Synchronous Converter Based Single-Inductor Multi-Output Buck Converter

[1] T. Suresh Kumar, [2]T. Murugan, [3]Chiranjeevi.Y,

[1,2,3] Dept of EEE, Sathyabama University, Chennai-119

vasumurugan2012@gmail.com, t.sureshkhumar@gmail.com, chiran1983@gmail.com

Abstract

To implement the Single-Inductor multi-Output Buck Converter which can operate within continuos conduction mode (CCM).The multiple outputs are obtained by using single DC supply with single inductor. The soft switching technique (ZVS) is incorporated in our project converter to reduces the switching losses and synchronous operation is obtained by using a switch instead of a diode so that the diode drop is eliminated.The different power outputs obtained by this converter are controlled individually by using different controllers and are applicable for various power application.

Keywords:- Buck converter, Single Inductor Multi output (SIMO), DC-DC converter.

I. INTRODUCTION

The fast market growth of battery-operated portable applications such as digital cameras, personal digital assistants, cellular phones, MP3 players, medical diagnosis systems, etc. demands for more and more efficient power management systems. In this area, DC-DC converters play a critical role in keeping long battery life while still providing stable supply voltage together with the required driving capability [1]. In these devices, an inductor stores magnetic energy and transfers part of it to a load while another part is converted into electrostatic energy stored in a capacitor. The result is high power efficiency, low cost, and small size [2], [3]. Often, in portable applications, the reduction of power is obtained by using multiple supply voltages for different functional blocks [4]. A dynamic regulation of the supply following the performance requests optimizes the use of power. However, since having in the system one inductor per DC-DC converters is expensive and not practical, the strategy is viable only if two or more converters share the same inductor as proposed in recent implementations (single inductor multiple output boost converter [5] and boost or buck converters with double output [6], [7]). Since the regulation of each output requires its loop control, a multiple-output system must foresee a multi feedback loop with the request of suitable processing of signals. Moreover, it is necessary to use extra power switches that must be properly driven.

This paper studies the above mentioned design problems and applies the identified solutions to a study case: a three output single inductor buck converter able to independently regulate the output voltages in the range 0 V – 7.6 V below the power supply voltage and able of an overall driving capability of 2.5 A. The switching frequency is 8.3 MHz and the external inductor is 100 μH.

II. BLOCK DIAGRAM

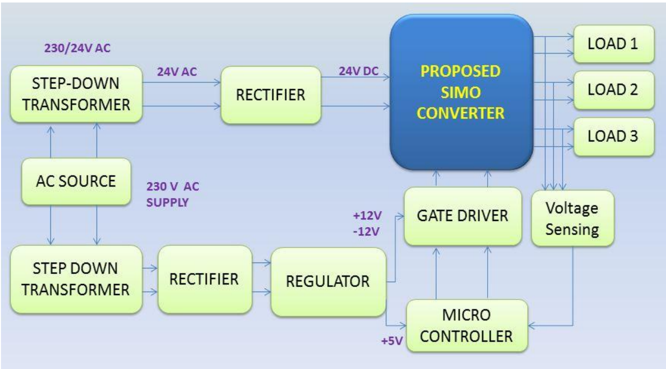

Fig: 1: Schematic block diagram of SIMO converter.

The proposed system contains a single inductor multi output converter. This converter includes Zero Voltage Switching (zvs) technique so that switching losses are avoided. it operates as a synchronous converter. The obtained multiple outputs are controlled individually with different controllers.

III. SIMO ARCHITECTURE

A dc-dc converter with multiple outputs time-shares the inductor current among different loads. Fig. 1 shows a buck converter with n-outputs. While a normal buck has just a PWM control for the high-side and low-side switches the n-output buck uses n additional power switches for the timesharing of the inductor current.

A. BUCK MODE OF OPERATION

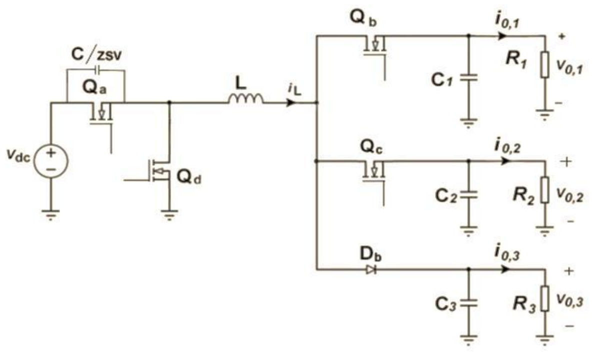

Fig.2 Buck converter

Fig.2 shows the propose converter in buck operation i.e., step-down mode. The PWM technique is used to control the switches Q_a and Q_b simultaneously by varying the duty cycle.

During this mode of operation, Switch Q_b , Q_c and diode Q_b is turned ON, while that of the switch Q_c and diode D_b is turned off. Here the energy of high voltage V_H is transferred to inductor and capacitor and then to the load. Thus the buck operation takes place in reverse direction of rotation of the motor.

IV. SIMULATION RESULTS

The fig.3 shows the Single Inductor multi output DC-DC converter connected with the input, output sense and an inductor connected in series with a DC-DC converter gate driver acting as buck converter.

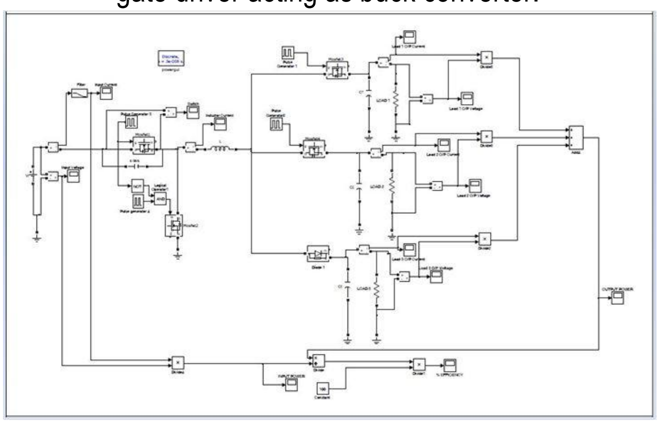

Fig.3. simulation diagram of Single Inductor Multi Output DC-DC buck converter.

Where two MOSFETs are triggered by PWM pulses generated by a PWM circuit. The scope is obtained for the input voltage along the DC source. On the other hand there is feedback controller which gives the input to the controller.

The voltage sense is connected across the terminal of the each output namely Load1, Load2 and Load 3.

The output from voltage sense is feed as the input to the controller present left side of it and it serves as the feedback to the PWM generator to produce pulse to drive the circuit according to loads.

The Synchronous switching of two switches namely Q_a and Q_b serves the main source to control the inductor charging. And hence continuous conduction mode of operation is possible by the reliable and fast switching of these two synchronously connected switches and driver circuit.

The Single Inductor Multi Output DC-DC buck converter fed DC drive is simulated using Mat lab and the results are presented. The input voltage is shown in Fig. 4. The result shows that continuous conduction mode of operation.

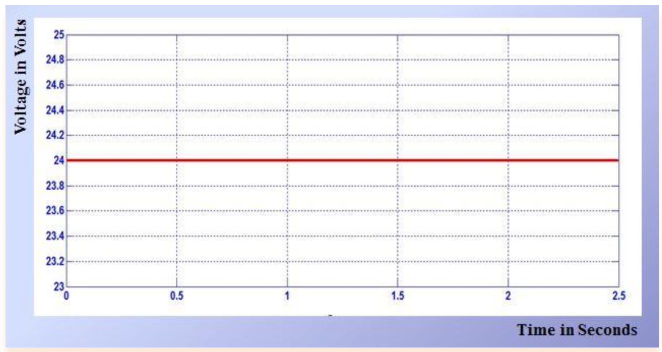

Fig.4 Input voltage

The output voltage waveform is shown in Fig.5. From the results it is clear that voltages starts gradually decreasing from given input voltage and then attains the steady state output up to the continuous conduction mode of operation. the voltage starts decreases and attains stabilized voltage after drive circuit able to control the output according to load.

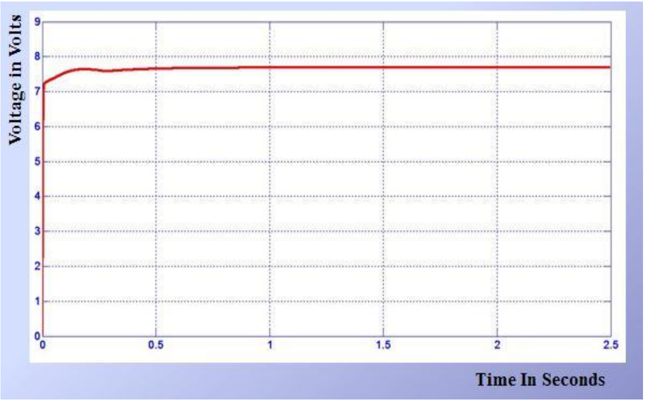

Fig.5 Output voltage respect to load 1

The output voltage waveform is shown in Fig.6. From the results it is clear that voltages starts gradually decreasing from given input voltage and then attains the steady state output up to the continuous conduction mode of operation and the voltage starts decreases and attains stabilized voltage after drive circuit able to control the output according to load..

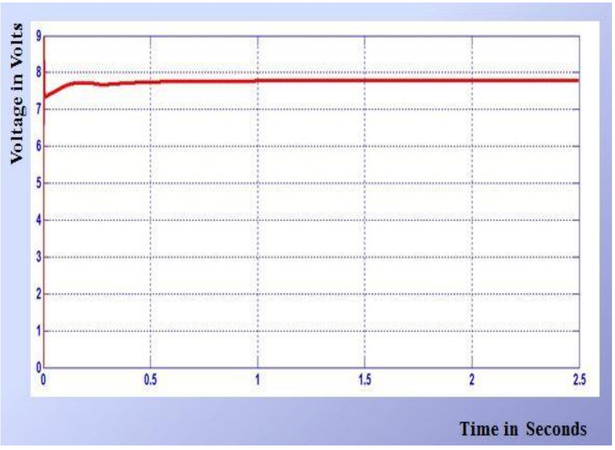

Fig.6 Output voltage with respect to load 2

The output voltage waveform is shown in Fig.7. From the results it is clear that the output of the load 3 is slightly higher than the previous output due the diode switching and it shows the soft switching of MOSFET and the output curves shows the gradually decrease in voltage.

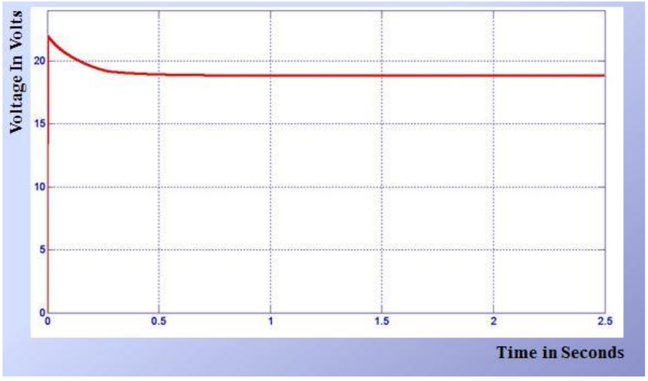

Fig.7 Output voltage with respect to load 3

The output wave form shows the overall efficiency of the Single Inductor Multi Output DC-DC buck converter.

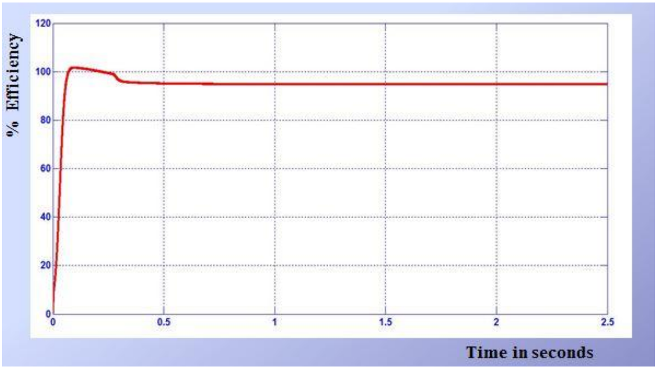

Fig.8 Overall Efficiency

V. HARDWARE DESCRIPTION

The hardware system of the proposed converter is implemented using a PIC micro-controller. The power supply circuit is designed that will control the PIC and driver circuit to drive the pulses to the MOSFET.

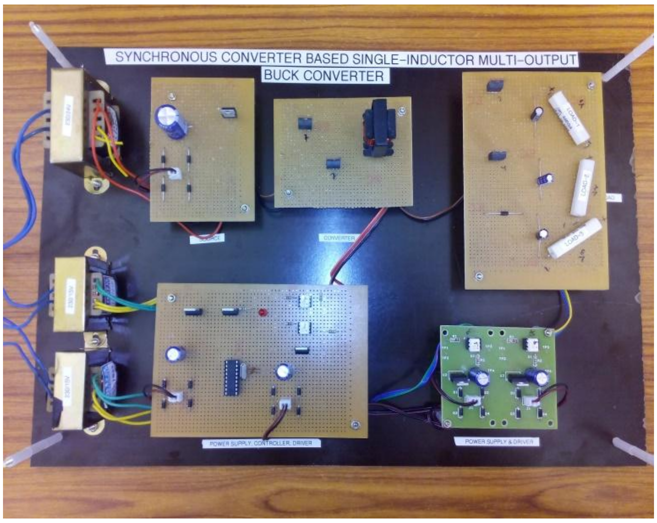

Fig: 9: Hardware kit.

VI. CONCLUSION

In this paper, the Design methodologies for Single Inductor Multi Output DC-DC Buck converter have been presented. The new control method suitable for any number of outputs is more robust than 2-Ouput counter parts. The approach has been verified for 3 Outputs with behavioral simulations and transistor level verifications. With proposed control gate driver technology. It is possible to achieve a 2.5 Amps driving capability with a peak of efficiency 95%.

VII. REFERENCE

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