Asian Journal of Applied Science and Technology (AJAST)
Volume 1, Issue 2, Pages 286-290, March 2017

High Gain Single Stage Boosting Inverter with Trap CL Filter for Photovoltaic Application

R.Thirumudukari[1] and R.Reshma[2]

[1]*UG Scholar, Department of Electrical and Electronics Engineering, IFET College of Engineering, Villupuram, India.*
[2]*Assistant Professor, Department of Electrical and Electronics Engineering, IFET College of Engineering, Villupuram, India.*

Article Received: 13 March 2017 *Article Accepted: 23 March 2017* *Article Published: 26 March 2017*

ABSTRACT

This project introduces a high gain single stage boosting inverter with trap cl filter for alternative energy generation. As compared to two stage and multi stage approach, single stage boosting inverter has a simpler topology and lower component count. Trap cl filter is used to eliminate the harmonics and it can reduce the size and weight. Single stage boosting inverter can realize high DC input voltage boosting, good inversion power decoupling, good quality of Alternating current output waveform and good efficiency.

Keywords: Photovoltaic system, Converter and Inverter.

1. INTRODUCTION

The photovoltaic system for domestic power generation in micro-inverter topologies. Photovoltaic energy generation are classified into three types such as single stage approach, to stage approach and multi stage approach. [1]: In single stage approach can achieve voltage step-up, maximum power point tracking and inversion in single stage approach. [2]: In two stage approach can be designed a maximum power point tracking controlled high gain DC-DC converter and a high frequency inverter. Load is connected between the two boost converters .and boosting inductors are connected to midpoint of leg.it can be designed in cascading model. [3]: Multi stage approach, it has high component count and complex in topologies.it has smaller decoupling capacitor and it is costly. It has limited circulating current and complex in control.

Photovoltaic panel is used for input source. Solar energy is the input from the solar panel. To convert the solar energy and solar energy is connected to the grid. It converting sunlight directly into electricity using solar cell. DC voltage is stepped up and to match the utility level. DC-DC converter cannot provide high gain at maximum efficiency. Research is dedicated to developing different topologies of high gain boost converters. It can be used in full bridge inverter to develop the solar energy generation.

Single phase inversion power system, is inversion power decoupling problem. Coupling inductor and decoupling capacitor is used in the DC link. Decoupling capacitor is connected between input and output stages. The decoupling capacitor value is depends on the power, frequency, average voltage across the capacitor.

The two stage inverter and multi stage inverter can have coupling inductor and decoupling capacitor on the DC link. Decoupling capacitor value is lower in the DC link. Single stage micro-inverter requires decoupling capacitor and coupling inductor at the photovoltaic module. Decoupling capacitor have short life and low ripple voltage.

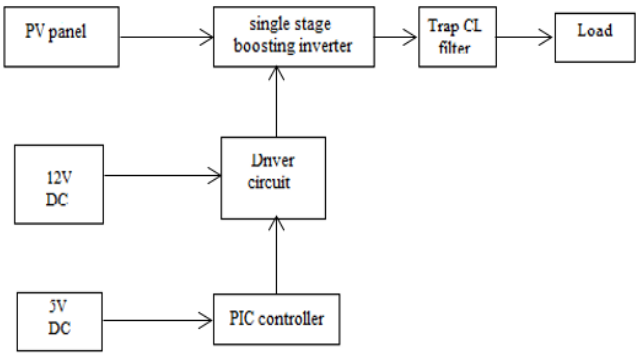
In micro-inverter design, power decoupling is one of the major problem, non- electrolytic capacitor is used in it because large electrolytic capacitor have short life. Power decoupling was suggested to decrease the decoupling capacitor. Trap-CL filter is used in single stage boosting inverter circuit to remove the harmonics because AC output waveform has harmonics. Harmonics was removed by trap-CL filter from output waveform. Boost converter is a DC-DC converter that step up voltage from its input to its output. Boost converter has two semiconductor diode and one energy storage element such as inductor and capacitor. MOSFET switch is used in the circuit. Ripple voltage is reduced in the single stage boosting inverter. Solar cell is used in the photovoltaic application. Maximum power tracking is applicable in the photovoltaic system.

Single stage boosting inverter has high gain and good quality of output waveform. Output voltage is higher than the input voltage and ripple voltage is less in the boosting inverter. It has good inversion power decoupling and has high efficiency. Compared to two stage and multi stage topologies, single stage topology has lower component and higher efficiency and output voltage is higher. Size and weight can be reduced in the single stage topology due to trap CL filter. Single stage boosting inverter is used for alternative energy generation and reduce the environmental pollution. It is used to solve the energy exhaustion. Size and weight are important consideration when designing an output filter. In two stage approach, circulating current is limited, gain is limited, impair efficiency and complicated control

2. DESCRIPTION

Photovoltaic panel, single stage boosting inverter, trap CL filter, driver circuit, PIC controller and load is considered in the block diagram. The supply of 5V DC is given to boosting inverter by photovoltaic panel and 12V DC is given to driver circuit. The driver circuit drives the gate pulse and given to inverter. The inverter converts dc to ac signal. Thus sinusoidal waveform is passes through trap cl filter. Trap cl filter is used

to eliminate harmonics from sinusoidal waveform and it is used to reduce the size and weight.



Trap CL filter is used to reduce harmonics from the sinusoidal waveform. Power factor and total harmonics distortion are important consideration when designing an output filter. Trap CL filter consists of trap filter and CL filter. Photovoltaic panel is made up of solar cells. Solar cells is working on the principle of photovoltaic effect. LC resonance passes a particular frequency in configuration of capacitor and inductor. Photovoltaic panel is used as input source. The input supply is given to the single stage boosting inverter.

Driver circuit is used for amplify the pulses and PIC controller is used for generating the pulses and it is also used for coding purpose. Driver circuit is an electrical circuit or electrical component used to control another circuit such as high power transistor. It is used to regulate current through a circuit and to control the faults. The output of driver circuit is given to the single stage boosting inverter. Inverter converts direct current into alternating current. Dc supply is given to the single stage boosting inverter and output of driver circuit is also given to the single stage boosting inverter.

Single stage boosting inverter produces alternating current and output is passes to trap CL filter. Trap cl filter eliminate the harmonics from the alternating current and thus output is given to the load. Harmonics are less when compared to the without trap CL filter. Trap CL filter is mainly used to reduce size and weight and improve the efficiency and eliminate the harmonics. CL filter handles a small harmonics in the multiples of switching frequency which is dominant in the output current waveform.

3. PROPOSED TOPOLOGY

Trap CL filter is the proposed system with single stage boosting inverter. Trap CL filter consists of trap filter and CL filter. Trap filter handles a harmonics. Trap filter is the addition of one small component such as capacitor, can transform a low pass filter with infinite attenuation at a desired trap filter. Trap filter is also called as harmonic filter. CL filter handles a small harmonics in the multiples of the switching frequency. Power factor and total harmonic distortion are very important consideration when designing an output filter. Coupled inductor are used to reduce voltage stress and avoid the damages of the diode. Trap filter is used for elimination of harmonics at resonant frequency. They have resonant frequency to avoid harmonics.

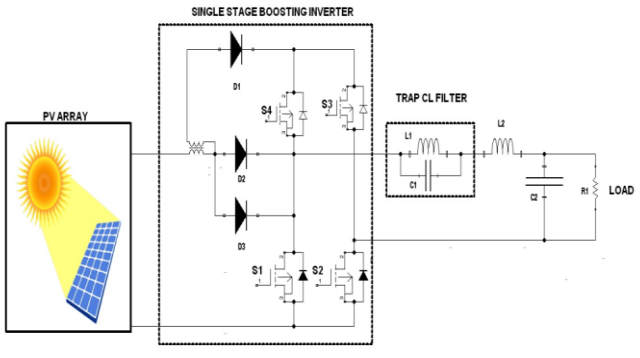
The design consideration of trap CL filter is filter impedance, power factor and resonance. To avoid the voltage drop of impedance at the fundamental frequency. Voltage drop must be less than 10% of normal voltage in filter impedance. Power factor is reduced by output filter because increase the reactive power. Capacitance value must be less than 5% of the normal capacitance value. Amplification of harmonics is caused by resonant frequency. Resonant frequency may be in the range between 10 times the fundamental frequency and half of the switching frequency to avoid the problem.

The capacitance value is calculated by ratio of total filter capacitance to the base capacitance. Inductance value is calculated by using resonant frequency range. The input capacitance value is minimum to limit the maximum voltage ripple on the switching period. Trap frequency is used to eliminate the harmonics and design factor is very important for trap cl filter consideration. Trap CL filter is considered in the parameter of trap filter inductance, trap filter capacitance, grid side inductance, grid side capacitance and damping resistance.

Voltage gain is higher than adjusting the taped inductor turns ratio and maintain the voltage level. Single stage topology has better performance and higher efficiency is attained. Single stage boosting inverter has DC-DC converter. Trap CL filter is mainly used for eliminate the harmonics and reduce size and weight of output filter.

4. CIRCUIT DIAGRAM

In this project, single stage boosting inverter is used for alternative energy generation. It consists of photovoltaic panel, coupled inductor, boost converter, MOSFET switch, trap CL filter and load. Photovoltaic panel is made up of solar cell. Photons of light is exposed, that energy is absorbed by semiconductor material. Solar cell converts solar energy into electrical energy such as direct current. Coupled inductor is used to avoid damage in diode. High frequency is passed through the diode so it has stress then diode is damaged. So coupled inductor is used to avoid stress across diode. Four MOSFET switches is used in the circuit.



MOSFET switch is a three terminal fully controlled switch. It has gate, drain and source. It is used to improve the switching speed and dynamic response under less power. MOSFET switch S1 and S4 turns ON then switch S2 and switch S3 is turns off. Then switch S1 and switch S4 turns OFF and so switch S2 and switch S3 turns ON.

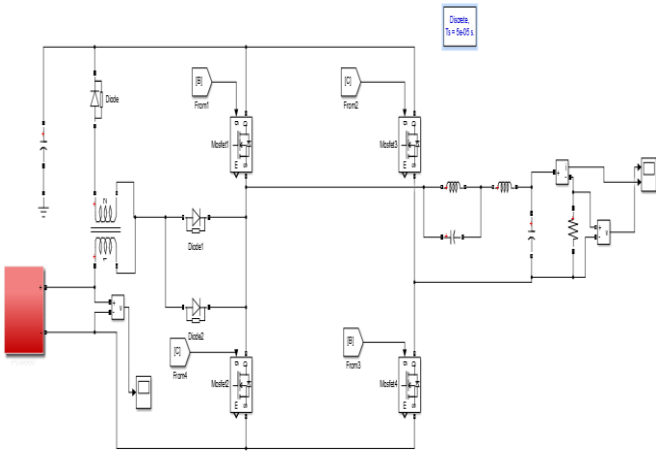
Photovoltaic panel is used for input source. The supply is passed to the coupled inductor. Thus the voltage is passed through diode 1 MOSFET switch S1 and switch S4 turns ON, and go to the trap CL filter and then passed to the load then returned to the switch 4 and go to the photovoltaic panel.

Photovoltaic panel give input supply, DC supply is passed to the coupled inductor. Coupled inductor is used to reduce the stress across diode. Diode current is produced across the diode. That current is passed to the switch S4 and passed to the trap CL filter. Trap CL filter is used to reduce the harmonics and passed to inductor, it stores the energy and passed to the capacitor and passed to the load. It energize the circuit and passed to the load and it passed to switch S1 because switch S2 and S3 and return to the photovoltaic array.

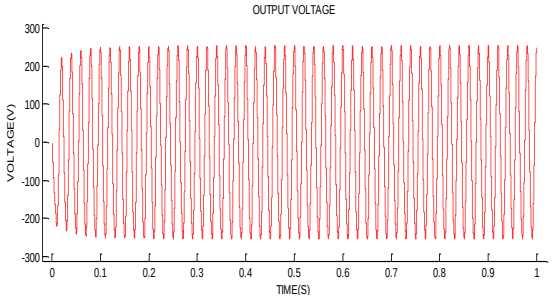
Similarly, DC supply from photovoltaic array is passed to the coupled inductor, thus coupled inductor reduce the stress across the diode. Diode current is produced across the diode. That current is passed to the switch S3 and passed through trap CL filter to inductor and capacitor. It stores the energy and passed to the load and it passed to switch S2 and directly return to the photovoltaic array.

Boost converter is used in the circuit. Boost converter is used to increase the output voltage than the input voltage. It improve the performance of the component and reduce the ripple voltage. Single stage boost inverter is used for alternative energy generation.

5. SIMULATION CIRCUIT DIAGRAM

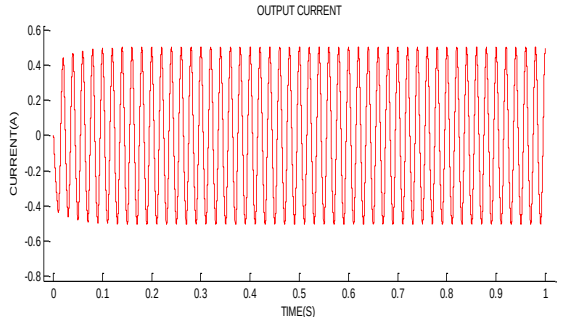


This is the simulation circuit diagram of single stage boosting inverter with trap CL filter. Solar panel is connected to the coupling inductor and diode is connected with the coupled inductor. Thus DC-DC converter or boost converter are used in the circuit. Gate pulse is given to the MOSFET switches. Boost converter is connected between the coupled inductor and MOSFET switches. Coupled inductor is used for reduce the stress across diode and it is mainly used to avoid damages in diodes. Trap CL filter is used to eliminate harmonics and improve efficiency. Trap CL filter is connected in leg of the MOSFET switch. Trap filter is also called as the harmonic filter. Voltmeter and ammeter is used in circuit for measure the output voltage and output current in the single stage boosting inverter. MOSFET switch is turned on and off based on gate pulse command. Output voltage is higher than the input voltage.

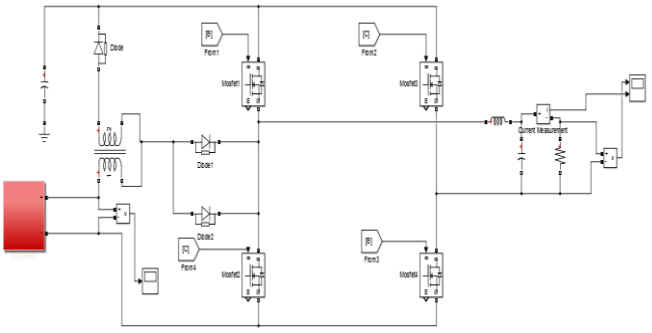


This is the output waveform of single stage boosting inverter with trap CL filter. The output voltage is 230V. It is high compared to the without trap CL filter. Pure sinusoidal waveform is attained in the output waveform. X-axis is represented as time in seconds and Y-axis is represented as voltage in volts. Voltage is varied with respect to the time.

Boost converter is used in this project so voltage must be higher than the input voltage. Harmonics is eliminated from the output waveform and given to the load. In previous two stage and multi stage topologies has less output voltage and impair in efficiency. The output voltage is pure sinusoidal waveform.



This is the output current waveform of single stage boosting inverter with trap CL filter. Pure sinusoidal waveform is produced in the output waveform. X-axis is represented as time in seconds and Y-axis is represented as current in amperes.

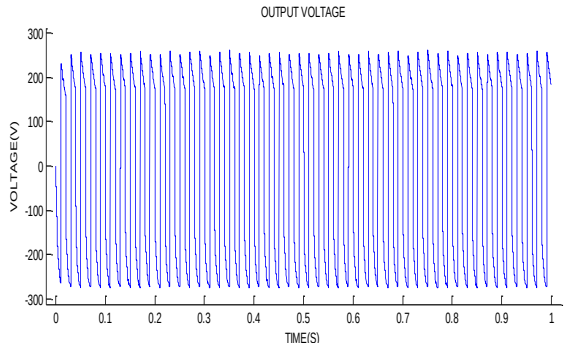


Harmonics are reduced in the output waveform due to trap CL filter. Trap CL filter is used to reduce the harmonics. Accurate value can be measured in the output waveform. This is high gain single stage boosting inverter without trap CL filter.

Coupled inductor is used in the circuit. Solar panel is used for input supply. Boost converter is used in the one cycle control. MOSFET switch is used in the circuit for commutation purpose. Turn ON and turn OFF process is based on the gating pulse. Inductor is used to store the energy.

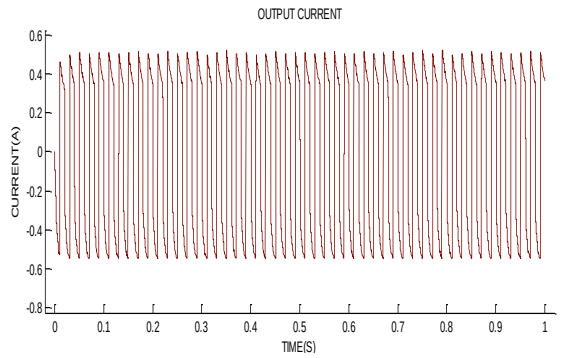
Coupled inductor is used to reduce the stress across the diode. Boost converter is used to increase the voltage and inverter is used to convert direct current into alternating current. Boost converter has two modes such as charging and discharging mode. Input supply is passed to inductor then it is charging and diode is reverse biased and current is passed to switch, it is turned ON and current flow is involved.

Switch is turned OFF so there is no current flow in the circuit. Inductor stores the energy, that energy is discharged then current is produced in the circuit. Then switch is turned ON then charging is occurred and switch is turned OFF then discharging is occurred. This process is simultaneously occurred.



This is output voltage of high gain single stage boosting inverter. Harmonics is involved in the single stage boosting inverter so pure sinusoidal waveform is not produced. Approximately 170V is produced in the boosting inverter. Efficiency drop is occurred due to some stress and harmonics.

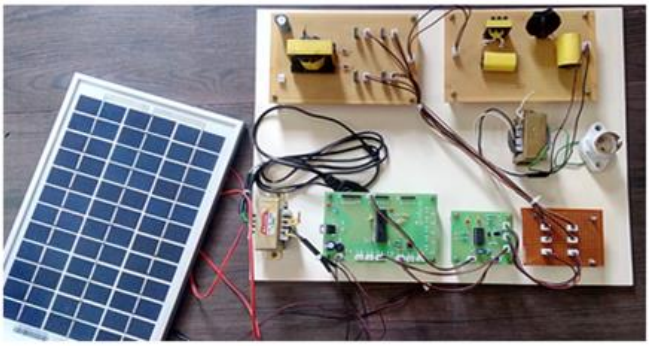
Output voltage is low compared to single stage boosting inverter with trap CL filter. Voltage is represented in Y-axis and time is represented in X-axis. It is overcome by using trap CL filter. Conduction losses is involved in the single stage boosting inverter.



This is the output current waveform of single stage boosting inverter. Approximately 0.3A is produced in single stage boosting inverter. Current value is depend upon the load variation.

6. HARDWARE

It consists of single stage boosting inverter, trap CL filter, PIC controller, driver circuit and signal bus. Solar panel is used for input supply.



Coupled inductor is used to reduce stress across diode and reduce the conduction losses. MOSFET switch is used in the boosting inverter. Ferrite core is used in the coupled inductor and it is operate in high frequency and low losses. Capacitor and diode is used for boosting inverter operation.

In DSPIC controller consists of bridge rectifier, capacitor and voltage regulator in power supply. Bridge rectifier is used to convert alternating current into direct current and capacitor is used for charging or storage purpose. Voltage regulator is used for supply the input voltage constantly. PIC controller is mainly used for generate pulse width modulating signal.

Driver circuit is used for amplification purpose and it is mainly used for drive the gate pulse. Driver circuit is used to produce the output constantly. Decoupling capacitor is used for avoid the coupling between the polarity.

Signal bus is used to sharing the supply for switches and it is used to supply for switches. The output of the driver circuit is connected to the signal. That signal is pass to the signal bus and share the signal and given to the switches.

Trap CL filter is used to reduce the size and weight of the output filter. Trap filter is mainly used to reduce the harmonics and CL filter handles small amount of harmonics. Trap CL filter is used to eliminate harmonics and improve efficiency. Trap CL filter is connected in leg of the MOSFET switch. Trap filter is also called as the harmonic filter.

Trap filter is efficient compared to the CL filter and it handles large amount of harmonics. It is used to reduce the harmonics and improve the efficiency. Trap filter is smaller in size compared to CL filter. Trap CL filter is operated in AC module. Pure sinusoidal waveform is obtained due to trap CL filter.

Ferrite core is used in the coupled inductor and coupled inductor is used for reduce the stress across the diode. Iron core is used in transformer. Ferrite core is involved in high frequency and it has low losses. Iron core is involved in low frequency and it has high losses. Coupled inductor is consists

of two inductor. Decoupling capacitor is involved in controller and driver circuit.

Single stage boosting inverter is used to convert direct current into alternating current with increase the output voltage. Boost converter consists of diode, inductor, capacitor, switches and load. Switch is simultaneously on and off due to gate pulse. PWM signal is pass to the switches.

Signal bus is used to share the signal and pass to the switches. More than one switch can attain in the supply. It has four switches in inverter. Pure sinusoidal waveform can produce in the circuit.

This is the output voltage of single stage boosting inverter with trap CL filter for photovoltaic application. Output voltage is greater than the input voltage due to boost converter. Efficiency is improved by trap CL filter.

7. CONCLUSION

High gain single stage boosting inverter with trap CL filter for alternative energy generation. Tapped inductor to attain high input voltage step up and allows operation from low DC input voltage. High voltage can be increased, adjusting the tapped inductor turns ratio. Trap CL filter is used to reduce the harmonics from the output. Single stage boosting inverter allows decoupled control function. Boost converter increase the output voltage than the input voltage. Trap CL filter can be designed a smaller size because total harmonics are reduced. Output filter size and weight is reduced. Efficiency is high in the single stage boosting inverter with trap CL filter.

REFERENCES

[1] Yong-Su Noh, Bong-Yeon choi, Soon-ryung lee, "An optimal method to design a trap-cl filter for a PV AC-module based on flyback inverter", *IEEE transactions on industry applications,* vol. 52, no. 2, March/April 2016.

[2] S. Jain and V. Agarwal, "A single-stage grid connected inverter topology for solar PV systems with maximum power point tracking," *IEEE Trans. Power Electron.*, vol. 22, no. 5, pp. 1928–1940, Sep. 2007.

[3] S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, "A review of single-phase grid-connected inverters for photovoltaic modules," *IEEE Trans. Industry Application*, vol. 41, no. 5, pp. 1292–1306, Sep. 2005.

[4] T. Konjedic, M. Truntic, M. Rodic, and M. Milanovic, "A single stage boost dc-ac converter for single-phase grid-connected photovoltaic systems," *Power Electronics South America,* Sept 2012.

[5] Y. Fang and X. Ma, "A novel PV micro inverter with coupled inductors and double-boost topology," *IEEE Transactions on Power Electronics,* vol. 25, no. 12, pp. 3139–3147, Dec 2010.

[6] H. Ribeiro, A. Pinto and B. Borges, "Single-stage DC-AC converter for photovoltaic systems," *in Proc. IEEE Energy Convers. Congr. Expo.*, 2010, pp. 604–610.

[7] J. P. Fohringer and F.A.Himmelstoss, "Analysis of a boost converter with tapped inductor and reduced voltage stress across the buffer capacitor," *in Proc. IEEE Int. Conf. Ind. Tech.*, 2006, pp. 126–131.

[8] A. Abramovitz, M. Heydari, Ben Zhao; K, Smedley, "Isolated flyback half-bridge OCC micro-inverter," Energy Conversion Congress and Exposition (ECCE), *IEEE*, vol., no., pp. 2967-2971, 14-18 Sept. 2014.

[9] Y. Patel, D. Pixler, and A. Nasiri, "Analysis and design of TRAP and LCL filters for active switching converters," *in Proc. IEEE Int. Symp. Ind. Electron. (ISIE'10)*, 2010, pp. 638–643.

[10] H. Hu, S. Harb, N. Kutkut, I. Batarseh, and Z. J. Shen, "A review of power decoupling techniques for micro inverters with three different decoupling capacitor locations in PV systems," *IEEE Trans. Power Electron.*, vol. 28, no. 6, pp. 2711–2726, Jun. 2013.