Journal of Futuristic Sciences and Applications
Vol. 2(2), Jul-Dec 2019, pp. 56-65
doi: 10.51976/jfsa.221908
www.gla.ac.in/journals/jfsa

PWM Strategy with Multiple Carriers for Hybrid Multilevel Inverters Adapted from PV-Based

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ABSTRACT

This research makes a design recommendation for a multilayer solar inverter that uses the level shift pulse width modulation technology. Inverters that have numerous layers are able to take advantage of switching at many frequencies, with the fundamental frequency being the frequency with the lowest switching rate. In this particular instance, we make use of not one but two signals: one serves the function of a carrier signal, while the other serves the function of a reference signal. In multilayer level inverters (MLI), the triangle wave is used as a carrier signal, while the sinusoidal wave is employed as a reference signal for the method of pulse width modulation. In addition, the sinusoidal wave is used as a reference signal for the pulse height modulation technique. These two waves are combined to produce what is known as a multilayer level inverter (MLI). This study will conduct an in-depth investigation into how adjusting the level shift of the carrier signals affects hybrid PV-based MLIs and how to count harmonics in multilayer PV-based inverters. Both of these things increase voltage and significantly reduce losses. Both of these things are important for this study. Both of these subjects are going to be discussed at length in this investigation. In order to do an analysis of the voltage and current harmonics, a level shift method simulation is run on a multilayer cascaded hybrid PV-based inverter using Matlab/Simulink. This simulation is utilised to accomplish the task.

Keywords: *PV System; HMI; Harmonics Distortion; PWM; Matlab/Simulink.*

1.0 Introduction

Alternatives to the use of unconventional and polluting fossil fuels must be researched in view of the rising demand for energy and the increasing concern for the status of the environment in recent years. This is due to the fact that fossil fuels have been used as a source of energy for millions of years. When it comes to the control of pulse width modulation, MOSFETs, IGBTs, and other comparable devices are among the elements that are often employed. The generation of additional harmonics, which increases losses and also contributes to the system's heat issue, is the fault of two-level inverters. Due to the enormous increase in popularity it has recently seen, the idea of multilevel power conversion has recently attracted a lot of attention. Numerous potentially useful components are connected to the concept of power conversion multilayer inverters [1]–[3]. Due to its potential to be used for applications needing a lot of power, the multilayer inverter has recently received a lot of positive attention. Not only does it declare the maximum power rating, but it also endorses the usage of unconventional energy sources like

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solar energy, wind energy, and power devices as being able to be seamlessly integrated with the system. This specific system contains not one, not two, but three different multilayer inverter topologies. These specific architectural arrangements go by the designations FC, DC, and CHB converter with isolated dc sources. For multilayer converters like sinusoidal PWM, a suitable modulation scheme and control standard have also been achieved. This has been achieved by using methods like space vector modulation (SVM), level and carrier shifting PWM, the complete harmonics removal technique, and several other approaches [4, 5]. Multilevel power conversion is the process of changing direct current (also known as dc-to-ac) into alternating current. There are more than two distinct voltage levels used in this. Overall, smoother and less twisted power transfers are made possible as a result of this. The stepped waveform is created when the load is connected properly, which generates several distinct voltage levels. They needed to perform high-frequency trading in close proximity to a number of pulse width regulation approaches that were connected to regulating single-stage or three-stage voltage inverter systems in order to enhance the waveform of the output voltage [7]. Strategies for multicarrier pulse width modulation make use of a reference waveform that is sinusoidal, in addition to multiple separate carrier signals that are coupled with a triangular waveform. This is done in order to improve the signal quality. In this instance, a sample of the reference signal is obtained by the use of a variety of distinct carrier signals.

In order to obtain power without any losses and with the elimination of any harmonics that could occur, the power is converted from direct current to alternating current using more than two voltage levels, such as five levels, seven levels, and so on. This allows the power to be obtained without any harmonics that could occur. Utilizing the several alternative PWM techniques that are available in the MLI in order to get a higher output voltage while simultaneously reducing the amount of harmonic distortion [8].

This research makes a design recommendation for a multilayer solar inverter that uses the level shift pulse width modulation technology. Inverters that have numerous layers are able to take advantage of switching at many frequencies, with the fundamental frequency being the frequency with the lowest switching rate. In this particular instance, we make use of not one but two signals: one serves the function of a carrier signal, while the other serves the function of a reference signal. In multilayer level inverters (MLI), the triangle wave is used as a carrier signal, while the sinusoidal wave is employed as a reference signal for the method of pulse width modulation. In addition, the sinusoidal wave is used as a reference signal for the pulse height modulation technique. These two waves are combined to produce what is known as a multilayer level inverter (MLI). This study will conduct an in-depth investigation into how adjusting the level shift of the carrier signals affects hybrid PV-based MLIs and how to count harmonics in multilayer PV-based inverters. Both of these things increase voltage and significantly reduce losses. Both of these things are important for this study. Both of these subjects are going to be discussed at length in this investigation. In order to do an analysis of the voltage and current harmonics, a level shift method simulation is run on a multilayer cascaded hybrid PV-based inverter using Matlab/Simulink. This simulation is utilised to accomplish the task.

2.0 Cascaded Hybrid Multilevel Inverter

2.1 Seven level cascaded hybrid inverter

There are three different types of multilevel inverters that are utilised in high power AC supplies. These include the cascaded Hybrid, flying capacitor, and diode clamped multilevel inverters, as well as the series H-Bridge. Additionally well-known is the television series H-

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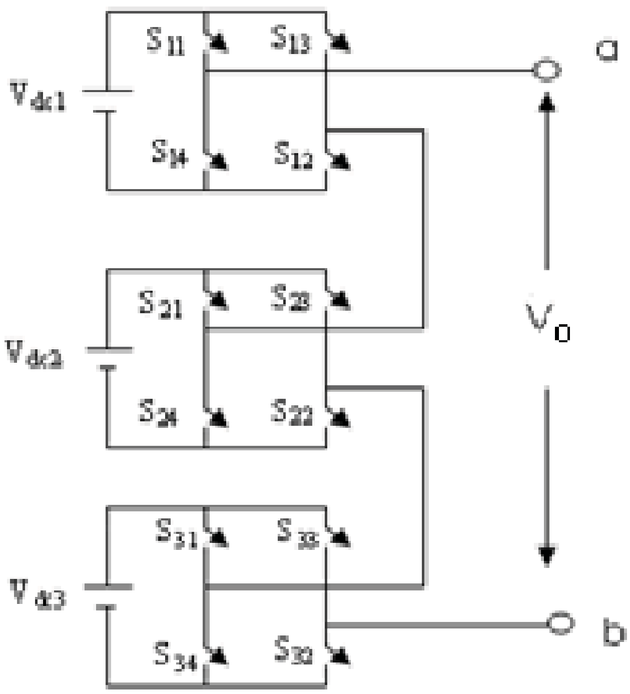
Bridge. The hybrid seven-level multilevel inverters that have been presented typically make use of a greater number of switches that are beneficial in the process of creating the output voltage when compared to other types of multilevel inverters that are already available on the market. This is because the hybrid seven-level inverters are able to convert between seven different voltage levels. In a series arrangement, the CHB is connected to each H-Bridge that is in the circuit. It comes with its own own dc sources that are built in. Controlling the output voltage of a cascaded multilevel inverter, which is equal to the total output voltage of each individual bridge in the cascade, may result in the production of a staircase waveform. This value is equal to the total output voltage of the cascade. As additional H-bridges are added to a stage, the voltage waveform that is produced at its output will, in general, take on a more sinusoidal shape. In order to create a single H-bridge system, the ac terminal voltages of many level inverters are linked in series using a variety of different combinations of the four switches designated as S1, S2, S3, and S4. Because of this, three separate voltage outputs are created, which are labelled as +Vdc, 0 Vdc, and –Vdc respectively. In order to solve the difficulty of calculating the level, one solution that has been proposed is to use the formula 2N+1, where N is the number of DC sources that are utilised in CHB. In this particular instance, N is a 3. After this is complete, we will go on to the first part of the PWM investigation, which will employ seven levels. Figure 1 [14]-[15] illustrates the seven layers of cascaded hybrid inverters that may be used:

Figure 1: Cascade Hybrid Multilevel Inverter with Single Phase

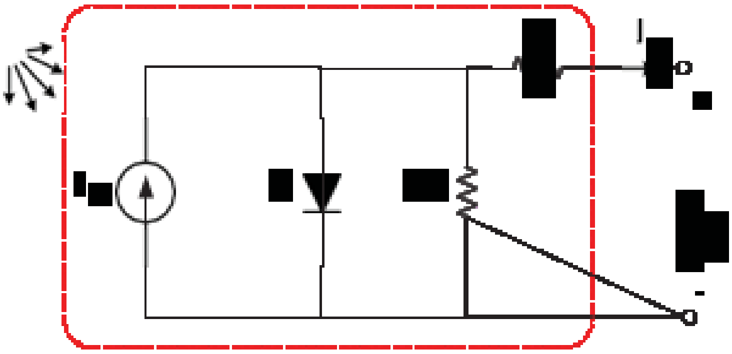


2.2 Equiva lent circuit of photovoltaic

Figure 2, which spans the range [9]–[10], contains the schematic representation of the PV module that corresponds to this range. In addition to a diode, it has a series resistance denoted by the symbol Rs and a shunt resistance denoted by the symbol Rsh. The created current (Iph), its progressions as a consequence of the sun's radiation, and the variable temperature all contribute to the overall effect. The output power, which is symbolised by the symbol Ppv, may be calculated by utilising the numbers [11]-[13] from the module:

$$P_{pv} = V_{pv} \times I_{pv}.$$

Figure 2: PV System



3.0 Switching Operation and Simulations

3.1 Switching operation of MLI

Table I: Switching of Multilevel Hybrid Multilevel PV Inverters

VDC	Switching of multilevel hybrid inverters											
	S11	S12	S13	S14	S15	S16	S17	S18	S19	S110	S111	S112
+3	1	1	0	0	1	1	0	0	1	1	0	0
+2	1	1	0	0	1	1	0	0	0	1	0	1
+1	1	1	0	0	0	1	0	1	0	1	0	1
	0	1	0	1	0	1	0	1	0	1	0	1
	1	0	1	0	1	0	1	0	1	0	1	0
-1	0	0	1	1	1	0	1	0	1	0	1	0
-2	0	0	1	1	0	0	1	1	1	0	1	0
-3	0	0	1	1	0	0	1	1	0	0	1	1

The energy needed to power the MLI's single phase comes from a combination of three different dc voltage sources. There is a chain of three CHB that must be completed in order to get all seven levels. The manner in which MLI may be modified is broken out in the table that is included with this article.

Throughout the course of this article, many different multicarrier-based modulation methods are discussed. These approaches are as follows.

a. PD PWM,

b. POD PWM and

c. APOD PWM

3.2 Phase disposition PWM

When using this strategy, the carrier signals travel in a phase from both above and below the reference axis. Additionally, they travel in both directions simultaneously.

Journal of Futuristic Sciences and Applications, Volume 2, Issue 2, Jul-Dec 2019
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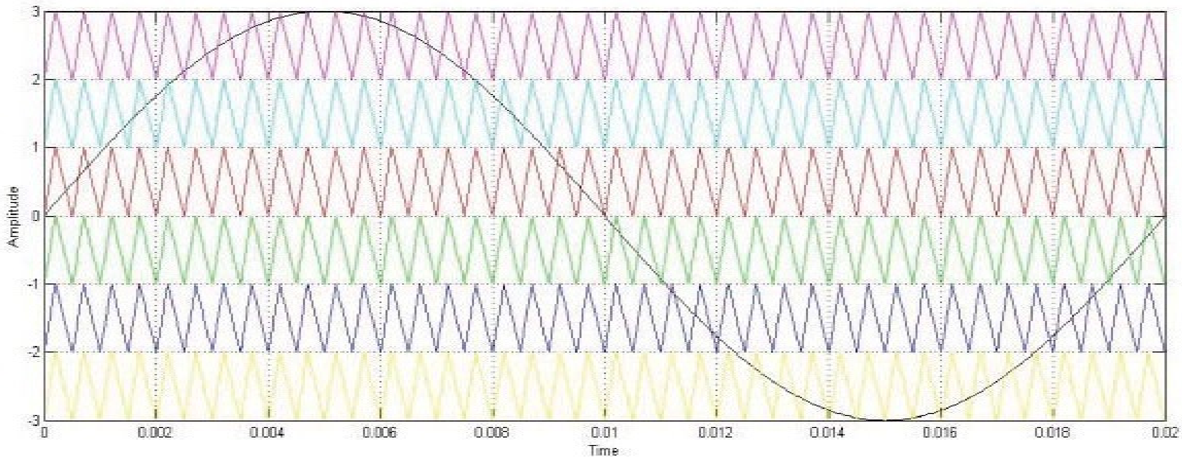
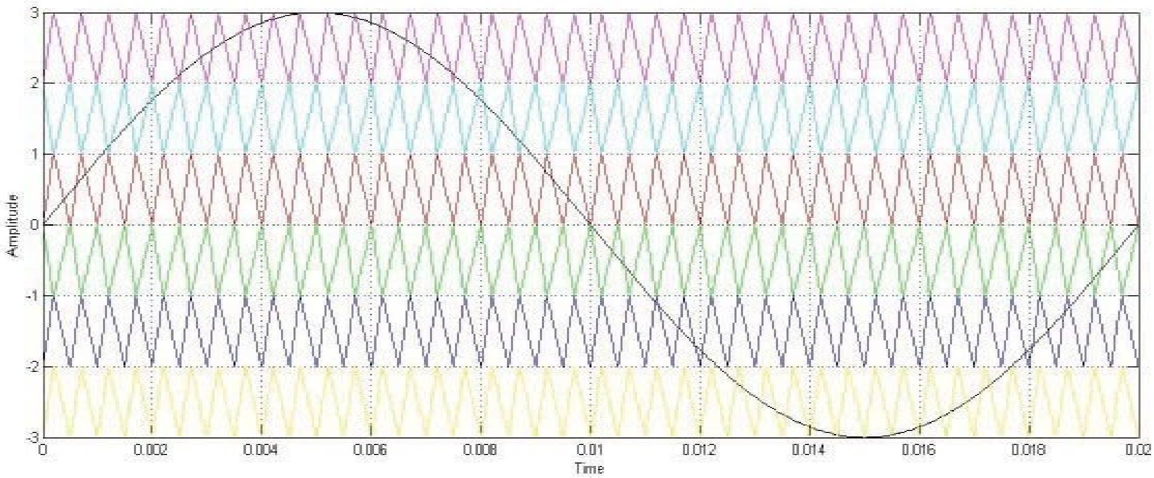
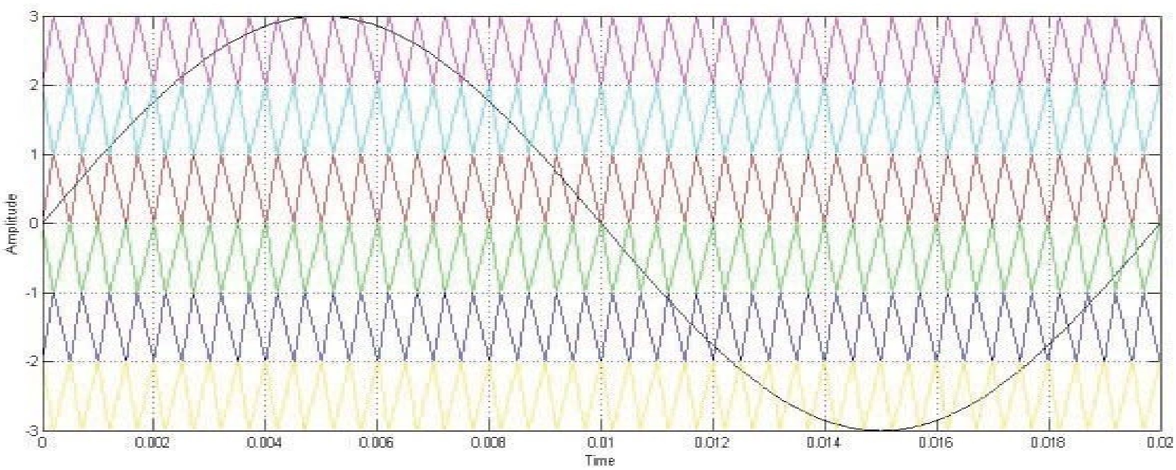


Phase Opposition and Disposition PWM:

Each of the carrier signals that are used in this strategy has its own distinct frequency as well as amplitude. The phase of the carrier signal above the reference axis is shifted by 180 degrees with regard to the phase of the carrier signal above it. However, the phase of all carrier signals above and below the reference axis are in sync with one another.



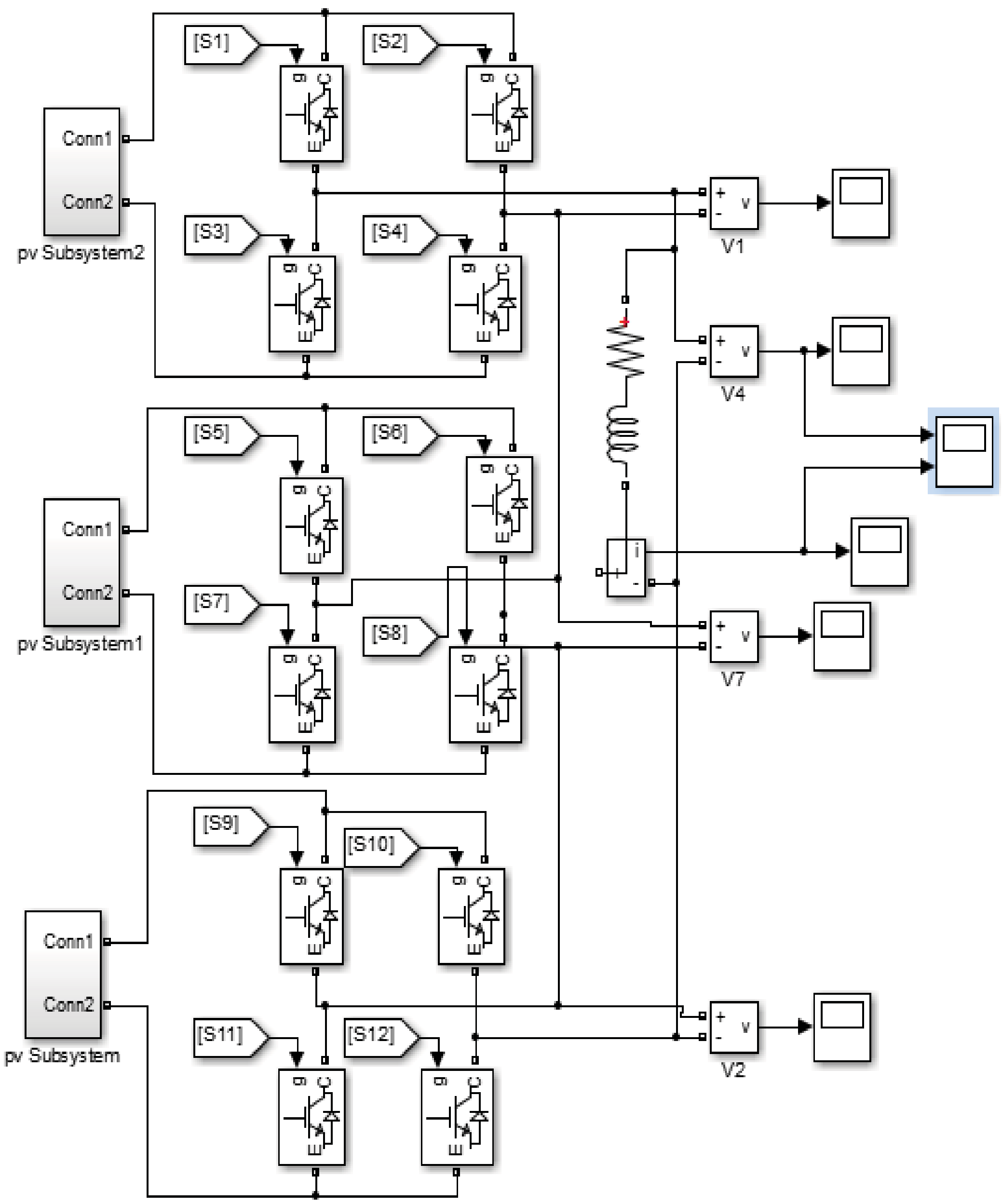
3.3 Alternate Phase opposition Disposition PWM



During the course of the implementation of this strategy, the amplitude and frequency of the carrier signals continue to be unaltered. The phase shift for the remaining alternative carriers is 180^0, and all of the alternative carriers are in phase with one another.

3.4 Modeling and Simulation of PV Inverter

Figure 3: Simulated Model of PV Connected Multi-level Inverter



The multi-level H-Bridge cascaded multilayer solar inverter simulation is now being carried out using the matlab/Simulink programming environment. Switching pulses for each H-bridge are generated by distinct multicarrier PWM algorithms, which are responsible for the creation of the switching pulses. The results of simulations run on a multilayer solar inverter are shown in Figure 3.

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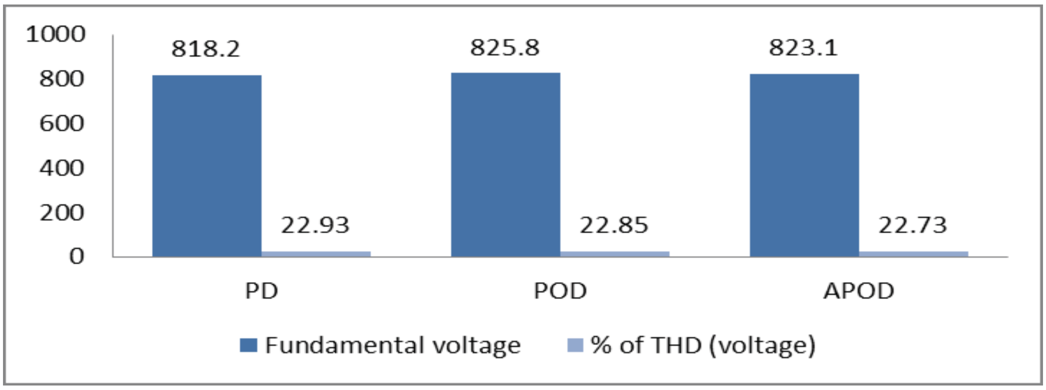
Table 2: Fundamental Voltage and Current, and Percentage of Voltage and Current THD on Different Strategy

Type of pwmstrategy	Fundamental voltage	% of THD (voltage)	Fundamental current	% of THD (current)
PD	818.2	22.93	7.655	22.67
POD	825.8	22.85	7.648	22.7
APOD	823.1	22.73	7.666	22.91

Figure 4: Depicts the Curve of the Percent of Voltage and Current THD for Carrier Placement PWM Systems



The fundamental output voltage and current are compared in Table 2, along with the percentage of total harmonic distortion (THD) for both the voltage and the current. The APOD method, which is one of the many included techniques, has the lowest feasible THD value compared to the others.

4.0 Results and Discussion

Figure 5: Response of Voltage THD Analysis for Phase Disposition PWM

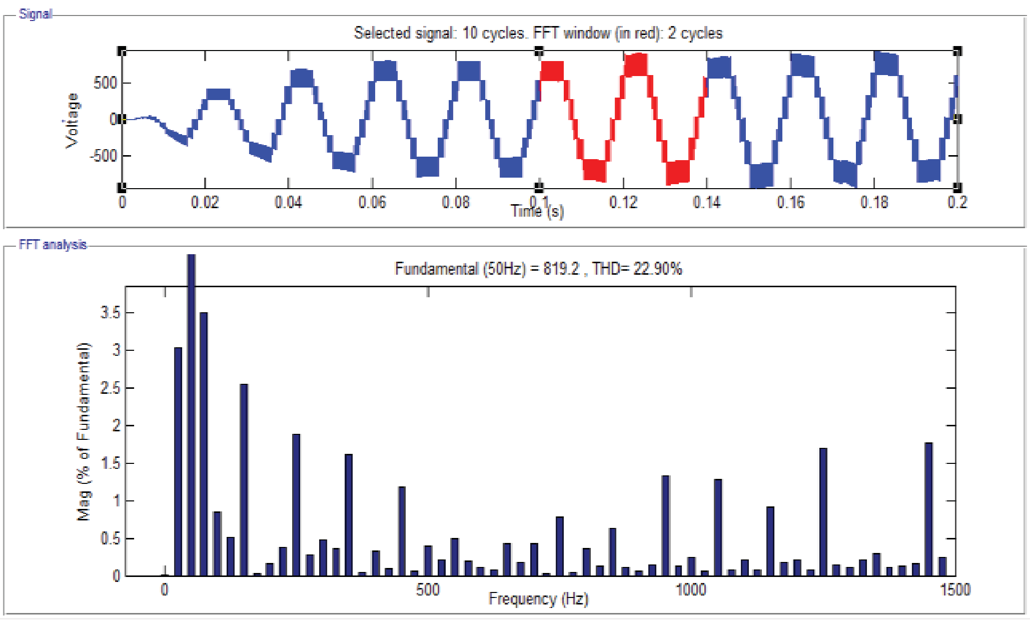


Figure 6: Response of Voltage THD Analysis for Phase Opposition and Disposition

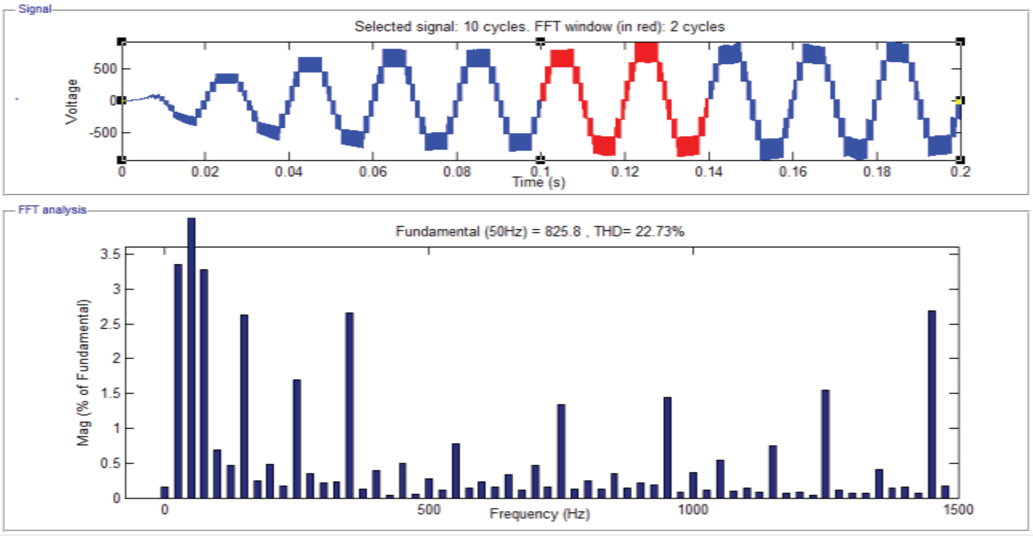
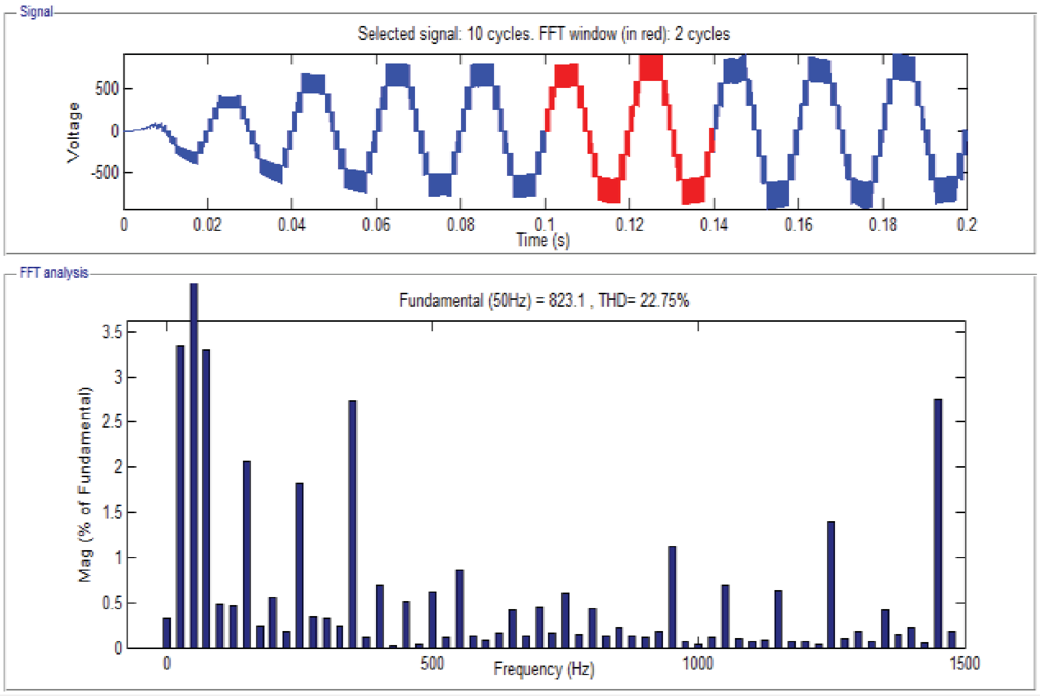


Figure 7: Response of Voltage THD Analysis for Alternate Phase Opposition Disposition



Figures 5 through 7 show the output voltage as well as an examination of the fast Fourier transform for the PD, POD, and APOD methods of a PV-based multilayer CHB inverter. All of the research results include the output voltage in addition to the proportion of voltage THD for each of the various methods. The POD approach is preferable to the PD strategy due to the fact that the percentage of voltage THD is lower under the POD strategy, despite the fact that the voltage is larger under the POD strategy. This is the reason why the POD method is better to the PD strategy. In addition, the APOD method provides a greater voltage while delivering a lower total harmonic distortion (THD) to others.

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5.0 Conclusion

Using a PV system-based hybrid multilevel inverter is recommended since the inverter's performance depends on the PWM techniques used. In the current investigation, a multilayer converter is used to connect the solar system to the reactive load (RL load), which enables the photovoltaic system to take in a greater quantity of electrical current. It has been shown that the PWM approach provides a number of performance indicators, such as total harmonics distortion and output voltage, which may be monitored. Other examples include the technology's ability to reduce power losses. As a consequence of this work's effective eradication of total harmonic distortion utilizing a number of methods, the fundamental output voltage was able to be increased. This was a significant improvement over previous effort. The Alternate Phase Opposition Disposition (APOD) approach of pulse width modulation (PWM) is the one that, as a consequence of all of these findings, generates the highest fundamental output voltage and the lowest overall harmonics distortion. Therefore, if you increase the level of the inverter, the output voltage will likewise rise. As a consequence, total harmonic distortion (THD) will be eliminated, and loss will be reduced. In order to manufacture an inverter with a higher level, the loss must be minimized to the greatest extent possible, and the whole harmonic distortion must be eliminated.

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