Master’s Thesis Abstract

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The increased interest in electrodynamic levitation systems for the purpose of commercial transportation has put a focus on the need to fully characterise their dynamic behaviour. The requirement for passenger comfort has introduced challenges related to the stability and control of vibrations that may be induced from track irregularities and changing weight distribution in the vehicle. The aim of the present thesis is to understand the solution to the inherent instability of the levitating system by means of a quarter car model, with the possibility of validating the same by means of a dedicated test bench. A voice coil that exhibits a sprung and unsprung mass provides the ability to practically study the system, by considering a lack of decoupling of the masses, as well as an application of passive damping. A COMSOL Multiphysics® model of the experimental system is refined to account for magnet misalignment and spacing, also considering two differing orientations of the Halbach array. Offset values for each nominal air gap are suggested, for each Halbach array, obtained from comparing numerical and experimental forces. A general offset value is also reported for each array, accounting for pad irregularities, with satisfactory correspondence between experimental and FEM data. To further improve on the discussion of stability, several control strategies are explored, where the initial approach consists of implementing extensively studied solutions in the automotive field, namely skyhook and groundhook damping. A stability analysis in MATLAB® and Simulink® is performed, and simulations in the time domain confirm certain favourable configurations. A general approach is then adopted, by means of the Linear Quadratic Regulator introduced in a simplified model of the system that exhibits observable states. The compatibility of the reduced order model with the model including the inherent instability is verified in frequency domain. The effect of the control input penalisation on the sensitivity of a single weighting parameter influencing the states of interest is explored and agreeable design choices are suggested, considering varying excitation profiles pertaining to the track. These include a sinusoidal profile used for the HTT test track, and a random profile defined by the ISO/TC 108/WG9 standard, as well as a combination of the two.