Critical Design of a Fluxgate Magnetometer and a Magnetic Torque Rod for Low Orbit Satellites

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Abstract. Attitude and orientation determination has crucial importance for almost all satellites having different space missions. For this purpose, the attitude determination sensors operating in different physical principles are used. These are mainly the horizon sensor, the star tracer, the sun sensor, and the magnetometer, at least two of which are frequently used in the same task. Vector magnetometers are the unique attitude determination sensors operating at the period of the launching of the satellite to its orbital settling. In the same way, the satellite settled in orbit tumbles at random times due to some external factors like solar eruptions. In this case, the satellite cannot again fulfill the mission. It is necessary to stop the tumbling and to provide the world orientation again. The vector magnetometers, together with the torque rods, take also active role in this period. In this work we aim to design and build space qualified vectoral magnetometer so called fluxgate magnetometer, and magnetic tork rod to be used in the ADCS (attitude determination and control systems) of LE (low orbit, 400-700 km), satellites.

One of the most important building block (the hearth) of both the fluxgate magnetometer and the torque rods are the ferromagnetic materials (except for the electronic circuit). The structural and magnetic properties of the ferromagnetic material are the most important parameters affecting the ultimate performance of these two devices. For example, the close proximity of the Curie temperature (ferromagnetic-paramagnetic phase transition temperature) of the ferromagnetic strips to the magnetometer working temperature (between -50 ^{o}C and +85 ^{o}C) affects worsely its temperature dependence due to the variation of magnetic parameters such as magnetic permeability and saturation magnetization. For sensors to be used under space conditions, the Curie temperature must be increased up to at least 400 ^{o}C in order to ensure absolute temperature independence. This work reveals the influence of critical parameters, like the Curie temperature, magnetic permeability, magnetostriction coefficient and the coercivity, on performances of both the magnetometer and the torque rod.