Making light work of orbit and attitude control

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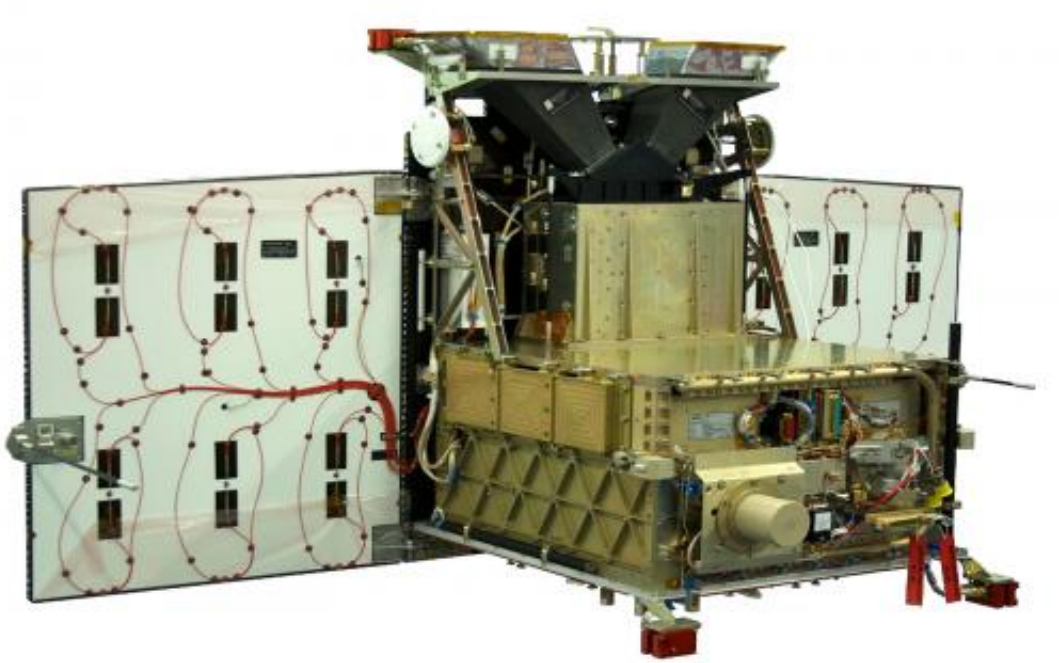

The new gyroscope could one day help a satellite bus like this with attitude detection: the platform of the approximately one-meter long TET-1 satellite. Credit: Astro Feinwerktechnik Adlershof GmbH

Microsatellites have to be very light – every gram counts. The same applies to the gyroscopes used to sense the satellite's orientation when in orbit. A novel prototype is seven times lighter and significantly smaller than earlier systems.

When you observe the sky on a clear night, the twinkling objects you see may not only be stars but also man-made satellites. Occasionally visible from Earth, these orbiting spacecraft come in different sizes, from large telecommunications and TV satellites to the smaller scientific satellites that serve as space laboratories. The measuring instruments they carry on board send back data to researchers on the ground for use in various projects. An example is the TET satellite, which scientists are using to test the capacity of new measuring systems to withstand the inhospitable conditions of space missions. If they pass these tests, they can be incorporated in other small satellites.

One such system is the gyroscope developed by researchers at the Fraunhofer Institute for Reliability and Microintegration IZM in Berlin in collaboration with the engineering specialists at Astro- und Feinwerktechnik Adlershof GmbH. Satellites use gyroscopic sensors to determine their orientation relative to their orbital position as a backup system if their star tracker is inoperative or if star visibility is degraded. Such attitude control systems require at least three gyroscopes, one for each direction of movement. They measure the satellite's rate of rotation and calculate its orientation on the basis of the most recent reliable data supplied by the star tracker.

The gyroscopes must be able to withstand the extreme temperature fluctuations encountered in low Earth orbit – where temperatures range between minus 40 and plus 80 degrees Celsius – without damage, and remain operable for several years despite the high solar radiation. A further requirement is that they should be as small and light as possible, because payload capacity is limited and every gram saved on the launch pad immediately translates into lower costs. Finally, the gyroscopes must be energy-efficient, because microsatellites only have a tiny solar panel to generate the power they need.

No larger than a wallet

"Our gyroscope withstands the inhospitable conditions of space, and is also significantly smaller, lighter, and consumes less energy than comparable solutions," says Michael Scheiding, managing director of Astro- und Feinwerktechnik Adlershof GmbH. Instead of the usual 7.5 kilograms, it weighs in at a little less than one kilo. And the scientists have also significantly reduced its volume. While similar devices are usually about the size of a shoe box, the new gyroscope measures just 10 by 14 by 3 centimeters, i.e. no larger than a wallet. The researchers' ultimate aim is to halve the size of the system yet again. Another advantage is that it requires approximately half as much energy as comparable devices.

How did the researchers achieve this result? To find out, it is necessary to take a look inside the fiber-optic gyroscope. Its main component is a fiber coil, a core with one to two kilometers of fiber wrapped around it. The longer the fiber, the more accurate the gyroscope. "We have reduced the length of the fiber to 400 meters, but can still obtain the same level of accuracy," says Marcus Heimann, a researcher at IZM. "One of the things we did to achieve this was to select more efficient optical components." The splice points between the different fibers that link the light source, the detector, and the coil have also been optimized. The scientists will be presenting their prototype at the Sensor + Test trade show in Nürnberg from June 3 to 5 (Hall 12, Booth 12-537). Visitors can test how accurately the gyroscope determines the rate of rotation by making it rotate on a turntable.

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