RESEARCH ARTICLE OPEN ACCESS

Implementation of shunt active power filter with comparative study of SPWM and SVPWM technique for reduction of THD

Ms.Priyanka S. Salunkhe[1],
[1]*Research Student*
(Electrical Engineering Department)
Zeal College Of Engineering,
Narhe Pune ,India

Mrs.Shruti Gaur[2]
[2]*Assistant Professor*
(Electrical Engineering Department)
Zeal College Of Engineering,
Narhe Pune ,India

Corresponding author: Ms.Priyanka S. Salunkhe

ABSTRACT
This paper presents a comparative study of two different PWM techniques, i.e. the sinusoidal pulse width modulation (SPWM) technique, and the space vector pulse width modulation (SVPWM) technique for three phase H bridge inverter with shunt active power filter (SAPF) to reducing the total harmonic distortion in a non linear loads. In conventional diode clamped inverter required balancing circuit and extra diodes for clamping. In proposing H bridge inverter no extra diodes and balancing circuit are required and reduce the complexity and cost. The performance of SPWM and SVPWM technique is analysed by using MATLAB / Simulink software.
Keywords: Shunt active power filter (SAPF), H- bridge inverter, sinusoidal pulse width modulation (SPWM) technique, Space vector pulse width modulation (SVPWM) technique, total harmonic distortions (THD).

Date of Submission: 14-08-2017 Date of acceptance: 13-09-2017

I. INTRODUCTION

In a recent years, use of power electronics devices has been extensively increased, due to this problem of power quality distortion also increased. The increased use of custom power devices which are highly uses power electronics switches, such as IGBT in UPS system, diode or thyristor bridges, etc. due to use of nonlinear loads, they draw a non sinusoidal current. so they produce huge no. of harmonics in supply mains.

The harmonic currents do not contribute to an active power and need to be eliminated to enhance power quality. The shunt passive filters consisting of tunes LC filters and/or high-pass filters are used to suppress the harmonics, and power capacitors are employed to improve the Power Factor (PF) of the utility/mains. But they have the limitations of fixed compensation and large size and can also excite resonance conditions [1]. Active Power Filter (APF) is the accepted method used to discard the undesired current components by injection of compensation currents in opposition to them.

Some methods of active power filters are available such as Series APF, Shunt APF, UPQC etc. Shunt active power filter (Shunt APF) is used to compensate source current harmonics as well as to supply reactive power. Series APF is used to mitigate voltage harmonics. UPQC is able to mitigate voltage as well as current distortions [3].

In Space vector pulse width modulation (SVPWM) technique generates the pulses by formation of sectors. Moreover the output voltage of inverter is given by reducing the total harmonic distortion.

II. LITRATURE SURVEY

Elango Sundaram and Manikandanvenugopal [1] introduce about this scheme consist of three phase three level diode clamped multilevel inverter which can be used to reduce the source current harmonics. The PWM scheme generates the inverter leg switching times, from the sampled reference phase voltage amplitudes and centers the switching time for the middle vectors in a sampling interval as in the case of conventional space vector pulse width modulation (SVPWM).

R.Zahira, A. Peer Fathima ,RanganathMuthu [2] exhibits a new pulse width modulation technique to overcome the low performance of a conventional pulse width modulation control strategy for an active filter. The voltage source inverter uses the PWM switching techniques to have a DC input voltage. That is usually constant in magnitude. SPWM technique are characterized by constant amplitude pulses with different duty cycles for each period. The width of these pulses are modulated to obtain inverter output voltage control and to reduce its harmonic content.

Swapnil Y. Gadgune.[3] two level inverter is used for mitigating the current harmonics in very high switching frequency (>10 KHz). So switching losses may very high. Also dv/dt stress on each switch is very high .so reducing all switching losses and dv/dt stress on each switch multilevel inverter is used and also application of multilevel inverter in active filters effectively reduces harmonics in high voltage system without use of converter topologies. In this paper comparison of diode clamped and cascaded H- bridge multilevel inverter based on shunt active filter and P-Q theory is used for reference current generation and SPWM technique is used for pulse generation.

Surabhi Chandra [4] is introduce the two pulse width modulation techniques i.e. bipolar sinusoidal pulse width modulation (SPWM) technique and unipolar SPWM technique for a single phase H- bridge inverter that is commonly used to regulate the magnitude and frequency of the inverters output voltage.

Abhinashparida ,J. mohapatra [5] is expose a conceptually study of SAPF has been performed for 3 phase 3 wire system under passive loading condition under nonlinear load. The sinusoidal current control strategy drives the SAPF in such a way that the supply system draws the constant sinusoidal current under steady state condition. In this paper the comparison shows that the sinusoidal current control strategy is efficient than constant instantaneous power control strategy.

A. Shunt Active Power Filter

The connection of active power filter is parallel or shunt to the system. It is used to eliminate current harmonics generated by non linear loads. The operation of active power filter as a current source is injected harmonic components generated by the load. The components of harmonic currents contained in the load current are cancelled by the effect of the active filter [1].

The advantage of this shunt active filter is that other hysteresis PWM technique sinusoidal PWM is efficiently used. Due high Switching losses in hysteresis control the efficiency of the shunt active filter is reduced[10].

As the APF compensate one or more loads; thus it avoids propagation of the current harmonics in the system. As the APF compensates the reactive power and cancels the harmonics, it is called as the active power line conditioners (APLC). The concept of shunt APLC was first introduced by Gyugyi and strycula in 1976 [2].

B. H - Bridge Inverter

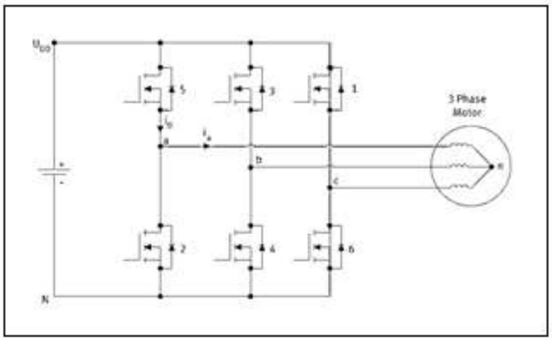

Fig 1: H – Bridge inverter

A separate dc source is connected to a single-phase full H-bridge inverter. Each inverter level can generate three different voltage outputs i.e. +Vdc, 0 and –Vdc by connecting the dc source to the ac output by different combinations of the switches. The ac outputs of each of the different full- bridge inverter levels are connected in series such that the synthesized voltage waveform is the sum of the inverter outputs [5].

C. Sine PWM Technique

The output voltage of the inverter needs to be varied as per load requirement. Whenever the input varies, the output voltage can change. Hence these variations need to be compensated. The sinusoidal pulse width modulation technique is better voltage control in inverter.

In single pulse and multiple pulse modulation techniques the width of all pulses are same but in sinusoidal pulse width modulation the width of each pulse is varied in proportional to the amplitude of sine wave.

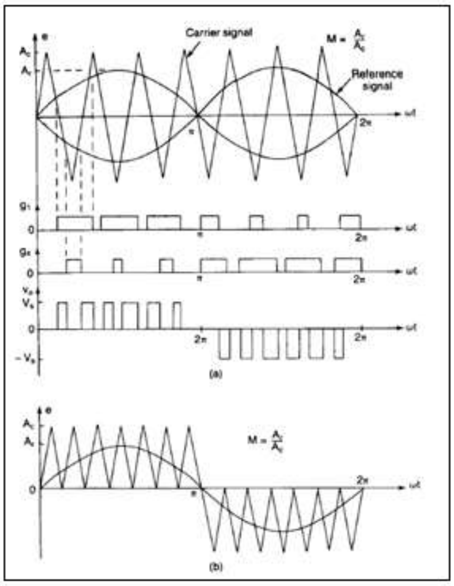

Fig 2: Principle of pulse width modulation

In SPWM technique, a high frequency triangular wave (called carrier wave) is compared with a sinusoidal wave of fundamental frequency. The junction of sinusoidal wave with triangular wave determines the switching instants of the switches in the H-Bridge inverter [4].

The width of the pulses depends upon the amplitude (A_r) of the sine wave .if amplitude is increased, widths increase. The ratio of A_r to A_c is called modulation index .

i.e. Modulation index $m = \frac{A_r}{A_c}$

The rms value of output voltage of the inverter depends upon width (∂_m) of the pulses. These width depends upon modulation index m. Thus modulation index m control the output voltage of inverter. The output voltage increases as the modulation index increases. The modulation index can be varied by changing the amplitude of the reference signal.

D. Space Vector PWM Technique

Space vector modulation is developed as vector approach to pulse width modulation for three phase inverters. This method is highly computation intense with dynamic calculations done to calculate the T_{ON} time of every switch within every sampling interval. The major advantage of SVPWM is the reduction of total harmonic distortion. Created by the rapid switching created by the PWM algorithm. The aim of any modulation technique is to obtain variable output having a maximum fundamental component with minimum harmonics.

Concept of space vectors:

Space vector involves a constant amplitude vector rotating at a constant frequency obtained from their three phase sinusoidal forms. The rotating vector is rotated in a stationary d-q coordinate frame plane and made to imitate its equivalent 3 phase rotating vector via 2 phase vectors. This is known as coordinate transformation.

For three phase system ,

$$V_{REF} = V_{RN} + V_{YN} + V_{BN} \qquad (1)$$

Where,

$$V_{RN} = V_m \sin(\omega t) \qquad (2)$$

$$V_{YN} = V_m \sin(\omega t - (2\pi/3)) \qquad (3)$$

$$V_{BN} = V_m \sin(\omega t - (4\pi/3)) \qquad (4)$$

And with d-q plane ,

$$V_{REF} = V_d + V_q \qquad (5)$$

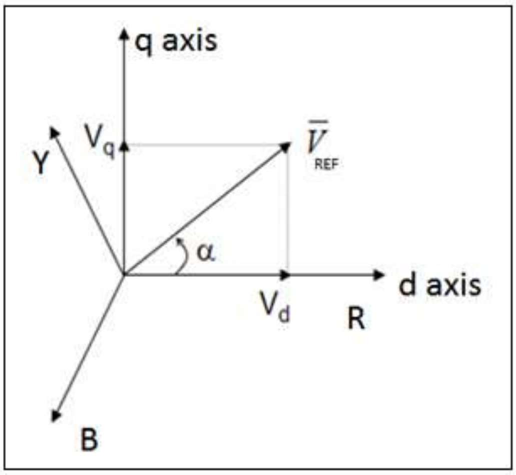

Fig 3: Coordinate transformation RYB to d-q

In fig. 5, six vectors states form the six corners of a hexagon structure around which the reference voltage revolves. Other two states namely [111] and [000] are null vectors as produce no effective outputs. The rotating V_{REF} takes the intermediate values between each sector using the adjacent space vector as d-q plane.

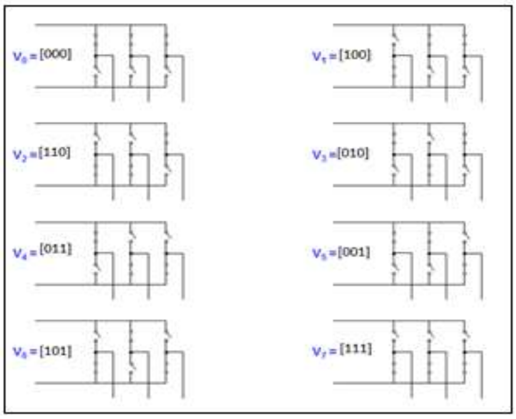

Fig 4: equivalent switching pattern of the space vector.

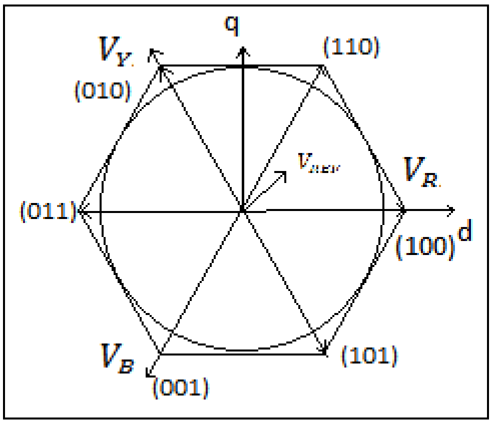

Fig. 5: Space vector diagram

III. SIMULATION RESULTS

The proposed simulation model for shunt active power filter is execute by MATLAB/SIMULINK software. The simulation elements used for the proposed system are given as follows : Input supply voltage is 20 $V_{ph\text{-}ph}$, 50Hz and Source Impedance are R_s= 0.8929 Ω, L_s=0.01658 H The resistance and inductance value for the filter network are R= 100Ω ,C=0.01nF respectively. The non linear load used for the simulation model are R=50Ω ,and L= 0.1H connected with a bridge rectifier circuit. The source current waveforms becomes nonlinear and total harmonic distortion is higher and its value becomes

Table1: Comparison of SPWM and SVPWM

Parameters	SPWM		SVPWM	
	Without Filter	With Filter	Without Filter	With Filter
THD	19.88	1.57	19.81	0.87

A.H-bridge inverter with SPWM technique.

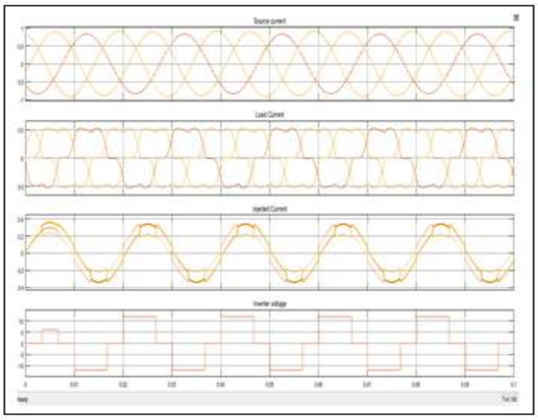

Fig.6 : simulation waveforms for input source current, load current, injected current, inverter voltage with SPWM

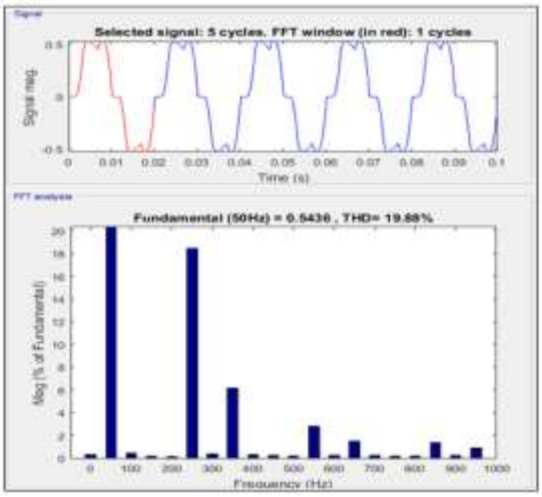

Fig. 7: Total Harmonic spectrum with SPWM and without filter

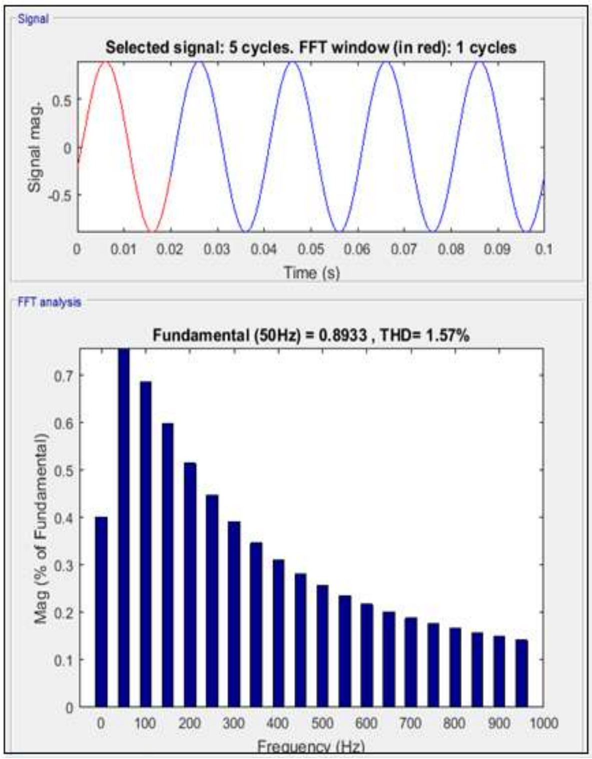

Fig.8 : Total Harmonic spectrum with SPWM and with filter

D. H-bridge inverter with SVPWM technique.

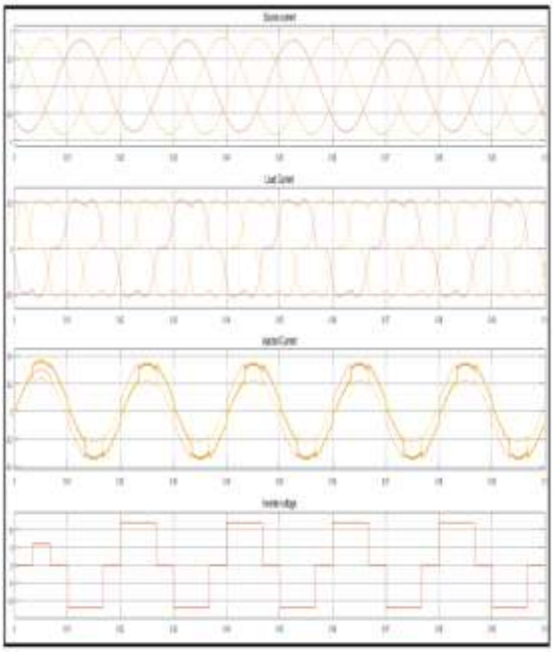

Fig.9 : simulation waveforms for input source current, load current, injected current, inverter voltage with SVPWM

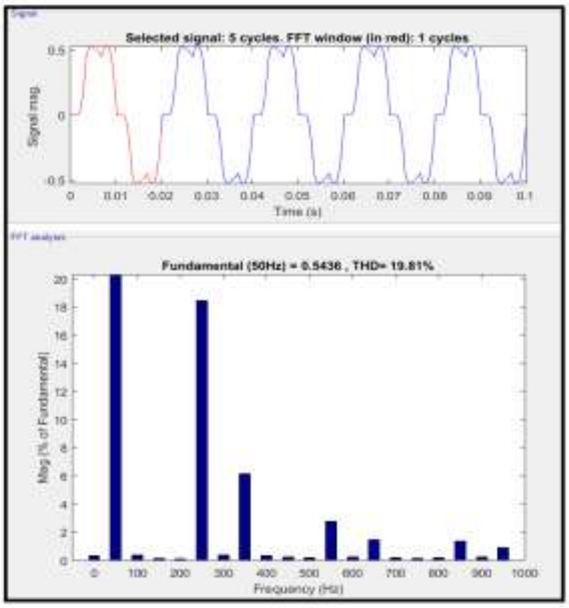

Fig.10: Total Harmonic spectrum with SVPWM and without filter

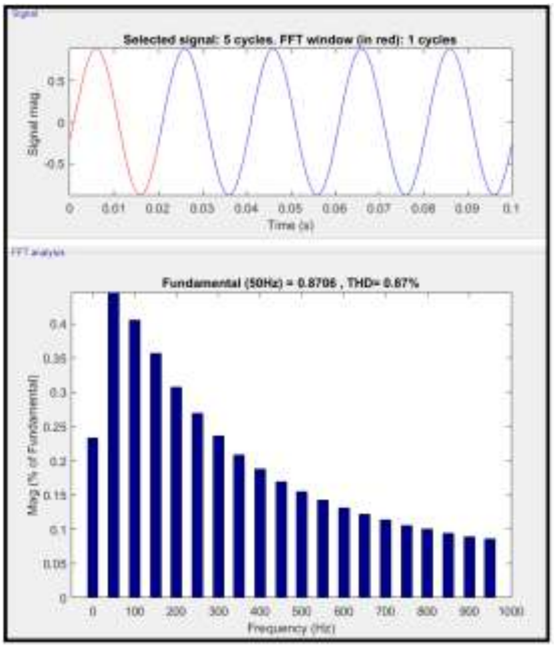

Fig.11 : Total Harmonic spectrum with SVPWM and with filter

IV. CONCLUSION

In this paper the shunt active power filter based on H bridge inverter is reduces the complexity of circuit. In this system no extra requirement of capacitors and diodes for clamping and also does not required the balancing circuit.The simulation result of Total harmonic distortion is compare with SPWM and SVPWM technique . the performance of both modulation technique without SAPF filter is 19.88% achieved in SPWM and 19.81% achieved in SVPWM and with SAPF is 1.57% achieved in SPWM and 0.87% achieved by SVPWM technique. It has been observed that SVPWM hasshows superior results by reducing THD as compare to SPWM technique.so we concluded that SVPWM technique provides greater overall performance and improve efficiency as compared to SPWM technique.

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International Journal of Engineering Research and Applications (IJERA) is **UGC approved** Journal with Sl. No. 4525, Journal no. 47088. Indexed in Cross Ref, Index Copernicus (ICV 80.82), NASA, Ads, Researcher Id Thomson Reuters, DOAJ.

Ms.Priyanka S. Salunkhe. “Implementation of shunt active power filter with comparative study of SPWM and SVPWM technique for reducing THD.” International Journal of Engineering Research and Applications (IJERA) , vol. 7, no. 9, 2017, pp. 42–47.