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# GLOBAL STABILIZATION FOR A CLASS OF COUPLED NONLINEAR SYSTEMS WITH APPLICATION TO ACTIVE SURGE CONTROL

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**Abstract.** We propose here a new procedure for output feedback design for systems with nonlinearities satisfying quadratic constraints. It provides an alternative for the classical observer-based design and relies on transformation of the closed-loop system with a dynamic controller of particular structure into a special block form. We present two sets of sufficient conditions for stability of the transformed block system and derive matching conditions allowing such a representation for a particular challenging example. The two new tests for global stability proposed for a class of nonlinear systems extend the famous Circle criterion applied for infinite sector quadratic constraints. The study is motivated and illustrated by the problem of output feedback control design for the well-known finite dimensional nonlinear model qualitatively describing surge instabilities in compressors. Assuming that the only available measurement is the pressure rise, we suggest a constructive procedure for synthesis of a family of robustly globally stabilizing feedback controllers. The solution relies on structural properties of the nonlinearity of the model describing a compressor characteristic, which includes earlier known static quadratic constraints and a newly found integral quadratic constraint. Performance of the closed-loop system is discussed and illustrated by simulations.

**Keywords.** Active Surge Control, Output Feedback Control, Quadratic Constraints, Circle Criterion, Nonlinear Systems, Three-state Moore-Greitzer model, Global Stabilization.

**AMS subject classification:** 93D15 (93D21, 93C10).

# 1 Introduction

The study reported in this paper is motivated by the problem of designing globally stabilizing output feedback controllers for the following nonlinear dynamical system

$$\tfrac{d}{dt}\phi = -\psi + \tfrac{3}{2}\,\phi + \tfrac{1}{2}\left[1-(1+\phi)^3\right] \tag{1}$$

$$\tfrac{d}{dt}\psi = \frac{1}{\beta^2}\,(\phi-u)\,, \qquad y=\psi \tag{2}$$