Chapter 5
Design Fabrication and Testing of a Single Actuator DCALS (Part 2)

ABSTRACT

Modeling, design, fabrication, and testing of single magnet, single axis DC attraction type levitation system (DCALS) has been presented in this chapter. The proposed two loop scheme is more attractive from control point of view than the mostly reported single loop position control. The order of the levitated system (plant) has been reduced by one due to the use of a controlled current source as the excitation of the magnet-coil. The analysis and design of the position controller becomes easier after considering the reduced order plant transfer function. The controllers have been designed based on classical control theory utilizing root-locus and frequency domain technique. The realization of the controller also becomes simple due to the use of analog circuits.

DESIGN OF POSITION CONTROLLER

The transfer function of the plant $G_p(s)$ in Eqn. 5.20 shows that the system is unstable in open loop having a pole at $\left(+\sqrt{\frac{K_X}{m}}\right)$ in the right half‘s’ plane. The root locus plot (Figure 1) of the closed loop system about an operating gap (10 mm) indicates that the system cannot be stabilized by simply adjusting

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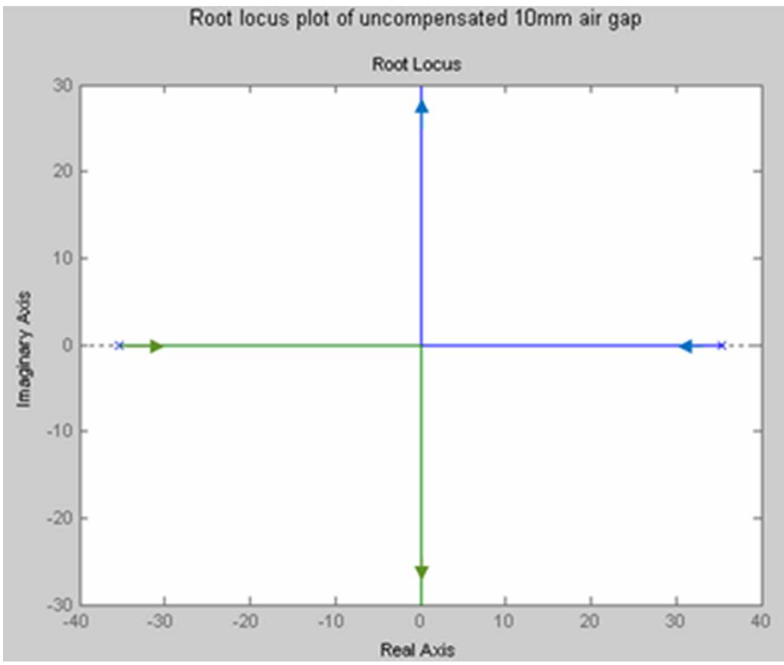
the amplifier gain. To make the levitation system stable, it is necessary to shift the root-locus to the left half of 's' plane.

For stabilization of unstable DCALS a cascade compensation control scheme utilizing PD, Lead, Lag-Lead, PID and combination of these controllers may be used. The reasons for its popularity can be attributed to simplicity, ease of design and robustness. The main aim of this part of work is to compare with the different designed controllers for the proposed designed DCALS at different operating points and to suggest a suitable classical controller that will provide fast response without any overshoots and steady-state error which is generally required for such type of critical systems.

Figure 1. Root locus plot of the uncompensated plant at 10mm gap



PD Controller

From the transfer-function as given in Eqn. 5.20, it is clear that the system is unstable in open loop and it can not be stabilized just increasing the gain of the system. Stabilization of this type of magnetically levitated system can easily be achieved by shifting the root-loci at the left-half of the s-plane (Figure 2). The addition of a zero to the open loop transfer function has the