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# Multi Renewable Sources With Space Vector Modulation

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**Abstract:**The objective of this paper is to study a novel Multi level multi string inverter topology for DERs based DC/AC conversion system. In this study, a high step-up converter is introduced as a front-end stage to improve the conversion efficiency of conventional boost converters and to stabilize the output DC voltage of various DERs such as PV, Wind and fuel cell modules for use with the simplified newly constructed multilevel inverter. The proposed multilevel inverter requires only nine active switches instead of the twelve required in the conventional cascaded H- bridge (CCHB) multilevel inverter, control with SVM technique. The algorithm is exact, fast, and applicable to any number of levels. It is based on a vector classification technique, which allows determination of the switching sequences and the calculation the switching instants in m-level inverters. The proposed technique reduces software complexity, decreases the computation time, and increases the accuracy of the positioning of the switching instants, when compared with the conventional implementation of the SVM in multi-level converters. Results are given for a 3-level inverter.

**Keywords**— Photo Volatic (PV), Space Vector Modulation, Multi Level Inverter’s

## 1. INTRODUCTION

In present days, photovoltaic (PV) energy appears quite attractive for electricity generation because of its noiseless, pollution-free, scale flexibility, and little maintenance. Because of the PV power generation dependence on sun irradiation level, ambient temperature, and unpredictable shadows, a PV-based power system should be supplemented by other alternative energy sources to ensure a reliable power supply. Fuel cells (FCs) are emerging as a promising supplementary power sources due to their merits of cleanness, high efficiency, and high reliability.

DES are small scale power generation technologies typically in the range exceeding from 1KW and termed as on site power generation systems. Renewable energies are the primary sources of DES that enhances the power electronics technology. Fuel cells (FCs) are emerging as a promising supplementary power sources due to their merits of cleanness, high efficiency, and high reliability. Because of long startup period and slow dynamic response weak points of FCs [1], mismatch power between the load and the FC must be managed by an energy storage system. Batteries are usually taken as storage mechanisms for smoothing output power, improving startup transitions and dynamic characteristics, and enhancing the peak power Capacity [2], [3].

Combining such energy sources introduces a PV/FC/battery hybrid power system. In comparison with single-sourced systems, the hybrid power systems have the potential to provide high quality, more reliable, and efficient power. In these systems with a storage element, the bidirectional power flow capability is a key feature at the storage port. Further input power sources should have the ability of supplying the load individually and simultaneously. Many hybrid power systems with various power electronic converter shave been proposed in the literature up to now. Traditional methods that integrate different power sources to form a hybrid power system can be classified into AC coupled systems [4],[5] and AC-coupled systems[6]–[12].

## 2. CONVERTERS CONTROL CHARACTERISTICS

The proposed system overview is shown in fig-1. The proposed converter interfaces three unidirectional ports for input power sources, a bidirectional port for a storage element, and a port for output load in a unified structure.

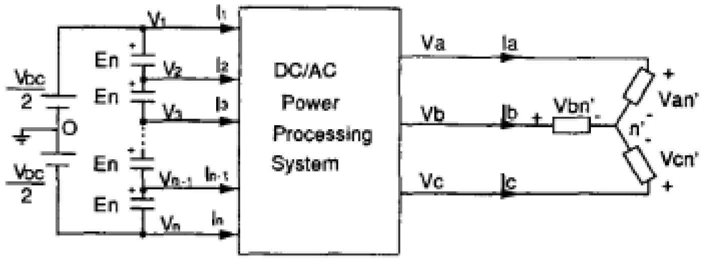


**Fig.1: Proposed System Overview**

The converter is current source type at the both input power ports and is able to step up the input voltages. The proposed structure utilizes only four power switches that are independently controlled with four different duty ratios. Utilizing these duty ratios facilitates controlling the power flow among the input sources and the load. Powers from the input power sources can be delivered to the load individually or simultaneously.

### *A. Control Characteristics For High Power Converter*

The architecture of a high power converter is shown in Fig. 2, and is composed of different converter topologies: boost, fly back, and a charge pump circuit. The coupled inductor of the high power converter in Fig. 2 can be modeled as an ideal transformer, a magnetizing inductor, and a leakage inductor. According to the voltage seconds balance condition of the magnetizing inductor the voltage of the primary winding can be derived as

$$V_{pri} = V_{in}\frac{D}{(1-D)} \quad (1)$$

Where $V_{in}$ represents DC input voltage source. The secondary voltage is

$$V_{sec} = V_{pri}\frac{N_S}{N_P} = \frac{N_S}{N_P}V_{in}\frac{D}{(1-D)} \quad (2)$$

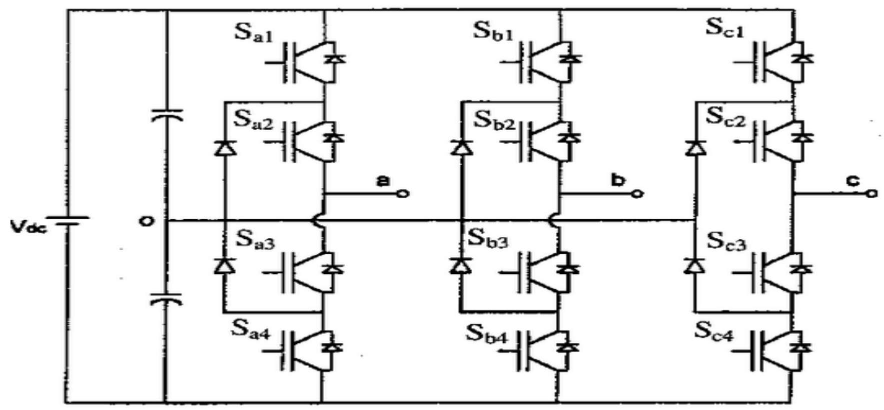


**Fig.2: High Power Converter**

### *B. Proposed Multilevel Stage Of Inverter*

To assist in solving problems caused by cumbersome power stages and complex control circuits for conventional multilevel inverters, this work reports a new three-phase multi string topology, presented as a new basic circuitry in Fig. 3. In this configuration the three capacitors in the capacitive voltage divider are connected directly across the DC bus, and all switching combinations are activated in an output cycle. The dynamic voltage balance between the two capacitors is automatically controlled by the preceding high step-up converter stage. Then, we can assume Vs1=Vs2=Vs3=Vs. This inverter topology uses two carrier signals and one reference to generate PWM signals for the switches. To verify the feasibility of the three-phase seven-level inverter, a widely used software program PSIM is applied to simulate the circuit according to the previously mentioned operation principle.

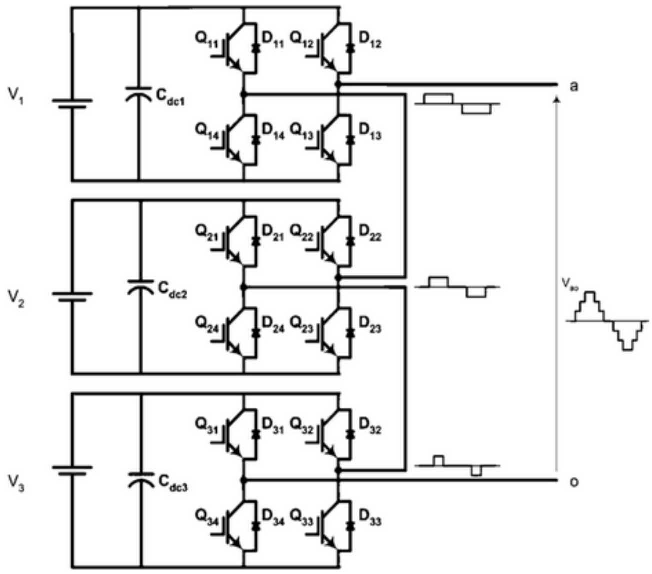


**Fig.3: Proposed Three Phase Multi phase Topology**

### *C. Control Of Space Vector Modulation*

Nine power switches of inverter with 8 possible combinations shown in ―Figure.2 are corresponding to effective voltage space vector U1– U9and 2 zero vector U0,U9. The phase angle between one effective voltage space vector and adjacent one is 40 degrees. They constitute 9 uniform segments. The three digits in brackets express the linking state between three-phase output A,B,C and the input DC, such as M=101 which represents
the switching of the switches Sai, Sbj and Sck.

The output voltage space vectors and the corresponding switching states are represented in ―Fig. 4.

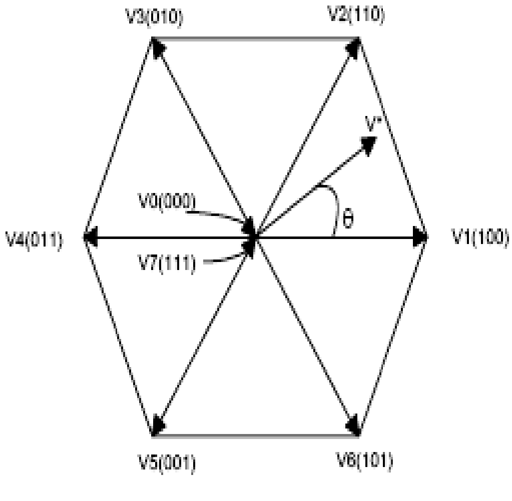


**Fig.4: Output Voltage Vectors**

## 3. SPACE VECTOR MODULATION

A different approach to SPWM is based on the space vector representation of voltages in the d, q plane. The d, q components are found by Park transform, where the total power, as well as the impedance, remains unchanged. Fig:5 space vector shows space vectors in according to 9 switching positions of inverter, V* is the phase-to center voltage which is obtained by proper selection of adjacent vectors V1 and V2. The reference space vector V* is given by Equation (17), where T1, T2 are the intervals of application of vector V1 and V2 respectively, and zero vectors V0 and V7 are selected for T0. In order to generate the phase voltages ua, ub and uc corresponding to the desired voltage vector u* the above SVM strategy is proposed.

$$V^* Tz = V1 *T1 + V2 *T2 + V0 *(T0/2) + V7 *(T0/2 \quad (3)$$

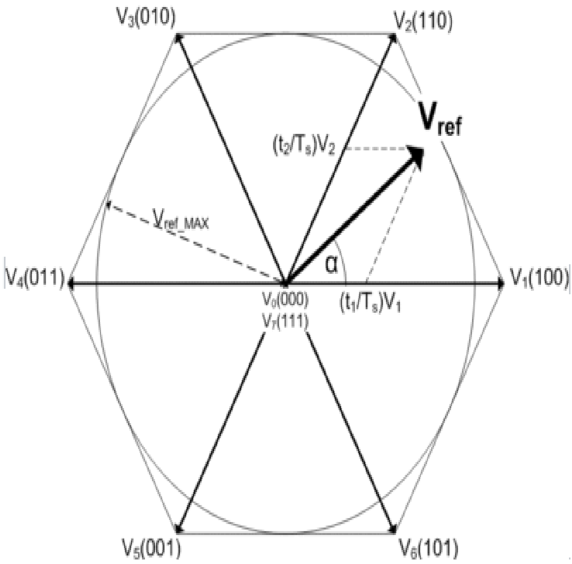


**Fig.5: Space Vector Modulation**

## 4. SIMULATION RESULTS

Multilevel inverters in Space Vector modulation is simulated and output voltage and current wave forms are in the fig.6 and fig.7
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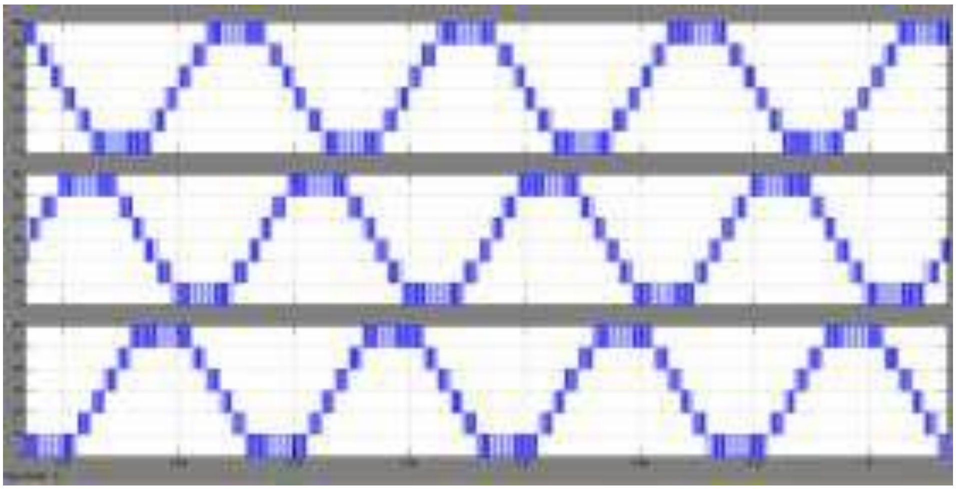

**Fig.6: Voltage Wave forms of Multi Level Inverters**

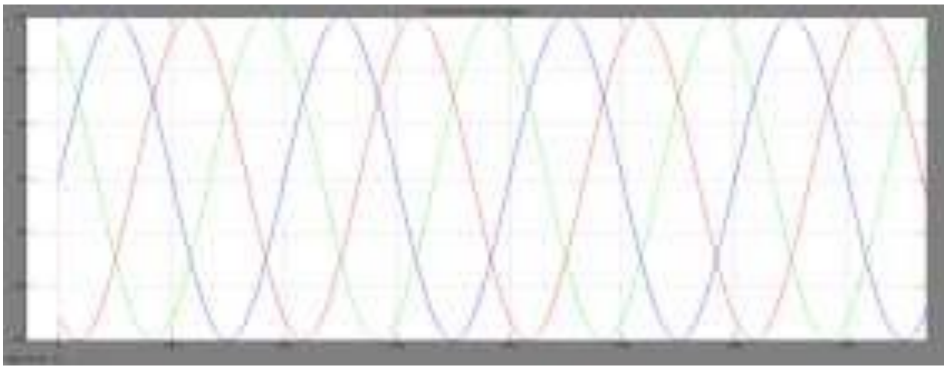

**Fig.7: Load Current with Multi Level Inverters**

## 5. CONCLUSIONS

The proposed system illustrates Renewable & Sustainable power generation strategies of a grid system with versatile power transfer. Also, this configuration allows the sources to supply the load separately or simultaneously depending on the availability of the energy sources. The turbine rotor speed is the main determinant of mechanical output from wind turbine to Permanent Magnet Synchronous Generator (PMSG) is coupled for attaining energy conversion system. Renewable energy resources like Fuel cell and Solar cell power generated are interconnected to DC Link. The inverter converts the DC output from non-conventional energy into useful AC power for the connected load (Industrial & Commercial Loads). This Grid system operates under normal conditions which include normal room temperature or At Any atmospheric Condition. This work reports a newly-constructed three-phase multi string multilevel inverter topology that produces a significant reduction in the number of power devices required to implement multilevel output for DERs.

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