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TITLE : SYNCHRONIZATION IN CHAINS, RINGS AND NETWORKS OF ELECTROMECHANICAL SYSTEMS

Abstract

This thesis deals with the dynamics and synchronization of coupled nonlinear electromechanical devices. Each electromechanical device is a moving coil electromechanical transducer that consists of a forced *Duffing* electrical oscillator with both cubic and quintic nonlinearities, magnetically coupled to a linear mechanical oscillator. The coupling between electromechanical devices consists of a series association of a capacitor and a resistor. This yields to dispersive-dissipative coupling.

A theoretical analysis of the dynamics of the single electromechanical device is carried out. Bifurcation structures are also investigated. A detailed attention is granted to the effects of the quintic nonlinearity. It is observed that the parametric domain of stable harmonic oscillations shrinks when the quintic nonlinearity increases. In this case, chaos arises for low values of the amplitude of the external voltage source.

The problem of collective dynamics in rings, chains and networks of unidirectionally and mutually coupled electromechanical devices, both in their regular and chaotic states, is considered. The resulting dynamical state of these networks is only of interest if it achieves synchronization. The stability of synchronization process is undertaken using the *Floquet* theory and the Master Stability Function (MSF) approach. The MSF approach is based on the parametric behavior of the maximal transverse *Lyapunov* exponent. The emanating properties of this method makes it possible to have a general study of the networks dynamics. The collective behavior in the networks is studied through the determination of the range of the coupling strengths leading to complete synchronization, cluster synchronization and spatiotemporal chaos. For some coupling strengths, it appears a no-synchronization phenomenon in the stable synchronization parametric areas. The properties of the MSF make it possible to explain this phenomenon. A detailed attention is paid to the effects of the dissipative component of the dispersive-dissipative coupling tested here. It is observed that the dissipative component of the coupling enhances synchronization, reducing the synchronization time. This result is even more important since one of the challenges in the realm of synchronization is to reduce the synchronization time.

Keywords: Networks of nonlinear electromechanical systems, Chaotic dynamics, Synchronization, Complete synchronization, Clusters synchronization, Spatiotemporal chaos.