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An Optimal Hybrid EMS System for a Hyperloop Prototype Vehicle

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Abstract : Hyperloop, a new mode of transport, is gaining significance. It consists of the use of a ground-based transport system which includes a levitation system, that avoids rolling friction forces, and which has been covered with a tube, controlling the inner atmosphere lowering the aerodynamic drag forces. Thus, hyperloop is proposed as a solution to the current limitation on ground transportation. Rolling and aerodynamic problems, that limit large speeds for traditional high-speed rail or even maglev systems, are overcome using a hyperloop solution. Zeleros is one of the companies developing technology for hyperloop application worldwide. It is working on a concept that reduces the infrastructure cost and minimizes the power consumption as well as the losses associated with magnetic drag forces. For this purpose, Zeleros proposes a Hybrid ElectroMagnetic Suspension (EMS) for its prototype. In the present manuscript an active and optimal electromagnetic suspension levitation method based on nearly zero power consumption individual modules is presented. This system consists of several hybrid permanent magnet-coil levitation units that can be arranged along the vehicle. The proposed unit manages to redirect the magnetic field along a defined direction forming a magnetic circuit and minimizing the loses due to field dispersion. This is achieved using an electrical steel core. Each module can stabilize the gap distance using the coil current and either linear or non-linear control methods. The ratio between weight and levitation force for each unit is 1/10. In addition, the quotient between the lifted weight and power consumption at the target gap distance is 1/3 [kg/W]. One degree of freedom (DoF) (along the gap direction) is controlled by a single unit. However, when several units are present, a 5 DoF control (2 translational and 3 rotational) can be achieved, leading to the full attitude control of the vehicle. The proposed system has been successfully tested reaching TRL-4 in a laboratory test bench and is currently in TRL-5 state development if the module association in order to control 5 DoF is considered.

Keywords : active optimal control, electromagnetic levitation, HEMS, high-speed transport, hyperloop
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