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STABILITY ANALYSIS OF A CLASS OF HYBRID DYNAMIC SYSTEMS

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Abstract. This paper studies the stability issue of a class of nonlinear hybrid dynamic systems, namely, dynamic systems with jump parameters. The hybrid system model is described first and compared with the conventional one. Sufficient conditions are established for the stability and asymptotic stability of the nonlinear hybrid systems. Extension to hybrid systems with time delay are also investigated. Stability criteria are obtained for both linear and nonlinear cases. Examples are given to illustrate the main results.
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1 Introduction

Fault prone dynamic systems may experience abrupt changes in their structures and parameters, caused by phenomena such as component failure or repairs, changing subsystem interconnections, and abrupt environmental disturbances. Such systems can be modeled as operation in different forms [1], where each form corresponds to some combination of these events. A mathematical model describing such phenomena is given by

$$x'(t) = A(r(t))x(t), \tag{1.1}$$

where $x'(t)$ is the derivative of $x(t)$, $r(t) \in S = \{1, 2, \cdots, N\}$. $r(t)$ may jump from i to j following some rules or randomly from time to time. For each $r(t) = i$, $t \in [t_i, t_i + \sigma_i)$, $A(r(t)) = A(i)$ has different form. If $r(t) = i$ in the internal $[t_i, t_i + \sigma_i)$, system (1.1) is be in the ith state in that interval. System (1.1) belongs to the category of hybird systems, since it combines a part of the state that takes values continuously ($x \in R^n$) and another part of the state that takes discrete values ($r(t) \in \{1, 2, \cdots, N\}$). In general, it is not known exactly when the system jumps from ith$(r(t) = i)$ state to jth$(r(t) = j)$ state, but the probability or relating coefficient that the system jumps from ith state to jth state is certain number α_{ij}, $\alpha_{ij} \geq 0$, $i, j = 1, 2, \cdots, N$. Such systems are often called systems with jump parameters. For simplicity, we shall call them jump systems. Clearly, jump systems are different from conventional dynamic systems given by

$$x'(t) = A(t)x(t) \tag{1.2}$$