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NSREC 2019: Rad Hard Power IC Portfolios Add New Functions And Higher Performance Options

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The growth in space applications, especially small satellites, has been driving the development of space-grade power ICs and modules for several years. In response to demands for efficient power conversion solutions, semiconductor manufacturers and power module makers have developed radiation hardened (rad hard) power supply ICs and discrete power semiconductors, point-of-load converters (POLs) and isolated dc-dc converters. But they haven't stopped with the components needed for power conversion. In recent years they have expanded their portfolios to include rad hard versions of power management functions such as power sequencing ICs. The latest step in this direction, which was in evidence at the recent IEEE Nuclear and Space Radiation Effects Conference (NSREC 2019, held July 8-12 in San Antonio, Texas), is the development of rad hard current limiters, load switches and load switch controllers. These devices simplify the implementation of power protection and power supply redundancy, offering compact, integrated alternatives to discrete load switch designs.

Meanwhile, development of rad hard semiconductors and modules for power conversion continues, and in the NSREC 2019 exhibition, semiconductor vendors showed their new reference designs for buck converters and isolated flybacks. Some of these take advantage of GaN power switches, which were also on display at NSREC along with their drivers. Another new twist in this area is the development of rad hard power conversion building blocks fabricated in a conventional CMOS foundry. These parts, which are being developed by a semiconductor startup, are intended to bridge the gap in performance between commercial and space-grade power ICs with the low cost requirements of small satellites in mind.

"Load switches, GaN power modules and IP blocks for power ASICs were among the newest rad hard power components on display at NSREC 2019."

Commercial space applications have also driven other power product trends such as the introduction of space-grade power semiconductors in plastic packages and power converter modules with lower levels of radiation hardness as seen in the NSREC exhibits.

Rad Hard Current Limiters And Load Switches

STMicroelectronics demo'd the RHRPMICL1A, a rad hard integrated current limiter designed to work with an external p-channel power MOSFET. This IC can be used to protect a power supply against overcurrent conditions or to control redundant loads. It could provide a resettable substitute for conventional fuses, or be used to protect them.

Designed by ST's engineering center in Catania, Italy, the RHRPMICL1A is described as the first *integrated* current limiter controller that is rad hard. Up until now, designers have relied on discrete implementations of this function for applications requiring radiation hardening. This part can also be contrasted with integrated current limiters that have the power MOSFET built in. Those are necessarily lower voltage parts whereas the RHRPMICL1A specifies a wide supply voltage range of 8.5 to 52 Vdc and this can be further extended up to 90 V.

The RHRPMICL1A is fully configurable. It features three user-configurable operating modes (retriggerable, latched and foldback), with different behaviors in case of an overload/short-circuit event. The current limit, the trip-off and recovery times and the undervoltage protection are all user configurable. An internal block diagram and package drawing are shown in Fig. 1. A demo board is also pictured. Although not yet formally announced, this device has been internally qualified and is awaiting QML qualification. A datasheet is available online.

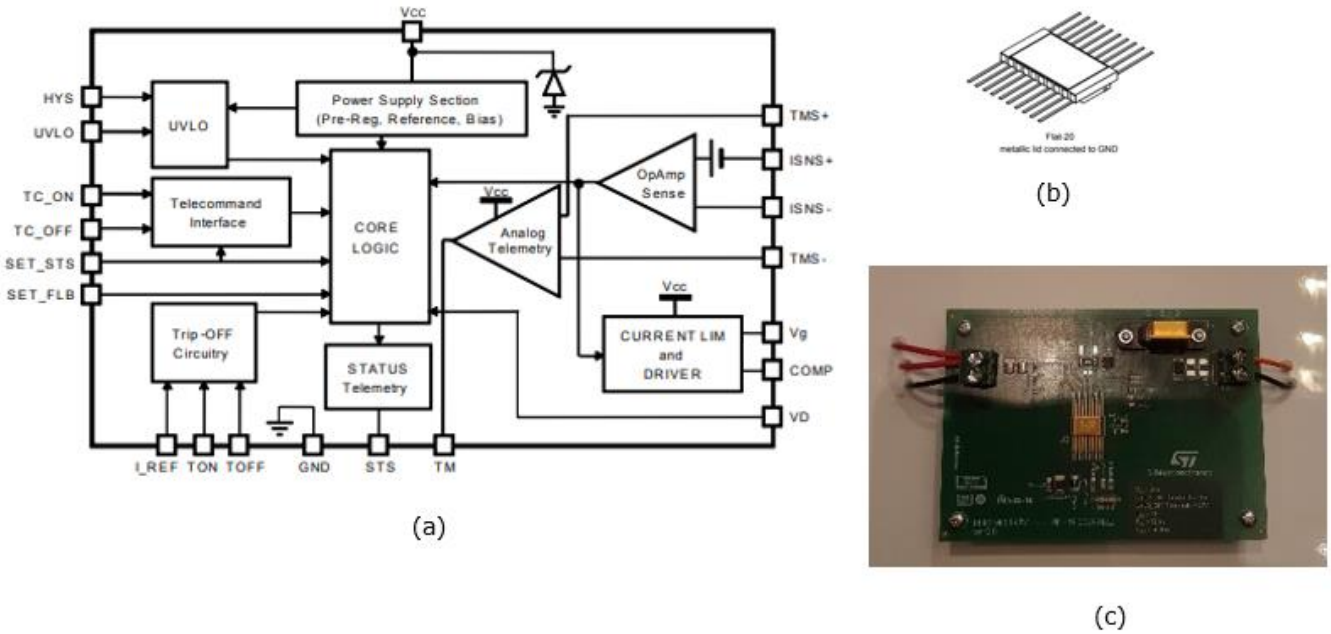


Fig. 1. STMicroelectronics' RHRPMICL1A is described as the first integrated current limiter controller that is rad hard. A block diagram (a) and the package (b) are pictured here. This IC replaces discrete solutions for higher voltage applications that require the use of an external MOSFET. The company used this evaluation board (c) (EVAL-RHRICL1AxV1) to demo the part at NSREC 2019. The board is offered in three versions corresponding to the three modes of protection, as denoted by the x in the part number—a latched version (x = L), a retriggerable version (x = T) and a foldback version (x = F).

At its booth, Cobham demo'd its UT36PFD103 smart power switch controller. This device can serve as a load switch or resettable fuse. As a load switch controller, it can be used to switch between power sources. As a resettable fuse, it can shut down a faulty power bus. This device operates with 8- to 36-V power buses. Contributing to its designation as a "smart" device is its inclusion of a PMBus interface, which enables it to be controlled by and report data to an external MCU. According to Cobham, this part is the first PMBus-enabled power switch controller for space (see the block diagram in Fig. 2 and eval board in Fig. 3).

Another NSREC 2019 exhibitor, Texas Instruments, discussed (but did not show) their new TPS7H2201-SP load switch. According to Mark Toth, marketing manager for High Reliability Products at Texas Instruments, this part was released in the first half of this year. A QML-Class-V certified version was released in January, while a radiation-hardness-assured version was released in June. At the time of its lease, the TPS7H2201-SP was the first space-grade load switch, says Toth.

The TPS7H2201, which integrates two FETs connected back to back, is a single-channel load switch featuring a configurable rise time to minimize inrush current and provide reverse-current protection. The device contains a p-channel MOSFET that can operate over an input voltage range of 1.5 V to 7 V and can support a maximum continuous current of 6 A. A simplified application schematic and package drawing are shown in Fig. 4.

A data sheet for this part is available online and a blog on the TI website explains some of the unique aspects of the part and its applications.

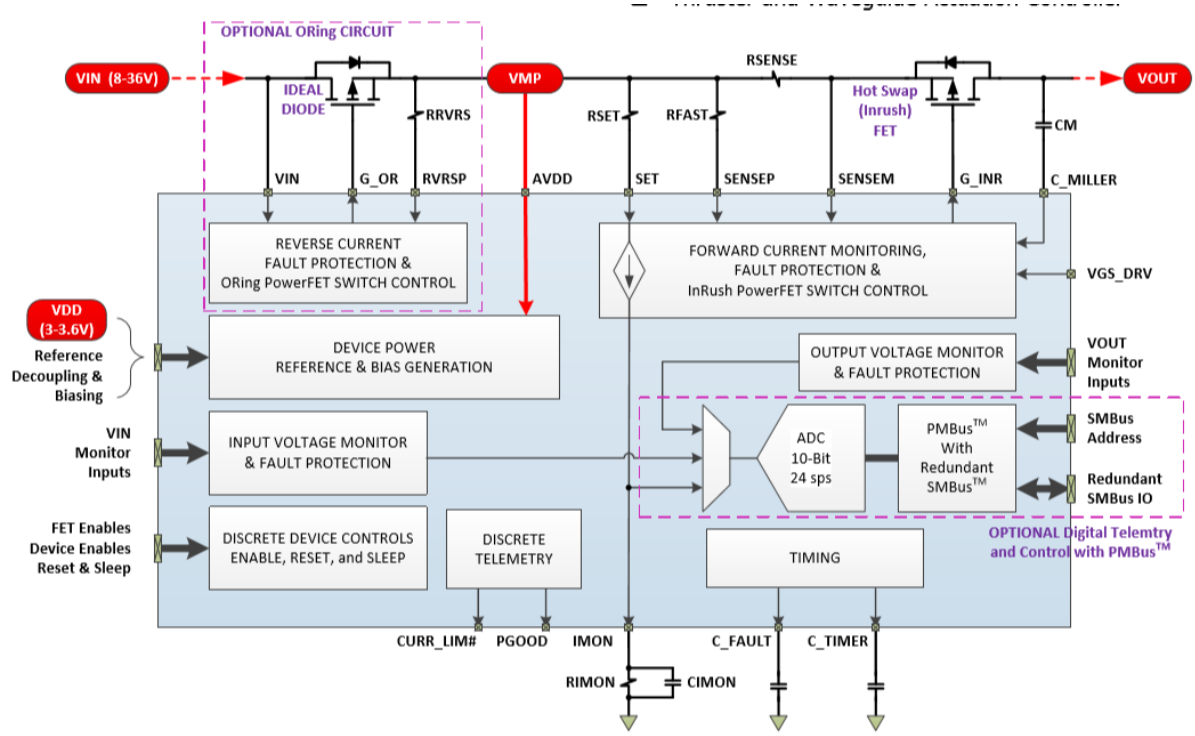


Fig. 2. Cobham's UT36PFD103 smart power switch controller (SPSC) is an intelligent power MOSFET controller with load-side inrush current limiting and eFuse protection of current faults. An optional ideal diode (ORing FET) facilitates redundant power architectures such as uninterruptable power supplies.

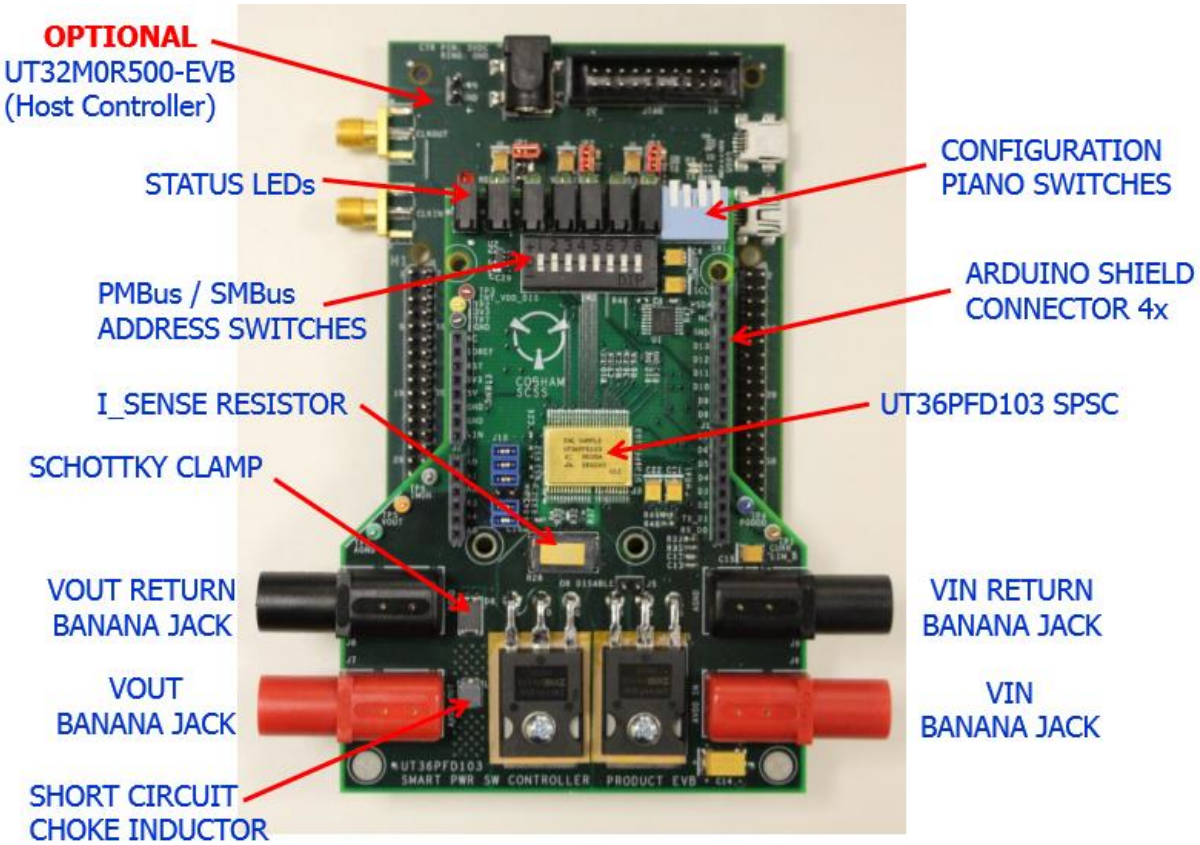


Fig. 3. An eval board for the UT36PFD103 smart power switch controller.

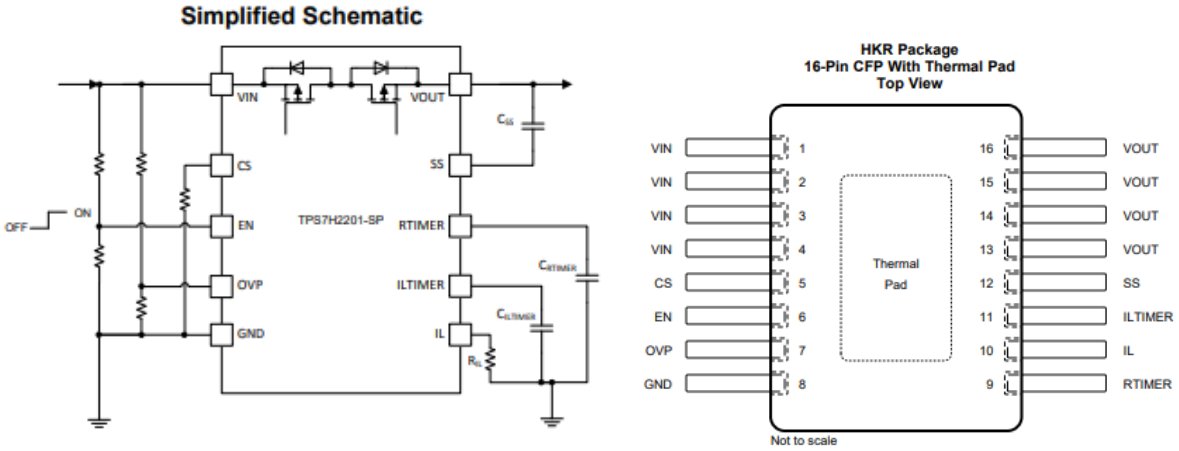


Fig. 4. Texas Instrument's TPS7H2201 simplified application schematic and package drawing with pinout.

Continued Progress With GaN

Freebird Semiconductor's exhibit offered a glimpse into how GaN power semiconductors are evolving for use in space. The company showed its GAM02 series of epoxy overmolded, multifunctional half-bridge driver modules for commercial space applications. These modules are offered with or without integrated GaN power switches (see part numbers and diagrams in Fig. 5). The company released the FBS-GAM02-P-R50 module, a 100-V, 10 A half-bridge driver with integrated power switches, earlier this year into full mass production. According to Jim Larrauri, co-founder and chief strategy officer for Freebird, the FBS-GAM02-P-R50 was the first GaN driving GaN commercial-space-rated rad hard device on the market.

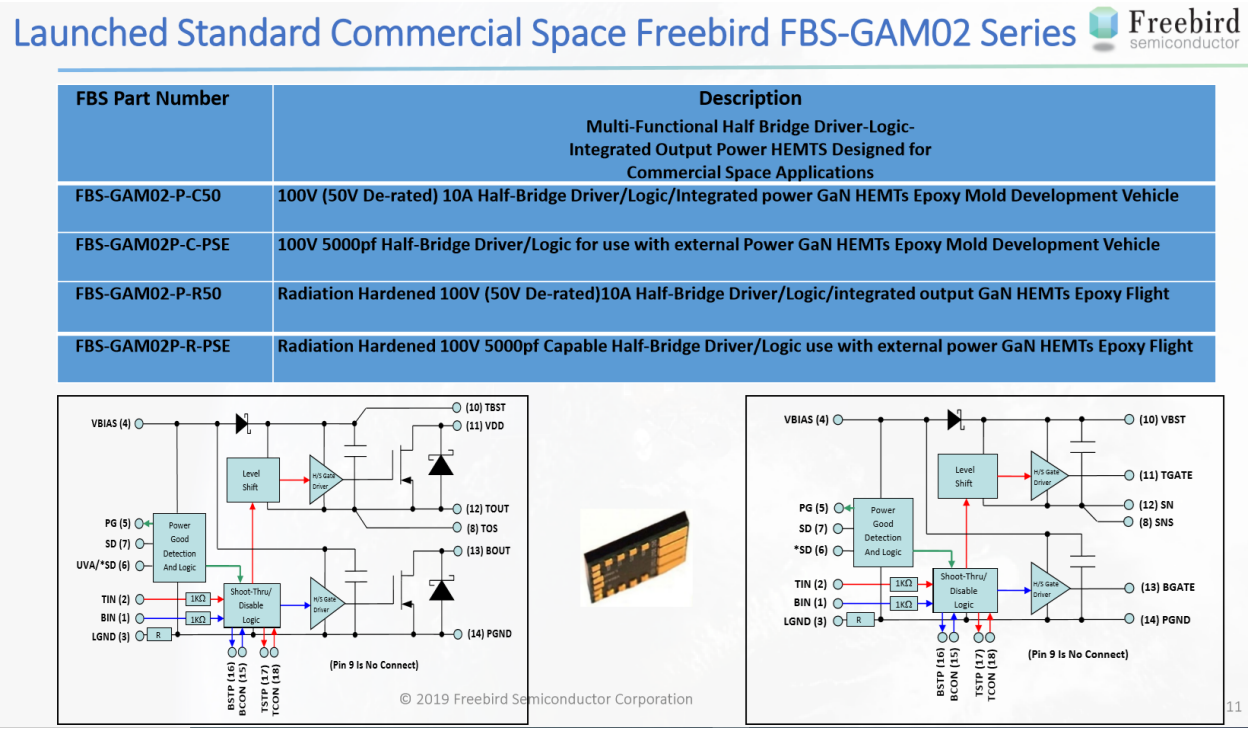


Fig. 5. Part numbers and block diagrams for Freebird Semiconductor's GAM02 series of fully integrated half-bridge multifunctional modules.

At NSREC, the company also showed the more recently released FBS-GAM01 series of single low-side gate drivers, another series of epoxy overmolded, rad hard components for commercial space designs. As with the GAM02 series, the GAM-01 series is offered with or without integrated GaN power switches (see part numbers and diagrams in Fig. 6). Commenting on both product series, Larrauri says "We are driving the commercial

space industry with the most advanced RHA validated epoxy over-molded and 'space flight proven' technologies."

FBS Part Number	Description
FBS-GAM01-P-C50	100V (50V De-rated) 12A Low-Side Driver/Logic/Integrated power GaN HEMTs (Development Vehicles)
FBS-GAM01-P-C100	200V (100V De-rated) 12 A Low-Side Driver/Logic/Integrated power GaN HEMTs (Development Vehicle)
FBS-GAM01-P-R50	100V (50V De-rated) 12A Low-Side Driver/Logic/Integrated power GaN HEMTs Epoxy Over Mold Flight Units
FBS-GAM01-P-R100	200V (100V De-rated) 12A Low-Side Driver/Logic/Integrated power GaN HEMTs Epoxy Over Mold Flight Units
FBS-GAM01P-C-PSE	5000 pf Drive Capable Low-Side Driver/Logic use with External Power GaN HEMTs (Development Vehicle)
FBS-GAM01P-R-PSE	5000 pf Drive Capable Low-Side Driver/Logic use with External Power GaN HEMTs Epoxy Over Mold Flight Unit

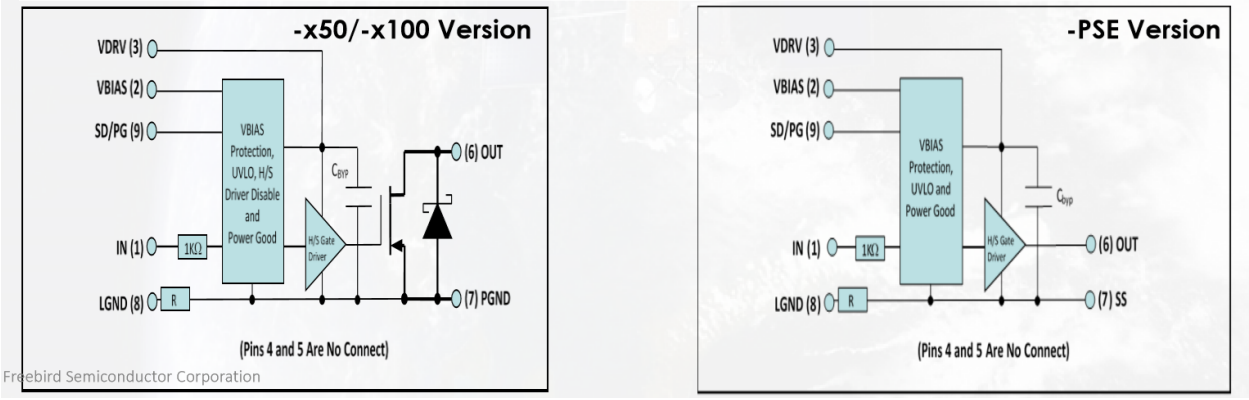
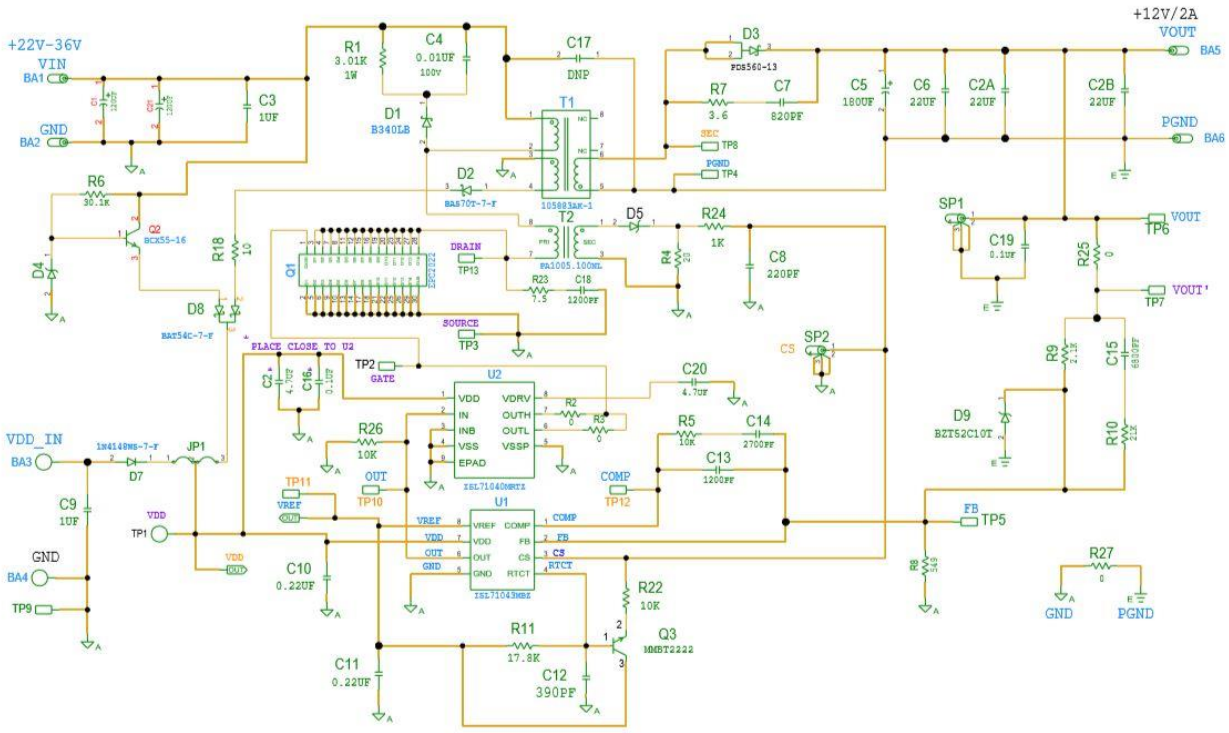


Fig. 6. Part numbers and block diagrams and for the GAM01 series of low-side gate driver modules.

Another company showing GaN power switches was Intersil. At their booth they displayed a reference design for a radiation tolerant flyback converter designed to stepdown a 28-V system bus to 12 V at power levels up to 24 W. According to Oscar Mansilla, senior strategic marketing engineer at Intersil, the design combined the company's ISL71043M rad tolerant PWM controller and ISL71040M rad tolerant low-side GaN FET driver, with EPC's eGaN FET, achieving efficiencies in the mid 80s percentages. Intersil's controller and FET driver target the LEO applications where a fully radiation hardened device is not required and the program is more cost sensitive, says Mansilla.

A schematic for this rad tolerant flyback reference design and a photo of the associated eval board are shown in Fig. 7. The user guide for this eval board is currently in development and is expected to be released shortly.

More information can be found on the ISL71040M product page and the ISL71043M product page.



(a)

(b)

Fig. 7. Intersil's radiation tolerant flyback converter reference design. Schematic (a) and eval board (b) are shown here.

A Building Block Approach To Better Power Supply ICs

Another company working to address the commercial, small satellites market is startup Apogee Semiconductor. According to Anton Quiroz, CEO of Apogee, the traditional hermetic, rad hard power parts are unacceptable for these applications both because of cost and because the components lag the state of the art in terms of what's available from commercial power components by 10 years or more. The lack of such high-performance power components is problematic because the developers of the small sats are trying to push their technology.

Apogee is working to bridge this technology gap between commercial and rad hard power components by developing rad hard building block functions, which customers can use to implement power conversion or power management functions. But ultimately, the company plans to use these building blocks to create technologically up-to-date and more complex functions like PWM controllers and "smart power" or digitally enabled power converter ICs.

Apogee's efforts to develop rad hard building blocks began when one of the company's founders developed a rad hard IC technology that could be manufactured in a standard CMOS foundry. The company then located a foundry partner, TSI Semiconductor, which was willing to address medical and space applications by developing a rad hard process that bolts onto their standard CMOS process. Working with the foundry, Apogee developed a radiation hardened process design kit that enables rad-hard mixed-signal design.

Since putting the process and design tools in place, Apogee has been working on designing the foundational IP blocks for power conversion and commercializing them. The first two blocks that have been developed so far are a rad hard oscillator and a rad hard reference with an adjustable output from 2.5 V to 0.6 V. Quiroz describes the oscillator and reference as completely robust and tested for both TID and SEE radiation immunity. These IP blocks can be used by customers as building blocks for power supply ASICs—ones offering better performance than currently available rad hard components.

The company has also developed a rad hard logic family, which customers can use to implement glue logic on their boards. In addition, Apogee has created a rad hard majority voter. These parts implement cold sparing, a form of redundancy used in space applications which requires parts to be isolated while turned off.

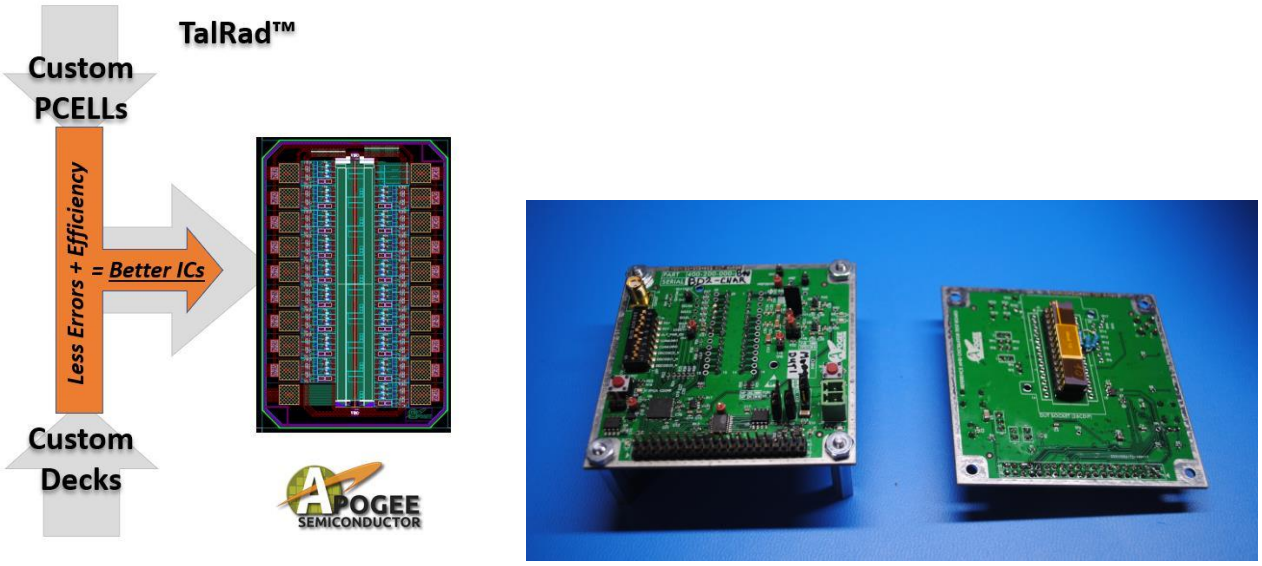


Fig.8. Apogee Semiconductor's TalRad process design kit (a) enables rad-hard mixed-signal design. A reference and oscillator IP test board (b) enable evaluation of these foundational IP blocks for power conversion.

POLs And Isolated DC-DC Converters

As in past years, the NSREC exhibition continued to showcase the latest rad hard point-of-load converters (POLs) and isolated dc-dc converter modules. Texas Instruments' TPS50601A, a 3-V to 7-V input, 6-A synchronous buck converter POL is considered the company's flagship rad hard POL. Although this part was originally released a couple years ago, an "A" version came out last year. According to Mark Toth, the A version

offered a wider input voltage range (up to 7 V max versus 6.3 V for the original) and higher peak efficiency (96.6% vs 95% at 3.3-V output). The A model also incorporates a p-channel MOSFET as the high-side FET rather than the n-channel MOSFET used in the original, enabling the A version to operate at 100% duty cycle.

Two other areas of performance that were improved in the A version were the accuracy of the reference and radiation hardness. VREF accuracy was improved from +2.5/-3.5% to ±1.5%, which is critical for sensitive FPGAs. SEE performance was improved to be free of single-event-transients (SETs) and single-event-functional interrupts (SEFIs) up to a linear energy transfer (LET) of 65 MeV.cm^2/mg.

At NSREC the company showed the application of this POL in a new reference design for powering the Xilinx KU060 FPGA. This design parallels four TPS50601-SP devices in parallel to deliver 24 A at 0.95 V to the FPGA core. A photo of the reference design is shown in Fig. 9 and more details are available on the TI website. The development platform that powers the Xilinx KU060 FPGA with TI space-grade power devices can also be viewed on the website.

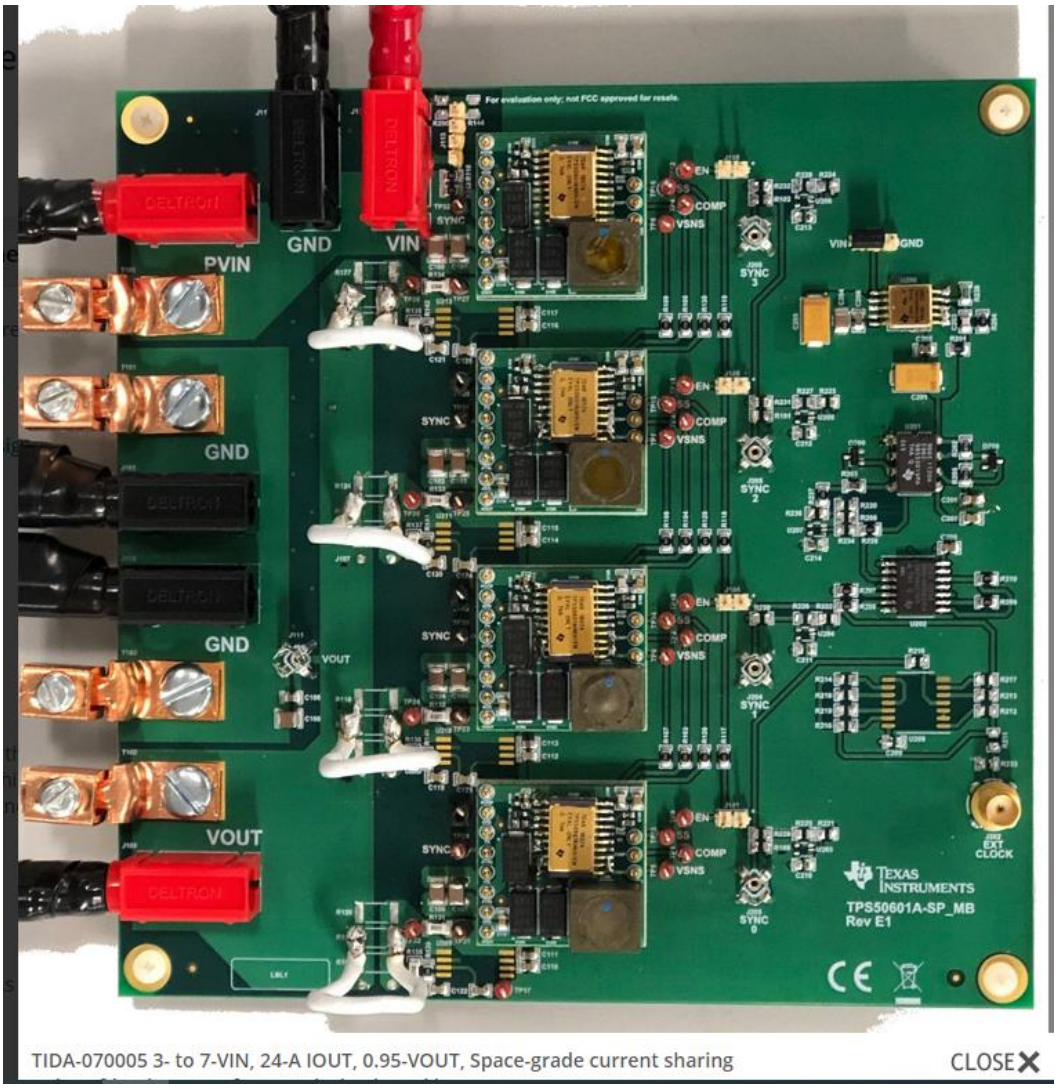


Fig. 9. A POL reference design from Texas Instruments for powering the Xilinx KU060 FPGA using four TPS50601-SP devices.

Meanwhile, Crane Aerospace and Electronics, showed a member of its new SMP 120 series. The SMP12028S is a 120-V input approx. 50-W dc-dc converter, which was introduced in March of last year, but is still largely in the prototype stage, according to Simon Abel, director of Business Development, Strategic at Crane Aerospace and Electronics. He adds that the company expects the product to be fully qualified and available in Q1 of next year.

This 120-krad TID rad hard, isolated converter with built-in EMI filter is available with either 28-V output capable of delivering 49 W (this is the SMP12028S) or with a 5-V output capable of delivering 40 W (SMP12005S). Its 120-V input is much higher than most of the company's products, which typically feature a 28-V input. A unit is shown in Fig. 10.

The SMP120 series converters operate over an input voltage range of 80 to 160 V with 180-V transient protection. The SMP120 includes unique features such as inrush current limiting and output overvoltage protection to make system integration easier. They are screened to Class H and Class K, per MIL-PRF 38534, with radiation tolerance of L 50 krad(Si) and R 100 krad(Si) for TID. A datasheet is available on the company website.

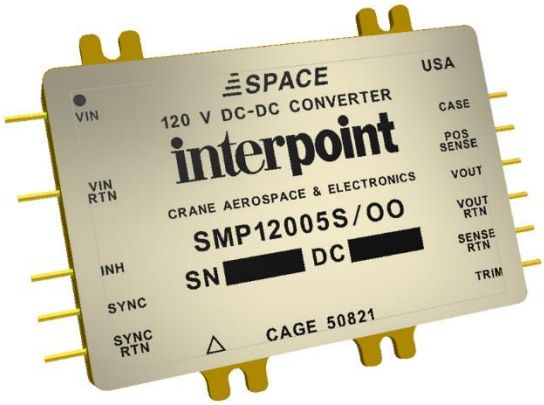


Fig. 10. Crane Aerospace and Electronics' SMP120 series rad tolerant isolated dc-dc converters are designed to operate from 120-V power buses.

VPT showed its SBRG series dc-dc converter, which was announced in May. The SGRB series features an integrated EMI filter, 100-V input and 28-V, 400-W output, and is rated for full power operation from -35°C to 85°C.

Using advanced GaN technology, the SGRB is capable of very high efficiency, up to 95%, as well as radiation tolerance. A fixed-frequency reduced-voltage switching topology results in very low input and output noise, making it suitable for use in telecommunication systems. According to VPT, this product is still in its preview stage. For more information, see the product announcement.

Next year's conference, NSREC 2020, will be held July 20-24, 2020 in Santa Fe, New Mexico. For more information, see the conference website.