IJCTA, 9(37) 2016, pp. 1009-1014

Optimization of Multilevel Inverter for Renewable Energy System

Udit Sharma[*] and K. Vijayakumar[*]

Abstract: The paper presents the optimization of Multilevel Inverter controlled by Sinusoidal Pulse Width Modulation (SPWM) scheme for renewable energy system. Depending on the modulation Index, the RMS voltage of the inverter and the Total harmonic distortion will vary. So an optimization technique is used to find the best value of modulation index for which the performance of the inverter is better.

Keywords: Multilevel Inverter, Optimization, Total Harmonic Distortion (THD), Modulation Index.

1. INTRODUCTION

Future generation of energy depends on renewable energy resources. Resources such as Solar and Wind is the fastest growing resources. In Solar Power generation the generation is DC, so inverter is must to convert DC into AC. For high power application multilevel inverters are used, because of its feature that it produces less harmonics. Harmonics are the distortion that is produced due to the switches when DC is converted into AC. Literature survey shows that H-bridge is best suited for such system. [1]-[3]. Modulation technique has huge impact on the performance of such system. So study of modulation technique for such system is important for evaluation.

Multilevel Inverter topology emanates to overcome the low power rating limitation of semiconductor switches for high power applications. In multilevel inverter several low power switches are connected in series with several low voltage DC sources. Batteries, fuel cells or renewable energy sources such as solar cells, wind turbine or micro turbine or any combination of these can be used as a source of multilevel inverter.

Features of multilevel inverter [1]-[4]

- The output voltage of multilevel inverter contains very less distortion.
- The input current drawn by them is very less distorted.
- They can operate at both low fundamental switching frequency and high switching frequency.

Different topologies of multilevel inverter

- Capacitive Clamped Multilevel Inverter.
- Diode Clamped Multilevel Inverter.
- Cascaded or H-bridge Multilevel Inverter.

In this paper H-Bridge Multilevel Inverter topology is used because of its various advantages like [5]-[6]:

- High quality voltage waveform.
- Smaller filters

* Department of EEE, SRM University

- Less switching power Loss.
- There is a possibility of independent voltage control in this type of inverters.

2. CASCADED H-BRIDGE INVERTER

A cascade H-Bridge multilevel inverter consist of series of H-Bridges Inverter units [7]. Each inverter unit can generate three different voltage output ($+V_{dc}$, 0, $-V_{dc}$). There are four semiconductor switches in each inverter and DC source is connecting with the output of these switch so that it can utilize the various combinations of switching.

CMLI topology has various advantages like it does not required clamping diodes or capacitors for balancing the voltage. With increase in number of levels the power rating of the inverter increases.

Advantages of H-Bridge Multilevel Inverter [4]

- They require very less no of components among all other multilevel inverter types.
- Modularized circuit Layout is possible because of same structure of each level and there are no extra clamping diodes or stabilizing capacitors.

  Soft switching can be implemented for this topology of multilevel inverter.

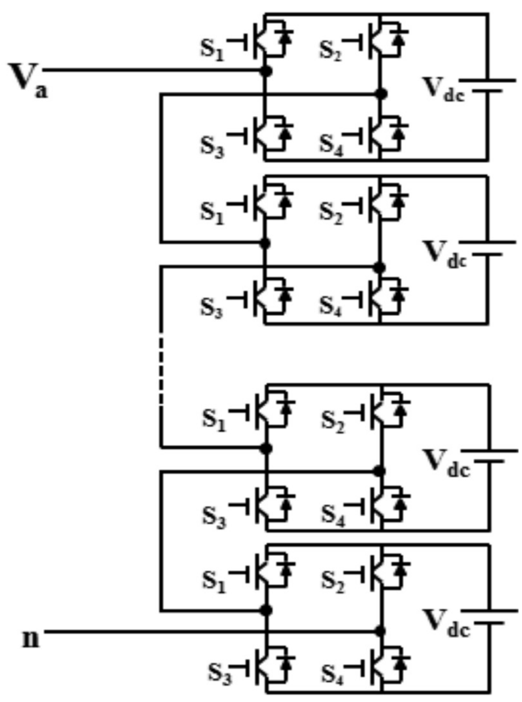

Figure 1: Single Phase H-Bridge Inverter

3. MODULATION TECHNIQUE

Modulation technique plays a vital role in performance of any power electronics converter. In this paper Sinusoidal Pulse Width Modulation (SPWM) technique is used. It is the simplest technique that can be implemented on both two level and multilevel inverters. In SPWM there are two signals one is reference signal and other is carrier signal (triangular). The frequency of carrier signal is high whereas the frequency of reference signal is low. The reference signal is compared to the carrier signal. At the point of intersection if reference signal is greater than carrier signal then active device corresponding to carrier turn on and if the reference signal is greater than active device corresponding to carrier is turn on. The min advantage of SPWM is that it reduces the THD of output wave.

The frequency of carrier signal is the switching frequency of the inverter. Amplitude Modulation Index is the ratio of amplitude of reference wave to the amplitude of the carrier wave.

$$M_A = \frac{A_R}{A_C}$$

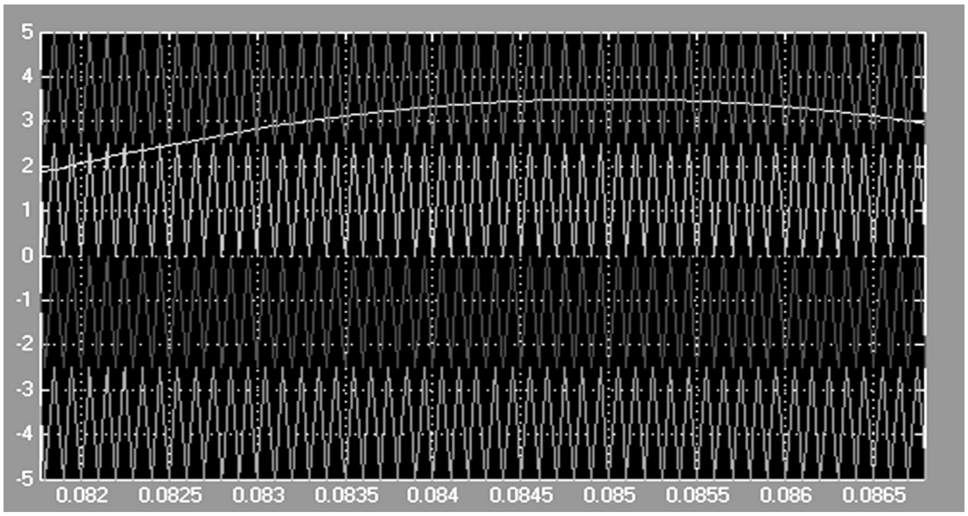

Figure 2: SPWM Switching Signal

A. Optimization

Total Harmonic Distortion is the summation of all the harmonic content of voltage or current waveform compared against the fundamental component of voltage or current. The switching pattern is obtained by sinusoidal pulse width modulation technique that is used for controlling the multilevel inverter.

V_{RMS} is the RMS value of input voltage and V_{1RMS} is the fundamental RMS value. Input Voltage in given by V_{IN}.

$$V_{RMS} = \frac{M_A \times V_{IN}}{\sqrt{2}}$$

$$THD = \sqrt{\frac{V_{RMS}^2}{V_{1RMS}^2} - 1}$$

$$V_{1RMS} = \frac{4 \times V_{IN}}{\pi\sqrt{2}} \sin\frac{\pi}{3}$$

$$THD = \sqrt{\frac{\frac{M_A \times V_{IN}}{\sqrt{2}}}{\frac{4 \times V_{IN}}{\pi\sqrt{2}} \sin\frac{\pi}{3}} - 1}$$

$$\min f(M_A) = THD + 1 - V_{RMS}$$

The range of modulation index lies between 0 to 1. For the value of modulation index at which the value of the function is minimum, gives the optimum point of the multilevel inverter.

Table 1
Font Sizes for Papers

Modulation Index	V_{THD}	V_{RMS}
0.6	5.67	386.2
0.7	5.21	367.6
0.8	1.03	459.8
0.86	1.25	468.18
0.90	1.72	468.18

All title and author details must be in single-column format and must be cantered. Every word in a title must be capitalized. Email address is compulsory for the corresponding author.

4. SIMULATION RESULTS

For different modulation index the THD and V_{RMS} is shown below:

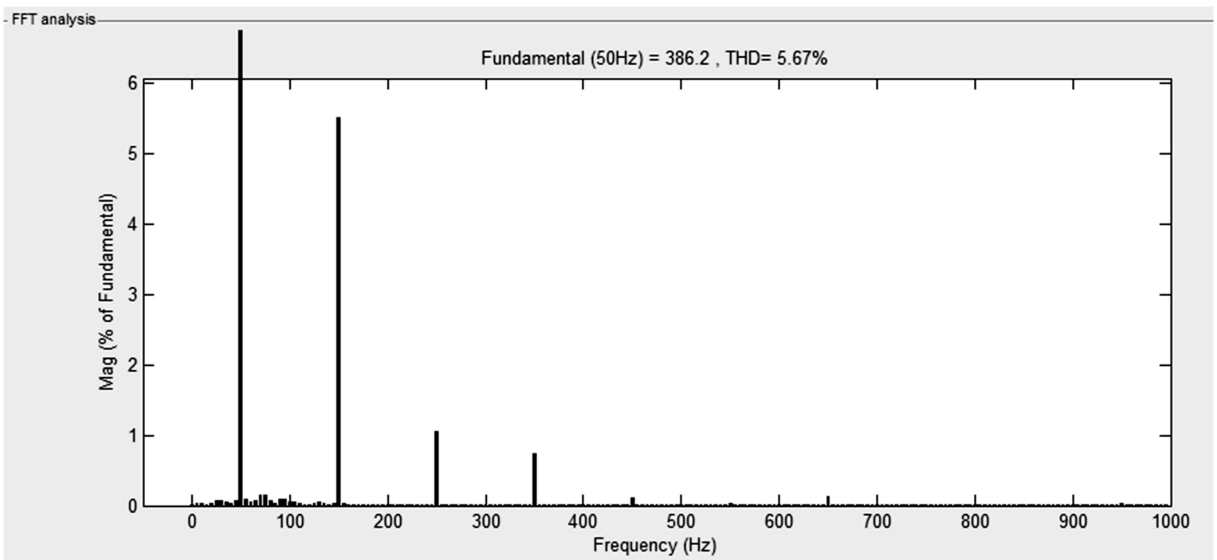

Figure 3: THD at Modulation Index Ma = 0.6

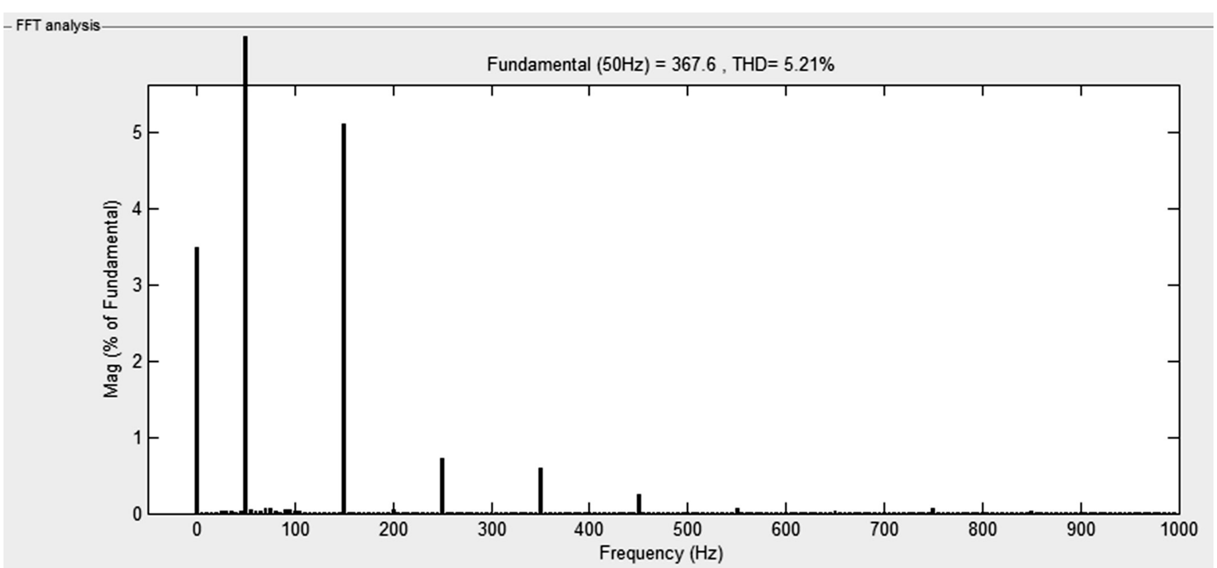

Figure 4: THD at Modulation Index 0.7

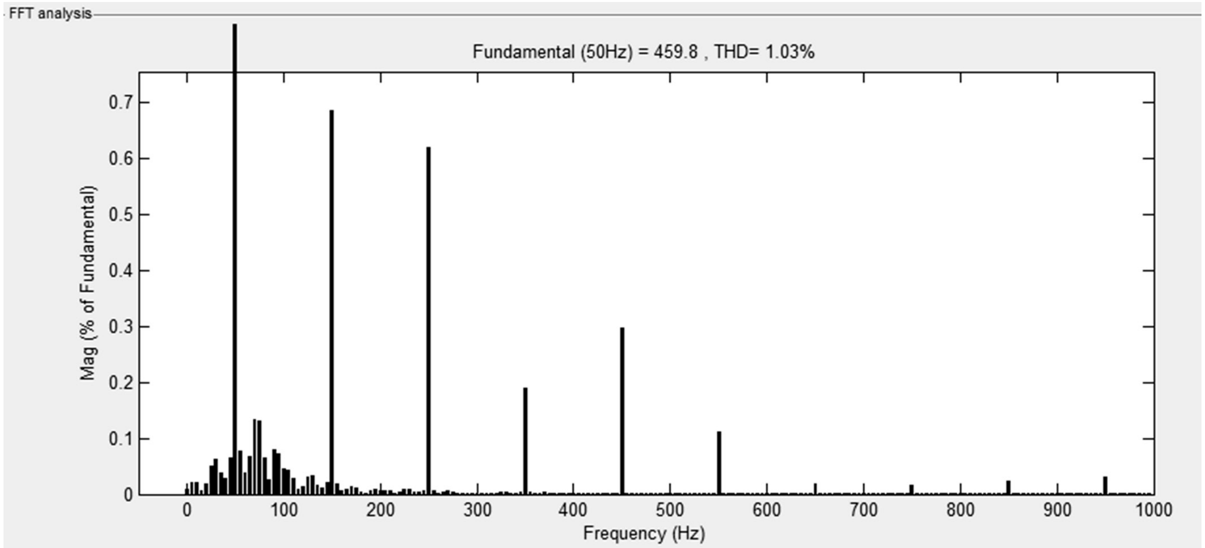

Figure 5: THD at Modulation Index 0.8

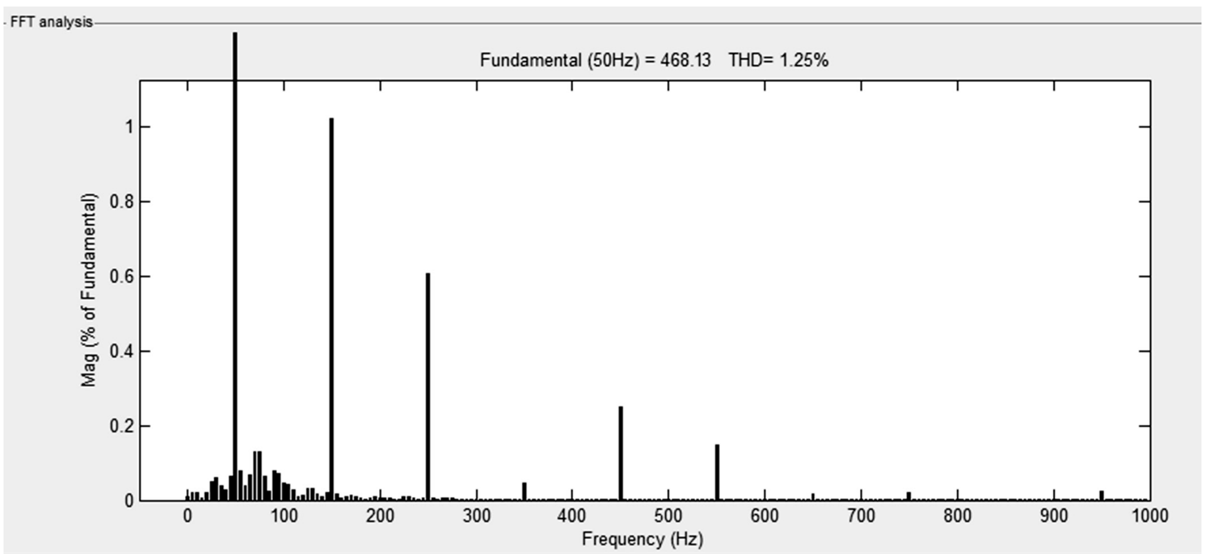

Figure 6: THD at Modulation Index 0.86

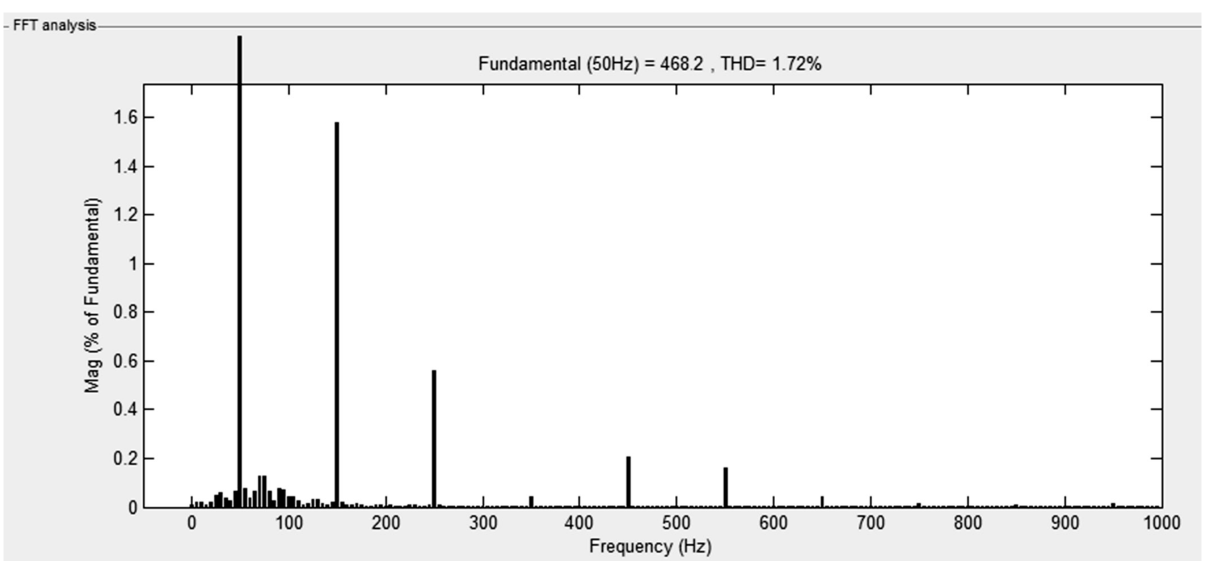

Figure 7: THD at Modulation Index 0.9

5. CONCLUSION

This work presents the optimal design of a multilevel inverter i.e. the design of the inverter which works on minimum THD and on high RMS value of the output voltage. THD and RMS of the inverter depends on the multilevel inverter, o by changing the modulation index harmonics and be minimized. Here, the optimal point of a multilevel inverter is calculated by constructing an objective function in terms of modulation index and input voltage. The point at which the inverter works more efficiently i.e. the THD is less at that point and the RMS value of output voltage is high is calculated using that objective function by using MATLAB.

References

1. Jih-Sheng Lai and Fang Zheng Peng, "Multilevel Converters-A new breed of power converters," *IEEE Trans. On Industrial Applications*, Vol. 32 No. 3, May/June 1996, pp. 509-517
2. L.M. Tolbert, F.Z. Peng, "Multilevel Converter a Utility a Interface for Renewable Energy System," in *Proceedings of 2000 IEEE Power Engineering Society Summer Meeting*. pp. 1271-1274.
3. "A Novel 15 Level Inverter for PV power system," Abdul Rahiman Bieg. Uday Kumar R.Y and V.T. Ranganathan.
4. Adithya S.N and Raghu Raman S, "Study of Multilevel Sinusoidal PWM Method for Cascade H-Bridge Inverter," *IEEE Trans*. 978-1-4799-3739, 2014.
5. Villanueva, Elena, Pablo Correa, Jose Rodriguez and Mario Pascas, "Control of a single phase cascaded H-Bridge multilevel Inverter for grid-connected PV system," *Industrial Electronics, IEEE Transaction on 56*, No. 11 (2009):4399-4406.
6. Chavrria, Javier, Domingo Biel, Frances Guinjoan, Carlos Mexa, and Juan J. Negroni, "Energy balance control of PV cascade multilevel grid-connected inverters under level-shifted and phase-shfted PWMs." Industrial Electronics, *IEEE Transactions on 60*, No. 1 (2013) 98-111.
7. Fang Zheng Peng, John W. Mckeever and Donald J. Adams, "A power line conditioner using Cascade Multilevel Inverters for Distribution system," *IEEE Transaction on Industrial Application*, Vol. 34, No. 6, pp. 1293-1298, Nov/Dec 1998.