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STABILITY CROSSING CURVES OF SISO SYSTEMS CONTROLLED BY DELAYED OUTPUT FEEDBACK

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Abstract. This paper focuses on closed-loop stability analysis of a class of linear single-input single-output (SISO) systems subject to delayed output feedback. The considered approach makes use of some geometric arguments in frequency-domain, arguments that simplify the understanding of the delay stabilizing mechanism. More precisely, the geometry of stability crossing curves of the closed-loop system is explicitly characterized (classification, tangent and smoothness, direction of crossing) in the parameter space defined by the pair (gain, delay). Such stability crossing curves divide the corresponding parameter space into different regions, such that, within each region, the number of characteristic roots in the right-half plane is fixed. This naturally describes the regions of (gain, delay)-parameters where the system is stable. Various illustrative examples complete the presentation.

Keywords. Crossing curves, Delay, SISO Systems, Quasipolynomials, Stability.

AMS (MOS) subject classification: 34K20, 39A11, 49K40, 37C28.

1 Introduction

In general, the existence of a time delay at the actuating input in a feedback control system is frequently associated to instability phenomena and/or poor (or bad) performances for the closed-loop schemes (see, for instance, [6, 15], and the references therein). At the same time, there exists situations in which the presence of some appropriate delay in the input may have the "opposite" effect, that is to induce *stability* in closed-loop under the assumption that the same control law without delay does not lead to stable behaviors in the corresponding closed-loop systems (as discussed by [1] in the delayed output feedback control of some second-order oscillatory systems). To the best of the authors' knowledge, such a "dichotomic" character of the delay (stabilizing/destabilizing) in feedback systems was not sufficiently discussed, and exploited in the literature, and there exists only a few papers devoted to the subject.