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Design of system-on-chip for real-time nanosatellite photovoltaic curves telemetry

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Abstract

This work presents a design of a system-on-chip for the telemetry of photovoltaic curves of a nanosatellite in real time, based on the work reported by Gutiérrez et al. [1]. In this type of application, the limitation of memory and communication bandwidth makes it difficult to store and transmit the whole I-V characteristic curve of any solar section in real time. The proposed solution is based on the real-time calculation of the equivalent single diode model of the solar section. Thus, once the parameters calculated, recorded and transmitted, regardless of the operating conditions, the specific curve could be reproduced later. The system is based on a 32-bit LEON3 microprocessor core implemented in a FPGA. LEON microprocessors were originally designed by the European Space Agency for use in space projects requiring high reliability. Moreover, in order to design the system as simple and reliable as possible, among all the methods available in the literature to extract the five parameters of the equivalent model (I_{ph}, I_s, n, R_s and R_{sh}), the method Asymptote Oblique (OA) [2] was chosen for its simplicity and precision. These parameters (I_{ph}, I_s, n, R_s, R_{sh}) are recorded and transmitted to the ground for later reproduction using the following equation:

$$I = I_{Ph} - I_S\left(e^{\frac{V+IR_S}{nV_T}} - 1\right) - \frac{V+IR_S}{R_{sh}} \quad (1)$$

In summary, the final system consists of three blocks:

1) LEON3 microprocessor, as shown in Figure 1, which executes the OA method to obtain PV characteristic values from the detected values.

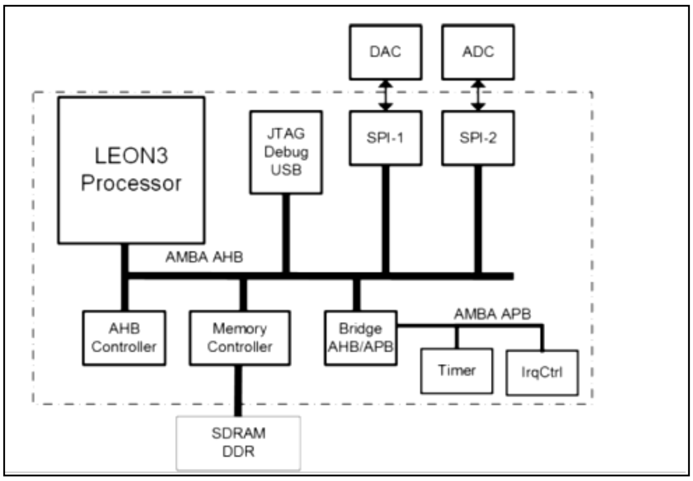

Figure 1. SoC used to implement the OA method.

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2) Electronic load, as shown in Figure 2 to set the PV output voltage to a value defined by SoC LEON3.

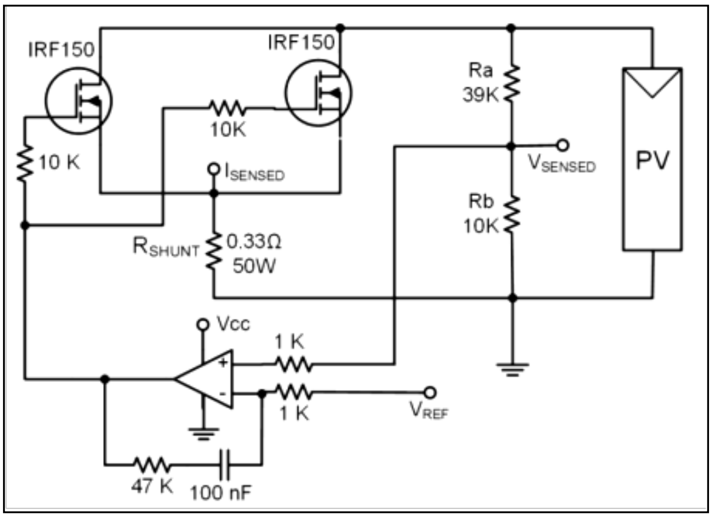

Figure 2. Electronic load used to control de the solar panel.

3) Acquisition interface, as shown in Figure 3 which allows to obtain the value of the voltage and the current of a pilot cell and to adapt them to values that can be acquired by the digital system.

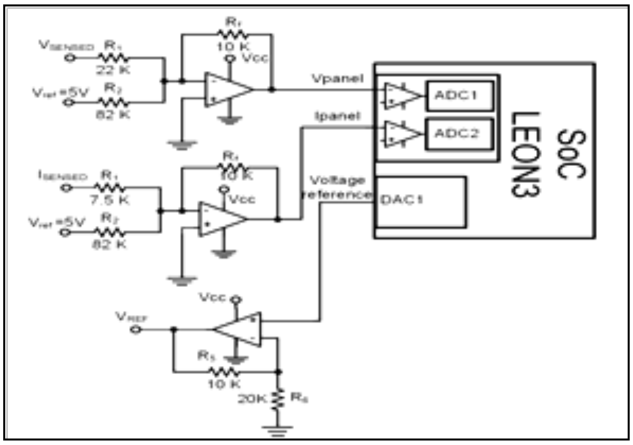

Figure 3. Auxiliary circuit to measure voltage and current from PV panel.

Keyword:
photovoltaics; system-on-chip; nanosatellite; telemetry

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