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A ZERO-DYNAMICS RE-DESIGN APPROACH TO PROBLEMS OF NONLINEAR OUTPUT REGULATION

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Abstract. In this paper we deal with the problem of output regulation for possibly non-minimum-phase nonlinear systems. The main goal is to provide a unifying framework for a number of recently proposed results. The underlying idea is to use a design paradigm based on zero-dynamics re-design which reduces the problem to a problem of set stabilization using high-gain feedback. In this unified setting, we are also able to show that uncertainties on the value of the so-called "high-frequency gain" coefficient of the system can be effectively handled by means of periodically varying controllers. This extends, to a nonlinear setting, robust zero-assignment techniques known for linear systems as "vibrational feedback".

Keywords. Regulation, Tracking, Vibrational Control, Averaging, Zero Dynamics.

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1 Introduction and Problem Statement

A classical problem in control theory is to force, by means of feedback, the output of a controlled plant to asymptotically track/reject any prescribed exogenous command/disturbance in a given class of functions of time. A problem of this kind is usually called a problem of *output regulation.* The pioneering role of Hassan Khalil in the development of methods for analysis and design of nonlinear systems is well known and has influenced the works of many others. Certainly, his contributions have been instrumental in the development of the theory of output regulation. Fundamental, in this respect, are his early studies on singularly perturbed systems, on which most of the "high-gain" design techniques repose, notably Khalil's robust observer [1], a powerful tool for the solution of problems of semi-global stabilization from measurement feedback. Khalil was the first author to observe that in dealing with problems of output regulation in the presence of parameter uncertainties, the so-called "internal model" must not only be able to generate inputs corresponding to trajectories of the exosystem, but also a number of their high-order nonlinear deformations [2]. He was also the first author to