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Digital Fluxgate Magnetometers, Trade-off Between Response, Sensitivity and Stability

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The fluxgate magnetometers (FGM) are one of “must-have” instruments onboard scientific or commercial spacecrafts because they are widely used for space research or service purposes. Creating small, state-of-the-art FGM is impossible without using recent digital technology of data acquisition and processing. The digital technology is a proven way of equipment miniaturization, decreasing weight and size.
A joint Swedish-Ukrainian team made the development of such a digital magnetometer for microsatellite. The magnetometer electronics combines flux-gate analog front-end circuits with a digital integrated circuit - a Field Programmable Gate Array (FPGA). The FPGA provides full processing of amplified and digitized fluxgate sensor output signals, FGM output data and feedback signals. Such digital design makes the instrument flexible, customizable according to different user needs and operation modes, reduces power consumption and complexity. Such an approach resulted in a making of a space FGM that was successfully flown onboard the NASA Cascades-2 sounding rocket, and the ESA REXUS-8 student sounding rocket [1]. The magnetometer is based on the smallest in the world low noise three-component fluxgate sensor with volume-compensation method.
But the digital implementation of an actual analogue instrument creates new problems related with discrete data processing as well. They did not allow realizing all possibilities of the miniature sensor in the first magnetometer prototype – the sensor parameters were deteriorated essentially and the final magnetometer parameters were far from the best possible values. These problems are related with the structure choice and design and necessity of making a trade-off between response, sensitivity and stability of the FGM.
The new approach to the digital data processing allowed us to improve the parameters of a new generation of the magnetometer electronics and realize all possibilities of the sensor.
The tests of the magnetometer have proved that its noise level has been reduced successfully to as low value as 15 picoTesla at 1 Hz and the desired dynamic parameters necessary for a rotating rocket have been obtained. Now, the new redesigned digital magnetometer is a good candidate for planned scientific missions (PoGOlite, SQUID, SWIM cubesate projects, Lunar mission etc.) and ready to be modified for different demands.
The description of the used method and obtained results of the electronic unit upgrade and recent FGM model tests are given.

References:

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