ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

**International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering**

*(An ISO 3297: 2007 Certified Organization)*

*Website: www.ijareeie.com*

**Vol. 6, Issue 3, March 2017**

# High Efficiency Asymmetrical PWM DC –DC Converter for Photovoltaic Application

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**ABSTRACT***:* This paper presents a high efficiency asymmetrical pulse width modulated dc-dc converter for photovoltaic application. The proposed dc-dc converter reduces the switching losses and current loss by zero voltage switching techniques. Moreover, the resonant circuit composed of the leakage inductance of the transformer and the blocking capacitor provides the zero-current switching (ZCS) turn-off for the output diode without the help of any auxiliary circuits. Finally,the reverse recovery problem of the diode is eliminated. The proposed paper is most suitable for variable input voltage (40-80V) application like PV. The results are verified with Matlab/Simulink and experimental results.

**KEYWORDS:** Asymmetrical pulse-width modulated(PWM), full-bridge converter, soft switching.

## I.INTRODUCTION

Generally, use of conventional sources (such as coal, diesel, etc)forproducing electricity lead to environmental pollution. In order to reduce the environmental pollution, the use of renewable energy (such as solar energy, wind) energy has been increased. The environmental condition may create voltage fluctuation in photo voltaic cell. Hence the converter is used between photo voltaic cell and the load. In order to reduce the cost, the capacity of the converter should be increased. For this purpose the common topologies such as active clamp with voltage doubler, LLC converter and phase shift full bridge converter are used. By utilizing the leakage inductance, the magnetizing inductance, and the parasitic capacitance, the zero voltage switching(ZVS) for switching can be realized by an active clamp. Due to the resonant current formed with the leakage inductance and the resonant capacitor, the zero-current switching (ZCS) of the diodes of the transformer secondary side can be provided by an active clamp with voltage doubler particularly forward/flyback converter. However across the primary switches of the transformer forward/flyback converters have a much higher voltage stress than a input voltage. Therefore low on-resistance RDS (on) of MOSFET cannot be employed. LLC resonant converter can be used in different application which required variable input and output voltage,high efficiency and power destiny with the help of variable frequency control.

However on account of very wide band width,the frequency has to be increased very high to achieve required voltage gain controllability. As the front end converter of micro inverter,LLC resonant topology is very hard to implement, because of its difficulty to maintain in high efficient over fluctuating input with different load condition. The structure of PSFB converters is very simple and soft switching is used in it. Hence for the high efficiency in the medium power application, the PSFB converters are widely used. However the full-bridge converter with the phase-shift control scheme is not appropriate under the fluctuating input voltage. This is because of the some serious disadvantages such as narrow ZVS range of lagging leg switches duty cycle loss, large current loss and voltage spikes across the output diodes present in its control scheme. In the application that required high voltage, a very serious is large voltage spike.

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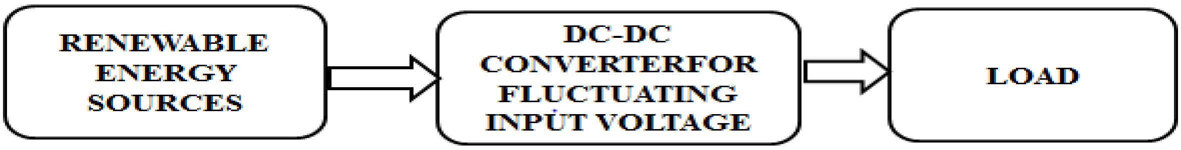


Fig.1. Renewable energy conversion system.

## II. ANALYSIS OF APWM FULL-BRIDGE CONVERTER

A circuit configuration of the extremely economical APWM fullbridgeconverter for low input voltage variation is shown in Fig. 2.The configuration of the planned convertor is largely similarto that of the traditional full-bridge convertor aside from thedc obstruction electrical device and also the secondary aspect of the electrical device.Theprimary aspect of the electrical device consists of the firstwinding turns $N_p$, the four switches, and also the dc obstruction electrical device$C_b$. The secondary aspect has the coil Ns, theoutput diode $D_o$, and also the output electrical device $C_o$.

To analyze the steady-state operation of the plannedAPWM full-bridge convertor, the subsequent assumptions are made.

1) The electrical device is shapely as a perfect electrical device with the first winding turns $N_p$, the secondary turns Ns, the magnetizing inductance lumen, and also the run inductance $L_{lk}$.

2) All switches $S_1$–$S_4$ are thought of as ideal switches aside from their body diodes and output capacitors ($CS_1 = CS_2 = CS_3 = CS_4 = C_{loss}$).

3) The dc obstruction capacitance $C_b$ and therefore the output capacitance Co area unit giant enough to neglect thevoltage ripple thereon, therefore the voltages across $C_b$ and Co area unit constant. whereas the switch $S_1(S_4)$ with a obligation magnitude relation D, betting on the input voltage and cargo condition, the switch $S_2(S_3)$ operates with a obligation magnitude relation 1−D. In different words, the switches $S_1(S_4)$ and $S_2(S_3)$ area unit operated unsymmetrically. Therefore, the current loss of the first aspect are often eliminated as a result of the projected convertor has no freewheeling amount. Fig. three represents the operative modes, and Fig. four represents the theoretical waveforms of the projected convertor underneath a steady-state condition. The operation of the projected convertor are often divided into six modes throughout a switch amount Ts.

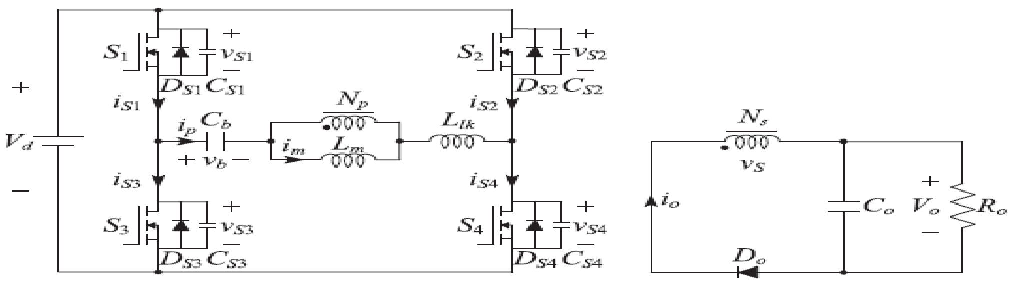


Fig. 2.1 Circuit diagram of the proposed APWM full-bridge converter.

While the switch $S_1(S_4)$ operates with a requirement magnitude relation D,depending on the input voltage andcargo condition, the switch$S_2(S_3)$ operates with a requirement magnitude relation 1−D. In different words, theswitches $S_1(S_4)$ and $S_2(S_3)$ square measure operated unsymmetrically.Therefore, the current loss of thefirst facet willbe eliminated as a result of the planned device has no freewheelingperiod. Fig. three represents the inoperation modes, and Fig. 4represents the theoretical waveforms of the planned deviceunder a steady-statecondition. The operation of the plannedconverter are often divided into six modes throughout a switch period T.

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***Mode 1 [t0, t1]:*** At $t_0$, the switches $S_2$ and $S_3$ are turnedoff. The first current scientific discipline discharges theoutput capacitances$CS_1$ and $CS_4$ of the switches $S_1$ and $S_4$ andcharges the output capacitances $CS_2$ and $CS_3$ ofswitches$S_2$ and $S_3$. The interval of this mode is incredibly short andnegligible as a result of the output capacitanceslinear unit of theswitches are terribly tiny. Thus, the first current scientific discipline andthemagnetizing current are thought to be constant value.

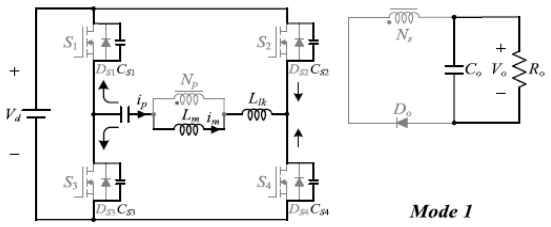


Fig. 2.2 (a) Mode 1

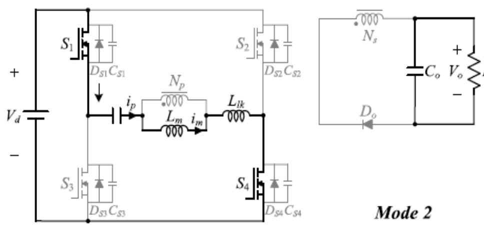


Fig. 2.2 (b) Mode 2

***Mode 2 [t1, t2]:*** At $t_1$, when the voltages $vS_1$ and $vS_4$ across the switches $S_1$ and $S_4$ become zero, the negative current flows through their body diodes $DS_1$ and $DS_4$ before the switches $S_1$ and $S_4$ are turned on. Then, ZVS operation is achieved with the turn-on of the switches *S*1 and *S*4, and the resonance occurs between the dc blocking capacitor $C_b$and the primary inductor $L_m$+ $L_{lk}$of the transformer, but resonance effect does not appear because the resonant period is much longer than one switching period $T_s$. Thus, by the difference between the voltages of the input and the dc blocking capacitor $C_b$, the direction of the primary current *ip*is changed and kept almost linearly.

**Mode 3 [t2, t3]:** At $t_2$, the switches $S_1$ and $S_4$ are turned off. The primary current ip charges the output capacitances $CS_1$, $CS_4$ of $S_1$, $S_4$ and discharges the output capacitances $CS_2$, $CS_3$ of $S_2$, $S_4$. Similar to Mode 1, the primary current $i_p$and the magnetizing current $i_m$ are regarded as constant value.

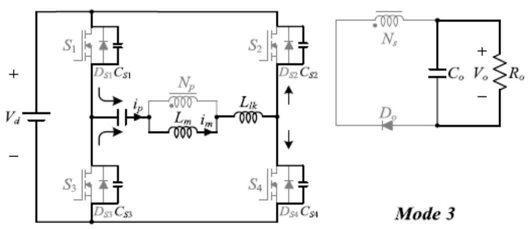


Fig. 2.2 (c) Mode 3

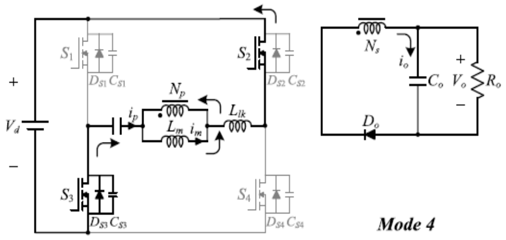


Fig. 2.2 (d) Mode 4

**Mode 4 [t3, t4]:** At $t_3$, similar to Mode 2, ZVS turn-on of the switches $S_2$ and $S_3$ is achieved. The energy storedin the magnetizing inductance is delivered to the secondary side of transformer, and the voltage across the magnetizing inductance Lm is clamped by the reflected output voltage across the leakage inductance Llk of primary side is the difference between $V_d + V_b$ and the reflected output voltage Vo/n from the secondary side.

**Mode 5 [t4, t5]:** At $t_4$, the primary current $i_p$ becomes zero and changes its direction. Also, the magnetizing current $i_m$ changes its direction during this interval. The output current $i_o$ approaches zero at the end of this mode with resonant characteristics. When the output current $i_o$ becomes zero, this mode ends**.**

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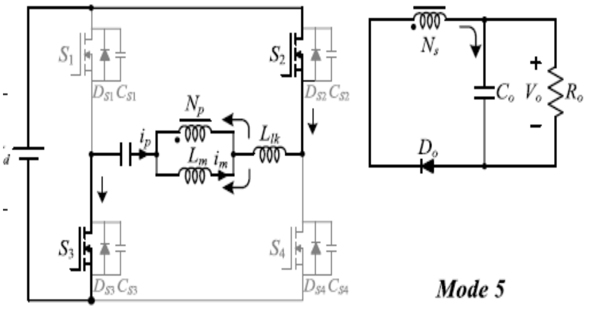


Fig. 2.2 (e) Mode 5

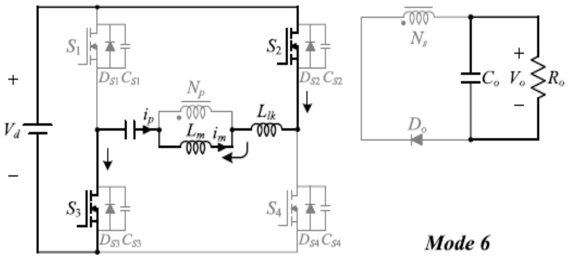


Fig. 2.2 (f) Mode 6

**Mode 6 [t5, t6]:** At $t_5$, because the resonance launched in Mode 4 is ended, the output current $i_o$ becomes zero. However, the output diode $D_o$ is maintained to on-state until the switches $S_2$ and $S_3$ are turned off. During this mode, the primary current $i_p$ is equal to the magnetizing current $i_m$. Thus, ZCS turn-off of the output diode Do is achieved.

## III.SIMULATION AND ITS RESULTS

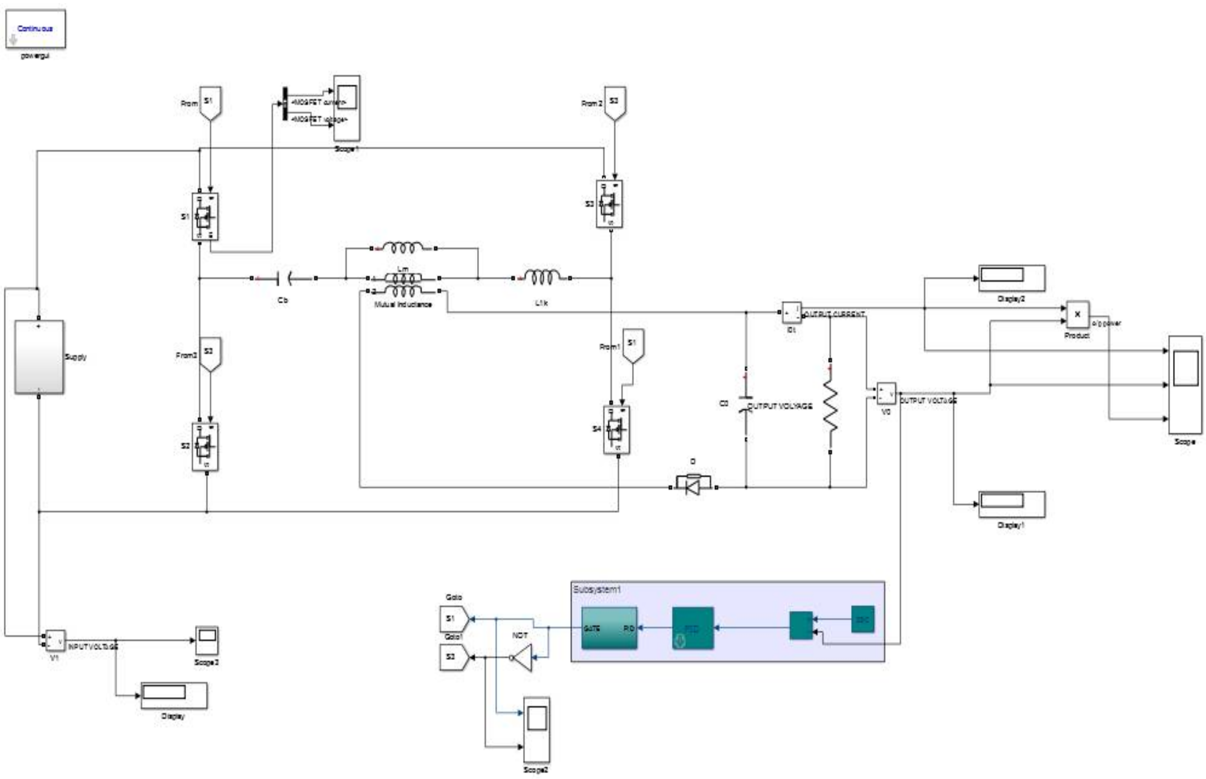

Fig. 3.1 Simulation of the proposed system

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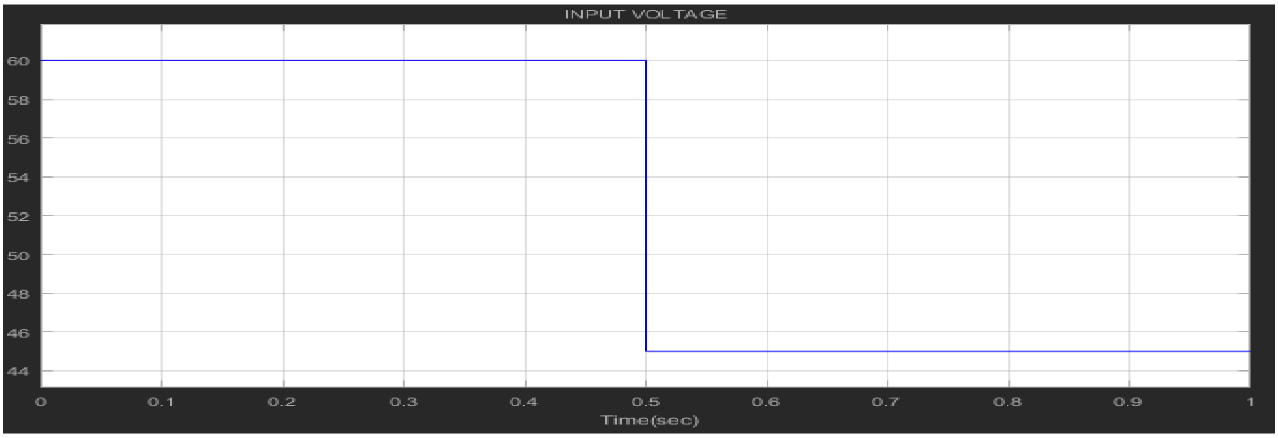


Fig. 3.2(a) INPUT VOLTAGE

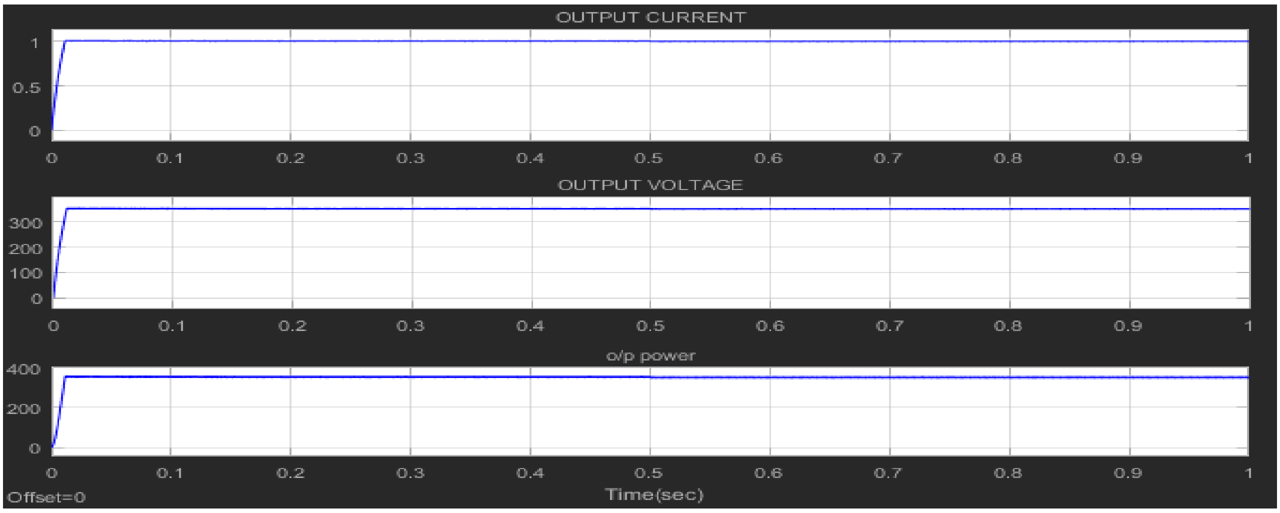


Fig3.2(b) OUTPUT VOLTAGE,CURRENT AND POWER

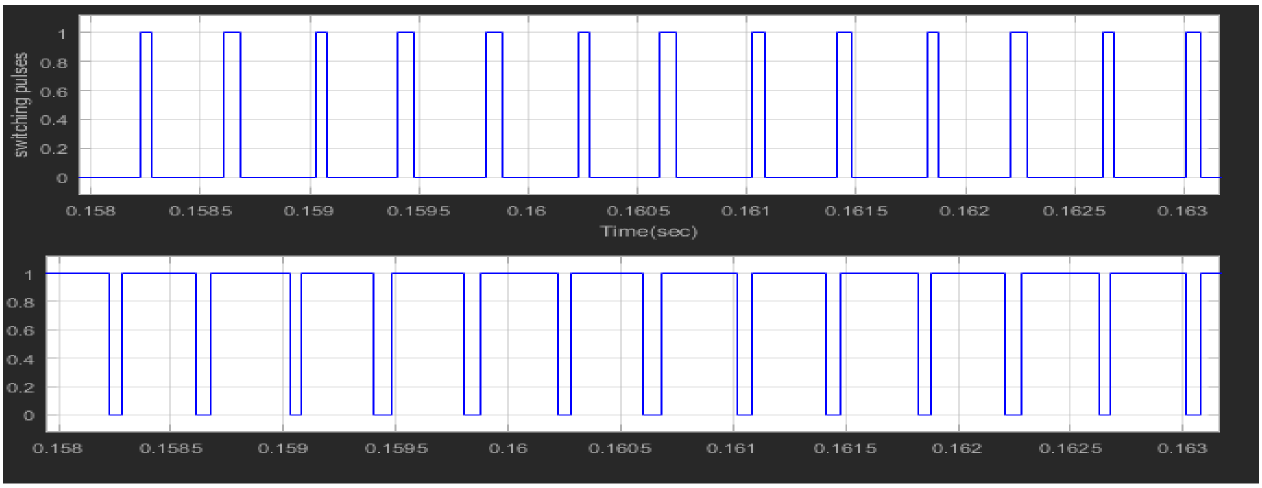


Fig. 3.2(c) SWITCHING PULSE

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## IV. CONCLUSION

In this paper, APWM full-bridge converter has been proposed for the renewable energy conversion systems that can fluctuate between the input voltage of 40 and 80 V. without extra components, output diode operates under ZCS and All power switches operate under ZVS. Thus, to minimize power losses the proposed converter has the structured.These advantages lead to make the system suitable for renewable energy conversion systems which has Fluctuating input voltage.

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