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A Novel Transformer-Much Less Four Phase Buck Converter With Low Voltage Stress And Automatic Current Sharing

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ABSTRACT—*In this paper, a novel four-phase interleaved high step-down converter is presented. The proposed converter can provide an extremely high step-down voltage conversion ratio within a moderate duty cycle. There are four main advantages of the proposed converter. First, the blocking capacitors can store energy as usual. Therefore, they are used as voltage sources to reduce the input voltage as well as to reduce the switch voltage stresses. Second, due to the charge balance of the dc blocking capacitors, the converter possesses an automatic uniform current sharing characteristic of the interleaved phases without adopting any extra circuitry. Third, due to the phase shift between the interleaved phases, the architecture provides a low output current ripple. Fourth, the number of phases can be expanded or reduced to any even phases; therefore, the converter has a wide range of applications. Finally, the operating principles and analysis of this architecture are given, and an experimental prototype is also provided to verify the effectiveness of the proposed converter.*

I INTRODUCTION

Nowadays high performance dc – dc converters are required for increasing high step-down conversion ratio with high output current applications like CPU boards and battery chargers, and distributed power systems [2] – [4]. For non-isolation applications with low output current ripple requirement, an interleaved buck converter (IBC) has received a lot of attention due to its simple structure and low control complexity. However, in the conventional multiphase IBC, as shown in active switches are required to use high-voltage devices that are rated above the input voltage. High-voltagerated devices generally render a number of undesirable characteristics, such as high cost, large on-resistance, large voltage drop, and severe reverse recovery. For high-input low-output voltage regulation applications, operations at higher switching frequencies are required to achieve a higher power density and better dynamics [5]. However, the buck converter with a high step down conversion rate yields a significant switching loss due to its extremely low duty cycle. This fact not only limits the achievable switching frequency, but also complicates its implementation. In addition, the efficiency is further compromised due to the short on-time and long freewheeling time within each switching cycle [6]. To overcome such disadvantages of the conventional IBC, a number of modified IBC structures have been proposed [7]–[14]. A multiphase IBC with extended duty ratio [7], [8]was proposed for high-input low-output voltage regulation applications. Two and four-phase versions of the topology were examined in [7] and [8]. The four-phase extended duty ratio IBC The mechanism of the extended duty ratio lies in the use of highly efficient input voltage dividers which reduce the switching voltage and the associated losses. However, the voltage stress to input switching devices remains rather high. In this paper, we propose a novel transformer-less dc converter that features low switch voltage stress and automatic uniform current sharing. An interleaved fourphase voltage divider is used to achieve a high step-down conversion ratio. In the proposed converter, series charging of the two capacitors from the input voltage and parallel discharging to the load facilitated by a new four phase IBC. This architecture provides a high step-down conversion ratio and a low output current ripple without requiring an extremely low duty cycle. Based on the capacitive voltage division, the new voltage-divider circuit in the converter achieves two major objectives, i.e., increased voltage conversion ratio, due to energy storage in the blocking capacitors, and reduced voltage stress of active switches. The low switch voltage stress offered by the proposed converter topology allows the use of lower voltage rating MOSFETs to reduce both switching and conduction losses, thereby improving the overall efficiency. Moreover, due to the charge balance of the capacitors, the converter features automatic uniform current sharing of the interleaved phases without adding extra circuitry or complex control methods.

II. NOVEL TRANSFORMER-LESS FOUR PHASE BUCK CONVERTER

The proposed converter is shown in Fig. 1, which is derived from the two-phase IBC with an extended duty ratio in [9]. In order to further reduce the output current and output voltage ripples, the converter is divided into fourphase small inductors via an interleaved operation. It is clear from Fig. 1 that the proposed converter consists of four inductors, four active power switches, four diodes, and four capacitors. The proposed converter topology with low switch voltage stress and high step down ratio can only

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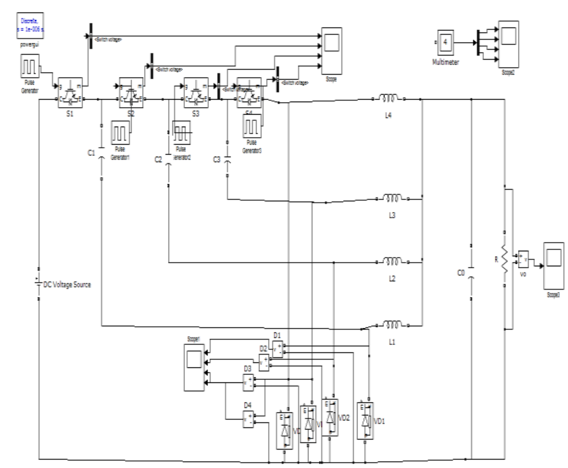
be achieved when the duty cycle is lower than 0.5 and operated in CCM. In addition, when the duty cycle is lower than 0.5, due to the charge balance of the blocking capacitor, the converter enables automatic current sharing so as to obviate any extra current-sharing control circuit. On the other hand, when the duty cycle is higher than 0.5 or when the converter is operates under DCM with a light load, the converter no longer possess the automatic current-sharing capability, and the current-sharing control between each phase should be taken into account.

III MODES OF OPERATION

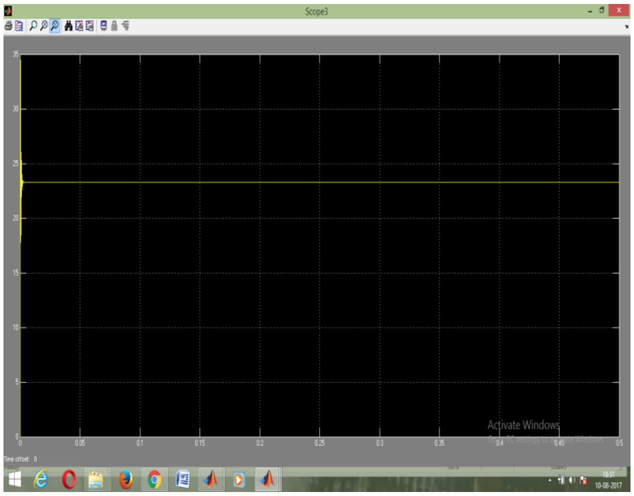
In order to clearly explain the operation principle, the operating duty ratios $0 < D < 0.25$ and $0.25 < D < 0.5$ by the proposed four-phase and two-phase interleaved strategies are, respectively, introduced. Referring to the gate signals shown in Fig. 2, the corresponding operating modes of the proposed converter for condition $0 < D < 0.25$ is discussed next. In first mode, switch S1 is turned on, and switches S2 , S3 , and S4 are all OFF. Hence, diode D1 becomes OFF whereas diodes D2 , D3 , and D4 remain ON. The stored energy of C1 is discharged to CA, L1 , and the output load, whereas current iL2 , iL3 , and iL4 are freewheeling through D2 , D3 , and D4 , respectively. In the next mode all switches gets off. In this case, iL1 , iL2 , iL3 , and iL4 are freewheeling through diodes D1 , D2 , D3 , and D4 , respectively .In next mode only S2 gets on an all others off. Corresponding changes as in mode 1 continues.

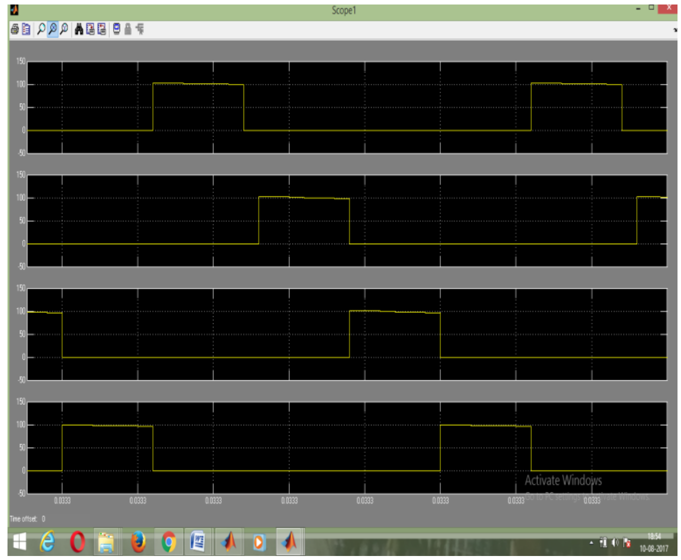
IV RESULTS:

MODEL FILE AND SIMULATION RESULTS:

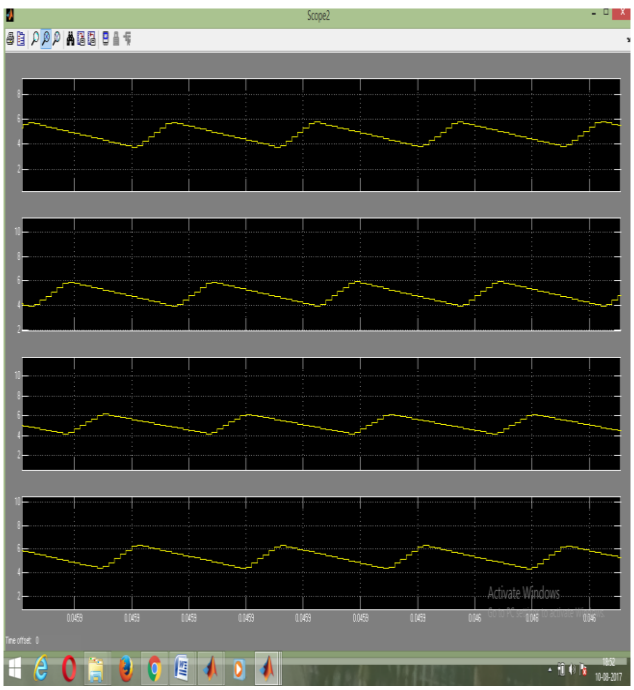


Vo





Inductor currents(Il1 and 2 3 4)



Vd1234

V CONCLUSION

In this paper, a novel four-phase interleaved converter is presented, which possesses a high step-down voltage gain and automatic current balance. Above all, the number of phases can be increased or decreased. Due to the dc blocking capacitors, the switches and diodes have relatively low voltage stresses, and hence the conduction and switching losses are reduced. Furthermore, unlike the converter shown in [19], the input and output grounds of the proposed converter are connected. Moreover, the associated mathematical deductions for the proposed converter are given first, and then some experimental results, based on a prototype with 400V input voltage, 24V output voltage and 500W output power, are used to verify the merits of the proposed converter. Accordingly, the

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experimental results show the low voltage stresses and the automatic uniform current sharing characteristic. In addition, the experimental results also show

the relationship between the input voltage and the dc blocking capacitor voltages during power-on and power-off transitions. When the input voltage linearly rises during the startup period, these dc blocking capacitor voltages also linearly rise. When the input voltage linearly falls to zero during the shutdown period, these dc blocking capacitor voltages also linearly fall to zero. Thus, there are no over-voltages on the switches during power-on and power-off transitions. The proposed converter can be used in the applications with high input voltage and low output voltage, such as battery chargers, distributed power systems, etc.

REFERENCES

[1] M. Bendali, C. Larouci, T. Azib, C. Marchand, and G. Coquery, "Design methodology of an interleaved buck converter for onboard automotive application, multi-objective optimisation under multi-physic constraints," IET Electr. Syst. Transp., vol. 5, no. 2, pp. 53-60, Jun. 2015.

[2] D. D.-C. Lu and V. G. Agelidis, "Photovoltaic-battery-powered DC bus system for common portable electronic devices," IEEE Trans. Power Electron., vol. 24, no. 3, pp. 849-855, Mar. 2009.

[3] M. Pahlevaninezhad, J. Drobnik, P. K. Jain, and A. Bakhshai, "A load adaptive control approach for a zero-voltage-switching DC/DC converter used for electric vehicles," IEEE Trans. Ind. Electron., vol. 59, no. 2, pp. 920-933, Feb. 2012.

[4] S. Kai, Z. Li, X. Yan, and J. M. Guerrero, "A distributed control strategy based on DC bus signaling for modular photovoltaic generation systems with battery energy storage," IEEE Transactions on Power Electronics, vol. 26, no. 10, pp. 3032-3045, 2011.

[5] O. Garcia, P. Zumel, A. de Castro, and J. A. Cobos, "Automotive DCDC bidirectional converter made with many interleaved buck stages," IEEE Trans .Power Electron., vol. 21, no. 3, pp. 578-586, May 2006.

[6] C. C. Ying, "High-efficiency ZCS buck converter for rechargeable batteries," IEEE Trans. Power Electron., vol. 57, no. 7, pp. 2463-2472, Jul. 2010.

[7] L. L. Ray, C. H. Cheng, and K. C. Shih, "Interleaved four-phase buckbased current source with isolated energy-recovery scheme for electrical discharge machining," IEEE Trans. Power Electron., vol. 24, no. 7, pp. 1788-1797, Jul. 2009.

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Volume 04 Issue 13
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[8] C. S. Moo, J. C. Yu, H. L. Cheng, and C. H. Yao, “Twin-buck converter with zero-voltage transition,” IEEE Trans. Ind. Electron., vol. 58, no. 6, pp. 2366-2371, Jun. 2011.

[9] M. Esteki, E. Adib, and H. Farzanehfard, “Soft switching interleaved PWM buck converter with one auxiliary switch,” IEEE ICEE’14, pp. 232-237, 2014.

[10] M. Uno, “High step-down converter integrating switched capacitor converter and PWM synchronous buck converter,” IEEE INTELEC’13, pp. 1-6, 2013.

[11] X. Song, C. W. Siu, C. T. Siew, and C. K. Tse, “A family of exponential step-down switched-capacitor converters and their applications in twostage converters,” IEEE Trans. Power Electron., vol. 29, no. 4, pp. 1870- 1880, Apr. 2014.

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