INSTITUT FÜR MIKROELEKTRONIK-
UND MECHATRONIK-SYSTEME

IMMS

PI Physik Instrumente

PIEZO NANO POSITIONING

PLANAR MAGNETIC 6D LEVITATING SYSTEM WITH COMPACT SENSOR

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Why does one need this?

- The main advantage of magnetic levitation is the absence of the mechanical contact
- In the result, there is no friction, no abrasive particles; lubricants are not necessary
- No friction means also no stick-slip → „nm“
- It is suitable for vacuum use

Source: youtube.com/

ISBN 978-3-00-038084-6

Our targets …

- Get into the 6D magnetic levitation technology
- Realize a traveling range of x, y, z = 100 x 100 x 0,1 mm^3 as a first step
- Minimize the effort → make it “simple”
- Realize a passive stage / no cable to the moved part
- No particle generation
- Integrate a 6D measuring system
- Reach Nanometer resolution
- Keep in mind, that the technology used should be scalable for customized designs

Source: youtube.com/

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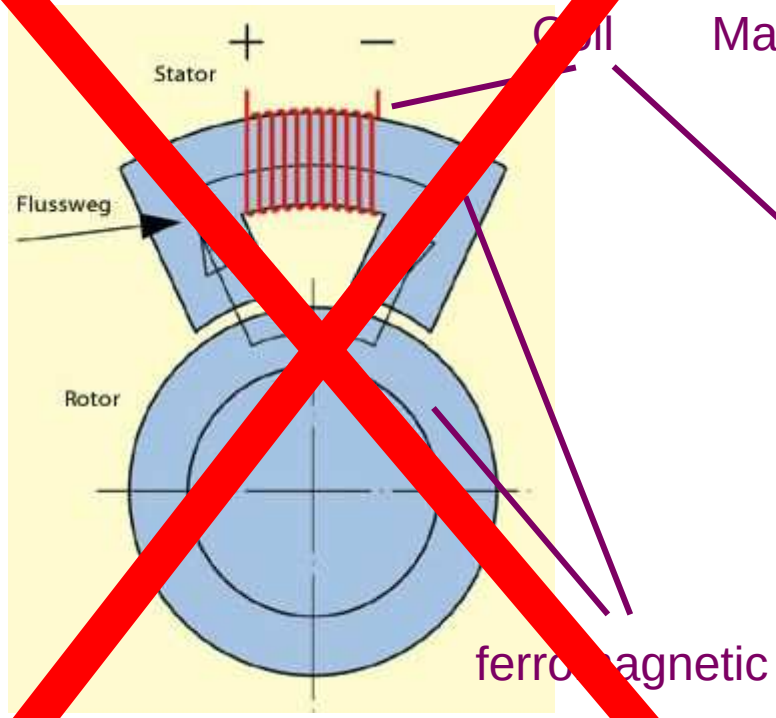
How can I magnetically levitate something?

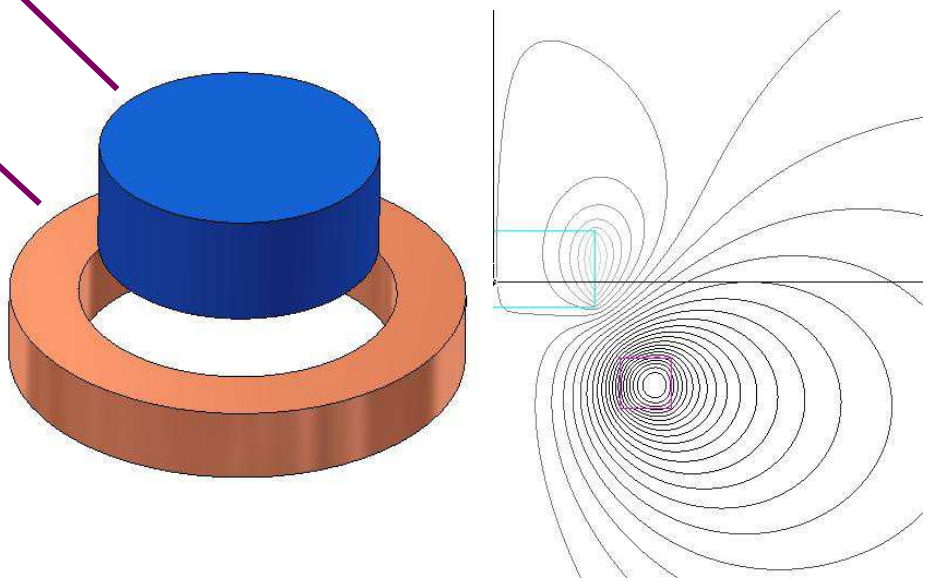
I pull from above



Source: Evolution Online 2012

Reluctance force

I push from below



Lorentz force

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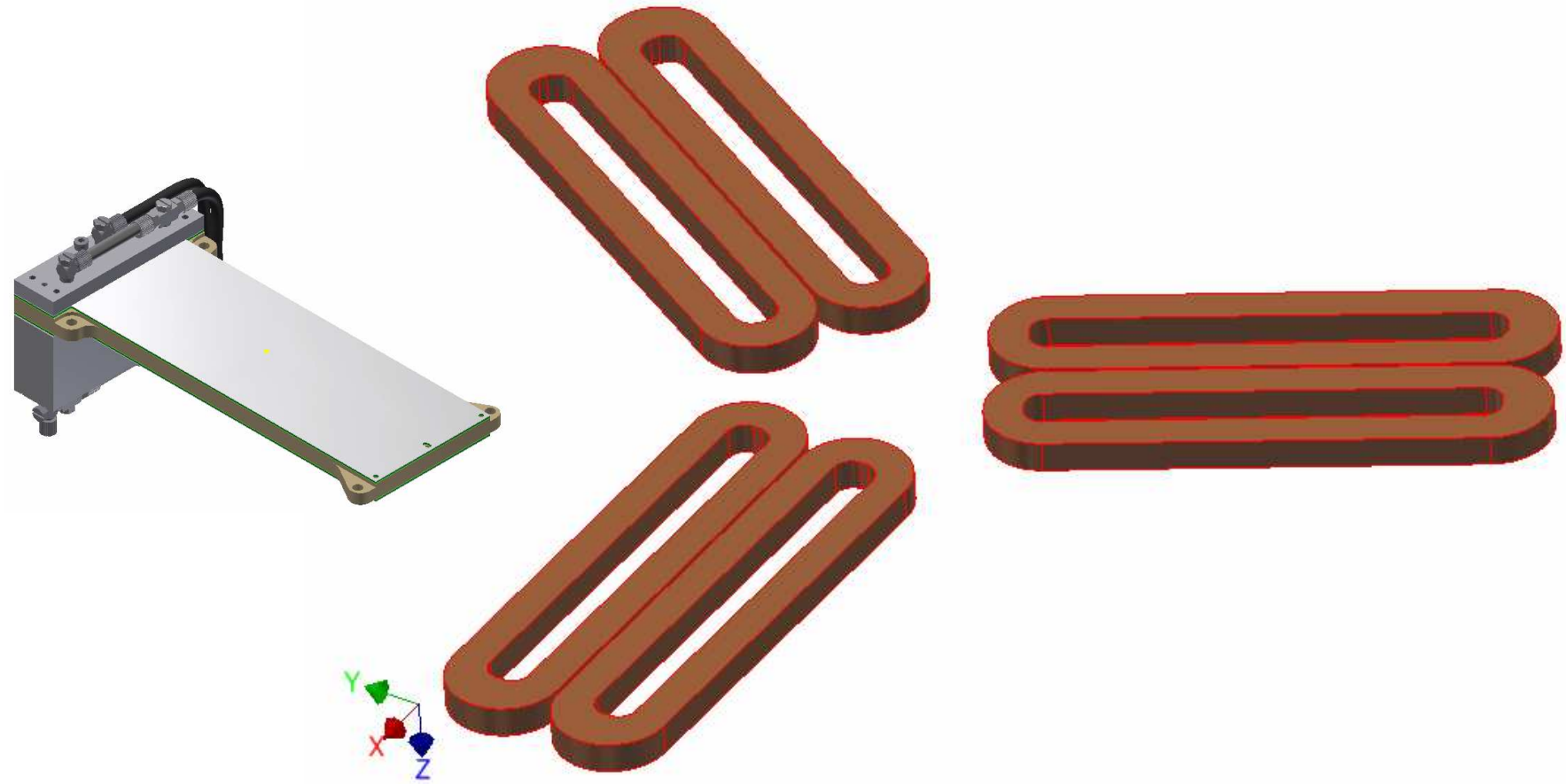
Mag6D - Platform … The Concept (1)

- 3 coil pairs placed on the stator



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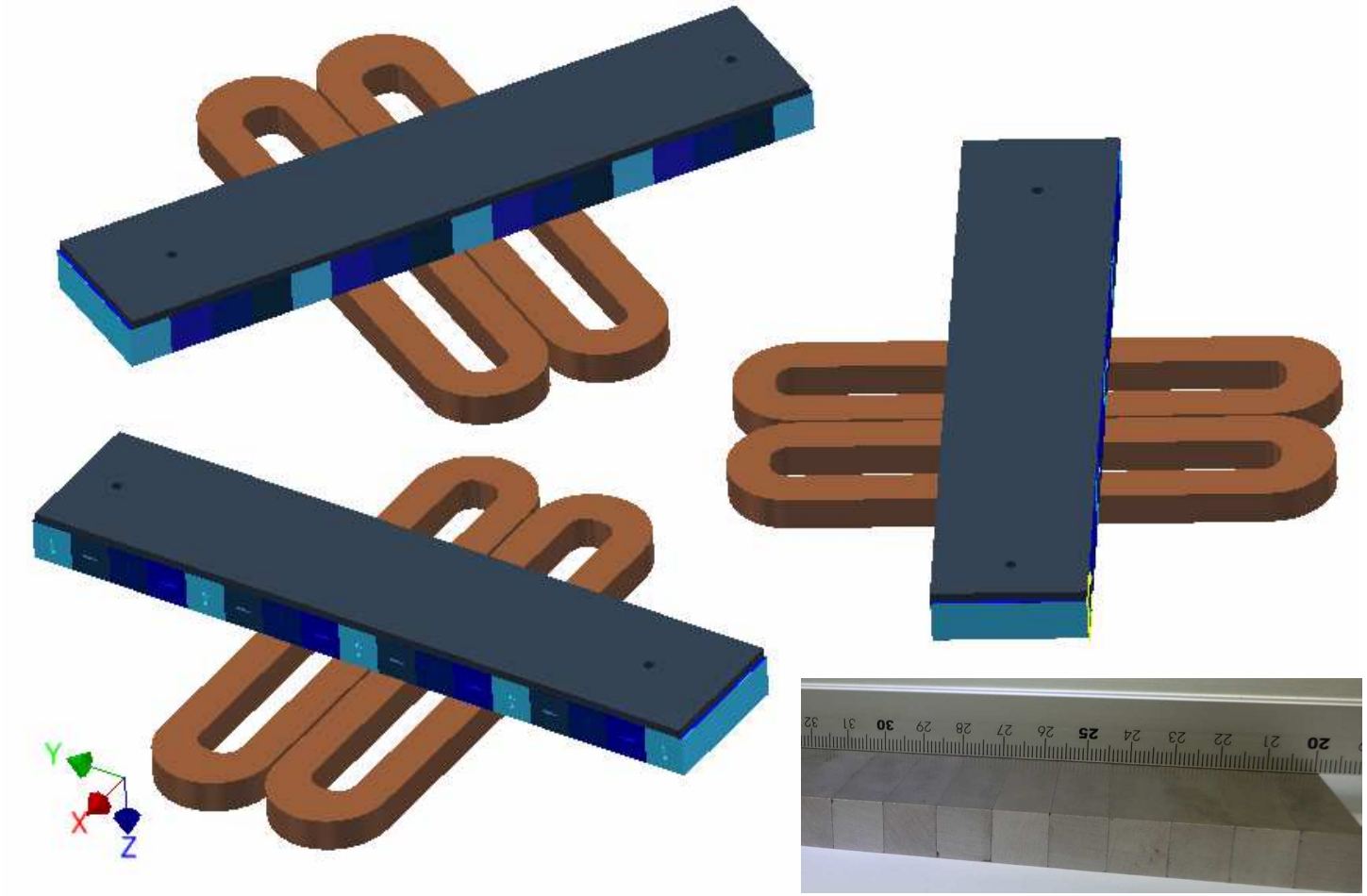
Mag6D - Platform … The Concept (2)

- 3 Halbach arrays inside the moving stage



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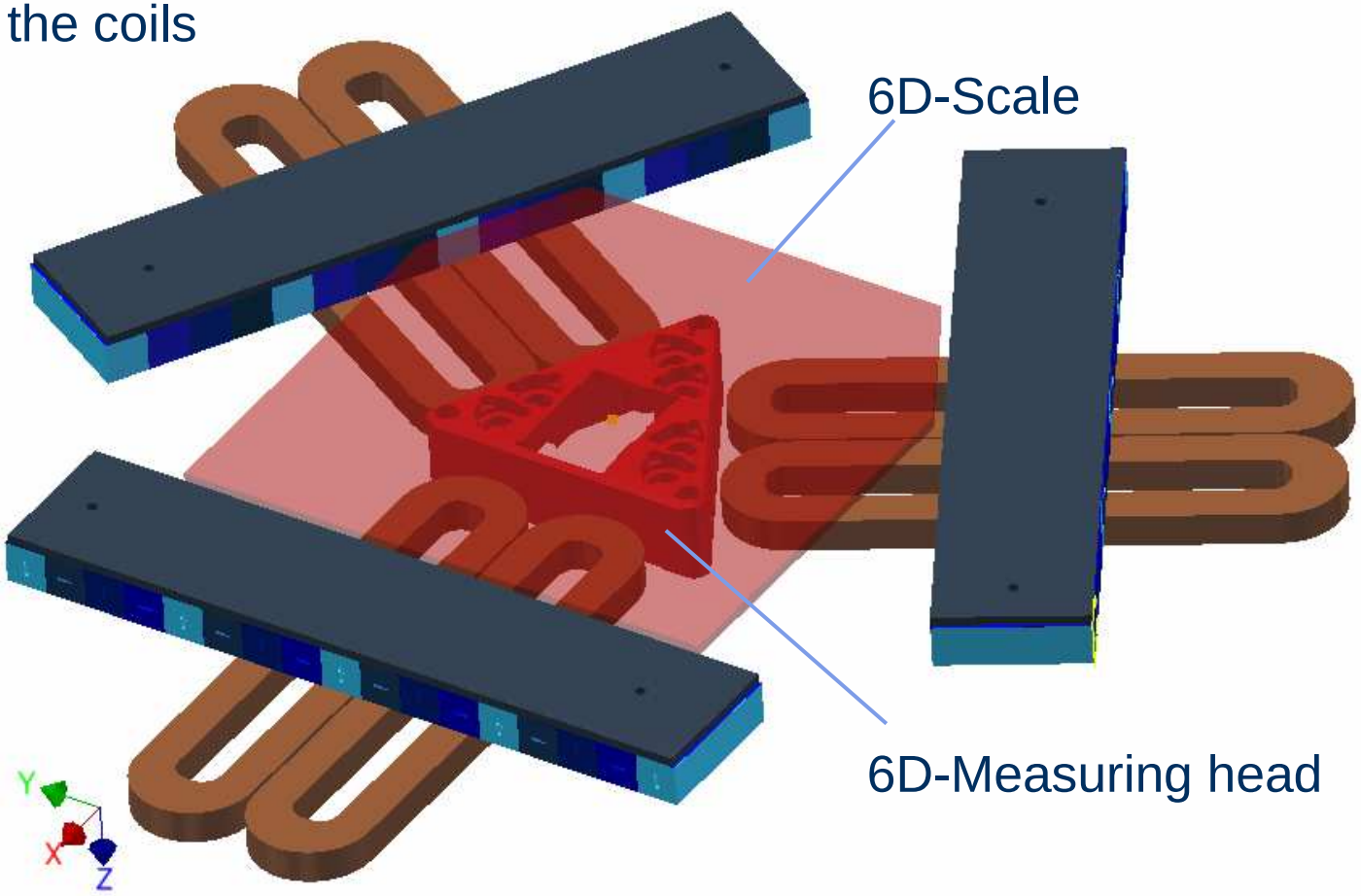
Mag6D - Platform … The Concept (3)

- Free space for a 6D-Measuring system in the center of the magnet array and the coils



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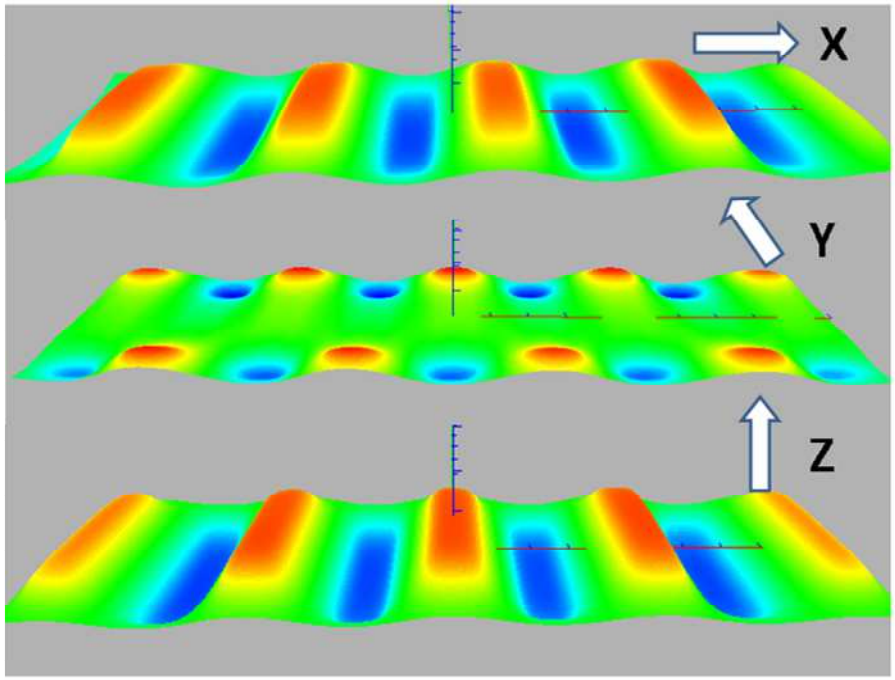
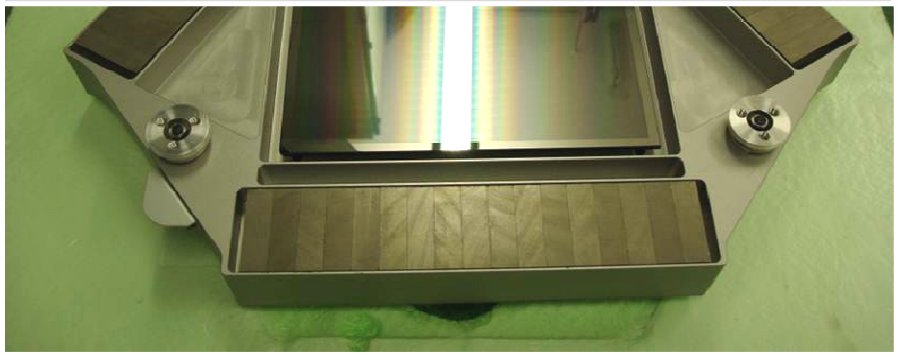
Halbach Array

Advantage:

- Strong magnetic field components on one side of the array
- Strong horizontal field components (for lifting)
- 90 degree phase between the two field components
- Low stray field behind the Halbach array





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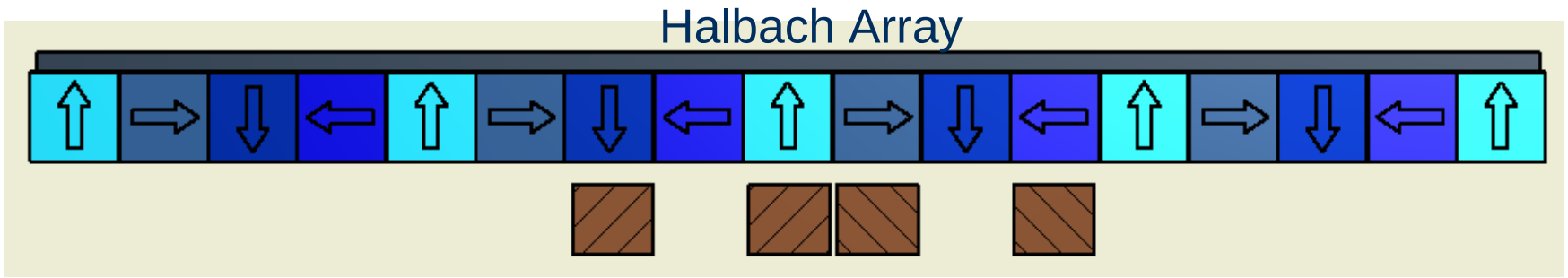
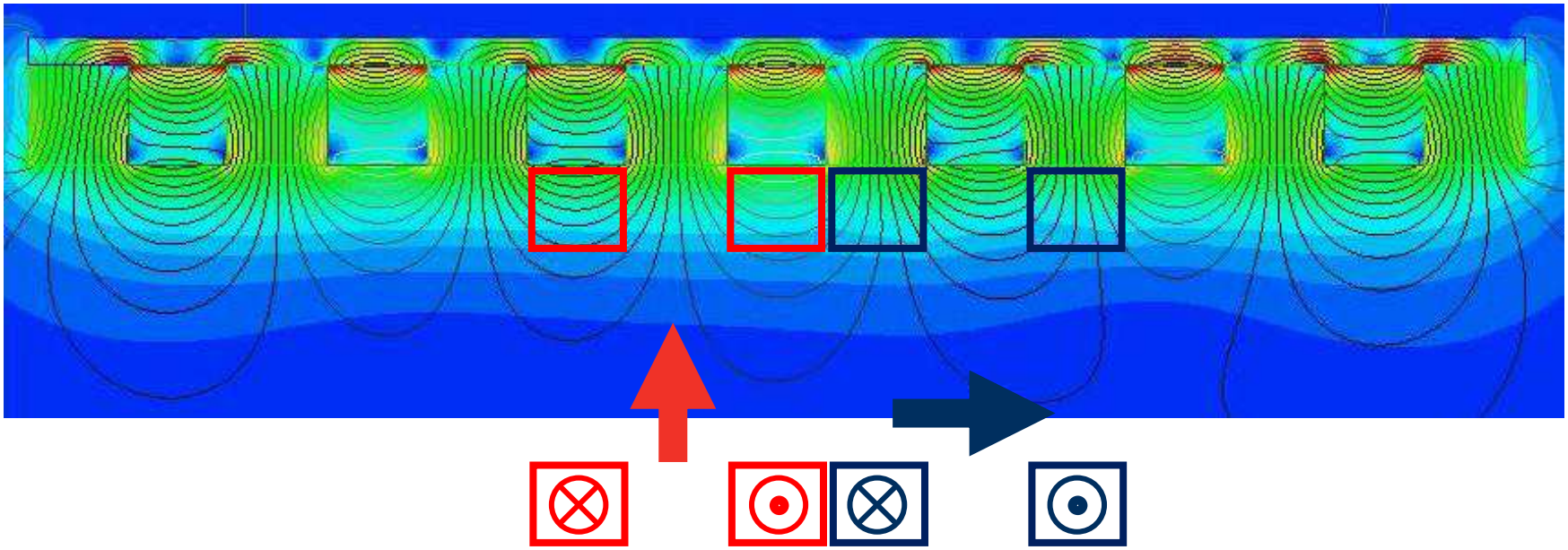
Mag6D - Platform … Modules → Actor & Guidance (1)





$F_{vertical}$ $F_{horizontal}$

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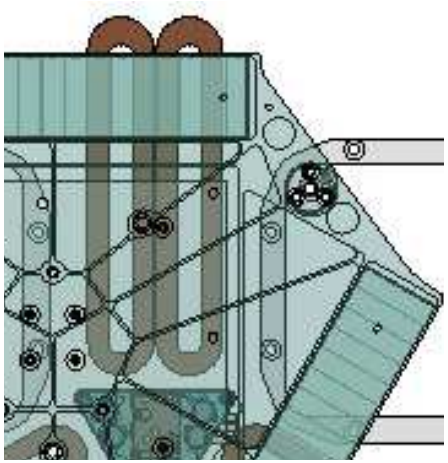
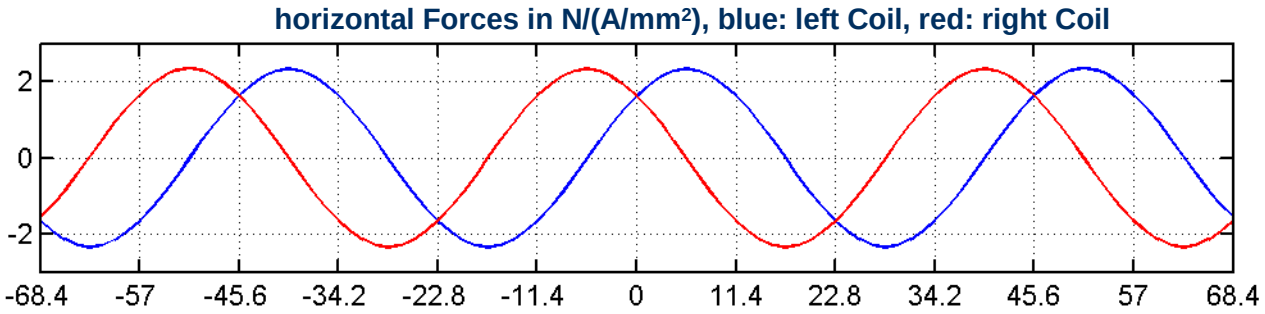
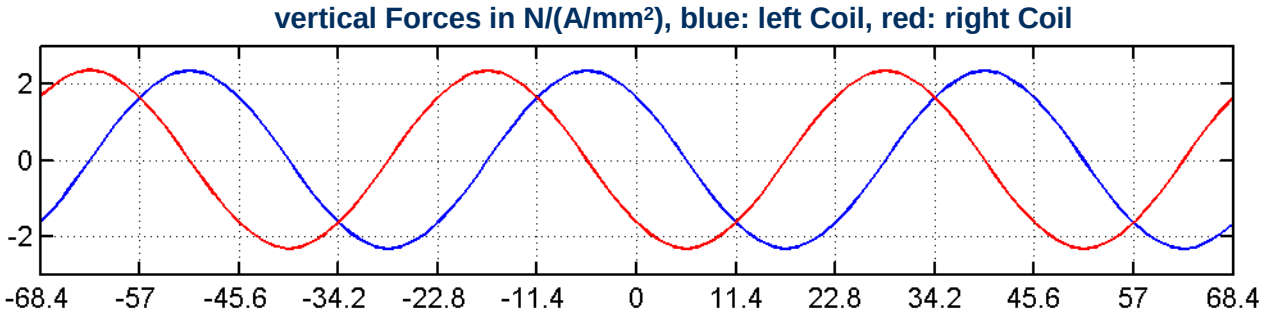
Mag6D - Platform … Modules → Actor & Guidance (2)

- Position dependent commutation of 3 coil pairs allows the generation of 3 independent lifting forces in vertical direction and 3 independent driving forces in horizontal direction.
- Resulting in a **6D-Drive system** with only 6 actor coils







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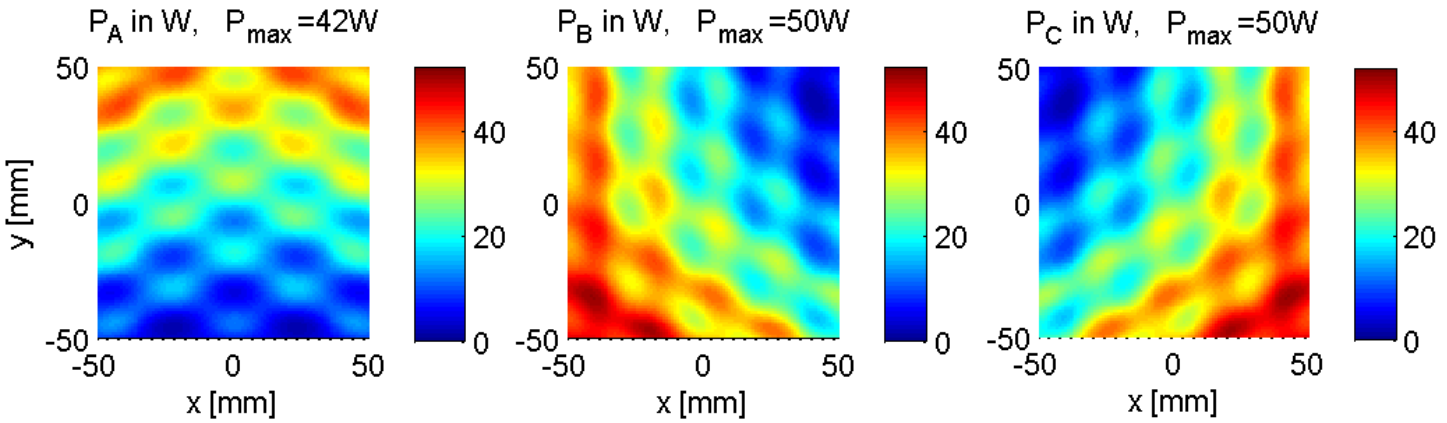
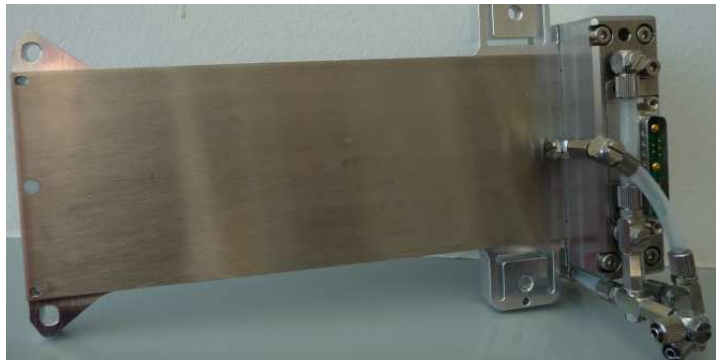
Mag6D - Platform … Modules → Cooling (2)

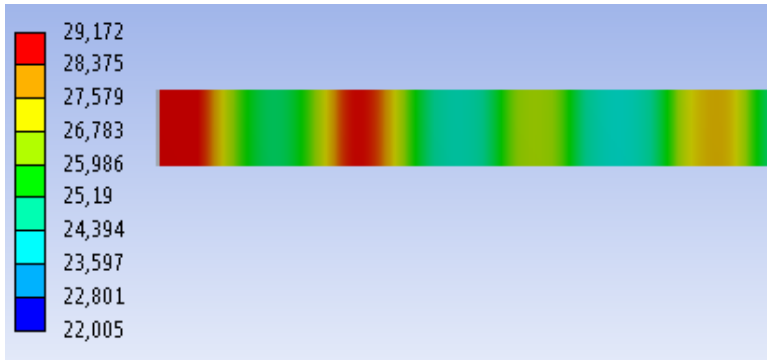


New Design!

Power loss per coil pair vs. slider position



Coil pair with housing



Temperature at top side

(Simulation result worst case)

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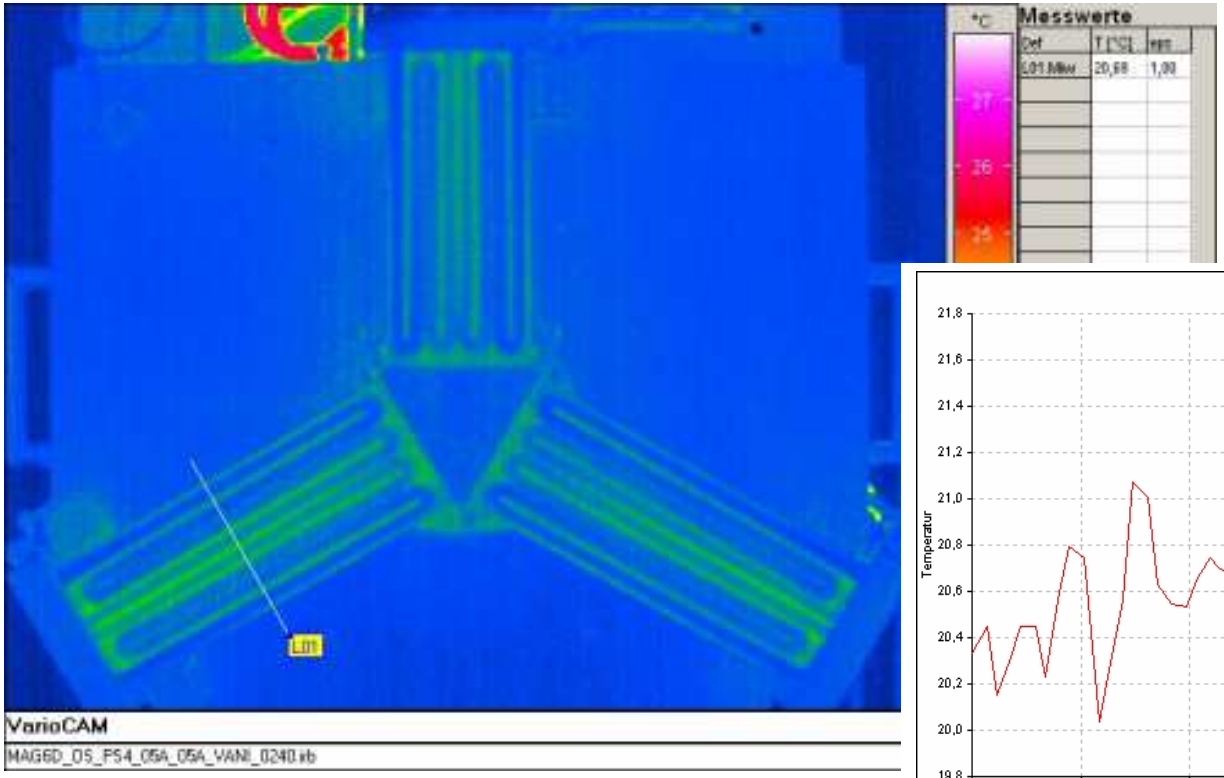
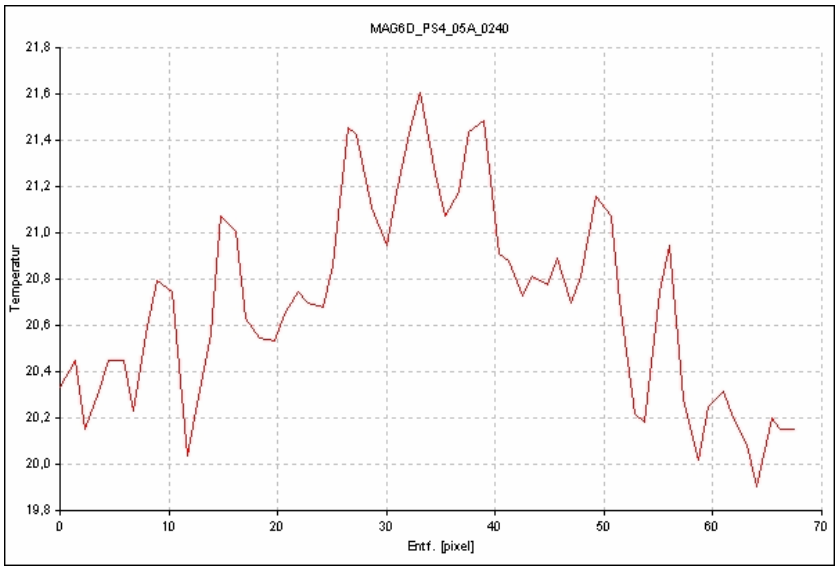
Mag6D - Platform … Modules → Cooling (3)





Temperature rise due to a power loss of 40 W per coil after 1 hour

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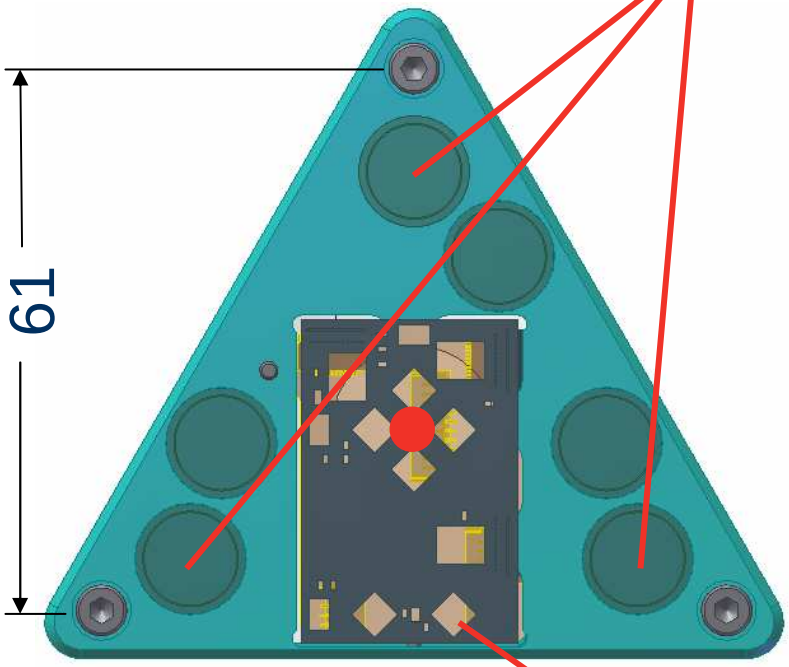
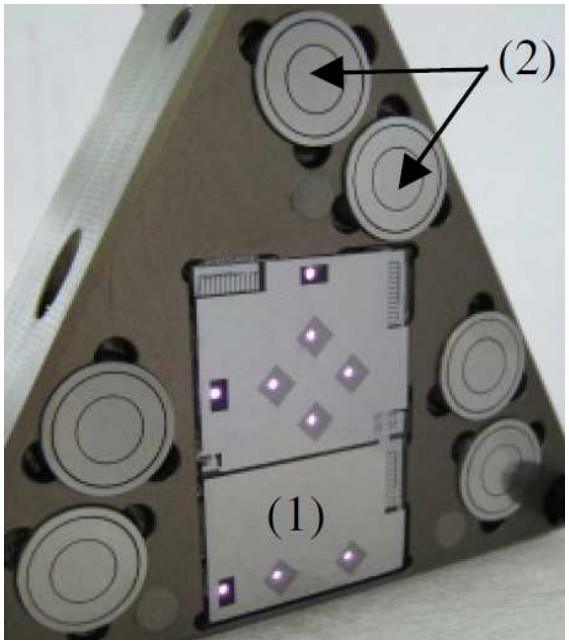
Mag6D - Platform … Modules → 6D-Measuring system

3 z-Sensor pairs (2) concentrically arranged around the center of the x-y-r_z-Sensor





Optical incremental x-y-r_z-Sensor (1)

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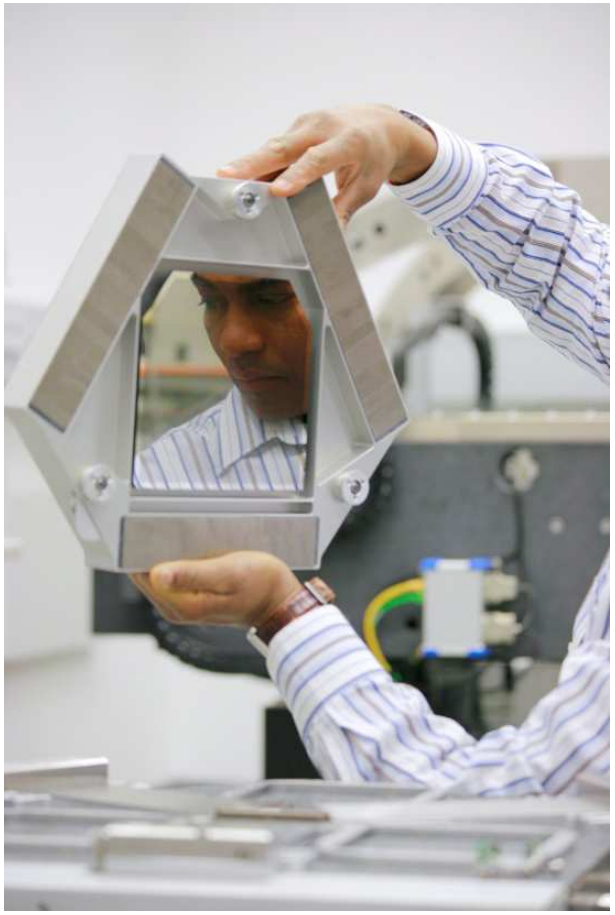
Mag6D - Platform … Parameters

- x,y: 100 x 100 mm²
- z: ± 50 µm
- $r_{x,y}$ ± 70 arcsec
- r_z ± 0,25°
- $Res_{x,y,z}$ 10 nm
- $v_{x,y}$ 100 mm/s
- $a_{x,y}$ 2 m/s²



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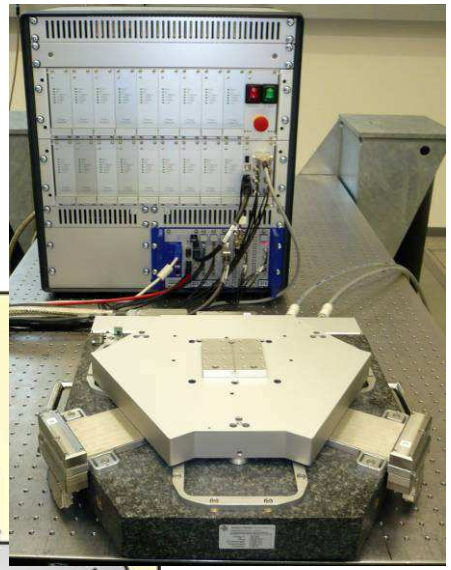
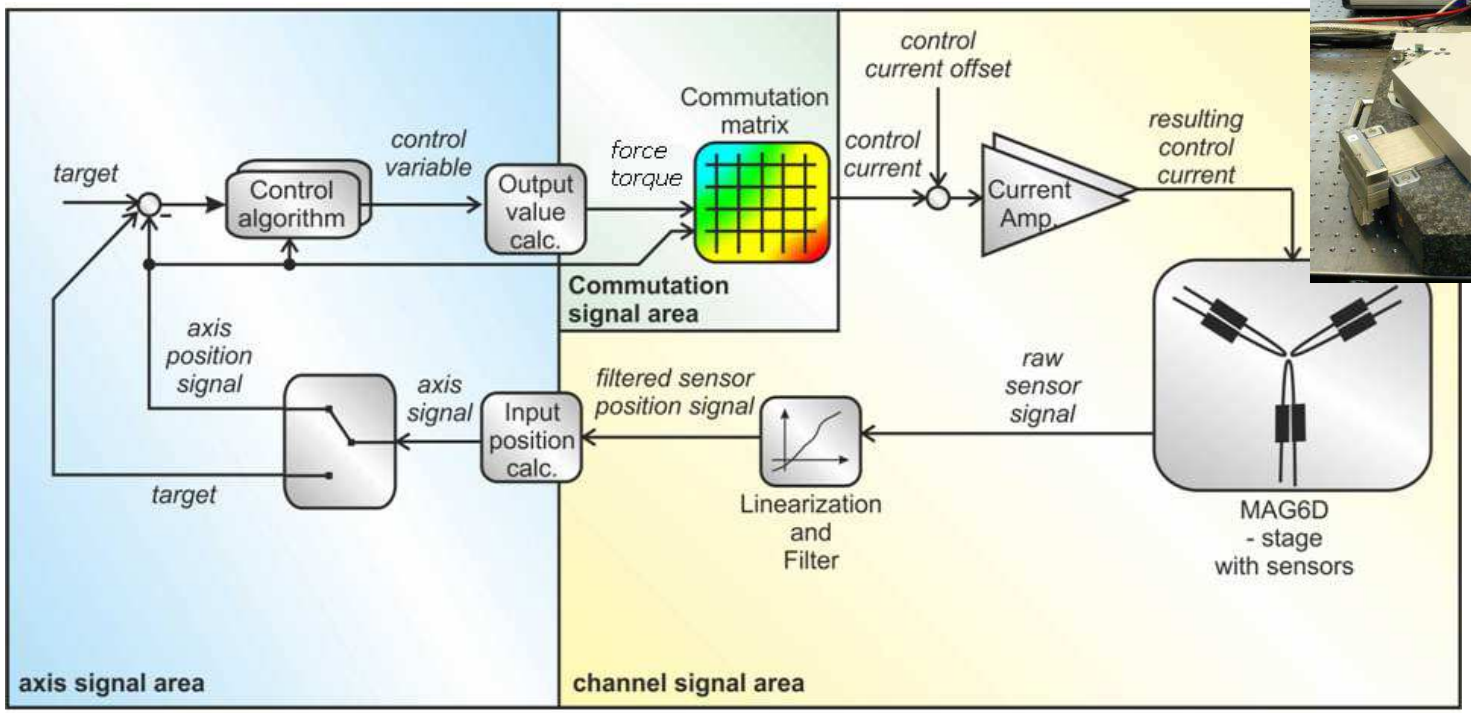
The electronics - base on PI standard controller E-712





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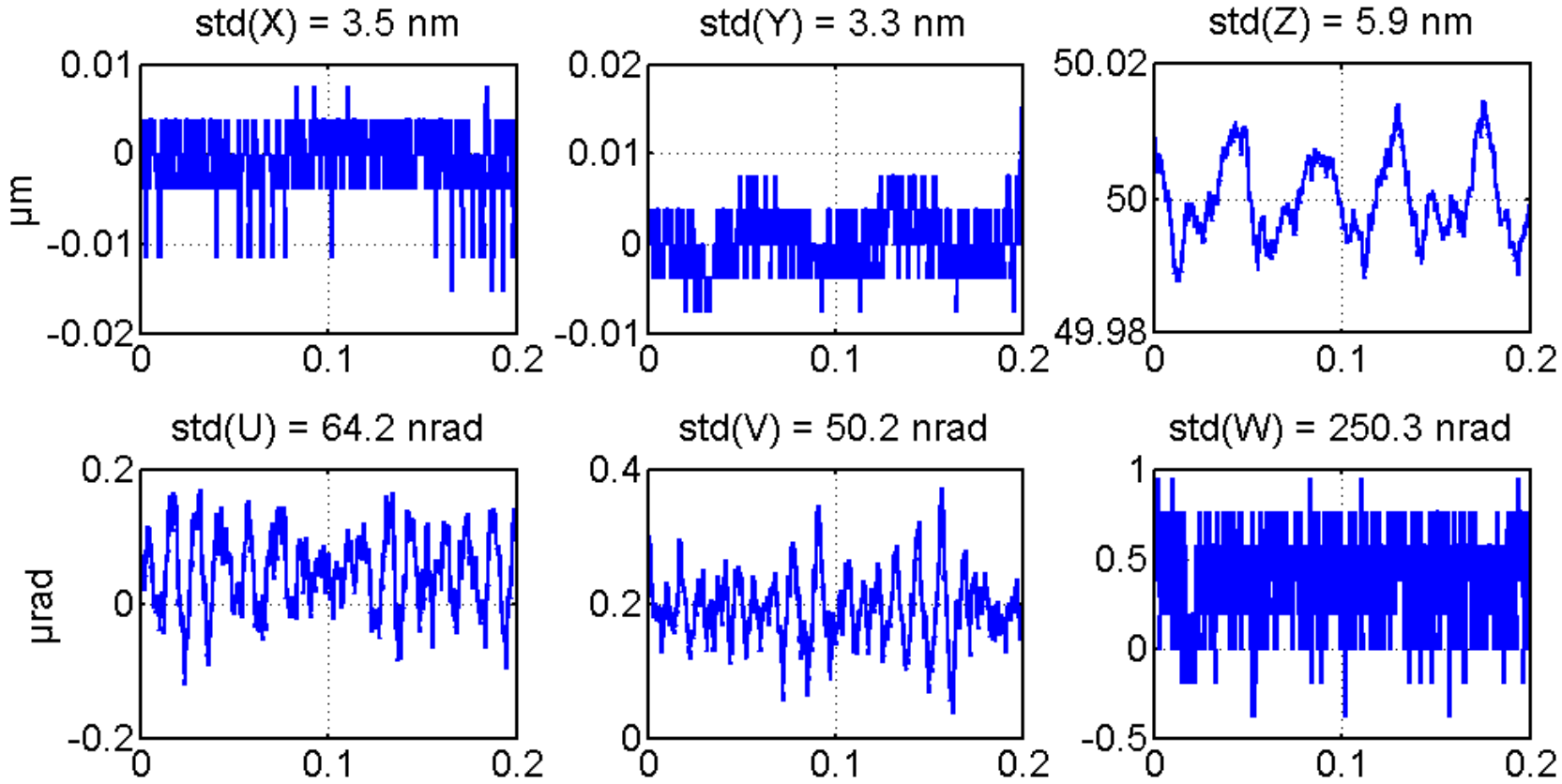
Mag6D - Platform … Performance (1)



Position stability at position x=y=0, z=50µm; u=v=w=0

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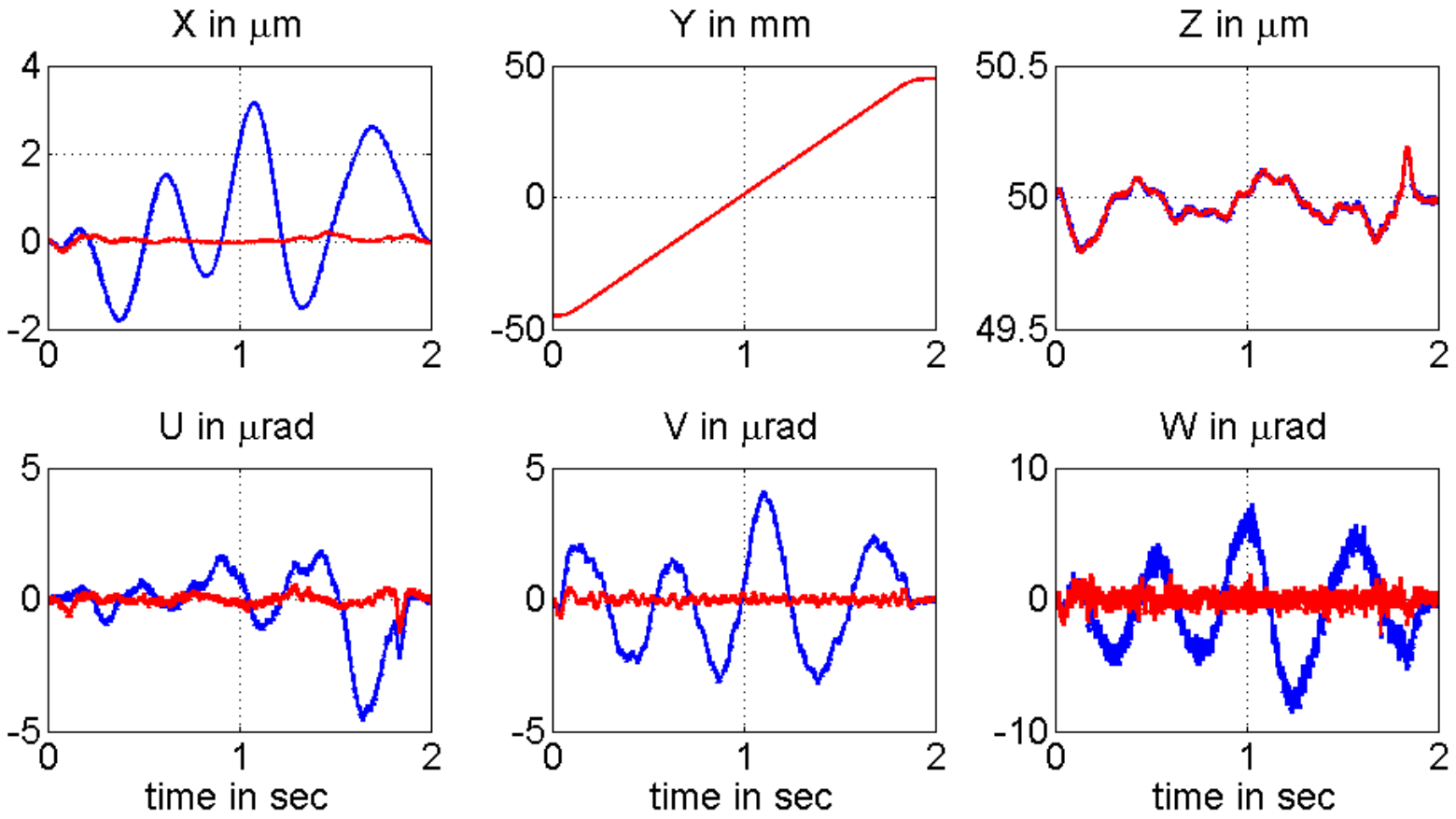
Mag6D - Platform … Performance (2)



Horizontal movement with 50 mm/s without (blue curves) and with correction matrices (red curves)

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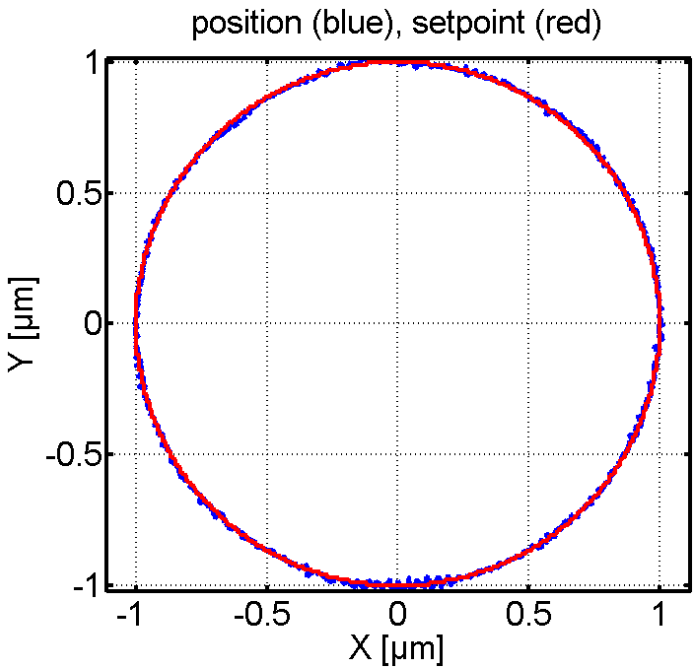
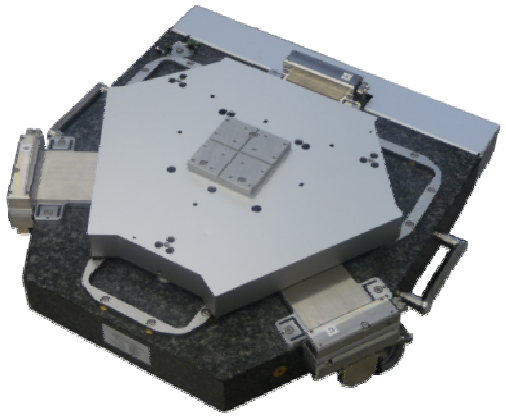
Mag6D - Platform … Performance (3)





r = 1 µm; v= 6.28 µm/s

Circle in the x-y-plane

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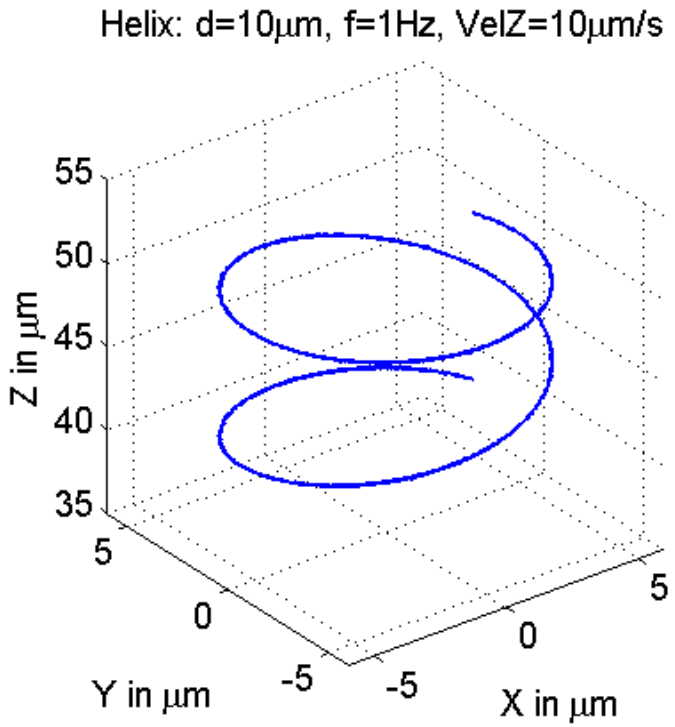
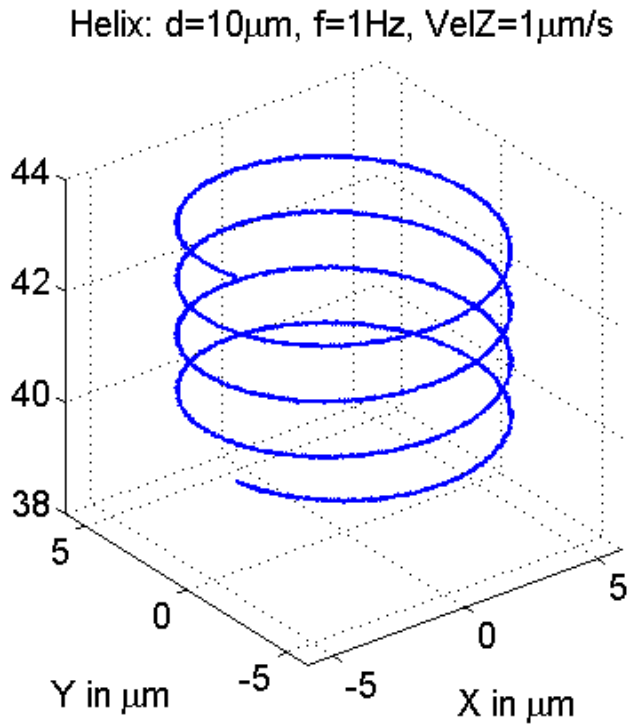
Mag6D - Platform … Performance (4)





v_z= 10 µm/s v_z= 1 µm/s

Helix movements with a diameter of 10 µm and different z-velocities

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Mag6D - Platform … for High-Tech Markets

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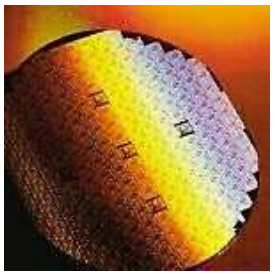
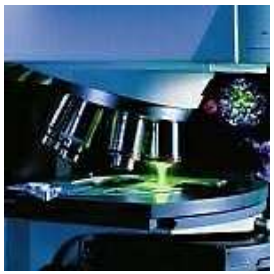
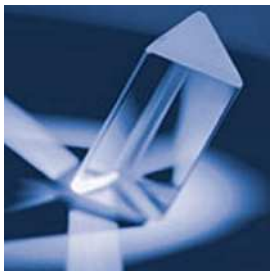


Semiconductor technology

Data storage technology



Microscopy



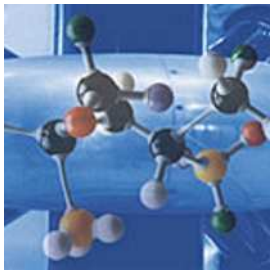
Metrology / laser systems

Life science / biotech

Photonics/ optics

Precision machining

Automation / handling



Nano-technology

Astronomy / aeronautics

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