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SYSTEM IDENTIFICATION OF THE LARGE-ANGLE MAGNETIC SUSPENSION TEST FACILITY (LAMSTF)

by

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Abstract

The Large-Angle Magnetic Suspension Test Facility (LAMSTF), a laboratory-scale research project to demonstrate the magnetic suspension of objects over wide ranges of attitudes, has been developed. This system represents a scaled model of a planned Large-Gap Magnetic Suspension System (LGMSS). The LAMSTF system consists of a planar array of five copper electromagnets which actively suspend a small cylindrical permanent magnet. The cylinder is a rigid body and can be controlled to move in five independent degrees of freedom. Five position variables are sensed indirectly by using infra-red light-emitting diodes and light-receiving phototransistors. The motion of the suspended cylinder is in general nonlinear and hence only the linear, time-invariant perturbed motion about an equilibrium state is considered.

One of the main challenges in this project is the control of the suspended element over a wide range of orientations. An accurate dynamic model plays an essential role in controller design. The analytical model of the LAMSTF system includes highly unstable real poles (about 10 Hz) and low-frequency flexible modes (about 0.16 Hz). Projection filters are proposed to identify the state space model from closed-loop test data in time domain. A canonical transformation matrix is also derived to transform the identified state space model into the physical coordinate.

The LAMSTF system is stablized by using a linear quadratic regulator (LQR) feedback controller. The rate information is obtained by calculating the back difference of the sensed position signals. The reference inputs contain five uncorrelated random signals. The control input and the system response are recorded as input/output data to identify the system directly from the projection filters. The sampling time is 4 ms and the data length is 24 sec. Preliminary results demonstrate that the identified model is fairly accurate in predicting the step responses for different controllers while the analytical model has a deficiency in the pitch axis (see the following figure).

Comparison (Step Response with Dynamic Controller)