



APPLICATION NOTE

VSC Series Space COTS DC-DC
Converters and EMI Filters

DC-DC CONVERTERS AND ACCESSORIES



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Introduction

New technological advancements and private sector investments are driving rapid growth in the commercial space industry and have led to the emergence of a NewSpace market. These innovations have made space more accessible and affordable by lowering the barriers to entry and allowing new companies to participate in the space economy. Emerging aerospace companies are driving innovations to reduce costs and development time.

Until now, the space market has relied exclusively on costly space-qualified, hybrid DC-DC converters. The VSC Series DC-DC converters are radiation tolerant, high-performance, and reliable, packed into a small, light package. VPT's VSC Series DC-DC converters are designed to meet the requirements for suborbital applications, low Earth orbit (LEO) satellites, and NASA class D missions, making the VPT's VSC Series DC-DC converter the leading, cost-effective, commercially available power solution for the NewSpace market.

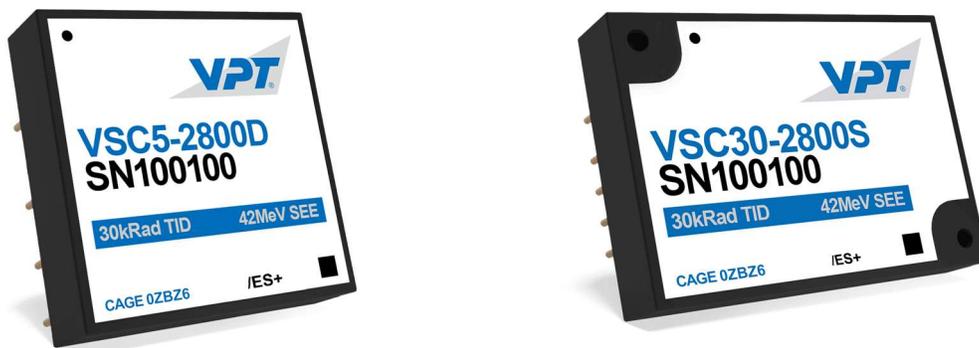


Figure 1. VSC5-2800D and VSC30-2800S

The VSC Series offers high-reliability, space-qualified COTS DC-DC converters, and EMI filters, supporting the need for a radiation tolerant, cost-effective power solution for NewSpace applications. Radiation performance guaranteed to 30 krad(Si) for TID, including LDR and no destructive SEE to 42 MeV/mg/cm² in accordance with VPT's in-house radiation hardness assurance (RHA) plan. This series is tested to 40 krad(Si) for TID and 42 MeV/mg/cm² for destructive SEE and is characterized at 30 MeV for transients. Designed for NASA class D and LEO missions, the VSC Series blends a proven design heritage, performance, and assembly techniques in a robust package. The VSC5 dual and VSC30 single output converters are shown above in Figure 1.

Proven Spaceflight Heritage

The internal electrical design of the VSC Series is based on our VPT Series high performance, Hi-Rel COTS, which have been integrated into thousands of aerospace, mobile, and ground applications. Backed by VPT's extensive experience in developing radiation hardened, space-qualified hybrid DC-DC converters. VSC Series products are radiation tested in accordance with VPT's in-house space COTS Radiation Hardness Assurance plan (RHA), which is based on VPT's DLA-approved hybrid RHA plan.

Series	Topology	Input Voltage Range	Input Voltage Transient	Output Trim Range
VSCPL1210S	Buck	4.5 to 13.2V	NA	0.8 to 5V
VSC5	Flyback	15 to 50V	80V	NA
VSC15	Flyback	15 to 50V	80V	+10% -20%
VSC30	Flyback	15 to 50V	80V	+10% -20%
VSC100	Forward	16 to 40V	50V	+10% -20%

Table 1. DC-DC Converter Topologies

The VSC product line of space-qualified DC-DC converters include output power ratings of 5W, 15W, 30W, 100W, and 50W for the POL, or point of load. Each has four different output voltages of 3.3V, 5V, 12V, and 15V apart from the VSC100 which also has a 28V output and the POL which has an adjustable output from 0.8 to 5V. Moreover, the VSC product will offer single and dual output converters. The VSC Series has a wide input voltage range of 15V-50V and an input voltage transient capability of up to 80V. VSC100 has an input voltage range of 16V to 40V and can handle an input voltage transient of 50V. The VSC Series uses flyback and forward topologies, both proven and reliable power stage designs. Table 1 shows each VSC DC-DC converter's different topologies, input voltage range, and input voltage transient.

Series	Single Output Functions	Dual Output Functions
VSCPL1210S	Sense, SYNC, INHIBIT, TRIM	NA
VSC5	INHIBIT	INHIBIT
VSC15	INHIBIT, TRIM	INHIBIT
VSC30	Sense, SYNC, INHIBIT, TRIM	SYNC, INHIBIT
VSC100	Sense, SYNC, SHARE, INHIBIT, TRIM	SYNC, INHIBIT, TRIM

Table 2. VSC Functional Features

The VSC Series converters have many of the protection features offered in our other families including undervoltage lockout (UVLO), output soft start, and output overcurrent protection. Internally the input L-C filter is designed to maintain low input current ripple and low output voltage ripple. All VSC DC-DC converters have the same useful functional features used on other VPT DC-DC converter product families. The INH pin is an output off/on control pin referenced on the primary side of the converter. TRIM allows for -20%/+10% output voltage adjustment by adding a resistor between TRIM and Vout or Trim and Outcom. Sense has two pins, a negative sense (-S) and a positive sense (+S) that compensates for pin, trace, connector, and diode voltage drops up to 10% of the nominal output voltage. Synchronization (SYNC) allows multiple converters to run at the same frequency and can be driven by an external clock. SHARE, also known as parallel operation, allows for active current sharing for multiple VSC100 converters. All these features allow the VSC Series converters to be integrated into any system. Refer to Table 2 for the different functional features of each VSC converter.

System Output Power (Watts)	Recommended Filter	Rated Current (Amps)
25	VSCF1-28	1.0
75	VSCF3-28	3.0
200	VSCF10-28	10.0
400	VSCF20-28	20

Table 3. Filter Recommendations

VPT also offers the VSC Series EMI filters compliant with all revisions of MIL-STD-461 at four different input current levels 1A, 3A, 10A, and 20A. Corresponding with four different power levels 25W, 75W, 200W, and 400W. VSC EMI filters are designed to reduce the conducted emissions of multiple VSC DC-DC converters up to the current rating. The VSC EMI filter uses the same six-sided packaging as the VSC Series DC-DC converters giving this product the ability for dual heatsinking. Furthermore, the VSC filters are also designed with the same label and packaging as the rest of the VSC Series DC-DC converters, reducing outgassing and eliminating floating metal. Filter recommendations for the VSC Series are shown in Table 3.

Space COTS

Space-qualified DC-DC converters need to be designed to withstand radiation in space. The amount of radiation in space depends on altitude and time. Low Earth orbit (LEO) is defined as 180 km to 3,000 km above the surface of the Earth, resulting in a lower amount of radiation exposure than deep space applications. The space-qualified VSC Series is guaranteed to 30 krad(Si) for TID, including LDR, and no destructive SEE to 42 MeV/mg/cm². The Series is tested

to 40 krad(Si) and 42 MeV/mg/cm². This level of radiation tolerance is sufficient for many NewSpace LEO applications. VPT uses radiation-immune magnetic feedback in all isolated DC-DC converters.

Radiation performance is backed by VPT's in-house Radiation Hardness Assurance (RHA) plan. The VSC Series converters are built using radiation lot acceptance testing (RLAT) components, which are tested to 40 krad(Si) for TID. Using RLAT components guarantees the radiation performance of the VSC Series and can be broken down into four main parts which are Bias Conditions, Dose Rates, Test Parameters and Limits, and Evaluation of Testing. The bias conditions during testing are the conditions the component is going to be in during normal operation rather than the components limit. The dose rate for most tests is 50-300 rad(Si)/s per MIL-STD-883, unless the component has been identified as having ELDRS sensitivity in which case LDR testing is also done at a rate of 10-50 mrad(Si)/s. The measured parameters and limits are defined by the worst case analysis of the converter and only the parameters that significantly affect the operation of the converter. Lastly, we use 90/99 statistics to determine if a lot passes or not. This means that 99% of bad components will be rejected 90% of the time, and a bad component is defined as one that went beyond the parametric drift limit set by the worst case analysis. To learn more about VPT's approach to NewSpace converter reliability, review our [VSC RHA plan white paper](#).

The VSC Series uses the same automated assembly process as VPT's other Hi-Rel COTS to deliver a cost-effective and reliable solution. Power stage, control circuitry, and magnetics are all integrated into a single multilayer printed circuit board (PCB). Built to withstand the extremes of space in a unique packaging consisting of conformal coating and epoxy encapsulation. The packaging protects the converter in shock and vibration environments and mitigates the risk of tin whiskers. This construction technique results in a small, lightweight, yet robust package. Using a single PCB and automated production reduces lead times and production costs. Integrated planar magnetics ease manufacturability and increase efficiency by reducing leakage inductance.



Figure 2. VSC15-2800S



The temperature range for a continuous operating condition at full load for the VSC Series converters is between -55 °C and 105 °C. This temperature should be measured on the baseplate of the converter. There is no derating or compromise of any electrical specifications on the datasheet over the full rated temperature range. This includes startup at -55 °C. The epoxy is very thermally conductive, and heat can be pulled from the top and bottom of the package. No paints are used on the packaging to maintain low outgassing. The VSC Series converters have a vinyl label to prevent electric charges from building up on the unit's surface.

Quality and Reliability

Components used to manufacture VSC products are acquired and tested through [VPT's internal space COTS RHA plan](#) based on VPT's DLA-approved hybrid RHA plan to ensure radiation performance. VPT's RHA plan documents all the processes and procedures for assuring the performance of VPT space COTS products under various environmental conditions, including Total Ionizing Dose (TID) and Single Event Effects (SEE). Furthermore, the converters were characterized for Enhanced Low Dose Rate Sensitivity (LDR) by testing samples at a rate of 50 mrad(Si)/s to reach 30 krad(Si). Radiation tolerance is assured by converter level characterization and sample High Dose Rate (HDR) TID testing of sequestered lots of all radiation-sensitive semiconductor components used in the converter. TID testing done on RLAT components is to 40 krad(Si) per MIL-STD-883 Method 1019. The VSC converters are characterized to 30 krad(Si). For SEE testing, the VSC converters are tested to LET \geq 42 MeV/mg/cm² for catastrophic events (SEL, SEB, SEGR) and to LET \geq 30 MeV/mg/cm² for transients (SET) and functional interrupts (SEFI) under heavy ion exposure. During testing, all VSC products experienced no destructive SEB up to 42 MeV/mg/cm².

VPT follows MIL-HDBK-217F guidelines when calculating the mean time between failures (MTBF). Manufacturing is performed in a J-STD-001, IPC-A-610 class 3, and ISO-9001 certified facility.

Environmental screening and qualification are to military levels, specifically MIL-STD-810 and MIL-STD-883. The VSC Series is offered in one screening level, which includes ten temperature cycles between -55 °C to 125 °C, a 96-hour burn-in at 105 °C, a 500V isolation test, and a final electrical test is done at -55 °C, 25 °C, and 105 °C. The qualification process includes a humidity test, 1000-hour life test, and 100 temperature cycles, in addition to mechanical shock and random vibration tests to ensure performance in space environments.

By putting low-cost, commercially available components through a rigorous qualification process, VPT improves reliability while keeping the cost per unit low.



Right for Your Next Application

VPT has extensive experience making high-reliability power supplies for avionics, military, and space applications. VPT parts have performed in thousands of applications, from the US Air Force's most critical satellites to ruggedized laptop computers, countless aircraft systems, UAVs, weapons, vehicles, ground, and man-portable, to almost any application imaginable. VPT is certified to MIL-PRF-38534 Class K, the highest quality certification awarded by the US Defense Supply Center Columbus (DSCC). VPT is the only manufacturer to offer both full MIL-SPEC and extensive COTS DC-DC converter solutions for avionics, military, and space applications.

VPT is the leading supplier of high-reliability DC-DC converters. Leverage our power conversion expertise and experience for your cost-sensitive applications with the VSC Series. The VSC Series is based on VPT's Hi-Rel VPT Series DC-DC converters using radiation tolerant components to meet the radiation requirements for many NewSpace applications. VPT understands the specific requirements of the avionics, military, and space markets, provides long-term production support and technical assistance, and can accept low-volume orders. For the most demanding or critical applications, choose from VPT's MIL-PRF-38534 hybrid DC-DC converter product line: fully hermetic, radiation hardened options, fully qualified to MIL-PRF-38534 and MIL-STD-883, and available on standard microcircuit drawings (SMDs).



Contact Information

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