SINGLE INPUT THREE OUTPUT DC-DC BUCK CONVERTER

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Abstract:- **Design methodologies for Single-Inductor three-Output (SITO) DC-DC switching converters are presented. the single inductor sharing between three outputs with low output voltages errors and limited load-regulation. The design methods to achieve SITO converters with a wide input supply voltage range and with an overall driving capability as large as have been verified with simulations at the transistor level. This project deal with dc-dc buck conversion for dual applications and control is pwm based controller we are using to get desired output voltage by using single source and its suitable for large input source and we need to maintain constant at mode of operation and reduced active and passive elements**

Keywords— **DC-DC converter, Pulse with modulation(PWM).**

I.INTRODUCTION

The fast market growth of multiple-voltage battery operated portable applications such as digital cameras, PDAs, cellular phones, MP3 players, etc. demands for more and more efficient power management systems. In this area, DC-DC switching converters play a critical role in keeping long battery life while still providing stable supply voltage together with the required driving capability. Typical features of these devices are high power efficiency, low cost, and small size. Often, in portable applications, the power reduction is obtained by using multiple supply voltages for different functional blocks. However, since in a system the use of one inductor per DC-DC switching converter is expensive (in terms of area and cost) and not practical, the strategy is viable only if two or more converters share the same inductor as proposed in recent implementations.

Single input buck converter with triple output. Since the regulation of each output requires its control loop, a multiple-output system must foresee a multi feedback loop with the request of suitable signals processing. Moreover, it is necessary to use extra power switches that must be properly driven. This paper studies the above mentioned design issues

For Single Inductor three Output (SITO) switching Converter topologies and applies the identified solutions to a study case. a three output single inductor buck converter able to independently regulate the three output voltages. This converter has been fully implemented at the transistor level and simulated by using a conventional 0.5-μm CMOS process Simulation results demonstrate the effectiveness of the proposed method. High-efficiency and high-power density step-down dc-dc converters have been demanded for applications like voltage regulator (VR) in communication power systems.

Sometimes, in the standard buck converter, the freewheeling diode is replaced by an active power switch, which is designed to operate at low output voltage and high efficiency typically required for battery-operated systems, this converter is called as synchronous dc-dc buck converterwhile A detailed comparison between synchronous buck converter and fly back topology is presented in different figures of merit were presented in this study, such as number of elements used, switches stresses, efficiency, stability, transient response and magnetic components. Despite the advantages of the synchronous buck converter uses fewer components and presents higher efficiency.

Synchronous buck converter is the most popular topology for today's VRs, and the use of the MOSFET instead of the diode results in tremendous conduction loss reduction. In many applications is required a dc-dc buck converter with three controlled outputs, such as in systems with onboard distribution schemes where different dc bus voltages have been required. In this type of system, synchronous buck converters output voltages. Besides using only one inductor, the solution presented in employs four power switches. The direct solution for a dc-dc buck converter with three outputs is depicted in which three standard buck converters are employed to control independently three output voltages.
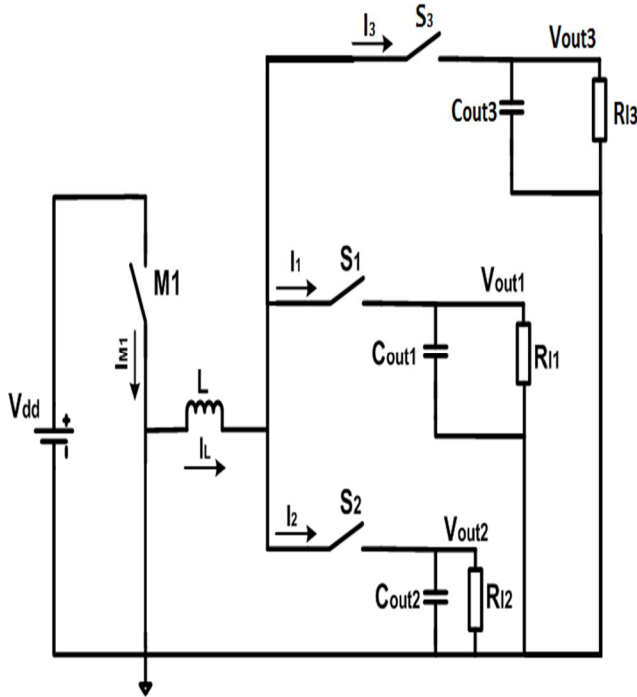
Fig.1 Circuit Diagram

A DC-DC switching regulator with multiple outputs time-shares the inductor current among the different loads. Fig. 1 shows a buck converter with three outputs (SITO buck). While a conventional SISO buck uses just a PWM control for the switches on the supply side, namely M1. the SITO configuration foresees two additional power switches, referred to as S1 and S2, and S3,for the inductor current time-sharing:

$$D = T_{on,M1} \, T \quad (1)$$
$$D_1 = T_{on,S1} \, T \quad (2)$$

Fig. 2 shows an example of the load switched currents, I_1 and I_2, in the cases in which $T_{on,M1} < T_{on,S1}$ (Fig. 3(a)) and $T_{on,M1} > T_{on,S1}$ (Fig. 3(b)) in the Continuous Conduction Mode (CCM), being $T_{on,sw}$ the on-time of the switch SW. The inductor current I_L is the sum of the two output currents I_1 and I_2. A main duty cycle D and a sharing duty cycle D_1 can be defined, respectively, as above.

As shown in Fig. 2, even if the buck converter operates in the CCM from the inductor point of view, currents I_1 and I_2, delivered to the output capacitors C_{out1} and C_{out2}, respectively, are discontinuous.

Indeed, during the discontinuous periods, the two output capacitors provide the current to the loads. DC to DC converters are now available as integrated circuits needing minimal extra components to build a complete converter. DC to DC converters are also available as complete hybrid circuits, ready for use within an electronic device.). Additionally, the battery voltage declines as its stored power is drained. DC to DC converters offer a method of generating multiple controlled voltages from a single variable battery voltage, thereby saving space instead of using multiple batteries to supply different parts of the device.
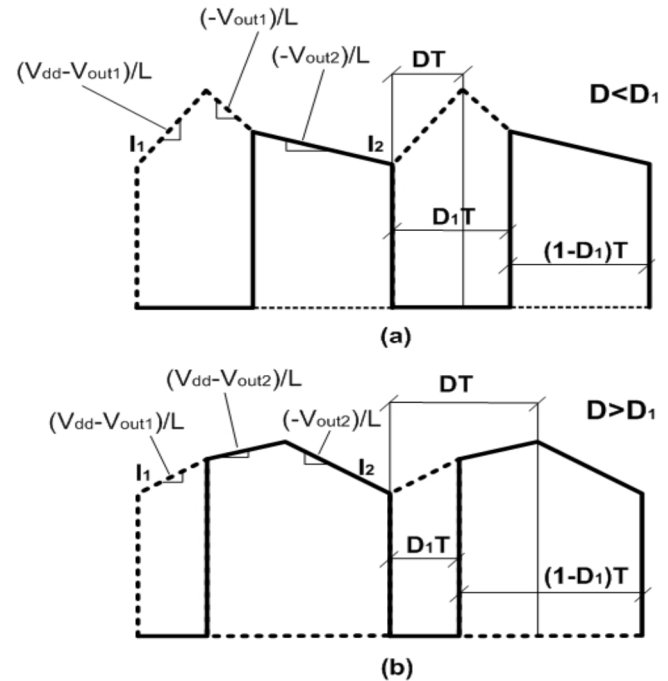

Fig. 2 Wave Form

In the system, three control loops are, hence, foreseen. The errors of the three outputs, $\varepsilon i = Vset,i – Vout,i$ (i = 1, 2), are the control loops inputs. Assuming a PWM control, the regulator provides three control signals. One is used to obtain the buck converter switching, while the other to divide the clock period into two slots. The control strategy for a SITO buck in the DCM is straightforward,
while, for a SITO buck in the CCM, it has been already discussed together with the compensation scheme in [9]. Its extension to the case of a SIMO buck is approached in [5].

PULSE WIDTH MODULATION

Output voltage from an inverter can also be adjusted by exercising a control within the inverter itself. The most efficient method of doing this is by pulse-width modulation control used within an inverter.

When a PWM signal is applied to the gate of a power transistor, it causes the turn on and turns off intervals of the

transistor to change from one PWM period to another PWM period according to the same modulating signal The frequency of a PWM signal must be much higher than that of the modulating signal, the fundamental frequency, such that the energy delivered to the motor and its load depends mostly on the modulating signal.In this method, a fixed dc input voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components. This is the most popular method of controlling the output voltage and this method is termed as Pulse-Width Modulation (PWM) Control.

The advantages possessed by PWM techniques are as under:
(i) The output voltage control with this method can be obtained without any additional components.

(ii) With the method, lower order harmonics can be eliminated or minimized along with its output voltage control. As higher order harmonics can be filtered easily, the filtering requirements are minimized.

The main disadvantage of this method is that SCRs are expensive as they must possess low turn-on and turn-off times. PWM inverters are quite popular in industrial applications. PWM techniques are characterized by constant amplitude pulses. The width of these pulses is however modulated to obtain inverter output voltage control and to reduce its harmonic content. The different PWM techniques are as under:

(a) Single-pulse modulation

(b) Multiple pulse modulations

(c) Sinusoidal pulse width modulation (Carrier based Pulse Width Modulation Technique)

SINUSOIDAL PULSE WIDTH MODULATION

The switches in the voltage source inverter can be turned on and off as required. In the simplest approach, the top switch is turned on If turned on and off only once in each cycle, a square wave waveform results. However, if turned on several times in a cycle an improved harmonic profile may be achieved. In the most straightforward implementation, generation of the desired output voltage is achieved by comparing the desired reference waveform (modulating signal) with a high-frequency triangular 'carrier' wave as depicted schematically in Fig.3 Depending on whether the signal voltage is larger or smaller than the carrier waveform, either the positive or negative dc bus voltage is applied at the output. Note that over the period of one triangle wave, the average voltage applied to the load is proportional to the amplitude of the signal (assumed constant) during this period.

Notice that the root mean square value of the ac voltage waveform is still equal to the dc bus voltage, and hence the total harmonic distortion is not affected by the PWM process. The harmonic components are merely shifted into the higher frequency range and are automatically filtered due to inductances in the ac system. When the modulating signal is a sinusoid of amplitude Am, and the amplitude of the triangular carrier is Ac, the ratio m=Am/Ac is known as the modulation index. Note that controlling the modulation index therefore controls the amplitude of the applied output voltage. With a sufficiently high carrier frequency,the high frequency components do not propagate significantly in the ac network (or load). However, a higher carrier frequency does result in a larger number of switching's per cycle and hence in an increased power loss. Typically switching Frequencies in the 2-15 kHz range are considered adequate for power systems applications. Also in three-phase systems it is advisable to use so that all three waveforms are Symmetric
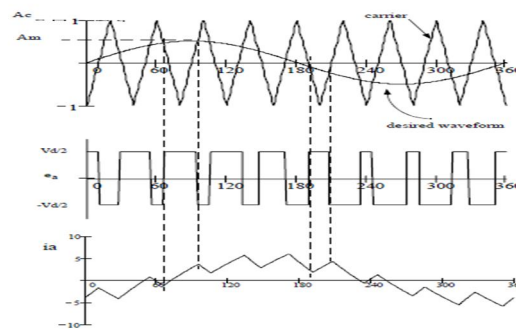

Fig.3 waveforms of SPWM

CIRCUIT OPERATIONS

Modes of operation
The load switched currents, I1 I2 and I3, in the cases in which Ton, M1<Ton, S1 discontinuous conduction mode and Ton, M1>Ton, S1 in the Continuous Conduction Mode (CCM), being Ton, SW the on-time of the switch SW. The inductor current IL is the sum of the two output currents I1, I2 and I3.
A main duty cycle D and a sharing duty cycle D1 can be defined, respectively, as follows

D = Ton, M1 T

D1 = Ton, S1 T

D2 = Ton, S2 T

D3 = Ton, S3 T

Even if the buck converter operates in the CCM from the inductor point of view, currents I1, I2 and I3, delivered to the output capacitors Cout1, Cout2 and Cout3, respectively, are discontinuous. Indeed, during the discontinuous periods, the three output capacitors provide the current to the loads. In the system, three control loops are, hence, foreseen. The errors of the three outputs, $\varepsilon i = Vset,i - Vout,i$ (i = 1, 2,3), are the control loops inputs. Assuming a PWM control, the regulator provides two control signals

One is used to obtain the buck converter switching, while the other to divide the clock period into three slots. The control strategy for a SITO buck in the DCM is straightforward, while, for a SITO buck in the CCM, it has been already discussed together with the compensation scheme in. Its extension to the case of a SIMO buck is approached.

IV.SIMULATION RESULTS

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non interactive language such as C or FORTRAN.

Sim PowerSystems and other products of the Physical Modeling product family work together with Simulink® to model electrical, mechanical, and control systems. Sim Power Systems operates in the Simulink environment. Therefore, before starting this user's guide, you should be familiar with Simulink. For help with Simulink, see the Simulink documentation Or, if you apply Simulink to signal processing and communications tasks (as opposed to control system design tasks), see the Signal Processing Block set documentation

Simulink uses MATLAB as its computational engine, designers can also use MATLAB toolboxes and Simulink block sets. Sim Power Systems and Sim Mechanics share a special Physical Modeling block and connection line interface.
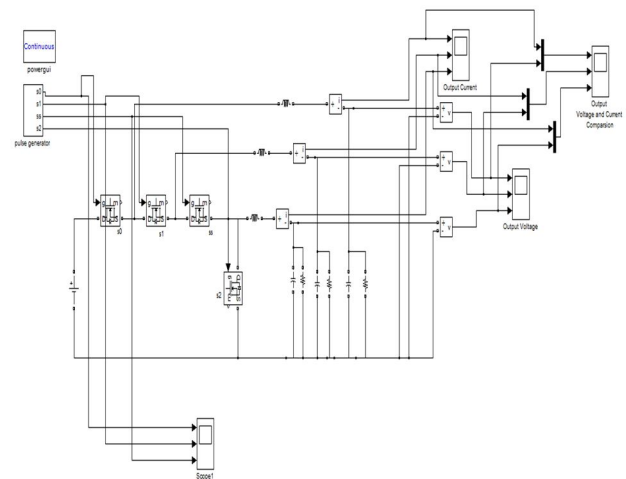
A. DC-DC BUCK CONVERTER CIRCUIT DIAGRAM
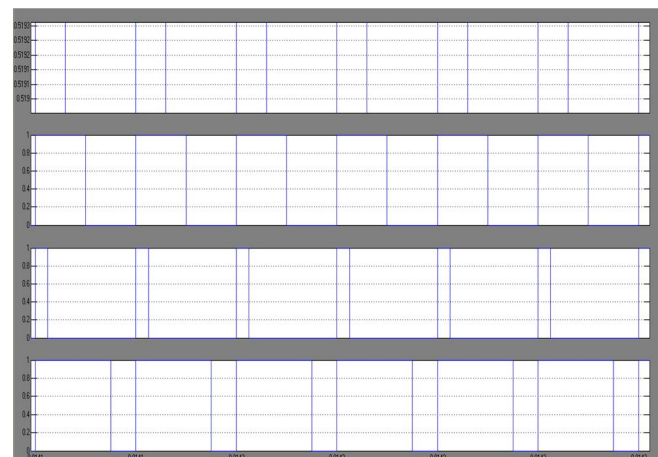

Fig.4 Simulation Diagram of DC-DC converter
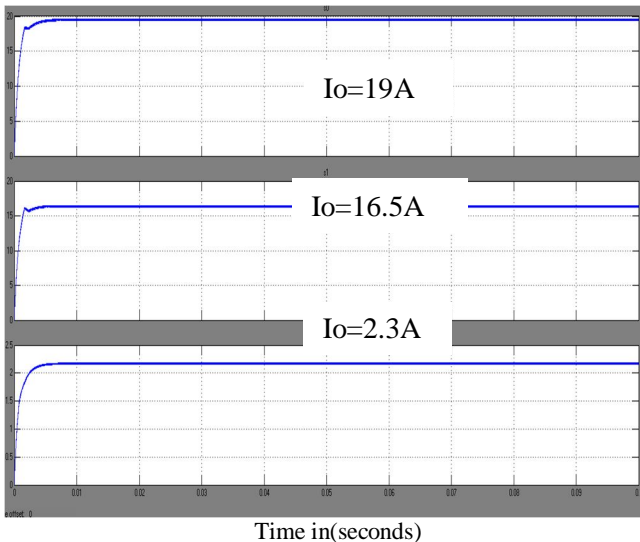

Fig.5 Pulse wave form

OUTPUT CURRENT WAVEFORM

Io=19A

Io=16.5A

Io=2.3A
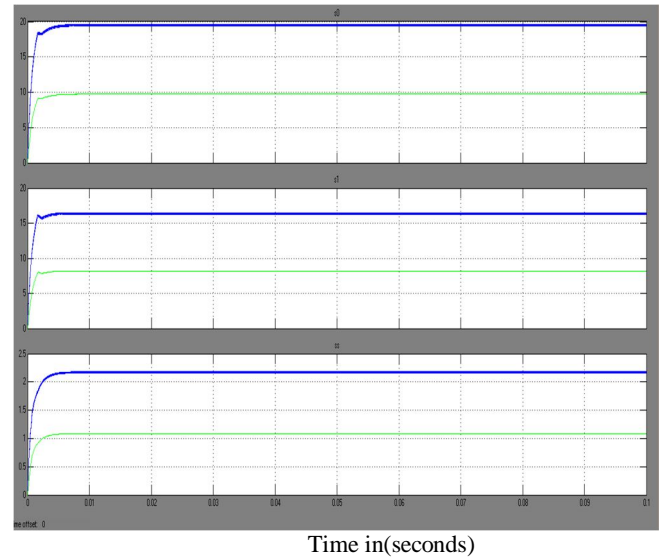
Time in(seconds)
Fig.6 Output current waveform

OUTPUT VOLTAGE WAVEFORM

Vo=9v

Vo=8v

Vo=1.1v
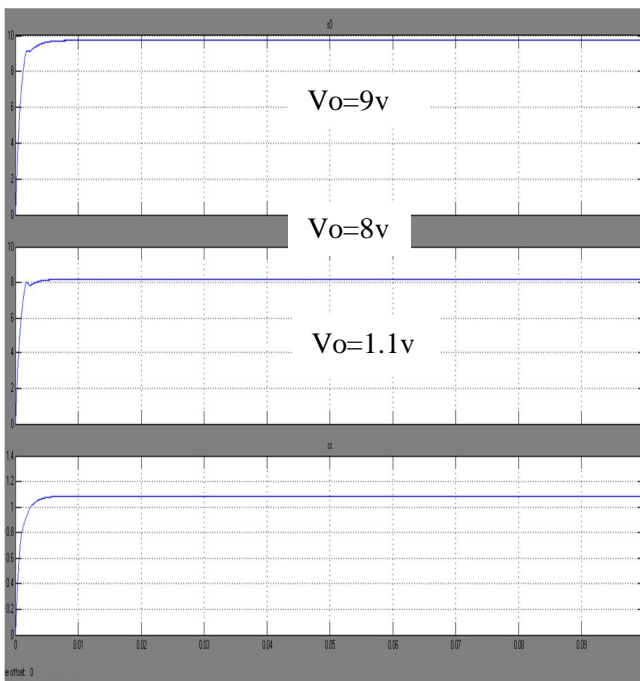
sFig.7 Output voltage waveform

COMBINED WAVEFORM OF OUTPUT VOLTAGE AND CURRENT WAVEFORM

Time in(seconds)
Fig.8 Combined waveform of output voltage and current waveform

CONCLUSION

In this project, the design methodologies for single inductor three-output DC-DC converters have been presented. Suitable controls of three feedback loops are discussed. Three-output single-inductor buck converter able to independently regulate three output voltages This converter has been fully simulated at the transistor level by using a conventional Simulation results demonstrate the effectiveness of the proposed method, showing excellent performances in terms of output voltages errors (less than 2% for Three outputs) and load-regulation

REFERENCES

[1] B. Arbetter, R. Erickson, and D. Maksimovic, "DC-DC converter design for battery- operated systems", IEEE Power Electronics Specialist Conference, vol. 1, pp. 103 – 109, June 1995.

[2] D. Ma, W.-H. Ki, and C.-Y. Tsui, "A pseudo-CCM/DCM SIMO switching converter with freewheel switching", IEEE International Solid-State Circuits Conf. (ISSCC) Dig. Tech. Papers, pp. 390 – 476, Feb. 2002.

[3] D.Ma, W.H. Ki, P.K.T. Mok, and C.-Y. Tsui, "Single-inductor multipleoutput switching converters with bipolar outputs", Proc. of International Symposium on

Circuit and Systems (ISCAS), vol. 3, pp. 301–304, May 2010

[4] E. Bonizzoni, F. Borghetti, P. Malcovati, F. Maloberti, and B. Niessen, "A 200mA 93% Peak Efficiency Single-Inductor Dual-Output DC-DC Buck Converter", IEEE International Solid-State Circuits Conf. (ISSCC) Dig. Tech. Papers, pp. 526 – 619, Feb.2010.

[5] J.M. Chang and M. Pedram "Energy minimization using multiple supply voltages", IEEE Trans. on Very Large Scale Integration (VLSI) Systems, pp. 436 – 443, Dec. 2011.

[6] M. Belloni, E. Bonizzoni, E. Kiseliovas, P. Malcovati, F. Maloberti, T. Peltola, and T. Teppo, "A 1.2A Output Current Single-Inductor 4-Outputs DC-DC Buck Converter with Self-Boosted Switch Drivers", IEEE International Solid-State Circuits Conf. (ISSCC) Dig. Tech. Papers, pp. 444–626, Feb. 2008.

[7] M. Belloni, E. Bonizzoni, and F. Maloberti, "On the Design of Single-Inductor Multiple-Output DC-DC Buck Converters", Proc. of 2008 International Symposium on Circuit and Systems (ISCAS), pp. 3049-3052, May 2008.

[8] N. Mohan, T.M. Undeland, and W.P. Robbins, "Power Electronics -Converters, Applications, and Design – Second Edition", John Wiley & Sons, INC., Ch. 7.2012,