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Nonlinear Dynamics and Control of Electrodynamic Tether for Deorbiting Space Debris

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Abstract: The ever increasing population of space debris poses a great threat to the sustainable development of space industry. Electrodynamic tether has been recognized as a promising technology for the active removal of space debris from overpopulated orbital regions. A typical electrodynamic tether system consists of two end-bodies connected by a conductive tether in space. The electric current flowing in the tether will interact with the magnetic field of the Earth to generate the Lorentz force, by which the system can be deorbited almost without expending propellant. Although technically appealing, the development of electrodynamic tether technology poses many challenging and interesting problems at the same time. One point of great concern is that the librations of the tether can grow dramatically in the deployment stage. To address this issue, a feedback control law, which explicitly includes the tension constraint, is presented for deploying the tether in a stable and fast manner. Besides, special attention should be paid to the inherent instability during deorbiting process since the Lorentz force acting on the tether may lead to significant energy injection into attitude motions. Therefore, an output feedback control law of the electric current is presented for deorbiting the electrodynamic tether system, along with a discussion on the nonlinear state estimation of attitude motions.