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An SVPWM-Based Multilevel Inverter for Photovoltaic Applications

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Abstract: *The increased power quality demands along with rising power rating requirements become achievable with multilevel inverters which offer reduced electromagnetic interference (EMI) and harmonic distortion. The simultaneous processing capacity of added switches becomes crucial to manage as multilevel inverters increase their levels. The paper presents the implementation of space vector pulse width modulation (SVPWM) for neutral point clamped (NPC) inverters having two and three levels of configuration. The geometrical symmetry within the six sectors connects the procedure of switching on-time calculations to the strategy of on-time arrangement. The modeling of two and three level inverters through MATLAB/Simulink happens alongside experimental data verification of the system performance. The results indicate that photovoltaic cells can serve as an appropriate power source for the NPC inverter.*

Keywords: *PV cell, SVPWM, NPC, LabVIEW, Two-level, Three-phase inverter*
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I. Introduction

Resources for renewable energy are becoming more and more important every day. Examples of these renewable energy sources are solar, wind, nuclear, and hydropower. It is anticipated that these renewable energy sources would provide 60% of our energy needs by 2050. Because PV energy is widely available and dispersed around the world, it has been utilized in the most instances of all of them. As a result, we are currently concentrating on developing novel tropologizes for enhanced inverters.

The usage of PWM-controlled multilevel inverters continues increasing its importance within these types. These types provide better performance along with many other advantages superior to other tropologies. Research has brought its highest achievements through the pulse width modulation technique that experts call "Vector modulation" based on space vector theory[2].

II. NPC Inverter

The vector modulation establishes itself as the top selection for three-phase switching inverters when implementing current controllers and testing real-time control loops in hardware for design purposes including controller implementation and independent source recovery and isolation. Researchers have expended significant effort to develop and study three main modulation strategies since the PWM converter conceptual method launched: multilevel SPWM, SVPWM and multilevel selective harmonic elimination[6]. The space vector PWM ranks foremost among the available techniques because it provides maximum flexibility in controlling switching waveforms while remaining well-suited for digital execution.

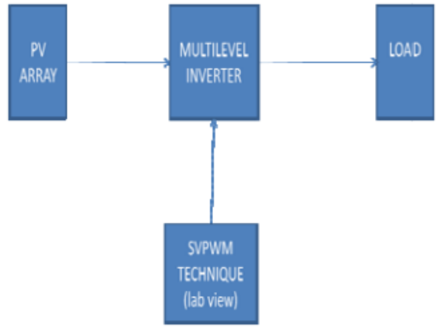

Fig 1: NPC Block Diagram

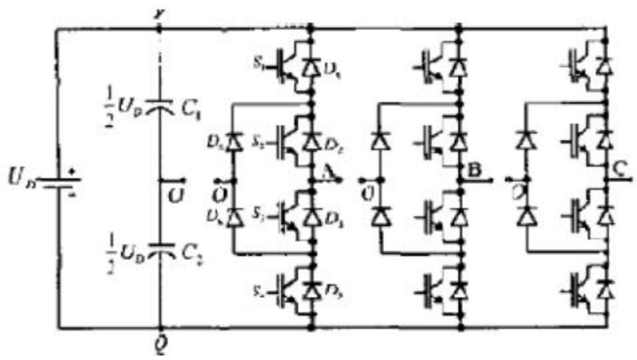

Fig 2: Neural point of Three Level schematic

III. Photovoltaic Arrays

The application of photovoltaic cells converts solar energy from the sun into usable electrical power that becomes known as electricity. A PV cell functions as the base component which builds up a PV array. PV cells group together to form PV panels before manufacturers use these panels for constructing PV arrays. The PV cells take shape either as rectangles or as circles[4]. Each PV cell functions as a basic p-n junction diode according to figures 3 and 4. The surface of the diode attracts direct sunlight to produce charge carriers that generate energy.

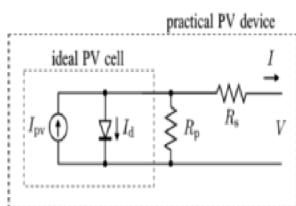

Fig 3: Basic Circuit diagram of a PV cell using one diode

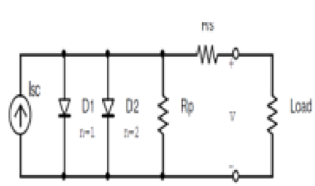

Fig 4: PV cell using two diode models

The figure 4 presents a PV cell schematic with a two-diode model that addresses measurement errors. Photovoltaic cells appear as current sources in Figure 4 while Rp stands for parallel resistance and Rs stands for series resistance. The analysed system generates an output voltage which we denote as V while delivering an output current called I. The net current I emerges from the sum of I $_{pv}$ and Id according to the displayed diagram.

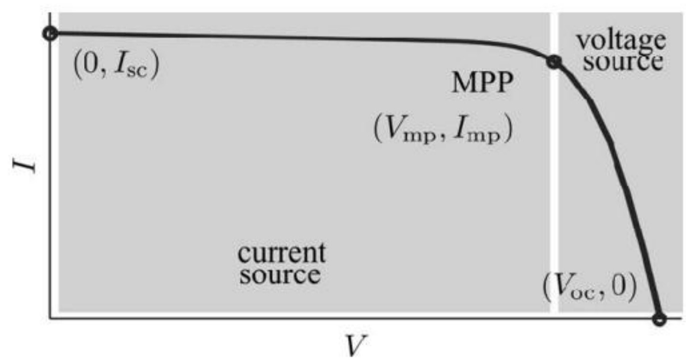

Fig 5: V-I characteristics of an PV cell

IV. MATLAB Simulink

Simulink is shown for Two level and Three level Inverter

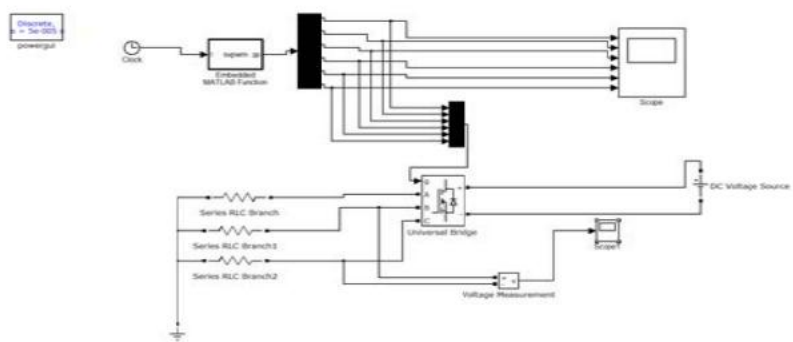

Fig 6: Two level SVPWM Inverter

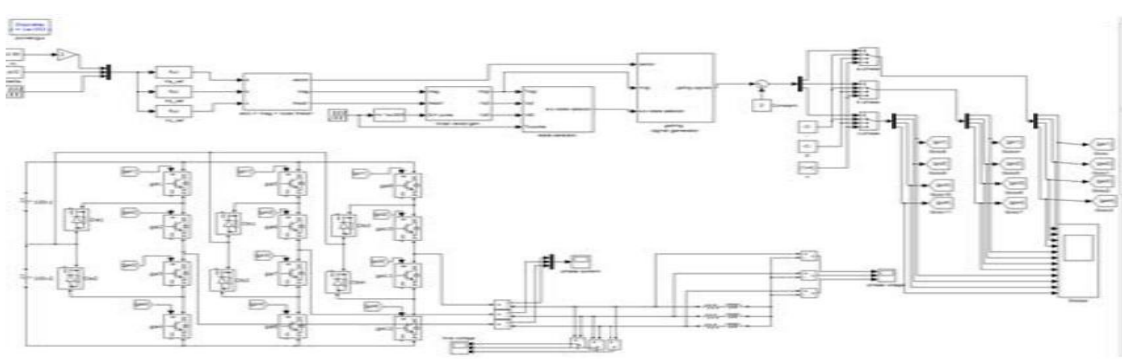

Fig 7: Three level SVPWM Inverter

V. Multilevel Inverter Integrated with A Photovoltaic Cell Using MPPT Algorithm

A minor modification goes into this algorithm structure. The solar module's power fluctuates as a result of this disturbance. Whenever a power rise occurs from this disturbance it extends toward the same direction. The disturbance reverts when power from the following moment drops to its lowest point after previously reaching maximum power[6]. The algorithm performs oscillations near the peak point after reaching its steady state condition. The input disturbance maintains minimal values because they produce minimal power alterations. The reference voltage for the module is set according to its peak level through the method design. A PI controller shifts the operational point of the module to reach that precise voltage level. Researchers have identified that this intervention results in noticeable power loss while also being incapable of monitoring changing air conditions effectively. The usage of this approach constitutes a straightforward implemented method which remains widely adopted. A boost converter functions to increase DC voltage before sending it to the inverter from the PV module

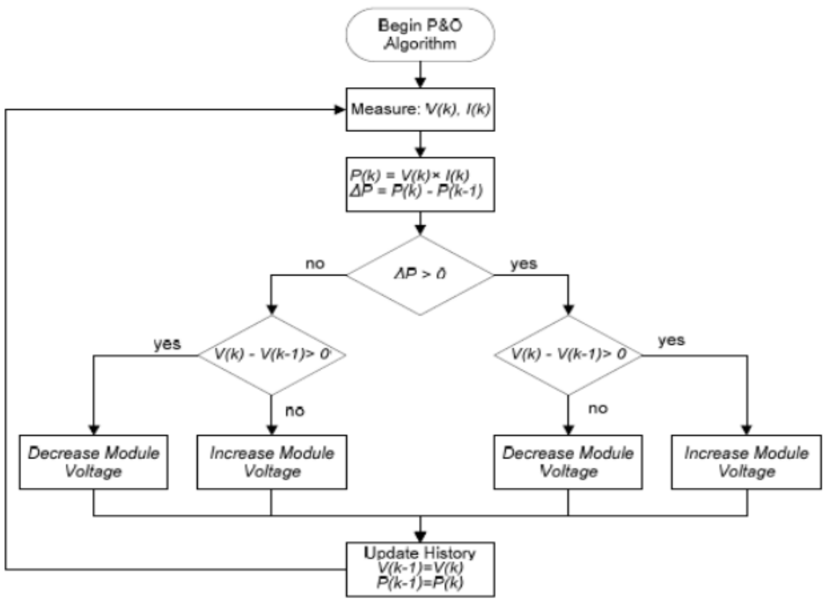

Fig 8: MPPT Algorithm

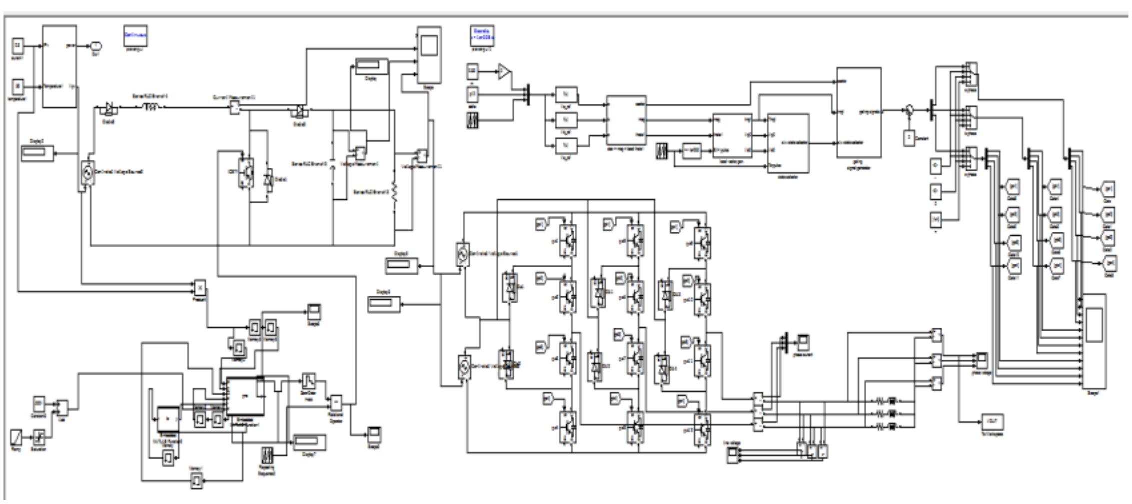

Fig 9: Simulation of the whole system implemented using MPPT algorithm

VI. Simulation Result

A minor modification goes into this algorithm structure. The solar module's power fluctuates as a result of this disturbance. Whenever a power rise occurs from this disturbance it extends toward the same direction

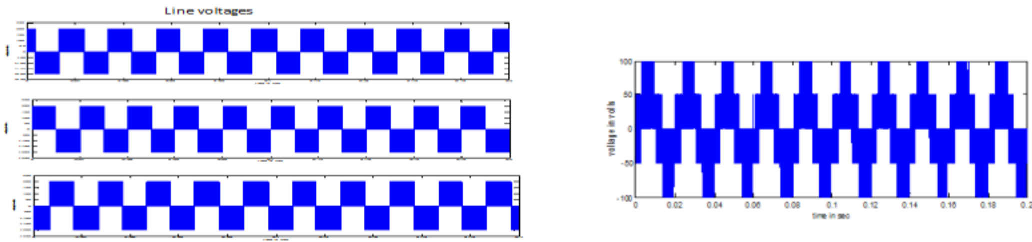

Fig 10: Phase and Line voltages for Two level Inverter

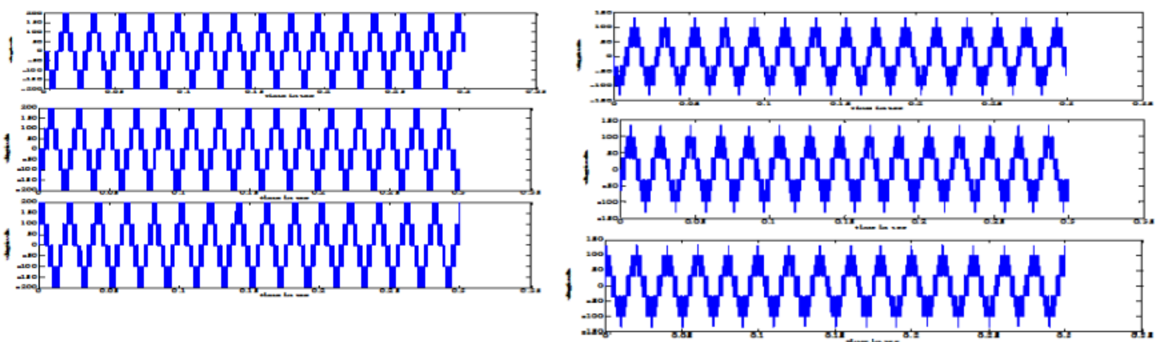

Fig 11: Line and Phase voltages for Three level SVPWM Inverter

VII. Hardware Configuration

The entire hardware development of the 3-level inverter takes place within this stage. The gate pulse generation takes place through LabVIEW before the gates receive protection from negative spikes by an optocoupler (TLP250). A transformer set functions in this part as well[8]. We obtained output waveforms from a three-phase three-level inverter through hardware connection of the entire circuit and accessed FFT analysis by selecting MATH functions on the DSO.

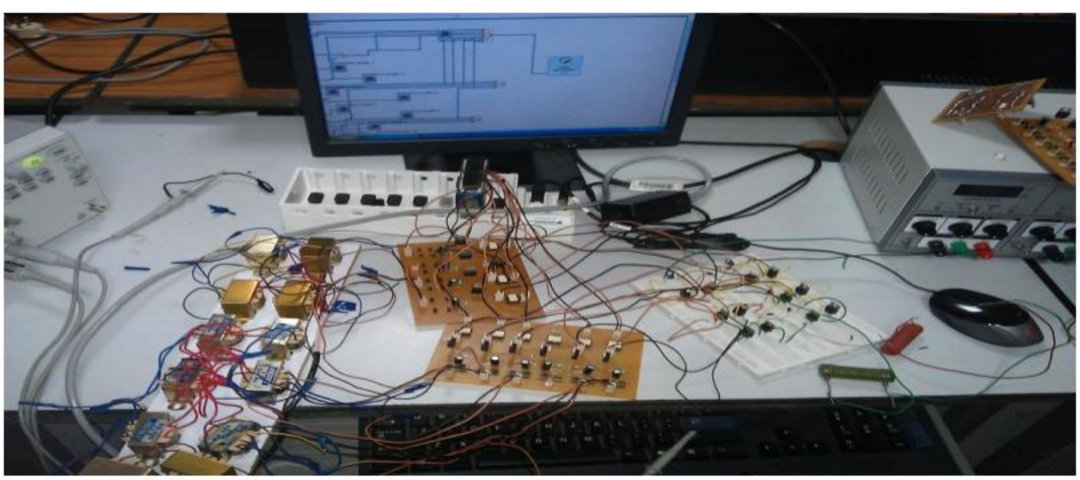

Fig 12: Hardware Setup for 3-phase 3-level inverter

VIII. Conclusion

The paper investigates the influence of RL loading conditions on the total harmonic distortion present in two and three level inverters under SVPWM operation. The simulations run using MATLAB/SIMULINK platform. The hardware verification is conducted by LabVIEW through experimental testing. Further cost savings result from the proposed diode clamped inverters because these devices decrease both the total VA ratings of clamping diodes and the total voltage ratings of voltage-splitting capacitors. The setups serve both as power generation distribution systems and as operating platforms for fuel cells and wind turbines along with solar-powered equipment and other devices.

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