A high-speed motor for satellites

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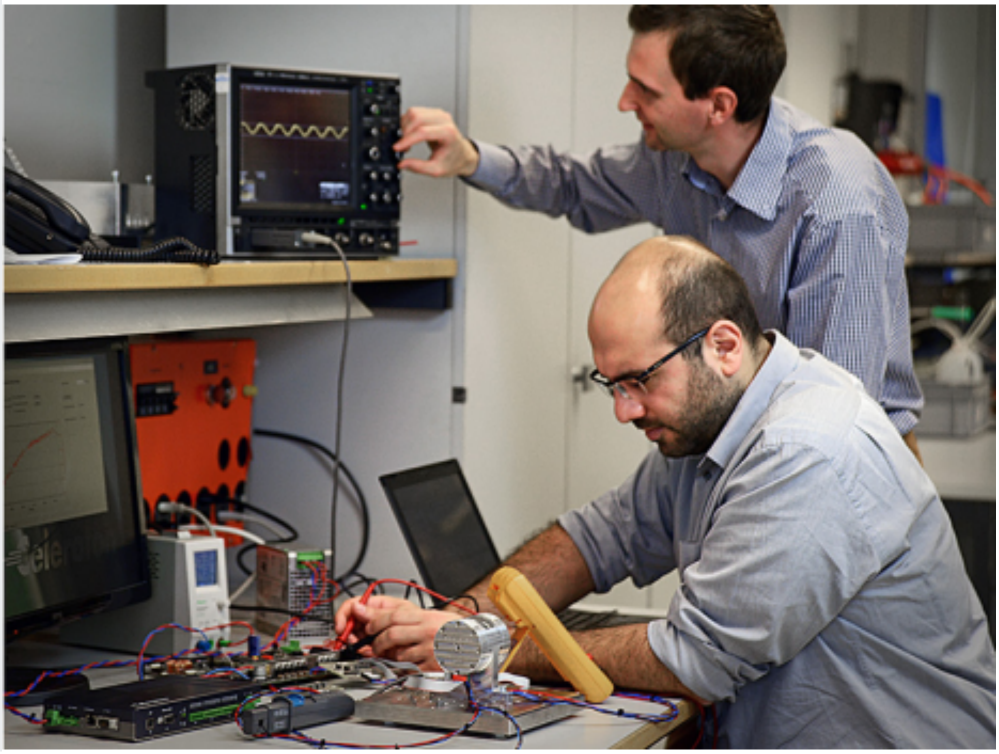
By: Peter Rüegg

A dizzying 150,000 revolutions per minute: researchers from ETH Zurich (Department of Information Technology and Electrical Engineering) and the ETH spin-off Celeroton have developed an ultra-fast magnetically levitated electric motor for reaction wheels. The high speed of rotation allows intensive miniaturisation of the drive system, making it attractive for use in small satellites.



Arda Tüysüz (ETH/PES; sitting in front) and an employee of Celeroton work on the new ultra-fast motor in their laboratory. (Photograph: PES/Celeroton)

"Actually, there is nothing particularly new about it," is the modest line taken by Arda Tüysüz, a postdoc at ETH Zurich's Power Electronic Systems Laboratory (PES). "The electronics, the magnetic bearings, understanding of the basic physical principle – it was all there already." However, the engineering skill of the PES researchers is evident in their

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Please note that the comment function on the ETH News webpages is currently not available for ability to combine these fundamentals into high-speed motor, which can run 20 times faster than the state of the art, and which is vastly smaller and more energy-efficient. In collaboration with the ETH spin-off Celeroton, Tüysüz and colleagues have developed a new kind of magnetically levitated reaction wheel motor that reaches speeds of more than 150,000 revolutions per minute.

technical reasons.

Electrically driven reaction wheels of this kind are used within satellites to change the satellite's attitude. Here, the reaction wheel is connected to an electric motor via a shaft (rotor). As soon as the flywheel driven by this motor rotates in one direction about its own axis, a torque is transmitted to the satellite, which then rotates in the opposite direction and thus a new orientation.

Existing systems have numerous disadvantages

In existing systems, the rotors and reaction wheels are typically mounted on ball bearings that wear down relatively quickly. In order to minimise mechanical wear, motors of this kind are usually operated slower than 6,000 revolutions per minute. They also have to be stored in a hermetically sealed housing in a low-pressure nitrogen atmosphere, in order to avoid oxidisation of the materials and evaporation of the lubricant.

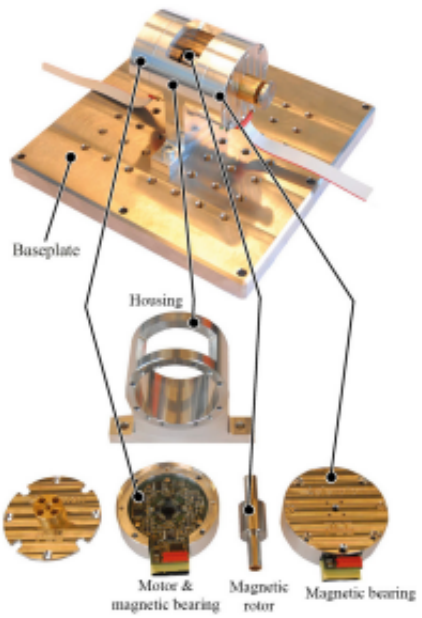
Furthermore, the balls in a ball bearing are not exactly identical, giving rise to forces that together with the imbalance of the rotor transfer microvibrations to the satellite's housing. This reduces the positioning accuracy, which satellites must exhibit in order to allow, for example, laser measurement or inter-satellite communication. In other words, enough reasons for ETH Zurich and Celeroton to design a new, magnetically levitated electric drive system.

A floating motor does not wear out

The development work began a few years ago with a doctoral thesis at PES. An initial demonstration unit was presented by the researchers two years ago at a specialist conference in Japan. More recently, at an international symposium in June this year, they presented an initial prototype of a new kind of motor for small satellites.

This prototype can be operated at up to 150,000 rpm – faster than comparable models in the past, as the rotor floats in a magnetic field. The high rotational speed has allowed the researchers to achieve a marked reduction in the size of the drive system, since it delivers the same angular momentum as a large motor despite its smaller dimensions. This makes it attractive for use in small satellites with sizes on the scale of a shoebox.

"Magnetic support also allows us to avoid the vibrations," says Tüysüz. As the system does not require lubrication, it can be operated in a vacuum, which makes it perfect for use in space. In addition, magnetic support also



Components of the reaction wheel motor and their assemblage. (Photo: from Zwyssig et al., 2014)

enables the reaction wheel to rotate softly and smoothly, as there is no frictional resistance when the system starts to move.

European Space Agency interested in the system

"Viewed as a whole, the new system we have developed is complex," says Tüysüz. Sophisticated power electronics are needed to steer and control it. "This ties in perfectly with another core area of the Power Electronic Systems Laboratory's expertise," says the electrical engineer. Tüysüz is currently working on how to further develop and improve the system's control electronics.

The system developed by the ETH researchers and their colleagues at Celerotron is only a prototype that was used to demonstrate the operating principle. The results have been presented on conferences, but the system is not yet commercially available. Nevertheless, initial interest has already been expressed by various parties, chiefly the European Space Agency (ESA).

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References

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