July – August 2020
ISSN: 0193-4120 Page No. 662 - 666

A Zero Voltage Transition DC-DC Boost Converter For PV Energy System

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Abstract

The basic propose of step-up converter is implemented by using zero voltage transitions with soft switching techniques to realize the maximum output of the PV system by using MPPT theorem. The basic ZVT converter is implemented using zero voltage transformations where as the auxiliary circuit is implemented using zero current transformations . The efficiency of hard switching converter is little, it is improved and losses are reduced by using soft switching techniques. Perturb and observe algorithm has been applied to maximise the output of MPPT.

Keywords: *72 solar cells; Boost converter; MOSFET switching.*

I. Introduction

The converters employing ZVT [2] (zero voltage transformations) aids in solving the trouble of EMI (Electromagnetic Interference) by employing diodes having slow turn OFF characteristics or by using snubber circuit. The Solar Energy is produced by the Sunlight is a non-vanishing renewable source of energy which is free from ecofriendly [1]. The slow characteristics of diode results in large turn OFF time resulting in increase in switching losses [2] whereas the snubber circuit employed results in increasing the conduction losses [3] [4]. Therefore, to enhance the efficiency of system soft switching method is employed. Soft switching method result in reduction of conduction as well as switching losses.

The primary principle of auxiliary circuitis that it carries current larger than the input current passing through the boost inductor which is primarily used for regulating the input current although the time period being very small for turn ON/OFF transformations. The auxiliary circuit resonates for smaller segment of the switching period and enhances soft transition from ON to OFF duration.[5] The soft switching employed help in increasing the efficiency of the converter by dipping the losses. The losses anticipated in hard switching is negligible in soft switching converter. The use of soft switching and snubber circuit helps in solving the problem of EMI in auxiliary circuits.[6]

II. BOOST CONVERTER FOR PV ENERGY SYSTEM

The usual block diagram shown in the figure comprises of PV Array, DC-DC Converter [7], voltage and current sensing devices, MPPT controller employing P & O ALGORITHM and load. The yield of PV Array rely on the external factor like temperature and solar irradiation. The output of PV Array is applied to the voltage and current sensor and dc-dc converter .The output of voltage and current sensor is passed through MPPT controller in order to maximize the output. The output of MPPT controller is then supplied to dc –dc converter whose output is provided to load.

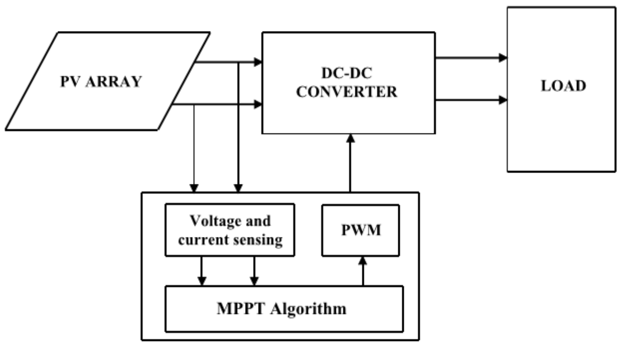

Fig.1.Block Diagram representation of DC-DC converter

As the yield of PV array is very small therefore the yield of PV array is passed through the step-up transformer in order to enhance it. The MPPT controller is being employed to enhance the yield of the PV array by adjusting it in the direction of maximum irradiation.

A. Power Losses In Hard-Switching Converters

Hard switching means simply forcing the device to turn ON and OFF by supply of additional current or voltages in the circuit .Hard switching is the conventional switching method which results in large amount of power loss when there is some value of applied voltage as well as some amount of current circulating through the switch. For the long-run of devices the reduced amount of voltage and current is always preferred.

When the switch is turned ON the voltage covering the switch is zero, similarly when it is turned OFF current across it is zero resulting in zero power loss. The power loss in the switch takes place during the turn ON and turn OFF transformation when the voltage and current across switch is not zero. This is shown as waveforms in figure 2, (i) showing power signal given to the switching device, (ii) the device voltage and current and (iii) power losses per switching cycle.

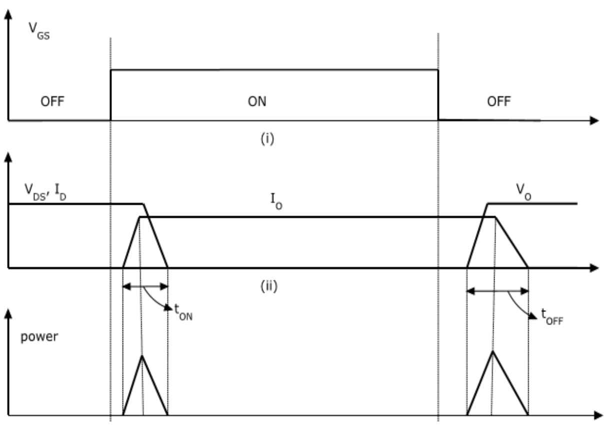

Fig. 2. switching losses in hard switching

The switching losses in unit switching cycle can be written in equation

$$P_{sw} = V_s I_s F_s \left[\frac{T_{on}+T_{off}}{2}\right]$$

As can be seen in the equations that the switching losses in some instrument depends on the supply voltage, supply current ,supply frequency and ON-OFF duration of the switch. Therefore it is important to configure the soft switching devices as hard switching devices cannot be employed at high frequency.

B. Soft switching technique

ZVS (Zero Voltage Switching) and ZCS (Zero Current Switching) are the two methods being employed for soft switching technique named deployed on the parameter being made zero.

I. Zero Current Switching

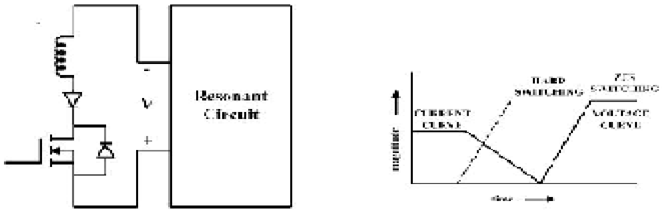

Fig 2.1. (a)With negative voltage ZCS turn OFF
(b) Hard switching waveform & ZCS

The basic circuit employed to obtain ZCS has been shown in the above figure. It mainly consist of a diode connected in series with inductor. The turn ON time depends on the increasing rate of current of the inductor after voltage across it becomes zero. It is mainly due to property of inductor reluctant to the variation of current .When negative voltage is registered across the resonating circuit the current across inductor and diode becomes zero.

II. Zero Voltage Switching

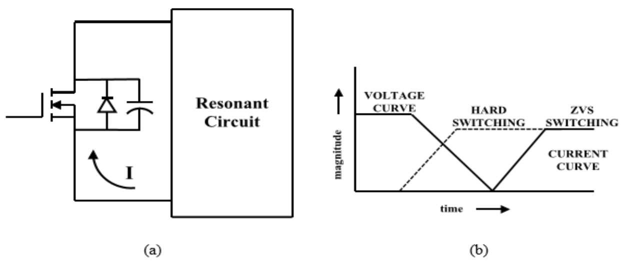

Fig. 2.2 a) With negative current ZVS turn ON
b) Hard switching waveform

The basic circuit employed to obtain ZVS is as shown in the above figure. It mainly consist of diode and a capacitor connected in anti parallel. During ZVS turn OFF operation can be performed only when the current is zero and the voltage across capacitor is zero. It is more popular than ZCS .It can operate at high frequency. The turn OFF characteristics of circuit depends on capacitor connected across the switch. It controls the voltage hike rate as current narrows to zero.

C. Zero Voltage Transformation DC-DC Step-up Converter

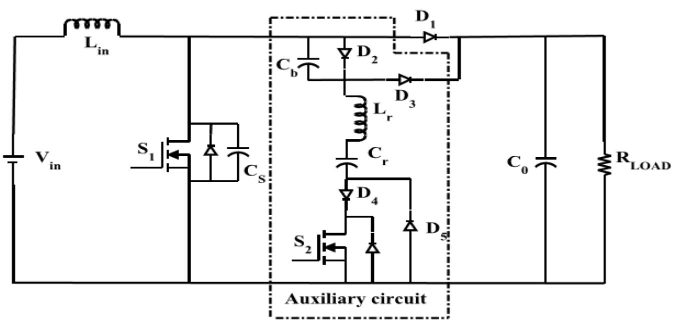

Fig. 3 ZVT dc-dc step-up converter

TEST Engineering & Management

July – August 2020
ISSN: 0193-4120 Page No. 662 - 666

The primary diagram of ZVT DC-DC converter is as indicated .It consists of inductor L_{in} diode Di ,a switch S_1 and a capacitor C_O connected across the load R_{LOAD}. It also consist of resonant circuit comprising of diodes D_2-D_5, a switch S_2 and series combination of capacitor C_r and inductor L_r with a C_b to feed resonant power to source .it also consist of a capacitor C_S which is a parasitic capacitor. In this, boost circuit operate on 0 voltage transition (ZVT) although the auxiliary circuit operate on 0 current switching (ZCS).

The zero voltage switching in zero voltage transition conductor takes place during both turn ON and turn OFF transition due to the capacitor and diode connected across the main switch.

III. CONVERTER DESIGN

The principal objective of converter design is to enhance the efficiency by reducing the switching and conduction losses of the converer. It also reduces the EMI (Electromagnetic Inteference) across the prime switch.The resonant circuit of auxiliary circuit is kept as small as possible to reduce losses.

A. The Design specifications:

The various design specification for the converter has been taken whose values has been listed in the below table :

SlNo.	Parameter	Specification	Value
1	Output power	P_{Out}	250W
2	Output voltage	V_{Out}	400V
3	Input voltage	V_{in}	90-265V
4	Switching frequency	F_{sw}	100kHz
5	Output voltage ripple	V_{rp}	1%
6	Input current peak ripple	ΔI_{rpp}	20%

Table1: Converter specifications for design

B. Design procedure

There is basically two design procedure for the converter design :

I. To layout the active boost and power circuit for whole switching cycle.[11]

II. To layout the active auxiliary resonant circuit for a resonant.

C. Simulation Of The Converter

By using the values listed in the given below table the converter circuit shown in the FIG 3 has been designed by simulation:[9]

Sl.no.	Circuit component	Symbol	specification
1	Resonant inductor	L_r	6µH
2	Resonant capacitor	C_r	15Nf
3	Feed-forward capacitor	C_b	3.5Nf
4	Boost inductor	L_{in}	1050µH
5	Output capacitor	C_0	470µF
6	Input voltage	V_{in}	265V
7	Switching frequency	F_{sw}	100kHz

Table 2: List of converter circuit element and specification

By varying the voltage in the range of 190V-265V ,the output voltage is obtained in the range of 400V for various values of duty cycle varying in the range of 56.45-81.20% as shown below :

Input voltage V_{in}(V)	Duty cycle δ (%)	Input voltage V_{in}(V)	Duty cycle δ (%)
265	35.00	185	56.45
260	36.25	180	57.80
255	37.60	175	59.25
250	38.90	170	60.70
245	40.20	165	62.10
240	41.60	160	63.60
235	42.85	155	65.10
230	44.20	150	66.54
225	45.56	145	68.10
220	46.90	140	69.70
215	48.30	135	71.3
210	49.60	130	73
205	51.00	125	74.7
200	52.30	120	76.6
195	53.70	115	78.65
190	55.00	110	81.2

Table 3 : the same to input voltage Duty cycle for 400V output

The performance of converter is demonstrated by varying the voltage range and corresponding duty cycle . The performance of the resonating circuit is observed for one resonating cycle which is very small. The output waveform of auxiliary circuit elements and main circuits elements is shown below:

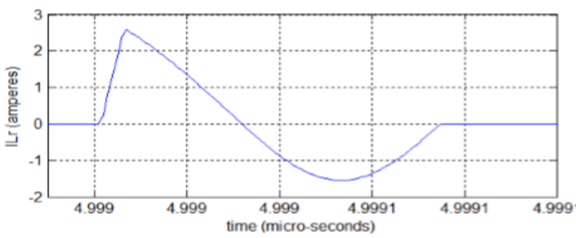

Fig. 6.1 Current waveform of Auxiliary inductor

Figure 6.1 shows the variation of auxiliary inductor current with respect to time for a resonant cycle .

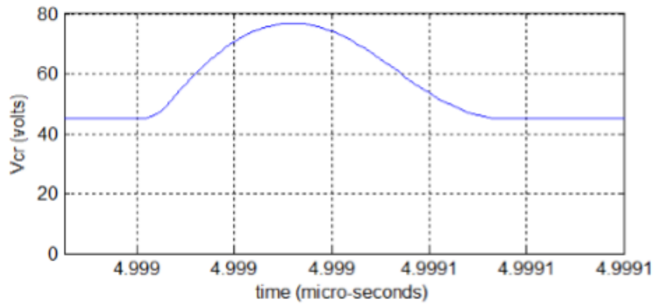

Figure 6.2 shows the auxiliary capacitor voltage waveform with respect to time.

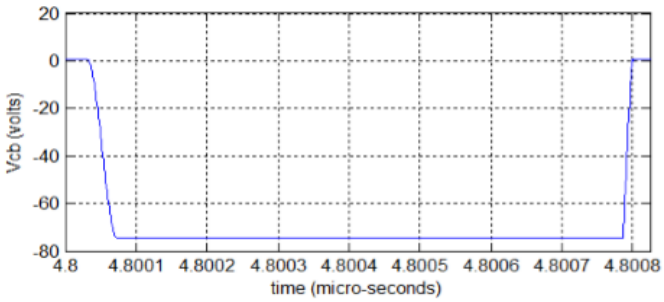

Fig. 6.3 Waveform of Feed-forward capacitor

Figure 6.3 Gives the capacitor voltage of feed forward waveform wrt. time.

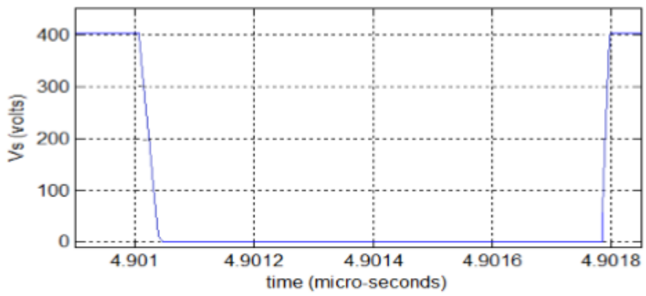

Fig. 6.4 Voltage of Main switch

Figure 6.4 Gives the waveform of voltage(main switch) wrt. time.

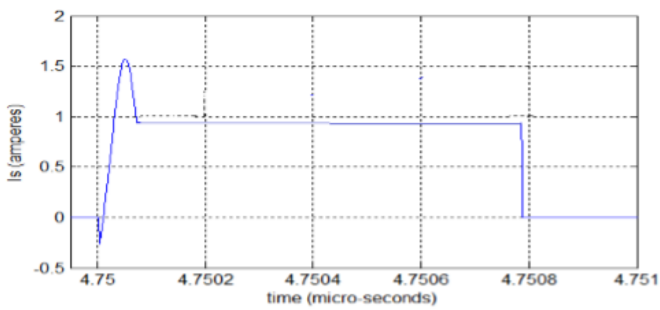

Fig. 6.5 current of Main switch

Figure 6.4 and figure 6.5 Gives the main switch voltage waveform and current waveform. respectively layering one on the other.

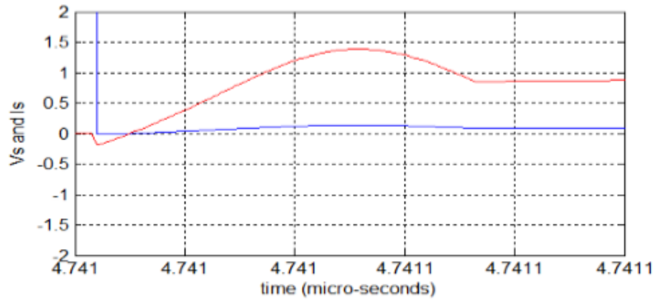

Fig. 6.6 switch on of S1 (ZVS)

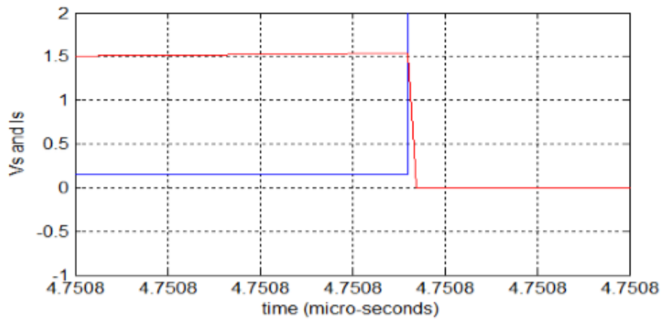

Fig 6.7 switch off of S1 (Reduced voltage)

The zero voltage switch on and the decreased voltage turn-off of main switch is given in figure 6.6 & 6.7 respectively During turn-OFF voltage is calculated to be 80 volts.

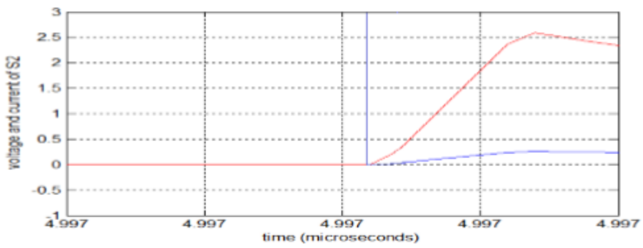

Fig. 6.8 ZCS Switch ON of S2

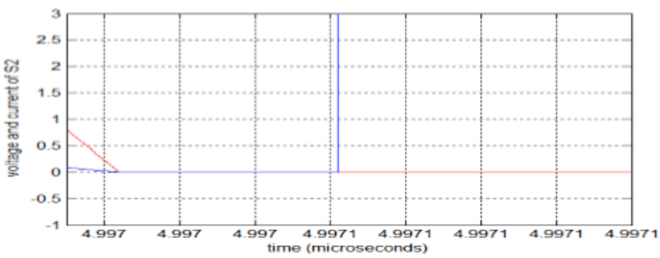

Fig. 6.9 ZVS Switch OFF of S2

Figure 6.8 represents the switching transition of ZCS switch ON of S2 and figure 6.9 represents the switching transition of ZCS turn OFF of S2

July – August 2020
ISSN: 0193-4120 Page No. 662 - 666

D. Simulation Of PV arrey

PV array are either connected in parallel or in series connection as the output produced by the single PVarray is very small .To maximise the output of PVarray MPPT theorem is applied. This help in maximising the concerntration of solar energy by focusing in the point of maximum solar irradiation. P&O (Perturb and Observe) algorithm has been used.It perform the perturbation by compairing the present value with the past value and if increases then the perturbation is continued in the same direction otherwise it is returned to the previous value.

The P-V and I-V description of PVarray is shown below. The open circuit voltage 250V and short circuit current 2.25A.[8]

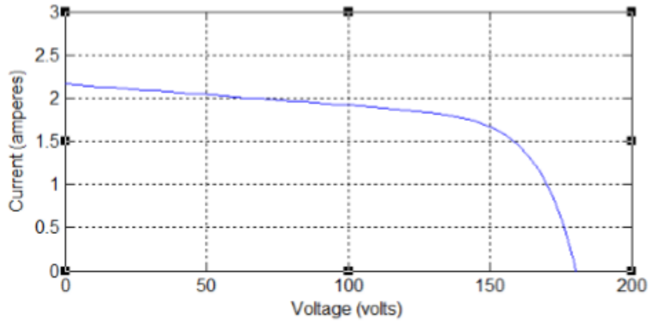

Fig. 7.1 I-V characteristics of the PVarray

Figure 7.1 represnts the voltage and current waveform of PVarray where horizontal and vertical axis represents voltage current respectively .

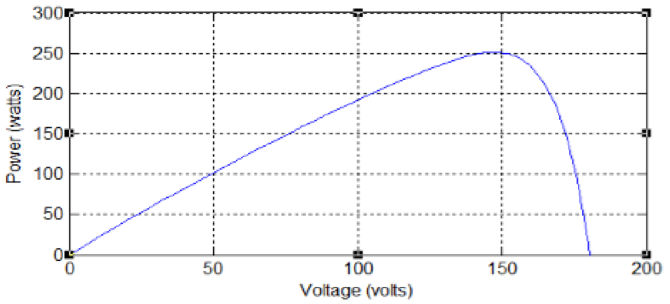

Fig. 7.2 PV characteristics of the PV array

Figure 7.2 represents power-voltage characteristics of PVarray where horizontal axis and vertical axis represents voltage (in volts) and current (in ampere) respectively.

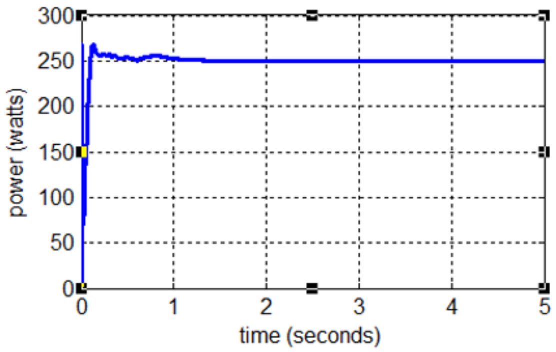

Fig. 7.3 PVarray after MPPT Output power

Figure 7.3 represents the variation with respect to time of output power of PVarray (in watts) .

IV.CONCLUSION

The soft switching losses of converter are very less as compared to hard switching losses. It can be used during the high frequency operation of converter as hard switching losses increases with frequency resulting in low value of efficiency. As the secondary circuit losses are summed up to transmission losses it is found to be more in gentle switch converter. Soft switching converter is found to be more useful and resourceful technique. It reduces EMI (Electromagnetic Interference) of the converter circuit. It reduced the switching and conduction losses of the converter however, losses across the diode remains comparatively constant.

IV. REFERENCES

[1] V V Prathibha Bharathi,V Pandurangadu and V V Naga Deepthi "Car runs by Solar Energy"ISSN 2278 – 0149 Vol. 4, No. 1, January 2015 IJMERR.

[2] Aliveli,Kumar, A. V. Pavan, and K.Uma Rao. "Implementation of MPPT control using fuzzy logic in solar-wind hybrid power system", 2015 IEEE International Conference on Signal Processing Informatics Communication and Energy Systems (SPICES), 2015.

[3] Ahmad Mousavi,Pritam Das,Gerry Moschopoulos, Praveen Jain. "A Study of AC-DC ZVS-PWM Boost Converters with Silicon Carbide Diodes", 2009 Twenty-Fourth Annual IEEE Applied Power Electronics Conference and Exposition, 2009.

[4] Umme Mumtahina ; Peter Wolfs;"A comparison study between series resonant and zero-voltage-resonant-transition DC-DC converters"2015 Australasian Universities Power Engineering Conference (AUPEC)Year: 2015 | Conference Paper | Publisher: IEEE

[5] Kyumin Lee,Kyuil Hwang,Ilsong Kim. "A High Speed Solar MPPT Controller Design", 2019 IEEE 28th (ISIE), 2019 International Symposium on Industrial Electronics.

[6] J R Gazoli and E R Filho, M G Villalva“ Comprehensive Approach to Modeling and Simulation of PV Arrays,” , vol.24, no.5, May 2009 IEEE Transactions on Power Electronics.

[7] David Sanz Morales, “Maximum power point tracking algorithms for PV applications,” student paper, Alto university.

[8] Prof Narendra Kumar,Shubham Singh Rao "Modeling and Simulation of Solar Energy System to enhance its Output Using Boost converter" Proceedings of International Conference on (ICRITETR-2017) Poornima College of Engineering, Jaipur, Rajasthan (India) ISBN: 978-93-5291-761-7, 23-24 December 2017.