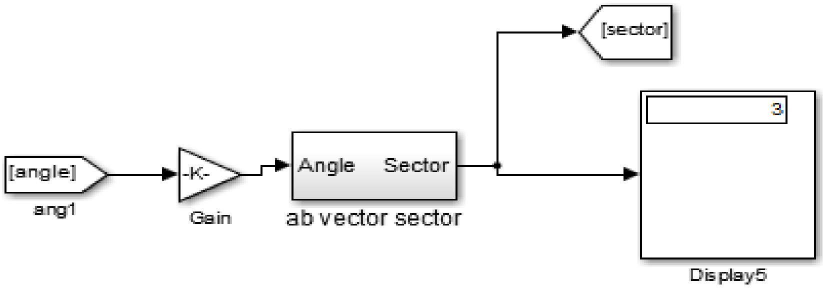

Fig 5. Simulink model for Sector definition.

Each sector is made up of 60 degree. In the sector block sectors are defined. There are six sectors out of eight which are obtained by switching of a typical three phase inverter shown in fig. The logic behind reference vector (Vref) is in which sector is designed in above model. The sectors are such as, sector 1 is 0- 60degree, sector 2 is 60- 120 degree, and so on. The 3 logic says that, If angle which is generated with Vreference is 140 degree then it lies in sector 3 as shown in fig 5.

D. Dwell Time

suppose the reference vector is in sector 1as shown in fig . time for which active vector 100 (+ - -) is applied is T1 and T2 is the time for which active vector 110(+ + -) is applied. Alpha (α) is an angle by which reference vector is rotating in. Applying T1 and T2for suitable time we get the proper value of reference vector. the total time for which null vector (Tz) and active vector are applied is Ts. T1, T2, Ts and Tz calculations are given below. Fig

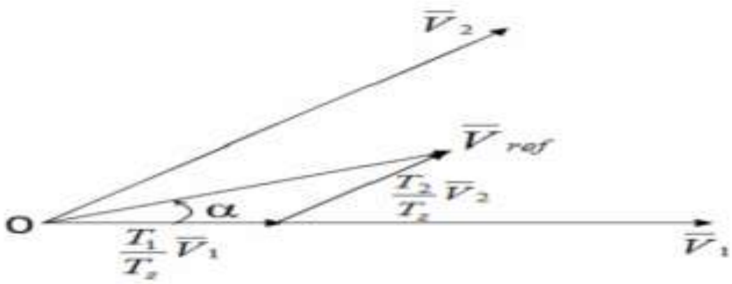

Fig 6. Reference vector in sector 1.

$$V_{ref}T_s = V_1T_1 + V_2T_2 + V_zT_Z$$

$$T_s = T_1 + T_2 + T_z$$

$$T_1 = \frac{V_{ref}\sin(60-\alpha)}{V_{dc}\sin(60)}T_S$$

$$T_2 = \frac{V_{ref}\sin(\alpha)}{V_{dc}\sin(60)}T_S$$

$$T_z = T_s - T_1 - T_2$$

the vectors (V1,V2, Vz) are applied for appropriate time then Modulating signal is generated .now compare this modulating signal with carrier wave for the generation of triggering pulses. These pulses are used as a gating signal to drive inverter switches

E. Proportional Integral(PI) controller

The inverter output is connected to the load, then output voltage is sensed and is given to a comparator this load output is compared with the reference signal to produces the error signal. This instantaneous error is given to a (PI) controller. The controller has two elements namely Proportional (P) and Integral (I). Proportional part is used to reduce the error while Integral part helps in reducing the offset. P depends on present error and I depends on past errors. So, step response of a system can be better improved with the use of PI controller. Also the integral term in the PI controller helps to improve the tracking by reducing the instantaneous error between reference and the actual value or desired value. The error signal is compared with a triangular carrier signal and its intersections decide the switching frequency and pulse width

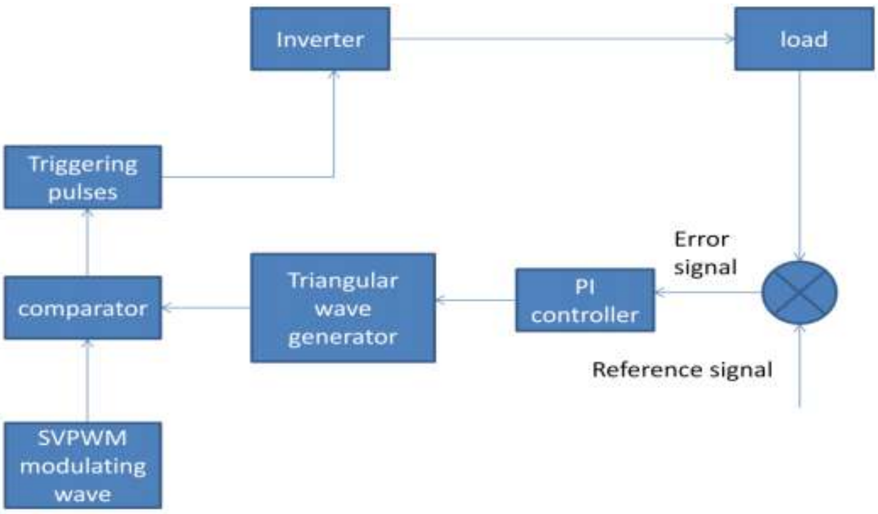

Fig 7 Block diagram of SVPWM controller using PIcontrol logic.

III. SIMULATIONS AND RESULTS

The behavior of SVPWM controller with control logic of PI as shown in fig. where non linear load is diode bridge rectifier. Fig shows the current harmonics spectrum and voltage harmonics spectrum respectively. Fig 13 shows three phase inverter stage with non linear load.

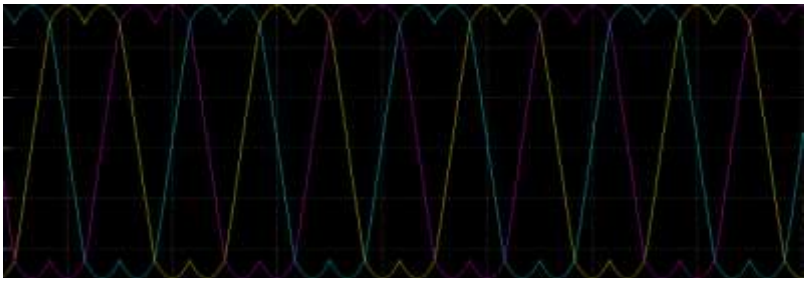

Fig 8 modulating waveform

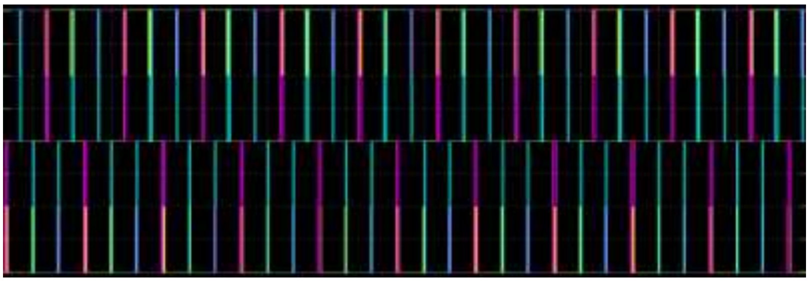

Fig 9 Three phase output.

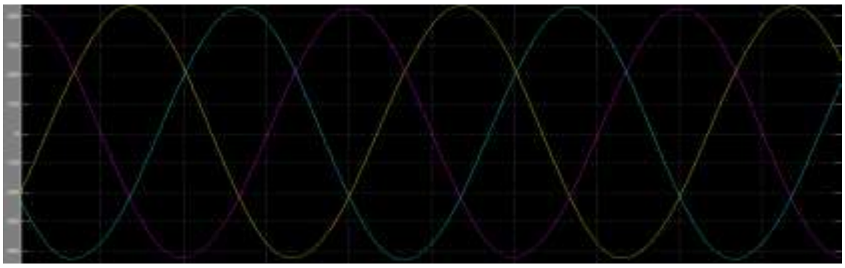

Fig 10 Three phase filtered output

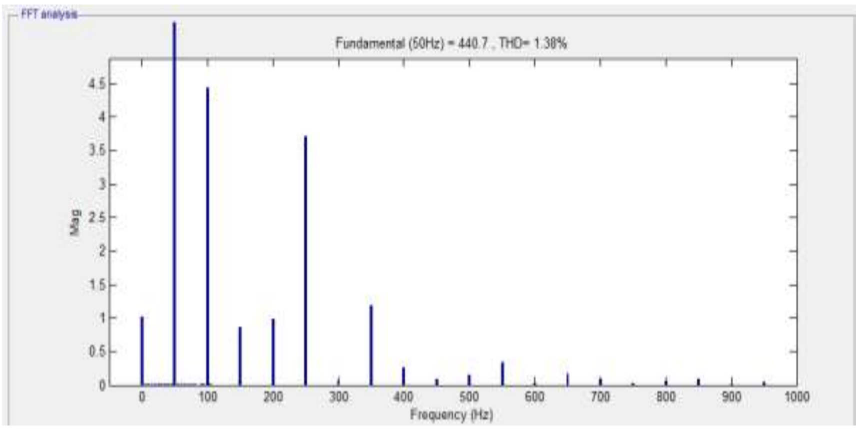

Fig 11 voltage harmonics spectrum

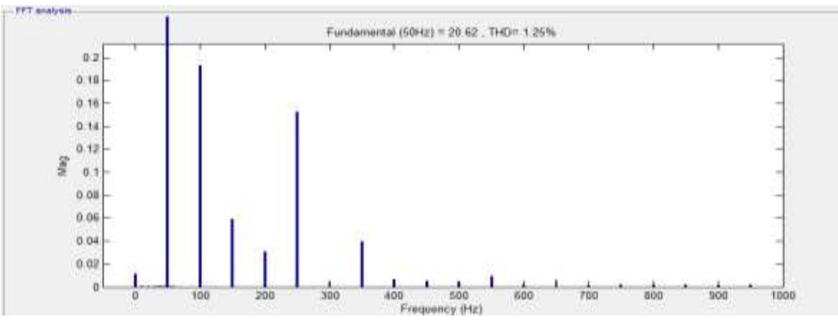

Fig 12 current harmonics spectrum

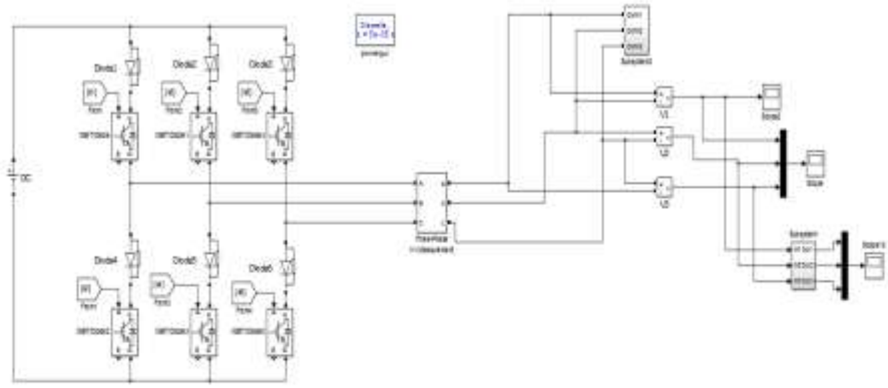

Fig 13. Simulink model for three phase inverter stage

IV. CONCLUSION.

This paper shows SVPWM controller with PI control logic for three phase inverter ,MATLAB/SIMULINK software are used for the analysis of simulations and result. The harmonic spectrum conditions shows that reduction of harmonics is better with the help of PI controller. It is also useful in increasing DC bus utilization as compared to other methods. The THD for load current under non linear load is reduced.

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