Development of Control Circuit for Inductive Levitation Micro-Actuators

Vitor Vlnieska¹, Achim Voigt¹, Sagar Wadhwa¹, Jan Korvink¹, Manfred Kohl¹, and Kirill Poletkin¹,²

1 - Institute of Microstructure Technology - Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany
2 - Institute of Robotics and Computer Vision, Innopolis University, 1 Universitetskaya street, Innopolis City, 420500, Russian Federation
- Materials Information
- Discovery Teratronics and Photonic
- Smart Nano and Microsystems
- Nanophotonics for Energy
Cooperative Multistage Multistable Microactuator Systems
Introduction

A 2D array of cooperative hybrid levitation micro-actuators (2DAMA)

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Investigation and development of an innovative and smart micro-actuation system.

- Newly improved performances:
  - Small operation current
  - Low operation temperature (it is comparable to the ambient temperature)
  - Considerably extended motion range
  - Wider operational capabilities
  - Transportation and manipulation of micro-objects
  - Higher accuracy and faster time of actuation
  - Significant reduction of the dissipated energy
  - Preventing a contact with harmful surfaces and the ensured long lifetimes.

A 2D array of micro-actuators
Introduction

• Several techniques can provide the implementation of electromagnetic levitation into a micro-actuator systems.
• Classification according to the materials used and the sources of the force fields.
• Two major branches:
  • Electric levitation micro-actuator (ELMA)
  • Magnetic levitation micro-actuator (MLMA)
    • MLAM can be further split into:
      • Inductive (ILMA)
      • Diamagnetic (DLMA)
      • Superconducting micro-actuators
      • Hybrid levitation micro-actuators (HLMA)

Methods

2D technology

- Proof Mass
- Eddy current
- Levitation coil
- Stabilization coil

3D technology

- Levitation coil
- Stabilization coil

- Low operation temperature
- Small operation current
- Significant reduction of the dissipated energy

1 - Kirill Poletkin - Levitation Micro-Systems: Applications to Sensors and Actuators
Methods

3D technology

- Low operation temperature
- Small operation current
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Simulation
(quasi-FEM method)

Coils
Microfabrication

- Current coils
- High frequency output

- Optimal design
- Coil eddy currents
- Electrical parameters

1 - Kirill Poletkin - Levitation Micro-Systems: Applications to Sensors and Actuators
Results

- High frequency output voltage supplier from 0 to 40 Vpp
- High frequency current (maximum peak to peak) from 0 to 400 mA
- Rectangular waveform of the current
- Frequency operation range from 8.4 to 40 MHz.

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Development

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Development

- High frequency current from 0 to 400 mA

H-bridge configuration:
- High frequency bandwidth
- High levitation coil impedance

It avoids the usage of a transformer (bandwidth limitation) and enhanced input current consumption

Experimental setup

- PCB of Control circuit
- Distance sensor (LK-G32)
- Laser spot
- Proof mass
- Cooling fan
- Optical table
- Stabilization coil
- Levitation coil

Results

- Disc shaped PM of 3.2 mm diameter
- Disc shaped PM of 2.8 mm diameter
- Square shaped PM of 2.8 mm side length

Graph showing:
- Height (µm) vs. Current (mA)
- Height (µm) vs. Voltage (V)

- ±12.6 V
- ±12.0 V
- ±11.5 V
Conclusions

- Applying a quasi-finite element method simulation:
  - The eddy current within the square shaped PM were simulated
  - The numerical analysis of the force interaction between the coils and the levitated proof mass confirms that the two coil design is the optimum design.
- A control circuit for application to inductive levitation micro-actuators was developed
- The size dimensions (60 × 60 × 25 mm) of the control circuit were comparable with ILMA setup
- The control circuit is able to generate AC current with squared shape in a range of frequency from 8 to 43 MHz and with peak-to-peak amplitude up to 420 mA.
- Successful levitation of disc shaped PM of diameters of 2.8 and 3.2 mm and, for the first time, square shaped PM of a side length of 2.8 mm.
- This fact confirmed the efficiency of the proposed circuit design and its compatibility with micro-actuation system.
Outgoings

- Miniaturization of the control circuit
- ILMA experimental setup with an array of 3D coils
Acknowledgements

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Vitor Vlnieska: vitor.vlnieska@kit.edu
Kirill Poletkin: kirill.poletkin@kit.edu

Thank you for your attention
References


