IJIREEICE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

NCAEE 2017

National Conference on Advances in Electrical Engineering

NMAM Institute of Technology, Nitte

Vol. 5, Special Issue 2, April 2017

Feedback Control of an Interleaved Buck Converter with Improved Conversion Ratio

Sridevi D[1], Ravikiran Rao[2]

PG Scholar, Electrical and Electronics Engg., NMAM Institute of Technology, Nitte, India[1]

Assistant Professor, Electrical and Electronics Engg., NMAM Institute of Technology, Nitte, India[2]

Abstract: Proposed Interleaved Buck Converter (IBC) which has a continuous input current, high step down conversion ratio, extremely low output current ripple. The proposed converter can provide current sharing control method. These benefits can be obtained without any additional stress on the circuit components. Proposed converter is suitable for high power application and operating duty cycle is below 50%.The feedback loop is used for the proposed buck converter to produce constant output voltage. The feedback loop control is given using PI control. Simulation is carried out with MATLAB and results are obtained.

Keywords: Interleaved Buck Converter, Improved Conversion Ratio, Feedback Control.

I. INTRODUCTION

An interleaved buck converter is extensively used as a stepdown, low output current ripple, non-isolated, and high output current with simple structure and low complexity. Conventional IBC has some advantages like power distribution, fast transient response,passive component size reduction and current ripple cancellation. When high input voltage is applied to the conventional IBC, voltage stress of all switches is equal to the input voltage.High voltage elements suffer from high forward voltage drop, high output capacitor, high on resistance[1].At high switching frequency the IBC operates with extremely small duty cycle(D), which causes very short regulation period and high step down. At small duty cycle input current ripple,switching peak current and filter size increases[2].In an IBC, little mismatch in the duty cycles of two interleaved modules with conversion ratio is equal to D, the module with higher D operates in continuous inductor current mode and other module operates in descrete inductor current mode(DICM) mode to equalise the gain of two modules.As a result, current sharing becomes unbalanced between two interleaved modules.Therefore the current sharing is very sensitive to the mismatch in dutycycles[3].The lifetime of the Fuel cell and Lead acid battery depends on the ripple of the current drawn from them which has to be low.The main limitation of the standard converters is that it requires high inductor value in order to accomplish low output current ripple to minimize the inductor losses[4].In order to reduce the current ripple paralleled converters with interleaved control is an attractive technique. Conventional IBC has pulsed input current in CICM.

The proposed converter does not need any additional current-sharing control module. The proposed converter almost suppresses the effects of mismatches in the duty cycles of the modules.

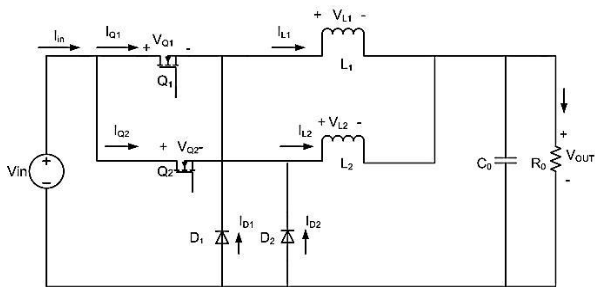

Fig.1 Conventional IBC

II. OPERATION PRINCIPLE OF PROPOSED IBC

Fig 2. shows the proposed converter in which two capacitors are connected at the input and an auxillary inductor at the output.The two active switches are controlled by two PWM pulses which are 180^0 out of phase.

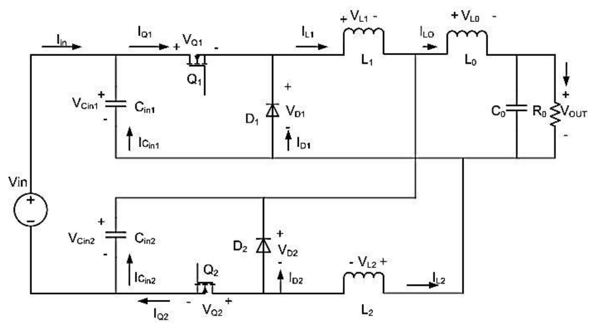

Fig. 2 Proposed IBC

IJIREEICE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

NCAEE 2017

National Conference on Advances in Electrical Engineering

NMAM Institute of Technology, Nitte

Vol. 5, Special Issue 2, April 2017

The following assumptions are made during the analysis.
1) All active switches and diodes are ideal.
2) Capacitors C_{in1}, C_{in2}, and C_o are large enough so that their voltage variations can be ignored. Also, $C_{in1}=C_{in2}$.
3) The currents in L_1 and L_2 are constant, and also, $L_1=L_2$

Modes of operation:
Mode 1:

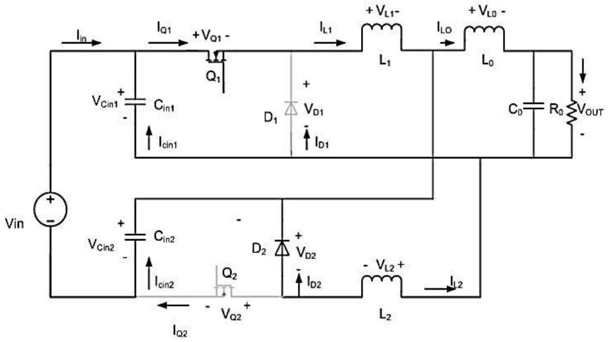

Fig. 3 Mode 1[t_0-t_1]

Interval 1 [to-t_1]:
Prior to this interval, both the switches are off, the freewheeling diodes are conducting and the input capacitorsC_{in1} andC_{in2} are charged. At t_0, Q_1 is turned on, so D_1 turns off.In this interval, C_{in2} is charged through V_{in} and $L_1$and C_{in1} is being discharged through L_1-L_o-C_o. In addition, L_1 current is increasing through both of the mentioned current paths. L_2 current is decreasingin this state.

Mode 2:Operation of Mode 2 [t_1-t_2] and Mode 4 [t_3- t_4]

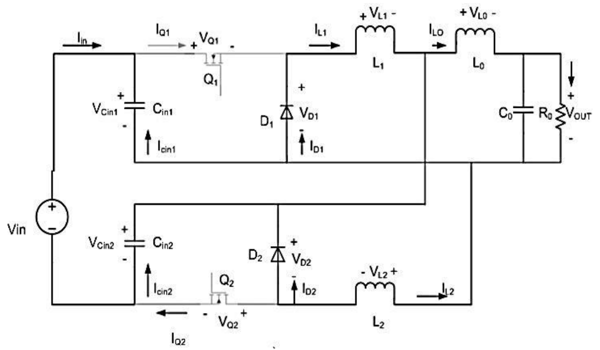

Fig. 4Mode 2 [t_1-t_2] and Mode 4 [t_3- t_4]

Interval 2 [t_1-t_2]: This interval starts when Q_1 turns off. By turning Q_1 on, L_1 continues its current and turns D_1 on. Part of the inductor current which was owing in C_{in1}-L_1-L_o-$C_o$continues its path through D_1-L_1-L_o-C_o, and the other part of L_1 current runs through V_{in}-C_{in1}-D_1 -L_1-C_{in2}. Therefore, during this interval, L_1 and L_2 aredischarging and C_{in1} and C_{in2} are charging through V_{in}-C_{in1}-D_1-L.C_{in2} and V_{in}-C_{in1}-L_2-D_2-C_{in2}.
Mode3:

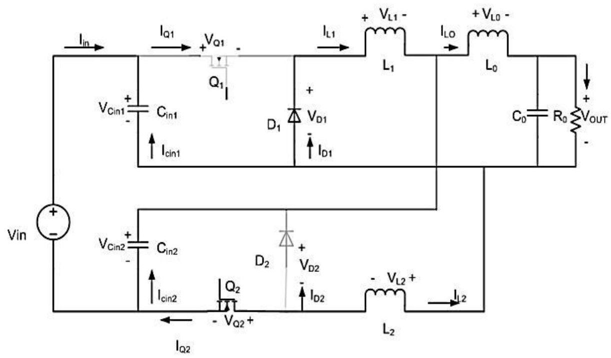

Fig. 5 Mode 1[t_0-t_1]

Due to symmetric operation of two modules in an interleaved converter, the operations of interval 3 and interval 4 are similar to those of interval 1 and interval2.

III. SIMULATION AND RESULTS

A. Open Loop Control of Proposed IBC

Proposed IBC has extremely low output current ripple and high step down conversion ratio in comparison with the conventional IBC, thusthe duty cycles of switch can be extended with reduced peak current. The output current ripple of the converter is considerably low even though a very small inductor is used.

TABLE1 Parameter values of the proposed IBC

Input Voltage	200V
Output Voltage	24V
Power Level	240W
Switching frequency	100KHz
Inductors L_1 and L_2	100uH
L_0	5uH
Input Capacitors C_1 and C_2	4.4uF
Output Capacitor C_0	1uF

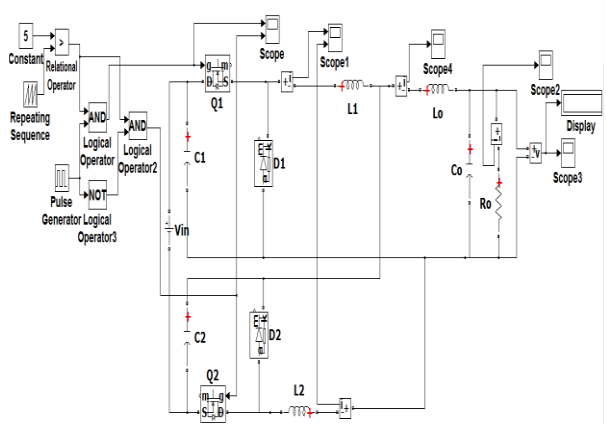

Fig. 6 Open loop control of proposed IBC

IJIREEICE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

NCAEE 2017

National Conference on Advances in Electrical Engineering

NMAM Institute of Technology, Nitte

Vol. 5, Special Issue 2, April 2017

B. Output voltage and output current of the proposed converter:

Output voltage of the proposed converter is 27.85V but with a minimum ripple of 0.2V.Output current ripple is decreased to 0.07A for a duty ratio of0.45.

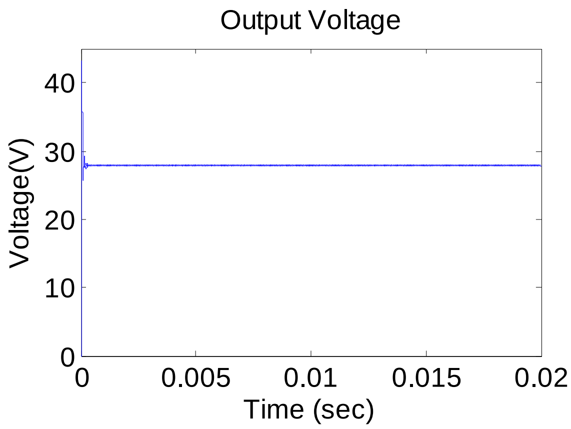

Fig. 7 Output Voltage

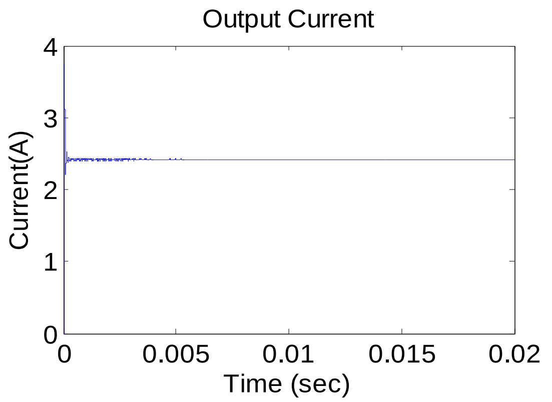

Fig. 8 Current through the Load

C) Closed Loop Control of Proposed IBC:

To produce constant output voltage, feedback loop is used. In feedback system output voltage is compared with a reference voltage and a PWM wave is generated.

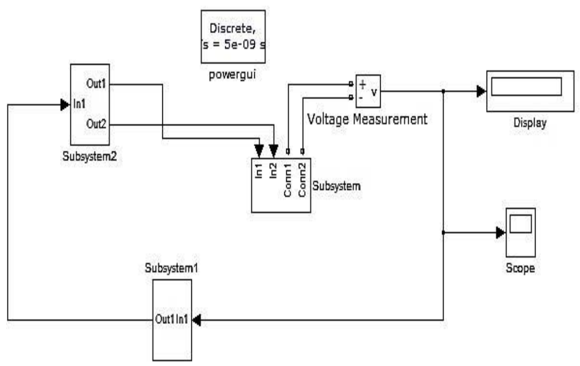

Fig. 9 Closed loop control of proposed IBC

C. Output voltage and output current of the proposed converter:

Output voltage of the closed loop IBC is 23.92V which is observed to be constant with any changes in the supply voltage.

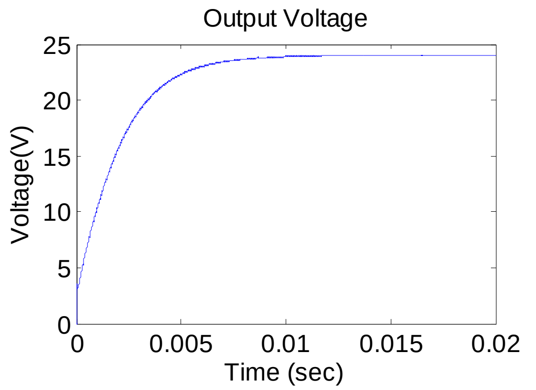

Fig. 10 Output Voltage

In comparison to other IBCs, the output current ripple is very low. Output current of the proposed closed IBC is 10A with minimum ripple of 0.07A for a duty ratio of 0.45.

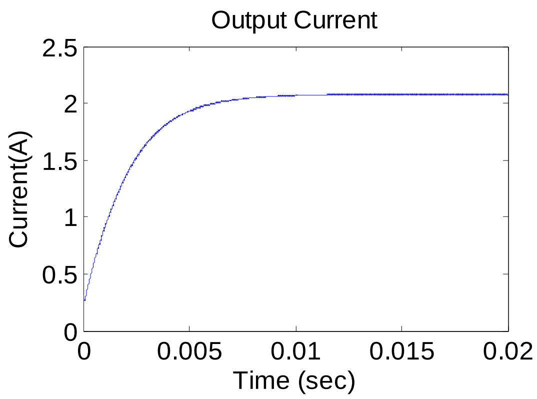

Fig. 11 Current through the Load

Current through the inductor and ripple is observed to be 0.263A for duty ratio of 0.45A.

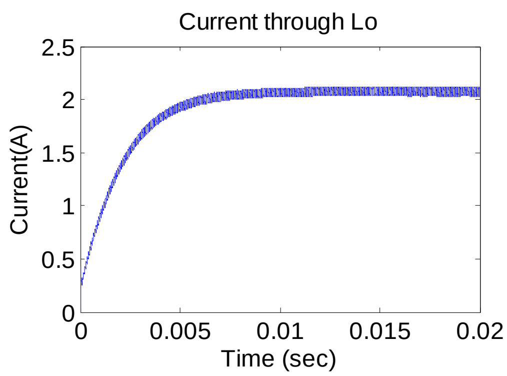

Fig. 12 Current through the inductor L_o

IJIREEICE
ISSN (Online) 2278-1021
ISSN (Print) 2319-5940
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
NCAEE 2017
National Conference on Advances in Electrical Engineering
NMAM Institute of Technology, Nitte
Vol. 5, Special Issue 2, April 2017

In the proposed converter input current is continuous and does not need any additional current-sharing control module. As aresult,current sharing between two interleaved modules becomes balanced.

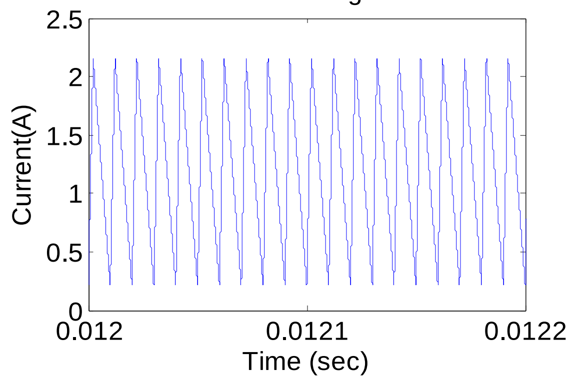

Fig. 13 Current through the inductor L_1

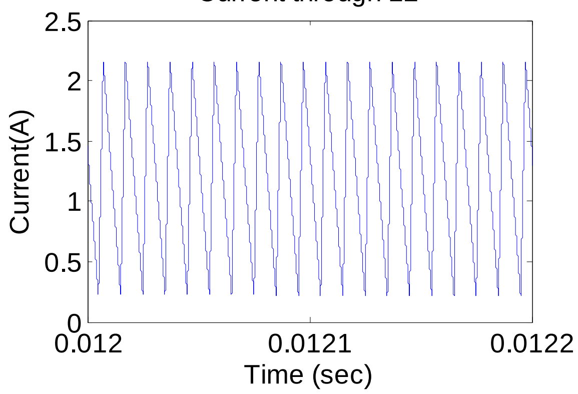

Fig. 14 Current through the inductor L_2

D. Comparison of results of all the parameters

TABLE.2. Comparison of results

Parameters	Conventional IBC	Proposed IBC
Output Voltage	42.8V	23.25V
Output Voltage Ripple	0.9V	0.2V
Output Current Ripple	0.36A	0.07A

IV. CONCLUSION

The proposed converter provides current sharing between two interleaved modules without using an additional current-sharing control module.The proposed converter has the advantages of continuous input current, extremely low output current ripple, low switching losses, and improved step-down conversion ratio, which makes it a proper candidate for high power, low output current ripple, high input voltage, and non-isolated step-down converters. Also, all of these benefits are obtained without any additional stress on the components. The closed loop control of the paper is carried out using MATLAB and results are obtained. The closed loop control is done using a PI controller.

ACKNOWLEDGMENT

I express my sincere gratitude to **Mr. Ravikiran Rao,** Assistant Professor, Dept. of E&E, for his cooperation and guidance.I extend my sincere thanks to our esteemed institution NMAM Institute of Technology, Nitte for supporting me in all the ways possible.

REFERENCES

[1] X. Du, L. Zhou, and H.-M. Tai, “Double-frequency buck converter,” IEEE Trans. Ind. Electron., vol. 56, no. 5, pp. 1690–1698, May 2009.
[2] D.Wang, X. He, and J. Shi, “Design and analysis of an interleaved flyback forward boost converter with the current autobalance characteristic,”IEEE Trans. Power Electron., vol. 25, no. 2, pp. 489–498, Feb. 2010.
[3] P.-W. Lee, Y.-S. Lee, D. K.-W.Cheng, and X.-C. Liu, “Steady-state analysis of an interleaved boost converter with coupled inductors,” IEEE Trans.Ind.Electron., vol. 47, no. 4, pp. 787–795, Aug. 2000.
[4] J. Garcia, A. J. Calleja, E. López rominas, D. Gacio Vaquero, and L. Campa, “Interleaved buck converter for fast PWM dimming of high brightness LEDs,” IEEE Trans. Power Electron., vol. 26, no. 9, pp. 2627–2636, Sep. 2011.
[5] MortezaEsteki, BehzadPoorali, EhsanAdib, and HoseinFarzaneh-fard, Interleaved Buck Converter With Continuous Input Current, ExtremelyLow Output Current Ripple, Low Switching Losses, and Improved Step-Down Conversion Ratio,"IEEE Transactions On Indusrial Electronics, VOL. 62, NO.8, August 2015
[6] NavamiMohan and Dr.N.Prabhakaran,\Closed Loop Control of an Interleaved Buck Converter with High Step-Down Conversion Ratio and Low Switch Voltage Stress,"International Journal Of Innovative Research In Elecrtical,Electronics,Instrumentation And ControlEngineerig Vol. 3, Issue 9, September 2015
[7] Nithya K and PriyaG.Das,\Interleaved Buck Converter with Closed Loop Control and Higher Step-Down Conversion Ratio,"Transactions on Engineering and Sciences,Vol.3, Issue 4, April-June 2015