Chapter 7

A Double Actuator-Based DC Attraction Type Levitation System for the Suspension of a Cylindrical Rod

ABSTRACT

In the earlier chapters, an attempt has been made for stable suspension of a cylindrical rod under single electromagnet controlling single-axis movement. During experimentation it has been observed that the rod gets tilted to one side that exerts more levitating force due to non-uniformity of the distributed field flux. Moreover, for some specific industrial applications (like induction heating, manufacturing industry, active magnetic bearing, precision instrumentation, mechatronics, etc.), it is required to levitate such cylindrical rods with better pitching control where both ends may be controlled independently. Obviously, for controlling the other degrees of freedom movement of the cylindrical rod, at least two electromagnets are necessary.

INTRODUCTION

In the earlier chapters, an attempt has been made for stable suspension of a cylindrical rod under single electromagnet controlling single-axis movement. During experimentation it has been observed that the rod gets tilted one side that exerts more levitating force due to non-uniformity of the distributed field

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flux. Moreover, for some specific industrial applications (like induction heating, manufacturing industry, active magnetic bearing, precision instrumentation, mechatronics etc.) it is required to levitate such cylindrical rod with better pitching control where both end may be controlled independently. Obviously, for controlling the other degrees of freedom movement of the cylindrical rod, at least two electromagnets are necessary.

This work describes design, implementation and testing of a DC attraction type levitation system where a ferromagnetic cylindrical rod of around 0.122 kg mass is made to remain suspended at the desired operating gap under two I-core electromagnets (Figure 1). The two electromagnets are controlled independently through two identical controllers and the stable levitation of the rod is achieved through single input and single output (SISO) control of each air-gap corner. The emphasis of this work is to design and development of controller unit for two actuators. The single switch based power circuit simplifies the overall hardware and it can be extended to any number of magnet-coil. A cascade compensation control scheme utilizing inner current loop and outer position loop has been designed and implemented for stabilization of such highly unstable and strongly non-linear system. The prototype has been successfully tested and stable levitation was demonstrated at the desired operating gap.

DESCRIPTION OF EXPERIMENTAL SET-UP

The block diagram of individual unit for the proposed DCALS is shown in Figure 1. In each case the current of the electromagnet is controlled through the DC to DC switch mode chopper circuit utilizing an outer position control loop and an inner current feedback control loop. The parameters of the maglev systems are given in Table 7.2. The photograph of the experimental setup is shown in Figure 2.

When the two electromagnets are simultaneously excited, a net attractive force is generated between the magnet pole-faces and the ferromagnetic rod, as a result of which the magnets try to pull up the complete ferromagnetic rod. The dedicated independent controller used for each magnet tries to control the air-gap between that magnet pole-face and the cylindrical rod by maintaining the required current in the corresponding magnet-coil. With each magnet cum controller unit working satisfactorily, each side of the cylindrical rod gets the desired vertical lift and in the process the whole cylindrical rod is levitated.

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