

FOUR OUTPUT FLY BACK CONVERTER WITH INTEGRATED AUXILIARY BUCK CONVERTERBY USING ZVS

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Abstract: The fly back converter has been widely used for multi outputs due to the simple structure and low cost in low-power applications. This paper presents a new four outputs converter. It consists of a Boost converter and High frequency inverter in primary side and a fly back rectifier that is integrated with an auxiliary buck converter in secondary side. The primary switches control the main output voltage and the secondary synchronous switches control the auxiliary output voltages. The main advantages of the proposed converter are that the transformer size can be reduced due to the lower magnetizing offset current, all the switches including synchronous ones can achieve the zero-voltage switching, and it has no cross regulation problems. The operational principle and design considerations of the proposed converter are described in this paper. The experimental result from four outputs (44V/11A, 26V/9A, 26V/9A & 26V/7.5A) prototype.

Index Terms- PVmodule, Boost, Buck, multioutput, synchronous switch, zero-voltage switching (ZVS)

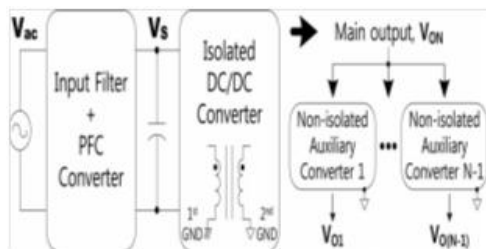
I.INTRODUCTION

Due to climate changes, planetary efforts are conducted toward energy saving by increasing the equipment efficiency. Especially the high efficiency not only under full-load conditions but also under light-load conditions is required in many applications such as personal and server computer, display devices, and so on. Also, system requirements often dictate the need for most switching power supplies to provide regulated and isolated multiple outputs[1-5]. The fly back converter has been widely used for multi outputs due to the simple structure and low cost in low-power applications. However, high-voltage stress of the primary switch and EMI problem from the hard switching limit the power rating for higher power application[6-12]. To overcome these drawbacks, half-bridge inverter can be a good solution. Especially, as the gate signals of two switches are operated in asymmetrical manner, the primary switch not only has low-voltage stress of the input voltage, but also can easily achieve zero-voltage switching (ZVS) using the transformer leakage inductance[13-16].

Fig.1 Block diagram of typical N multi output power supply with nonisolated auxiliary converters

Fig.1 shows the block diagram of typical N multi output power supply with nonisolated converters. The isolated dc/dc converter has dc input voltage V_S , which comes from the input filter and power factor correction converter in ac line. It has the main output and, from this, auxiliary ones are made with a same ground[17-21]. However, this structure has some disadvantages: the isolated dc/dc converter has large transformer due to the large magnetizing offset current as using the fly back converter, and the hard switching problem in the nonisolated auxiliary converters degrades the overall efficiency, especially under light load conditions. The buck or boost converter is usually applied to them for step-down or step-up function. To solve this problem, nonisolated ZVS converters are proposed. The active-clamping technique is applied. The additional switch, capacitor, and inductor consist of the active-clamping circuit. Two switches are asymmetrically controlled[22-26], and the additional inductor is resonated with the output capacitor of the switches, which results in ZVS. However, many additional components are needed. A tapped inductor can be utilized in buck converter for ZVS. The tapped inductor with series-connected diode makes ZVS current and its path. In the buck converter in critical conduction mode is improved by using a tapped inductor. It extends the duty cycle of conventional CRM converter and thus reduces its conduction and switching loss[27-31]. However, these techniques can increase the inductor size or can only be applied in the critical conduction mode. In this paper, a new isolated multi output dc/dc converter is proposed. The proposed converter is based on the half-bridge Fly back converter for the main output and buck converters for the auxiliary outputs[32-36]. The buck converter is integrated with the secondary fly back rectifier. This integration makes simple structure, and lower transformer size, and ZVS of all the switches are achieved by gate Control without additional components[37-41]. In addition, cross regulation problems among the outputs do not occur.

II-OPERATIONAL PRINCIPLE



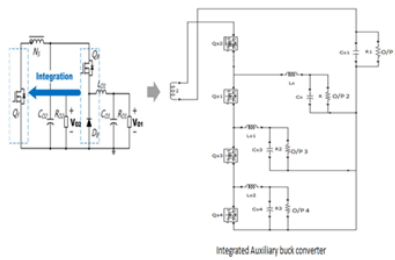


Fig 2 (a) Integration of the secondary switches.

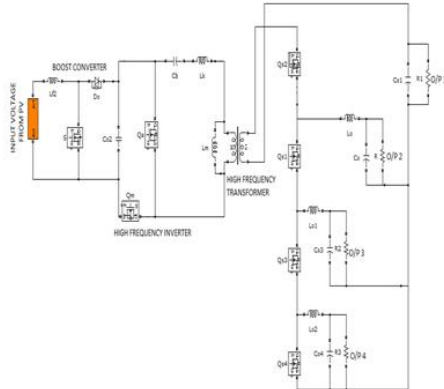


Fig 2(b) proposed fly back converter with four outputs

Fig 2(a) shows the switch QB and diode DB of the buck converter are integrated with QF, and it is divided four synchronous switches QS1, QS2, QS3 and QS4. These four switches provide the current path for the main output as usual. Also, QS1, QS2, QS3 and QS4 offer the powering and freewheeling path for auxiliary output, respectively. Switch Qs1 delivers main output and other switches gives auxiliary outputs. Main output is greater than auxiliary outputs. This multifunction is the result from the gate signal controls of these switches, which will be analyzed in the following section. Fig. 2(b) shows the circuit configuration of the proposed fly back converter with four outputs. It consists of boost converter and High frequency inverter in primary side and fly back converter integrated with auxiliary buck converter in secondary switch. The input voltage of Boost converter Input is taken from PV (photo voltaic) module. Each switching period is subdivided into eight modes and their operational modes are shown in Fig. 3. The main switch Qm is operated in a duty ratio of D, and the auxiliary switch Qa is operated complementary to the main switch Qm. The main and auxiliary output can be regulated by controlling the duty ratios D and DS, respectively, where D is the duty ratio of the main switch Qm, and DS is the duty ratio of the overlap interval of Qm, Qs1, Qs3 and Qs4. In order to illustrate the steady-state operation, several assumptions are made as follows: 1) All parasitic components except for those specified fig.2 (b) are neglected [42-45]; 2) The parasitic capacitances of the primary switches are the same capacitance. 3) The output voltages VO1, VO2, VO3 and VO4,

and blocking capacitor voltage VCB are constant during a switching cycle; 4) The transformer turns ratio $n = N_P / N_S$.

2.1 Boost converter operation

A boost converter is sometimes called a step-up converter since it "steps up" the source voltage. The key principle that drives the boost converter is the tendency of an inductor to resist changes in current. In a boost converter, the output voltage is always higher than the input voltage. A schematic of a boost power stage is shown in Fig 3. Fig.3.1 the two configurations of a boost converter, depending on the state of the switch S. When the switch is turned-ON, the current flows through the inductor and energy is stored in it. When the switch is turned-OFF, the stored energy in the inductor tends to collapse and its polarity changes such that it adds to the input voltage. Thus, the voltage across the inductor and the input voltage are in series and together charge the output capacitor to a voltage higher than input voltage.

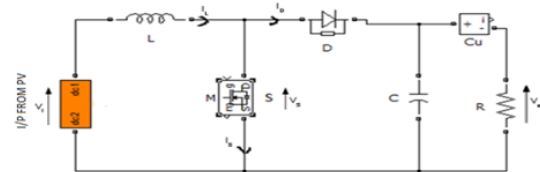


Fig.3 schematic diagram of boost converter

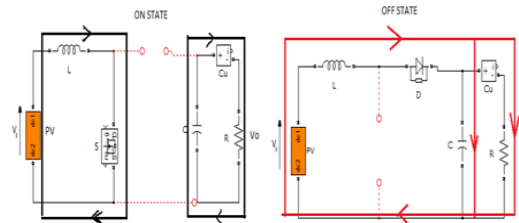


Fig 3.1 Two configurations of boost converter

Proposed converter is operated in eight modes. fig 4 shows (a, b, c, d, e, f, g & h) various modes from 1 to 8 of the converter.

Mode 1 - In the primary side, $V_S - V_{CB}$ is applied to the transformer, so the magnetizing current $i_{Lm}(t)$ is linearly increased. In the secondary side, the output inductor current flows through the switch QS1, QS2 & QS3 and the auxiliary outputs is in powering mode.

Mode 2 In this mode, QS2 and QS4 are turned OFF. $i_{LO1}(t)$ flows through QS1 and QS3, so the auxiliary outputs enters into the freewheeling mode. $i_{LO1}(t)$ is not reflected to the primary side.

Mode 3 begins when the main switch Qm is still in on condition t. In the secondary side, QS2 & QS4 are turned ON with ZVS. Co4 & Co5 are linearly charged and discharged by $i_{Lkg}(t)$, respectively. When the primary voltage reaches $-V_{CB}$, the ZVS of the switches Qa and QS1, QS2, QS3 & QS4 can be achieved.



Fig 4.Operational modes of proposed converter

Mode 4 begins when Q_a is turned ON with ZVS. The power is transferred from the primary side to the main output VO1. In secondary side Q_{S1} & Q_{S3} are turned On with ZVS. The voltage across the leakage inductance is the difference between the voltage reflected from the secondary side and the blocking capacitor voltage, VCB. The secondary transformer current i and the auxiliary output is still in auxiliary mode. In this mode all the Synchronous switches are ON condition.

Mode 5 begins with Q_{S4} is turned OFF with ZVS. In secondary side, Q_{S1} , Q_{S2} & Q_{S3} are still on state. Secondary side capacitors and inductors are linearly charged.

Mode 6 begins when Q_{S3} is turned OFF with ZVS. In this mode primary source not connected with the circuit. Primary side capacitor and inductances supply the power to primary winding. Secondary side step down voltage is induced. Synchronous switch Q_{S3} is turned off with ZVS. Q_{S1} and Q_{S2} are still ON condition.

Mode 7 begins with Q_{S3} and Q_{S4} are turned on with ZVS. In these mode auxiliary outputs are in freewheeling mode. In primary side Capacitor C_b , inductance L_m and L_k are discharged the supply to Switch Q_a . In secondary side Q_{S2} is turned off. Synchronous switch Q_{S1} is still in ON state.

Mode 8 begins when main switch Q_m and auxiliary switch Q_a are turned off with ZVS. In this mode parasitic capacitances

C_{o4} & C_{o5} are linearly charged and discharged by leakage current I_k , respectively. In secondary side Q_{S2} is turned on with ZVS. In this mode all the secondary switches are ON condition

Magnetizing Offset Current I_{Lm} can be obtained from the current-second balance on the blocking capacitor C_b . Because the average current flowing through C_b is zero, the average primary current reflected from the transformer secondary side is the same as the magnetizing offset current. In the proposed converter, the powering period of the auxiliary and main output are separated each other during DTS and $(1 - D)$ TS, respectively.

III-EXPERIMENTAL RESULTS

Voltage from PV is given to that input voltage of boost converter.

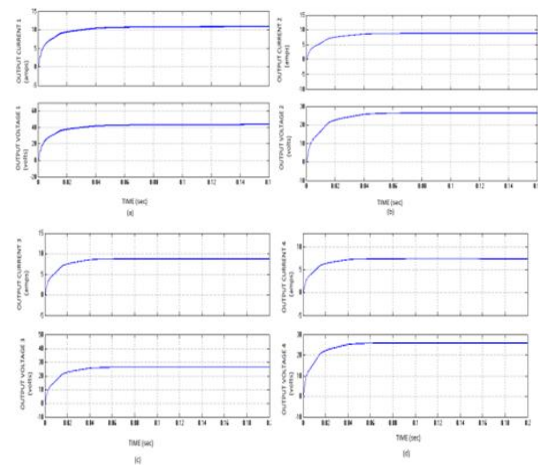


Fig 5 output voltages and output currents (1, 2, 3 & 4)

From boost converter output given is given to the High frequency inverter. High Frequency inverter is used to convert Boost converter Dc output voltage in to High frequency AC voltage. High frequency inverter is also used to reduce the switch voltage stress and improve the efficiency. Inverter output is given to the input of High frequency Transformer. High frequency Transformer is used to Transfer the electrical power from source of AC power to some devices or equipment while isolating the powered device from the power source, usually safety. It is used for step down purpose. The transformer size should be small due to high frequency. L_k is the Leakage inductance. During energy storing and discharging the both the inductor between positive and negative cycles. L_m and L_k are primary side inductors of the transformer. The inductor L_o , L_{o1} & L_{o2} are connected secondary side of the transformer. These inductances are used by filtering purpose combine with capacitor. These inductances are mainly used in auxiliary outputs. Fig 5 (a) shows the main output voltage1 is 44 V and the current1 is 11A. Fig 5(b) shows the auxiliary output2 from the converter is 26 V/9 A. The auxiliary output delivered from Switch Q_{S1} and load. LC filter is used to reduce the ripple content from

voltage and current for all the auxiliary outputs. The auxiliary output2 is 26V/9A. Fig 5(c) shows the auxiliary Output3 from the converter is 26 V/9 A. Fig5 (d) shows the auxiliary Output4 from the converter is 26 V/9 A. The auxiliary output delivered from Switch QS4 and load

IV-CONCLUSION

The study and design of Solar PV Module in this project is simple and also efficient. The PV module is modeled using governing equation of solar cell. The result shows that the PV model in moderate complexity provides good matching with the real PV module. The multi output fly back converter with integrated auxiliary buck converter is designed to extract maximum power output of PV module. This paper presents design and Implementation of soft switched multi output fly back converter with integrated auxiliary buck converter. In this project the simulation of whole system model is done using MATLAB.

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