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Multilevel Inverters based on Photovoltaics System used with Multicarrier PWM

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ABSTRACT

The fundamental purpose of this research is to develop a photovoltaic-based MLI that implements a pulse width modulation strategy as its mode of operation. Within the context of this specific illustration of a multilayer inverter, two switches are used so that the fundamental frequency and the carrier frequency may be switched. The first three sections of this article focus on analyzing and discussing the impact that varied levels of carrier signal have on inverters. Determine the effect that it has on the voltage, current, and harmonics distortion. Check to determine what type of impact it has. Second, the effect of the change in output under various loads in the PV-based multilayer inverter and the counting of the harmonics that resulted from that change. Another one of the comparisons between a seven-level inverter and a nine level hybrid inverter and its harmonics used a multilevel PV-based inverter to decrease the harmonics distortion, boost the output voltage, and illustrate the influence in losses. This was one of the comparisons that involved a seven-level inverter. Calculations and results acquired from a modified version of the MATLAB program indicate that the whole harmonics range may be covered by combining the level change technology with multi-stage hybrid inverters. These calculations and results were achieved.

Keywords: *Photovoltaic System; Multilevel Inverter; Nine Level Inverter; PWM Strategy; Harmonics Elimination.*

1.0 Introduction

The present situation of energy consumption is rapidly expanding to levels not seen in a few decades thanks to the activities of consumers. Since the beginning of the previous several decades, this has been the situation. The quality of the energy that is generated is continually deteriorating as a result of the rising load demand that is occurring all across the globe. On the other hand, the conventional resources will all of a sudden become far more difficult to get. The majority of countries have made the decision to generate a large quantity of energy from renewable sources [1], as a result of a decrease in conventional resources and an increase in the number of problems caused by conventional resources for the environment, such as the depletion of fossil fuels, changes in the atmosphere, and the effects of greenhouse gas emissions, etc. The majority of these problems have been caused by conventional resources, which have also led to an increase in the number of these

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problems. In addition, there has been a persistent upward trend in the demand for energy that is derived from renewable sources. In this context, the advantages of not being contaminated are more adequately brought into play. Solar photovoltaic panels are anticipated to be the most favourable sources of energy in the future given that they supply a substantial amount of energy at rates that are affordable and release a very low amount of carbon [2]. [3]. The photovoltaic (PV) applications are connected to the inverter, which has a structure that is quite simple; nonetheless, the harmonics distortion causes a rising quantity of energy to be squandered [4]. In order to address these concerns, it was decided that power applications would benefit from making use of several inverters. The classic MLI method is comprised of the NPC, FC, CHB, and modular multilevel converter as its constituent parts [5].

The term "multilevel inverters" refers to an increase in the number of levels that are capable of being converted in addition to an improvement in the overall quality of the power that is distributed throughout distribution networks [6]. The inverter has an output voltage that is not sinusoidal and has a pattern that is similar to a wavelength that has been skipped through. connected in such a manner that the load is given with the optimal number of levels together with the sine wave by the switches that are being adjusted. In other words, the switches are linked in such a way as to make this possible. [7].

The PWM strategy was included into the MLI plan and played an important role. The operation was successful in establishing a constant switching frequency of the MLI by making use of a number of different techniques, such as PD, POD, and APOD. The technique for N-number of level multilevel inverters (N-1), which can be found in [8]-[10, includes the usage of carrier signals as an integral element of the process. The MLI has been proposed as a possible new PWM switching technology in recent discussions. Inverters designed for a single phase with a total of nine levels, complete with the essential inductor and the required minimum capacity. The different strategies used by the MLI are analysed in [11] and [12], respectively. On the other hand, they do not have any connections to any photovoltaic sources. In [13], a novel PWM switching mechanism is presented as a potential answer to the problem of MLI. Inductor, as well as an insufficient market demand for single-phase nine-stage inverter capacity [14]. The nine-level CHB is related to PV sources by the use of LC filters [15], however there is only one PWM scheme used.

The fundamental purpose of this research is to develop a photovoltaic-based MLI that implements a pulse width modulation strategy as its mode of operation. Within the context of this specific illustration of a multilayer inverter, two switches are used so that the fundamental frequency and the carrier frequency may be switched. The first three sections of this article focus on analyzing and discussing the impact that varied levels of carrier signal have on inverters. Determine the effect that it has on the voltage, current, and harmonics distortion.

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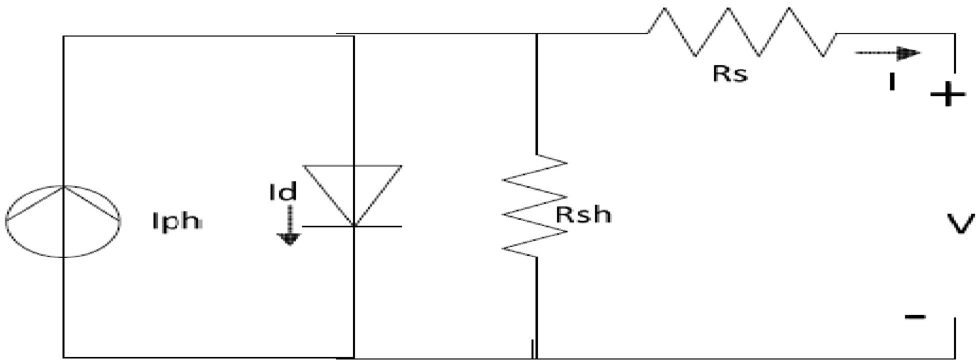
2.0 Photovoltaic System

2.1 Photovoltaic system

The solar system is integrated into the circuit by the use of the 1-O MLI, which is the component that connects the PV system to the circuit [16]. They are used as four distinct dc sources, and sixteen switches, so that a nine-level output voltage may be constructed using the components.

Figure 1: Photovoltaic System



2.2 Modeling of photovoltaic system

The diagram in [16] provides a graphical illustration of the schematic representation of a PV system in its equivalent form. The current at the output is determined by utilizing the figure shown at the top, Module photocurrent,

$$I = I_{ph} - I_d - I_{sh} \qquad (1)$$

$$I_{ph} = [I_{sc} + k_i\,(T - T_r)]\;G \qquad (2)$$

Diode current given as-

$$I_d = I_o\left[\exp\left(\frac{qv}{nkT}\right) - 1\right] \qquad (3)$$

Module reverse saturation current,

$$I_{rs} = \frac{I_{sc}}{I_d = I_o\left[\exp\left(\frac{qv_{oc}}{nkT}\right) - 1\right]} \qquad (4)$$

$$I_o = I_{rs}\left[\frac{T}{T_r}\right]^3 \exp\left[\frac{qE_{go}}{nk}\left(\frac{1}{T} - \frac{1}{T_r}\right)\right] \qquad (5)$$

The PV output current is

$$I = N_p I_{ph} - N_p I_o\left[\exp\left(\frac{\frac{V}{N_s} + \frac{IR_s}{N_p}}{nV_t}\right) - 1\right] - I_{ph} \qquad (6)$$

$$V_t = \frac{kT}{q} \quad \text{and} \quad I_{sh} = \frac{V\frac{N_p}{N_s} + IR_s}{R_{sh}} \qquad (7)$$

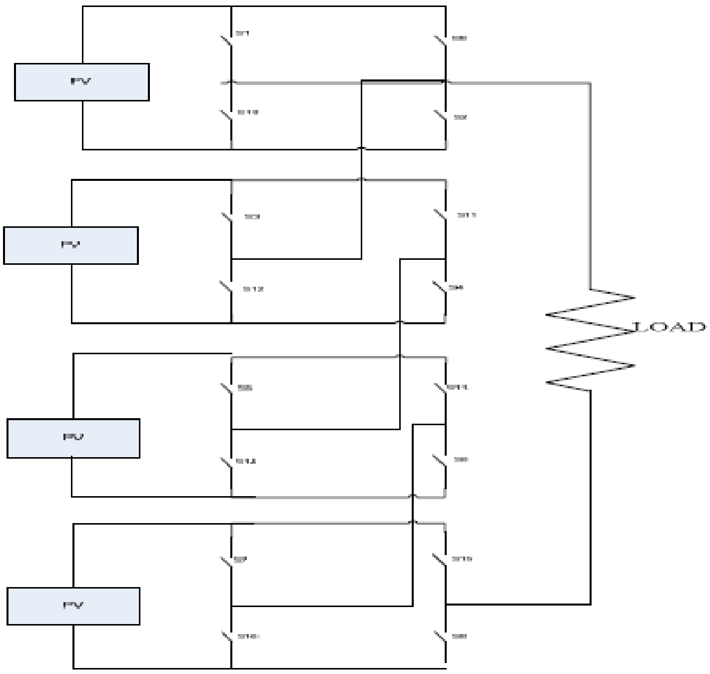
Series Resistance (Rs), shunt resistance (Rsh) etc.

3.0 Cascaded Hybrid Multilevel Inverter (Chb-Mli) and PWM Strategy

3.1 Cascaded hybrid multilevel inverter

An inverter that is powered by photovoltaic cells and has nine different levels is referred to as a serial-connected complete bridge inverter. This particular kind of inverter accepts input from more than one source at once. These direct current sources are provided by the batteries that are a component of the photovoltaic system. The modulation of the output range from the many different dc sources was primarily the responsibility of CHB. Each hybrid was required to have one PV in addition to a clear boost converter load of MLI for the photovoltaic-based NLI, as shown in figure [17]. This was a requirement for the NLI.

Figure 2: Circuit Diagram of PV based Nine Level Inverters



$$V_o = \sum_{4N-1}^{N} HBn = V_{HB1} + V_{HB2} + \cdots \ldots\ldots + V_{HBk}$$

In the event that there is a problem, CHB-MLI will provide a straightforward replacement of either the individual component or the whole circuit that is creating the problem. Even if the component [18] that is malfunctioning is removed from the circuit, electricity would still continue to flow through it. [Citation needed] In spite of the fact that the output voltage will gradually decrease, this will continue to be the case. Because a traditional VSI has two levels, the whole circuit will be blocked while this period is in effect because of this feature. The magnitude of the variable has a significant role in determining the level of the output voltage:

$R = 2h + 1$

Where, output voltage level (G), number of H-bridge (h).

3.2 Nine level cascaded hybrid inverter

The majority of the time, the nine-level hybrid MLI that has been proposed will dispose of a selection of switches that are helpful for generating the current as well as the contrasting output voltage. These switches are often removed from use. The CHB and each H-Bridge are now connected to one another through the created link. It is powered by a separate dc source that is independent. The output of a cascaded MLI is the cumulative output of the individual bridges, which may be altered in order to create a waveform stair flight. This is the same as saying that the output of an individual

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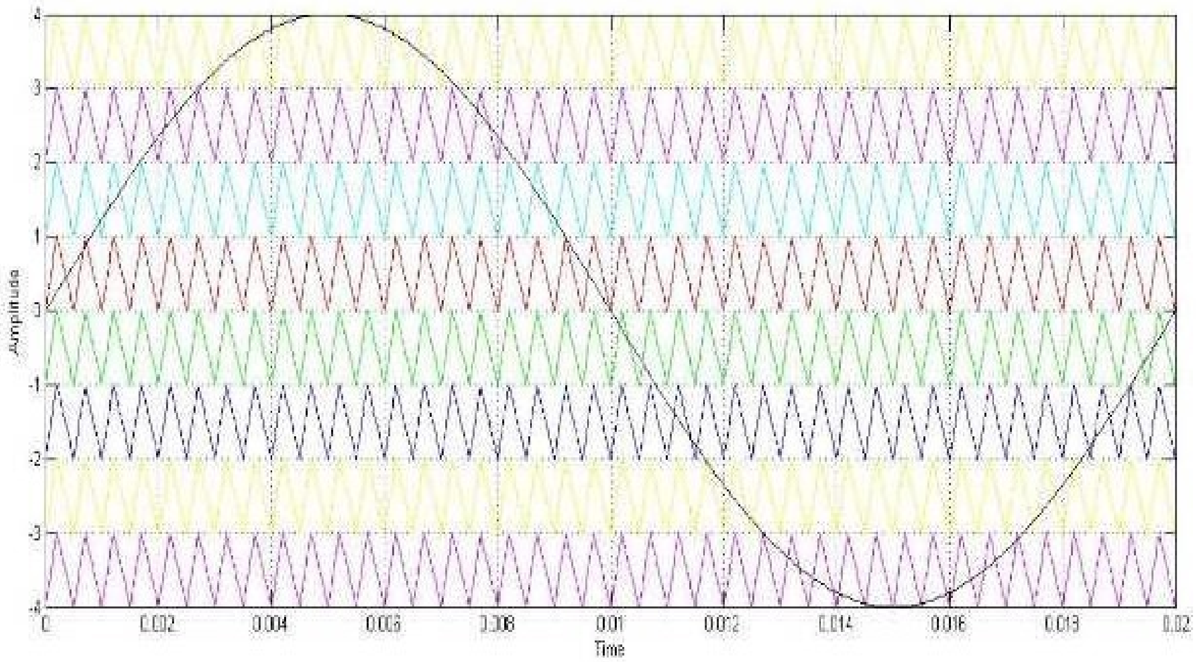
bridge equals the output of the cascaded MLI. You may think of this output as the total of the outputs from all of the various bridges. When all is said and done, the waveform of the output voltage is more sinusoidal, and it has a rise that corresponds to each step that the H-bridge takes. Within this framework, doing an analysis of the PWM presentation will be broken up into nine parts.

3.3 Modulation using pulse width

The NLI makes use of a wide range of modulation methods in order to create its firing pulses. The SVM and CBM algorithms are the ones that shine the brightest in the scenario in which the switching frequency is rather high. When there are more voltage levels, the SV approach is more difficult to put into practise because of the added complexity. As a result, the CBM technique is used almost exclusively. The CBM approach uses either level shifting methods or level shifting strategies to arrange the carriers in their CBM configuration. The level shift modulation technique that was developed in this paper is applied to the PV-based multilevel inverter in its most fundamental form. PD modulation, POD modulation, and APOD modulation methods are the names given to the three distinct forms of level shifting modulation techniques.

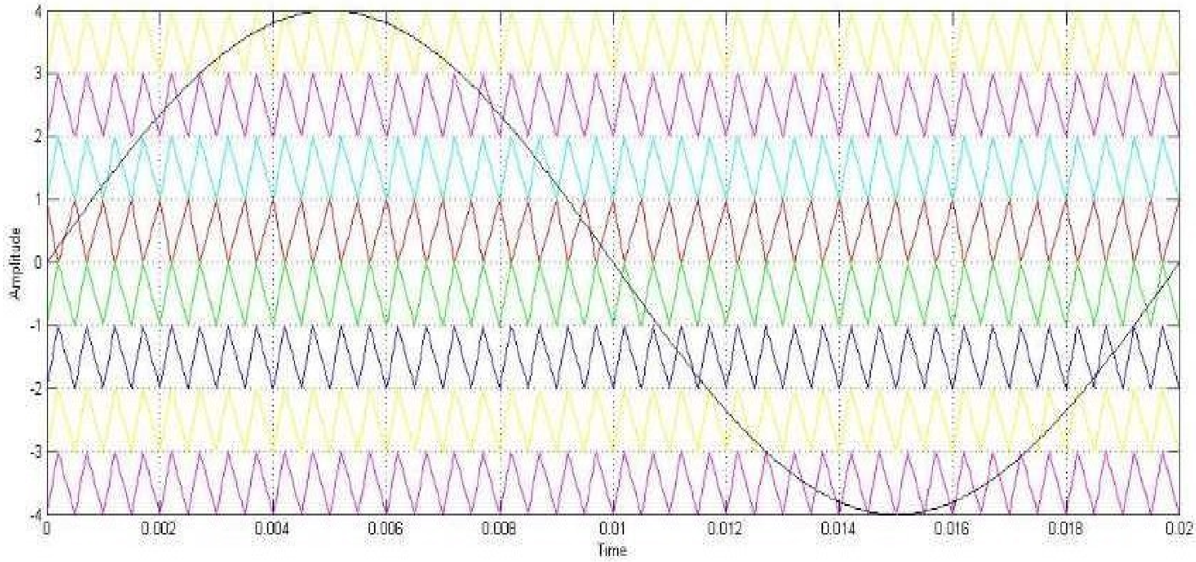
3.4 Phase disposition PWM



At one level of this approach, the carrier signals flowing from both above and below the reference hub are taken into consideration.

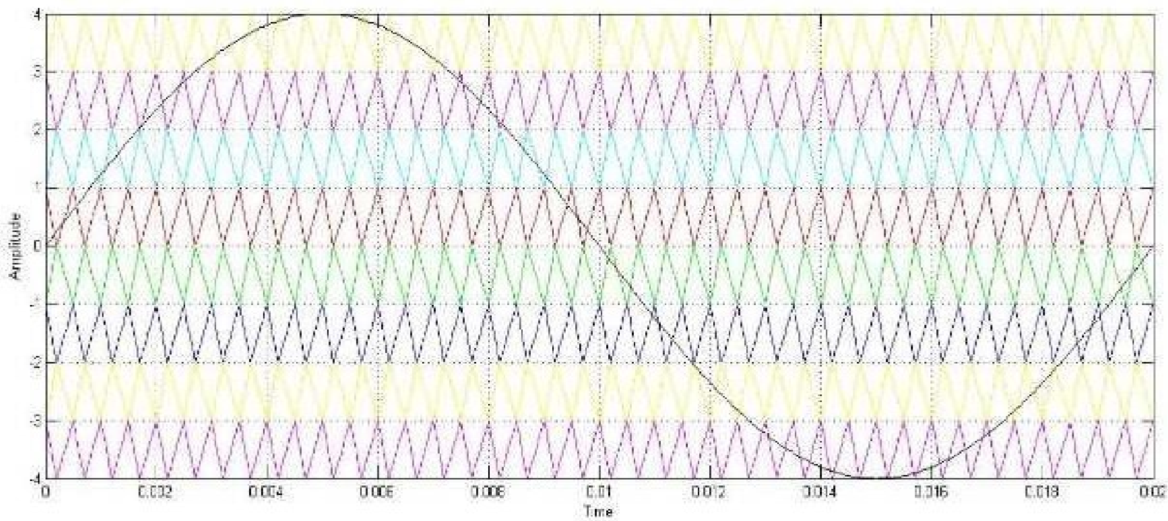
3.5 Phase Opposition and Disposition PWM

When this particular action is being carried out, the signals of the carrier have both an amplitude and a frequency. Along with the carrier signal that is located above the reference pivot, the carrier signals that are located above and below the pivot are also shifted by 180 compliance to the same point as the carrier signal that is located above the pivot.



3.6 Alternate Phase opposition Disposition PWM:

While this procedure is being carried out, neither the loudness nor the frequency of the transmitter will change. Both of the options now being considered are going through a phase, and 1800 is exerting pressure on the other options.



4.0 Results and Discussions

Table I: distribution of voltsge and current

PWM Strategy	voltage	% of THD (Voltage)	Current	% of THD (Current)
PD	878.6	19.36	0.08786	19.32
POD	878.5	19.49	0.08785	19.47
APOD	880.3	19.23	0.08803	19.41

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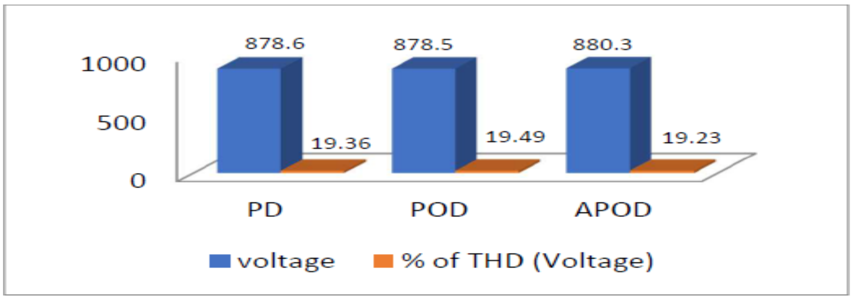


The graph on the right shows the total harmonic distortion (THD) as a percentage and the basic output voltage for each of the available methods. A variety of PWM approaches show how the fundamental voltage and the total harmonic distortion are affected by the different strategies. With all of the PWM approaches, harmonic distortion was fully eradicated.

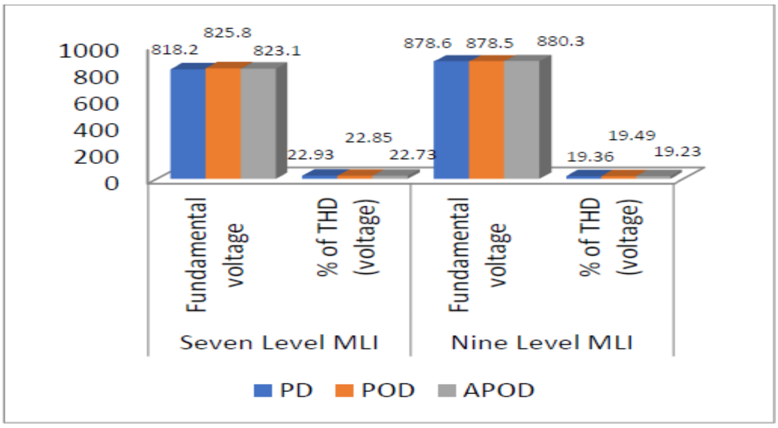
Table II: Shows the Percentage of Total Harmonics Distortion at Various Loads

	% of THD (Voltage) at various load			
PWM Strategy	100 KΩ	10 kΩ	1 kΩ	100 Ω
PD	19.33	19.36	19.55	22.21
POD	19.46	19.49	19.67	21.31
APOD	19.2	19.23	19.43	20.98

The load comparisons are shown in the graph above for your consideration. The THD count shows that when the load increases, the total harmonic distortion decreases as compared to its level when the load is modest. This is due to the fact that one of the several PWM algorithms is used to calculate the THD count.

Table III: Shows the Comparison of the Seven Levels and Nine Levels MLI

PWM Strategy	Seven Level MLI		Nine Level MLI	
	Fundamental voltage	% of THD (voltage)	Fundamental voltage	% of THD (voltage)
PD	818.12	22.92	878.61	19.35
POD	825.8	22.85	878.5	19.49
APOD	823.1	22.73	880.3	19.23



The results of a comparison between MLI levels seven and nine are shown in the graph included in this article. The graph shows that the fundamental output voltage increases as the overall harmonic distortion decreases for a total of nine level inverters. It's also clear from the graph that this is happening despite the fact that overall harmonic distortion has decreased.

Figure 3: Analysis of THD of Voltage for Phase Disposition

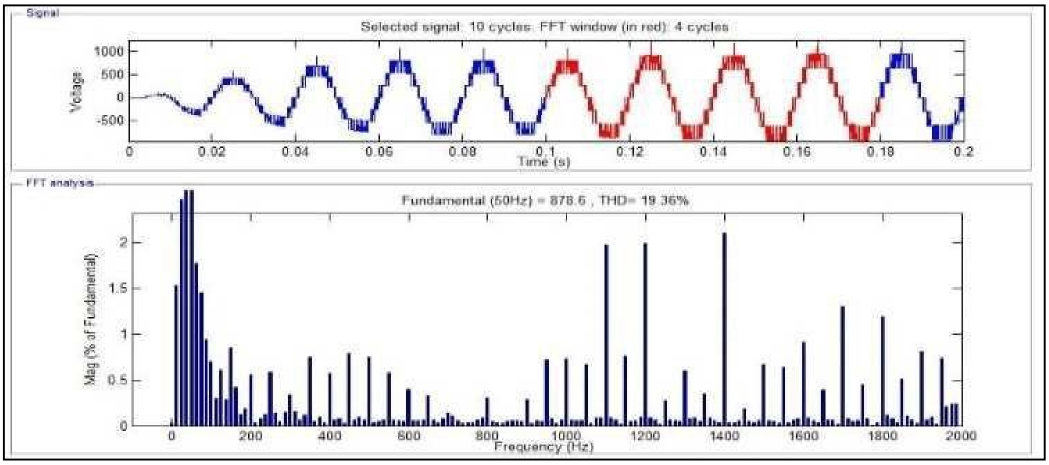


Figure 4: Analysis of THD of Voltage for Phase Opposition Disposition

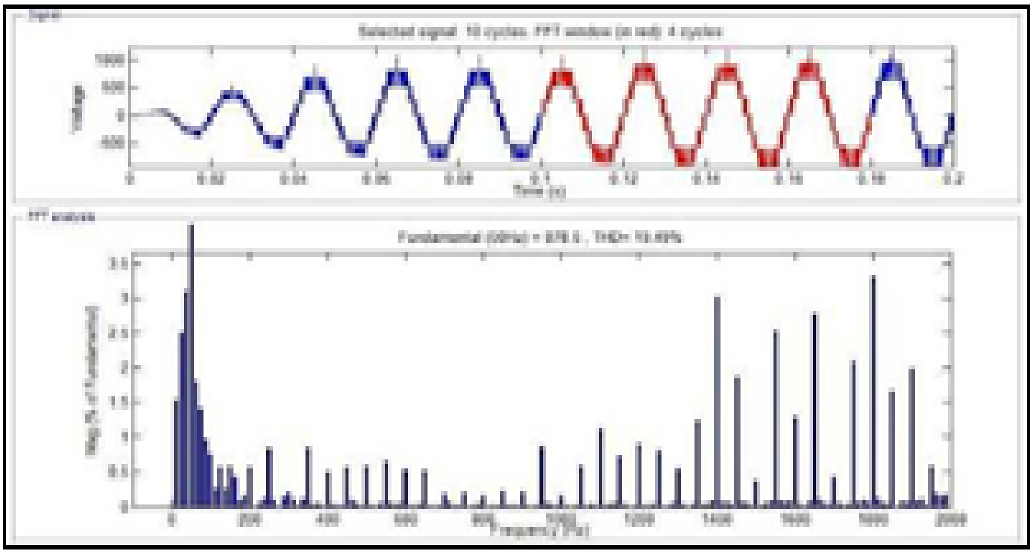


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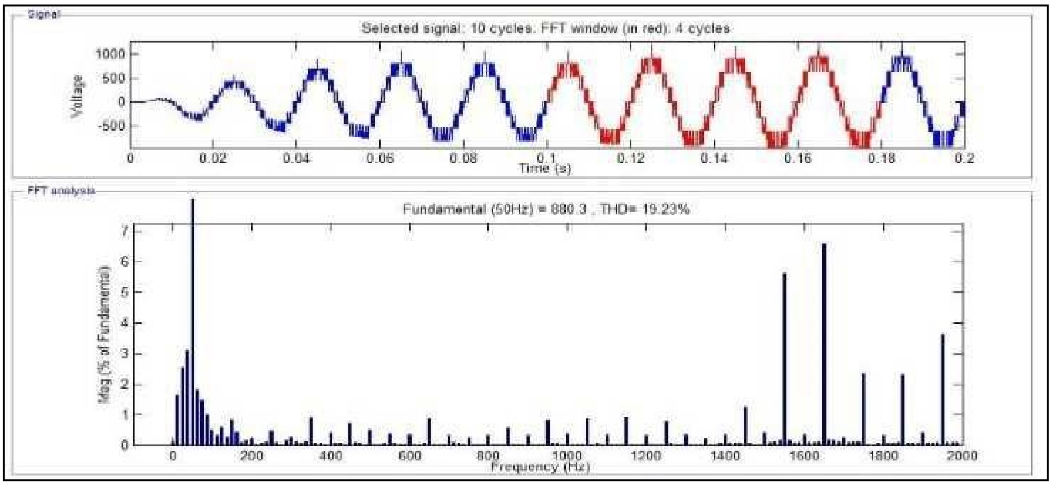
Fig. 5. Analysis of THD of voltage for Alternate Phase opposition Disposition



To investigate the output voltage of PD, POD, APOD, and MLI CHB PV dependent inverters, see Figures 3 through 5. These detailed data provide insight on the voltage and voltage level of the THD during the various operations. Because the quantity of THD voltage is less and has higher voltages than other processes, the two approaches correlate more than other systems. ' As a result, voltages are higher in both directions. As can be seen, this is because the THD voltage is directly proportional to the square of the signal.

5.0 Conclusion

A particular kind of nine-level inverter is being investigated by researchers in order to obtain data for their study on how to eliminate harmonics. The MLI claims to improve the output voltage waveform while decreasing the total harmonic distortion (THD). The CHB MLI's output smooths out and becomes more sinusoidal as the voltage level is raised. Over the course of this essay, nine different inverters are explored. APOD was determined to provide the highest output voltage, lowest harmonic distortion, and lowest losses out of the three separate PWM techniques used on the MLI. However, all three approaches were compared and contrasted. As load increases to 100, the THD for RL load due to CHB MLI is reduced. ' That's in contrast to the increased THD at lesser loads. When the load is set to 100 percent, the total harmonic distortion (THD) is decreased, but the voltage generated is increased as a consequence. A comparison between the results of seven and nine level inverters is shown in the third part of this article. The nine level inverters outperform the seven level inverters in terms of output voltage and harmonic distortion. PWM's overall performance is enhanced by the use of nine-level inverters, which reduce harmonic distortion and increase output voltage. The method's nine various level inverters are directly responsible for these benefits. MATLAB A study conducted using Simulink came up with positive results in favor of the strategy advocated. The increasing power density of PV applications makes this approach, despite its uncontrolled information flow, a viable option.

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