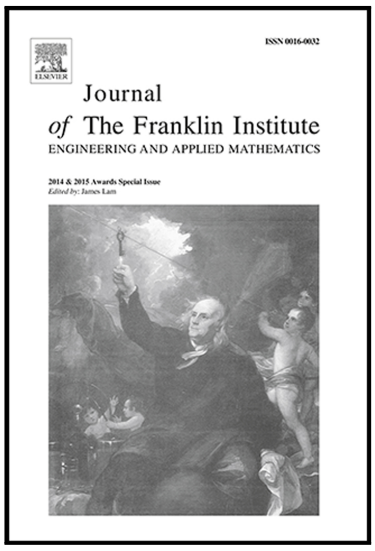

New absolute stability criteria for uncertain Lur'e systems with time-varying delays

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New absolute stability criteria for uncertain Lur'e systems with time-varying delays

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Abstract

This paper deals with absolute stability of uncertain Lur'e systems with time-varying delay. By introducing a Lyapunov-Krasovskii functional related to a second-order Bessel-Legendre inequality, some absolute stability criteria are derived for the system under study. Different from some existing approaches, a remarkable feature of this paper is that the time-derivative of the Lyapunov-Krasovskii functional is estimated by a linear function rather than a quadratic function on the time-varying delay, thanks to the introduction of four extra vectors. As a result, the resulting absolute stability criteria are of less conservatism than some existing ones, which is demonstrated through three examples.

Keywords: Lur'e systems, absolute stability, time-varying delay, sector-bounded nonlinearity.

1. Introduction

A Lur'e system is a nonlinear system in which the linear part is fixed by a constant matrix while the nonlinear part satisfies sector constraints. The Lur'e system model is originally from a pilot robot [1]. The well-known Chua's circuits, Goodwin models and Swarm models can also be categorized as Lur'e-type systems [2]. Due to the strong practical background, absolute stability of Lur'e systems has been attracting much interest of researchers and some results can be founded in the literature in the past two decades, see, e.g. [3–7]. There are two classes of methods to study absolute stability of Lur'e systems, namely frequent-domain method [8, 9] and time-domain method (Lyapunov direct method) [10, 11]. Fortunately, some relationship between these two methods is established by the well-known Kalman-Yakubovich-Popov (KYP) lemma [12]. It is evidenced that the classical circle criterion can be equivalently transformed into a linear matrix inequality, which is easy to check [13, 14]. As a result, in recent years, more attention has been paid to the time-domain method based on Lyapunov stability theory [15–18].

In practical engineering systems, time-delays are common, which are usually regarded as an important factor to degrade the performance of dynamic systems [19–22] including Lur'e systems. Thus, absolute stability of delayed Lur'e systems has gained growing attention [23]. The main concern is to derive an allowable maximum upper bound (AMUB) such that the Lur'e system under study remains global asymptotic stability for any time-delay less than the AMUB. The AMUB is thus regarded as a key index to judge if an absolute stability criterion is conservative. For the purpose of deriving less conservative absolute stability criteria, a number of methods are proposed, to name a few, free-weighting matrix approaches [16], integral inequality approaches [24], delay-decomposition approaches [25, 26]

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