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Vibration harmonic suppression technology for electromagnetic vibrators based on an improved sensorless feedback control method

Key words: Vibration calibration; Electromagnetic vibrators; Harmonic suppression; Sensorless control method; Velocity feedback control

Corresponding author: Junning CUI
E-mail: cuijunning@hit.edu.cn
ORCID: https://orcid.org/0000-0002-4418-8936

Motivation

- Vibration calibration by electromagnetic vibrators is the most widely used method at present. However, the total harmonic distortion (THD) of the vibration waveform causes uncorrectable errors in the calibration, which should be suppressed as much as possible.
- High-precision vibration sensors with a frequency response lower than 0.1 Hz are usually seismometer types, which are too bulky to use in the vibrators, and the use of sensors will reduce system reliability and increase the cost of hardware and maintenance. Hence, a sensorless feedback control method is needed to reduce the THD of the low-frequency vibration waveform.

Method

- The velocity estimation accuracy is improved by adopting the alternating current (AC) resistance of the driving coil.
- A method for optimizing key parameters is proposed to increase the harmonic suppression capability of velocity feedback control.
- The harmonic suppression capability of the sensorless velocity feedback control method is improved.

Method

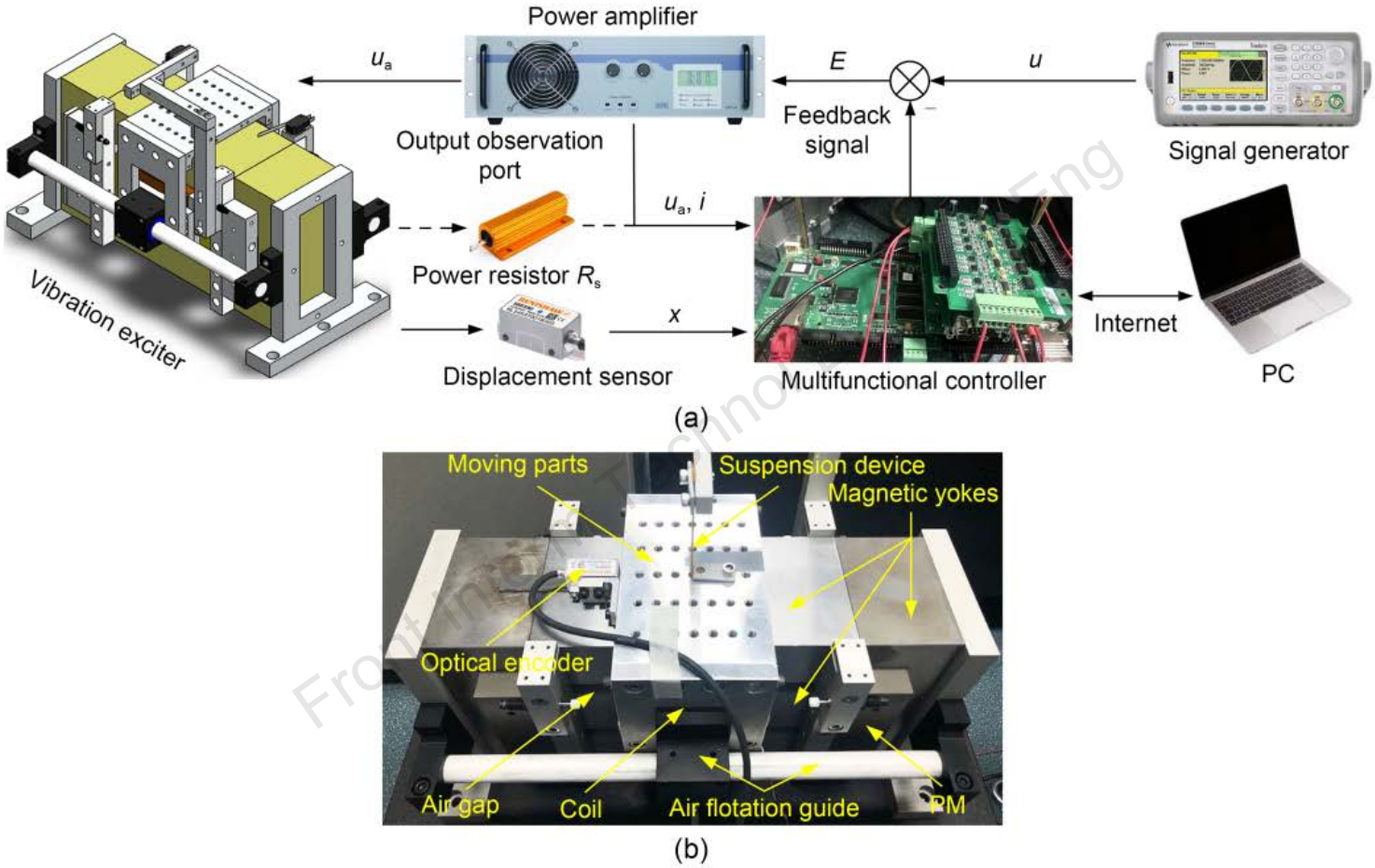

Fig. 6 Low-frequency horizontal electromagnetic vibrator system: (a) main configuration; (b) experimental device (PC: personal computer; PM: permanent magnet)

Major results

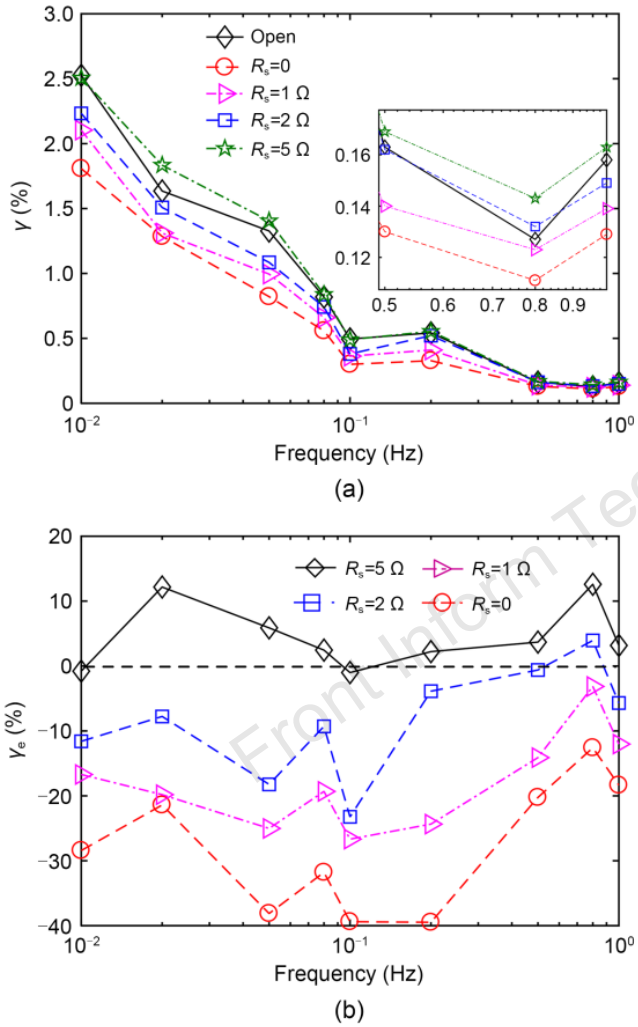

Fig. 8 Influence of different R_s's on velocity feedback control: (a) γ; (b) γ_e

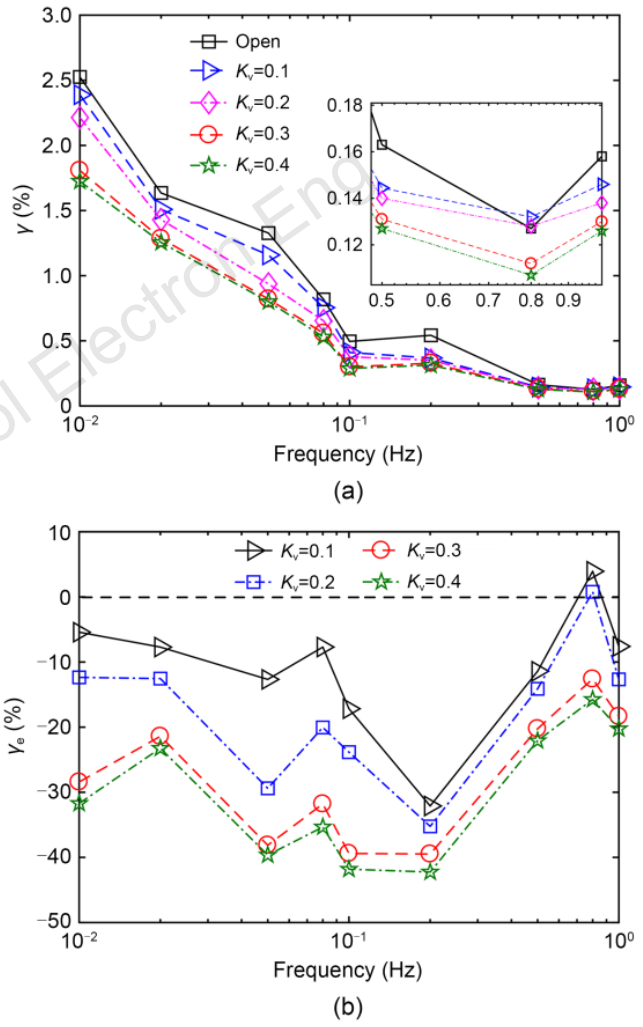

Fig. 9 Influence of different K_v's on velocity feedback control: (a) γ; (b) γ_e

Major results

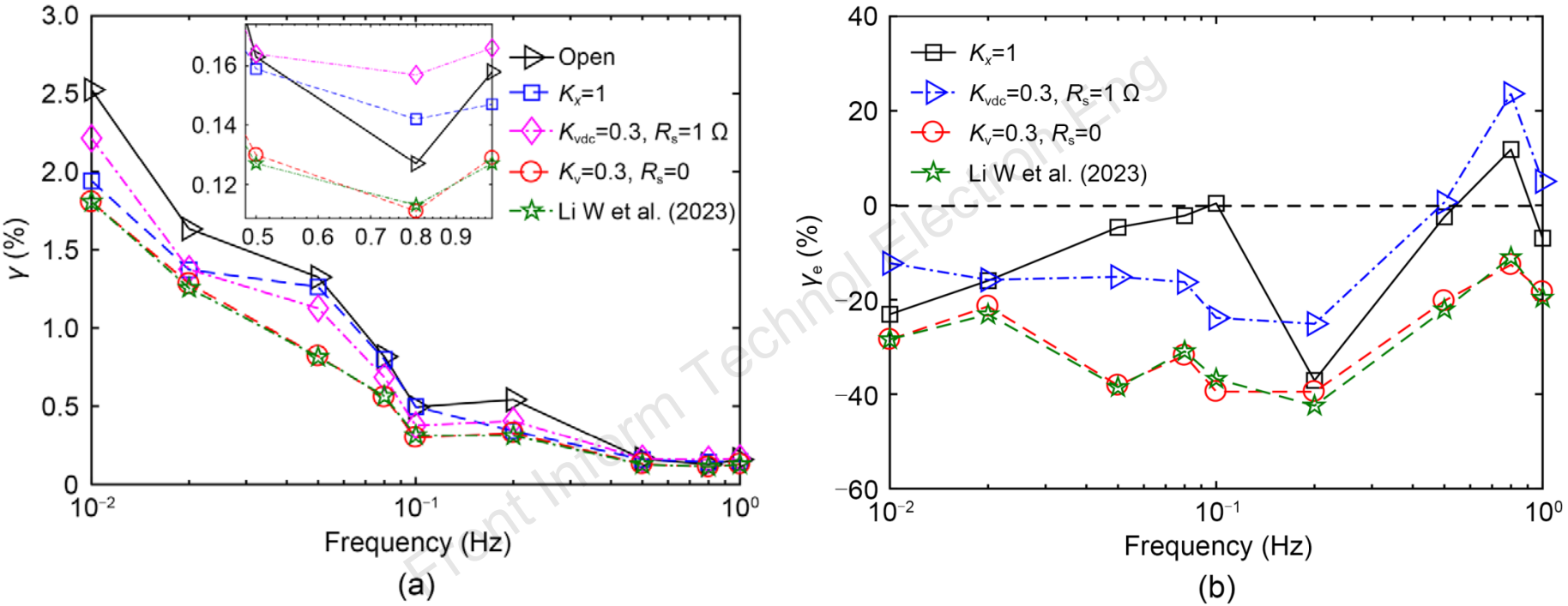

Fig. 12 Comparison of the THD suppression abilities of different control methods: (a) γ; (b) γ_e

Conclusions

- The use of AC resistors improves the accuracy of vibration velocity estimation. The harmonic interference introduced by the velocity estimation error, which is difficult to suppress with feedback control, is reduced.
- The proposed method reduces the THD of the vibration waveform by about 20% compared to the conventional sensorless velocity feedback control method.
- The proposed method has a THD suppression capability comparable to that of a recent advanced method. However, the proposed method has a simpler parameter adjustment process that does not use sensors and is more reliable, less costly, and easier to maintain.

Wei LI received the B.S. and M.S. degrees from Kunming University of Science and Technology, Kunming, China, in 2016 and 2019, respectively, all in the Faculty of Information Engineering and Automation. He is currently pursuing the Ph.D. degree with the Harbin Institute of Technology, Harbin, China. His research interests focus on techniques of precise vibration calibration and motion control.

Junning CUI received the B.S. and Ph.D. degrees from the Harbin Institute of Technology, Harbin, China, in 2004 and 2010, respectively, all in Instrument Science and Technology. He is currently a professor at the Department of Instrument Science and Technology, Harbin Institute of Technology. His research interests include vibration calibration, precision machinery, and instrument engineering.