

Where To Find DC-DC Converters And Related Power ICs For Space Applications

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A number of companies offer rad hard dc-dc converters, voltage regulators or related power ICs for use in space applications. Some of these devices are complete, functional power modules, while others are ICs, which may require additional circuitry. The dc-dc converters may be either isolated or nonisolated, but are generally performing voltage stepdown. These converters, which are typically built using hybrid or PCB-based construction, are mostly offered by power supply/power module manufacturers.

Meanwhile, semiconductor manufacturers with rad hard capabilities also offer non-isolated dc-dc converters and switching regulators built either as monolithic ICs or multi-chip modules. They also offer related chips such as linear regulators, plus building block functions for creating dc-dc converters and switching regulators. These chips include PWM controllers, gate drivers, and voltage references plus power MOSFETs and other discretes.

This document lists the manufacturers providing rad hard (or in some cases, rad tolerant) versions of all these devices, describing what device types they offer along with some details on their rad hard capabilities. These descriptions are based on information posted by the companies. If you have questions or comments on this list, contact [me](#).

Companies listed in this section include:

- **API Technologies***
 - BAE Systems
 - CISSOID
 - Cobham
 - Crane Interpoint Aerospace & Electronics
 - Freebird Semiconductor
 - Intersil
 - IR Hi Rel, An Infineon Technologies Company
- **Isocom***
 - Linear Technologies (Analog Devices)
 - Microsemi
 - Modular Devices
 - M.S. Kennedy (Anaren)
 - Peregrine Semiconductor (Teledyne Hired Electronics)
 - STMicroelectronics
 - Texas Instruments
- **3D Plus***
 - VPT.



API Technologies

API Technologies designs and manufactures a wide range of space-qualified, rad-hard linear regulators qualified for space. Product lines include positive and negative linear voltage regulators (and voltage references) at up to 1.5-A output. Models in this product series offer quiet, linear voltage regulation with stabilities over the full temperature range approaching that of a very stable voltage reference. Features include both adjustable and fixed outputs with remote sense capability, as well as excellent power supply rejection ratios. In addition, there is an option to include a resistor to limit output voltage rise should the remote sense connection be severed.

API Technologies' rad-hard power conversion and control products are designed for extreme environmental conditions and radiation exposure. API Technologies specializes in reducing size, weight, and power consumption (SWaP) for critical space systems where strict constraints are of the utmost importance. The AP

Series products feature radiation hardness assurance up to 300 kRad TID, hermetically sealed packaging, and operation over the full -55° to +125°C temperature range. For more information, see the [website](#).

BAE Systems

BAE Systems develops and produces a wide array of radiation-hardened space products, from standard components and single-board computers, to complete system payloads. BAE Systems specializes in a broad domain of rad-hard electronics, including ASICs, application-specific standard products (ASSPs), microprocessors, memories, FPGAs, and single-board computers. After making power supply products for internal use for many years, the company recently introduced point-of-load converters (POLs) in its standard product portfolio. Operating from 3-V to 5.5-V or 6-V input, these products are rated for output currents up to 14 A or 22 A, when paralleled, while offering total dose immunity to 100 krad. For more information, see <http://www.baesystems.com/en-us/our-company/inc-businesses/electronic-systems/product-sites/space-products-and-processing>.

CISSOID

CISSOID is a provider of high-temperature semiconductor solutions, delivering standard products and custom solutions for power management, power conversion and signal conditioning in extreme temperature and harsh environments. CISSOID provides high reliability products guaranteed from -55°C to +225°C and commonly used outside that range. Power products, typically offered in IC packaging, include voltage references and voltage regulators, dc-dc converters, gate drivers and motor drivers. The company also offers discrete transistors, power switches and diodes plus various analog functions.

Regarding the radiation hardness of these components, the company notes that the most common failure mechanism in applications that are subject to radiation exposure—as well as to high temperature operation—is latch-up. CISSOID products are intrinsically immune to latch-up. As a result, these products exhibit outstanding performance against radiation.

Successful total dose tests were carried out on a number of CISSOID ICs up to 50 krads and 96 krads, with various dose rates. Heavy ion single-event effects (SEE) tests were conducted on various CISSOID products: no SEL, SEU or SET was detected up to 55.9 MeV mg-1cm-2 (Si). Actual performance varies between products; contact CISSOID for more information. See <http://www.cissoid.com/>.

Cobham

Cobham's Power Distribution Modules (PDMs) offer high end-to-end efficiency from the satellite bus (22 to 100 V) down to the point of load. The PDMs are a two-stage solution that leverage resonant mode control, zero-voltage/zero-current switching, chip on board manufacturing, planar magnetics, proprietary FETs, controllers and drivers to provide greater than 50 W of power at 83%+ end-to-end efficiency to an FPGA or ASIC. All of this is accomplished in a footprint of ~4 in². These modules are also radiation hardened to meet 50 krad(Si) TID and SEL immunity up to 80 MeV-cm²/mg.

The PDMs are a family of input regulator modules (IRM) and isolated point of load modules (iPOLs) that together make up a power conversion system. The IRM provides a regulated intermediate voltage to the iPOL which can be set to adjust to load condition by utilizing the adaptive loop feature between the IRM and iPOL. The iPOLs are isolated, unregulated, dc-dc converters that divide down the intermediate bus voltage, provided by the IRM, by a constant k-factor. These PDMs can generate an adjustable output voltage as low as 0.65 V to meet the core voltage requirements of the latest FPGAs and ASICs.

Cobham also offers radhard PWM controllers and radiation-tolerant single and dual adjustable voltage regulators. Each regulator is easy to set-up and the design has been optimized for excellent regulation and low thermal transients. In addition, Cobham also offers voltage supervisors.

The Cobham RHD (RadHard-by-Design) series provides spacecraft designers with a complete set of building blocks to support rapid and affordable implementation for RadHard Analog Circuit applications on space programs. Cobham's line of RadHard-by-Design Analog Function Products for LEO, GEO, MEO and deep space missions include op amps, comparators, analog muxes, digital-to-analog & analog-to-digital converters, level shifters, voltage references and temperature sensors. For more information, see <http://ams.aeroflex.com/pagesproduct/prods-hirel-rhd.cfm>

Crane Interpoint Aerospace & Electronics

The space Interpoint dc-dc converters are available with SMD numbers up to class K and RHA levels of P 30, L 50 or R 100 krad(Si). The company's space EMI filters are compliant up to class H or K with RHA of H. For more information, see <http://www.craneae.com/Products/Power/Power.aspx>.

Freebird Semiconductor

Freebird Semiconductor is a fabless design and domestic (USA) manufacturing company offering advanced high-reliability wide-bandgap power switching technology. The company is focused on delivering enhancement-mode gallium nitride power transistors (eGaN HEMT) with eGaN-based portfolios facilitating evolutionary advantages over silicon-based solutions.

Freebird Semiconductor provides a portfolio of proven radiation hardened "eGaN" based high-reliability power switching transistors addressing critical space-borne environments with Freebird Semiconductor patent filed design technologies. A high-reliability performance qualification test vehicle is employed with guaranteed radiation hardness assurance. For more information, see <http://freebirdsemi.com/about/>.

Intersil

Intersil offers a broad range of radiation hardened (rad hard) and single-event effects (SEE) class V (space level) compliant products for space and harsh environment applications. These include analog, digital and power management ICs. Intersil's rad hard power products achieve the stringent voltage accuracy required of FPGAs, ASICs, microprocessors and microcontrollers used in space and harsh environment applications.

The company's solutions enable regulation accuracy over input voltage, load current variation, switching noise, and large load transients and have proven highly reliable within mixed radiation exposure rates and other harsh environment variants. Rad hard products include linear regulators, MOSFET drivers, supervisory ICs, switching controllers and switching regulators.

Intersil is one of only a few RHA Defense Logistics Agency (Land and Maritime) QML suppliers. All Intersil radiation hardened SMD products are MIL-PRF-38535/QML compliant and are 100% burned in. For more information, see <http://www.intersil.com/en/products/space-and-harsh-environment/rad-hard-products.html>.

IR Hi Rel, An Infineon Technologies Company

Space hardware must operate in extreme environmental conditions including exposure to severe ionizing radiation that necessitates the use of radiation-hardened components. International Rectifier offers a comprehensive portfolio of high-reliability, ruggedized discretes and integrated ICs including solutions for dc-dc conversion, solid state switching and motor control.

Offerings include space-level point-of-load non-isolated dc-dc converters with output voltage as low as 1.0 V for processor power and isolated intermediate bus converters; a selection of hermetic, hybrid dc-dc converters from standard to rad-tolerant to rad-hard for launch vehicles; a large portfolio of space-level hermetic, hybrid dc-dc converters qualified to MIL-PRF-38534 class K and available as SMD; and a selection of space-level, hermetic, hybrid dc-dc converters for RF applications.

Built around proprietary RAD-Hard processes, IR's family of HiRel discretes includes RAD-Hard MOSFETs, IGBTs and Schottky rectifiers. The company also offers a comprehensive family of hermetically sealed devices that encompasses IGBTs, Schottky and ultra-fast rectifiers. There are also fixed and adjustable versions of IR's Rad-Hard ULDO voltage regulators and industry-standard hermetic linear voltage regulators. Other products include single, dual and octal, 1 to 20 A, ac and dc, rad-hard solid-state relays in surface-mount and thru-hole packaging. For more details, see <http://www.irf.com/product/ /N~1njci1>.

Isocom

Isocom is a specialist manufacturer of optocouplers in Europe including rad hard optocouplers such as the IS49, CSM141A and CSM1800 devices. The company also offers a wide range of power MOSFETs including n-channel devices with breakdown voltage ratings from 30 to 1200 V and p-channel devices with ratings of -60 and -100 V; and a range of solid-state relays (SSRs). These rad hard devices are specified to a TID of 100 krad (Si). Note that ISOCOM also offers custom-designed voltage regulators and POLs. For more information, see the [website](#).

Linear Technologies

Linear Technology, now part of Analog Devices, manufactures a broad range of rugged radiation tolerant (rad hard) voltage regulators (both linear and switching.) In addition, Linear Technology partners with several

outside vendors to provide monolithic packaged and hybrid products of Linear Technology RH DICE. Linear Technology and [AEI Systems](#) have teamed to provide SPICE models and worst case analysis support for the company's entire range of rad hard products. For more information, see http://www.linear.com/products/Space_Qualified_Linear_Regulators.

Microsemi

Microsemi's radiation hardened products have guaranteed total ionizing dose (TID) radiation performance through radiation acceptance testing. This may or may not include official DLA/DTRA RHA certification and designation in the 5962 SMD number or JAN slash sheet. The company's broad portfolio of radiation-hardened and radiation-tolerant space products includes FPGAs, ASICs, RF components, diodes, transistors, MOSFETS, hybrids, power supplies, custom semiconductor packaging and integrated power distribution systems.

Microsemi's radiation hardened analog/mixed-signal ICs and power modules/hybrids provide efficient solutions for power management and power conversion applications. With current-mode and voltage-mode switching regulators, Microsemi continues to innovate, with power management solutions for military and space applications. Microsemi's radiation hardened regulators includes hybrid switching regulators with integrated FETs and inductors, as well as both LDO and non-LDO linear voltage regulators.

Microsemi provides power/military MOSFETs in hermetic packaging to support the needs of our high reliability customers. These devices are DLA qualified and offer great value for mission critical applications. All these QPL listed devices come in JAN, JANTX, JANTXV qualification levels. Some are available in JANS space grade versions, and commercial grade versions are also available. We have cross references to many International Rectifier MOSFETs that are not available in JANx qualified versions from IR.

BJTs offer higher transconductance than MOSFETS and don't require separate gate drivers. A particular strength is that they are current amplifiers capable of very high current densities. They can be used as amplifiers, switches, and oscillators and are capable of very high frequency operation. They can also be used as temperature sensors and logarithmic converters. Microsemi's broad offering of QPL qualified BJTs spans voltages from 10 V to 760 V, rated currents from 0.01 A to 50 A and power ratings from 0.15 W to 300 W. Maximum junction temperatures up to 200°C are available, as are many leaded and surface mount packing solutions. For more information, see <http://www.microsemi.com/product-directory/high-reliability/3239-radiation-hardened-devices>.

Modular Devices

Modular Devices continues new product innovation and development to supplement its comprehensive line of Proton rad hard 100K+ hybrid dc-dc converters with devices that make power component integration for space power systems engineers and satellite systems designers easier, faster and more reliable.

Hybrid products include inrush limiters for control of input current to downstream dc-dc converters with large capacitive inputs; power bus controllers, which enable control and selection of dual redundant input power buses; point-of-load dc-dc buck regulators; a solid-state relay; an active diode ORing circuit; and ruggedized dc-dc converters that meet MIL-STD-461 D/E/F conducted emissions, power leads CE101 and CE102. For more information, see http://www.mdipower.com/index.htm?./product/prod_home.html&3.

M.S. Kennedy

MSK Products, now part of Anaren, designs and manufactures rad hard, complex custom hybrid microcircuits. The company's rad hard products have been tested to one or more of the following radiation assurance tests; total ionizing dose (TID), enhanced low dose rate effects (ELDRS), neutron and proton displacement damage, and single event effects (SEE, SET, SEL and SEB.)

The company's standard rad hard and radiation tolerant products for space flight continue to expand. Currently these products consist of operational amplifiers, motor controls, linear and switching power supply components. More specifically, the power supply components include a current sense amplifier, bridges with gate drive, many linear regulators (including LDOs), an H-bridge PWM driver, multiple buck converters, and voltage references and drivers.

MSK Products is certified and qualified to MIL PRF 38534 for both class H (military) and class K (space) microelectronics and certified to MIL PRF 38535 for class Q and class V single chip products. For more information, see <http://www.mskennedy.com/products/Rad-Hard-Products>.

Peregrine Semiconductor

Peregrine Semiconductor, now part of Teledyne Hires Electronics, has a broad portfolio of high-reliability products for space applications including phase-locked loops (PLLs), prescalers, mixers, digital step attenuators (DSA), switches and point-of-load (POL) dc-dc converters. These products are offered by e2v through a strategic reseller agreement. Peregrine's silicon-on-sapphire (SOS) process is proven to be immune from single event latch-up (SEL) and enhanced low dose rate sensitivity (ELDRS)—making it well suited for space applications. [Visit e2v](#) for more information on these products.

Peregrine's power management products follow a steep tradition of high performance and efficiency. The flagship power management family supports dc-dc conversion with radiation-tolerant point-of-load (POL) synchronous buck regulators with integrated switches. These devices offer SEE immunity to a linear energy transfer (LET) greater than 90 MeV.cm²/mg and TID of 100 kRad(Si). By offering superior performance, smaller size and reduced weight, these power management products can replace multi-chip modules in space-sensitive applications.

Dc-dc converters from Peregrine can replace traditional multi-chip modules that power FPGA, DSP, ASIC and SRAM power management designs. The combination of small size, high levels of integration and efficiency lowers total system weight and associated costs. Peregrine's converters are designed to operate from a wide bus rail and provide an output voltage supply rails for analog, digital and RF payloads while delivering continuous output current. The converters also achieve high peak efficiency of 93+ percent through monolithic integration that reduces switch loss. The components feature an external resistor that provides adjustable slope compensation to optimize closed-loop bandwidth across output voltage and switching frequency range.

STMicroelectronics

Electronics in aerospace applications such as satellites and aircraft are subjected to high levels of radiation from high-energy particles (heavy ions). ST proposes a large portfolio of products specifically designed, packaged, tested and qualified so they comply with the standards for aerospace defined by the qualifying agencies.

ST is qualified by the European Space Agency (ESA) since the agency's inception. ST has broadened its efforts by qualifying products according to the American QML-V standard (of the US DLA - Defense Logistics Agency), and in accordance with Radiation Hardness Assurance (RHA) certification.

ST offers a wide space product range, from diodes and transistors to A-D converters and voltage regulators, through its traditional logic circuits range. It is actively working on further expanding this offering.

ST's rad-hard voltage regulators offer very good performance inside many applications such as satellites and aircraft. They are available with an input voltage of up to 12 V, maximum current up to 3 A and fixed and adjustable output voltage versions starting from 1.23 V. They are available in a range of packages: FLAT-16, SMD5C, SMD.5, TO-257, and SMB5C. Other power products for space include current limiters, gate drivers, voltage references and PWM controllers. Among the rad hard discretes are power MOSFETs, bipolar transistors, and fast recovery and Schottky diodes. For more information, see <http://www.st.com/en/aerospace-and-defense-products/space-products.html>.

Texas Instruments

TI offers leading-edge QML class V and radiation hardness assured (RHA) products qualified for space flight. The company's selection of rad hard ICs includes power management devices, amplifiers, data converters, processors, logic, clocks and timing chips, memory, and interface chips. Power management devices include voltage references, linear regulators, switching regulators (buck converters), pulse-width modulators, a FET driver, a resonant controller, and motor controllers. The company also provides tools and software for space & high reliability such as WEBENCH Designer for Space Power and a Mini POL reference design. See <http://www.ti.com/lscs/ti/space-high-reliability/space.page>.

3D Plus

3D Plus is a supplier of advanced high-density 3D microelectronic products and bare die and wafer level stacking technology meeting the demand for high reliability, high performance and very small size of today's and tomorrow's electronics. 3D Plus offers a full lineup of radiation tolerant products including memories, POL converters, interfaces, peripherals and protection ICs, and industrial memories, solid-state drives, camera heads and more complex system-in-package (SIP) solutions.

Radiation hardened by design, the company's space qualified point-of-load dc-dc converter provide a single and adjustable output voltage with a very high efficiency and excellent dynamic performance required by fast and

low voltage digital electronics such as FPGAs, DDR and DDR2 SDRAM memories. The company also offers a rad hard DDRII termination regulator. For more information, see the company's POL Converter [page](#).

VPT

Create your power distribution system with a complete array of radiation tolerant or radiation hardened isolated dc-dc converters, radiation hardened non-isolated point of load converters, and radiation immune EMI filters in varying TID and SEE levels to fit your LEO, MEO, GEO, deep space, or launch program. VPT offers two series of dc-dc converters and accessories designed, tested, and proven for the challenging environment of space: the SVR and SV series.

The SVR series offers a TID of 100 krad(Si), an SEE of 85 MeV-cm²/mg, MIL-PRF-38534 Class K, on-DLA SMDs, a DLA-approved RHA plan, and was developed for TOR Compliance. The SV series offers a TID of 30 krad(Si), an SEE of 44 MeV-cm²/mg, MIL-PRF-38534 Class K, on-DLA SMDs, and a DLA-approved RHA plan. For more details, see <http://www.vptpower.com/applications/space-systems/#.WJCbRBsrKUK>.