Nonlinear Dynamics and Systems Theory, **21** (5) (2021) 447–456

Delay-Independent Stability Conditions for a Class of Nonlinear Mechanical Systems

A. Yu. Aleksandrov *

Saint Petersburg State University, 7–9 Universitetskaya Nab., St. Petersburg, 199034, Russia

Received: May 17, 2021; Revised: September 10, 2021

Abstract: A mechanical system with linear gyroscopic forces and nonlinear homogeneous dissipative and positional forces is studied. The case is considered where there is a time-varying delay in positional forces. With the aid of the decomposition method and the Razumikhin approach, conditions are obtained ensuring that the trivial equilibrium position of the system under investigation is asymptotically stable for any nonnegative, continuous and bounded delay. Estimates for the convergence rate of motions are derived. The developed approach is used in a problem of stabilization of mechanical systems via controls with delay in a feedback law. An example is given to demonstrate the effectiveness of the obtained results.

Keywords: *mechanical system; nonlinear forces; stability; time-varying delay; decomposition; stabilization.*

Mathematics Subject Classification (2010): 34K20, 93D30.

1 Introduction

Systems of high-dimensional second-order differential equations are widely used as mathematical models of gyroscopic devices [1–3]. An effective approach to the analysis of stability and other dynamic properties of such models consists of the decomposition of the complete system into first-order precession and nutation subsystems.

The justification of the correctness of such a decomposition for linear stationary gyroscopic systems was given in [1, 2] by the Lyapunov first method via the expansion of the roots of the characteristic equations in series with respect to negative powers of a large parameter. It was proved that, for sufficiently large values of the parameter, the asymptotic stability of the isolated nutation and precession subsystems implies the same property for the complete system.

* Corresponding author: mailto:a.u.aleksandrov@spbu.ru