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Performance Analysis of Three-Phase Inverter using Different Techniques for the grid-connected PV system

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***Abstract*- The model of a three-phase a voltage source inverter is examined based on space vector theory. SVPWM offers a improved outcome with the inverter as compared to the conservative SPWM technique for inverter. There is 15.5% upsurge in the line voltage of the inverter. SVPWM better exploit the available DC link power with SVPWM inverter. It has been revealed that the SVPWM method utilizes DC bus voltage extra competently and produces a smaller amount of harmonic distortion and easier digital realization in a three-phase voltage-source inverter. Results are verified by MATLAB/Simulink**

Key Word— Maximum Power Point Tracking (MPPT); Three-Phase Inverter; Voltage Source Inverters (VSIs)

1. Introduction

As we know the increasing concern to find and use the alternate of the conventional energy generation is essential. The energy produced by fossil fuel is not only limited but also affect the environment and contribute in a very large scale to the problem of global warming [1], [2]. A wide exploration and use of clean power for power generation such as solar energy, wind power as well as hydro energy is going on with a good pace. Since the availability of sun is everywhere solar power generation can be at any place both at large scale and small scale [3-4]. Large scale power generation can be used to supply power to a big population or can be connected with the grid of conventional power system. Small scale solar power generation can be used for different applications such as for operation of motor, domestic loads, water pump etc [5-9].

The power capability of the sun is enormous, but despite this limitless solar energy resource, garnering, it is a challenge mainly due to the restricted efficiency of the whole system. The output voltage of photovoltaic power system is not only low but also consist of voltage and current harmonics [10]. The objective of this dissertation is to recognize these places and customs to upgrade them [11]. One of such area is array increasing and pursuing device that moves or locations solar array to absorbing prolonged solar irradiance for uttermost power output. Another such area is exploring different kinds of solar cells from earlier to present and the upcoming trend and recognizes the causes of losses and how to lessen them. Lastly, some acute modules that are necessary for effective process of solar energy inverter method are explored [12-15].

The Orthodox sources of power are quickly reducing [16]. Additionally the cost of energy is increasing and hence photovoltaic system is a hopeful substitute. They are ample, contamination free, dispersed throughout the earth and eco-friendly [17]. The burden factor is its high setting up cost and low translation efficiency [18]. Therefore our purpose is to upsurge the proficiency and power production of the structure [19]. It is also essential that continuous voltage be provided to the load regardless of the disparity in solar irradiance and temperature. PV arrays comprise of parallel and series arrangement of PV cells that are used to produce electrical energy depending upon the atmospheric situations (e.g solar irradiation and temperature) [20]. So it is essential to couple the PV array with a boost converter. In addition our system is planned in such a way that with deviation in load, the alteration in input voltage and energy fed into the converter trails the open circuit features of the PV array. Our method can be used to supply continuous stepped up voltage to dc loads [21-23].

2. Solar Energy

Solar power is a non-conventional kind of power. Solar energy has been yoked by individuals since earliest times by means of a diversity of technologies. Solar radiation, alongside with secondary solar-powered assets such as wave and wind control, hydroelectricity and biomass, reason for most of the accessible non-conventional type of power on earth. Only a small portion of the obtainable solar energy is used [24].

Solar power-driven electrical generation depend on on photovoltaic system and heat machines. Solar energy's uses are inadequate only by human creativity [25]. To yield the solar power, the most usual way is to use photo voltaic panels which will obtain photon energy from sun and transform to electrical power. Solar technologies are broadly classified as either passive solar or active solar dependent on the way they keep, translate and dispense solar power. Active solar methods contain the usage of PV panels and solar thermal gatherers to band up the energy. Passive solar techniques comprise positioning a building to the Sun, choosing ingredients with advantageous thermal mass or light scattering possessions and scheme spaces that obviously circulate air [26]. Solar energy has a massive space of use such as electricity generation for distribution, warming water, lightening construction, harvest ventilation etc [27].

3. Power Electronics converter

Since as a result of rising demand of electrical power and debauched, dependable and carefully power flow control purposes, distinct control strategies are required. This chapter stretches an impression of Power Flow Regulatory Devices, categories of devices, functioning principles and the benefits and restrictions of each device [28].

3.1 Three Phase Voltage Source Inverters

Single-phase VSIs involve low-range power uses and three-phase VSIs involve the medium- to high-power uses. The key resolution of these topologies is to deliver a three-phase voltage source, where the amplitude, phase, and frequency of the voltages should constantly be manageable. Even though most of the uses need sinusoidal voltage waveforms (e.g., ASDs, UPSs, FACTS, VAR compensators), random voltages are also essential in some developing uses (e.g., active filters, voltage compensators) [29].

The typical three-phase VSI 120 degree mode topology is presented in Fig. 3.9 and the eight valid switch states are given in Table 3. As in single-phase VSIs, the switches of any leg of the inverter (S1 and S4, S3 and S6, or S5 and S2) cannot be switched on instantaneously since this would outcome in a short circuit across the dc link voltage supply. Likewise, in order to evade indeterminate states in the VSI, and therefore indeterminate ac output line voltages, the switches of any leg of the inverter cannot be switched off at the same time as this will result in voltages that will depend upon the individual line current polarity [5]. Of the eight valid states, two of them (7 and 8 in Table 3) produce zero ac line voltages. In this situation, the ac line currents freewheel through either the upper or lower mechanisms. The residual states (1 to 6 in Table 3) generate non-zero ac output voltages [9]. In direction to produce a given voltage waveform, the inverter changes from one state to another [30]. Thus the resulting ac output line voltages consist of discrete values of voltages that are Vi, 0, and -Vi for the topology displayed. The choice of the states in order to produce the specified waveform is done by the modulating method that should safeguard the use of only the valid states [31].

The fundamental significance of the line voltages is √3 times to the phase voltage. The line voltage waveforms have a form of six different steps therefore the inverter is called six-step inverter. It is allowable to use any arrangement of star- or delta-connected primary and secondary windings because the currents related with the secondary windings are proportional [32].

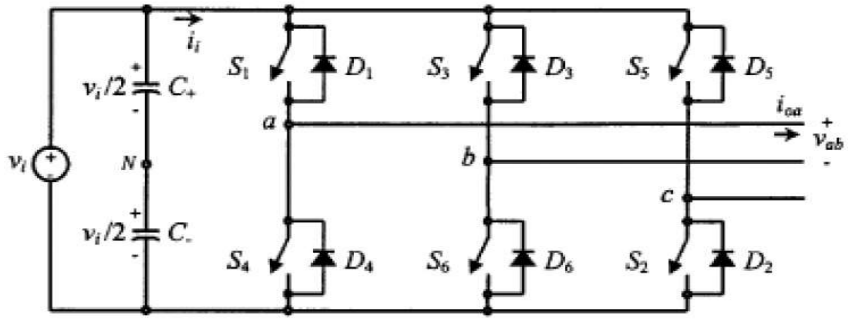

Figure 1. Three-phase VSI topology

4. Space vector PWM (SVPWM)

Space vector PWM (SVPWM) is a more refined method for producing a fundamental sinusoidal wave that delivers a greater voltage to the load and lower total harmonics distortion. Nevertheless, the conventional Direct Current/ Alternate Current (DC-AC) method has the drawbacks for instance low utilization of DC voltage, tough operation voltage and high harmonics substance, which cannot meet the necessities of inverter [33]. The SVPWM can be operational to resolve these glitches and get greater inverter application of DC voltage and lower harmonic matters [34].

4.1. Operation Principle of SVPWM

The topology of a three-leg voltage source inverter is presented in Fig. 2. Since the restriction that the input lines essentially never be shorted and the output current must permanently be continuous a voltage source inverter can accept only eight distinct topologies. These topologies are displayed on Fig. 3. Six out of these eight topologies create a nonzero output voltage and are recognized as non-zero switching states and the left behind two topologies produce zero output voltage and are recognized as zero switching states [35].

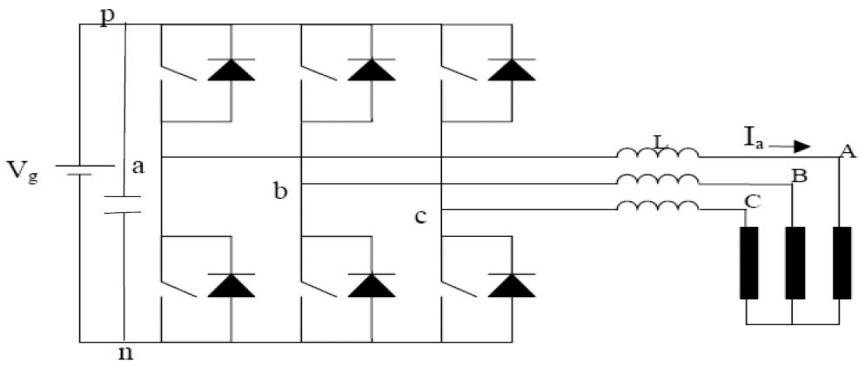

Figure 2. Topology of a three-leg voltage source inverter

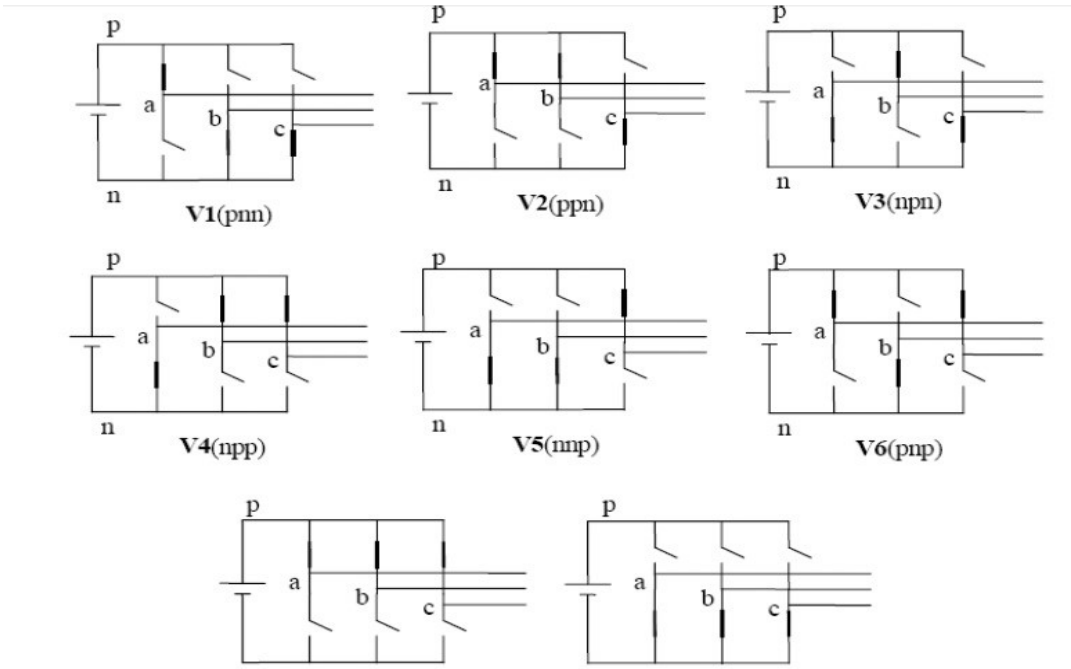

Figure 3. Eight switching state topologies of a voltage source inverter.

5. Simulation and Test Results

Figure 4 shows the MATLAB simulation of the space vector PWM based three phase inverter. Three phase input sinusoidal voltage is generated using the functional block of sin wave block.

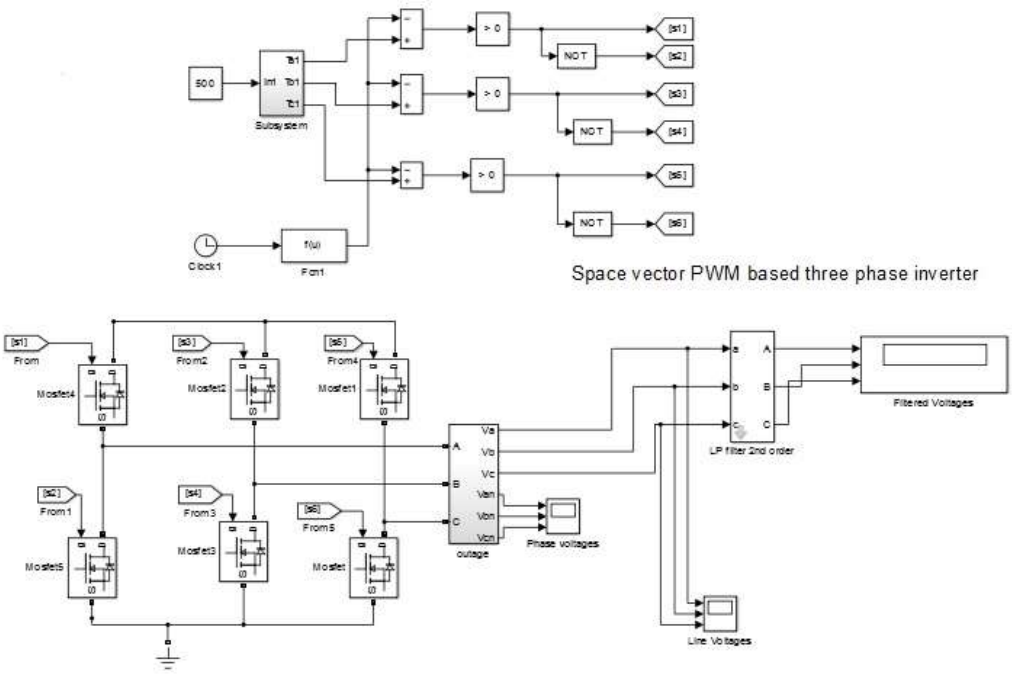

Figure 4. Simulink diagram of sinusoidal PWM three phase inverter

The output waveform of the sinusoidal PWM based three phase inverter are in form of phase voltage and line voltage as shown in figure 5 to figure 7 below. The X axis shows times in seconds and Y axis shows the Amplitude of voltage (V).

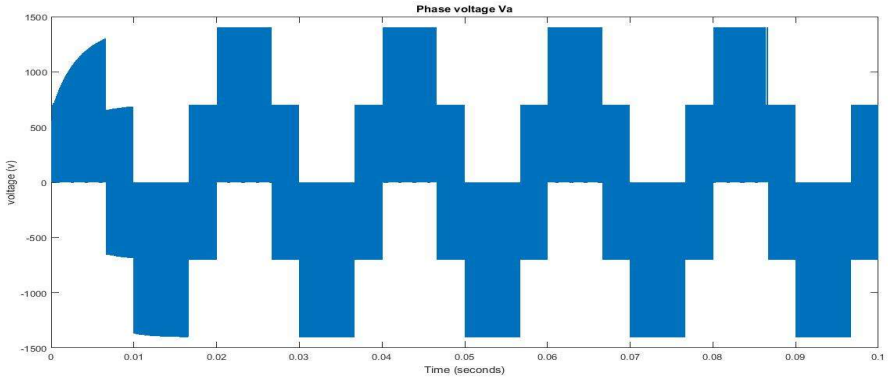

Figure 5. Phase voltage Va

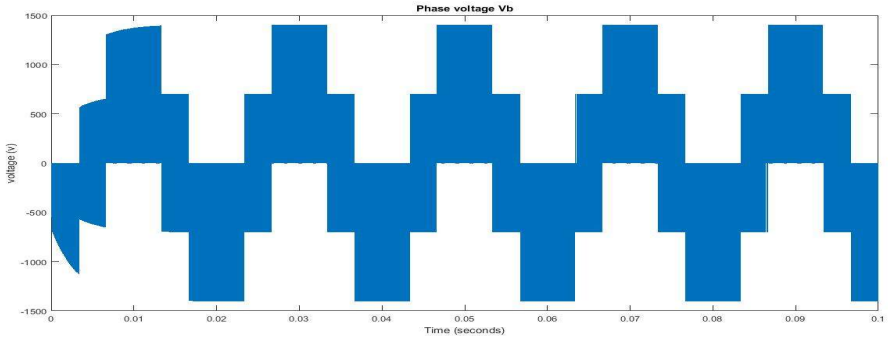

Figure 6. Phase voltage Vb

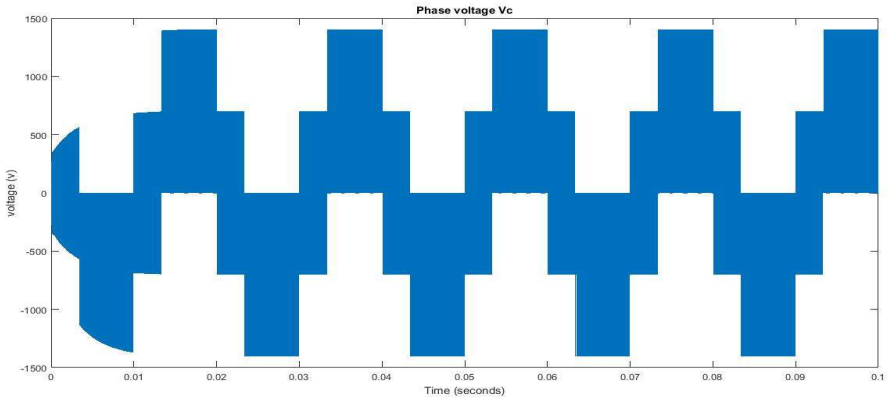

Figure 7. Phase voltage Vc

The output voltage of the three phase inverter consist of many distortions and harmonics. In order to remove these distortion and harmonics a low pass second order filter is used. The filtered output voltage waveform is shown in figure 8 to figure 10. The X axis shows times in seconds and Y axis shows the Amplitude of voltage (V).

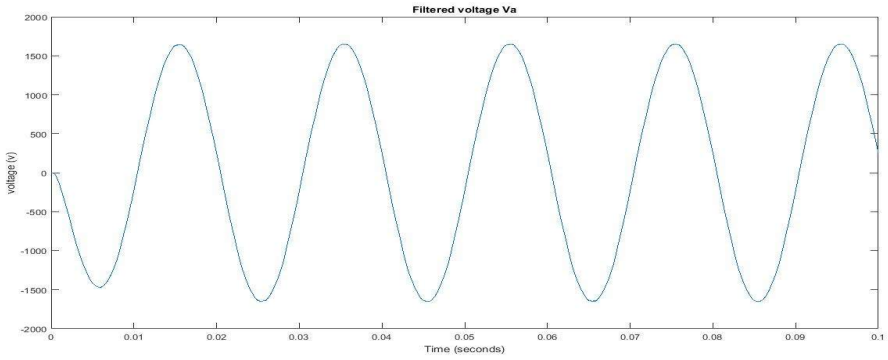

Figure 8. Filtered output Va

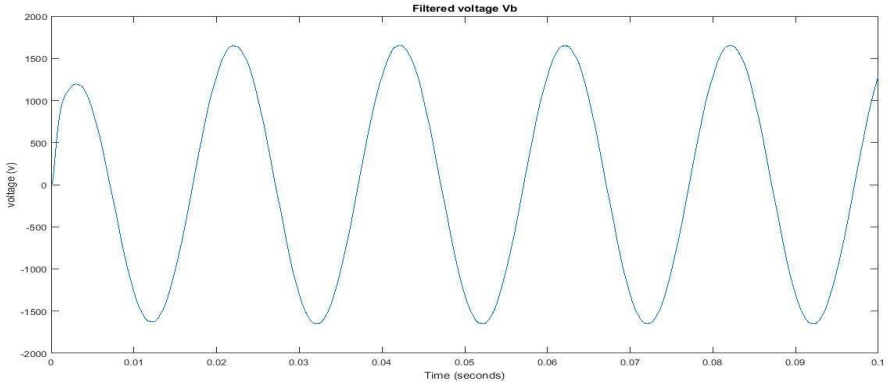

Figure 9. Filtered output Vb

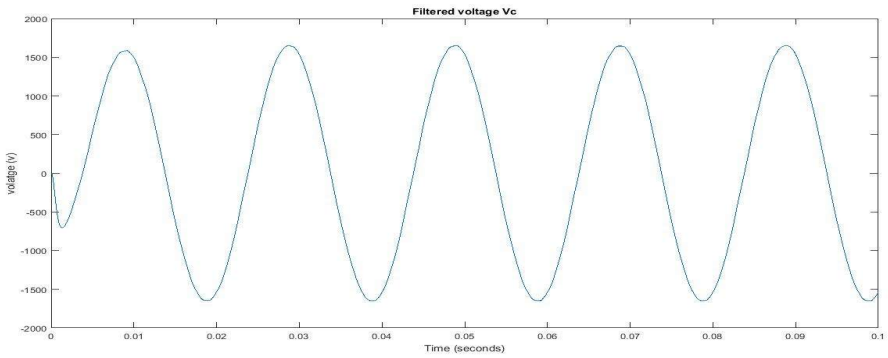

Figure 10. filtered output Vc

The maximum output phase voltage of three phase inverter is Vmax = 1650 V

6. Conclusion

In this paper the mission for such an inverter is to increase the photovoltaic low voltage up to the greater-level voltage of the grid and to convert it from DC into AC. Furthermore, the three-phase voltage source inverter should be designed with Space Vector Modulation (SVM) as switching arrangement by using MATLAB/Simulink for the grid-connected PV system. A hypothetical study regarding the use of the SVPWM the three-level voltage inverter and simulation results are offered to prove the usefulness of the SVPWM in the involvement in the switching power losses lessening, output voltages with less-harmonics. The attained simulation outcomes were satisfactory. As prospects, future experimental works will authenticate the simulation results.

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