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Review on Wind-PV System based Three Phase Multi-level AC-DC Converter

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ABSTRACT: Over the last decade, energy demand from the power grid has increased significantly due to the increasing number of users and the emergence of high-power industries. This has led to a significant increase in global emissions with conventional energy generation. Therefore, the penetration of renewable energy resources into the power grid has increased significantly. Photovoltaic systems have become the most popular resources as their potential is enormous, thus, the worldwide installed PV capacity has increased to more than 635 gigawatts (GW), covering approximately 2% of the global electricity demand. Power electronics are an essential part of photovoltaic generation; the drive for efficient power electronic converters is gaining more and more momentum. Presently, multilevel inverters (MLI) have become more attractive to researchers compared to two-level inverters due to their abilities to provide lower electromagnetic interference, higher efficiency, and larger DC link voltages. This paper reviews multilevel inverters based on their classifications, development, and challenges with practical recommendations in utilizing them in renewable energy systems. Moreover, PV systems with various maximum power point tracking (MPPT) methods have been extensively considered in this paper as well.

KEYWORDS: MLI, MPPT, Converter, Energy

I. INTRODUCTION

In modern technology, power electronics and processor plays a vital role in the field of motor control, light control, heat control, power supplies, vehicle system, HVDC, FACTS and renewable applications. The philosophy focuses on preserving the energy and meeting the power demand accurately and the power modulator pertaining to inverter / converter technology fulfills the requirements and this attracts the researchers to explore in the inverter field. The above-mentioned applications work in the range of medium power, high power at a higher voltage. With the help of semiconductor device technology, power converters are to be designed with higher operating voltage [1, 2]. As a single device fails to support such high voltages, a number of devices need to connect in series to meet the voltage rating. Another challenge in the industrial sector is the requirement and maintenance of the sinusoidal power supply with variable voltage and frequency. The above demerits are overcome by the introduction of Inverters. The series connected switches in the inverters and through control mechanism, the voltage stress with respect to high voltage rating is shared among the series switches and also the losses are minimized. Due to advantage of minimum losses, inverters are also used for medium voltage applications. The classical square wave inverter operating at higher voltage introduces the dominant harmonics, thereby the performance on the load side and on the front end of the inverter has a large impact and the performance is affected. Though the solution is sought through the passive filters, the loss is increased and occupies more space. The alternative path is provided by Multilevel Inverters (MLI). MLI generates sinusoidal voltage waveform in the form of voltage steps through switching sequence. The other advantages of MLI are reduced electromagnetic interference, reduced current distortion, good quality voltage waveform, good current waveform. The basic types of MLI are neutral point clamped MLI, flying capacitor MLI and cascaded H-bridge MLI. To synthesize nearly sinusoidal voltage, higher number of levels needs to be generated with the help of more number of switches, more number of sources and more number of gate drivers. Due to this, the efficiency decreases as more number of switches are utilized in the conduction path [3].

II. LITERATURE REVIEW

Dodi Garinto et al. [1], this paper presents another 3-stage 3-level 3-wire AC-DC converter structure for wind energy change frameworks (WECS). The multi-channel converter design with a stage moving standard is proposed to tackle the specialized difficulties of future MV PMSG WECS with 5 – 20 MW power rating. Too, the Discontinuous Conduction Mode (DCM) activity is utilized to accomplish a minimal expense arrangement and to diminish the control intricacy. If there should be an occurrence of 5 – 20 MW yield power levels, the information furthermore, yield swell flows at the inductance and capacitance channels are concentrated on utilizing PSPICE reproduction investigation. Recreation results show that the information and result swell flows are diminished fundamentally, which lead to more modest inductance and capacitance esteems so high-effectiveness, high-unwavering quality and light-weight WECS can be figured it out.

D. Garinto et al. [2], in this paper, a 3-stage 3-switch 3-level 3-wire AC-DC converter geography with awry Vienna rectifier is Proposed. The awry Vienna rectifier is controlled utilizing DCM (Discontinuous Conduction Mode) activity to accomplish a basic and minimal expense control techniques. Simultaneously, the upside of the topsy-turvy Vienna rectifier is concentrated on utilizing PSPICE reproduction examination. The point of this paper is to give a straightforward control and minimal expense answers for high power factor 3-stage AC-DC converter applications. The voltage weights on semiconductor gadgets, additionally the conduct of current and voltage waveforms in awry Vienna rectifier with DCM activity will be examined in this paper. The benefit of the proposed awry Vienna rectifier in regards to the conduction misfortunes is likewise talked about.

A. Mesbahi et al. [3], this paper presents an execution of a Wind Energy Conversion System dependent on a Permanent Magnet simultaneous Generator. The turbine is copied by a Permanent Magnet Direct Current Motor. The power created is changed over to constant wave structure through a Boost Converter. The control keeping up with consistent the voltage at the terminal, load depends on traditional PI regulator. The equipment arrangement is demonstrated and recreated utilizing MATLAB/SIMULINK. Trial rig utilizing Permanent Magnet Direct Current Motor - Permanent Magnet simultaneous Generator is utilized for approval.

The topology suggested in (**Abderezak Lashab et al. [4]**) comprises of a combination of three-level (3L) active neutral-point-clamped inverter and floating capacitor connected parallel to the legs of H-bridge. Two switches operated at fundamental frequency are connected across the DC link structure and enhances the topology performance by a two-fold increase in RMS value. Through logical mapping, the switches are turned on /off by deriving the pulses through voltage balancing scheme and the scheme balances the floating capacitor voltage regardless of load angle.

Cascading five-level diode clamped MLI with seven level or 9 level conventional Cascaded H Bridge (CHB) Multilevel Inverters (MLI) results in hybrid topology (**A. Lashab et al., [5]**) for generating 11-level / 13-level respectively. The conventional MLI has a case to case merits and demerits. In the presented topology, the demerits of the conventional topology are minimized by cascading two different conventional topologies. The MLI switches at the fundamental frequency and the operation is shown for a particular modulation index and variable load angle. Capacitor balancing is attained between the charging cycle and the recharging cycle.

A new symmetric structure for cascade multilevel converter is developed in (**Q. Huang et al., [6]**) which is composed of several series-connected switched capacitor diode units and an H-Bridge inverter for polarity reversal. A fewer number of device count is required for configuring the topology. Besides, optimal structures derived from the topology projects the merits by maximizing the number of levels with different objectives such as a minimum number of switch count and sources. The simulation and experimental results added to show the performance of the implemented method and the results are compared with other structures.

MLI structure using a cascade connection of sub multilevel inverter by (**M. Abarzadeh et al., [7]**). The sub-MLI consists of a switched-capacitor converter circuit with inherent boosting and capacitor self-balancing through a series-parallel connection operated in asymmetric mode. The main advantage of the topology is low voltage stress, because the H bridge is not used and the other merit is providing a conduction path for the inductive load reverse current. The topology is validated by simulation and by experiment.

A. Lashabet et al. [8], in this work, the near-state pulse width modulation (NSPWM), adjusted to be utilized as a part of dual-voltage source inverter (VSI) fed open-end load, is acquainted essentially pointing with obviously limit the voltage add up to harmonic distortion (THD). Inside the framework of the strategy, the active time of pulses at the second inverter is moderately balanced inside switching interim (contrasted with the principal VSI). The phase voltage harmonics are detailed for dual-inverter regulated by NSPWM; at that point, ideal change is distinguished by means of a three-dimensional bend of phase voltage THD versus modulation file (MI) and phase edge displacement (PAD). Because of the restriction of MI in NSPWM, the coveted yield voltage is orchestrated with altering MI as well as PAD between references of two VSIs. Moreover, NSPWM naturally exploits better productivity contrasted with traditional space vector modulation because of switching just two phases inside an interim (by clipping one phase to positive/negative dc-rail). The dual-VSI provided by two isolated dc sources is amassed in the lab to tentatively assess the THD diminishment highlight of the implemented technique; additionally, the simulation comes about acquired by methods for a MATLAB/Simulink condition indicate close concurrence with exploratory information.

III. MULTI LEVEL INVERTER

Figure 1 shows the multilevel converter modulation methods. The modulation control schemes for the multilevel inverter can be divided into two categories, fundamental switching frequency and high switching frequency PWM such as multilevel carrier-based PWM, selective harmonic elimination and multilevel space vector PWM. Multilevel SPWM needs multiple carriers. Each DC source needs its own carrier. Several multi-carrier techniques have been developed to reduce the distortion in multilevel converters, based on the conventional SPWM with triangular carriers. Some methods use carrier disposition and others use phase shifting of multiple carrier signals. By generalizing, for an 'n' level multilevel inverter, (n-1) carriers are needed. The implementation of the various carrier PWM techniques that is possible for multi-level inverters are [4, 5]:

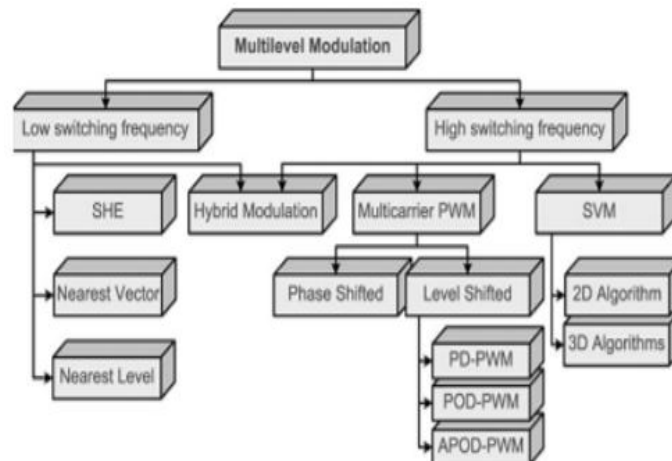


Figure 1: Multilevel converter modulation methods

Level Shifted PWM (LSPWM)

This modulation method is especially useful for NPC converters, since each carrier can be easily associated to two power switches of the converter. LSPWM leads to less distorted line voltages since all the carriers are in phase compared to PSPWM [6]. In addition, since it is based on the output voltage levels of an inverter, this principle can be adapted to any multilevel converter topology. However, this method is not preferred for CHB and FC, since it causes an uneven power distribution among the different cells. This generates input current distortion in the CHB and capacitor unbalance in the FC compared to PSPWM [7, 8]. Figure 6 shows the LS-PWM carrier arrangements.

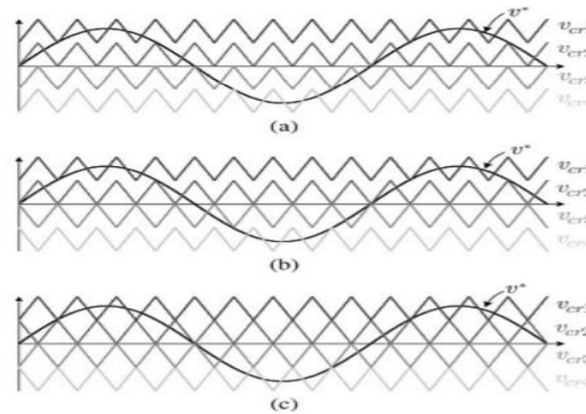


Figure 2: LS-PWM carrier arrangements: (a) PD, (b) POD, and (c) APOD

Phase Shift Pulse Width Modulation

PWM signals are pulse trains which are applied to the gate of switches to perform the operation of converter. The pulse trains are fixed frequency and magnitude and variable pulse width [9]. There is one beat of settled extent in each PWM period. In any case, the width of the beats changes from period to period as indicated by a regulating signal. At the point when a PWM flag is connected to the entryway of a power transistor, it causes the turn on and kills interims of the transistor to change starting with one PWM period then onto the next PWM period as indicated by the same regulating signal and thus working of converter begins. The recurrence of a PWM flag must be substantially higher than that of the regulating signal, the major recurrence, with the end goal that the vitality conveyed to the heap depends generally on the tweaking signal. The control of yield voltage is done utilizing beat width balance [10].

This technique uses a set of carriers that are all phase-shifted. The four triangular carriers are phase-shifted by 90° . Using the same sampling period, it has four times larger switching frequency than that of other techniques. This technique is specially conceived for FC and CHB converters. Since each FC cell is a two-level converter, and each CHB cell is a three-level inverter, the traditional bipolar and unipolar PWM techniques can be used, respectively. Due to the modularity of these topologies, each cell can be modulated independently using the same reference signal [11].

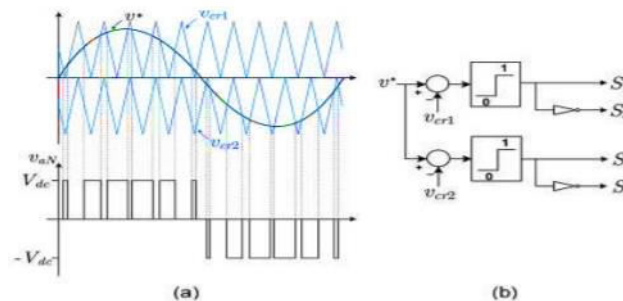


Figure 3: Phase Shift PWM

IV. PV ARRAY

The photovoltaic cell converts the light energy into electrical energy depending on the irradiation of the sun and temperature in the atmosphere. Basically PVC is a PN junction diode [12]. But in PN junction diode DCI AC source is needed to work, but here light energy is used as a source to produce DC output. PVC is a current control source not a voltage control source. The equivalent electrical circuit diagram of PVC is shown in the Figure 4.

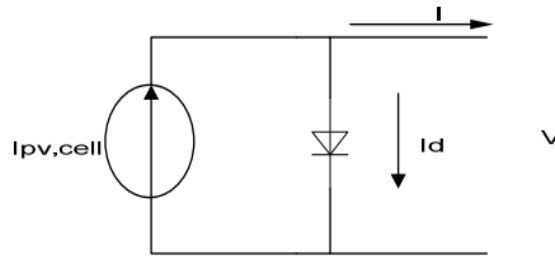


Figure 4: Show ideal photovoltaic cell equivalent circuit

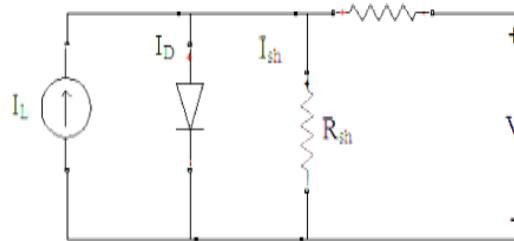


Figure 5: Equivalent Electrical Circuit of PVC

$$I_D = I_0 [\exp(V + IR_S) / KT - 1] \quad (1)$$

Therefore PVC output current is given in equation 2.

$$I = I_L - I_D - I_{sh} \quad (2)$$

$$I = I_L - I_0 [\exp(q(V + IR_S) / KT - 1) - (V + IR_S) / R_{sh}] \quad (3)$$

Where I_D the diode is current, R_{sh} is the shunt resistance, I_L is the light generated current of solar array. Solar cell is basically a p-n junction fabricated in a thin wafer or layer of semiconductor. The electromagnetic radiation of solar energy can be directly converted electricity through photovoltaic effect. Being exposed to the sunlight, photons with energy greater than the band-gap energy of the semiconductor are absorbed and create some electron-hole pairs proportional to the incident irradiation. Under the influence of the internal electric fields of the p-n junction, these carriers are swept apart and create a photocurrent which is directly proportional to solar insolation. PV system naturally exhibits a nonlinear I-V and P-V characteristics which vary with the radiant intensity and cell temperature [13].

Wind Energy

Wind energy is the energy which is extracted from wind. For extraction we use wind mill. It is renewable energy sources. The breeze energy needs less cost for age of power. Support cost is likewise less for wind energy framework. Wind energy is available very nearly 24 hours of the day. It has fewer outflows. Beginning expense is likewise less of the framework. Age of power from wind is rely on the speed of wind streaming. The real impediments of utilizing free sustainable power source assets are that inaccessibility of energy forever. For conquering this we utilize sun oriented and wind energy together. With the goal that any one wellspring of energy falls flat other will deal with the age. In this proposed framework we can utilize the two sources join [7]. Another way is that we can utilize any one source and keep another source as a remain by unit. This will prompts congruity of age. This will make framework solid. The primary detriments of this framework are that it needs high introductory cost. But that it is dependable, it has fewer outflows. Kept up cost is less. Life expectancy of this framework is more. Proficiency is more. A principle preferred standpoint of this framework is that it gives constant power supply.

Wind energy has the biggest share in the renewable energy sector [1], [3]. Over the past 20 years, grid connected wind capacity has more than doubled and the cost of power generated from wind energy based systems has reduced to one-sixth of the corresponding value in the early 1980s [3]. The important features associated with a wind energy conversion system are:

- Available wind energy
- Type of wind turbine employed
- Type of electric generator and power electronic circuitry employed for interfacing with the grid.

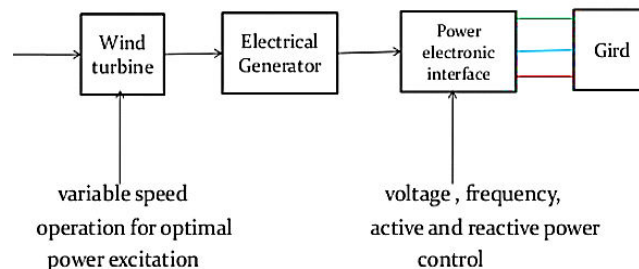


Figure 6: Variable speed wind energy conversion system

The power converter framework utilizes a rotor side air conditioning dc converter, a dc interface capacitor, and a dc-air conditioning inverter associated with the matrix as appeared in Fig.

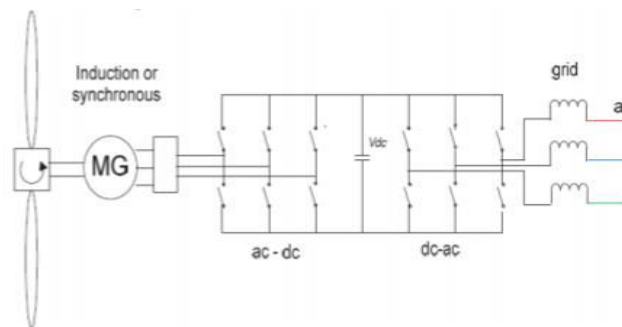


Figure 7: Fully variable wind energy conversion system

V. CONCLUSION

The presented research work has been focused on the construction of variable amplitude sinusoidal voltage using the different topologies. The first effort has been related to the development of new MLI topology using diodes and switching devices under symmetric and asymmetric mode. The advantage of the topology articulates any desired voltage level with a reduced total number of devices and sources over basic and similar topology. The reduced stress of the sources achieved through pulse swapping among the cell switches, balances the load power and reduces the voltage stress of the devices.

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