Unfolding the Zero Structure of a Linear Control System

Jordan M. Berg
Postdoctoral Member
Institute for Mathematics and Its Applications
514 Vincent Hall
206 Church Street SE
Minneapolis, MN 55455
(612) 624-0284
e-mail: jberg@ima.umn.edu

Harry G. Kwatny
Raynes Professor of Mechanical Engineering
Dept. of Mechanical Engineering and Mechanics
Drexel University
Philadelphia, PA 19104 USA
(215) 895-2356
e-mail: harry.kwatny@coe.drexel.edu

Abstract

The invariant zero structure of a linear, finite dimensional, time invariant, control system is the set of invariants, under strict equivalence transformation, of the matrix pencil known as the system matrix. Many compensation techniques depend critically on aspects of the zero structure such as the relative degree, or the nonminimum phase property. In cases where the system is parameter-dependent or uncertain, small changes in parameter values may have profound effects on the appropriate compensation strategy. This occurs because many systems of practical interest have a structurally unstable zero structure, and because these systems may bound regions corresponding to distinct qualitative behavior. The main result of this paper is an unfolding for such systems. The unfolding imbeds the structurally unstable system in a parametrized family, chosen so that the system persists as a member of every sufficiently small perturbation of the family. The unfolding uses the fewest possible parameters necessary to achieve this property. The unfolding presented in this paper is derived from results previously reported by the authors. It is based on a canonical form that preserves the system matrix structure. Therefore all perturbed systems are easily interpreted as control systems. Several examples are discussed. The unfolding is given in full in an Appendix.