Status of electrical power supply of OUFTI-1 nanosatellite as of mid-2012: design, implementation, and tests

Valéry Broun (1), Pierre Vignisse (1), Xavier Werner (2), Nicolas Crosset (2),
Amandine Denis (3), Jacques G. Verly (2)
1: HEPL, Engineering Department, Electronics Service, Liège, Belgium
2: University of Liège, Dept. of Electrical Engineering and Computer Science, INTELSIG Lab., Liège, Belgium
3: University of Liège, Dept. of Aerospace and Mechanics, Liège, Belgium

Abstract

We describe the principles and performances the OUFTI-1 nanosatellite electrical power supply (EPS), which is designed to provide subsystems with the required voltages and currents, with as high a reliability as possible.

We report on the current status of the design/architecture, implementation, and tests of the electrical power supply (EPS) of the educational OUFTI-1 nanosatellite. The work on the EPS subsystem started in the summer of 2008. Not surprisingly, the required functionalities and capabilities of the EPS changed many times over the last four years. The main reason for this is the many changes in operating voltages and currents required by the other subsystems, especially by the VHF/UHF radiocommunication (COM) subsystem, consisting in a D-STAR/AX.25 voice and data transceiver and in an OOK emergency beacon. In particular, circumstances and tradeoffs led us to change, on several occasions, the frequency assignment for the uplink (now 435 MHz) and downlink (now 145 MHz), with direct consequences on the link budgets, the selection of RF power amplifiers circuits, and the required voltages and currents. Nevertheless, we have progressively converged towards a design that is highly modular/flexible, and can cope with various faults, while remaining as simple as possible.

The main EPS functionalities are to: collect energy from the solar cells; store it in batteries; dissipate excessive power; protect the batteries in voltage and temperature; provide currents to the thermal cutters used for antenna deployment; provide the required currents at appropriate voltages to the client subsystems; protect the switching converters and clients (mainly COM, two on-board computers (OBC's), and analog-to-digital converters); acquire several measurements (voltages, currents, and temperatures); and allow monitoring and recharging of the batteries on the ground. The EPS also includes the remove-before-flight and deployment switches.

The heart of the EPS consists in three buck-boost switching (i.e. DC-DC) converters. Two are connected in parallel through diodes to provide, at 3.3V, the appropriate currents for the COM and homemade OBC; one provides, at 5V, the appropriate current for the commercial, off-the-shelf OBC. A significant feature of our design is the use of three identical copies of the same electrical circuit for the three converters, except for one resistor. This allowed us characterize in great detail the integrated circuit at its core and the circuit built around it, to optimize their usage, and to achieve maximum efficiency, which is critical. The parallel connection via diodes was studied in great detail. We verified experimentally that the converters would each contribute almost exactly one half of the total output current at 3.3V, and that either would automatically step up to the total current in case of failure of the other. We could so parallelize as many identical converters as desired, for both 3.3V and 5V. Space constraints limited us to two for 3.3V. Since 5V is only used by one of the two redundant OBCs, there was a lesser need to provide redundancy for 5V. Each converter is surrounded by appropriate filters and protections (including electronic, resettable fuses upstream).

We have built a breadboard prototype of the latest version of the EPS and we have tested it successfully in the laboratory. We have routed, and will soon have, a corresponding six-layer electronic board in the PC104 format (10x10 cm). Such a board had already been produced in 2010 for an earlier version of the EPS. The batteries and the antenna deployment mechanism have already been tested in the space-environment chambers of the Centre Spatial de Liège of the University of Liège.