



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 investment 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 brick. 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, low-cost, commercially available power solution for the NewSpace market.

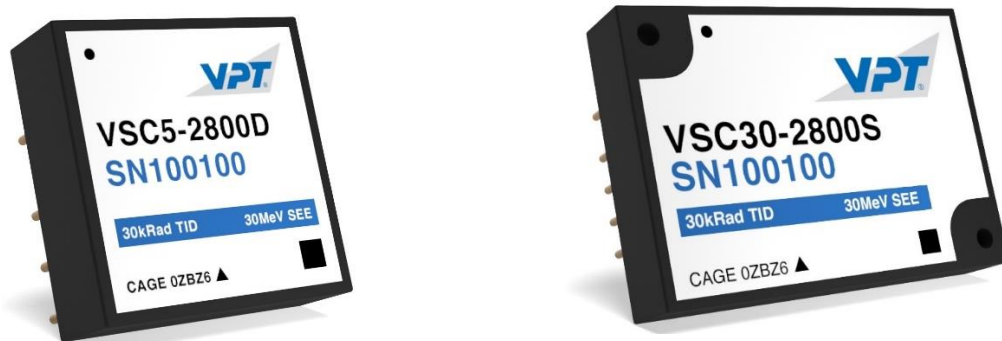


Figure 1. VSC5-2800D and VSC30-2800S

The VSC Series offers high-reliability, space-qualified COTS DC-DC converters, and EMI filters, supporting the need for a radiation tolerant, low-cost power solution for NewSpace applications. Radiation performance guaranteed to 30krad(Si) for TID, including ELDRS and SEE performance to 30 MeV/mg/cm<sup>2</sup>. 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
VSC5	Flyback	15 to 50V	80V
VSC15	Flyback	15 to 50V	80V
VSC30	Flyback	15 to 50V	80V
*VSC100	Forward	16 to 40V	50V

\*VSC100 product line is scheduled for release in Q4 in 2023

Table 1. DC-DC Converter Topologies

The VSC product line of space-qualified DC-DC converters include output power ratings of 5W, 15W, 30W, and 100W. Each has four different output voltages of 3.3V, 5V, 12V, and 15V. 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. This makes the VSC Series able to comply with most input power requirements for NewSpace applications and MIL-STD-704. 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
VSC5	INH	INH
VSC15	INH, TRIM	INH
VSC30	Sense, SYNC, INH, TRIM	SYNC, INH
*VSC100	Sense, SYNC, SHARE, INH, TRIM	SYNC, SHARE, INH, TRIM

Table 2. VSC Functional Features

The VSC Series converters have the same reliable protection features, undervoltage lockout (UVLO), output soft start, and output overcurrent protection found on VPT's other isolated DC-DC converter products. Internally the input L-C filter is designed to maintain low input current ripple and low output voltage ripple and noise. 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 off/on control pin referenced on the primary side of the converter. TRIM allows for -20%/+10% output voltage adjustment. 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	VCSF1-28	1.0
75	VSCF3-28	3.0
200	VSCF10-28	10.0

Table 3. Filter Recommendations

VPT also offers the VSC Series EMI filters compliant with MIL-STD-461C-G at three different input current levels 1A, 3A, and 10A. Corresponding with three different power levels 25W, 75W, and 200W. VSC EMI filters are designed to reduce the conducted emissions of multiple VSC DC-DC converters up to the current rating. Compliant with MIL-STD-461 C-G for conducted emissions, radiated emissions, and susceptibility when using other VSC DC-DC converters. 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. Low Earth orbit (LEO) is defined as 180km to 3,000km 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 30krad(Si) for TID, including LDR and 30 MeV/mg/cm<sup>2</sup> for SEE. 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 42krad (Si) for TID and 40 MeV/mg/cm<sup>2</sup> for SEE. Using RLAT components guarantees the radiation performance of the VSC Series.

The VSC Series uses the same low-cost assembly techniques as VPT's other hi-rel COTS to achieve unmatched performance and reliability. 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 100°C. 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 packaging allows for creative thermal management solutions with a dual heatsinking option. Potting is thermally conductive, allowing the temperature to be recorded on the top and bottom of the converter. 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 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 (ELDRS) by testing samples at a rate of 50mrad(Si)/s to reach 30krad(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 40krad per MIL-STD-883 Method 1019. The VSC converters are characterized to 30krad(Si). For SEE testing, the VSC converters are characterized to LET  $\geq$  42 MeV/mg/cm<sup>2</sup> for catastrophic events (SEL, SEB, SEGR) and to LET  $\geq$  30 MeV/mg/cm<sup>2</sup> for transients (SET) and functional interrupts (SEFI) under heavy ion exposure.

VPT strictly 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 100°C, a 500V isolation test, and a final electrical test is done at -55°C, 25°C, and 100°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

For further information about any of VPT's products, policies, or programs contained herein, or to request a quotation or place orders please contact your sales representative or the VPT Inc. Sales Department at:

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