Reduction of Conducted Perturbations in DC-DC Voltage Converters by a Dual Randomized PWM Scheme

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Abstract: **Randomized Pulse Width Modulation (RPWM) deals better than Deterministic PWM (DPWM) with Electro-Magnetic Compatibility (EMC) standards for conducted Electro-Magnetic Interferences (EMI). In this paper, we propose a dual RPWM scheme for DC-DC voltage converters: the buck converter and the full bridge converter. This scheme is based on the comparison of deterministic reference signals (one signal for the buck converter and two signals for the full bridge converter) to a single triangular carrier having two randomized parameters. By using directly the randomized parameters of the carrier, a mathematical model of the Power Spectral Density (PSD) of output voltage is developed for each converter. The EMC advantage of the proposed dual randomization scheme compared to the classical simple randomization schemes is clearly highlighted by the PSD analysis and confirmed by FFT (Fast Fourier Transform) analysis of the output voltage.**

Index terms: Electromagnetic compatibility, DC-DC converters, RPWM, power spectral density.

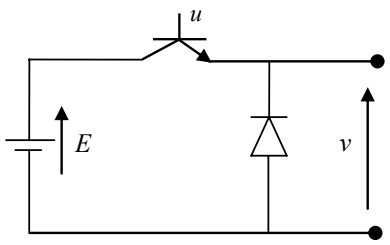
I. INTRODUCTION

Deterministic Pulse Width Modulation (DPWM) generates discrete harmonics with important magnitudes. The recent Electro-Magnetic Compatibility (EMC) standards impose more and more filtering effort in power converters [1]. In order to relax the filtering effort, the switching frequency is generally increased. However, this solution remains limited by the switching losses and the radiated electromagnetic interferences (EMI) generation [1]. One of the recent solutions is to use RPWM technique, which deals better with EMC standards by spreading the voltage spectrum in a large frequency range and reducing its amplitude [2-4]. Several works regarding this new control technique has been published lately, principally two randomization schemes are proposed; Randomized Carrier Frequency Modulation (RCFM) and Randomized Pulse Position Modulation (RPPM), for DC-DC conversion [4, 5] and for DC-AC conversion [2, 3, 5, 6]. Combinations of two randomized parameters have been also applied to the buck converter [1, 7] and to the three phase full bridge inverter [8].

In order to obtain a more spread spectrum with a significant reduction of its amplitude [9], we propose in this paper a combination of two simple RPWM schemes (RCFM and RPPM schemes) that we call RCFM-RPPM or dual RPWM scheme, for DC-DC voltage converters: the buck converter and the full bridge converter. The switching signals are generated by comparing a triangular carrier having two randomized parameters to deterministic reference signals (one reference signal for the buck converter and two reference signals for the full bridge converter). Generally the randomization is introduced directly into the switching signals and this isn't a simple task for converters needing more than one signal such as the full bridge converter [5, 6]. In the proposed scheme, the randomization is applied to the carrier rather than switching signals, which allows limiting the random parameters to those of the carrier only and thus facilitates the randomization [8, 9]. At first, we propose the modulating principle. Then a general analytical model of the voltage PSD is developed for the two converters, this model is expressed directly using the random parameters of the carrier. The particular cases (RCFM and RPPM schemes) can be deduced from the general model. The PSD analysis shows that the proposed dual RPWM scheme allows a better spread shape of PSD compared to the simple randomization schemes that is the desired EMC advantage. Finally, the FFT (Fast Fourier Transform) analysis of the voltage confirms this advantage.

II. MODULATING PRINCIPLE

The structures of the two converters under study are given in Fig. 1; the buck converter requires one switching function u and the full bridge converter requires two switching functions u_a and u_b.



a. Buck converter

Manuscript received November 07, 2007, and revised December 30, 2008.
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