NSREC Notes:
Space Power Components Answer Calls For Higher Performance, Lower Cost

by David G. Morrison, Editor, How2Power.com

Walking through the exhibition at the Nuclear & Space Radiation Effects Conference (NSREC), which is usually held in July, offers a unique opportunity to learn about the latest developments in radiation hardened and radiation tolerant components including the latest power semiconductors, ICs and modules. In 2020, conference planners shifted to a virtual event in December (they had the foresight to go virtual back in July when other conferences were still promoting live events for 2020).

While it’s difficult to replace the experience of a live expo, NSREC exhibitors took advantage of the digital platform to provide updates on their product developments through scheduled webinars, Zoom interviews and online chats. Companies used these resources to share information on the development of plastic packaged parts, a higher-performance PWM controller for GaN power switches, smart power switch controllers, and new point-of-load converters, and other component news. The component developments shared by NSREC vendors highlight some ongoing trends as semiconductor companies respond to market requirements for higher performance, smaller size, and lower cost.

For those interested in following rad hard component developments, the next edition of this conference, NSREC 2021, will be held July 17-23, 2021 and will be virtual once again. See the NSREC website for information on the technical program, short course and any conference news.

Bringing Higher Reliability To Plastic Parts

At NSREC 2020, Renesas gave a presentation on its Intersil space plastic products, which included details on a few new power ICs. According to the company, Renesas was the first hi-rel IC supplier to introduce lower-cost space plastic parts for LEO (low earth orbit) applications with the first releases of these products in 2017. Since then the parts have been gaining acceptance in the market.

These radiation tolerant (as opposed to radiation hardened) parts address requirements for lower cost, smaller size and lighter weight. While cost may have been the main driver of developing these parts for the small satellites, the company learned from its customers that smaller form factors parts were also needed for more traditional missions (i.e., higher orbit MEO and GEO with longer life). In these applications, cost reductions are helpful but size and weight are the main drivers, as the amount of electronics increases on small system and payload boards.

Steve Singer, product marketing engineer at Renesas Electronics, observed that the company approached the development of plastic parts for space “from a high-rel mindset”. The company is currently developing four parts on a radiation-hardened flow using the PEMS flow outlined by SAE AS6294/1 with the goal of creating a plastic Class V type flow to give customers confidence in plastic parts for critical missions. The company also notes that the DLA has tentatively approved a Class P for new SMD part class for plastic packaged ICs.

Material and assembly choices reflect the high-rel approach. For example, Singer noted that these parts use only gold bond wires, not copper. They also use a NiPdAg or NiPdAg-Au plated lead frame, and a high-glass-transition-temperature mold compound. Each device is manufactured at a single assembly site in southeast Asia using automotive assembly lines. The company will perform ongoing radiation lot acceptance testing (RLAT) on plastic space parts up to 100 krad with SEE characterization up front.

As noted above, Renesas is currently developing four parts on this new radiation-hardened flow. These include the ISL73033SEH low-side driver & 100-V GaN FET (samples and flight models are now available) and the ISL71001SLH/SEHM 6-A synchronous buck regulator (samples are now available with flight models coming in April).

There are also two digital isolators—one with passive input, the ISL71610SLHM (samples and flight models are now available) and one with active input, the ISL71710SLHM (samples are now available with flight models coming in July). For more on the different flows, see Tables 1- 3 below. For further information, contact Steve Singer.

Table 1. Renesas radiation-hardened plastic production test flow.

RH PLASTIC PRODUCTIONS FLOW – ALL UNITS GET THIS TESTING

Screen	Test Method	Condition
External Visual, and Serialization	MIL-STD-1580	
Radiography	MIL-STD-1580	
Temperature Cycling	MIL-STD-883, Method 1010	Temperature cycles, 20 cycles minimum
Initial electrical measurements	Per device specification	-55C, +25C, +125C
Engineering review		
Static Burn-In test at +125C	MIL-STD-883, Method 1015	Condition A or B
Post static BI electrical measurements	Per device specification	+25C
Dynamic Burn-In test at +125C	MIL-STD-883, Method 1015	Condition D
Final parametric and functional test	Per device specification	-55C, +25C, +125C
Calculate percent defective	Maximum acceptable PDA	<5%
Radiography	MIL-STD-1580	
Acoustic Microscopy Inspection	J-STD-020, J-STD-035	
External visual packing	MIL-STD-1580	

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Table 2. Lot qualification testing for radiation-hardened plastic products.

RH PLASTIC LOT ASSURANCE TESTING FLOW – SAMPLES PULLED AFTER PRODUCTION FLOW

Test	Sub Test	Test Method and Conditions	Quantity
Radiation Analysis		TID Only	TBD
External Visual Inspection		MIL-STD-1580 for PEMs	
Preconditioning	Moisture Soak	JESD22-A113	32
	SMT Devices Reflow Simulation	JSED22-A113, peak reflow temp +235C	
Acoustic Microscopy	All parts	J-STD-020	
Electrical Measurements	Per device spec	-55C, +25C, +125C	
Life Testing Subgroup 1	HTOL 125C	MIL-STD-883, Method 1005 2000 hrs	16
	Electrical Measurement	Hot/cold/room, per device spec	
Temperature Cycling	Temperature Cycling	MIL-STD-883 -55C to +125C, 500 cycles	
	Electrical Measurement	-55C, +25C, +125C, per device spec	
	Acoustic Microscopy		
	Failure Analysis		
HAST	Biased HAST	JSED22-A110 +130C, 85% RH 96 hrs	16
	Electrical Measurement	-55C, +25C, +125C, per device spec	

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Table 3. Comparison of different space-grade flows offered by Renesas.

RENESAS SPACE FLOW OVERVIEW

	Radiation Tolerant Plastic	Radiation Hardened Plastic	Class QMLT	Class QMLQ	Class QMLV	/PROTO
Package	Plastic	Plastic	Ceramic	Ceramic	Ceramic	Ceramic or Plastic
Single Wafer Fab	Yes	Yes	Yes	Yes	Yes	Yes
Single Assembly Site	Yes	Yes	Yes	Yes	Yes	Yes
Bond Wires	Au	Au	Al	Al	Al	Al or Au
Lead Finish	NiPdAu/NiPdAu-Ag	NiPdAu/NiPdAu-Ag	NiAu	NiAu	NiAu	NiAu
Production Temperature Test	+25C	-55C to +125C	-55C to +125C	-55C to +125C	-55C to +125C	-55C to +125C
SEE Levels	Up to 43MeV	Up to 86MeV	No	No	Up to 86MeV	Up to 86MeV
TID Levels	Up to 30krad	Up to 100krad	No	No	50krad - 300krad	50krad - 300krad
Radiation Lot Assurance Testing	No	Yes	Yes	Yes	Yes	No
Production Burn In	No	Yes	Yes	Yes	Yes	Yes
Serialization	No	Yes	No	No	Yes	No
Production Temperature Cycling	No	Yes	No	Yes	Yes	No
Quality Lot Assurance Testing	No	Yes	Yes	Yes	Yes	No

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A PWM Controller Fast Enough For GaN

Apogee Semiconductor discussed their development of a radiation-hardened PWM controller designed for use with GaN power switches, supporting power supply applications ranging from 0.9 V to 200 V. According to Anton Quiroz, CEO of Apogee Semiconductor, existing rad hard controllers developed for silicon MOSFETs are too slow for use with GaN, so the AFP1422 controller will offer performance more on par with commercial (non-space-grade) parts. The controller will operate at an adjustable switching frequency from 20 kHz to 2 MHz and will be synchronizable up to 2 MHz.

Built for 300 krad of total ionizing dose (TID) resilience, the chip will feature triple redundancy, ESD cells and cold sparing built into the control pins. For additional specs and features see Table 4 below. The company is looking to make samples available by the end of the year. For more information, see the website or email the company.

Table 4. The AFP1422 radiation hardened PWM controller.

Specifications

- 3.3 VDC to 5.5 VDC operation
  - Designed to control power supplies from 0.9V to >200V
- Adjustable constant frequency 20kHz to 2MHz
  - Synchronizable up to 2MHz
- Adjustable non-overlap times
- Direct drive of logic level or GaN low side or transformer coupled FETs
- Programmable soft-start time
- 1% regulation accuracy
- Extended operating temperature range (-55 °C to +125 °C)
- Built-in triple redundancy for enhanced reliability
- Accurate adjustable enable threshold with adjustable hysteresis
- Fast switch disable when enable goes low
- Over-temperature warning
- Class 2 ESD protection (4000 V HBM, 500 V CDM)

Radiation Performance

- TID resilience of 300 krad (Si)
- SEL resilient up to LET of 75 MeV-cm^2/mg
- SEFI resilient up to LET of 75 MeV-cm^2/mg

Expanding A Superjunction MOSFET Family

As part of their participation in virtual NSREC, IR HiRel's Andrew Popp shared information about their new R9 rad hard power MOSFETs in his presentation, "Upgrading a flight-proven DC-DC converter with R9 rad hard silicon MOSFETs" which is also the subject of his contributed article in this March issue of How2Power Today. His presentation included updates on the superjunction R9 devices, which offer lower figure-of-merit than previous generation rad hard MOSFETs.

N-channel versions of the R9 devices were introduced in recent years, but in the time that's elapsed since NSREC 2019, the company has introduced p-channel versions. Announcements on these p-channel parts are expected soon. All R9 devices are JANS-qualified to MIL-PRF-19500 and released direct to QPL for use in space applications. Fig. 1 below shows information on the different die sizes available for the company's rad hard MOSFET families. For more information, see the R9 rad hard MOSFET technology page or contact Andrew Popp.

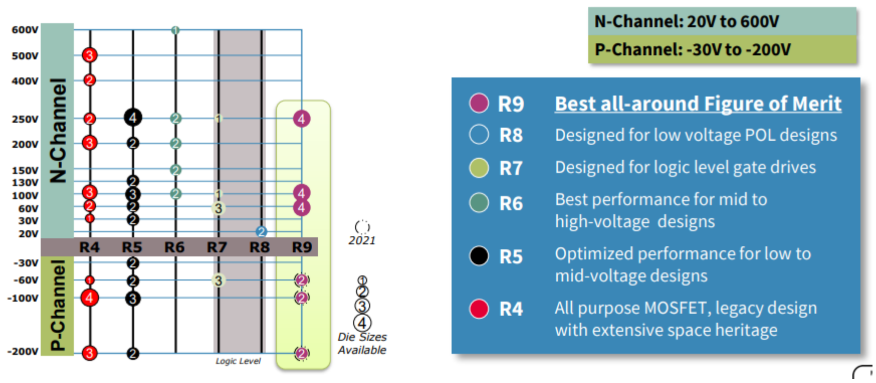

Fig. 1. From IR HiRel, an Infineon Technologies company, the R9 superjunction MOSFETs offer better (lower) figures of merit than their R5 and R6 predecessors, which are planar devices.

Smart Power Switch Controller Brings Greater Integration

CAES, formerly COBHAM, gave a paper in the data workshop on its smart power switch controller (SPSC), the UT36/UT05PFD103, and also mentioned it in a short webinar, according to Matt Von Thun, technical fellow at CAES. The company had previously demo'd the UT36PFD103 at NSREC 2019 as reported by How2Power (see the reference).

The UT36/UT05PFD103 smart power switch controller is described as the space industry's first highly integrated power switch controller providing extensive fault detection, isolation, and recovery capabilities combined with built-in digitized telemetry of input voltage, output voltage, and load current. Adding PMBus protocol over I^2C communication, the UT36/UT05PFD103 provides system-level integration with reduced size, weight, power and cost that was previously unattainable for high-channel count power distribution units, according to the vendor.

For more information, see the power management ICs page or email Tim Meade.

Higher Current And Wider Input Range For Point-Of-Load Converters

While not officially launched at NSREC, Texas Instruments (TI), a NSREC exhibitor, released two power devices for space while the conference was being held, according to Mark Toth, marketing and applications manager for Space Power Products at TI. These parts offer performance gains for point-of-load converters (POLs)—one is a radiation-hardness-assured, ceramic-packaged device, while the other is a rad-tolerant plastic part.

The TPS7H4001-SP is a space-grade 18-A buck converter intended for satellite POL applications. "In addition to being the highest-current POL in our space-grade portfolio, this is the smallest ceramic-packaged device in the industry at this current level, which supports our space customers' needs for increased power density," said Toth (see Fig. 2).

He adds "This device is also a key part in the power supply solution for the Xilinx KU060 FPGA, as showcased in [a] development board which uses TI Space Grade power for all the rails. I'd also call your attention to the extensive technical documentation and design collateral, including detailed radiation reports, SPICE models, app notes and evaluation modules supporting between one and four POLs operating in parallel."

The device is rated for 100-krad total ionizing dose (TID) and is characterized for single-event effects (SEE) up to 75 MeV-cm^2/mg. Toth also notes this part features "a unique design in the 34-pin ceramic dual flat package that uses slugs under the package body to increase the output and GND current capacity, keeping the package small while supporting up to 18 A." For more on this converter, see the TPS7H4001-SP page. For more on the Xilinx KU060 development board see this page.

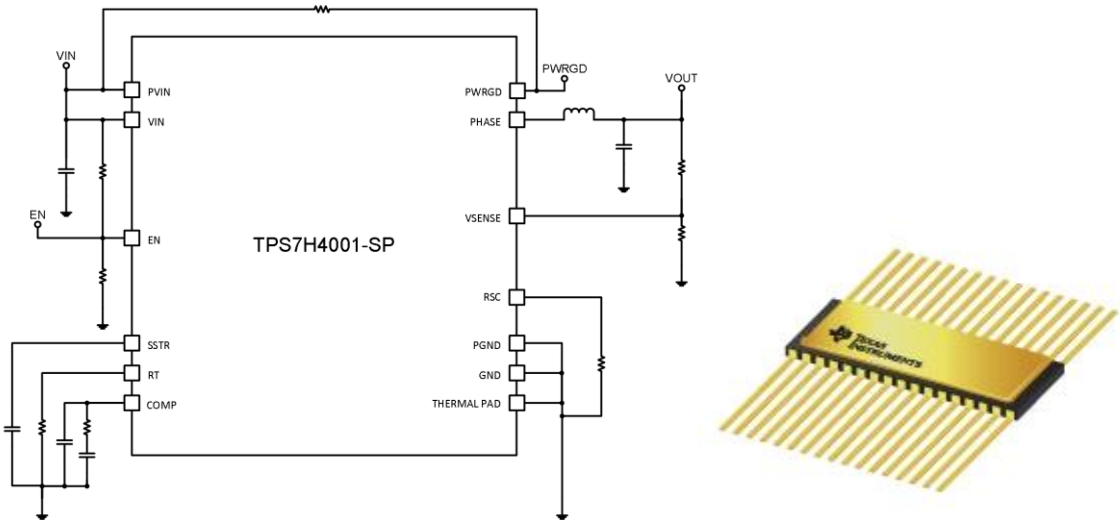

Fig. 2. The TPS7H4001-SP is a rad hard, 18-A synchronous stepdown converter that operates from a 3-V to 7-V input. Its ceramic flat pack package is shown on the right.

The TPS7H4010-SEP is a space-enhanced plastic 3.5-V to 32-V, 6-A buck converter targeted for POL applications in LEO satellites and shorter-duration satellite missions. "This is the first POL in TI's Space EP line, and the widest-voltage monolithic radiation-tolerant POL in the industry," says Toth (see Fig. 3).

The wide input voltage allows customers to interface directly to intermediate rails like 12 V and 24 V that are more common in small satellites. The 4-mm x 6-mm QFN package and radiation characterization to 30 krad TID and 43 MeV-cm^2/mg for SEE make it suitable for requirements in LEO orbits. For more information, see the TPS7H4010-SEP page.

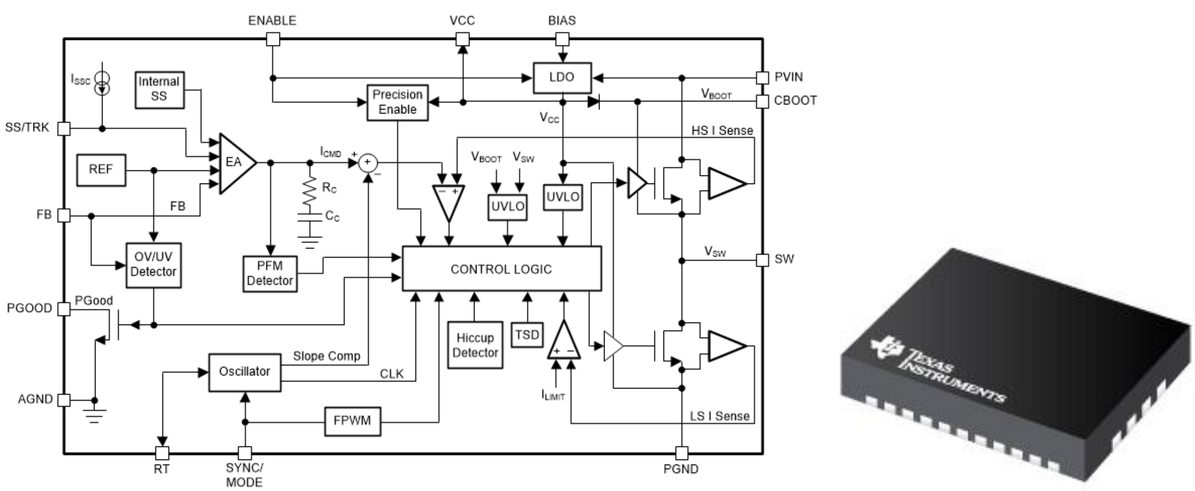

Fig. 3. The TPS7H4010-SEP is a space-enhanced plastic-packaged 6-A buck converter whose wide 3.5-V to 32-V input range voltage allows it to operate from intermediate rails like 12 V and 24 V that are more common in small satellites.

Reference

"NSREC 2019: Rad Hard Power IC Portfolios Add New Functions And Higher Performance Options," How2Power Today, September 2019.

