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ON A CLASS OF NONLINEAR OPTIMAL SYNCHRONIZATION AND TRACKING CONTROL PROBLEMS

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Abstract. *In this paper, we consider a new class of nonlinear optimal tracking and synchronization control problems subject to control constraints, where the motions of two distinct objects are required to achieve synchronization at the minimum time while achieving the optimal tracking of a reference target. A computational method is developed for constructing such an optimal switching control law. The method proposed is then used to solve a practical problem, which arises from the study of the angular velocity tracking and synchronization of two spacecrafts during their formation flight. The results obtained are highly satisfactory.*
Keywords: Nonlinear system, Synchronization control, Optimal control, Tracking control, Minimum time, Control parameterization, Time scaling transform

1. **Introduction.** Synchronization control of different objects aims at achieving the synchronized motions of the objects with reference to desired target motions. These objects can be mechanical systems, robots, electrical motors, precision optical instruments or spacecrafts [1-6], just to name a few. It has attracted an increasing attention in recent years. There are two main approaches to the synchronization control – the master-slave mode approach and the equal-status mode approach. For objects with distinct characteristics in their dynamics, it is more suitable to use the master-slave mode approach, where the object with a slower dynamics is taken as the master, while the object with a faster dynamics is taken as the slave. Its objective is to ensure that the motion of the slave will synchronize with that of the master. If the dynamic characteristics of the two objects are close, it is more suitable to use the equal-status mode approach. In this approach, the cross coupling terms for measuring the synchronization errors are introduced. Both these approaches are well studied in the literature. Arimoto et al. [7] developed a cooperative motion control scheme for the synchronization of a set of robot arms or fingers with tele-operation of the master-slave robotic systems, where the second method of Lyapunov was utilized to show the asymptotic stability. Tao et al. [8] proposed a compliant coordination control method for two moving industrial robots by using the master-slave mode approach. A computational scheme was then presented. Keron [9] improved the performance of a conventional biaxial system by introducing a symmetrical cross-coupling control, where the whole system is considered as a single unit. Srinivasan and Kulkarni [10] designed a cross-coupling controller to improve the accuracy of the high-speed contour that is independent of the tracking accuracy in a biaxial machine tool feed driver. Tomizuka [11] presented an adaptive cross-coupling control law to synchronize the motions of two DC motors. This control law consists of a proportional feedback controller, an adaptive disturbance compensator and an adaptive feedforward controller. Zhou et