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HYBRID MULTILEVEL INVERTER FED PV/WIND SYSTEM FOR MITIGATION OF HARMONICS USING SPACE VECTOR PWM (SVPWM) TECHNIQUE

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ABSTRACT

The primary goal of this project is to develop a hybrid PV/wind system powered by a multilevel inverter that uses the Space Vector PWM (SVPWM) technology to reduce harmonics. In recent years, renewable energy sources have gained popularity as a source of electricity. Solar energy is widely available on the world since it is pollution-free. Industry for far-flung and dispersed uses.Applications that combine wind and solar energy with another renewable energy source are in high demand in remote areas.

To reduce total harmonic distortion, a hybrid PV/wind model with a hybrid multilevel inverter using SVPWM is intended. The SVM method, as opposed to the NLC method, can easily provide more flexibility in optimising switching patterns without requiring complex common-mode voltage designs. The effectiveness of the proposed topology is confirmed by simulation results. The effectiveness of the topology is verified using MATLAB/SIMULINK.

Index Terms— Photo-voltaic (PV), Multilevel Inverter (MLI), Nearest Level Control (NLC), Space Vector PWM (SVPWM), Maximum power point tracking (MPPT), Total Harmonic Distortion (THD)

I. INTRODUCTION

Users from all around the world have been drawn to distributed generating using renewable energy sources. For clean electricity, solar and wind energy are widely used. Solar energy (light) from a photovoltaic system is turned directly into electricity. Glasstech Solar was established in 1984 by inventor and businessman Harold McMaster. He started Solar Cells, Inc. (SCI) in 1990 after experimenting with amorphous silicon and switching to CdTe. By purchasing SCI in February 1999, True North Partners went on to form First Solar. First Solar, the world's largest manufacturer of PV cells, reached a production rate of 1 GW of energy by the end of 2009. Worldwide, 305GW of solar power capacity was installed in 2017, and another 104GW was installed in 2018. Wind power is one of the fastest-growing energy sources. Because to dropping prices, usage is increasing on a global scale. From 7.5 gigawatts (GW) in 1997 to about 564 GW in 2018, the installed wind-generation capacity onshore and offshore has expanded by a factor of almost 75 during the past two decades. The kinetic energy of the wind is converted by a wind turbine into electrical energy. Mostly suitable for rural areas, a wind turbine system offers a renewable energy source. Due of high winds at night, feeble winds on cloudy days, and calm winds on sunny days, hybrid wind and solar resources complement one another. A hybrid generation system is crucial for ensuring the reliability of the supply and a constant supply of electricity in isolated locations [1].

In where the performance of STATCOM is examined by connecting to a grid-connected system, under the steady state and dynamic state conditions, a cascaded multilevel inverter with two distinct DC sources, energised by a photovoltaic-wind hybrid energy source, is utilised. Research on freestanding hybrid generation systems utilising PV and wind has been conducted in a few different ways during the past few years. For high-power applications and DC-AC conversions, multilevel inverters have been used extensively during the past few decades. There have lately been many topologies developed for multilevel inverters, which began with three-level converters. A staircase voltage waveform is produced by the use of switches connected in series with DC sources to obtain high power. Any one of many DC sources is possible. A staircase voltage waveform is produced by connecting switches in series with DC sources to get high power. Any renewable energy source, battery, capacitor, etc., may be used as a DC source. The power switches' on/off cycles assist in achieving a high-level voltage at the multilevel inverter's output stage, where the switch voltage ratings are dependent on DC sources [3].

The advantages of a multilevel inverter over a traditional two-level converter with high Pulse Width Modulation (PWM) switching frequency are greater. The characteristics include lower dv/dt stresses that lessen electromagnetic implications and staircase waveform quality with minimal distortion (EMI). CM voltage, which causes stress in a motor's bearings, is reduced utilising sophisticated modulation techniques, minimal distortion. At fundamental frequency and higher switching frequencies, multilevel inverters function via pulse width modulation [8-9]. The intended inverter generates voltages at 3k levels (as opposed to 9 levels for an inverter with k=2). In the usual method, lower levels of inverter will not produce a pure sinusoidal waveform, resulting in significant harmonics. A sinusoidal waveform results from an inverter with higher voltage levels and high resolution. For the modified cascaded H bridge multilevel inverter (MCHBMLI), the researcher used minimal power switches in this article as opposed to previous traditional topologies [12]. The disadvantages of the traditional approach, which uses a large amount of current and results in voltage swings, include electromagnetic inference and common mode voltage issues. A notable example is the rolling lines used in televisions with inverters. A single phase cascaded multilevel inverter bridge is created via a series connection [7].

The inverter's DC sources produce three separate output voltages: +EDC, 0 and -EDC. In this study, harmonic minimization is accomplished through the design and simulation of a hybrid microgrid that combines battery storage, PV, wind, and other renewable energy sources for integration. This is done using a modified cascaded multilevel inverter. For both PV and wind, the MPPT utilising incremental conductance approach is used. The switches in the suggested topology are turned on and off using the nearest level control (NLC) approach. Utilizing MATLAB/Simulink, the suggested system is used to calculate total harmonic distortion [4].

II. HYBRID MULTI-LEVEL INVERTER:-

Multilevel inverters require the employment of innovative and clever approaches to enhance the power quality in areas where renewable energy microgrid integration is being done. In order to discuss the most recent advancements in the aforementioned topic, a literature review has been conducted. Research centred on developing different multilevel inverter topologies with few switching devices. Other topologies based on symmetrical and asymmetrical types have also been proposed in the literature in addition to the basic topologies. The article included recommendations on MPPT and MLI for grid applications. A 3-phase MLI for RES applications was proposed by Karasani et al. (2017) after a modular 7-level cascaded H-bridge inverter for 3-phase was designed and tested with PV panels under varied partial shading circumstances.

Less switch count, capacitor, and gate driver requirements were demonstrated as improved qualities in a comparison study between the traditional CHB and the flying capacitor (FC). Each PV module had several MPPs in the articles' suggested control scheme in order to extract a significant amount of solar energy and balance the current of the three-phase grid integrated with variable solar power and MPPT algorithm with NLC method [14]. In order to generate switching angles via selective harmonic elimination (SHE) with minimal memory consumption and high efficiency, the author developed a hybrid method [15-16]. The need for neurons and chip memory was decreased using ANN. Using the Quasi-Newton technique, an 11-level modulated staircase was created and its validity was tested by experiments. The effectiveness of robust stochastic search algorithms, such as Resultant Theory and Newton Raphson, was tested by simulating an 11-level and 13-level CMLI. In this study, a hybrid genetic algorithm (GA) with a 3-phase, 2-level inverter and two Artificial Neural Networks (ANN) were used for offline optimization of 11-level switching angles. MATLAB was used to calculate switching angles. A symmetrical quarter-wave and bipolar waveform were created to get the output voltage [5]. In order to achieve better performance, the author in this case used a 5-level inverter for direct torque control (DTC) drives. The voltage source inverter (VSI) of a 5-level hybrid cascaded H-bridge was designed using a modified conventional DTC. Utilizing a multilevel hysteresis controller, the flux and torque were determined. In order to generate a modulation table using selective harmonic elimination, a cascaded multilevel inverter with 11 levels was used, along with approaches from the Genetic Algorithm (GA) and particle swarm optimization (PSO). Results were then contrasted using ANN techniques [10-11][13].

A variety of pulse width modulation (PWM) techniques, including MCPWM-level shifted and phase shifted, space vector PWM, etc., have been documented in research work for high frequency techniques. Phase disposition (PD) and phase opposition disposition are further classifications for level shifted (POD). Multilevel inverters with fact controllers can generate high voltage and lower harmonics through their own circuit topologies, as explained in the paper. Carrier frequency is one of the main factors limiting the inverter's power output. It is possible to lower the output harmonics while increasing the corresponding carrier frequency. In order to achieve reduced total harmonic distortion and higher efficiency, the research examines the contemporary topology of multilevel inverters, which are ideal for high power solar applications [2].

This paper proposes a new modified topology with fewer switches, DC sources, and the creation of a fundamental unit to reduce switches, which is then used to raise levels. The literature review demonstrates that different levels have been designed for cascaded H bridge multilevel inverters using cutting-edge techniques. However, a few research projects have been conducted using renewable hybrid PV/wind energy sources along with batteries as microgrids and symmetrical modified multilevel inverters [6].

III. SIMULATION RESULTS:-

The below figure.1 shows the SIMULINK circuit modal for SVPWM technique. This is the one of the advance technique which is used to mitigation of harmonics in hybrid system. From the input side we can connect three inputs i.e., PV system, Wind System and Battery System and these are connect to boost converters, boost converter are controlled by deputy control technique and this combination is connect common DC-DC converter after this it will connects to multilevel inverter after that we are that we are connecting Voltage and Current measurements.

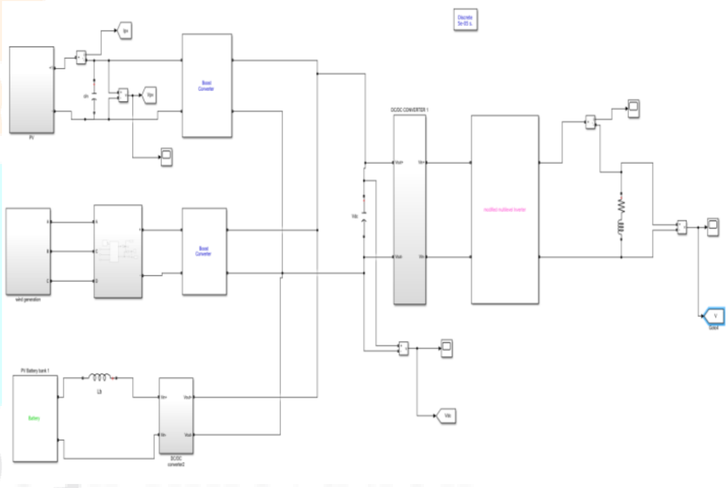

Fig 1 MATLAB/SIMULINK circuit diagram of the proposed system

The figure.2 shows the SIMULINK subsystem modal of Multi Level Inverter. The multi-level inverter circuit modal is designed by using IGBT Switches. Basically the IGBT switch having low power loss ad fast switching speed.

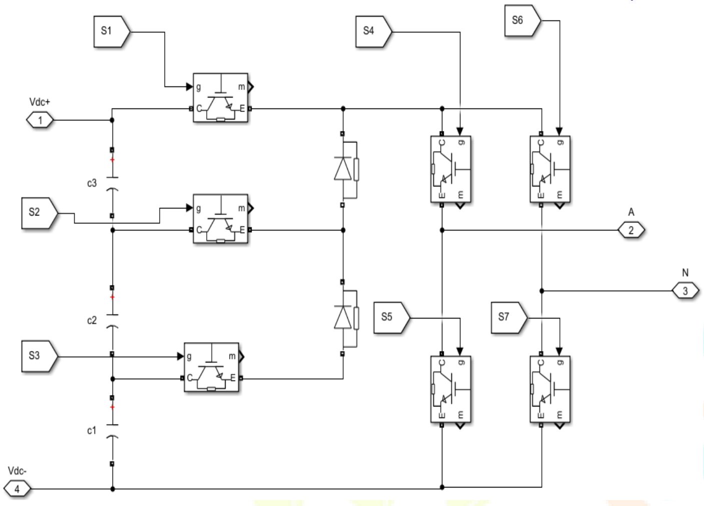

Fig 2 Multilevel inverter subsystem

Nearest Level Control (NLC) Technique

Results:-

The figure.3 shows the subsystem of NLC technique. This is the traditional method which is used to mitigate the harmonics in the system.

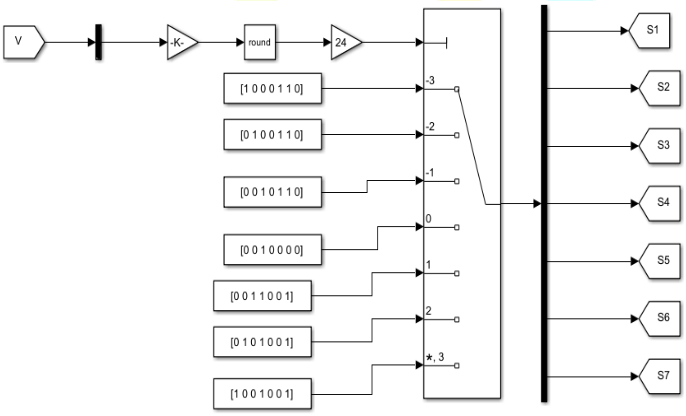

Fig.3 Subsystem of Nearest Level Control Technique

The figure.4 shows the output voltage wave form using NLC Technique.

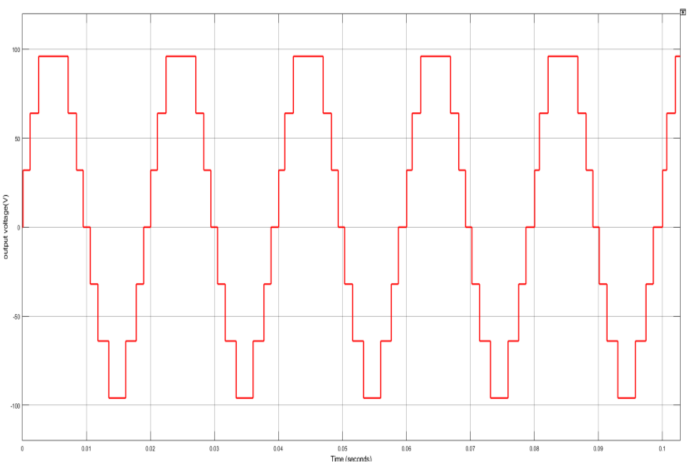

Fig.4 Output voltage (V)

The figure.5 shows %THD of output voltage wave by using NLC Technique. By using this NLC technique the THD value is 13.64% in the output voltage.

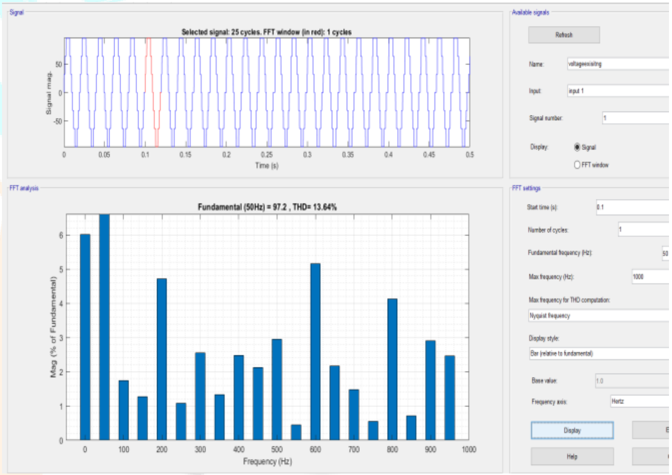

Fig. 5 THD% of output voltage (13.64%)

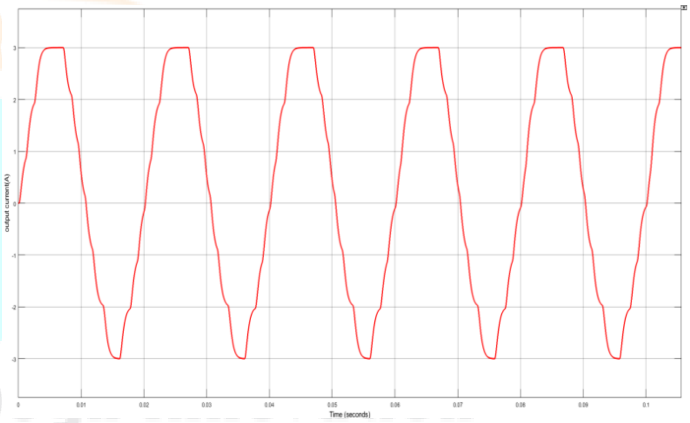

Fig.6 Output current

The figure.6 represents the output current wave form using NLC Technique.

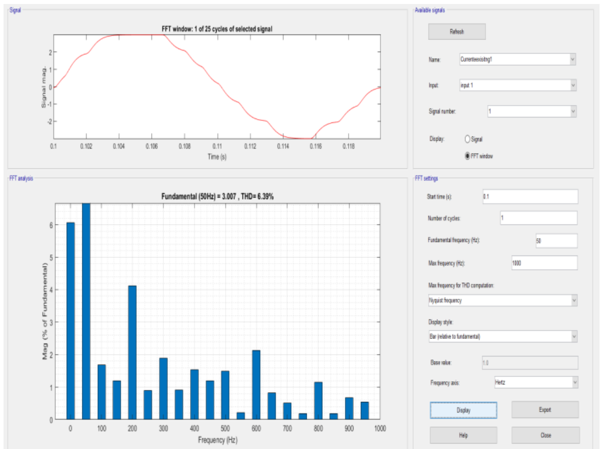

Fig.7 THD% of output current (6.39%)

The figure.7 shows the %THD of output current by using NLC technique. By the use of NLC the THD is 6.39% in the output current.

Space Vector PWM Technique Results:-

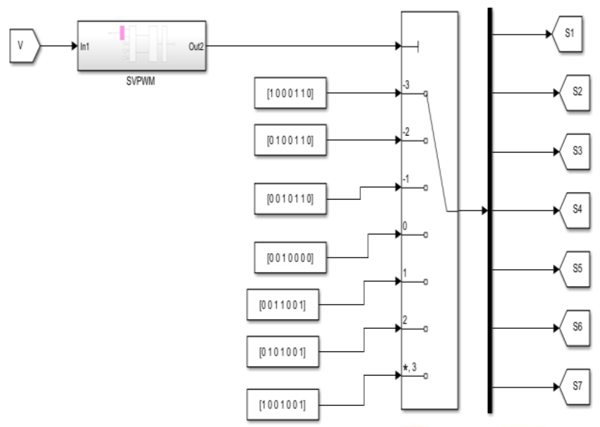

Fig.8 subsystem of proposed SVPWM control technique

The figure.8 shows the subsystem of proposed SVPWM control Technique. The SVPWM technique is one of the advanced technique used to reduce the harmonics.

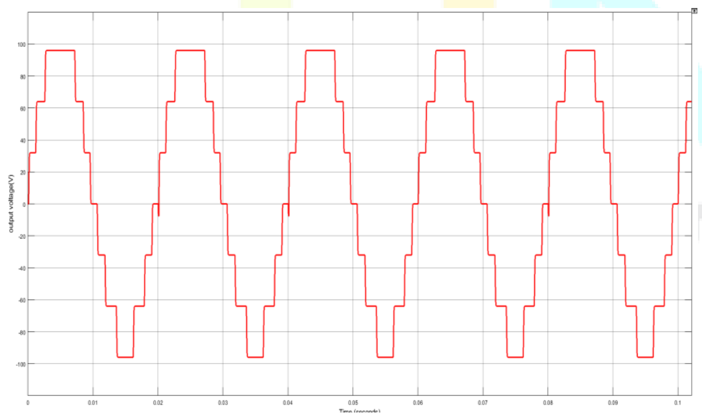

Fig.9 Output voltage

From the fig.10 shows the %THD of output voltage wave. In the NLC control technique the %THD value is 13.64% by the use of SVPWM technique it will again reduced to 12.12%.

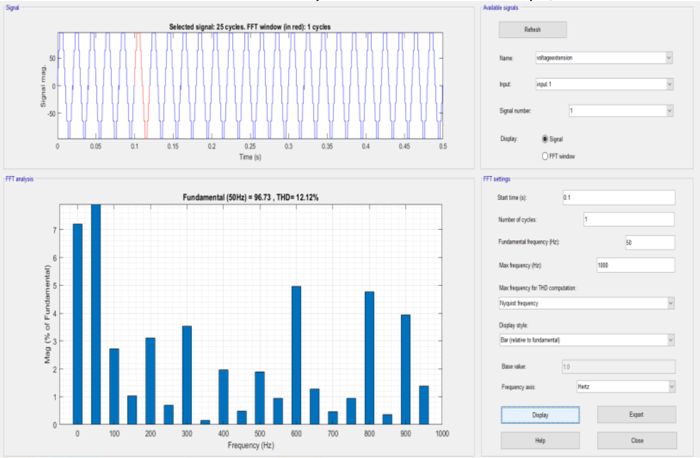

Fig.10 THD% of output voltage (12.12%)

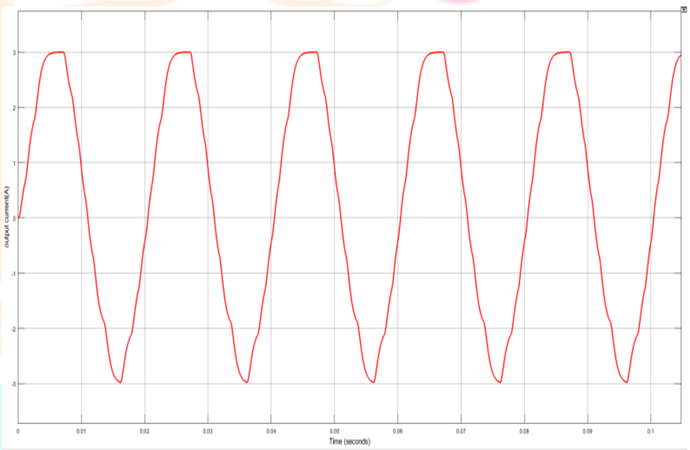

Fig.11 Output current

By the use of NLC technique the %THD value of current is 6.39% and it will reduced to 4.69% by using SVPWM technique.

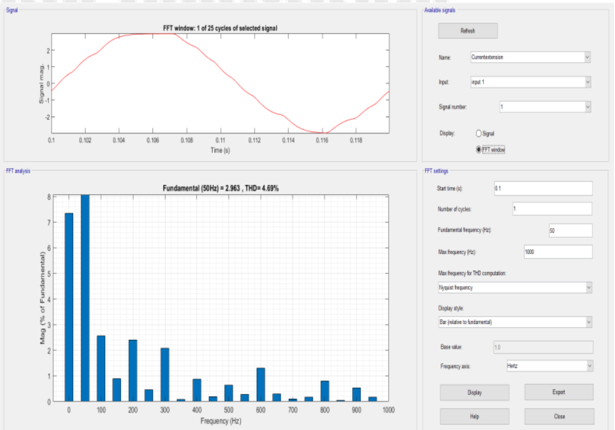

Fig.12 THD% of output current (4.69%)

Table: Comparison of %THD values of voltages and currents by NLC Technique and SVPWM Technique

Technique	Voltage THD in %	Current THD in %
NLC	13.64%	6.39%
Proposed SVPWM	12.12%	4.69%

IV. CONCLUSION:-

For a hybrid PV/wind microgrid, a novel asymmetrical modified CHBMLI topology is proposed. With fewer switches, the suggested approach is useful for higher levels. When compared to standard CHBMLI, the switches are reduced from 100% to 50%, which minimises switching losses. For the MLI, hybrid renewable energy sources produce sinusoidal output voltage with little harmonic content. Modified CHBMLI's switching losses are lower than those of a standard inverter, which increases system efficiency while lowering costs thanks to fewer switches, driver circuits, and diodes. The SVPWM approach has assisted in reducing the MLI's overall harmonic distortion. Therefore, a hybrid PV/wind microgrid is affordable and very practical in outlying places. This level control is nearby.

The proposed topology is more productive than traditional topologies. To reduce total harmonic distortion, a hybrid PV/wind model with a hybrid multilevel inverter using SVPWM is intended. The SVM method, as opposed to the NLC method, can easily provide more flexibility in optimising switching patterns without requiring complex common-mode voltage designs. The effectiveness of the proposed topology is confirmed by simulation results. The effectiveness of the topology is verified using MATLAB/SIMULINK. Future work will focus on designing new modified topologies to eliminate switches, DC sources, and higher voltage levels in order to improve the power quality of the microgrid in terms of harmonics. This will result in improved performance with lower harmonic distortion for higher voltage levels.

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