State Feedback Control of Boost Converter Using S1-ΣΔ PWM Method

M. Davari[*1], *Graduate Student Member, IEEE* , and B. Abdi[**2], *Graduate Student Member, IEEE* , and H. Nafisi[**3], and G. B. Gharehpetian[**4], *Senior Member, IEEE* , and H.R. Karshenas[*5]

[*] Department of Electrical and Computer Engineering, Isfahan University of Technology, Daneshgah Sanati Avenue, Isfahan, Iran.

[**] Department of Electrical Engineering, Amirkabir University of Technology, Hafez Avenue, Tehran, Iran.

[1] masoud_davari@ieee.org, [2] babakabdi@ieee.org, [3] nafisi@aut.ac.ir, [4] grptian@cic.aut.ac.ir, [5] karshen@cc.iut.ac.ir

***Abstract*—There are many applications which are very sensitive to the noise and should be supplied constant voltage. The Boost converter is one of these applications for supplying mobiles, Digital Signal Processors (DSP) and etc. In this paper, it is shown that the control strategy, which is based on Digital Pulse Width Modulation (DPWM) with second-order 1-bit quantizer sigma-delta (ΣΔ) modulation and the state feedback, results in a better response than the control strategy, which is based on Pulse Width Modulation (PWM) and the state feedback. The comparison is based on the simulation of the boost converter by MATLAB software.**

***Keywords*—Boos Converter; State Feedback Control; S1-ΣΔ PWM**

I. Introduction

The loads with very fast variations need DC-DC power supplies with fast transient response [1]. An acceptable transient response may be obtained by using a linear DC-DC converter. This solution has a low efficiency for high current applications. The conventional switching DC-DC converter will improve the efficiency and decrease the weight and the volume, but results in a much slower transient response than the linear DC-DC converters [2]. To overcome this problem the V^2 or V^2C control strategies have been presented [1-8].

These methods are based on PWM method and have output voltage variations during transients [1-8]. They are not categorized in the variable frequency modulation methods and as a result they do not have significant effect on Electromagnetic Interference (EMI) or noise immunity [9].

The general PWM control strategy for power electronics devices is always realized by comparing the modulating signal with the reference triangular train. The merit of the approach is to reduce harmonics and easy filter design at fixed frequency operation. However, it is difficult to have high stability and low harmonic by the PWM based power electronics devices due to open-loop control strategy.

In order to remedy the mentioned drawback, a closed-loop control Delta Modulation (DM) is then proposed to generate modulation drives for the power electronics devices by using the feedback error signal through a hysteresis comparator. In spite of precisely tracking the reference signal, the DM control always produces almost fixed harmonic distortion with low amplitude in low-order harmonics when operating in wider frequency range. However, the frequency of modulating signal could not be fixed and is subject to the slope of the DM feedback signal (triangular). It will then distort the harmonic spectrum and results in phase shift in the output signal after demodulation. To solve, the mentioned phase-shift problem, the power conversions strategy based on ΣΔM is proposed.

In the new generation of power converters, the digital control plays an important role, considering its accuracy, robustness, flexibility and high noisy immunity. But the drawback of digital controls is their slow transient response. The Sigma-Delta Pulse Width Modulation (ΣΔ-PWM) is a digital modulation method which matches with the digital nature of the digital control strategy [10]. This modulation method is an improved modification of DM and well known in digital communications [10].

The ΣΔ-PWM reduces the output noise of the switching power supply while increasing the dynamic range of the closed-loop system [10]. The reduction of the output noise is due to noise shaping property of ΣΔ-PWM. Based on this property, ΣΔ-PWM has been used in many applications; such as digital controller Integrated Circuit (IC), Power Factor Correction (PFC) and control of EMI from Switch-Mode Power Supplies (SMPS) [11-13].

There are many applications which are very sensitive to the noise, EMI and should be supplied by a constant voltage. In this paper, it is shown that for Boost converter, the control strategy based on DPWM with second-order 1-bit quantizer ΣΔM (S1- ΣΔM) and the state feedback results in a better response than the control strategy based on PWM and the state feedback. The comparison is based on the simulation results and results of [14].

This paper is prepared in the following sections. In section II, the modeling and linearization of general ΣΔM is mentioned. Section III presents the sampled-data model of DC-DC converters, which is suitable for converters based on digital controllers (like S1-ΣΔM) and for Boost converter. Also, in this section, the analysis of DC-DC