Application Note

Using Space Grade Power Components to Power Microsemi RTG4 FPGA

ABSTRACT

This application note provides a recommended space rated power design for the Microsemi® RTG4™ FPGA. The report outlines recommendations for the individual power rails and the benefits of rad-hard (-SP) and rad-tolerant (-SEP) devices. Then, example power block diagrams are provided for each of the different power design variations to include both 5-V and 12-V inputs.

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1 Introduction

Architectural advancements continue to be developed in FPGAs with the growing need for more on-board processing and re-programmability in space applications. As such, Microsemi's RTG4 FPGA has seen a wide use in different satellite payloads. As new FPGAs are developed, the power requirements have continued to evolve requiring the need for higher currents, and lower voltages. The designs that power the RTG4 must be able to meet these increased requirements and be resilient to withstand the harsh environment of space.

This application note reviews two product grades TI offers with proven radiation performance and provides a selection guide for comparing the different power management devices within each flow. The report also covers the value the space grade power management portfolio brings to the overall system, and provides example power maps for both rad-hard and rad-tolerant implementations.

2 Space Qualification Flow Overview

TI has had a long history supporting the space industry by providing hermetically sealed QMLV (Qualified Manufacturer List, Class V) and RHA (Radiation Hardness Assured) components all in accordance with the MIL-PRF-38535 specification. In addition to the qualification standard, these devices are typically supported with extensive Total Ionizing Dose (TID) and Single Event Effects (SEE) radiation reports that are readily available in the product folder for each device. TI continues to support the highest-reliability space applications with ongoing and new development in hermetically sealed QMLV devices.

However, with the reduction in launch costs and stricter budgets, this has resulted in a different approach to satellite manufacturing for new commercial and government applications. To provide a design, TI has provided more cost-effective and smaller designs through a growing portfolio of devices in rad-tolerant Space Enhanced Plastic (denoted by -SEP) to meet the reduced assurance requirements for LEO and MEO constellations. Table 2-1 provides an overview between the differences of Space Enhanced Plastic and QMLV-RHA. For more information on TI's rad-tolerant flow, read how to Reduce the Risk in Low-Earth Orbit Missions with Space Enhanced Plastic Products.

Table 2-1. Space Enhanced Plastic and QMLV-RHA

	Rad-tolerant (-SEP)	**Rad-hard (-SP)**
Packaging	Plastic	Ceramic-Hermetic
Single Controlled Baseline	Yes	Yes
Meets DLA spec for less than 2% Sn	Au	Al
Production Burn-in	No	Yes
Typical Temperature Range	-55°C - 125°C	-55°C - 125°C
Radiation: TID Characterization	30 to 50 krad(Si)	100 krad(Si)
Radiation Lot Acceptance Testing (RLAT)	20, 30 or 50 krad(Si)	100 krad(Si)
Radiation: SEE Characterization	43MeV-cm^2/mg	≥75MeV-cm^2/mg
Outgassing tested per ASTM E595	Yes	N/A
Lot Level Temp Cycle	Yes	Yes
Per tube, tray or reel single lot date code	Yes	Yes
Life Test Per Wafer Lot	No	Yes

3 Space Rated Power Devices

TI's portfolio of leading power density ICs is capable of providing a full power management design through a selection of buck converters, LDOs, DDR termination regulators and PWM controllers as shown in the table below.

The TPS7H4001-SP and TPS7H4003-SEP are high current 18-A buck converters with integrated FETs and the key feature of being able to parallel up to 4 devices 90 degrees out of phase without the need for external clocking meant to meet the increasing need for higher current on the core rail. The 0.6-V reference allows them to meet the low voltage requirement typically seen for this rail. The TPS50601A-SP is a smaller 6-A highly efficient buck converter with over a decade in flight heritage used to power many of the auxiliary rails. The footprint compatible TPS7H4002-SP can also be used for powering auxiliary rails as it is architecturally very similar to the TPS50601A-SP with a lower current limit for smaller inductor sizing. For a similar 6-A rad-tolerant design, the TPS7H4010-SEP provides an extremely compact design in a 4x6 mm WQFN package and is the widest V_{in} space grade switching regulator at 32 V_{in}.

The RHA buck converters are limited to a 7-V_{in} recommended operating condition. If a designer needs to accommodate a higher input voltage, the TPS7H5001-SP PWM controller can be used to build a discrete buck converter. This highly flexible controller paired with a gate driver is capable of working with both Si and GaN FETs to be used as a first stage conversion or in a high efficient GaN supply that powers the core rail directly. The 0.6-V reference with +0.7%/-1.0% reference accuracy provides a very tight tolerance to meet the core voltage.

For noise sensitive rails, TI can provide a number of low-dropout regulators. The TPS7H1101A-SP offers the most integrated design with enable, configurable soft-start, and power good for power sequencing as well as added protective features like current foldback protection. For a rad-tolerant alternative, the TPS73801-SEP provides an extremely versatile LDO to be used across its wide input range (2.2 V to 20 V_{in}) all in a small plastic 6.5-mm x 3.5-mm SOT package. The TPS7H1111-SP and TPS7H1111-SEP can be used as alternatives for applications needing high PSRR and noise performance.

Lastly, for powering DDR memory, the TPS7H3301-SP or TPS7H3302-SEP is a linear design with the capability to sink and source current and able to power DDR1, DDR2, DDR3, DDR3L, and DDR4. The links in the table below will direct you to the product page of each device for more product specific information.

Table 3-1. Selection Guide for Space Grade Power Management

	Function	Vin Range (V)	Lowest Vout (V)	Iout (A)
TPS50601A-SP	Buck Converter	3 - 7	0.8	6
TPS7H4002-SP	Buck Converter	3 - 7	0.8	3
TPS7H4001-SP	Buck Converter	3 - 7	0.6	18
TPS7H1101A-SP	LDO	1.5 - 7	0.8	3
TPS7H3301-SP	DDR Termination Regulator	2.3 - 3.5	0.5 (VTT)	3
TPS7H5001-SP	PWM Controller	Scalable	0.6	Scalable
TPS7H4010-SEP	Buck Converter	3.5 - 32	1	6
TPS7H4003-SEP	Buck Converter	3 - 7	0.6	18
TPS73801-SEP	LDO	2.2 - 20	1.21	1
TPS7H3302-SEP	DDR Termination Regulator	2.3 - 3.5	0.5 (VTT)	3

For more detailed information regarding set up, sequencing and measurements, please see the application note: TI Space Rated Power Solution for Microsemi® RTG4™ FPGA.

4 Example Power Maps

The following sections provide two example power maps. One section with rad-hard hermetically sealed devices for traditional space, and one section with space enhanced plastic devices for new space applications.

4.1 Rad-Hard Power for RTG4

Figure 4-1 shows an example power map for a power management design capable of meeting 100krad(Si) in TID performance and DSEE immune to 75MeV-cm^2/mg.

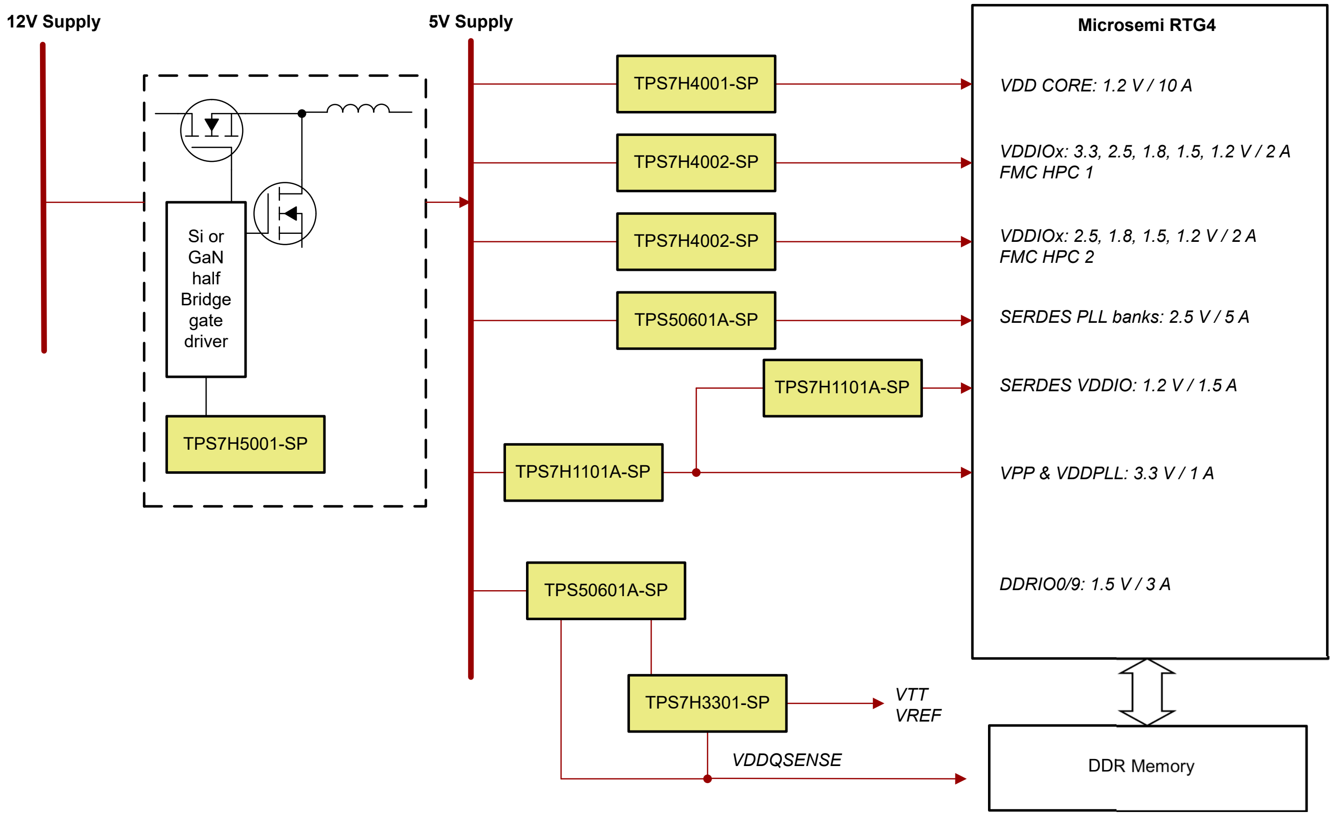

Figure 4-1. Rad-Hard Power for RTG4

4.2 Rad-Tolerant Power for RTG4

Figure 4-2 shows an example power map for a power management design capable of meeting 30krad(Si) in TID performance and DSEE immune to 43MeV-cm^2/mg.

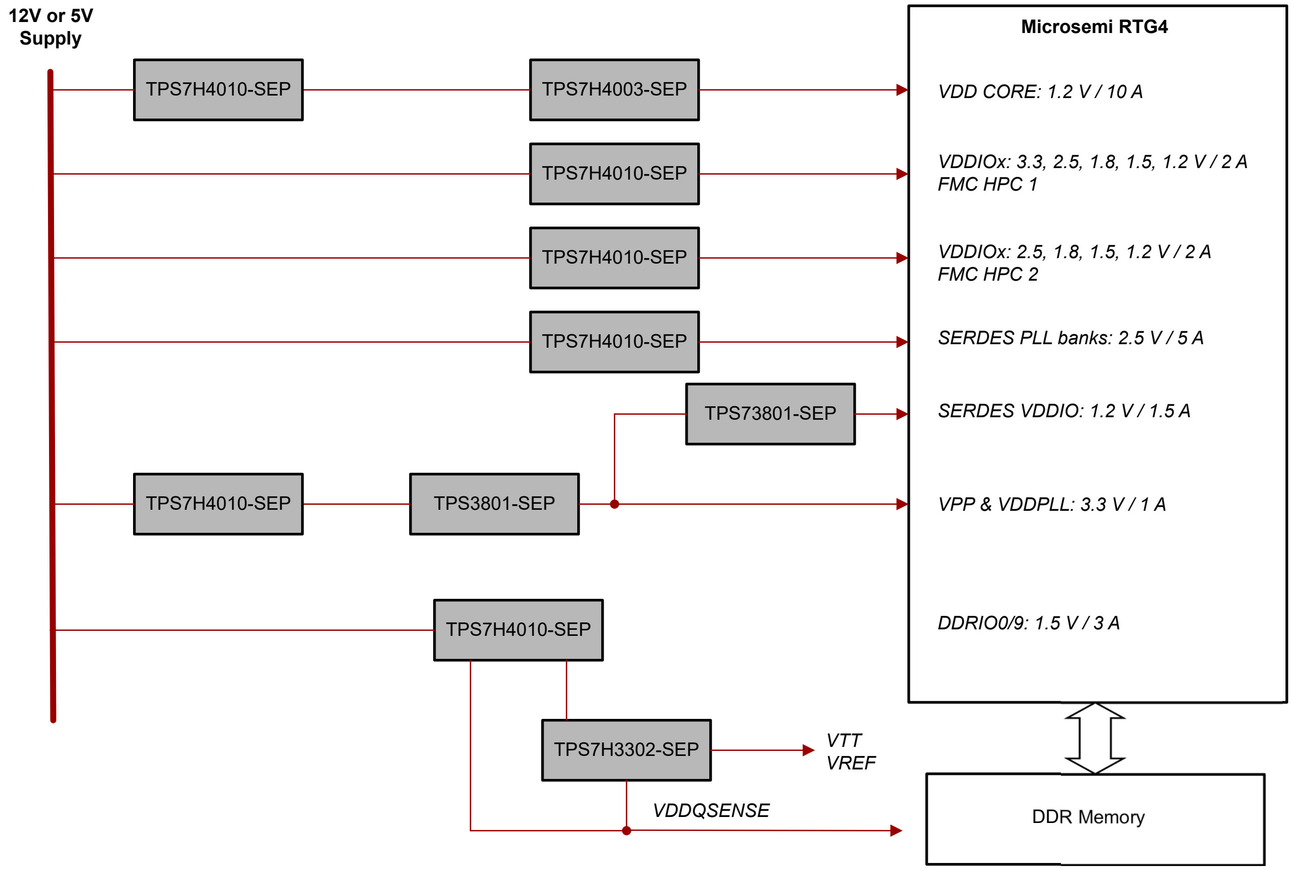

Figure 4-2. Rad-Tolerant Power for RTG4

5 Conclusion

TI space grade power management product offerings provides a full board design for powering the Microsemi RTG4. Two different space qualification flows are offered to support a dynamic range of varying mission assurance profiles. With easily accessible radiation reports and a robust set of documentation and design tools, designers need to feel confident in designing a robust and reliable power supply. Using space grade ICs with proven data can help reduce mission risk and enable faster time to market, in addition to the technical benefits the power management portfolio provides.

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