SPS - Smart Power Supply for NewSpace Electronics

Assessment to Prepare and De-Risk Technology Developments

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Abstract

This document summarizes the de-risk project regarding the development of the Smart Power Supply – SPS.

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1 Summary

The de-risk project "SPS Smart Power Supply for New Space Electronics" was about the minimization of risks in the development of a multi-channel secondary power supply. The idea of the SPS is to build these multiple supply channels using commercial components but achieving a high reliability also for space application. Therefore, two hot redundant supply lines have been combined into each supply channel. The key technical specification for the SPS as a module is:

- 8 supply channels per module, each of with based on two parallel and hot redundant supply lines.
- 1.0 .. 3.3 Volt, max. 3 Ampere per supply channel, 2% voltage stability
- Over-current (latch-up) and over-voltage protection per supply channel with on-the-fly adjustable current limitation range

Circuit simulations, component trade-offs, component radiation testing and several iterations of hardware breadboarding have been carried-out in order to identify a supply channel configuration with the potential to fulfil the requirements. This led to an architecture for the SPS as outlined in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**

With the components selected, the architecture was transferred into a PCB design, i.e. schematic and layout as outlined in chapter 3. Three iterations of PCB manufacturing and assembly → commissioning and test have been performed. The final breadboard was used as SPS demonstrator for performance and environmental testing.

Laboratory and environmental tests have been performed with the SPS demonstrator. Test setups, results and data evaluation are shown in chapter 5.

In summary, the goals of the de-risk activity have been achieved and the feasibility of the SPS concept has been demonstrated. The SPS module will be well suited for its application to supplying commercial and potentially radiation-sensitive parts. The SPS design has been made to cope with radiation effects. A clear plan regarding the further development steps towards an SPS flight model has been established.

2 Introduction

Smart Power Supply (SPS) modules serve as secondary power supply for basically any kind of electronics inside a satellite. It is able to power low-voltage and high-current, potentially non-qualified and thereby latch-up sensitive equipment. Due to these characteristics, the SPS is dedicated to supply onboard processor systems. Therefore, it requires the following key features:

- Providing 8 output channels with voltage ranges of 1.0 up to 3.3 Volts and maximum currents of 3 Ampere per channel and 2% voltage accuracy over the entire load range.
- Each supply channel is implemented hot redundantly achieving an uninterrupted supply
- Loads connected to the SPS are overcurrent, and under-/over-voltage protected.

In the NewSpace domain, commercial processors and System-on-Chips (SoC) are on the technology roadmaps for future missions. Modern high-performance SoCs require several supply lines with various voltage levels and required accuracies. Especially in view of implementing artificial intelligence into satellite processing, SoC are required. FPGA-based hardware accelerators are a power efficient way to perform image processing algorithms. Also, for the implementation of neural networks, FPGAs are promising for space applications.

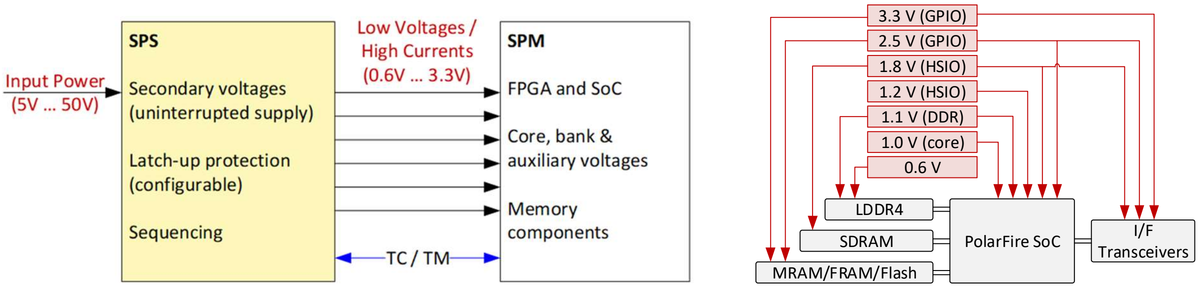

Figure 1: SPS target application: Supply of a Smart Processing Module (SPM), an SoC-based processor module.

The Smart Power Supplies has the following key features:

- SPS modules shall provide uninterrupted functionality by "radiation-tolerant by design" redundancy and automatic switching for circuits that might be radiation sensitive.
- The current threshold and limitation shall be adjustable by the protected system itself to enable adjustment to several operation conditions in flight.

3 SPS Design

Based on the suitable components, the conceptual design of the SPS has been derived as shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** for one supply channel. Two converter channels are combined via Current Share Controllers *CSC*. These components implement an OR-ing FET controller with low on-resistance FET minimizing power losses and allowing to combine the outputs of the two converter paths.

A sequencer circuit allows to control the swich – on/off sequence of the SPS supply channels. Analog-to-Digital Converters *ADC* measure output voltages and currents to provide housekeeping data.

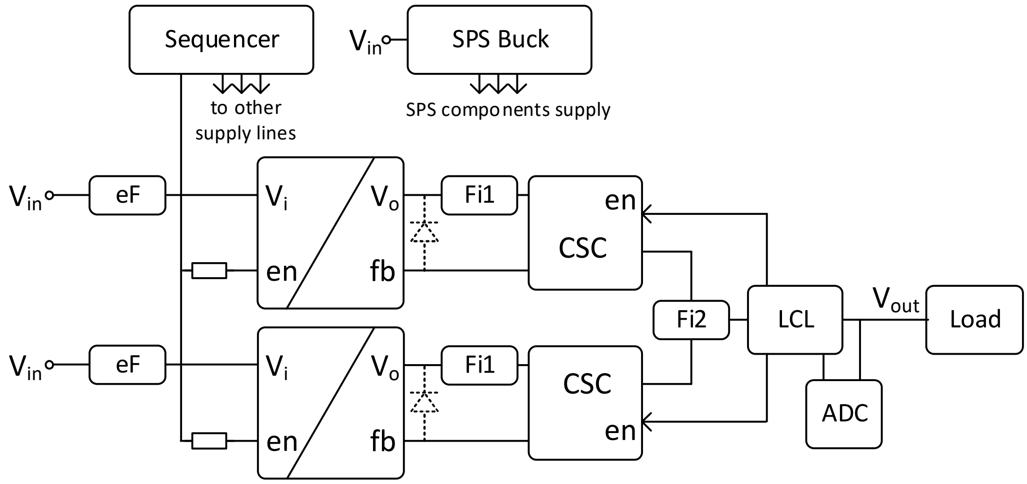

Figure 2: Conceptual design of SPS showing with main components.

4 SPS Test Results

Load sharing was measured with an oscilloscope and is shown in the charts in Figure 3. The individual supply lines are switched at the transitions indicated by the lowercase letters:

a) Supply line 1 is switched off and supply line 2 takes over the entire load current.
b) Supply line 1 is switched on again and the load current is shared.
c) Supply line 2 is switched off, supply line 1 takes over all load current
d) Supply line 2 is switched on again and the load current is shared.
e) See a)
f) Both supply lines are turned off.

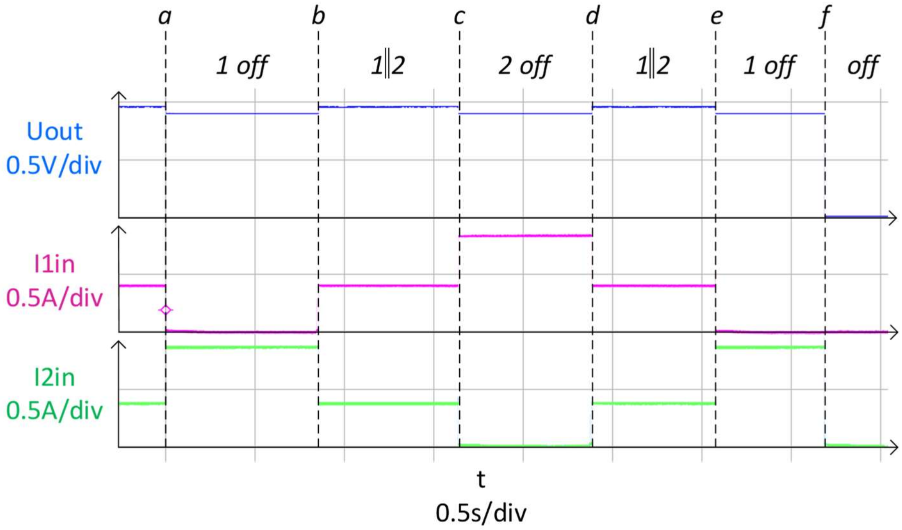

Figure 3: SPS load sharing behaviour.

5 Summary and Conclusion

The SPS demonstrator demonstrated performance within its specifications. The selection of components based on technologies that indicated a certain radiation tolerance yielded a circuit that is able to withstand 10 krad of TID, which will be sufficient for targeted mission scenarios in Low-Earth Orbit. The modular concept of SPS, however, allows to interchange components with radiation-hard versions, in case a higher level of radiation tolerance is required.

In the next development phase, an combined model of SPS and SPM will be developed achieving a turn-key onboard processing system including its secondary power supply. The SPS will further be equipped with a radiation-tolerant micro controller acting as watchdog and FPGA reconfiguration engine.