

# A New Interconnection of Micro Grid Distributed Energy Sources using Space Vector Multilevel Inverter

S. Senthil, K. Ravi

**Abstract---** This paper describes on a new compilation of micro grid era the usage of multilevel inverter. In this paper we have linked three renewable resources are parallel like wind turbine, PV cellular and Pico Hydel generator set to deliver strength to a exceptionally small assortment of residential, reputable of business building in a locality. The electricity is generated from renewable power resources and it's far connected to space vector primarily based multilevel inverter. Therefore the power is completely computerized for this reason the strength losses can be less, reduced switching sample losses and grids have the capacity to reply robotically to the versions in electric parameters answerable for the clean functioning of the grid [1]. Moreover, decrease prices of power switches in the new semiconductor technologies as well as the current demand on excessive overall performance inverters required through Renewable Energy Systems (RES) decreased total Harmonic distortion (THD) within the spectrum of switching waveform have extended the programs of Multilevel inverters.

**Keywords---** Renewable Energy Sources, Micro grid, Multilevel inverter and space vector modulation.

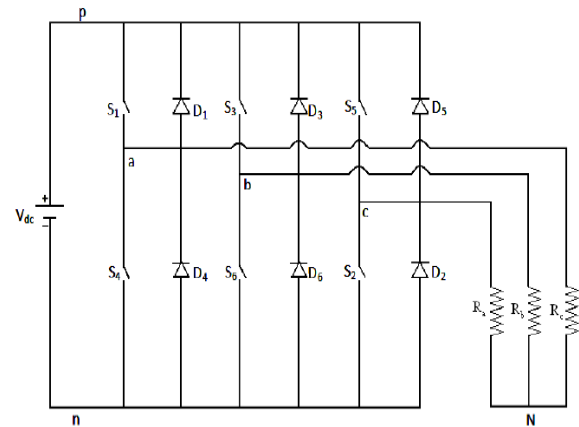
## I. INTRODUCTION

i. Multilevel inverters generate sinusoidal voltages from discrete voltage levels and PWM strategies accomplish this venture of generating sinusoidal of variable voltage and frequency. The area vector modulation is taken into consideration as a higher technique of PWM implementation because it has blessings over SPWM in phrases of excellent usage of dc bus voltages decreased switching frequency and coffee modern ripple [2].

ii. Space vector is defined in a dimensional (2-D) plane and a SVM is achieved inside the 2-D plane furthermore a 3 dimensional (three-D) space vector has been defined for cascaded H-bridge multilevel inverter

iii. SVPWM for 3 leg voltage source inverter

The topology of a 3 leg voltage supply inverter is shown in determine (1). The eight possible switching mixtures are generated through the switching community. The six out of these eight topologies producing a non zero output voltage are referred to as the remaining topologies producing zero output voltage are referred to as zero switching states.



**Fig. 1: Three phase voltage inverter**

iv. Voltage space vectors

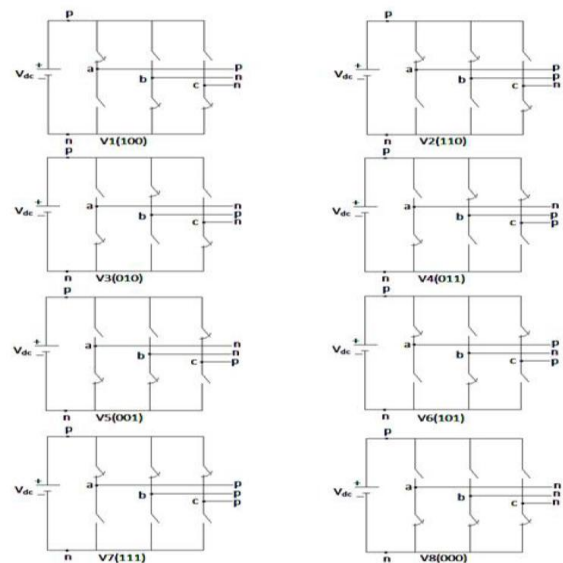
Space vector modulation (SVM) for three leg VSI is based totally on the representation of the 3 section portions as vector in a two dimensional ( $\alpha, \beta$ ) aircraft. The line voltages  $V_{ab}$ ,  $V_{bc}$  and  $V_{ca}$  are given via

$$V_{ab} = +V_{dc} \quad (1)$$

$$V_{bc} = 0 \quad (2)$$

$$V_{ca} = -V_{dc} \quad (3)$$

This can be represented in the ( $\alpha, \beta$ ) plane as proven in parent (2), in which voltage  $V_{ab}$ ,  $V_{bc}$  and  $V_{ca}$  three line voltage vectors displaced  $120^\circ$  in area.



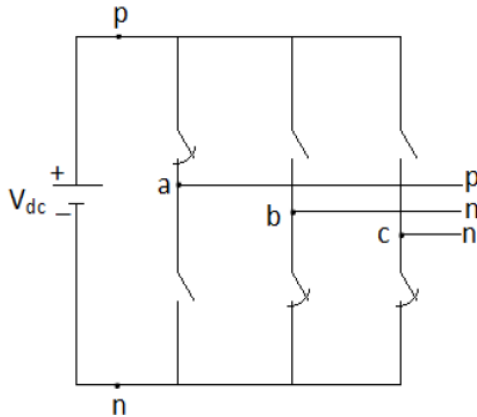
**Fig. 2: Eight switching state topologies of three phase inverter**

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The powerful voltage vector generated by means of this topology in represented as V1 (pnn) in parent (3).

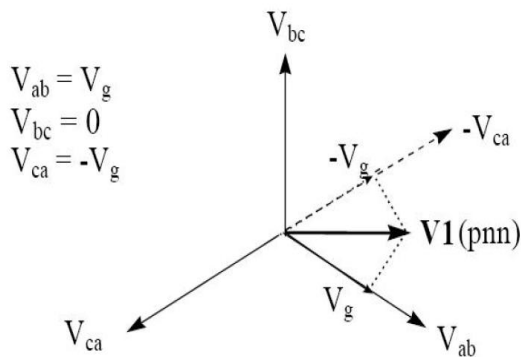


**Fig. 3: Topology V<sub>1(100)</sub> voltage source inverter**

The switching community has produced the full of eight feasible switching combos.

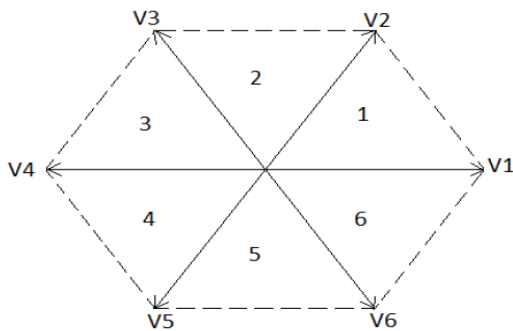
## II. EIGHT SWITCHING STATE TOPOLOGIES OF THREE PHASE INVERTER

Each switching combination effects in a hard and fast of 3 phase voltages on the AC terminal of the switching community. A reference vector V1 may be obtained by transforming the reference three section voltage into the  $\alpha - \beta$  aircraft as proven determine by figure 4.



**Fig. 4: Topology representation of  $\alpha - \beta$  plane**

A balanced 3 $\Phi$  sinusoidal wave shape is received whilst the reference vector is rotating in the  $\alpha - \beta$  aircraft. It is intending on comparable strains the six non zero voltage vectors (V1 – V6 ) may be shown to count on the positions shown in discern figure 5.



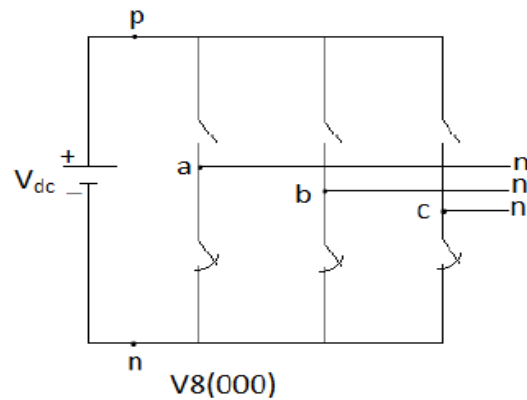
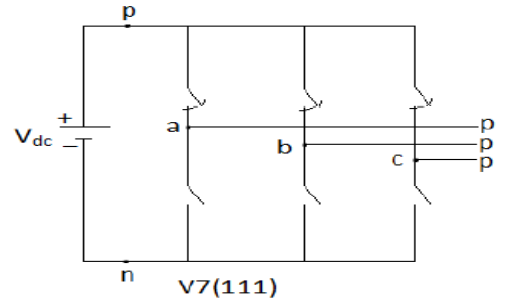
**Fig. 5: Non Zero voltage vectors in the  $\alpha - \beta$  plane**

The output voltages are represented as vectors that have zero importance and therefore are called 0 switching nation vector or 0 voltage vectors. A general of 8 vectors are obtained by reworking the 3 $\Phi$  voltages into the a-b

coordinate and the identical are called switching kingdom vectors [3].

## III. SPACE VECTOR MODULATION

The favored 3 $\Phi$  voltage on the output the inverter will be represented via an equal vector V rotating within the counter clock clever path. The magnitude of this vector is associated with the magnitude of the output voltage as proven in determine (6). And the time of this vector takes to finish one revolution is the same as the fundamental term of the output voltage.



**Fig. 6 Zero output voltage topologies**

When the preferred line to line output voltage vector V is in region 1 as proven figure (7)., vector V could be synthesized by the heart beat width modulation (PWM) of the 2 adjoining switching nation vectors V1 (pnn) and V2 (ppn) , obligation cycle of each being d1 and d2 respectively and the 0 vector (V7(nnn) /V8(ppp)) of responsibility cycle

$$d_1 \vec{V1} + d_2 \vec{V2} = \vec{V} = mV_g e^{je} - 4$$

$$d_1 + d_2 + d_0 = 1 - 5$$

Where  $0 \leq m \leq 0.850$  is the modulation index. This might correspond to a maximum line to line voltage of one.0Vg , which is 15% than conventional sinusoidal pwm.

## IV. SPACE VECTOR MODULATION ALGORITHMS

Two dimensional area vectors for any balanced 3 section variable,  $V_a + V_b + V_c$  , wherein  $\vec{V}$  be voltage vector, there is a dating

$$V_a + V_b + V_c = 0 - 6$$

The above equation indicates that the three variables might be mapped right into a vector  $\vec{V}$  at the orthogonal  $\alpha - \beta$  aircraft, wherein

$$\vec{V} = \vec{V}\alpha + j\vec{V}\beta - 7$$

The transformation for this orthogonal co-ordinate mapping a while referred to as 3/2 transformation is expressed as

$$[V\alpha, V\beta]^T = T_2[V_a V_b V_c]^T - 8$$

Where T is the transformation matrix is expressed as

$$T = \frac{2}{3} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} - 9$$

Three dimensional space vector for any balanced 3Φ inverter as assumption is usually made that,  $V_a + V_b + V_c = 0$ , where  $\vec{V}$  be the voltage vector. The 3 variables in a-b-c coordinate  $V_{abc}$  can be mapped right into a vector  $\vec{V}$  at the orthogonal  $\alpha - \beta$  plane. Therefore each variable maintains the same section distinction for every section. Zero collection contemporary is robotically nullified as the reference vectors might be on a aircraft [4].

## V. TWO DIMENSIONAL SVPWM FOR CALCULATING SWITCHING ANGLES

A two dimensional scheme for an n-level ( $n \geq 3$ ) cascaded multilevel inverter is proposed. In this proposed approach, a simple set of rules of forming switching series is applied that results in minimal trade in voltage.

An powerful hybrid multilevel inverter ought to ensure that the overall harmonic distortion (THD) inside the voltage output waveform is small enough. The algorithm consequences in the minimal THD of output voltage of the cascaded multilevel inverter into equal voltage steps.

## VI. MATHEMATICAL FORMATION

The set of rules can be expressed from the fundamental waveform by means of making use of Fourier series analysis, the amplitude of any peculiar nth harmonic can be expressed as

$$V_n = \frac{4}{n\pi} \sum_{k=1}^n [E_k \cos(n\theta_k)] - 10$$

Where n is an strange harmonic and  $\theta_k$  (okay) is the Kth switching angle. The amplitude of all even harmonics is zero. The modulation index m is definad as

$$m = \frac{\pi V_1}{4 \sum_{i=1}^n E_i} - 11$$

$V_n$  is the whole harmonic thing and  $V_1$  is the fundamental harmonic thing.

The total harmonic distortion voltage

$$THD = \sum_{n=3,5,7,\dots}^{\infty} \sqrt{\frac{V_n^2}{V_1^2}} - 12$$

$$m = \sum_{k=1}^n e_k \sqrt{1 - (\mu_k p)^2} - 13$$

$$e_k = \frac{E_k}{\sum_{i=1}^n E_i} - 14$$

$$\mu_k = \frac{\sum_{i=1}^{nk} E_i - \frac{E_k}{2}}{\sum_{i=1}^n E_i - \frac{E_n}{2}} - 15$$

The switching angle is determined by

$$\theta_k = \sin(\mu_k p) - 16$$

The output voltage of the inverter is

$$V = \sum_{k=1}^{\infty} E_k (V_{\theta_k} - V_{\pi-\theta_k} + V_{\pi+\theta_k} + V_{2\pi+\theta_k}) - 17$$

Where V is unit function by Fourier series expansion

$$V = \sum_{n=1,3,5,\dots}^{\infty} V_n \sin(n\theta) - 18$$

Where

$$V_n = \frac{4}{n\pi} \sum_{n=1,3,5,\dots}^{\infty} [E_1 \cos(n\theta_1)] - 19$$

Modulation index m for the basic output voltage

$$m = \frac{\pi}{4} V_1 = \frac{\pi}{4} \sum_{n=1}^{\infty} [E_1 \cos(n\theta_1)] - 20$$

The THD is expressed as

$$THD = \sum_{n=3,5,7,\dots}^{\infty} \sqrt{\frac{V_n^2}{V_1^2}} - 21$$

## VII. MODULAR HYBRID SYSTEMS

According to that information, it is glaring that a tool capable of changing a unmarried dc voltage from a battery bank into an ac voltage is a key detail of maximum stand-on my own photovoltaic (PV) systems, Wind form and Pico hydel. These dc/ac converters that are usually known as inverters have skilled tremendous evolution inside the ultimate decade due to their wide use in uninterruptible energy elements and business programs. The Block diagram for proposed system is shown in figure (7). There is a connectivity of three renewable sources inside the systems and it's far linked three styles of converter and booster to get an unmarried DC supply. It is stored in a battery the use of raise converter for maintaining non-stop charging the voltage and modern. After connecting a space vector modulation multilevel inverter to the battery its miles transformed into a DC to AC. It is attached to micro grid device with reactive power reimbursement method.

3- 3 PHASE THREE OR FIVE LEVEL MULTILEVEL INVERTER USING SPACE VECTOR PWM TECHNIQUES

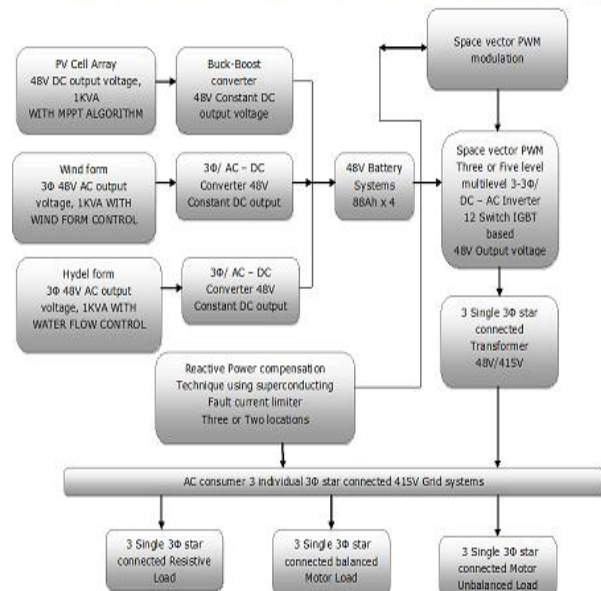


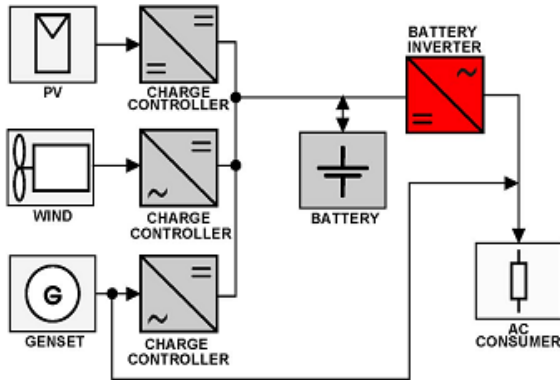
Fig. 7: Block diagram for proposed system

Most of the small SARES for rural electrification present configurations which can be versions of the complicated hybrid systems which can be provided in figure (eight). In both dc- and ac-bus configurations, for the reason that generator does not constantly function and thinking about the intermittency of the RE resources, it's far viable to finish that the battery inverter must be designed to completely

guide the loads at a while durations. Therefore, independently of the device configuration, it is feasible to pick out that at the least one “strong battery inverter” is required. This way, to the excellent of the author’s information, the maximum critical traits of a RES battery area vector pulse width modulation inverter, concerning the order of significance, are as follows:

- 1) Reliability (most crucial);
- 2) Surge strength ability;
- three) No-load consumption and efficiency.

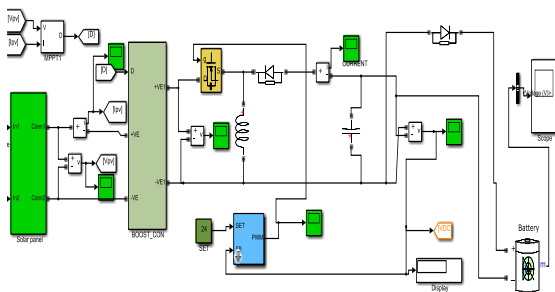
This paper investigates which multilevel topologies betterment the contemporary call for on high-performance battery inverters for stand-on my own RES gadget packages.



**Fig. 8: Modular hybrid systems. (a) DC-bus modular system**

## VIII. SIMULATION MODEL FOR MODULAR HYBRID SYSTEM

The proposed version for MPPT primarily based PC machine, PMSG wind turbine and p.C. Hydel plant are proven parent (9, 10 & 11). These 3 systems had been connected within the micro grid line to deliver power with none power disturbances in the line. The area vector modulation based totally inverter is likewise proposed on this inverter to optimize the switching losses and keep the unity modulation index. The MPPT algorithm is designed in this version to get the most dc output voltage [5].



**Fig. 9: MPPT based PV model**

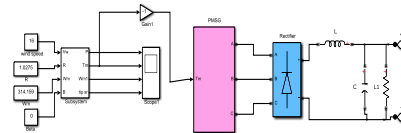
The buck boost converter is implemented to hold the consistent output voltage within the connectivity of grids. It proposes adaptive control structure for optimum strength factor tracking (MPPT) in photovoltaic systems. MPPT technology has been utilized in photovoltaic structures to

deliver the most available electricity to the burden underneath changes of the sun insolation and ambient temperature. To enhance the overall performance of MPPT, this paper develops a two-stage adaptive control structure that could reduce complexity in machine control and efficaciously manage the uncertainties and perturbations within the photovoltaic systems and the surroundings. The first level of manage is ripple correlation manage (RCC), and the second stage is model reference adaptive control (MRAC) [2].

The variable pace wind turbine with complete scale frequency converter is an appealing answer for studies on dispensed power era systems. The generator in this case may be double fed induction device or an everlasting magnet synchronous generator (PMSG). The advantages of PMSG over induction machines are the excessive performance and reliability, since there may be no want of outside excitation, smaller in length and smooth to control.

`set(0,'ShowHiddenHandles','on')`

`>> set(gcf,'menubar','figure')` Also PMSG has a few disadvantages like higher fee and a repair excitation. Over the years the PMSG has end up a greater appealing answer to use it in variable wind turbine packages. The generator is hooked up via a full scale voltage source converter: generator converter is used to control the torque and the rate and grid aspect converter used to control the power waft a good way to preserve the DC-link voltage regular. The two converters are connected by using a DC hyperlink capacitor with a view to have a separate manage for each converter. For controlling the PMSG is vital to recognize the rotor role and pace.



**Fig. 10: PMSG based wind turbine model**

Pico hydro is a green power that the use of small river to generate energy without counting on any assets of non-renewable energy. This opportunity energy gives a green scheme this is reliable, efficient and cost-powerful. No extra difficulty approximately the value of capital, pollution, gas resources, and existence expectancy. On the alternative hand, many people nonetheless lack of know-how approximately the working mechanism of the p.C. Hydro generation device. The coronary heart of a percent hydro device is water turbine and primarily based at the literature studies, the selection of turbines is depends on the circumstance of available water sources. Besides that, using misguided generator, penstock and consumption system also affected the efficiency price of device and simultaneously wastes the water energy available.



Pico hydro is the exceptional option to enhance the dwelling popular of rural human beings in situation; the machine itself needs to be designed nicely consistent with the available water supply [2].

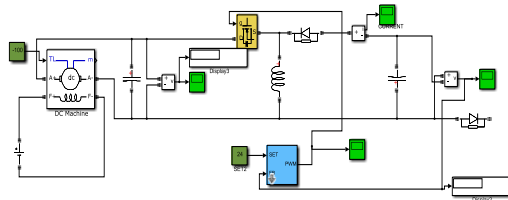


Fig. 11: Pico hydel plant model

## IX. SIMULATION RESULTS

The simulation consequences had been simulated the use of MATLAB and the outputs are demonstrated with real time parameters. The connectivity of all power assets in parallel to micro grid and routinely communicated to with their availability by means of space vector modulation inverter. The outputs are shown in figure 12.

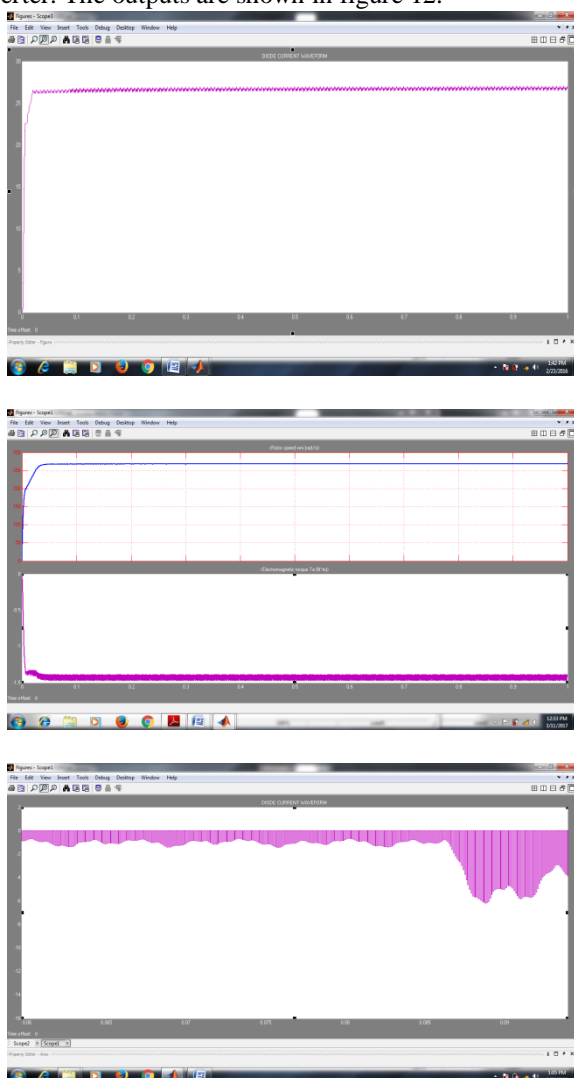
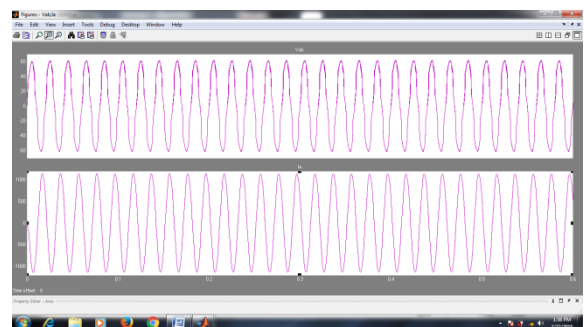
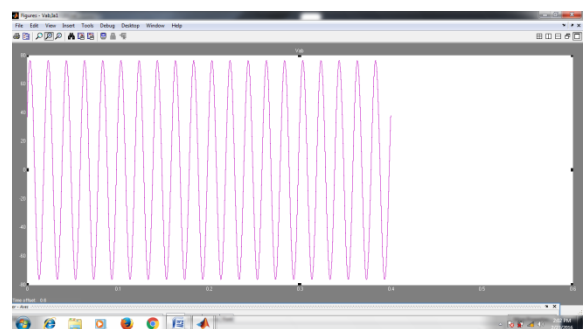
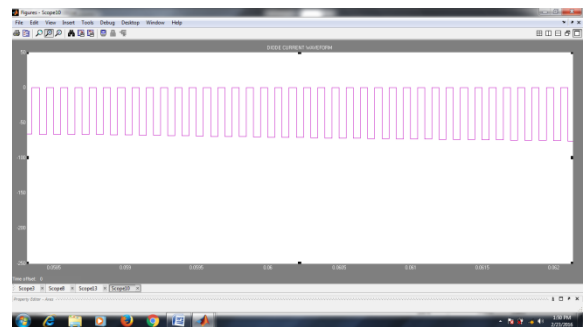


Fig. 12: Simulation results for Diode current for three systems, DC voltage and Inverter output voltage

## X. CONCLUSION

This paper is used to attach three exclusive sources like Wind, Solar and Pico Hydel. The present day method is used to transform the 3 different power resources into DC voltage and it's miles saved within the Battery [1]. From Battery the DC voltage is converted into AC supply and it's far



related Grid systems. Therefore on every occasion a deliver exceeds the call for at any forged anybody of the source or three resources are to grid and satisfy the requirement of the deliver call for. This proposed model is simplify the switching sample and contains the twin output voltage and current. The complexity of this version has been reduced because of the reduction of switches. Thus the switching losses also are minimized. As the switches are minimized, harmonic aspect gets reduced which results inside the minimization of distortion component .Therefore 1/3 harmonic distortion issue are notably minimized. The simulation results are proven in Fig 12 [5].

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## A NEW INTERCONNECTION OF MICRO GRID DISTRIBUTED ENERGY SOURCES USING SPACE VECTOR MULTILEVEL INVERTER

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