WALIA journal 30(1): 119-123, 2014
Available online at www.Waliaj.com
ISSN 1026-3861
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Implementation sinusoidal pulse width modulation (SPWM) in three level inverters for hybrid PV/Wind system

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Abstract: This paper is going to represent the application of sinusoidal pulse width modulation in Three Level Diode clamped inverters for renewable energy sources. In this era utilization of renewable energy sources is more. The producing of the renewable energy power to loads is very important .In this section multilevel inverter is used to convert power to load according to requirement .A control technique sinusoidal pulse width modulation is applied to the three levels inverter to produce AC output voltage to load. The simulation results are given below using MATLAB in this shown output values.

Key words: *Renewable energy sources; Multilevel inverters; Sinusoidal pulse width modulation*

1. Introduction

Meat The Demand for renewable energy has increased significantly over the years because of shortage of fossil fuels and greenhouse effect. The definition of renewable energy includes any type of energy generated from natural resources that is infinite or constantly renewed. Examples of renewable energy include solar, wind, and hydropower. Renewable energy, due to its free availability and its clean and renewable character, ranks as the most promising renewable energy resources like solar energy, Wind energy that could play a key role in solving the worldwide energy crisis. Among various types of renewable energy sources, solar energy and wind energy have become very popular and demanding due to advancement in power electronics techniques. Photovoltaic (PV) sources are used today in many applications as they have the advantages of effective maintenance and pollution free. Solar electric energy demand has grown consistently by 20% to 25% per annum over the past 20 years, which is mainly due to its decreasing costs and prices. This decline has been driven by the following factors.

1) An increasing efficiency of solar cells

2) Manufacturing technology improvements

3) Economies of scale

PV inverter, which is the heart of a PV system, is used to convert dc power obtained from PV modules into ac power to be fed into the grid. Improving the output waveform of the inverter reduces its respective harmonic content and, hence, the size of the filter used and the level of Electromagnetic Interference (EMI) generated by switching operation of the inverter. In recent years, multilevel inverters have become more attractive for researchers and manufacturers due to their advantages over conventional three level PWM inverters. They offer improved output waveforms, smaller filter size and lower EMI, lower Total Harmonic Distortion (THD). The three common topologies for multilevel inverters are as follows:

1) Diode clamped (neutral clamped)

2) Capacitor clamped (flying capacitors)

3) Cascaded H-bridge inverter

In addition, several modulation and control strategies have been developed or adopted for multilevel inverters, including the following multilevel sinusoidal (PWM), multilevel selective harmonic elimination, & Space Vector modulation. A typical single-phase three-level inverter adopts full-bridge configuration by using approximate sinusoidal modulation technique as the power circuits. The output voltage then has the following three values: zero, positive (+Vdc), and negative (−Vdc) supply dc voltage (assuming that Vdc is the supply voltage). The harmonic components of the output voltage are determined by the carrier frequency and switching functions. Therefore, their harmonic reduction is limited to a certain degree. To overcome this limitation, this paper presents a five-level PWM inverter whose output voltage can be represented in the following five levels: zero, +1/2Vdc, Vdc, −1/2Vdc and −Vdc. As the number of output levels increases, the harmonic content can be reduced. This inverter topology uses two reference signals, instead of one reference signal, to generate

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PWM signals for the switches. In balanced dc bus voltage, and low common mode voltage. The three level multilevel configuration is explained in section II. The sinusoidal pulse width modulation is most advantageous technique, which is used in three level diode clamped inverter, is showed in section III (Mohan, et al., 1995).

2. Multilevel inverter configuration

In the 1990s several researchers published articles that have reported experimental results for four-, five-, and six-level diode-clamped converters for such uses as static var compensation, variable speed motor drives, and high voltage system interconnections .A three-phase three-level diode-clamped inverter is shown in Figure 1. Each of the three phases of the inverter shares a common dc bus, which has been subdivided by two capacitors into three levels. The voltage across each capacitor is V_{dc} and the voltage stress across each switching device is limited to V_{dc} through the clamping diodes. Advantages of the diode clamped multilevel inverter as given below. All of the phases share a common dc bus, which minimizes the capacitance requirements of the converter.

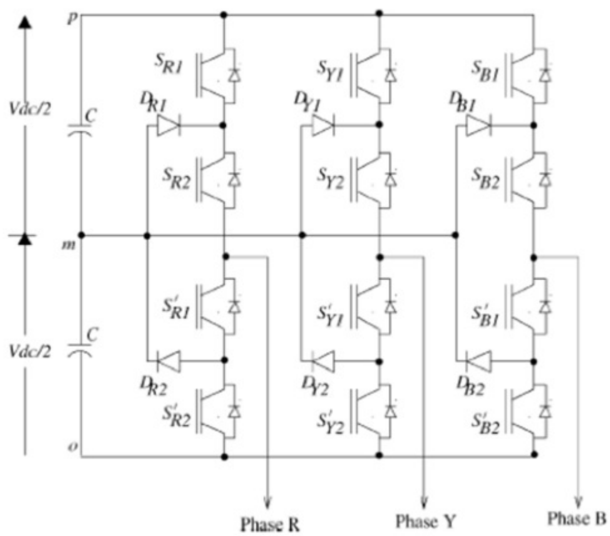

Fig.1: three level diode clamp inverter

For this reason, a back-to-back topology is not only possible but also practical for uses such as a high-voltage back-to-back inter-connection or an adjustable speed drive. The capacitors can be pre-charged as a group. Efficiency is high for fundamental frequency switching. As well as the disadvantages of the these inverter are shown below. Real power flow is difficult for a single inverter because the intermediate dc levels will tend to overcharge or discharge without precise monitoring and control. The number of clamping diodes required is quadratically related to the number of levels, which can be cumbersome for units with a high number of levels.

The renewable energy source like wind, solar and fuel cells are used to input to the supply of diode clamped inverters in this inverter. It is promising that a dc micro grid consisting of a photovoltaic panel as a RES, battery as an energy storage (ES), and a diesel generator set as a standby source is implemented so that net-zero energy for telecommunication building could be accomplished. The dc micro grid with superb quality distribution system for residential application has been proposed in (Stankovic and Lipo, 2000). And the low voltage distribution system for commercial power systems with sensitive electronic loads has been investigated in (Moran et al., 1992). For dc distribution in telecommunication buildings, a high power converter (about 100 kW) with high quality output voltage waveform, high efficiency, and single phase and three phase electrical system available is required Therefore, multilevel inverters are suitable for this application because a multilevel inverter can provide the high volt-ampere ratings; more specially, in renewable energy applications, a cascaded H-bridge multilevel inverter can be applied to interface a group of batteries, photovoltaic or fuel cells. A cascaded multilevel inverter may have more potential than other multilevel topologies since input separated dc sources (SDCS) could be naturally interfaced to the multilevel inverter to provide higher output voltages with high quality waveforms.

3. Sinusoidal pulse width modulation

In the paper control technique of sinusoidal pulse width modulation (SPWM) strategy is employed. In this method, a number of triangular waveforms are compared with a controlled sinusoidal modulating signal. The switching rules for the switches are decided by the intersection of the carrier waves with the modulating signal. The proposed seven level inverter, one modulating signal and six carrier waves are necessary for each phase of the inverter as shown in Figure 2.

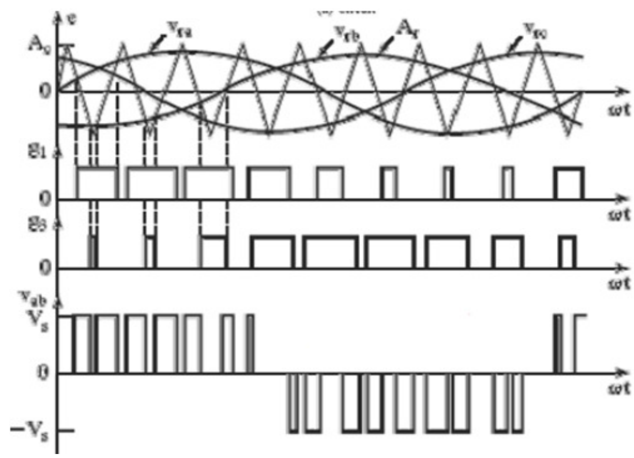

Fig.2: Sinusoidal pulse width modulation

It is similar to single-phase SPWM but with 3-reference sine waveforms shifted by 120° each.

$$m_f = \frac{f_c}{f_o}$$

m_f=frequency modulation

frequency modulation should be odd multiple of 3. Although the SPWM waveform has harmonics of several orders in the phase voltage waveform, the dominant ones other than the fundamental are of order n and n±2 where n = fc/fm. This is evident for the spectrum for n=15 and m = 0.8 shown i. Note that if the other two phases are identically generated but 120o apart in phase, the line-line voltage will not have any triple n harmonics. Hence it is advisable to choose, as then the dominant harmonic will be eliminated. It is evident from Fig 5, that the dominant 15th harmonic is effectively eliminated in the line voltage. Choosing a multiple of 3 is also convenient as then the same triangular waveform can be used as the carrier in all three phases, leading to some simplification in hardware. It is readily seen that as the where E is the dc bus voltage, that the rms value of the output voltage signal is unaffected by the PWM process. This is strictly true for the phase voltage as triple harmonic orders are cancelled in the line voltage. However, the problematic harmonics are shifted to higher orders, thereby making filtering much easier. Often, the filtering is carried out via the natural high-impedance characteristic of the load (Moran et al., 1992).

4. IV.SIMULATION RESULTS

The simulation results are shown in MATLAB. Here one wind source & one solar sources are connected as input to the diode clamped inverter .The input supply of the wind source is given 630 V and solar power given input is 100 V when supply voltage is given to supply the sinusoidal pulse width modulation is applied to three level diode clamped inverter shown in Fig. 3.

The above figure shows the connection of the diode clamped inverter with two sources wind and solar supplies .For this diode clamped inverter pulse are given with reference voltage 5V with 50Hz frequency triangular .Whenever the pulses are given to the switches the switches will on according to the carrier frequency of the signal .Pulse signal given to the switches are shown in below Fig. 4.

In output wave forms the out voltage is increasing that means because of wind variation of the output voltage slowly increases. The output voltage is increases as shown in Fig. 5.

And also output current is shown in fig.5.according to the wind variation of the wind energy. The wind energy of the wind turbine vary with the wind speed .Based upon wind speed the voltage will vary .solar source will produce power depending upon irradiation of solar rays .If any distortions occurs in the wind supply & solar irradiations two sources simultaneously will produces the output power.

5. CONCLUSSION

The above simulation results will show output results of three level inverter .The above proposed system is very efficient compared with the other multilevel system .it produce power required load demand of the load .this will be very use full in the renewable energy systems. Now a days renewable energy sources demand increasing very highly .in this cases to produce the electrical power according to the load demand. Sinusoidal pulse width modulation is applied to this system to give best control of the switches. This technique is less cost and very easy to implement in circuits.

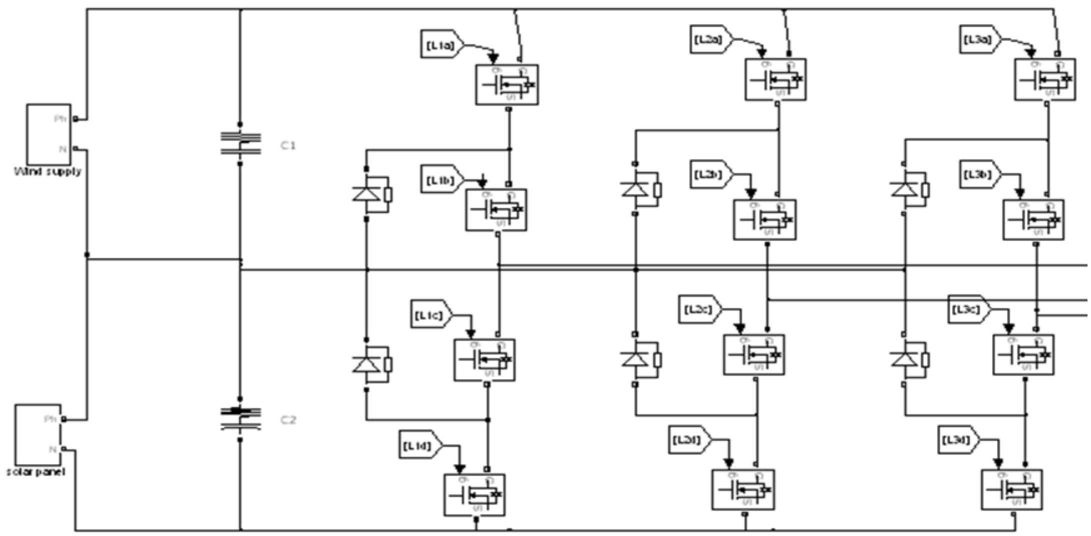

Fig. 3: simulation circuit in Matlab

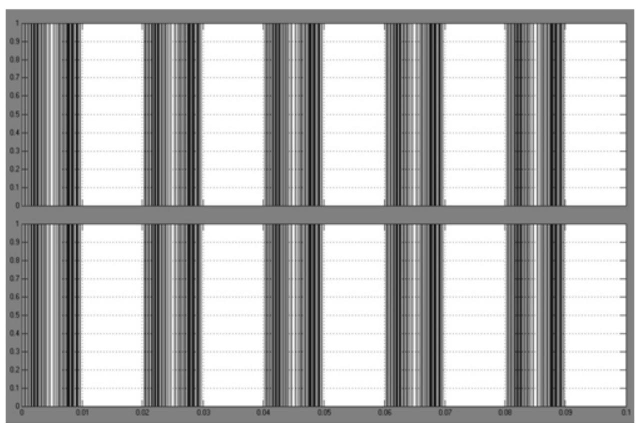

Fig. 4: pulses to switches

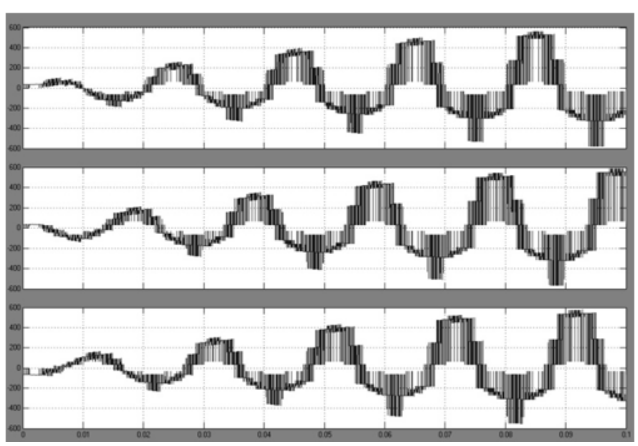

Fig. 5: output voltage of the inverter

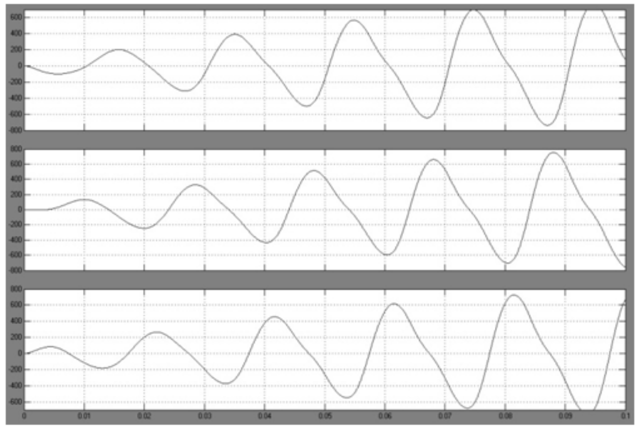

Fig. 6: Output currents of three levels inverter

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