

Article

A Sliding Surface for Controlling a Semi-Bridgeless Boost Converter with Power Factor Correction and Adaptive Hysteresis Band

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Abstract: This paper proposes a new sliding surface for controlling a Semi-Bridgeless Boost Converter (SBBC) which simultaneously performs Power Factor Correction (PFC) and DC bus regulation. The proposed sliding surface is composed of three terms: First, a normalized DC voltage error term controls the DC bus and rejects DC voltage disturbances. In this case, the normalization was performed for increasing system robustness during start-up and large disturbances. Second, an AC current error term implements a PFC scheme and guarantees fast current stabilization during disturbances. Third, an integral of the AC current error term increases stability of the overall system. In addition, an Adaptive Hysteresis Band (AHB) is implemented for keeping the switching frequency constant and reducing the distortion in zero crossings. Previous papers usually include the first and/or the second terms of the proposed sliding surface, and none consider the AHB. To be best of the author's knowledge, the proposed Sliding Mode Control (SMC) is the first control strategy for SBBCs that does not require a cascade PI or a hybrid PI-Sliding Mode Control (PI-SMC) for simultaneously controlling AC voltage and DC current, which gives the best dynamic behavior removing DC overvoltages and responding fast to DC voltage changes or DC load current perturbations. Several simulations were carried out to compare the performance of the proposed surface with a cascade PI control, a hybrid PI-SMC and the proposed SMC. Furthermore, a stability analysis of the proposed surface in start-up and under large perturbations was performed. Experimental results for PI-SMC and SMC implemented in a SBBC prototype are also presented.

Keywords: sliding surface; sliding mode control; semi-bridgeless boost converter; adaptive hysteresis band; power factor correction; non-linear control



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1. Introduction

Many electrical devices such as motors, computers and household appliances use passive rectifiers for supplying energy to DC loads. The rectifying action usually injects lower order harmonics which increase the Total Harmonic Distortion (THD_i) of the current, reduces the Power Factor (PF) and worsens the energy quality of electrical grids [1–3]. Active rectifiers have become an attractive alternative for overcoming these problems [4,5]. They are current-controlled rectifiers used to control the current in the AC side and provide a regulated DC voltage to load, their controllers are usually designed for keeping PF and THD_i within admissible ranges ($PF > 0.9$ and $THD_i < 5\%$) according to IEEE Std. 519 and IEC/EN 61000-3-2 [6,7].

Several active rectifiers with PFC-based on boost converter have been proposed to replace passive rectifiers [8–10]. Among these, SBBC is a promising topology since it stands