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PERIODIC FLOWS AND STABILITY OF A SWITCHING SYSTEM WITH MULTIPLE SUBSYSTEMS

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Abstract. In this paper, the stability and bifurcation of periodic flows in a switching system of multiple subsystems with transport laws at switching points are presented in general. The periodic flows and stability for linear switching systems are discussed as an example. Analytical prediction of the periodic flow in such linear switching systems is carried out and numerical illustrations are given for a better understanding of dynamical behaviors of switching systems. The effects of the transport laws in the switching system are also discussed. The methodology presented in this paper can be applied to nonlinear switching systems. The further results on chaos, stability and bifurcation of periodic flows in nonlinear switching systems will be presented in sequel.

Keywords. Switching systems, impulsive systems, transport laws, stability, bifurcation.

AMS (MOS) subject classification: 37B55, 37N35, 70G60

1 Introduction

Consider a C^{r_i}-continuous system ($r_i > 1$) on an open domain$D_i \subset R^n$, in a time interval $t \in [t_{k-1}, t_k]$

$$\dot{\mathbf{x}}^{(i)} = \mathbf{F}^{(i)}(\mathbf{x}^{(i)}, t, \mathbf{p}^{(i)}) \in R^n,\ \mathbf{x}^{(i)} = (x_1^{(i)}, x_2^{(i)}, \cdots, x_n^{(i)})^{\mathrm{T}} \in D_i. \qquad (1)$$

where $\dot{\mathbf{x}}^{(i)} = d\mathbf{x}^{(i)}/dt$. $\mathbf{p}^{(i)} = (p_1^{(i)}, p_2^{(i)}, \cdots, p_{m_i}^{(i)})^{\mathrm{T}} \in R^{m_i}$ is a parameter vector. On the domain $D_i \subset R^n$, the vector field $\mathbf{F}^{(i)}(\mathbf{x}^{(i)}, t, \mathbf{p}^{(i)})$ with the parameter vector $\mathbf{p}^{(i)}$ is C^{r_i}-continuous in $\mathbf{x}^{(i)}$ for time $t \in [t_{k-1}, t_k]$. With an initial condition $\mathbf{x}^{(i)}(t_{k-1}) = \mathbf{x}_{k-1}^{(i)}$, the dynamical system in Eq.(1) possesses a continuous flow as

$$\mathbf{x}^{(i)}(t) = \mathbf{\Phi}^{(i)}(\mathbf{x}_{k-1}^{(i)}, t, \mathbf{p}^{(i)}) \text{ with } \mathbf{x}_{k-1}^{(i)} = \mathbf{\Phi}^{(i)}(\mathbf{x}_{k-1}^{(i)}, t_{k-1}, \mathbf{p}^{(i)}). \qquad (2)$$

To investigate a switching system consisting of many subsystems, the following assumptions of the i^{th} subsystem should be held.

(A1) $\mathbf{F}^{(i)}(\mathbf{x}^{(i)}, t, \mathbf{p}^{(i)}) \in C^{r_i}$ and $\mathbf{\Phi}^{(i)}(\mathbf{x}_k^{(i)}, t, \mathbf{p}^{(i)}) \in C^{r_i+1}$ on D_i for $t \in [t_{k-1}, t_k]$, (3)