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Sepic Converter Based Hybrid Energy System For Micro Grid Applications

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Abstract: Due to the popularity of renewable sources of energy generation of power for alternative electrical energy source is not practical in a traditional way. During the past years remarkably photovoltaic and wind generation of power is highly expanding. In this work, combination of wind turbine generator and solar panel is the proposed hybrid energy system which is the further source for power system with conventional sources like hydro and thermal power generation. To track the point of operation a basic control method is proposed in which wind turbine generator coerces excessive power and also excessive power from PV is coerced under stable environmental changes. The proposed DC-DC converter provides constant voltage to the voltage source inverter from hybrid energy system. The Maximum power point tracking methods perturb and observe algorithm utilized to extract extreme power from the hybrid system. With simulation results which evaluate the system feasibility the whole hybrid system is illustrated. A Matlab/Simulink model is evolved using software simulation.

Keywords— SEPIC converter, Inverter, Solar panel, Wind energy, Matlab

1. INTRODUCTION

Modern trends and developments in consumption of electric power show that the renewable energy usage is increasing. Nearly all the regions in the world have one or other kind of resources of renewable. Owing to this, studies related to renewable sources of energies has gained a lot of recognition. Most commonly used renewable sources of energy are energy of wind and energy of solar. In existence energy of wind is the renewable energy with low cost and has high attentiveness of educators and scientists all over the universe. DC electricity is generated from the energy from sunlight by Photovoltaic cells. Comparing with other renewable sources PV has some benefits that are need practically no maintenance and there is no noise. Combining wind and solar sources of power produce a practical form of generation of power.

Earlier, more projects were presented and several studies are made on renewable sources of energy usage for power generation. Because of its nature of uncertainty of solar and energy of wind systems are extremely unreliable. In a Photovoltaic, electric power system with diesel is included with panel to examine the diminution in the consumed fuel. Fuel consumption is reduced by including additional renewable source. When source is inadequate or not available in load demand meeting, other sources of energy will remunerate for the dissimilarity. Initially some hybrid PV/wind power systems with control of Maximum Power Point Tracking (MPPT) was designed.

To execute the control of MPPT for all renewable power sources in fusion a discrete DC/DC buck- boost and buck converter is utilized in rectifier stage. Because of the environmental factors, influenced wind turbine generator has a problem, hence there is a need for injection of current harmonics with maximum frequency. The harmonic produced is cannot be neglected by Buck-boost and buck converters. So to neglect it the system needs passive input filters which make the system more costly and bulky.

In this project, for wind and solar energy hybridization a transformed topology of converter has been developed. Solar and wind energy sources are involved jointly by utilizing an integration of two modified SEPIC converters in this topology, if a single source is not present other sources will remunerate for it. Common structure used in high power factor (HPF) rectifiers is boost converter to increase power factor (PF) and THD reduction. Significantly efficiency is reduced in minimum operation condition is taken in account in design of power converter. Lower line voltage with improved efficiency is significant as heat sinks size and thermal design are explained by considering minimum operation point. Various works are developed to increase the power converter operational characteristics used in HPF input rectifiers.

Operational efficiency with reduced input voltage is increased by utilizing minimum switching voltage and high static gain topology. In case of maximizing static gain for boost converter with minimum switching voltage, voltage multiplier method is used. Universal input voltage HPF rectifier is not utilized for boost voltage doublers; since increased input voltage is less than double of voltage in the output. In universal input HPF rectifier boost voltage doublers is used for multiphase modification. In reduce input voltage high static gain is acquired with similar Boost converter DC output voltage levels. Modified SEPIC converter with integrated voltage multiplier cell is developed to get maximum step up static gain operation with reduced input voltage and high operation of input voltage reduced with step up static gain. Modified converter operates in low switching voltage than the voltage in output and with current ripples in input is lesser than conventional boost converter. The converter circuit developed is integrated with regenerative snubber to obtain soft commutation switching and high efficiency.

In the wind generator the SEPIC-SEPIC integrated converters remove the HF current harmonics with its ability. This system exclude requirement of passive input filters. For all renewable energy source operations of step up and step down are supported by these converters. They can also support simultaneous and individual operations. Input of one modified converter is solar energy source and input for other modified SEPIC converter is wind energy source. The addition of the input of these two systems will be the average voltage in output which is provided by power system. The developed hybrid system becomes more reliable and efficient by these all benefits.

2. SEPIC CONVERTER

The existing typical boost converters disadvantages are overcome by the developed modified high gain DC-DC SEPIC converter, this modified converter is the upgraded version of elementary SEPIC converter, and this modified topology of converter have protection of voltage and current. Also this converter input current is highly continuous

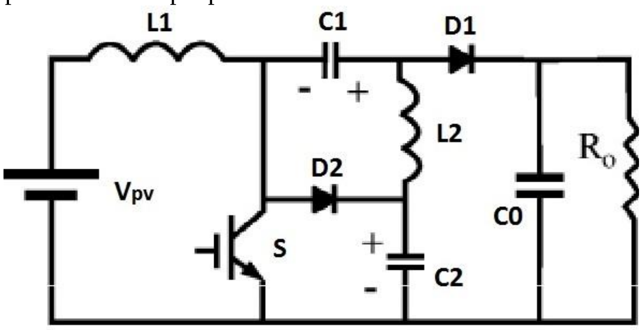

Fig 1.Modified Single Ended Primary Inductance Converter circuit

In this system a high step-up Modified SEPIC Converter is used it increase the cost and reduce the efficiency. Hence in developed system a converter with high step-up is in relevant stage since such a system needs conversion with high step-up with increased efficiency. Theoretically with high efficiency high step-up conversion cannot be obtained by Modified SEPIC Converter due to elements resistances or inductance leakage; also, the voltage stresses are high.

3. PROPOSED SYSTEM OPERATION

Owing to the expansion of global warming renewable energy sources and destruction of typical resources renewable energy have to be utilized. In this work, a renewable energy system of hybrid wind solar integrated single phase inverter is developed. Wind generator and photo voltaic (PV) array is the combination of the modified technique. Wind generator will generate the wind power and PV arrays will generate solar energy and by SEPIC converter all the produced voltages are boosted down or up. These boosted voltages are supplied to inverter with single phase.

Conventional SEPIC converters' power circuit is presented in Fig. 1. The SEPIC converter step-down and step-up static gains characteristic operation is attractive for wide range of applications in input voltage. Nevertheless the summation of input and output voltages is equivalent to the switching voltage, this methodology is not applicable for the input of universal HPF rectifier. The technique of voltage multiplier was developed [18] to maximize static gain of multiphase and single-phase dc–dc boost converters. Voltage multiplier strategy for SEPIC converter adaptation is illustrated in Fig. 2. The development of modified SEPIC converter is done by injecting capacitor C2 and diode D2. The conventional SEPIC converter's operational characteristics are modified with the developed method. Charging of capacitor C2 is made with the conventional boost converter output voltage. Hence during the power conduction switch (S) is greater than modified SEPIC when inductor voltage L2 is applied, hence static gain increases. In the proposed system the voltage stored capacitor polarity C1is inverted, and capacitor voltage expression and characteristics of further operation are explained in the theoretical evaluation.

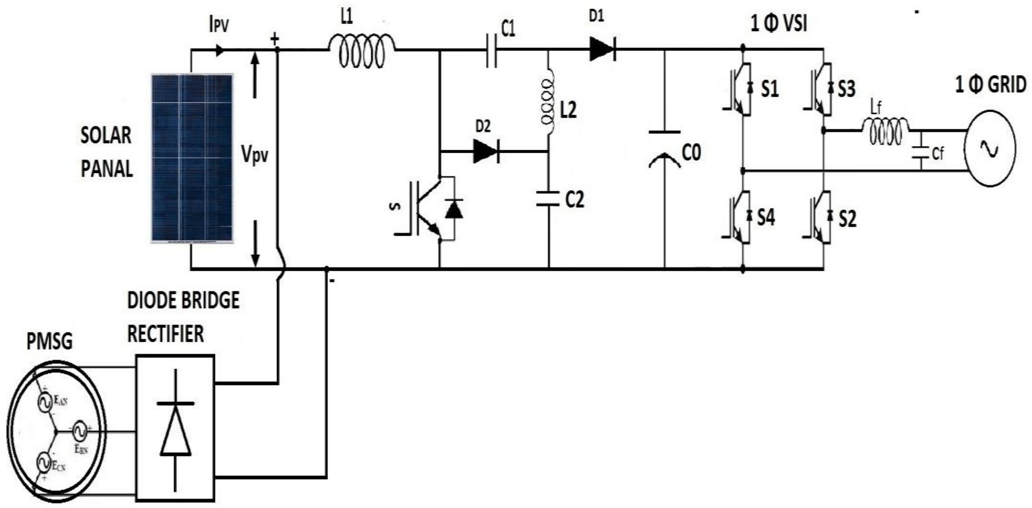

Fig 2. Proposed system modified DC-DC converter based system

The modified SEPIC converters continuous conduction-mode (CCM) operation presents the following three stages of operation.

First Stage [t0 - t1] (Fig. 3) – During the conduction of power switch S energy across input voltage L1 (VL1) is stored in the inductor input. Voltage beyond L2 (VL2) is equivalent to voltage in capacitor C2 minus voltage in capacitor C1. As illustrated in (1), the dissimilarity of voltage is same as input voltage. During this stage of operation energy is stored in inductors L1 and L2 and same voltage is supplied across these inductors. Current through inductor L1 and L2 increase following (3) and (4) respectively, hence L2 is less than L1, the current dissimilarity in L1 is lesser than in L2, as exhibited in the conceptual waveforms given in Fig.3. During this operation stage the diodes D2 and D1 are blocked.

Second Stage [t1 – t2] (Fig. 4) – At the instant t1, turn-off switch S and input inductor L1 energy stored is shifted to output through C1capacitor and output diode D1. Capacitor C2 energy is shifted through diode D2 and high switch voltage is equivalent to capacitor voltage C2. Stored inductor energy L2 is shifted to output and capacitor C1 through diodes D1 and D2. Voltage in capacitor C2 is same as voltage across L1 minus input voltage and the differentiation is similar to capacitor voltage C1 as analyzed by (1). Capacitor voltage C1 is negative and voltage across inductor L2 is similar to each other. Hence inductor voltage across L1 and L2 are similar to negative capacitor voltage C1 during operation and variation of current in inductor is evaluated by (6) and (7) respectively. As exhibited in Fig. 3 (t2-t1) during the operation of second stage time interval exhibited is known as td and it is equivalent to energy in L1 and L2 inductors, period of transference through diodes D1 and D2. When value of current L2 becomes similar to L1 value of current with alike direction, the diode currents D1 and D2 is nullified. This operational stage is completed therefore td is the time for conduction of diode D2 and D1 when inductors energy L1 and L2 is transferred.

Third Stage [t3 – t4] (Fig. 4) – When diodes D1 and D2 at the instant t3 is blocked, the inductors voltage across L1 and L2 becomes null, by maintaining the current in inductors constantly is given in (9) and (10). Similar value is shown by inductors current L1 and L2, and operates in freewheeling stage. In the instant t4 when switch is turned on operation stage will be completed, and returns to the initial stage of operation.

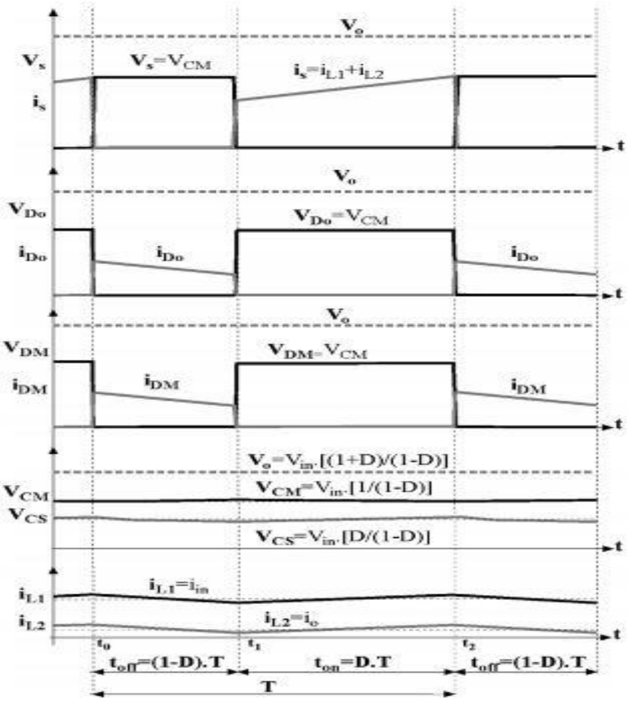

Fig 4 Main theoretical waveform

The operation of hard switching commutation for theoretical waveforms is exhibited in Fig. 4. Voltage of capacitor C2 is equivalent to all diode and power switch voltages. The current in input and inductor average current L2 is equivalent to output voltage and input current is equivalent to average inductor current L1. In steady state average capacitor current C1 and C2 are nullified hence diodes D2 and D1 average current are equivalent to output current.

. In this mode the inductor current L1 is

$$\Delta IL1 = \frac{V0}{L1}(0.5 - D)T \quad \text{--- (1)}$$

$$\frac{dIL1}{dt} = (Vg + kV0)/(1 - k^2)L1 \quad \text{--- (2)}$$

$$\frac{dIL2}{dt} = -(V0 + kVg)/(1 - k^2)L2 \quad \text{--- (3)}$$

Where k is the winding constant.

D is the SEPIC converter PWM duty cycle.

T is the PWM pulse total time.

In this mode the duty cycle is comes to more than 0.5, it is the boost mode. Here the inductor current IL1 and IL2 is keeps on increasing.

$$\frac{dIL1}{dt} = Vg/(1 + k)L1 \quad \text{--- (4)}$$

$$\frac{dIL2}{dt} = Vg/(1 + k)L2 \quad \text{--- (5)}$$

The voltage in capacitor C1 is equal to the DC input voltage Vg. The change in inductor current can be expressed as,

$$\Delta IL1 = \frac{V0}{L1}(D - D')T \quad \text{--- (6)}$$

Due to this inductor current the output voltage becomes high.

The developed converter main equations and theoretical analysis is given in this session. To exhibit the developed convertors positive and negative characteristics the output of the theoretical analysis is distinguished with traditional boost converter.

The developed method acquired from the convertor hence a differentiation is made with modified SEPIC converter is illustrated. Theoretical analysis is used for defining the equations for evaluation of developed converter capacitance and inductance. By considering HPF rectifier operation and AC voltage source usage and input connected full-bridge rectifier is developed by theoretical analysis of developed converter. For application of AC input voltage the voltage changes from Vi= 60Vrms and output voltage similar to Vo=425Vdc.

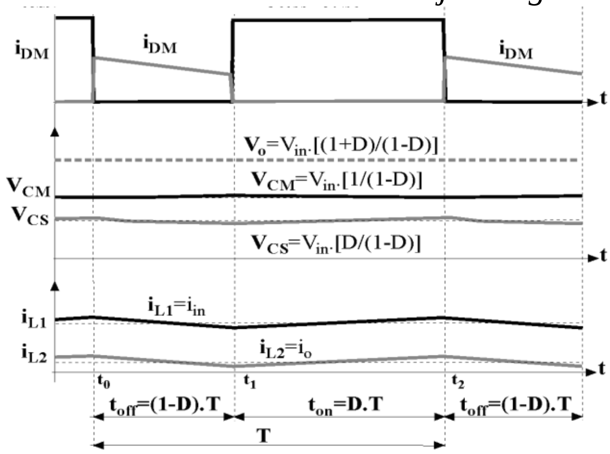

Fig 4 SEPIC converter output waveform

4. INTEGRATED CONVERTER TOPOLOGY

To minimize the total number of components integrated in converter topology has been proposed and it also increases efficiency of the proposed technique totally. The following are few of the significant advantages of tour systems.

1) This system does not need any separate filters for PF correction.

2) This system can be operated in both buck and boost mode for each source.

3) It can work even if only one source is available.

The developed circuit configuration is shown in figure. The system takes two inputs one from a PV array and the other from a generator. Thus allowing individual operation when there is an absence of one source

Applications:

1. Servo motor Speed control.
2. Battery charging.
3. Renewable energy system
4. Telecommunication applications

The power produced by a renewable energy system is unreliable and is constantly subjected to changes by environmental factors. To overcome this problem a maximum power extraction method is incorporated in most renewable energy system. In this project also we have used a MPPT algorithm which uses hill climbing method to extract maximum power. In this method the operating voltage is moved one step and it checks the output power generated. If there is an increment in the output the new value will be continued or else it goes back to its previous stage. As we are using two voltage sources each depending on different environmental sources like wind and solar the major parameters which are altered for max power extraction is discussed below. In wind energy conversion system the only parameter which needs to be varied to get high power in the speed of turbine which corresponds in accordance with the variable wind speed so we can maintain the TSR equal to the required MPPT coefficient. Similarly when it comes to solar the major parameters which determine the output are temperature and irradiance. MPPT plays an important role it solar power generation system as with a proper MPPT system the voltage will collapse so a MPPT algorithm avoids this condition. The given PV module generation of power relies on solar irradiants and system temperature without MPPT. A three level inverter with a sinusoidal PWM control technique which uses a carrier signal with a frequency of 10 KHz along with a PI controller convert the MODIFIED SEPIC DC output to AC also it maintains AC voltage which is kept in synchronization with the GRID voltage and frequency thus improving PF.

5. SIMULATION RESULTS

To analyse the ability of the developed technique, simulations are performed.

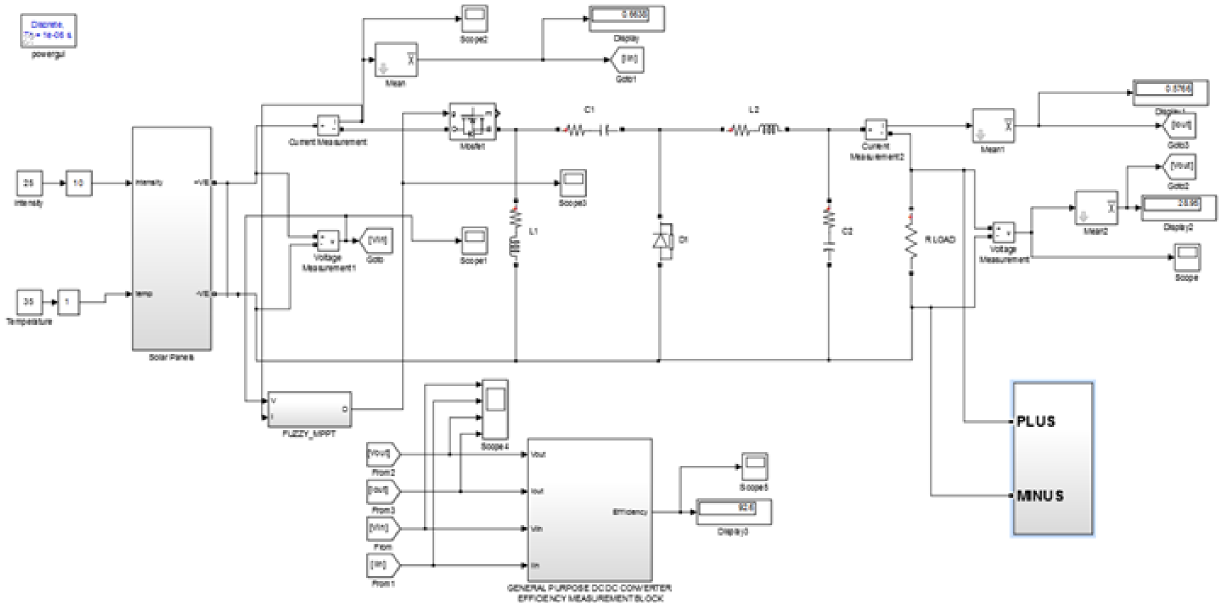

Fig 5. Proposed system hybrid energy based grid system

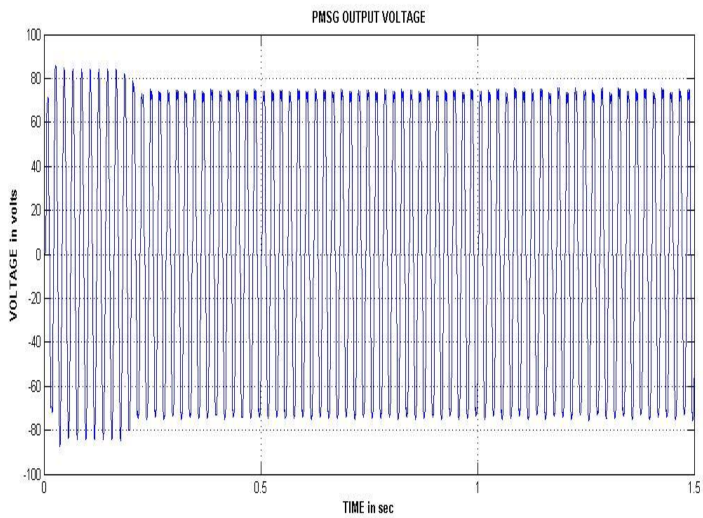

Fig.6.Output voltage waveform from the DFIG

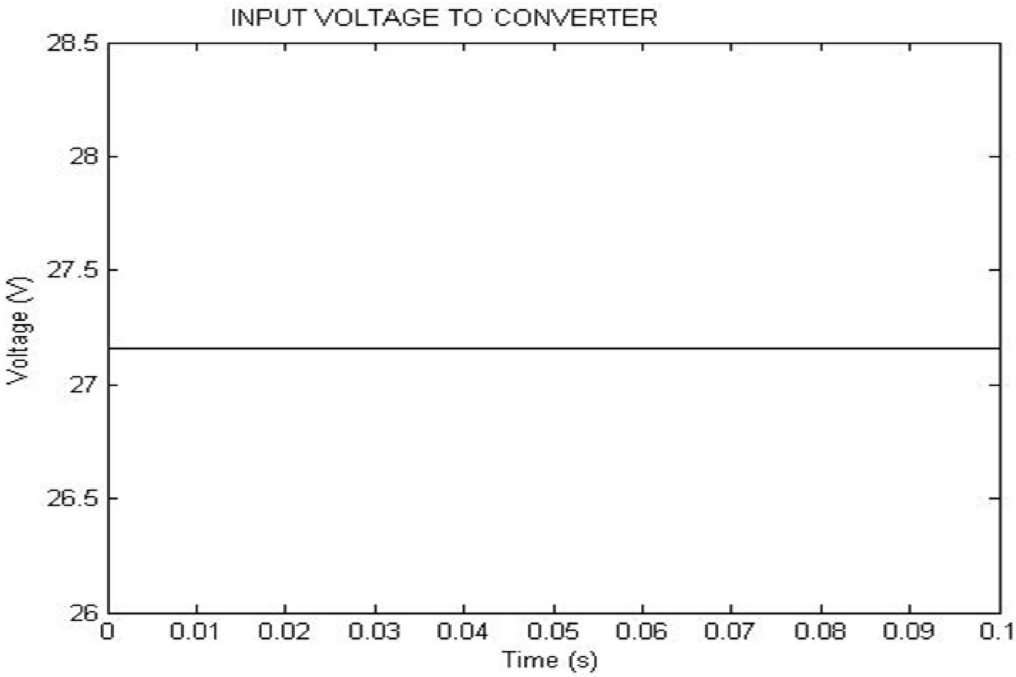

Fig.7 Hybrid energy output voltage waveform to the SEPIC converter

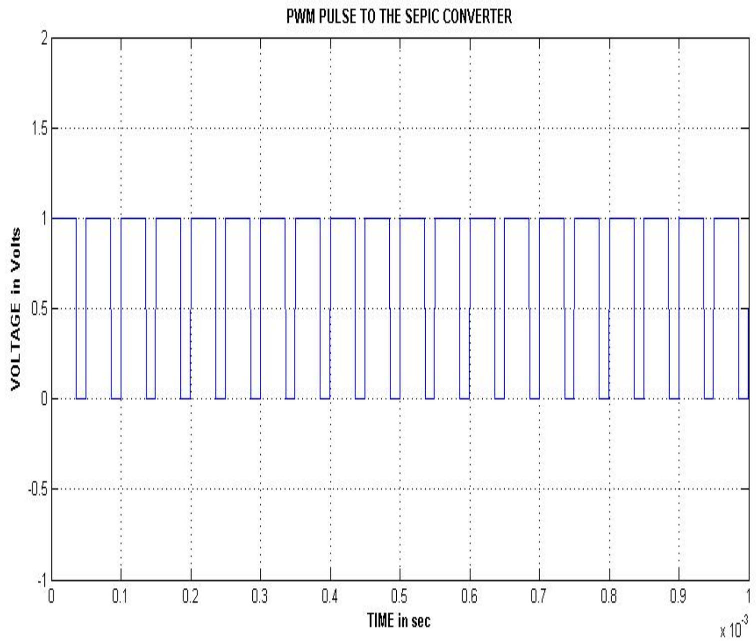

Fig.8 PWM pulse waveform to the SEPIC converter

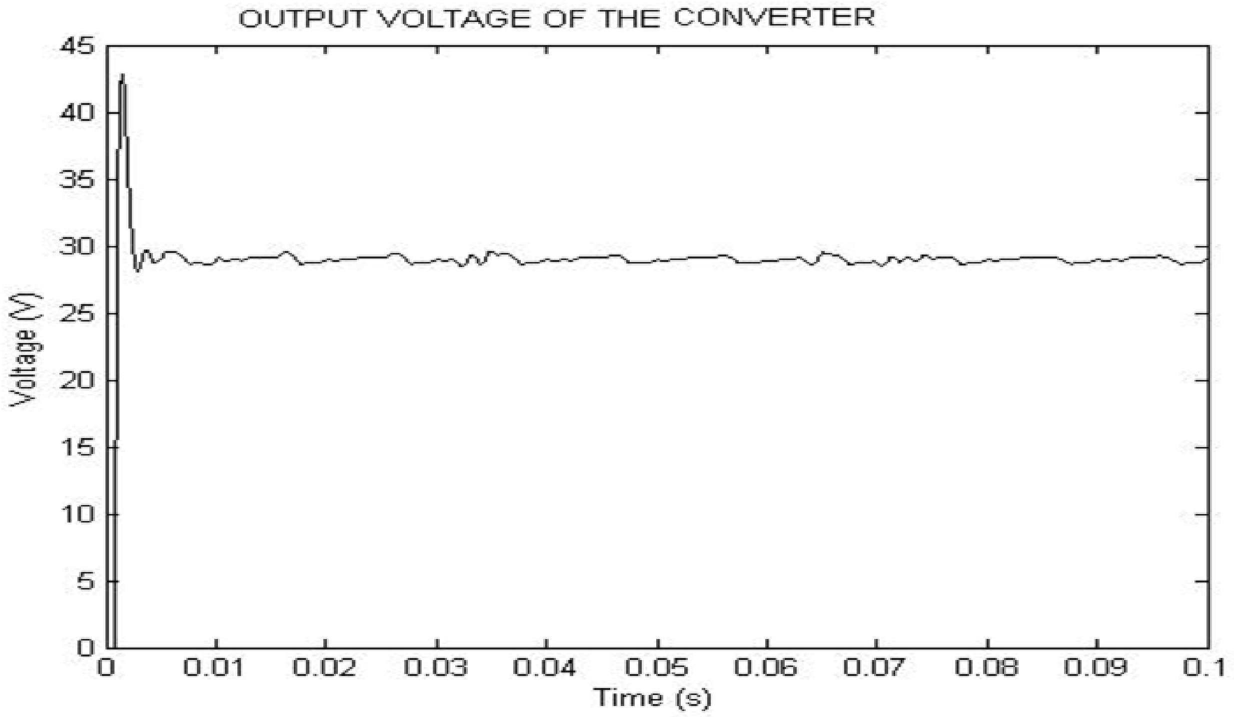

Fig.9 High gain SEPIC converter output voltage waveform

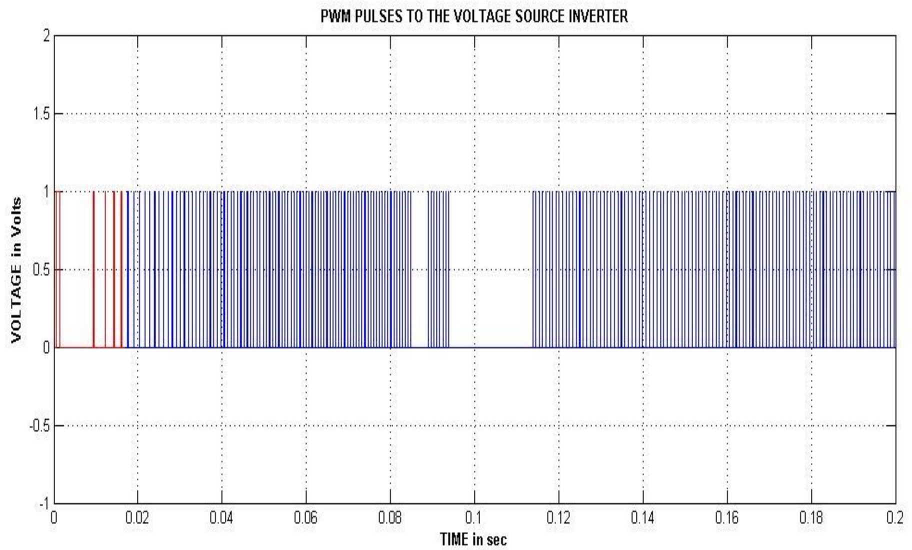

Fig.10. Sinusoidal PWM pulse waveform to the voltage source inverter

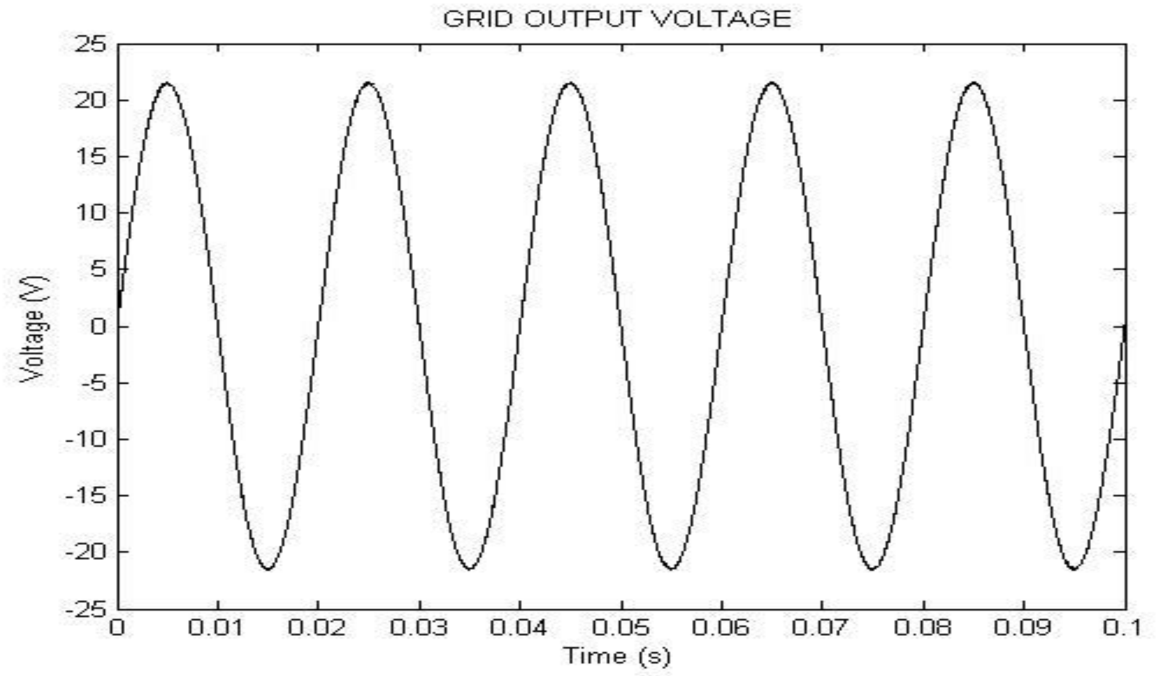

Fig.11 Grid connected inverter output voltage waveform

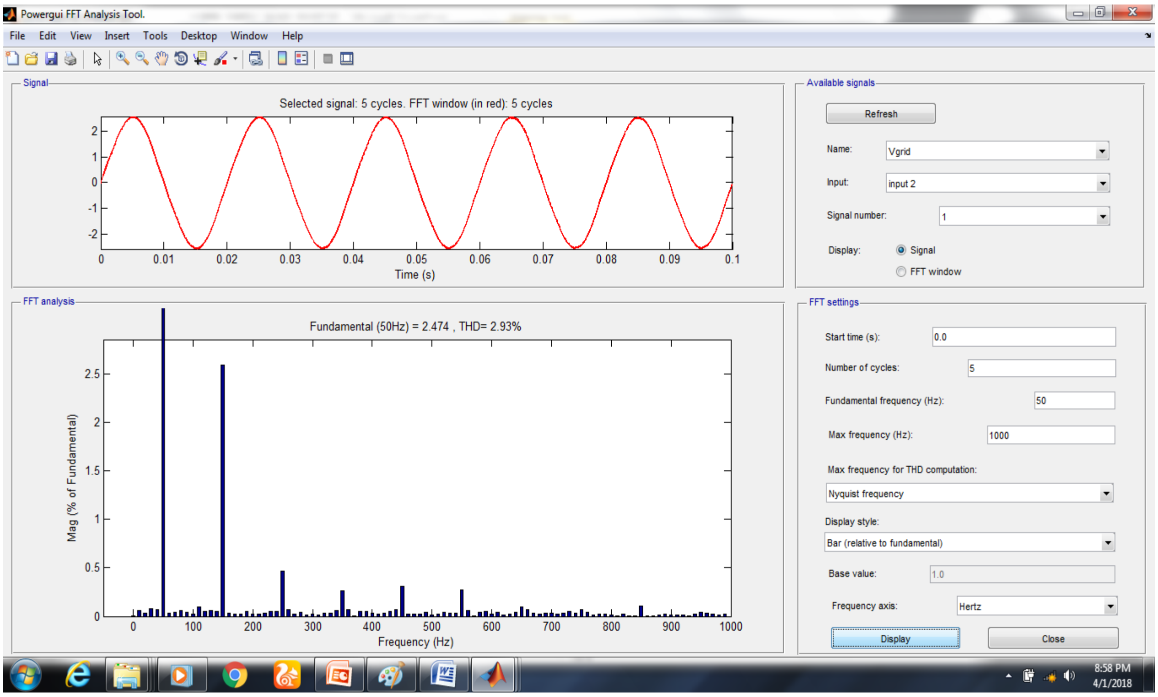

Fig.12 Grid connected inverter voltage THD result

The value of THD is exhibited in figure 12 by supplying stable voltage to the inverter the SEPIC converter will minimize the THD.

The FFT analysis of the inverters output voltage is exhibited in above figure (Fig.12), the results show reduction in the THD value as the MODIFIED SEPIC converter is capable of delivering a constant input voltage to the inverter.

6. CONCLUSIONS

Due to gradual degradation of fossil fuels and increase in fuel extraction cost has paid way for development of new power production methods which uses Renewable energy sources like solar energy and wind energy has been proposed and some of them are current deployed all over the world to meet electrical power demand. Due to the raising power demand this system is in need of an upgrade to face the demand. In this paper we have discussed a renewable energy based power generation system which combines two most commonly used energy conversion methods the solar and wind energy system accompanied by a power converter topology which makes use of two MODIFIED SEPIC converter circuits. The significant pros of using this topology is its capability to supply load by both the sources either simultaneously or separately as per the load demand availability of power from the two sources. The output voltage produced by the developed system is equivalent to summation of input voltage to both the converters and also the two converters circuit are integrated to make a single circuit thus reducing the total number of components being used. Other advantages of this project are its low operation and installation cost. And find application in electrification of remote and rural areas. The whole developed method was designed by utilizing MATLAB/SIMULINK software where we used computed generated models of PV panel and wind turbines along with converter circuit and its feasibility was studied and a THD analysis was done and we got 2.95% in THD.

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