Qualitative Behaviour Analysis of Feedback-Controlled Buck-Boost Power Converters Thru Three Different Techniques.

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Abstract: This work is based on the comparison of three techniques for analyzing the qualitative behaviour of nonlinear dynamic systems, including the study of their finite and infinite equilibrium points. The qualitative techniques used are: the direct method of Lyapunov, the theorems of Dickson and Perko for second order quadratic differential systems and the linearization around finite equilibrium points. These techniques provide information about the local or global stability of nonlinear systems. The state feedback controlled Buck-Boost power converter will be used as a case of study.

Keywords: Nonlinear system, bounded system, qualitative analysis of dynamical systems, Lyapunov method, Buck-Boost power converter.

Análisis Cualitativo del Comportamiento del Convertidor de Potencia Buck-Boost por Realimentación del Vector de Estado a Través de Tres Diferentes Técnicas

Resumen: Este trabajo se basa en la comparación de tres técnicas de análisis del comportamiento cualitativo de sistemas dinámicos no lineales, incluyendo el estudio de los puntos de equilibrio finitos e infinitos. Las técnicas cualitativas utilizadas son: el Método Directo de Lyapunov, los Teoremas de Dickson y Perko para sistemas cuadráticos de segundo orden y la Linealización alrededor de los puntos de equilibrio finitos. Estas técnicas aportan información respecto a la estabilidad global o local del sistema no lineal. Como sistema dinámico no lineal se utilizará el convertidor de potencia Buck-Boost realimentado por medio del vector de estados.

Palabras claves: Sistemas No Lineales, sistemas acotados, análisis cualitativo de sistemas dinámicos, técnicas de Lyapunov method, convertidor de potencia Buck-Boost.

1. Introduction

It is known that some of the inherent qualitative characteristics of dynamic systems have been specified through rigorous analytic techniques. However in the specific case of nonlinear systems, there may be examples where there are not explicit solutions for the differential equations that describe their dynamics, and further, there are systems that exhibit multiple equilibrium points, limit cycles, bifurcations, among other features. Under these circumstances, the qualitative analysis of differential equations is a viable alternative to learn about the dynamic behaviour of these systems.

In this sense, the converse theorems are key tools in the stability analysis of dynamic systems. Some classical references on the subject are the works reported in Krasovskii (1963) and Hahn (1967). More recent references are the papers presented in Khalil (2000) and Fantoni and Lozano (2002). The references mentioned have been developed as a result of the research effort published in Lyapunov (1892); where the local and global equilibrium points in linear systems and in some nonlinear systems are studied. A concise reference to the concepts of the theory of Lyapunov is the text by Slotine and Li (1991).

In general, local results do not provide a comprehensive explanation of the behaviour of nonlinear systems. Therefore it is necessary to use other tools for the study of systems of second order quadratic differential equations, as the one considered in this paper. For this purpose, two references that analyze the behaviour of these differential equations are used: the first is aimed at sorting through the use of inequalities the different behaviours of bounded quadratic systems Coppel (1966), and the second is the work shown in Dickson and Perko (1970) which, through qualitative analysis of these dynamic systems, seeks to classify them in terms of an atlas represented in phase portraits. Both references are summarized in the textbook Perko (2000).

An application to stability analysis through the qualitative techniques referenced above is presented in Spinetti-Rivera (2011), where the behaviour of the Boost power converter is discussed.

The analysis technique presented in Spinetti-Rivera (2011) was

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