International Journal of Engineering Innovation & Research
Volume 7, Issue 6, ISSN: 2277 – 5668

# Designing of Efficient High Voltage Three Phase Bipolar SPWM Inverter and Analysis

**Avinash Bajpayee [1*], Prof. Mithlesh Gautam [2], Prof. Meha Khare [3] and Prof. Akhilesh Barsainya [4]**
[1*] M. Tech Research Scholar Truba College of Science and Technology Bhopal.
[2] Truba College of Science and Technology Bhopal.
[3] Truba Institute of Engineering and Information Technology Bhopal.
[4] Truba College of Science and Technology Bhopal.
*Corresponding author email id: avinash.bajpayee999@gmail.com

*Date of publication (dd/mm/yyyy): 03/12/2018*

***Abstract* – The SPWM inverters are widely used for energy conversion in renewable sources viz. solar power, Wind and bio plants. The paper has evaluated the FFT performance of three different inverting architectures triggered using the sinusoidal pulse width modulation (SPWM). Commonly PWM is used for changing the Gain of the inverter unit. Usually inverters are used for the conversion of DC energy to AC mains for connecting to the grid line. The paper first analyze the performance of the simple IGBT based single phase half wave and full wave inverter without PWM action. In the further architectures, SPWM based Uni polar and Bi polar inverter architectures are evaluated via FFT analysis. All these inverters are implemented and there outputs are described and compared. Simulation results are compared based on the FFT performance and bode analysis using LTI viewer using Simulink. The inverting action is tested for operating the high voltage AC motors.**

***Keywords* – Power Electronics, Insulated Gate Bipolar Junction Transistor, Sinusoidal Pulse Width Modulation Inverter, Linear Time Invariant Viewer, Fast Fourier Transform Analysis, Simulink.**

## I. Introduction

Usually the inverters are used widely for the solar panel based voltage applications. Conventional fossil-fuel generating facilities have in past met the majority of global electrical energy demands. However, environmental and climate change implications of fossil fuel-based generation present serious challenges to society and the environment Currently, solar energy is the most commonly used among the renewable energy sources, since installation of PV panel is very flexible it can be down to few kilowatts for residential applications or up to Tens Megawatts for solar farms.

- However, the disadvantage is that solar energy harvesting only operates during day time, and the amount of extracting energy highly depends on the weather conditions.

It creates power quality issues for the future smart grids due to this unpredictable energy flows. Furthermore, emerging semiconductors is getting close to the market. The design of PV inverters will be a new era to achieve high energy efficiency and reliable the basic principal of the PWM is to control the motor or drives energy based on the successive pulses of varying widths. The PWM generation procedure is very simple. A comparator can do the task. Usually the sinusoidal signal is applied on the non-inverting and triangular reference signal is applied on the inverting terminal of the op amp as comparator. Based on the comparison the comparator produces the PWM output with varying successive pulses of different widths as shown in the Figure 1a). The respective output waves are shown in Figure 1 b).

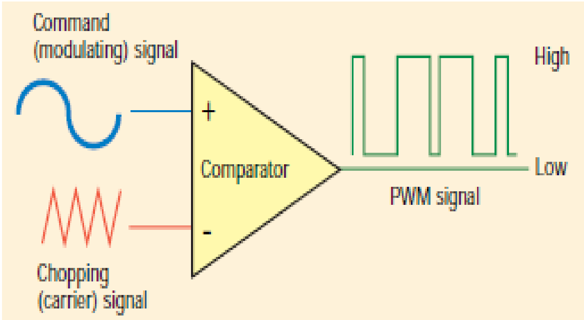



Fig. 1 a) PWM generation process.

Usually in PWM the either the amplitude or the frequency of the triangular carrier is varied with respect to the controlled sinusoidal input signal as in Figure 1b)

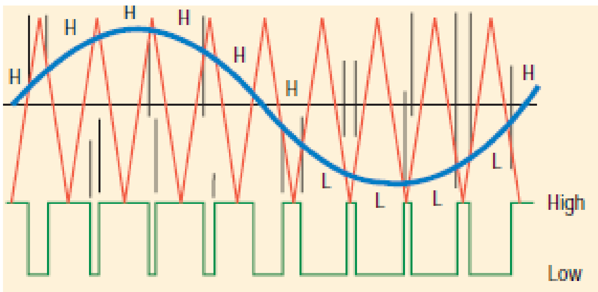



Fig. 1.b) PWM random Wave representation.

Mohamed A. Ghalib et al [6] have designed and pure sine inverter for the application in the photovoltaic fields. They have proposed a control circuit capable of generating sine waves. Microcontroller (PIC) is used for producing the pure sine wave using PWM. But they have focused on the low power electronic applications as loads. A. I. Andriyanov et 10al2 [7] have proposed to use a nonlinear control system for SPWM single phase inverter design. There control was triggered oriented control thus it was dynamic in nature.

Apart from this Anuja Namboodiri et al [3] have compared the performance of the unipolar and Bi-polar PWM inverters. They have described the concept of PWM used for triggering or control of switching devices. Nazmul Islam Raju et al [2] have proposed an SPWM inverter design for stand-alone Micro-grid system. Paper has explained generation of SPWM using Operational Amplifier circuits.

Anubha Gupta have proposed an architecture of three phase inverter design using the SPWM system design. There system was designed using IGBT's and performan- -ce is tested using RL load circuit. The application was used for induction motor speed control.

Bijoyprakash Majhi [5] have analyse the performance of the SPWM inverter during their research work they have compared the performance of different PWM techniques used for inverting applications. They have also explained different inverter types as square wave, modified square wave, sine wave inverters.

## II. PWM For Inverter Design

The performance of the inverting operation depends on the efficiency of the thyristors switching efficiency. Pulse-width modulation (PWM) is widely used for switching purpose in the inverter. The principal of the PWM methods is to provide the shaping of the voltage and current wave personalized to the explicit needs of the applications under consideration. Usually the PWM is used as the control system 2 for the inverting operation which decides the accuracy of the sinusoidal inverting output by controlling the switching operations. The PWM pulses operate the Gates of the switches in a controlled manner successively. Out of many PWM methods SPWM is very popular for inviting operation. But still there is great scope of improvement

In the remaining part of the paper various Inverting architectures are classified in the section II. B2ased on this classification in the section III the existing works are reviewed and problem and challenges are described. Section IV described the basic inverting architectures and there operating principals. In this paper basic IGBT based inverters are described and followed by the working of the sinusoidal Pulse width modulation (SPWM) based polar and Bi-polar inverters.

## III. Different Inverting Methods

There are different types of inverting operations as half wave and full wave inverter. For full wave inverter the most basic is the single phase inverter

3.1 *Single Phase Inverter Concep*

This section describes the basic concepts of the inverting operations of the full-bridge inverter & half-bridge inverters using IGBT. A converter based on single phase bridge in the form of DC-AC inverter is given in Figure 3. A single phase DC-AC inverters is analyzed by taking following assumptions and conventions into account.

1. The current entering nodes shown in the Figure 3 is considered as positive.
2. The thyristor switches named S1, S2, S3 and S4 are usually a unidirectional switches i.e. they conduct current in one direction.

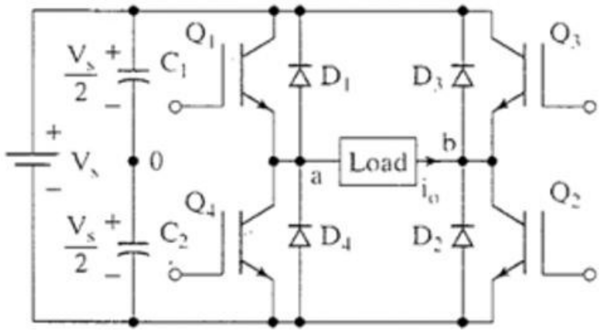


Fig. 3. Single Phase Full wave inverter.

When the switches S1 and S2 are turned on simultaneously for a duration $0 \leq t \leq T1$, The input voltage Vin appears across the load and the current flows from point a to b as shown in the Figure 4

Q1 – Q2 ON, Q3 – Q4 OFF ==> v o = Vs

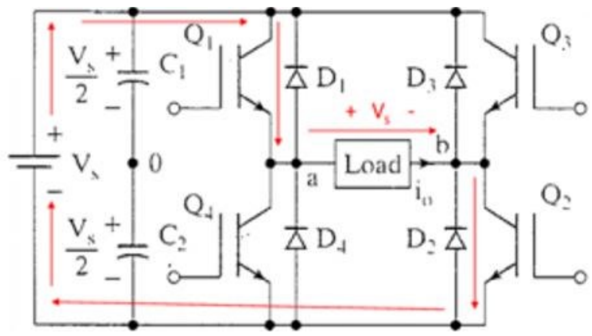


Fig. 4. Current flow pattern in single Phase inverter.

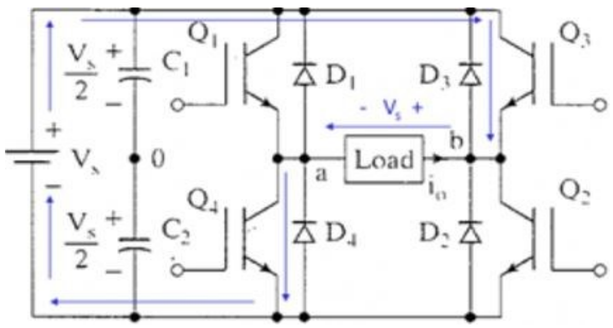


Fig. 5. The current flow under S3-S4 Condition.

If the switches S3 and S4 turned on duration $T1 \leq t \leq T2$, the voltage across the load the load is reversed and the current through the load flows from point b to a.

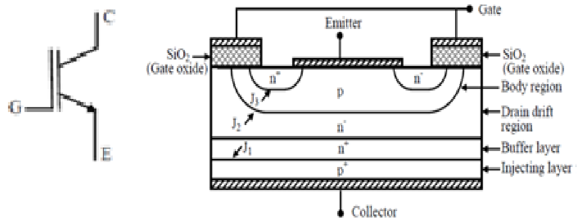
Q1 – Q2 OFF, Q3 – Q4 ON ==> v o = -Vs

The voltage and current waveforms across the resistive load are shown in Figure 5

Usually IGBT is used for inverter design at high voltage applications. The basic IGBT construction is given in the Figure 6.

The main advantage of IGBT selection for design an inverter are its capacity to be uses at high voltage applications more than 220 V, its driving is easy and having low on resistance, and can be used for the high speed stitching for higher voltage applications.

International Journal of Engineering Innovation & Research
Volume 7, Issue 6, ISSN: 2277 – 5668



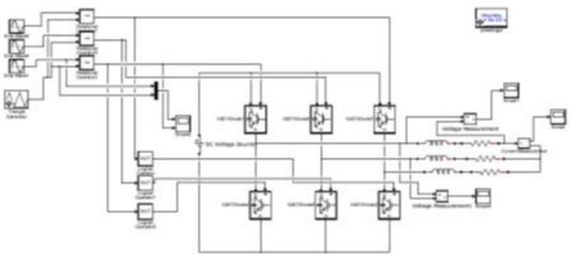

a) symbol b) IGBT

Fig. 6. IGBT construction.

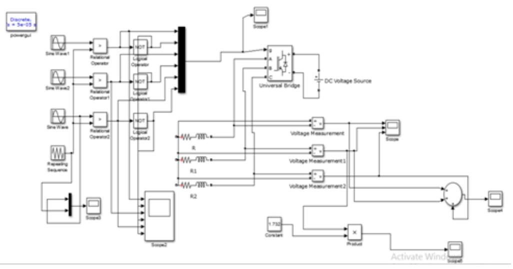
It is since IGBT provides hybrid combination of MOSFET's insolating gate property and poses the output characteristics as good as BJT's. Therefore, IGBT can be voltage controlled like MOSFETS but its output performance is like BJT. This forces for fast switching and higher output performance.

## IV. Results of Bpolar Three Hase Inverter

The section presents few results of the proposed Bipolar three phase inverter dseign. The model of biplar inverter designed for the three phaes is shown in the Figure 7 for the existing Anubha [4] dewign and our proposed models .



a) Model of the Anubha [4].



b. Our proposed model

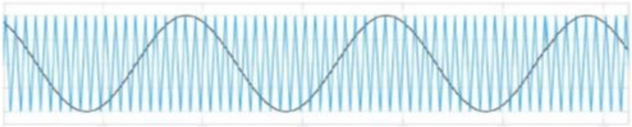
Fig. 7. Model of Bipolar three phase inverters.

The proposed model is different than Anubha [4] model in three manors.

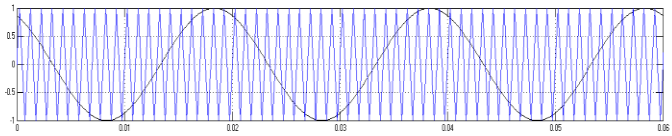
1. The swatooth wave generator is used for triangular wave generation using optimized sampling.
2. The generated PWM is different than previous one.
3. Against of individual IGBT's a Universal hybrid bridge block is used for inverter design for better efficiency.

*Validation*

The waveform comparison of base paper and proposed design are compared. The our inputs pattern matches with the patterns of the Anubha [4] as in Figure 8. It can be seen except the slight phase shift pattern is exact same.



a) Sinusoidal and triangular inputs of model of Anubha 8[4].



b) Sinusoidal and triangular inputs of proposed model.

Fig. 8. Comparison of the validation of proposed and previous inputs.

The results of the proposed method are given sequentially below for line and phase voltages.

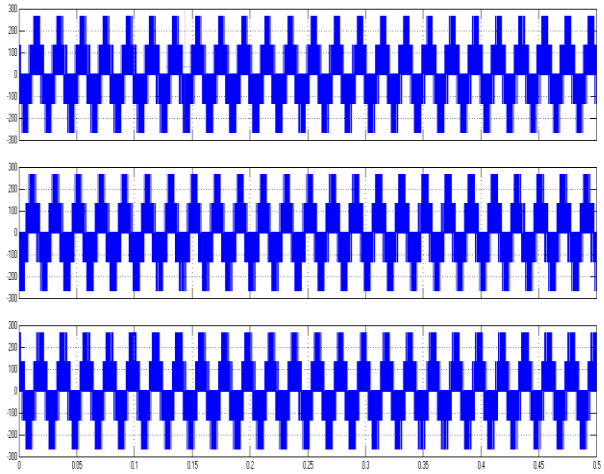


Fig. 9. Waveform of phase voltages of proposed inviter.

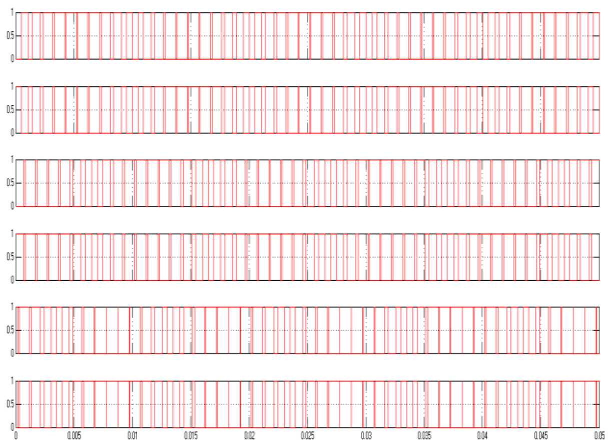


Fig. 10. PWM waves for the phase 1, 2 and 3.

The Figure 11 gives the multiplexed PWM generated data to be used for triggering the gates of the six IGBT's used for three phase inverter design.

*Parametric Comparison*

Total Harmonic Distortion (THD) is defines degree of closeness of the shape between output and its fundamental FFT component and is mathematically given as;

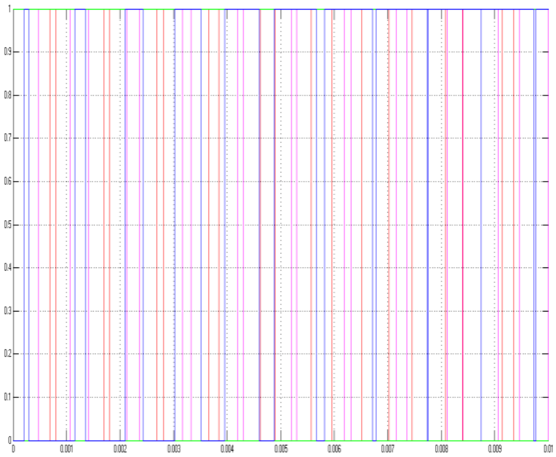


Fig. 11. The Multiplexed PWM training data.

$$\mathrm{THD} = 1/V_{o1}\left\{\sqrt{\sum_{n=2,3}^{\infty}(V_{on})^2}\right\} \qquad (1)$$

Table 1. Comparison of THD with single phase 2 performance of Anja et al [3]

| | Bipolar Single Phase Inverter | Three phase Bi-polar inverter |
|---|---|---|
| 1. | 90.16 % | 87.37 |

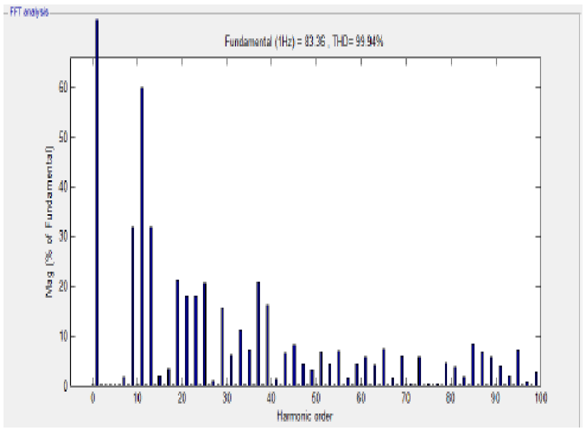



Fig. 12. FFT analyses of Bipolar Inverter Anuja et al. [3]

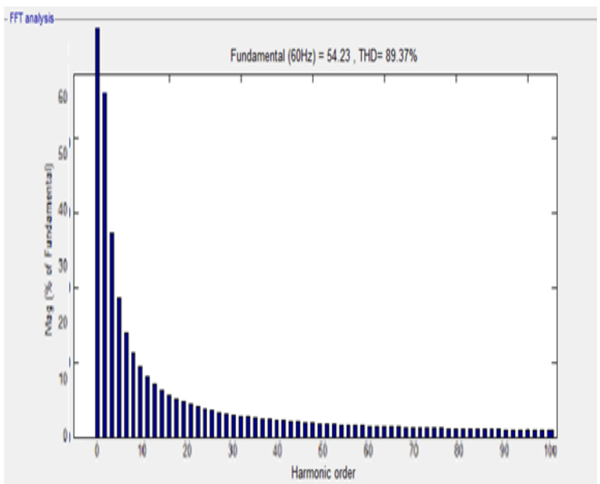



Fig. 13. FFT analysis of our IGBT based bipolar three phase Inverter TSD comparison.

## V. Conclusions

This paper the prime concern is to evaluate the performance of the IGBT based inventing architectures in terms of the FFT analysis. The major challenges in inverter design are the harmonic distortion and maintain the sinusoidal nature of the output. Paper also reviews the various existing paper in the field of the inverter design based on our classification cart. It is found that it is required to analyze the FFT performance for evaluating harmonic distortions. Following major conclusions are drawn from current research paper:

## Acknowledgment

Author here by acknowledges each and every individual who have supported directly or indirectly for the current research and helped the authors. Author also deeply acknowledges all referenced authors to help me understanding the work better from there indirect contributions.

## References

[1] Mohamed A. Ghalib, Yasser S. Abdalla, R.M. Mostafa, "Design and implementation of a Pure Sine Wave Single Phase Inverter for Photovoltaic Applications" in American socoity for Engineering Education in 2014.

[2] Maheshri S, Khampariya P, "Simulation of single phase SPWM inverter," IJIRAE Mag., vol. 1, isuuue 9, Oct. 2014.

[3] Anuja Namboodiri, Harshal S. Wani, "Unipolar and Bipolar PWM inverters", IJIRST–International Journal for Innovative Research in Science & Technology| Volume 1 | Issue 7 | December 2014.

[4] Anubha Gupta- "Three Phase Inverter Simulation using Sinusoidal PWM Technique ", J International Journal OF Advanced Research IN Electrical, Electronics AND Instrumentation Engineering Vol. 6, Issue 5, May 2017.

[5] Nazmul Islam Raju, Md. Shahinur Islam, Ahmed Ahsan Uddin " Sinusoidal PWM Signal Generation Technique for Three Phase Voltage Source Inverter with Analog Circuit & Simulation of PWM Inverter for Standalone Load & Micro-grid System, International journal of renewable energy research nazmul islam raju et al., vol.3, no. 3.

[6] Susmitha Vekkot, and Pancham Shukla, "A Novel Architecture for Wavelet based Image Fusion" *Journal of World Academy of Science, Engineering and Technology*, Vol. 57, pp. 32-3, 2009.

[7] B Ismil, S Taib, A Saad, M Isa, " development of control circuit for single phase inverter using atmel microcontroller" First IEEE International Conference PEC, p 437-440, November 2006.

[8] S.M Islam, G.M sharif, "microcontroller based sinusoidal PWM inverter for photovoltaic application" First IEEE International Confe8rence development in renewable energy technology, p 1-4, December 2009.

[9] P Zope, P Bhangale, P Sonare, S Suralkar, "design and implementation of carrier based sinusoidal PWM inverter" International Journal of advanced research in electrical, electronics and instrumentation engineering, Vol 1, pp. 230-236, October 2012.

[10] R Senthilkumar, M Singaaravelu "design of single phase inverter using dsPIC30F4013" International Journal Engineering Research & Technology (IJERT), Vol 2, pp. 6500-6506, 2012.

[11] D Chauhan, S Agarwal, Suman M.K, Policies For Development Of Photovoltaic Technology : A Review" International Journal of software & hardware research in engineering, Vol. 1, pp. 52-57, December 2013.

[12] A Qazalbash, A Amin, A Manan, M Khalid, "design and implementation of microcontroller based PWM technique for sine wave inverter" International Conference on power Engineering E-

-nergy and Electrical Drives,, P 163-167, March 2009, IEEE.

[13] A Mamun A, M Elahi, M Quamruzzaman, M Tomal, "Design and Implementation of Single Phase Inverter" International Journal of Science and Research (IJSR), Vol.2, PP 163-167, February 2013.

[14] L Hassaine, E Olias, M Haddadi, A Malek, "Asymmetric SPWM used in inverter grid connected" Revue des Energies Renouvelables Vol. 10, pp. 421-429, 2007.

[15] M.N Isa, M.I Ahmad, A.Z Murad, M.K Arshad, "FPGA Based SPWM Bridge Inverter ", American Journal of Applied Sciences, Vol. 4, pp. 584-586, 2007.

[16] Rajesh Kumar Ahuja Amit Kumar “Analysis, Design and Control of Sinusoidal PWM Three Phase Voltage Source Inverter Feeding Balanced Loads at Different Carrier Frequencies using Matlab, International Journal OF Advanced Research IN Electrical, Electronics AND Instrumentation Engineering Vol. 3, Issue 5, May 2014.

[17] Dutta A, “Some aspects on three phase bridge inverter”, IJEI, vol 3, issue 4, pp : 18-21, Nov 2013.

[18] Mathukiya M.G., “three phase inverter with 180 and 120 conduction mode”, IJMTER, vol. 4, issue 3, pp. 113–118, Mar 2017.

[19] Pankaj H Zope, Pravin G. Bhangale, Prashant Sonare, S. R. Suralkar “Design and Implementation of carrier based  SPWM Inverter**”,** IJAREEIE, vol. 1, issue 4, Oct 2012.

[20] B Ismail, S Taib, M Isa, I Daut, A.M saad, F Fauzy, " Microcontroller Implementation of single phase inverter switching strategies" International Conference on Control, Instrumentation and Mechatronics Engineering, p 104-107, May 2007. 2, May 2013.