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Spandita Das, Sananda Chatterjee, Sayantan Chakraborty, Madhubanti Maitra

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Periodic Compensation of Cart Inverted Pendulum System: A Comparative Robustness Study of 2-Periodic and 3-Periodic Controller

Spandita Das[1], Sananda Chatterjee*[2], Sayantan Chakraborty[3] and Madhubanti Maitra[4]

[1] Research Scholar, Department of Electrical Engineering, Jadavpur University, Kolkata, India, spandita24@gmail.com

[2] Associate Professor, Institute of Engineering and Management, Kolkata, India, sananda.chat@gmail.com

[3] Asistant Professor, Department of Electrical Engineering, Jadavpur University, Kolkata, India, sayan.ju@gmail.com

[4] Professor, Department of Electrical Engineering, Jadavpur University, Kolkata, India, madhubanti.maitra1966@gmail.com

Abstract. The stabilization of Cart Inverted Pendulum System (CIPS) is widely regarded as a benchmark problem in control system engineering owing to the several challenges it presents for being an unstable, non-linear, non-minimum phase (NMP), under-actuated system. It is well established that linear time invariant (LTI) controllers cannot provide satisfactory robustness while compensating the CIPS. Additionally, the limits on physical track length and the control voltage levels impose further constraints on the stabilization of this system. On the other hand, it has been reported in literature that periodic controllers are capable of significantly improving the robustness of such unstable, NMP systems. This work aims to explore the capabilities of discrete-time periodic controllers, generally known as M-periodic controllers, in respect of robust compensation of the CIPS. In this regard a controller synthesis algorithm for 3-priodic controller, is presented and the results are compared with that yielded by 2-periodic controllers.

Keywords: CIPS, Loop-zero placement, Periodic Control.

1 Introduction

The Cart Inverted Pendulum System model can be employed to study multiple real-world systems, such as self-balancing robots, missile launching systems, and two-wheeled personal transporters, to mention a few. It is important to note that the control objective in such systems involves stabilization of the plant/component of the plant in the vertical upright position which is analogous to the case of stabilizing the pendulum of the CIPS in the upright position. Moreover, CIPS being a single input multiple output (SIMO), non-linear, non-minimum phase (NMP), under-actuated and highly unstable at the upright vertical position offers numerous control challenges. Additional restrictions on the physical track rail length and control voltage levels further complicate the stabilization of the CIPS, making it an even more critical problem [13,15-19].