Design and Implementation of Interleaved Boost Cascaded with Buck Converter Using PV Inverter

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Abstract: A single phase load connected with help of photo voltaic inverter use in residential application is presented. The inverter is derived from interleaved boost cascaded with buck converter using the converter modes of operation we will get the high efficiency with help of power MOSFET. It is the only switch operates at a high frequency. This model indicates the interleaved boost will increase the efficiency and reduce the ripple factor which is easily control and greater stability can be achieved. By using this model we get very low conduction and switching losses then switching frequency is improved and size of the system also reduced.

Key words: Power MOSFET • Derived from interleaved • Efficiency and reduce

INTRODUCTION

In this block diagram the interleaved boost cascaded with buck converter is proposed at the first stage of operation the interleaved boost converter will boost voltage from the PV array then the voltage flow to the inverter unit. The inverter used to convert the dc voltage to ac voltage then it flow to load. As the second stage of operation buck converter is to activate whenever the load requirement is less both these operations performed with the help of power MOSFET. By using these converters we should get the voltage constantly without any interrupt [17]. Microcontroller which is used to generate the pulse from the PWM control then driver circuit used to amplitude the pulse from the microcontroller and moves to activate the boost and buck mode of operations.

Power demand is improving day by day so we used to get the power from the photo voltaic (PV) [1-15]. Photo voltaic power supply to residential, industrial applications gets more attention nowadays so more no of inverter circuits and control schemes are used for PV power conditioning systems (PCS)[16]. For residential purpose single phase inverter are more interest this type of application requires less than 5Kw power. The output voltage from the PV panels varies greatly due to temperature, irradiation conditions, shading and clouding effects so the input voltage of residential inverter also varies greatly because of this we are not getting constant voltage. For this interleaved boost cascaded with buck converter is proposed with help of this we should do either step up or step down function depend upon the load requirement before the inverter stage. This type of arrangement is widely used in PV PCS.

The circuit runs either in boost or buck mode, its first stage can be very efficient if the low conduction voltage drop power MOSFET and ultrafast reverse recovery diode are used [18]. For the second stage, because the un-folding circuit only operates at the line...
frequency and switches at zero voltage and current, the switching loss can be omitted. The only loss is due to the conduction voltage drop, which can be minimized with the use of low on-drop power devices, such as thyristor or slow-speed insulated gate bipolar transistor (IGBT). In this version, IGBT is used in the unfolding circuit because it can be easily turned ON and OFF with gating control. Since only the boost dc-dc converter or buck dc-dc converter operates with high-frequency switching all the time in the proposed system, the efficiency is improved. Also, because there is only one high-frequency power processing stage in this complete PCS, the reliability can be greatly enhanced.

Finally [19], after analyzing its model, as shown in Fig. 3, an interleaved-boost-cascaded-with-buck (IBCB) converter is proposed to increase the resonant pole frequency by the use of a smaller boost inductor value, which improves both control and stability. Analysis of a middle capacitor and CCM/DCM operation condition is also presented.

**Operation Principle**

**Boost Mode:** When the PV panel’s voltage is lower than the instantaneous load voltage, it will operate in boost mode, in which S boost will be switched ON and OFF and S buck will be always ON and the buck part of the circuit will act as an output filter as shown in Fig. 4(a).

**Buck Mode:** When the PV panel’s voltage is higher than the instantaneous load voltage, it will operate in buck mode, in which S buck will be switched ON and OFF and S boost will always OFF and the boost part of the circuit will act as an input filter as shown in Fig. 4(b) [20].

Thus, if the PV panel’s voltage is lower than the grid’s peak voltage, the PV inverter will switch between buck mode and boost mode depending on the instantaneous grid voltage as shown in Fig. 5. However, if the PV panel’s voltage is higher than the grid’s peak voltage, it will always run at buck mode. In stead of a dc bus in the middle, the voltage across the capacitor CL in boost/buck PV inverter varies with the grid, if PV panel’s voltage is lower than the grid’s peak voltage as shown in Fig. 6.
However, if PV panel’s voltage is higher than grid’s peak voltage, CL’s voltage will be the same as the PV panel’s voltage.

**Interleaved Scheme and Implementation Method:** If the switching frequency can be increased so that a smaller inductance is utilized, the system will be easier to compensate and more stable. However, the efficiency may decrease in this case. In order to keep high efficiency and stability, an interleaved-boost-cascaded-with-buck converter is proposed. Fig. 7 shows the complete circuit diagram. The model of such a circuit is similar to that of the circuit shown in Fig. 4, so the same model derived in this section can be used for compensator design. The maximum power point tracking can be implemented as an outer loop with lower band-width control, providing the magnitude of the output current. Figs. 8 and 9 show analog and digital control diagram.

**Modeling Analysis of the Inverter:** In order to achieve unity power factor, L2’s current needs to be controlled as a rectified sinusoidal shape. The pulse width Modulation (PWM) switch models have been established for this PV inverter both in buck mode and in boost mode as shown in Fig. 10(a) and (b) with parasitic parameters considered.

The PV panel is simplified as a dc-voltage source and the grid with bridge switches is simplified as a rectified sinusoidal voltage source. Although the output voltage is rectified sinusoidal instead of constant output, it can also be treated as “steady state,” since the output voltage is changing with line frequency that is much smaller than switching frequency.

During buck mode, L2’s current can be treated as normal buck converter’s output inductor current which can be easily controlled. However, it is critical to control L2’s current in boost mode because the control target in this mode is its output filters inductor current. Thus the compensator of boost mode needs to be designed first and then applied to the buck mode.

**Simulation:** The proposed PV inverter along with its closed-loop controller has been simulated in PSIM. Fig. 11(a) and (b) compares the simulation results with different input-voltage conditions. In Fig. 11(a), the input voltage V in is assumed to be 200 V. As can be seen in the figure, buck or boost switch does not work simultaneously. S boost works when V in is smaller than the instantaneous grid voltage and S buck works when V in is larger than the instantaneous grid voltage. In this case, the ripple current of L2 during boost mode is smaller than that during buck mode, because L2 performs as the output filter’s inductor of boost converter but performs a normal output inductor of buck converter. Fig. 11(b) shows the simulation results when the in-put voltage is 400 V. Unlike the previous case, there is no boost mode and only S buck is working. The voltage on the middle capacitor CL always is equal to the input voltage since D boost is always conducting.
Fig. 10: (a) Model of boost mode. (b) Model of Buck mode

Fig. 11: (a) Simulation results with small input voltage. (b) Simulation results with Large input voltage

Fig. 12: Hardware prototype

Fig. 13: Experiment results of PWM signals

Fig. 14: (a) Experiment results with small input voltage. (b) Experiment results with Large input voltage
the testing results when V in is greater than the peak of the output voltage. Other than the proposed structure and control method, testing with different control methods with different voltages on CL has been conducted. Instead of making the middle capacitor CL’s voltage the same as the grid voltage during boost mode, we should control its voltage constant higher than the grid voltage. With 1-kW power, the efficiency curves of different input voltages are shown in Fig. 15, which include the proposed solution, different AVC link and constant VC link. The results indicate that the peak efficiency is reached in the proposed control method if Cool MOS are used in the circuit, the loss in this part will be less than two stage conversion. Thus, the overall efficiency is still high.

CONCLUSION

The implementation of interleaved boost cascaded with buck converter using PV inverter for residential application has been presented. As a result by using this model the switching frequency is reduced and size of the system also reduced. So overall efficiency of the system is increased [21-25].

REFERENCES


