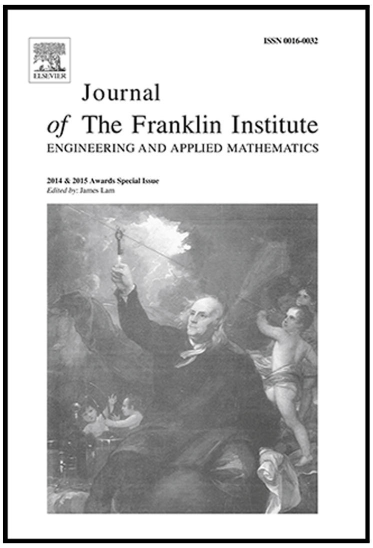

Exponential Input-to-state Stability under Events for Hybrid Dynamical Networks with Coupling Time-Delays

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EXPONENTIAL INPUT-TO-STATE STABILITY UNDER EVENTS FOR HYBRID DYNAMICAL NETWORKS WITH COUPLING TIME-DELAYS *

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Abstract. This paper studies the exponential input-to-state stability under events (called as exponential ISS under events) for hybrid dynamical networks (HDNs) with coupling time-delays. Notions of input-to-state exponent, exponential ISS under events, and uniform exponential ISS under events are proposed. The exponential ISS under events and the uniform case are studied according to whether the flow gain is a small-gain or not. When the flow gain is a small-gain, Halanay-type ISS Lemmas are firstly established and used to derive criteria of exponential ISS under events and uniform exponential ISS under events. And the minimal dwell time between two consecutive events required for HDNs to achieve uniform exponential ISS under events is estimated. When the flow gain may be not a small-gain, by the method of Lyapunov-Krasovskii functional and M-matrix theory, criteria of exponential ISS under events and uniform exponential ISS under events are also established. And the maximal dwell time between two consecutive events is given for the uniform case. All conditions and results on the uniform case are easily checkable. Examples are given through the paper to illustrate the theoretical results.

Key words. Input-to-state stability (ISS), exponential ISS under events, hybrid dynamical network (HDN), time-delay, Halanay-type ISS Lemma, small-gain, multiple Lyapunov-like functions.

AMS subject classifications. 93C30, 34K34, 34K45, 93D20, 93C65

1. Introduction. Recently, the issue of input-to-state stability (ISS) ([1-2]) for dynamical networks, hybrid systems, and more generally, hybrid dynamical networks (HDNs) has been studied. The dynamical networks are also named as interconnected systems in the literature. Due to the large-scale interconnections and the complexity, a method based on a single Lyapunov function is hard to be efficient in the ISS analysis of dynamical networks. In the literature, small-gain theorems ([3-5]) and vector Lyapunov functions ([9]) have been used for the ISS analysis of such networks. Very recently, by integrating with the small-gain arguments, the Razumikhin method as well as the Krasovskii approach were adopted to develop ISS and small-gain ISS and integral input-to-state stability (iISS) theorems for dynamical networks with time-delays, see [11-15, 26, 40-41]. The relation between the Razumikhin-type theorems and the small-gain ISS theorems given in [6] was used to establish the Razumikhin-type small-gain theorems. For ISS of hybrid systems, the Lyapunov formulation of ISS theorem was established in [16-20, 25, 27-28] via a smooth or non-smooth ISS-type Lyapunov function. The small-gain ISS theorem, matrix-small-gain theorem, and cyclic-small-gain theorem have been generalized to dynamical networks or HDNs composed of ISS subsystems, see [7-8, 10]. Also the small-gain iISS theorems via Lyapunov-Krasovskii functionals are established for dynamical networks with time-

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