Dynamics of Continuous, Discrete and Impulsive Systems
Series **B:** *Applications & Algorithms* **16 (2009)** 107-121
 http://www.watam.org

PREDICTION OF HOPF BIFURCATION IN DC-DC BUCK CONVERTERS

Xiao-Ping Yang, Hao Zhang[1] and Xi-Kui Ma

State Key Lab of Electrical Insulation & Power Equipment,
School of Electrical Engineering, Xi'an Jiaotong University,
Xi'an 710049, China

Abstract. This paper deals with the Hopf bifurcation phenomena in DC-DC Buck converters with proportional-integral (PI) voltage control. An averaged model is derived to describe the nonlinear dynamics of the converters. Based on the averaged model, Hopf bifurcation is identified, and the corresponding bifurcation point is predicted with the help of Routh stability criterion. Moreover, the analytical expressions for the oscillating frequency and the oscillating amplitude at the bifurcation point are given. These results are very helpful in the optimum design of the circuit parameters and the improvement of the system performance. Finally, the theoretical results are verified by the numerical simulations and circuit experiments.

Keywords. Hopf bifurcation, DC-DC switching converter, averaged model, low-frequency oscillations.

1 Introduction

DC-DC switching converters are widely used in various applications such as industrial, commercial, residential and aerospace environments, *etc*, where they allow the conversion of voltage from a given level to a desired value[1]. Due to the nonlinearity of the switch components, DC-DC converters will give rise to a great variety of nonlinear behaviors such as bifurcations, subharmonics, and chaos. These nonlinear phenomena in the DC-DC converters have been studied both experimentally and numerically[2, 3, 4, 5, 6, 7, 8, 9]. However, the aforementioned studies mostly focused on the fast-scale, *i.e.*, high-frequency regime so that they were seldom concerned with the low-frequency dynamical behaviors, *i.e.*, Hopf bifurcation. In practice, these low-frequency bifurcation phenomena often occur in the switching converters so that they can affect the transfer efficiency and switching stress of the converters. Thus, the investigation of the Hopf bifurcation behaviors has become a very important goal and subject of much on-going research.

In the past few years, some investigations have been carried out about the Hopf bifurcation behaviors[10, 11, 12, 13, 14]. Although the results have greatly improved the understanding of the Hopf bifurcation in power electronics, they have been made based on the nonlinear discrete maps such as stroboscopic, S-switching and A-switching maps only from the bifurcation viewpoint. Hence, these results

[1]Corresponding author. Email: haozhang@xjtu.edu.cn