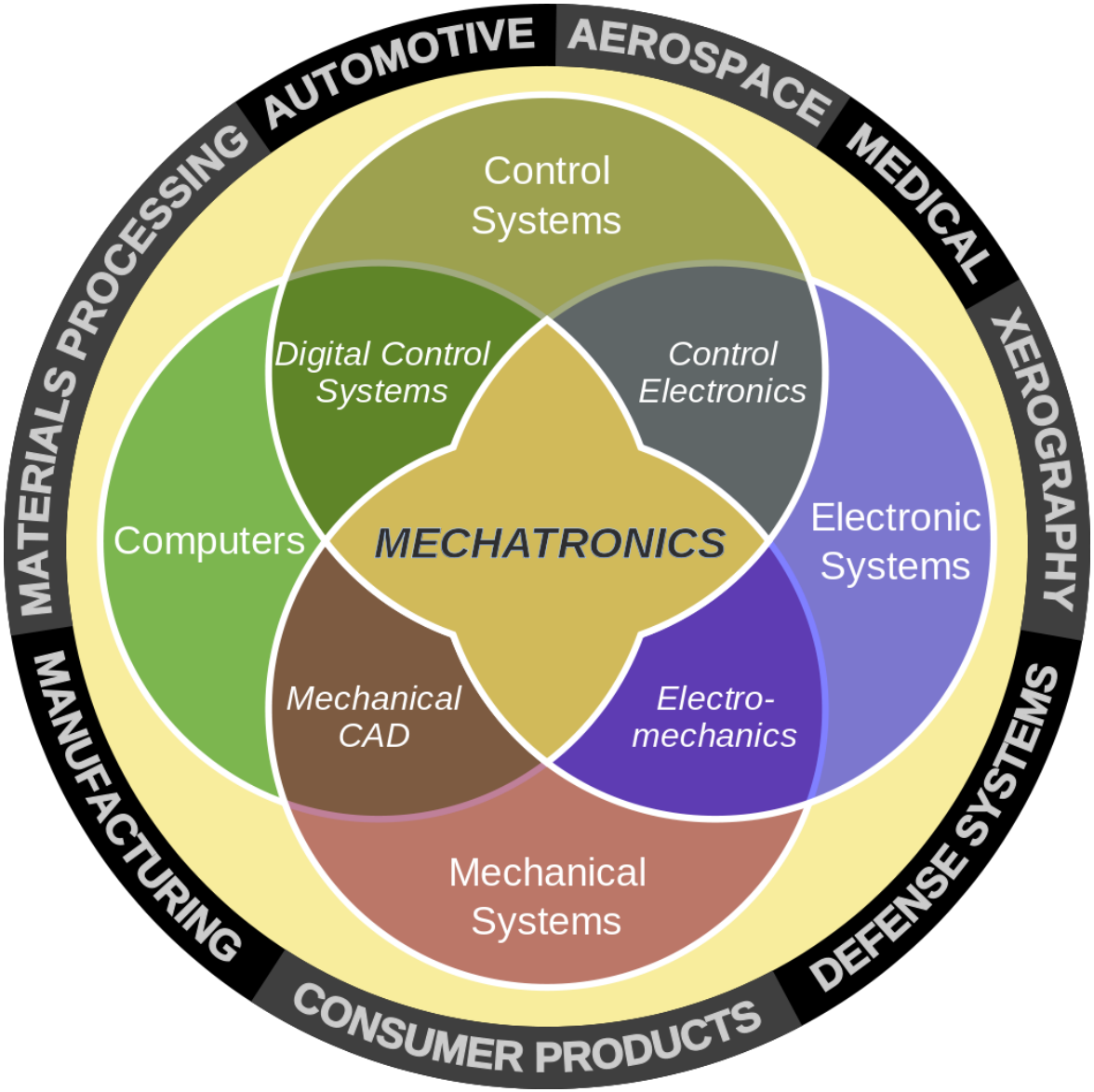
Mechatronic System Instrumentation
- MECH 421 -

Minkyun Noh

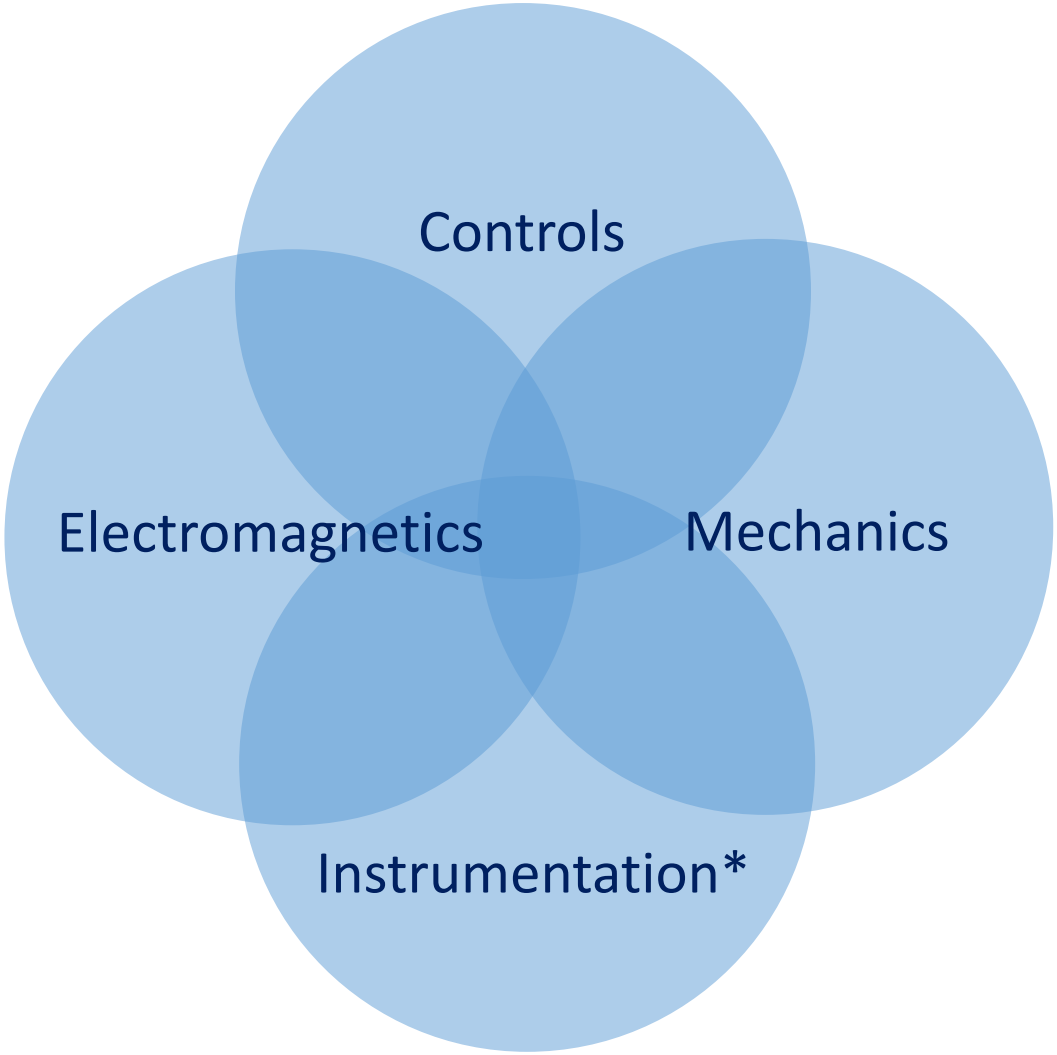
Assistant Professor
UBC Mechanical Engineering

THE UNIVERSITY OF BRITISH COLUMBIA
Mechanical Engineering

Wikipedia's View



Dr. Noh's View



* The term *instrumentation* usually connotes sensing and measurement. For mechatronic systems, we use it in a broader sense.

Q. What is this course about?

MECH 421 is about “Control and Instrumentation”

Control and Instrumentation are complementary areas of knowledge

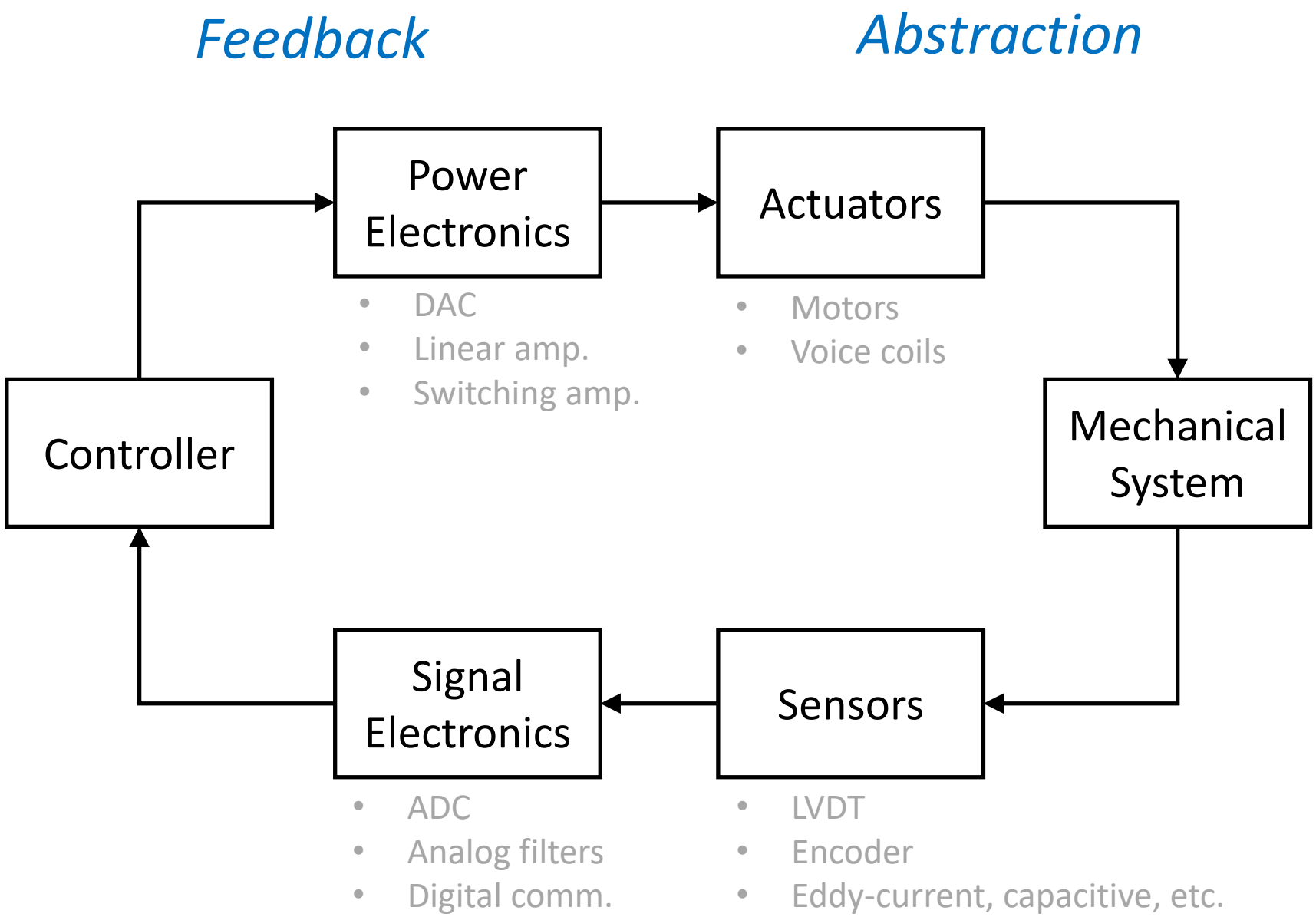
- **Control**
  :Theoretical knowledge to design and analyze mechatronic systems

- **Instrumentation**
  :Hardware-oriented knowledge to realize mechatronic systems

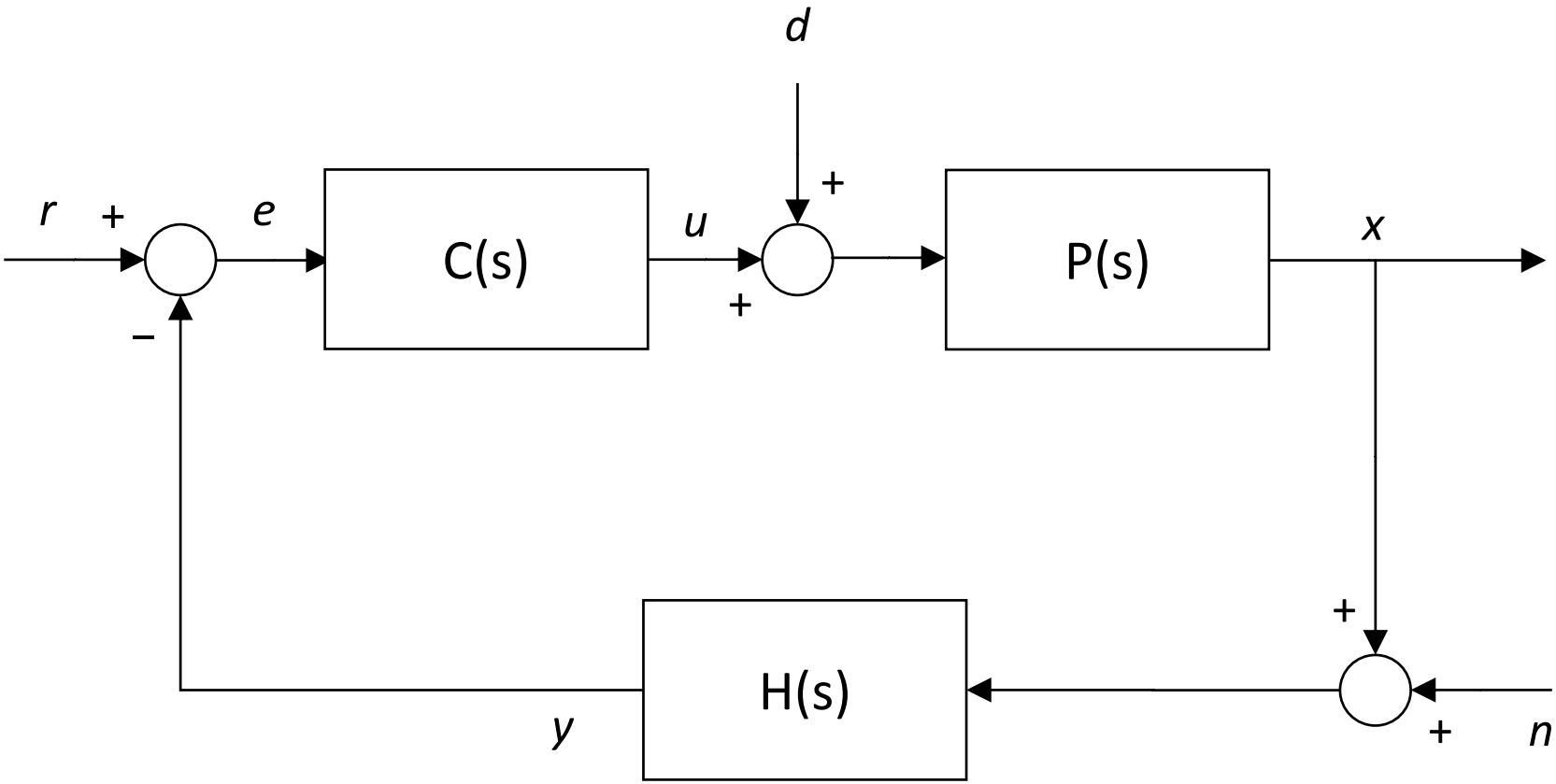
We need to understand these two to interconnect various subsystems, such as controller, sensors, actuators, and mechanical systems.

Electronics are “glue” between the subsystems.

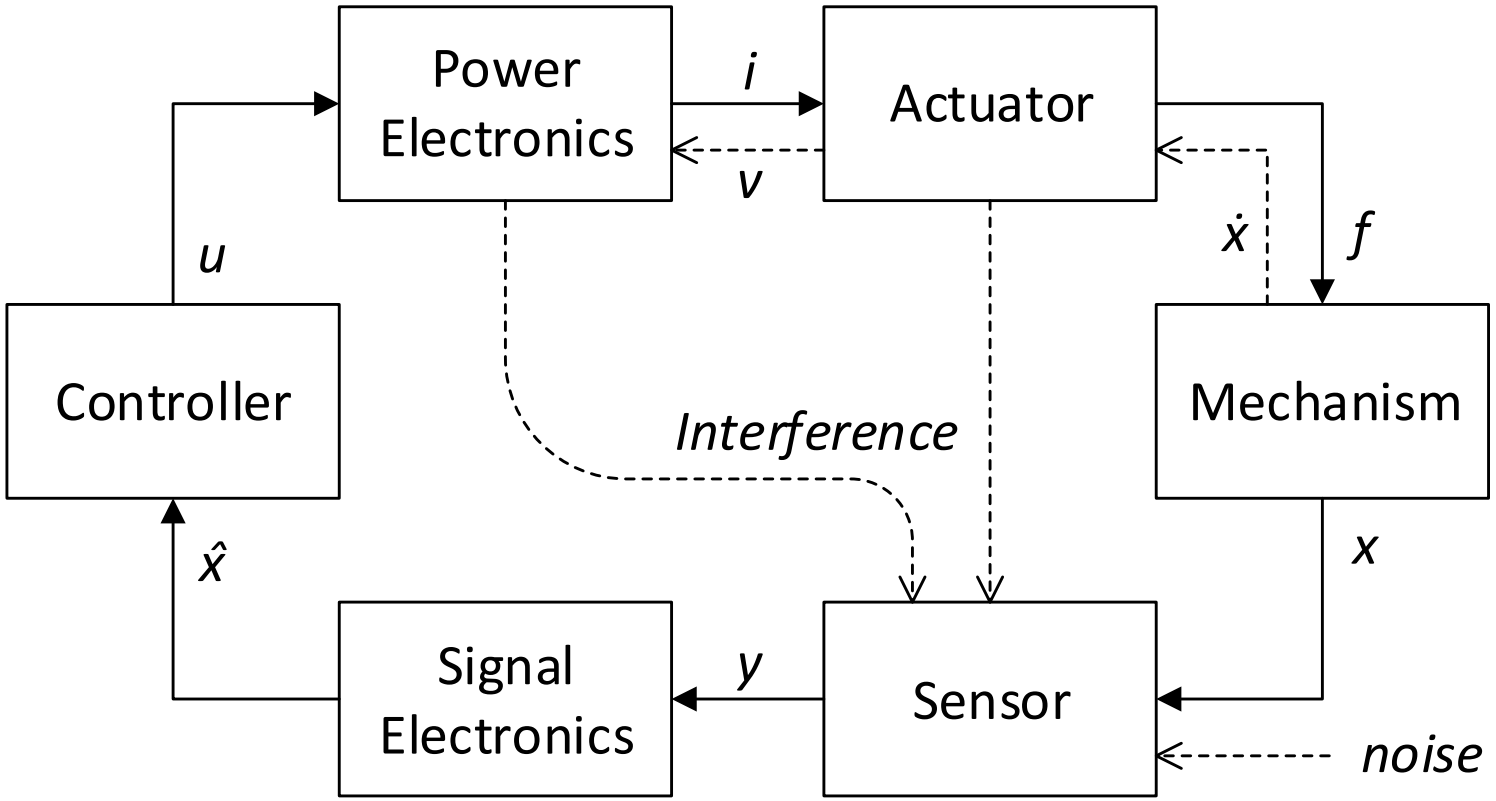
Mechatronic System



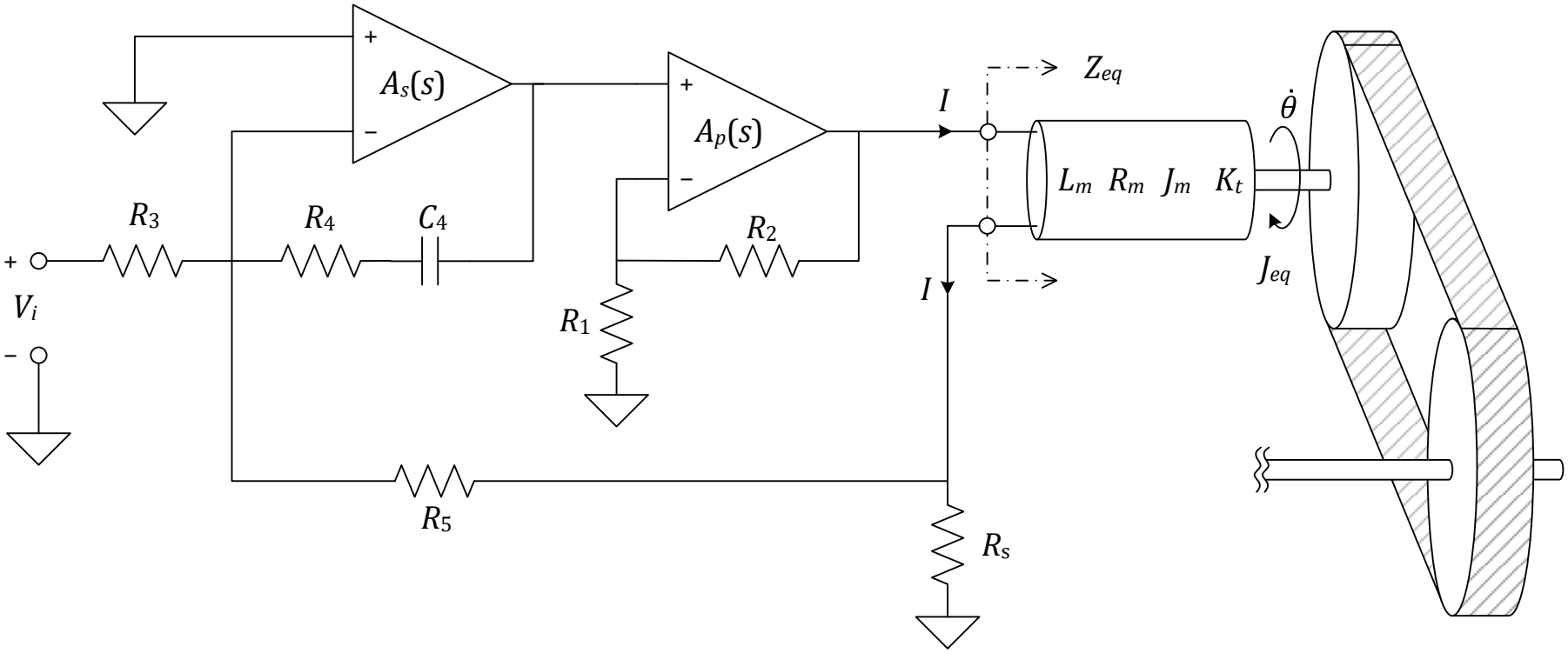
Control View



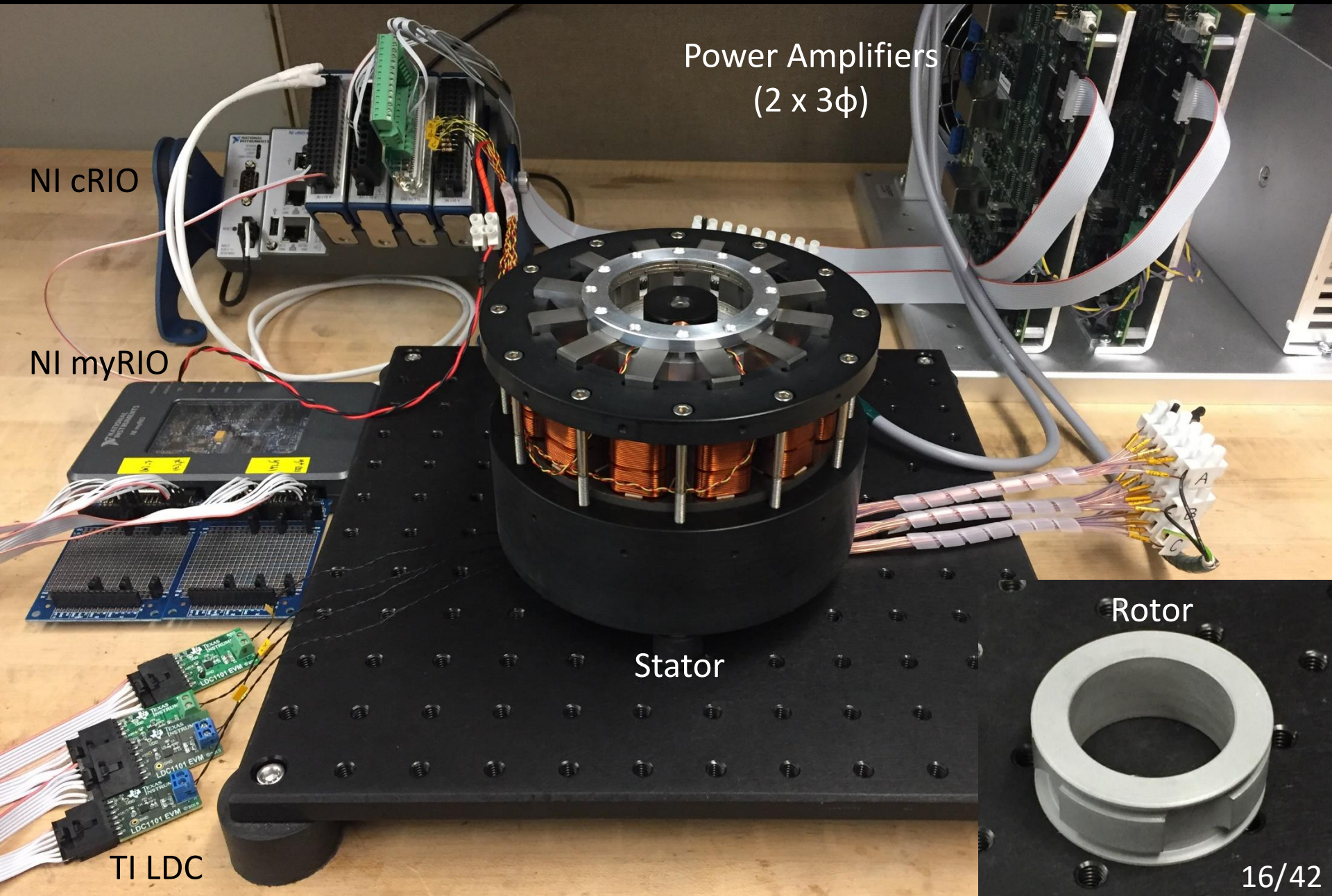
Instrumentation View



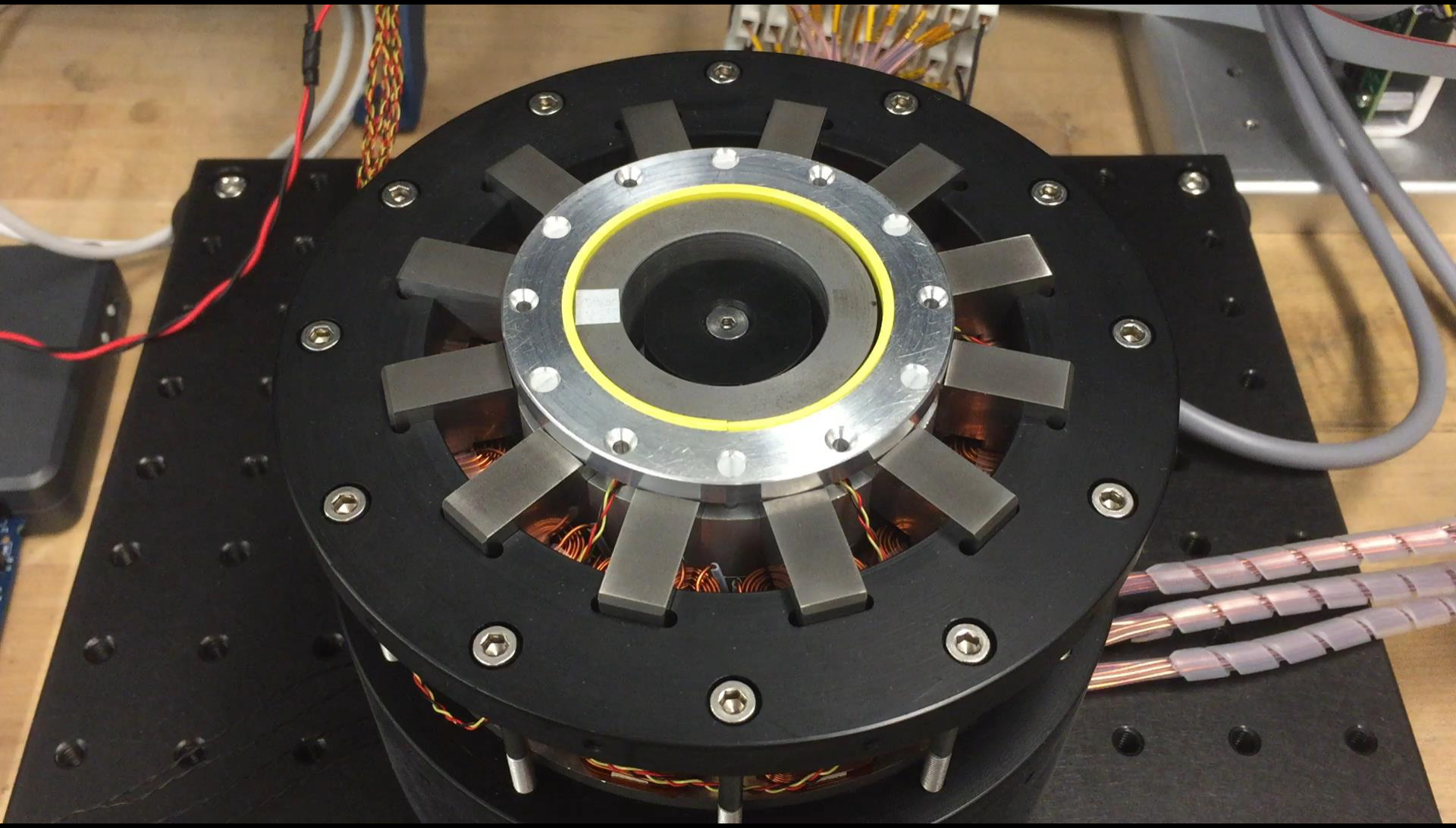
Instrumentation View +



Example: Magnetic-levitation Motor

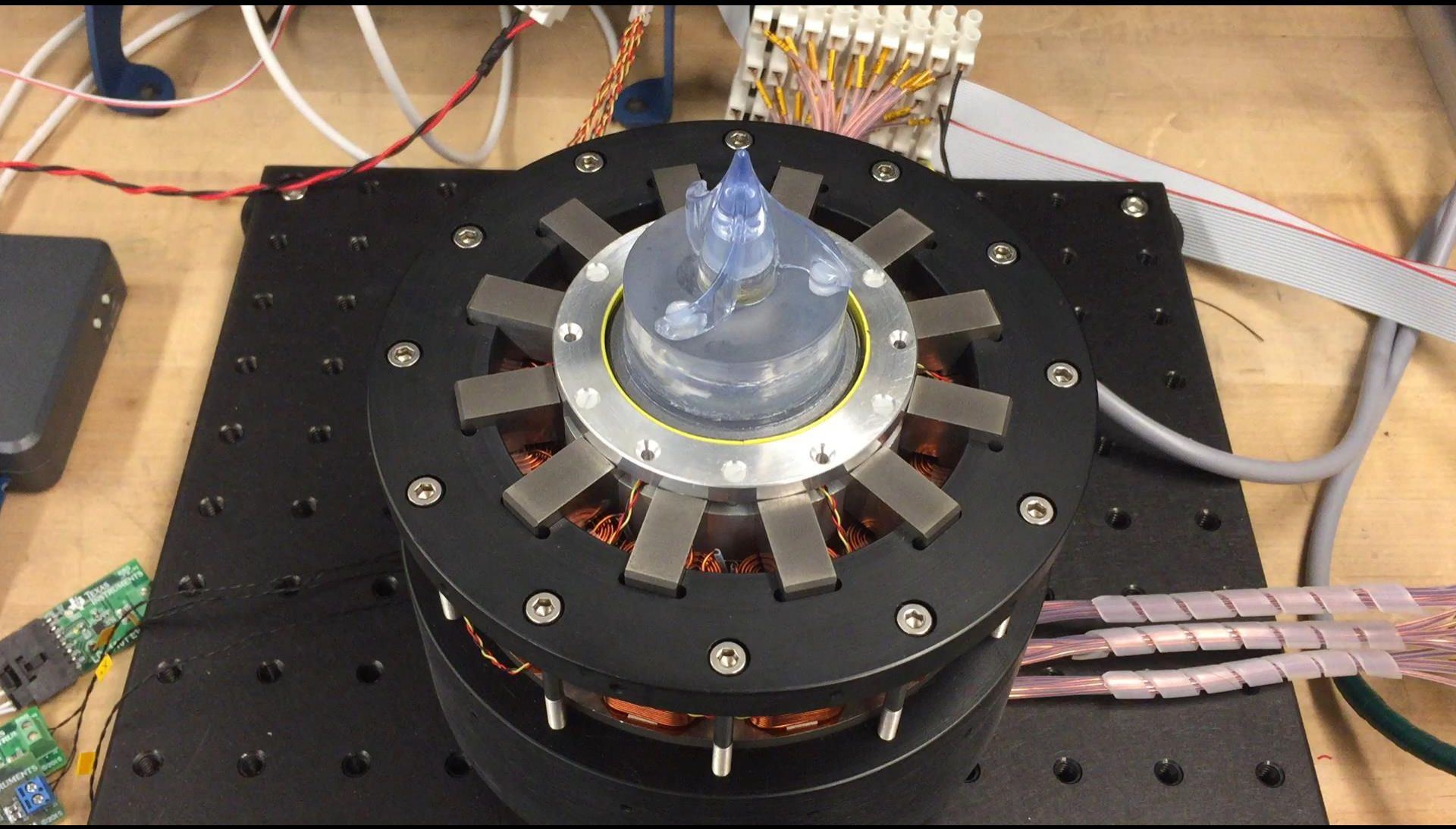


Suspension Test



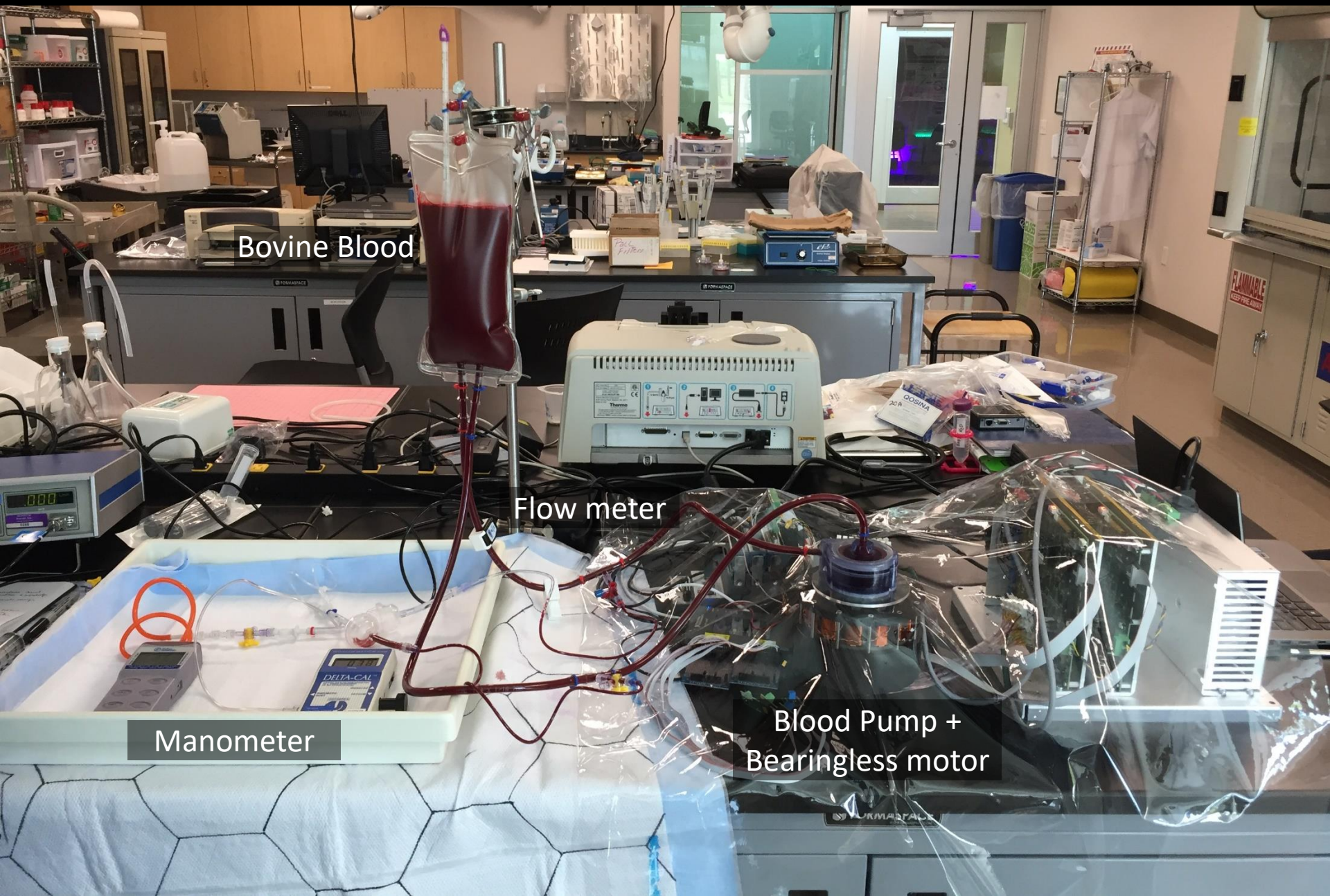
- M. Noh and D. L. Trumper, *IEEE Transactions on Industrial Electronics*, Sep. 2019.
- M. Noh *et al.*, in *Proc. 16th International Symposium on Magnetic Bearings*, Aug. 2018.
- M. Noh and D. L. Trumper, U.S. Patent Application, Dec. 2018.

Rotation Test

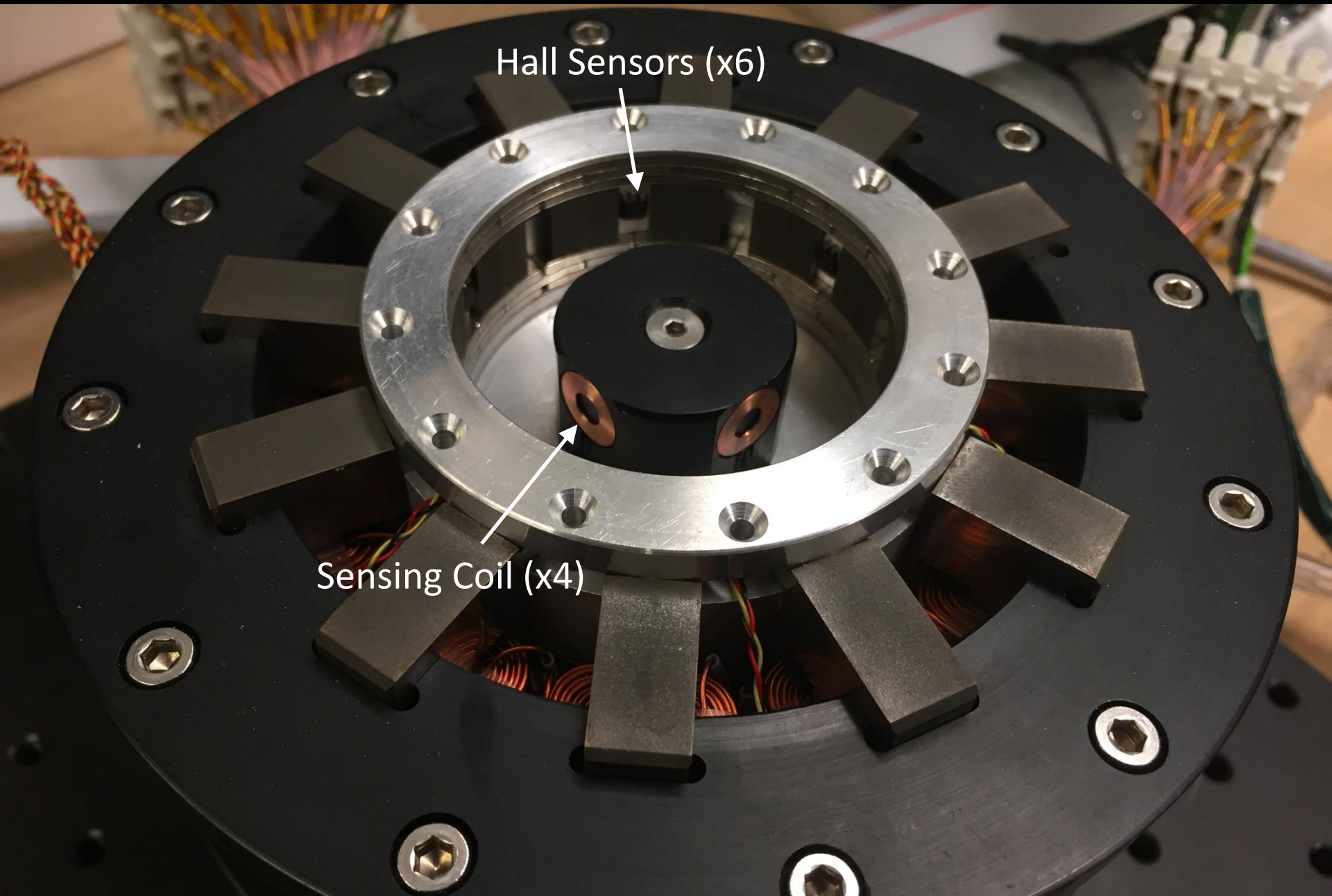


- M. Noh and D. L. Trumper, *IEEE Transactions on Industrial Electronics*, Sep. 2019.
- M. Noh *et al.*, in *Proc. 16th International Symposium on Magnetic Bearings*, Aug. 2018.
- M. Noh and D. L. Trumper, U.S. Patent Application, Dec. 2018.

Blood Pumping Test

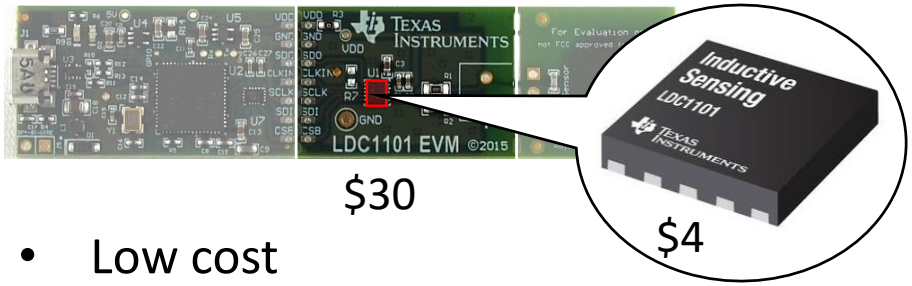


Sensor Instrumentation



Signal Electronics

Inductance-to-Digital Converter (LDC)



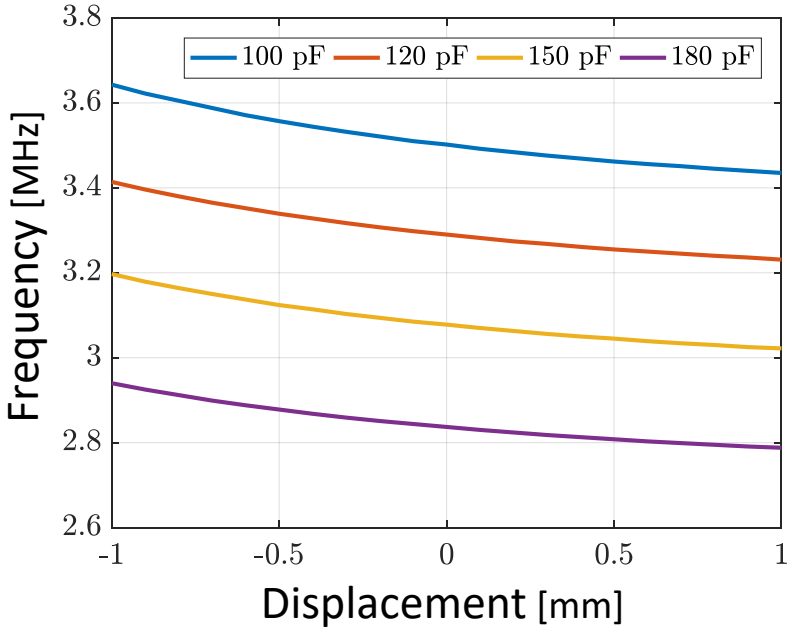
$30

$4

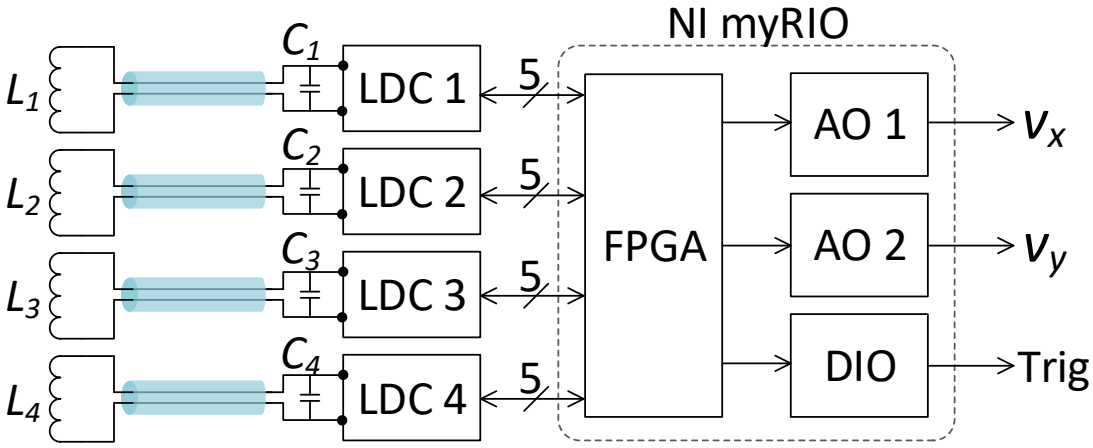
- Low cost
- Resonance frequency measurement

$$f_i = \frac{1}{2\pi\sqrt{L_i C_i}}$$

Staggered Tuning



LDC Interfacing with FPGA



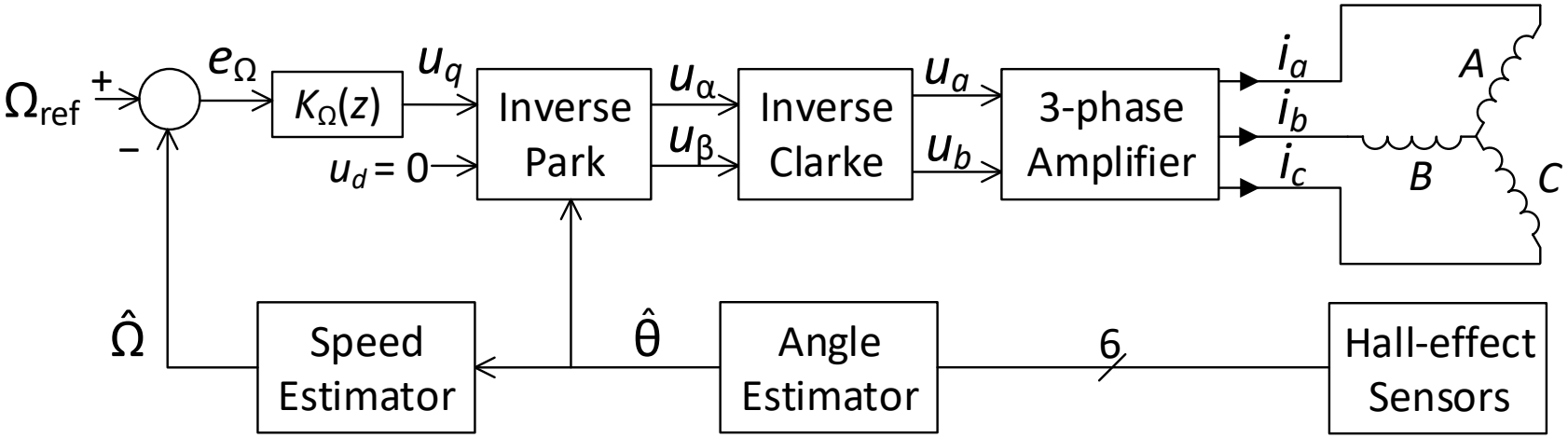
- Synchronized SPI ports (x4)
- Simultaneous sampling @2kHz
- Position signals:

$$v_x = a_x(f_2 - f_1)$$

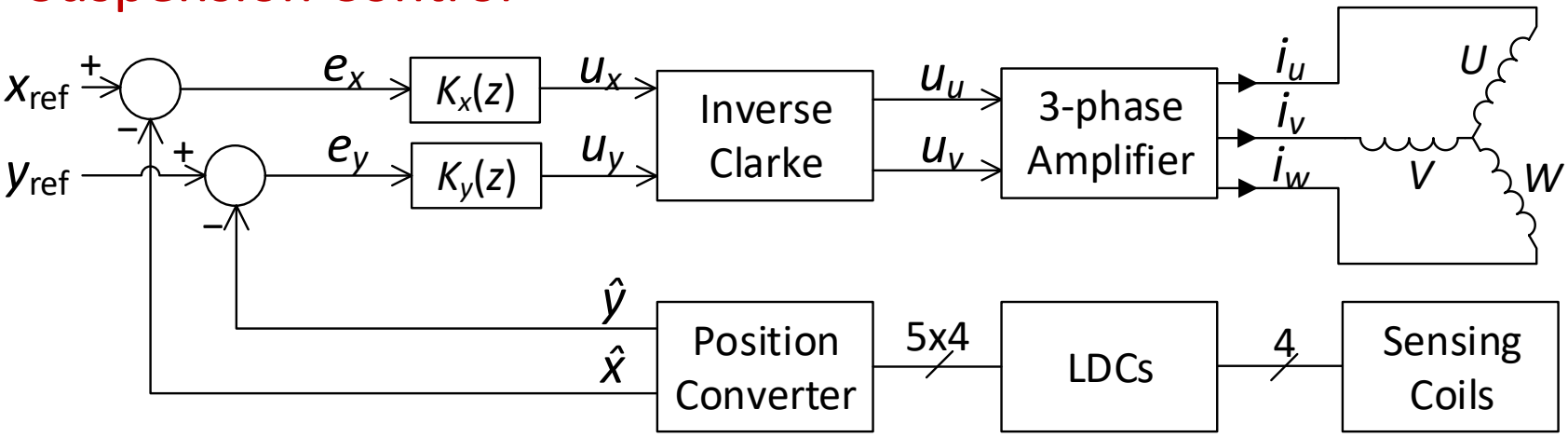
$$v_y = a_y(f_4 - f_3)$$

Controls

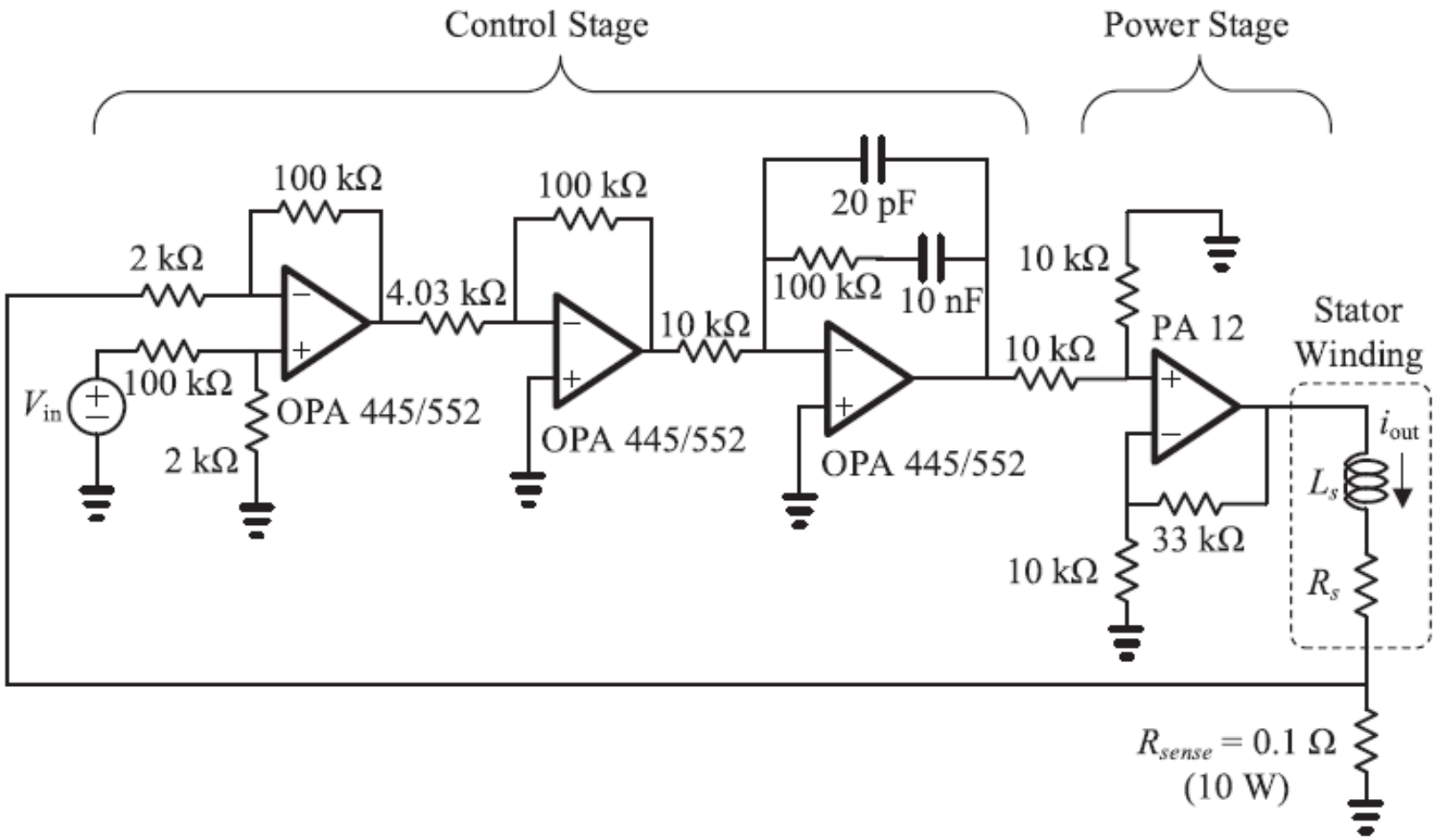
Rotation Control



Suspension Control



Power Amplifier



M. Noh et al., *IEEE/ASME Transactions on Mechatronics*, Oct. 2017

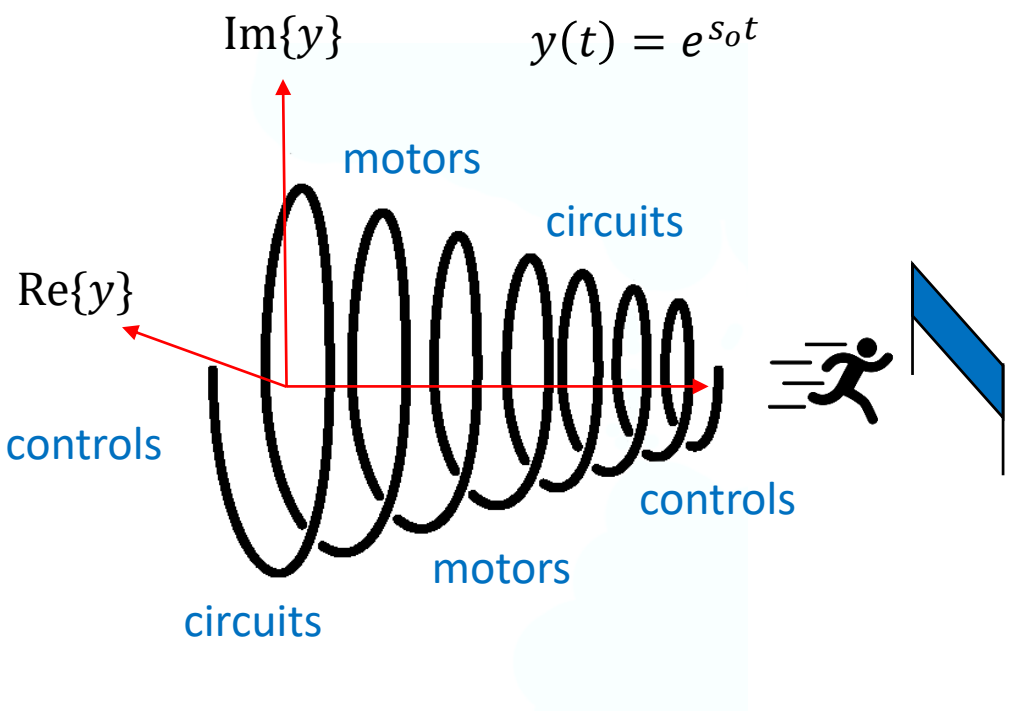
Course Contents

Circuits

- Linear circuits
- Op-amp circuits
- Power amplifier
- Differential measurement

Controls

- LTI systems
- Loop shaping
- Digital control
- Noise Filtering



Motors

- Brushed dc motor
- Brushless dc motor (permanent-magnet synchronous motor)