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A Novel Attitude Control System Minimization solution using Reaction Sphere

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Attitude Control

Every spacecraft need to precisely control its orientation along X, Y, and Z axis. This is called “Attitude Determination and Control System (ADCS)” .

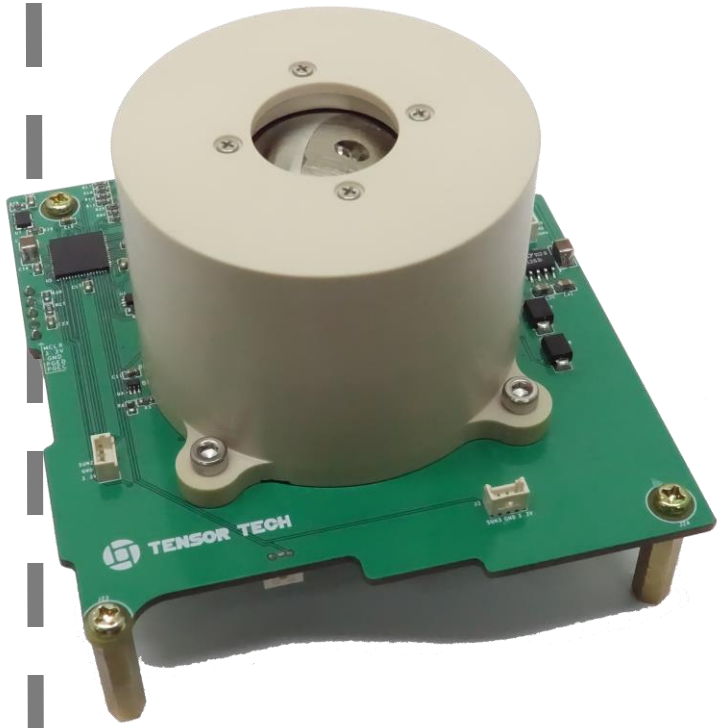
Pain Point

Traditional ADCS needs 3 reaction wheel motors + 3 magnetic coils.

600 cm^3
Volume Occupied

Solution

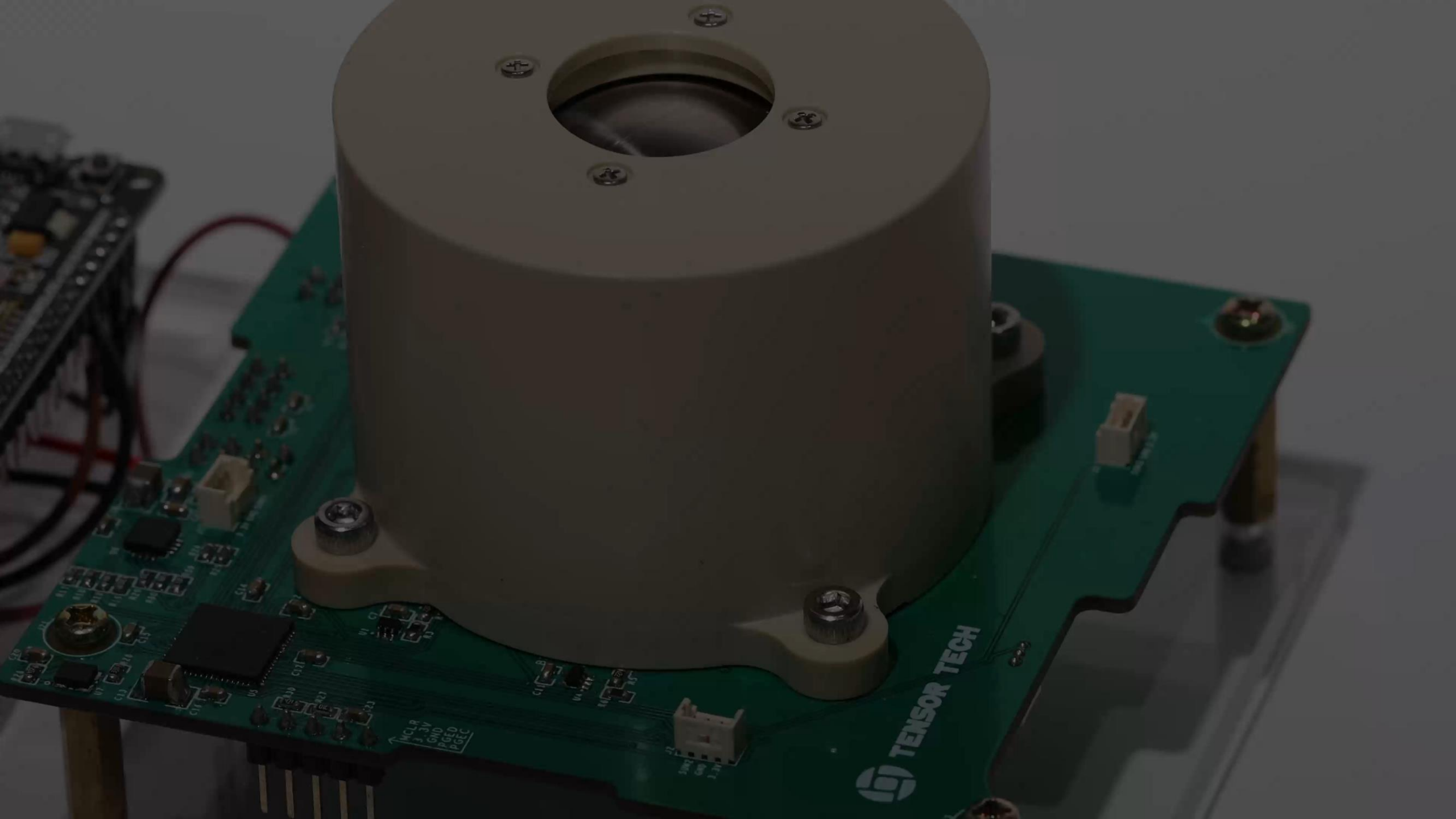
1 reaction sphere can replace the traditional system and provide 1/3 of the weight, volume, and power consumptions compares to the traditional ADCS.



200 cm^3
Volume Occupied

Two Taiwan / USA Invention Patents in pending:

1) **Magnetic Field**
2) **Control Method**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Mechanical Design of Reaction Sphere

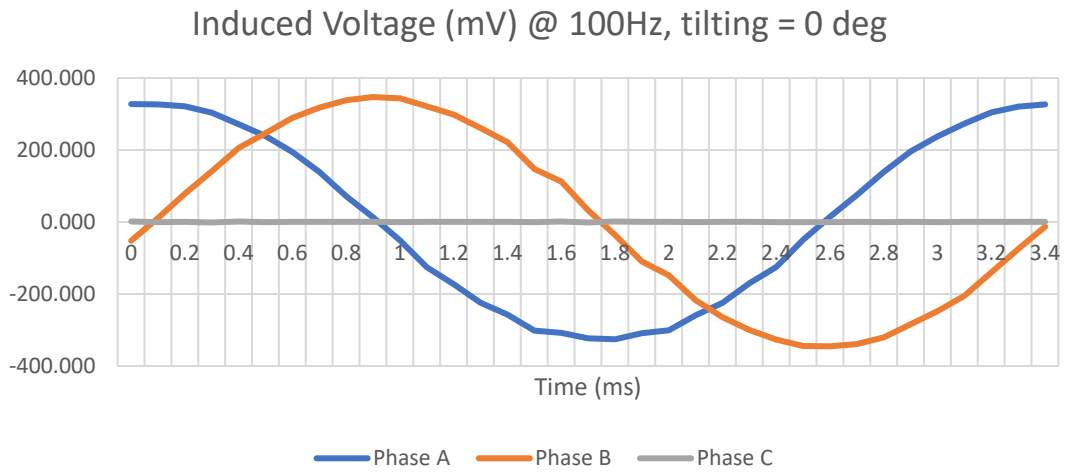
- The rotor has only 2 degrees of freedom, surrounded by a hexahedron stator.
- It functioned like a variable speed, singe-gimbal control moment gyro in terms of rotational dynamics.
- Patented magnetic field and driving method.

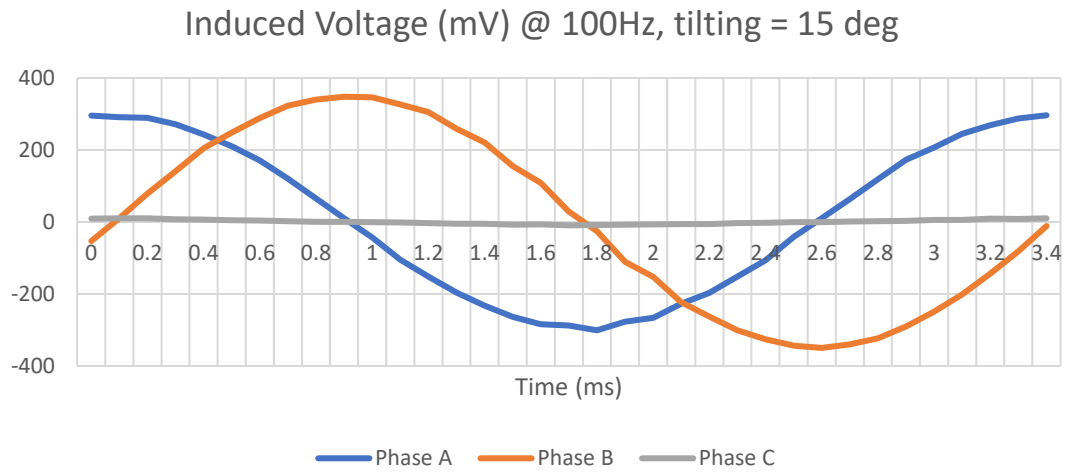
X-AXIS

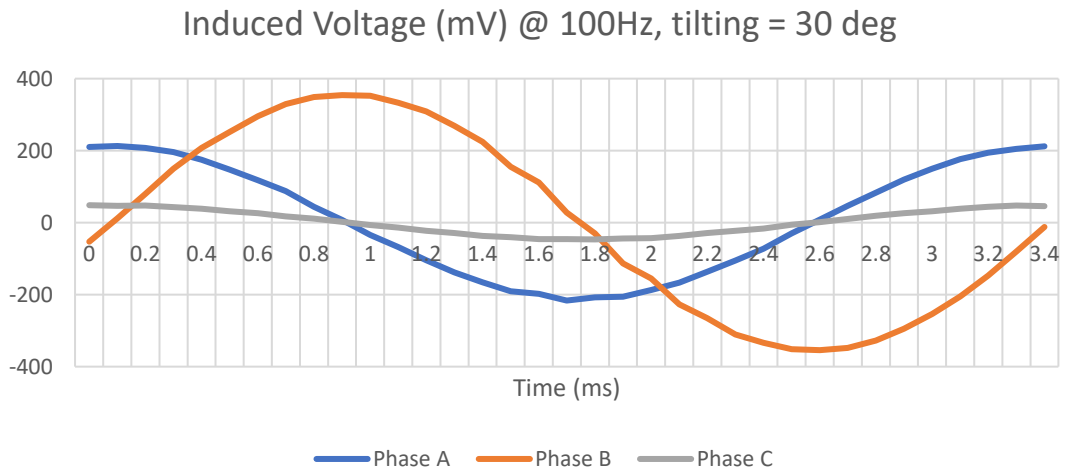
Y-AXIS

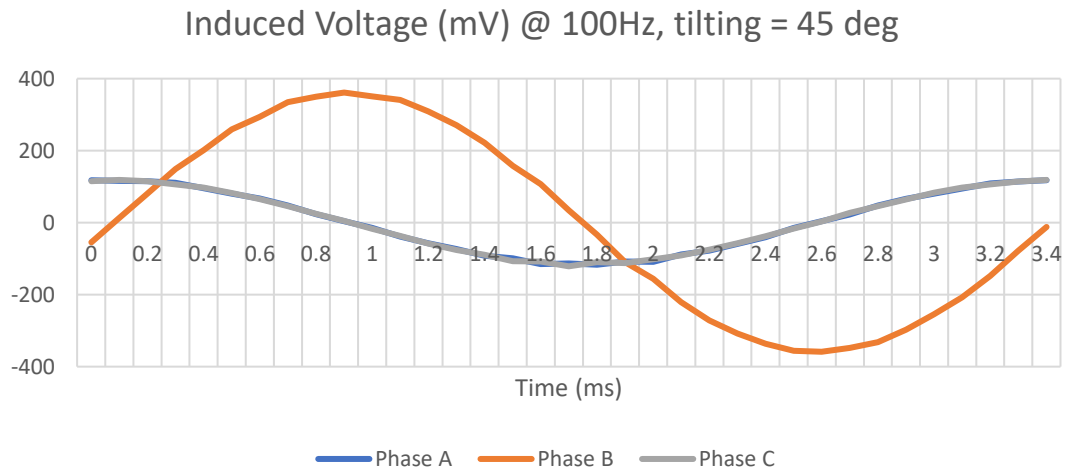
Z-AXIS

How does it work? (motor perspective)









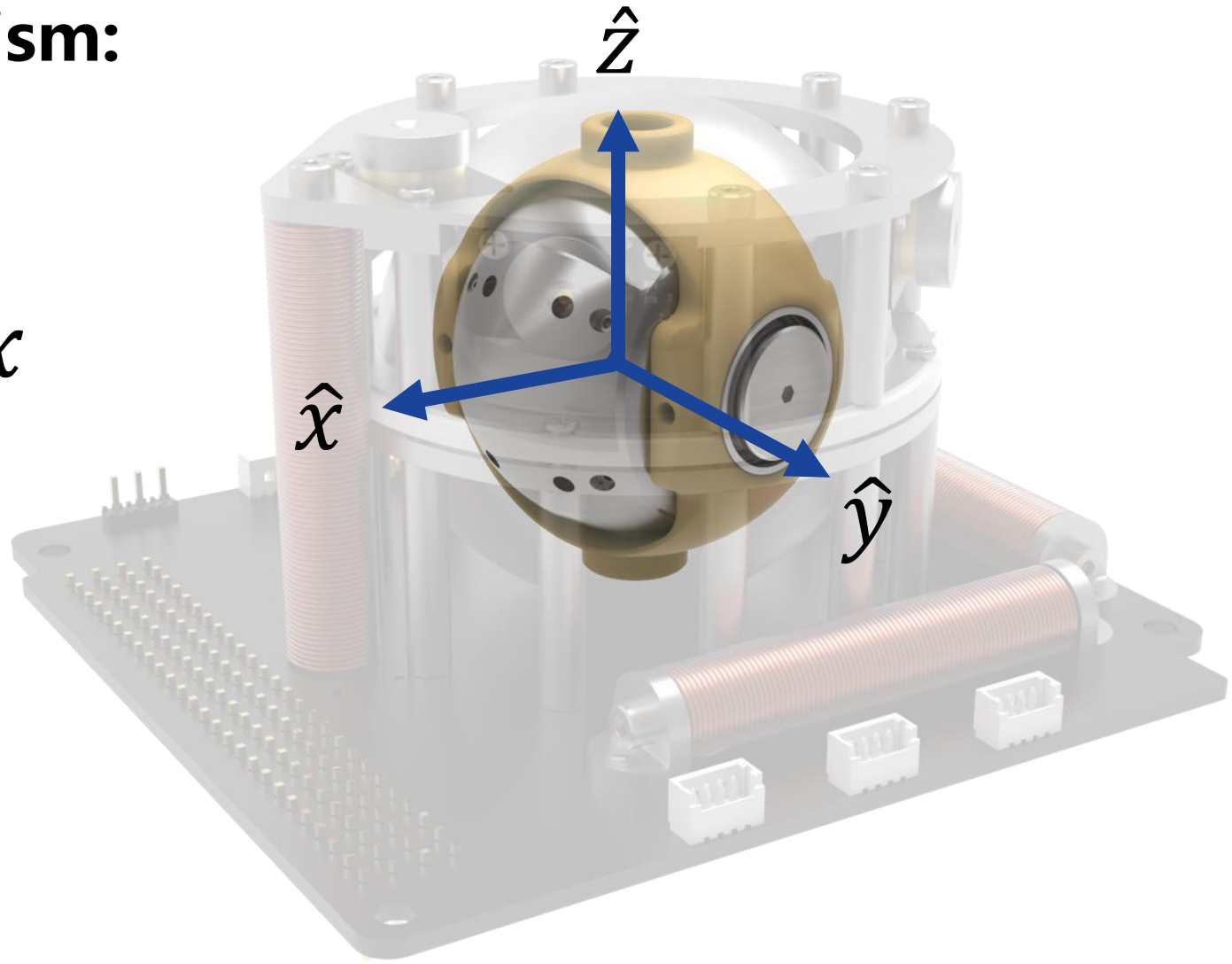
How does it work? (torque perspective)

Torque Exerting Mechanism:

$$\tau_x = \mathrm{I}_y \omega_y \omega_x$$

$$\tau_y = \mathrm{I}_y \dot{\omega}_y$$

$$\tau_z = \mathrm{I}_z \dot{\omega}_z$$



Pros and cons of Reaction Sphere

- Lower weight, power consumption, and volume could be achieved compared to traditional multiple-reaction wheels system.
- The z axis torque has to be controlled by the magnetorquer.
- Torque output accuracy on x/y axis largely depends on the tilting angle control accuracy of the motor.
- High output torque verses power consumption ratio is its advantage. (because of the utilization of the gyroscopic torque) However, this benefit could be bigger when applied on larger spacecrafts. [3]

References

[1] Nano Avoinics, “CubeSat Reaction Wheels Control System SatBus 4RW0”, available at: https://www.mendeley.com/guides/web-citation-guide

[2] ISIS Space, “iMTQ Magnetorquer Board”, available at: https://www.isispace.nl/product/isis-magnetorquer-board/

[3] L. Zhu, J. Guo, and E. Gill, “Review of reaction spheres for spacecraft attitude control”, in Progress in Aerospace Sciences, Vol. 91, 2017, pp. 67–86.

[4] R. Votel and D. Sinclair, "Comparison of Control Moment Gyros and Reaction Wheels for Small Earth-Observing Satellites." 26th Annual AIAA/USU Conference on Small Satellites, Logan, Utah, 2012.

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One last key for Satellite Minimization: Reaction Sphere

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