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Lur'e feedback systems with both unbounded control and observation: Well-posedness and stability using nonlinear semigroups

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Dedicated to our parents: Maria († July 29, 2001) and Henryk († November 21, 1993); Marie-Jeanne († April 18, 1967) and Pierre († December 27, 1990).

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ABSTRACT

This paper is a complement of information to Grabowski and Callier (2006) [1]. A SISO Lur'e feedback control system consisting of a linear, infinite-dimensional system of boundary control in factor form and a nonlinear static incremental sector type controller is considered. Well-posedness and a criterion of absolute strong asymptotic stability of the null equilibrium is obtained using a novel nonlinear semigroup approach. A quadratic form Lyapunov functional is considered via a Lur'e type linear operator inequality. A sufficient strict circle criterion of solvability of the latter is found, using the solution of an operator Riccati equation by a novel self contained exposition, via reciprocal systems with bounded generating operators as recently studied and used by R.F. Curtain. The noncoercive case is finally considered using, in a novel way, LaSalle's invariance principle.

1. Introduction and overview of the main results

The objective of this paper is to demonstrate the effects of nonlinear semigroup theory on the Lur'e feedback stability problem, studied earlier in [1] and to provide self-contained proofs. For motivation and a background discussion see the latter paper and the references therein. The present paper contains seven sections. Section 1 is the present introduction and overview of the main results, given hereafter (certain definitions and terms will be clarified later).

Consider the Lur'e feedback control system in Fig. 1.1, which consists of a linear plant described by

$$\begin{cases} \dot{x}(t) = A[x(t) + du(t)] \\ y(t) = c^{\#}x(t) \end{cases}, \tag{1.1}$$

and a scalar static controller nonlinearity $f : \mathbb{R} \longrightarrow \mathbb{R}$.

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