International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 8 (2015) pp. 21395-21408

http://www.ripublication.com

A Novel Asymmetrical Interleaved Converter with Voltage Multiplier for a Photovoltaic System

B. Rohini and E. Annie Elisabeth Jebaseeli

PG Scholar, Sathyabama University, Chennai-119.
rohinidevara40@gmail.com
Assistant Professor, Faculty of Electrical and Electronics Engineering, Sathyabama University, Chennai-119.
anniejebaseeli@gmail.com

ABSTRACT

A novel asymmetrical interleaved converter with voltage multiplier is fed for photovoltaic system. The voltage multiplier comprises of boost converters and coupled inductors along with voltage lift capacitor. The voltage multiplier obtains a high amount of output voltage with less duty ratio. This configuration reduces ripples in output voltage with low conduction losses. The proposed converter is simulated and analyzed in MATLAB. The results obtained in open loop and closed loop are compared

Key words: Photovoltaic system, voltage multiplier, asymmetrical interleaved converter, coupled inductors.

I. INTRODUCTION

Renewable energy sources includes fuel cell, wind power, geothermal energy, hydro power and solar power and so on. Out of these solar energy is most commonly used across the world since it is generating electricity with less pollution. Solar energy is infinite and can be extended to remote areas with less expense [1], [2]. Generally solar energy produce very less amount of output voltage, thus step up dc/dc converters are engaged in order to boost up the output voltage [3].

A novel asymmetrical interleaved structure is involved in voltage multiplier for high step up voltage gain since conventional step up converters like fly back converter, cuk converter cannot achieve high voltage conversion because of conduction losses which occur due to the presence of leakage inductors and resistances. Two coupled inductors are used along with the boost converters which are designed as asymmetrical interleaved structure. Coupled inductors has effect on output ripple current by reducing the ripples [4]-[7].

The block diagram of proposed converter is shown in Fig. 1. Voltage multiplier obtains high voltage gain from voltage lift capacitor which offers high voltage conversion ratio. This converter is exercised for high power applications. For a high gain, PI controller is used which gives maximum overshoot with no steady state error[3].

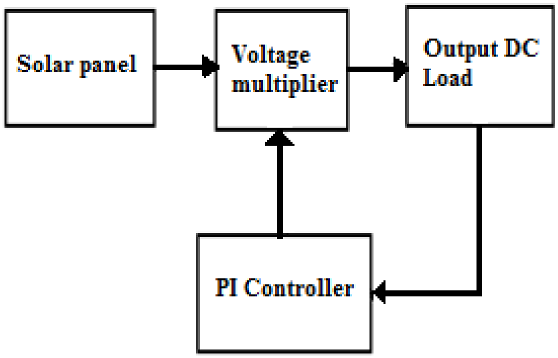


Fig.1.Block diagram of proposed converter.

II. ASYMMETRICAL INTERLEAVED CONVERTER

The proposed novel asymmetrical interleaved converter with a voltage multiplier module with PV module is shown in Fig. 2. Two conventional boost converters are piled on each other by including the two coupled inductors in the voltage multiplier module in order to form a novel asymmetrical interleaved structure [8], [9].

The conventional coupled inductors consists of primary windings and secondary windings in which the former one is exercised for the reduction of input current ripple and the latter one is allied in series to enlarge the voltage gain[4], [5].

The proposed converter consists of power switches S_1, S_2 and S_3, voltage lift capacitor C, magnetizing inductors Lm_1 and Lm_2, filter capacitors C_1, C_2 and C_3, leakage inductors L_1, L_2 and L_3.

The continuous conduction mode (CCM) is employed in the proposed converter. It attains duty cycle of greater than 0.5 and interleaved with a phase shift of 180˚ during steady state operation.

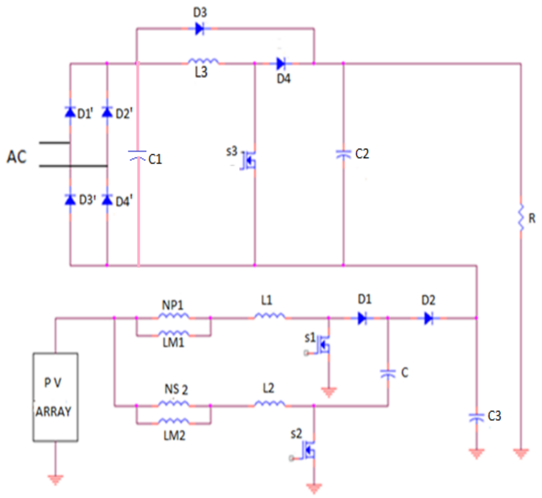


Fig.2.Circuit diagram of the proposed converter

The different modes of operation of the proposed converter are depicted in Fig.3.

A. Modes of operation

(a) Mode 1 [t_0, t_1]: At t=t_0, the power switches S_1 and S_2 are both turned ON. All of the diodes are reversed-biased. Magnetizing inductors Lm_1 and Lm_2 as well as leakage inductors L_1, L_2 and L_3 are linearly charged by the input voltage source V in.

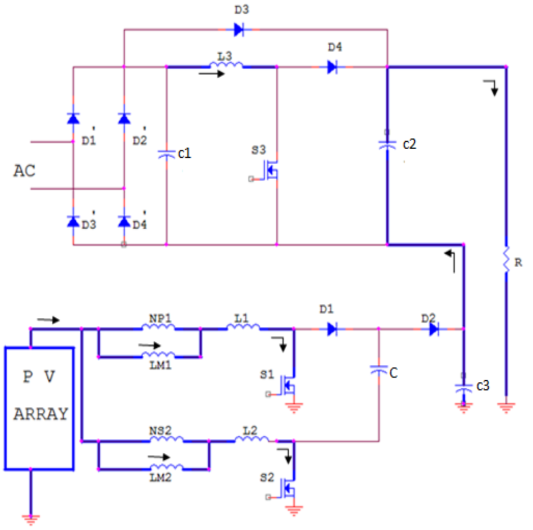
(b) Mode 2 [t_1, t_2]: At t=t_1, the power switch S_2 is switched OFF, S_3 turn ON, thereby turning ON diodes D_2 and D_3. The energy that magnetizing inductor Lm_2 has stored is transferred to the secondary side charging the output filter capacitor C_1. The input voltage source, magnetizing inductor Lm_2, leakage inductor L_2, and voltage-lift capacitor C release energy to the output filter capacitor C_3 via diode D_2, thereby is extending the voltage on C_3.

(c) Mode 3 [t_2, t_3]: At t=t_2, diode D_2 automatically switches OFF because the total energy of leakage inductor L_2 has been completely released to the output filter capacitor C_3. Magnetizing inductorLm_2 transfers energy to the secondary side charging the output filter capacitor C_1 via diode D_3 until t_3.

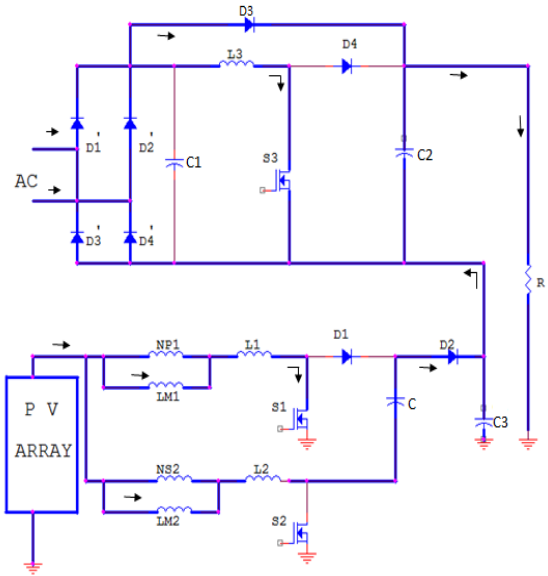
(d) Mode 4 [t_3, t_4]: At t=t_3, the power switch S_1,S_2 is switched ON and S_3 turned OFF and all the diodes are turned OFF. L_3 has been completely released to the output filter capacitor C_2 via diode D_4, which stores extra energy in C_1.

(e) Mode 5 [t_4, t_5]: At t=t_4, the power switch S_1 is switched OFF, which turns ON diodes D_1 and D_4. The energy stored in magnetizing inductor Lm1 is transferred to the secondary side charging the output filter capacitor C_2. The magnetizing inductorLm_1 and input voltage source release energy to capacitor C via diode D_1, which stores extra energy in voltage-lift capacitor C.

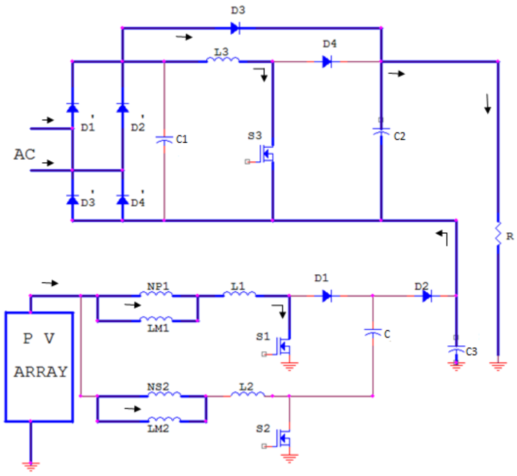
(f) Mode 6 [t_5, t_0]: At $t=t_5$, diode D_1 is automatically turned OFF because the total energy of leakage inductor L_1 has been completely released to voltage-lift capacitor C. Magnetizing inductor Lm_1 transfers energy to the secondary side charging the output filter capacitor C_2 via diode D_4 until t_0.



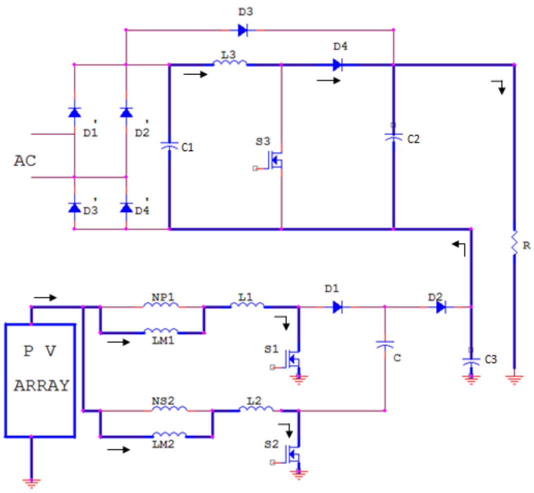
(a) Mode 1 [t_0, t_1]



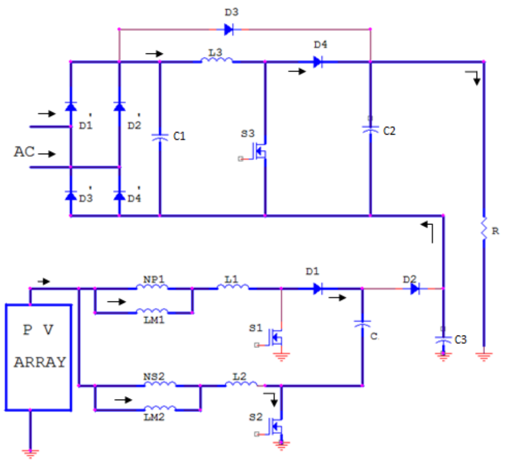
(b) Mode 2 [t_1, t_2]



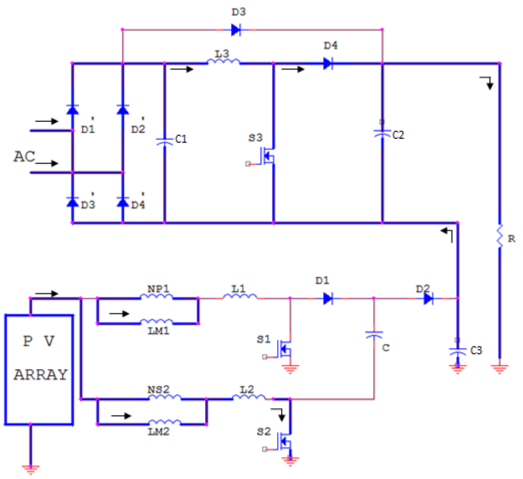
(c) Mode 3 [t_2, t_3]



(d) Mode 4 [t_3, t_4]



(e) Mode 5 [t_4, t_5]



(f) Mode 6 [t_5, t_0]

Fig.3.Operating modes of the proposed converter.

III. SIMULATION IN OPEN LOOP

The dc voltage from solar panel is used as one input and ac voltage is used as another input. The ac voltage is fed to a diode bridge rectifier through which ac voltage is converted to dc voltage. This dc voltage is boosted up through active power factor converter. The dc voltage from solar panel is fed to voltage multiplier which consists of boost converter with coupled inductors which are formed as a novel asymmetrical interleaved converter. The two outputs from ac voltage input and dc voltage input are clubbed and fed to dc load.

This open loop method is having simple layout, so easier to construct. But due to the absence of feedback mechanism, it is in accurate in terms of output result hence it is unreliable.

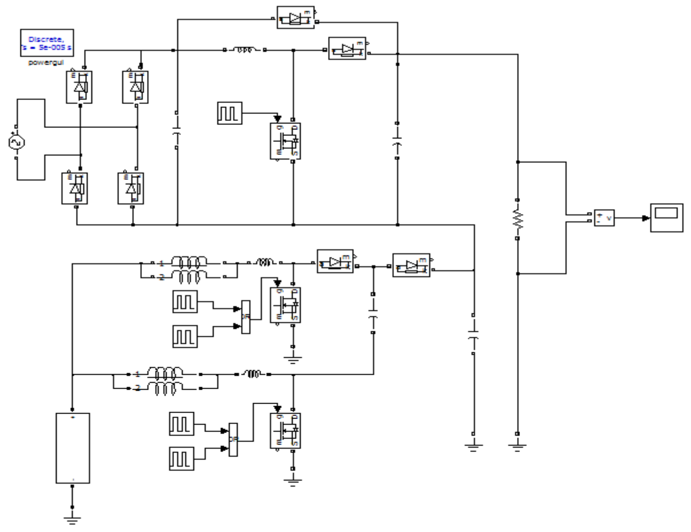


Fig. 4.Simulation circuit in open loop.

The Fig. 4.shows simulation circuit in open loop mode.

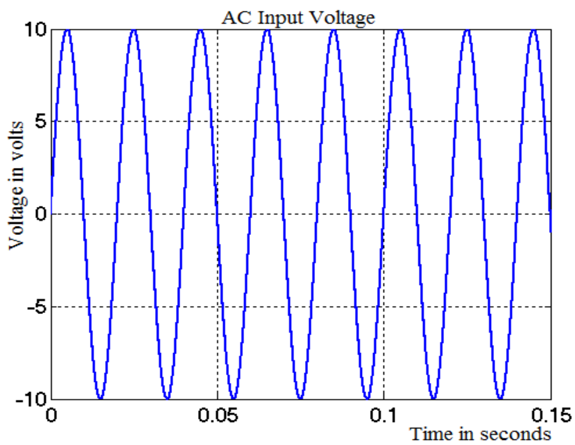


Fig.5.AC Input Voltage.

The Fig.5.showsAC Input voltage. It gives input to diode bridge rectifier. The magnitude of the voltage is 10 V_{p-p}.

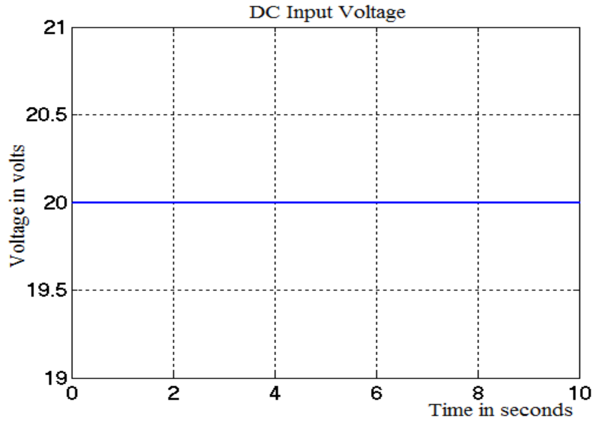


Fig.6. DC Input voltage

The Fig. 6.shows DC input voltage from solar panel. It gives input to voltage multiplier. The magnitude of the voltage is 20 V.

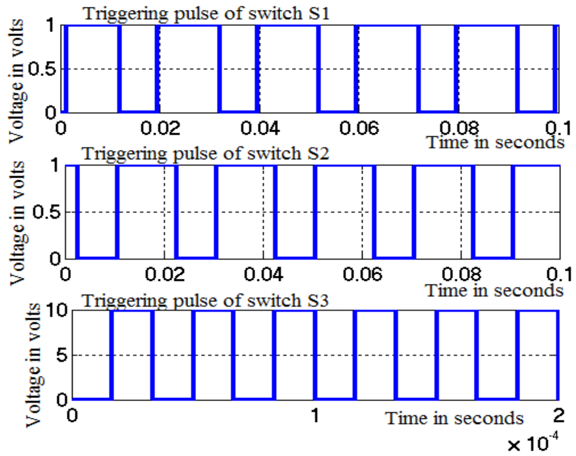


Fig.7.Triggering pulses of Power Switches.

The Fig. 7.shows triggering pulses of power switches S1, S2 and S3 at steady state operation.

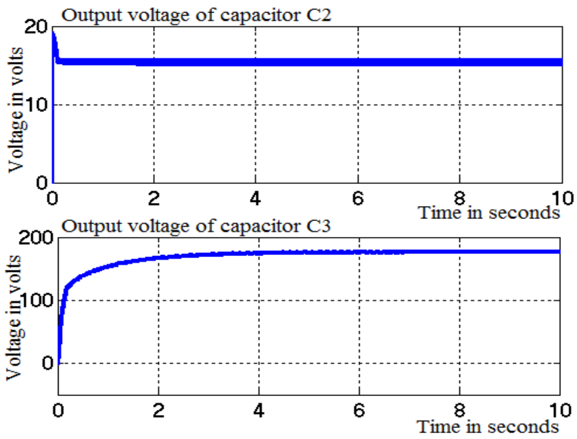


Fig.8. Output voltages of capacitor C2 and C3

The Fig. 8.shows the output voltage of capacitor C2 which is obtained from diode bridge rectifier along with power factor converter arrangement and output voltage of capacitor C3 which is attained through voltage multiplier.

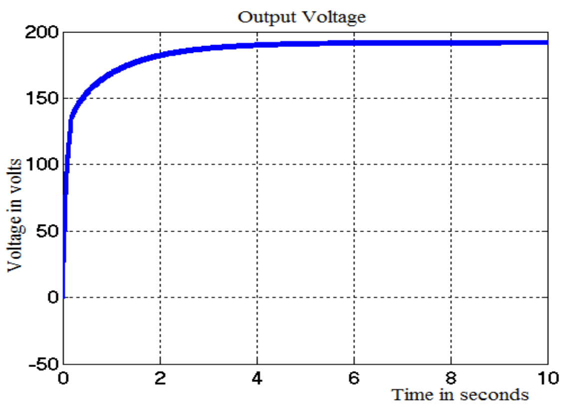


Fig.9. Output voltage for open loop

The Fig. 9.shows output voltage for open loop which is formed by merging the output voltages of capacitors C2 and C3.

IV. SIMULATION IN CLOSED LOOP

Feedback system is employed in closed loop method. The dc voltage from solar panel is used as one input and ac voltage is used as another input. The ac voltage is fed to a diode bridge rectifier through which ac voltage is converted to dc voltage. This dc voltage is boosted up through active power factor converter. The dc voltage from solar panel is fed through voltage multiplier which consists of boost converter with coupled inductors which are formed as a novel asymmetrical interleaved converter. The two outputs from ac voltage input and dc voltage input are clubbed and fed to dc load. The dc input voltage of solar panel is given to MPPT algorithm and is then given to PI controller along with the final dc output. Carrier signal from PI controller and triangular reference signal are compared and fed as the triggering pulses to power switches S1 and S2. Thus the final output is varied due to the presence of feedback system. Therefore in closed loop system the errors are automatically reduced and the stability of the system is increased.

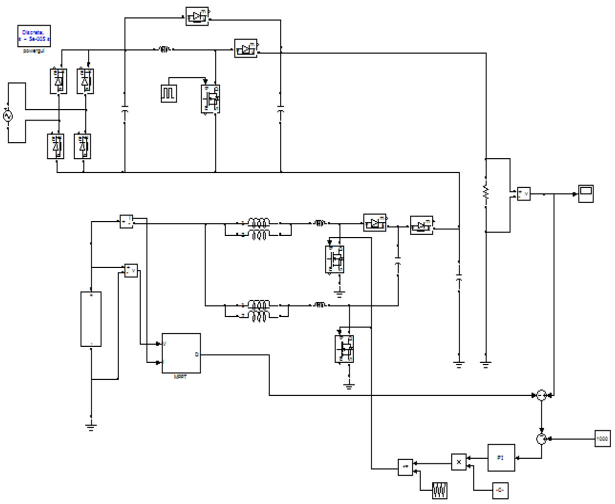


Fig.10. Simulation circuit for closed loop

The Fig. 10.shows simulation circuit closed loop mode.

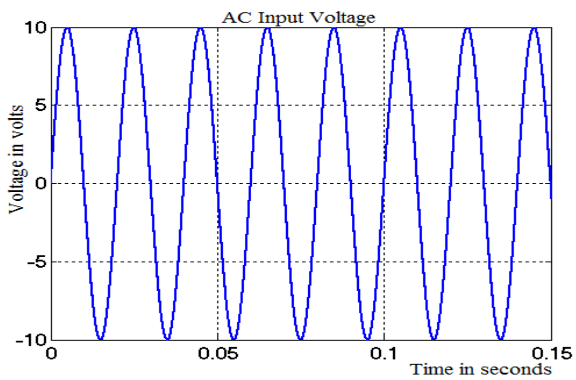


Fig.11. AC Input voltage

The Fig. 11.shows AC Input voltage. It gives input to diode bridge rectifier. The magnitude of voltage is 10 $V_{p\text{-}p}$.

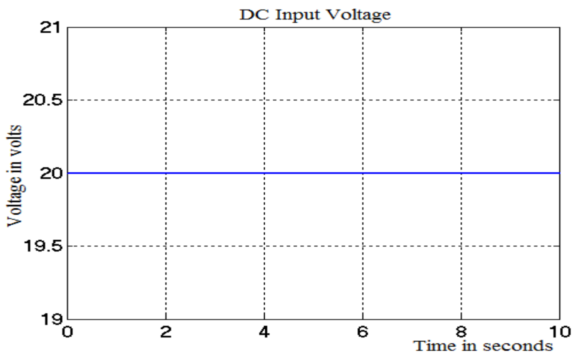


Fig.12. DC Input voltage

The Fig. 12.shows DC input voltage from solar panel which gives input to voltage multiplier. It has a magnitude of 20 V.

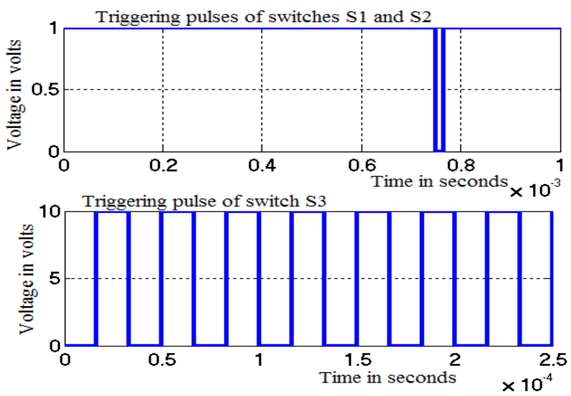


Fig.13.Triggering pulses of Power Switches.

The Fig. 13.shows triggering pulses of power switches S1, S2 and S3 at steady state operation. Due to the presence of feedback system, the power switches S1, S2 have same triggering pulses fed by the controller.

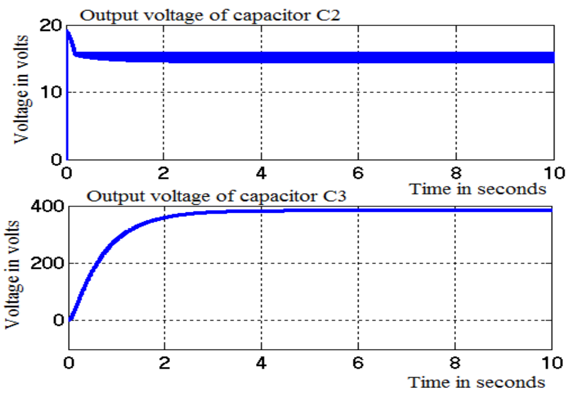


Fig.14. Output voltages of capacitor C2 and C3

The Fig. 14.shows the output voltage of capacitor C2 which is obtained from diode bridge rectifier along with power factor converter arrangement and output voltage of capacitor C3 which is attained through voltage multiplier.

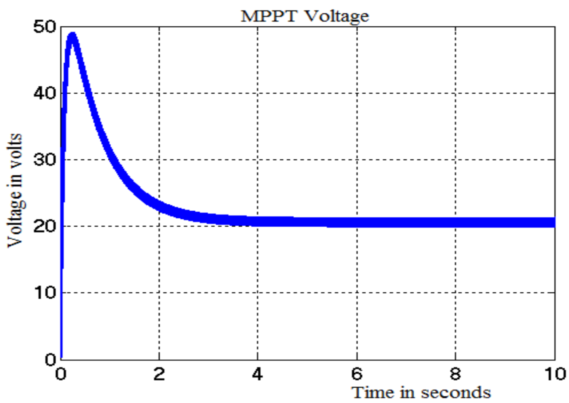


Fig.15. MPPT voltage

The Fig. 15.shows output voltage of MPPT. It takes inputs of current and voltage from solar panel and achieve maximum power tracking through perturb and observe method and generate the voltage.

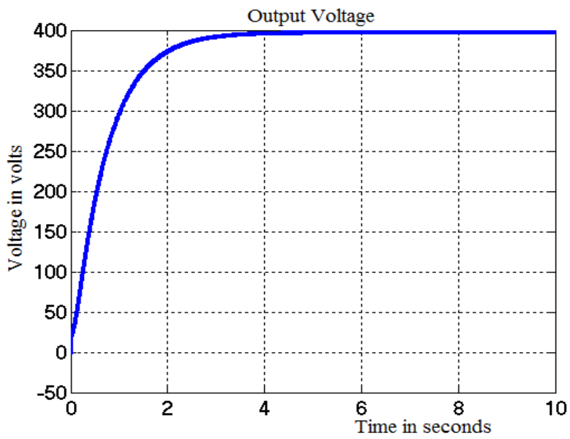


Fig.16. Output voltage for open loop

The Fig. 16.shows output voltage for open loop which is formed by merging the output voltages of capacitors C2 and C3.

V. PERFORMANCE COMPARISON

Table I. Comparison of Open loop and closed loop for proposed system.

Parameters	Open loop	Closed loop
Input voltage at AC supply	10V	10V
Input voltage at DC supply	20V	20V
Output DC voltage	191.4V	397.9V

The Table I. shows comparison among input and output voltages of open loop and closed loop.

VI. CONCLUSION

The steady state analysis and experimental results of proposed converter has been obtained. These experimental results shows that leakage energy is fed back through capacitor C to output terminal. The output voltage of closed loop is 50% high compared to output voltage of open loop. Therefore, the performance of closed loop is better than open loop. Thus the proposed novel asymmetrical interleaved converter with voltage multiplier is appropriate for photovoltaic systems when high power application is involved.

VII. REFERENCES

[1] J. T. Bialasiewicz, “Renewable energy systems with photovoltaic power generators: Operation and modelling,” IEEE Trans. Ind. Electron., vol. 55, no. 7, pp. 2752-2758, Jul. 2008.

[2] R. J. Wai, W. H. Wang, and C. Y. Lin, “High-performance stand-alone photovoltaic generation system,” IEEE Trans. Ind. Electron., vol. 55, no. 1, pp. 240-250, Jan. 2008.

[3] J. W. Baek, M. H. Ryoo, T. J. Kim, D. W. Yoo, and J. S. Kim, “High boost converter using voltage multiplier,” in Proc. 31stAnnu. Conf. IEEE Ind. Electron. Soc., May 2005, pp. 567-572.

[4] W. Li and X. He, “A family of isolated interleaved boost and buck converters with winding-cross-coupled inductors,” IEEE Trans. Power Electron., vol. 23, no. 6, pp. 3164-3173, Nov. 2008.

[5] W. Li, Y. Zhao, J. Wu, and X. He, “Interleaved high step-up converter with winding-cross-coupled inductors and voltage multiplier cells,” IEEE Trans. Power Electron., vol. 27, no. 1, pp. 133-143, Jan. 2012.

[6] C. T. Pan, and C. M. Lai, “A high efficiency high step-up converter with low switch voltage stress for fuel-cell system applications,” IEEE Trans. Ind. Electron., vol. 57, no. 6, pp. 1998-2006, Jun. 2010.

[7] W. Li, X. He, D. Xu, and B. Wu, “General derivation law of non-isolated high-step-up interleaved converters with built-in transformer,” IEEE Trans. Ind. Electron., vol. 59, no. 3, pp. 1650-1661, Mar. 2010.

[8] W. Li and X. He, “Review of Nonisolated high-step-up DC/DC converters in photovoltaic grid-connected applications,” IEEE Trans. Ind. Electron., vol. 58, no. 4, pp. 1239-1250, Apr. 2011.

[9] W. Li, Y. Zhao, Y. Deng, and X. He, “Interleaved converter with voltage multiplier cell for high step-up and high efficiency conversion,” IEEE Trans. Power Electron., vol. 25, no. 9, pp. 2397-2408, Sep. 2010.