Nonlinear Feedback Synthesis: A Volterra Approach

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Dissertation Abstract

The Total Synthesis Problem (TSP) approach to design of nonlinear feedback systems was introduced for a single point of operation by Peczkowski, Sain, and Leake in 1979, and extended to general operating regions by Peczkowski and Sain in 1981. This dissertation contributes an extension to the 1979 TSP work, which was phrased in terms of transfer functions. The TSP definition itself is extended by means of the Volterra representation for input-output behavior of a nonlinear system. Using operators based upon Volterra convolutions, TSP is extended initially in the time domain; using transforms of Volterra kernels, TSP is then extended also in the transfer function domain. A proposed method of TSP design is outlined, proceeding recursively from the first-order, 1979, methods to second, third, and higher orders. For linear analytic plants with multiple control inputs, a tensor representation of kernels is obtained. For unity feedback controllers, higher order kernel transforms for the compensator are studied in detail. When the first plant kernel is invertible, explicit and recursive representations for the compensator are obtained. When the closed loop design goal is feedback linearization, explicit realizations of the compensator are given. Three examples are computed, including a two-input/two-output plant based upon a rotating DC to AC converter. The examples support the hypothesis that higher order control can be used to improve controller performance.