Design, implementation, and test of a digitally-controlled electrical power supply for the OUFTI-1 nanosatellite

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The electrical power supply (EPS) of the educational OUFTI-1 nanosatellite under development at the University of Liège consists of two switched-mode power supplies (SMPS). One is a robust, fully analog, main power supply (mEPS) providing the necessary currents at 3.3, 5.0, and 7.2 V. The other (a payload) is an experimental, digitally-controlled power supply (xEPS) providing current only at 3.3 V. This type of EPS has never been used in space. Digitally-controlled SMPSs have many attractive features for space applications, such as noise robustness and adjustment/reprogramming capability. Since it is risky to test innovating techniques in space, OUFTI-1 represents an excellent testbed for the space industry to investigate new concepts in space, such as those of the xEPS. We focus here on the xEPS.

The "plant" of the xEPS is a flyback converter, and the digital control/feeback is provided by a peripheral interface controller (PIC). The goal of the PIC is to produce a pulse-width-modulation (PWM) signal, first digital, and then analog. The analog PWM signal controls the switching devices on the converter. Stability considerations quickly show that there is a need to significantly increase the time resolution of the PWM signal, which requires a faster clock speed, with the resulting disadvantage of increasing the power consumption. One way to solve this dilemma is to use dithering, which is implemented here via sigma-delta modulation (and thus oversampling). Noise shaping is also used to control the discretization noise. The net result is a digital "filter" with a finite number of coefficients. The flexibility of the approach comes from the possibility of easily changing these coefficients. We have also design a reliable way of interconnecting the 3.3 V ouputs of the two supplies.

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Engineering models of the mEPS and xEPS have been built. Preliminary tests have shown that both supplies work as expected. For the xEPS, we have verified that the low-frequency limit cycles are considerably reduced once the sigma-delta modulation is turned on.