

A LOW VOLTAGE DYNAMIC SYNCHRONOUS DC-DC BUCK-BOOST CONVERTER FOUR SWITCHES

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ABSTRACT

This paper presents the design and modeling of synchronous DC-DC buck-boost converter four switches controlled with PID controller for mobiles devices applications. The design of the converter circuit needs modeling and simulating its mathematical equations using MATLAB/SIMULINK. The evaluation of the output performance has been based on dynamic respond in term of rise time, settling time and peak time. Also the goal of the designer is regulated the output voltage to 3.24 regardless the variation of the input voltage, with input voltage [2.5V-5V] and switching frequency is 50 MHz. The converter is operated in Buck (step-down) and Boost (step-up) modes.

KEYWORDS: PID Controller, Switch, System Modeling, DC-DC, Buck-Boost Converter, Matlab/ Simulink.

I. INTRODUCTION

Current trends in consumer electronics demand progressively lower supply voltages due to the unprecedented growth and use of wireless appliances. Portable devices, such as laptop computers and personal communication devices require ultra-low-power circuitry to enable longer battery operation. The key to reducing power consumption while maintaining computational throughput and quality of service is to use such systems at the lowest possible supply voltage. The terminal voltage of the battery used in portable applications (e.g. Ni-MH, Ni-Cd and Li-ion) varies considerably depending on the state of their charging condition. For example, a single NiMH battery cell is fully charged to 1.8 V but it drops to 0.9 V before fully discharged [1]. Therefore, systems designed for a nominal supply voltage (say, 1.5 V with a single NiMH battery cell) require a converter capable of both stepping-up and stepping-down the battery voltage. While both buck (step-down) [2,3] and boost (step-up) [4] converters are widely used in power management circuits. The DC-DC Converter must provide a regulated DC output voltage even when varying load or the input voltage varies.

Therefore, the topologies for generating a voltage higher and lower than the supply is : non inverting buck-boost converter [5-7] which is essentially achieved by cascading a buck with a boost converter Figure 1, The trend in portable applications is to use the topologies that incorporate less number of external components and move closer to cost effective SOC designs [8].

Controller design for any system needs knowledge about system behavior. Usually this involves a mathematical description of the relation among inputs to the process, state variables and output. This description in the form of mathematical equations which describe behavior of the system (process) is called model of the system [9,10]. This paper describes an efficient method to learn, analyze and simulation of DC-DC Buck-Boost converter four switches, with PID, The MATLAB/SIMULINK software package can be advantageously used to simulate power converters.

The paper is organized as follows. The section 2 presents the discussion of the dynamic synchronous Buck-Boost converter, and the analysis and modeling of the mathematical equations using MATLAB/SIMULINK, In Section 3, results of the converter and discussions are offered. Finally, the paper is concluded in Section 4.

The Eq.(1) and Eq.(2) are implemented in Simulink as shown in Figure 2 to obtain the states, $i_L(t)$ and $V_{out}(t)$ [10-14].

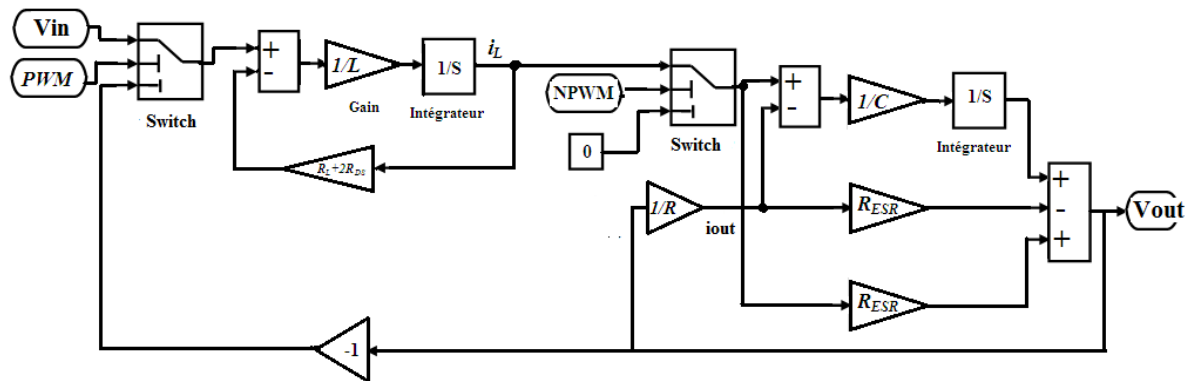


Figure 2. Open-loop of Buck-Boost Converter model

2.2. Close-Loop Synchronous Buck-boost converter Model

The Figure 3 is presented the model by SIMULINK/MATLAB of Buck-Boost converter with PID controller, it uses the compensator of PID, and the model aims to regulate the output voltage in 3.24 V with variation of input voltage and load.

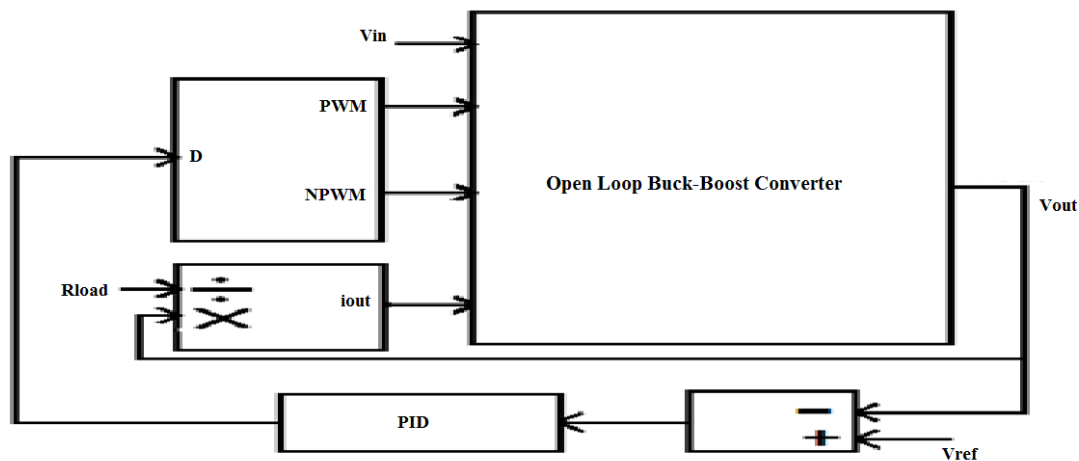


Figure 3. Close- Loop Buck-Boost Converter Model with PID Controller

III. RESULTS AND DISCUSSION

In this section, we simulate the model of Buck-Boost converter closed loop with PID controller. The table 1 shows the parameters of simulations on Boost mode and Buck mode.

Tables 1 Buck-Boost Converter Parameter on Buck and Boost Mode

	Boost mode	Buck mode
Vin	2.5 V	5 V
Vout	3.24 V	3.24 V
Inductance	0.28 μ H	0.28 μ H
Capacitance	0.25 μ F	0.25 μ F
Resistance (L+2RDS)	0.5 Ω	0.5 Ω
Rload	4 Ω	4 Ω
Resr	0.1 m Ω	0.1 m Ω
Duty Cycle	D>0.5	D<0.5

3.1. Boost (step-up) mode

The Figure 4 shows output voltage waveforms of mode Boost model using Matlab/Simulink, the input voltage is 2.5 V and nominal switching frequency is 50 MHz.

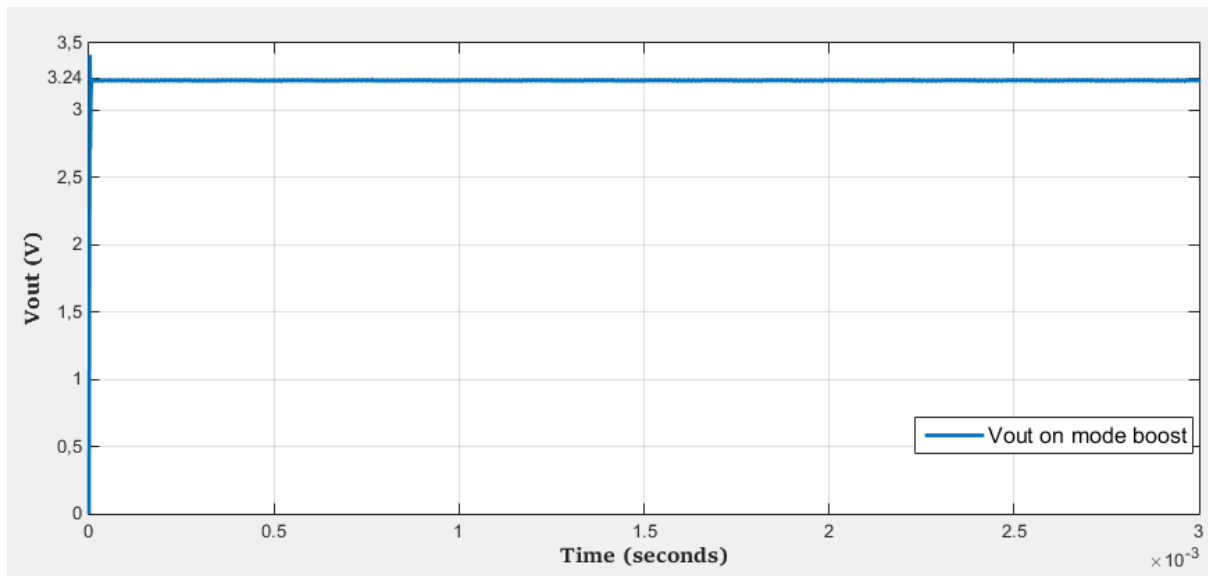


Figure 4. Output voltage of Buck-Boost converter on Boost mode

The simulations results show that the output voltage is regulated around of 3.24 V on mode boost independent of input voltage and load variation.

3.2. Buck (step down) mode

The Figure 5 shows output voltage waveforms of mode Buck model using Matlab/Simulink, the input voltage is 5 V and nominal switching frequency is 50 Mhz.

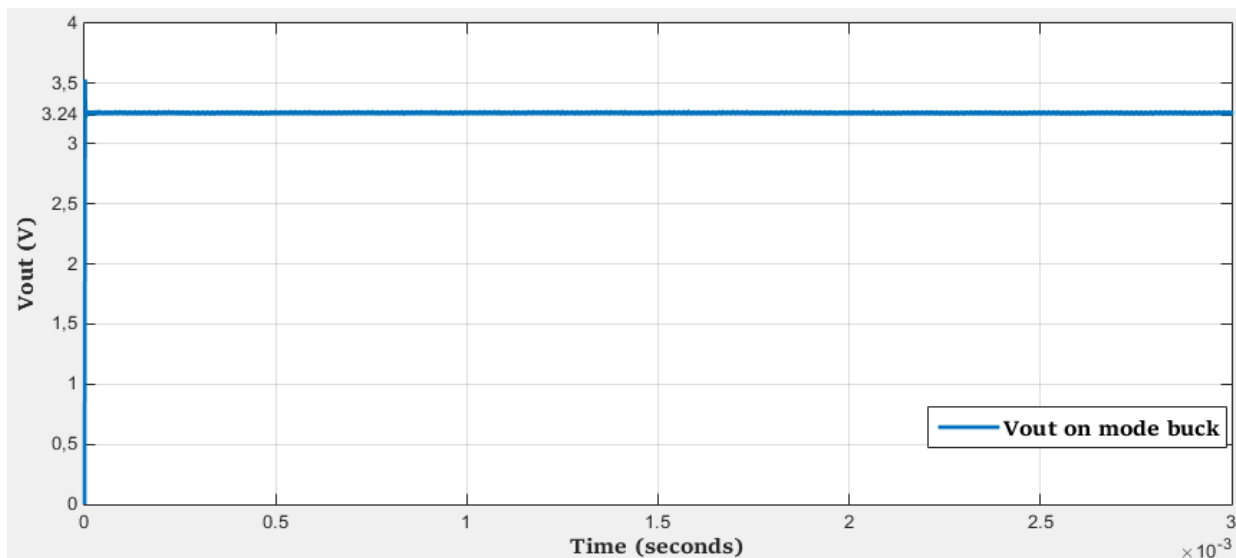


Figure 5. Output voltage of Buck-Boost converter on Buck mode

The simulations results show that the output voltage is regulated around of 3.24 V on mode Buck independent of input voltage and load variation.

IV. CONCLUSIONS

In this paper, we designed and modeled a Buck-Boost converter miniaturized for mobiles devices applications. We modeled the switching equations of the converter using Matlab/Simulink. The converter is compensated using the PID controller. The simulations results show that the output voltage is regulated around of 3.24 V on two mode Boost and Buck independent of input voltage and load variation.

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