Dynamics of Continuous, Discrete and Impulsive Systems
Series **B:** *Applications & Algorithms* **14 (2008)** 99-109
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SOME REALIZATIONS IN THE STUDY OF OSCILLATIONS WITH A FREQUENCY METHOD

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Abstract. Some state-space realizations, critical when applying certain types of frequency methods, are more appropriate than others for studying oscillations in nonlinear systems. In this paper we suggest some few criteria and a procedure, based mainly on controllability and observability properties, that yield satisfactory state-space realizations. Some simple non trivial examples are presented and discussed.

Keywords: Hopf bifurcation, Frequency domain, Controllability, Observability.
AMS (MOS) subject classification: 34A34; 34H05; 93B05; 93B07; 93C80.

1 Introduction

The choice of a suitable representation of a linear system in terms of state variables has received quite a lot of attention in the majority of control system textbooks ([9], [13]). However, most of these realizations stem from the linearization of a nonlinear system about an equilibrium point, which is often prone to developing periodic or even chaotic behavior for certain parameter combinations.

Studying the appearance of soft oscillations under the variation of a main parameter using the graphical Hopf method ([6], [7]) requires an appropriate selection of the linear plant and the nonlinear feedback gain. This method has been extensively used in the past to capture smooth oscillations in electric power systems ([3], [4]) as well as biological, chemical, mechanical and physical systems ([8], [11]). However, in the existing literature, there is no clue for finding a good realization that reduces the computational burden needed for detecting and analyzing bifurcations in general nonlinear systems.

In this work, we propose a procedure for choosing a suitable representation of state-space matrices. The suitability of the resulting characteristic polynomial will depend on whether or not the corresponding linear part satisfies the conditions of controllability and observability, which are standard results in the field of linear systems, but seem to be quite underemphasized when dealing with nonlinear ones, except perhaps the mentioning in some