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Model-free adaptive control for three-degree-of-freedom hybrid magnetic bearings

Key words: Model-free adaptive control; Hybrid magnetic bearings; Nonlinear areas; Faster response; Higher stability

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Motivation

- Mathematical models are disappointing due to uneven distribution of the air gap magnetic field and significant unmodeled dynamics in magnetic bearing systems.

- The effectiveness of control deteriorates based on an inaccurate mathematical model, creating slow response speed and high jitter.

Main idea

- A model-free adaptive control (MFAC) scheme is proposed for a three-degree-of-freedom hybrid magnetic bearing (3-DoF HMB) control system.
- The scheme for 3-DoF HMB depends only on the control current and the objective balanced position, and it does not involve any model information.
- The design process of a parameter estimation algorithm is model-free, based directly on pseudo-partial-derivative (PPD) derived online from the input and output data information.

Method

1. The rotor start-of-suspension position of the HMB is regulated by auxiliary bearings with different inner diameters.

2. Adopt two kinds of operation situations (linear and nonlinear areas) are present to analyze the validity of MFAC in detail.

Major results

- Experimental results of start-of-suspension

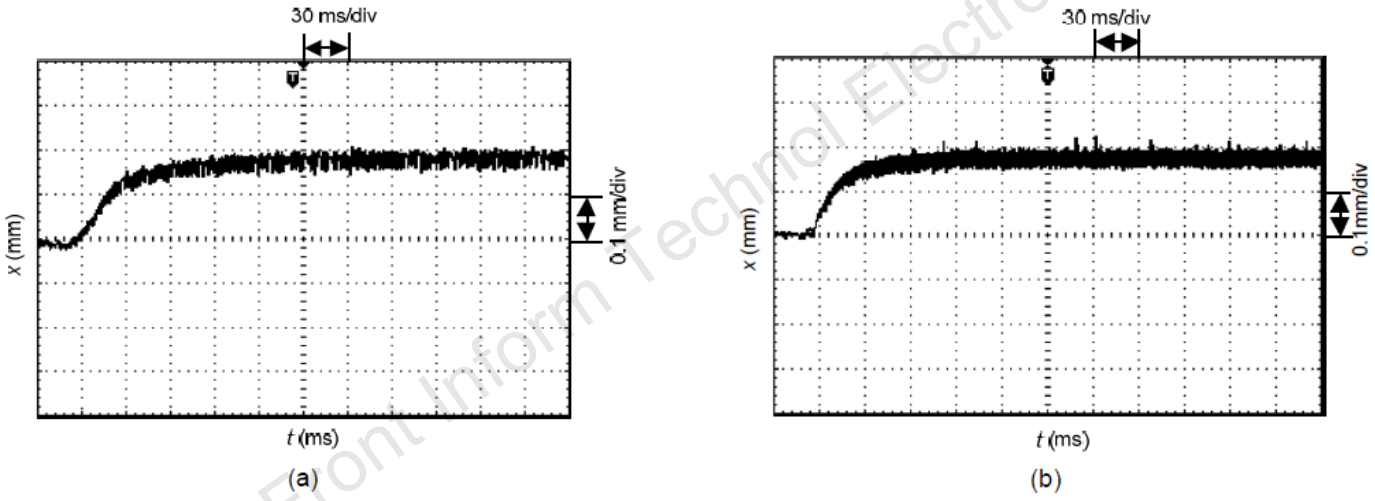

Fig. 1 Start-of-suspension waveform of HMB in the linear area: (a) start-of-suspension waveform with PID; (b) start- of-suspension waveform with MFAC

Experimental results of stable suspension

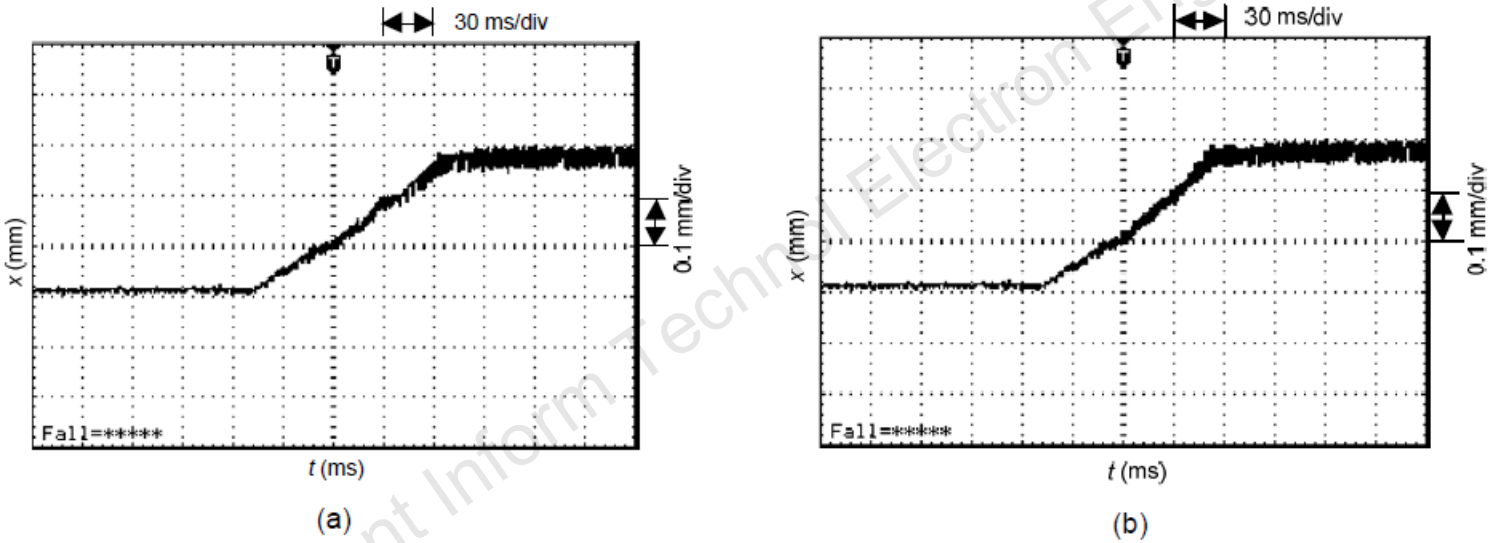

Fig. 2 Start-of-suspension waveform of HMB in the non-linear area: (a) start-of-suspension waveform with PID; (b) start-of-suspension waveform with MFAC

Conclusions

- For the start-of-suspension in linear areas, the response speed with MFAC is 50 ms faster than with PID control; in nonlinear areas, the response speed with MFAC is 20 ms faster than with PID control.

- In the stable suspension stage, the experiments demonstrate that the proposed 3-DoF HMB MFAC handles dynamic rotor control with a smaller steady-state error and higher stability.