APPLICATION NOTE

Selecting the Correct Level of DC-DC Converter for Your Application

DC-DC CONVERTERS AND ACCESSORIES

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

Contents:

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

Introduction

Most power systems for high-reliability applications can be constructed from standard power modules. The typical scenario requires various DC output voltages and power levels and is usually met with standard DC-DC converters, EMI filters, and accessory modules. A modular power system can be developed quicker and cheaper than a custom approach. This is true even for critical applications and reliability as high as or higher than that of a custom design.

Critical applications range from undersea to military ground to commercial and military avionics to deep space. Various manufacturers offer DC-DC converters, point-of-load converters, EMI filters, and other power modules, all claiming high-reliability. The question is, how do you know what level of quality and reliability you are getting, and how do you select the correct level for your application?

What Is High-Reliability?

High-reliability is more than just a claim from the manufacturer. High-reliability DC-DC converters must meet specific electrical and environmental performance standards and quality requirements. Those requirements depend on the reliability grade of the product. They can be divided into three categories: high-reliability COTS, Mil-Spec/true military grade, and space grade.

The differences between these reliability grades can be subtle and can be concealed with clever marketing. The product literature must be studied carefully to determine exactly what the product is and, equally importantly, what it is not. Important specifications include temperature rating, hermeticity, military specification compliance, and rigorous environmental qualification. Beyond that, the ultimate test of reliability is official qualification and certification by the Defense Logistics Agency (DLA) Land and Maritime.

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

Defining High-Reliability COTS

High-reliability commercial off-the-shelf (Hi-Rel COTS) DC-DC converters came about in response to acquisition reform spearheaded by Secretary of Defense William Perry in the 1990s, commonly referred to as "The Perry Initiative." Perry's COTS initiative sought to improve the Department of Defense's access to state-of-the-art technology and reduce costs while foregoing military standards for commercial specifications and standards. With the intent of using commercially available or non-developmental hardware where possible and reducing the need for full Mil-Spec compliance.

The VPT and VXR Series of Hi-Rel COTS DC-DC converters are intended for military applications and are commercially available, but they are not fully Mil-Spec compliant. The VPT and VXR Series of Hi-Rel COTS use commercial-grade components and commercial best practices. These DC-DC converter product lines are specifically designed to achieve high-reliability in military applications and harsh environments. Hi-Rel COTS are intended for cost-sensitive applications that impose extreme conditions and require high-reliability, including avionics, UAVs, ground systems, ground vehicles, shipboards, weapons, and other similar applications.

Several important considerations for COTS DC-DC converters are listed below. These characteristics will differ between manufacturers, so evaluating the product you select carefully is important. How that product addresses each item can affect the absolute reliability of your system.

TEMPERATURE RANGE: A wide operating temperature range is essential for most high-reliability systems. If the system is required to operate over a -40°C to 85°C range, it is safest for the DC-DC converter to have a wider range than that. The VPT Series offers full power, continuous operation from -55°C to 100°C. The VXR Series operates continuously at full power from -55°C to 105°C.

INPUT VOLTAGE: A wide input voltage range and high transient capability will greatly simplify system design, accommodating line drops, transients, and noise often present in military electrical power systems.

NO OPTOCOUPLERS: The performance properties of optocouplers vary widely. It is difficult to design a linear optocoupler feedback circuit that can be shown with a worst-case analysis to operate properly over the full temperature range and life required by Hi-Rel applications. Hi-Rel DC-DC converters use magnetic feedback isolation, usually in the form of a pulse transformer, whose properties vary little over temperature and life.

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

FIXED FREQUENCY: All DC-DC converters utilize a switching topology that generates EMI at the fundamental switching frequency. The switching frequency can be fixed or variable, varying with line and load conditions. A fixed frequency is almost universally preferred when it comes to system design. A fixed frequency greatly simplifies EMI compliance, input and output filter design, worst-case analysis, and interaction analysis with other system parts.

PACKAGING: The VPT Series offers a six-sided metal package that reduces the radiated emissions of the DC-DC converter and the radiated susceptibility of the EMI filter. It will facilitate the system EMI design and significantly reduce the likelihood of board-level noise problems compared to open-frame or plastic-packaged DC-DC converters. VXR Series products have an epoxy encapsulated packing with V-Shield® technology with an integrated six-sided metalized shield for the best EMI performance. This packaging is compatible with aqueous cleaning processes and is also offered for many VPT Series products.

TIN WHISKER MITIGATION STRATEGY: Tin whiskers are hair-like crystalline structures that can grow from a pure tin finish. Tin whiskers are electrically conductive and can produce electrical shorts and device failures. Hi-Rel COTS products will invariably contain pure tin finishes internal to the product, often in semiconductor or passive component termination finishes. Since there is a risk of tin whisker formation, a mitigation strategy is essential. A typical strategy prohibits bright tin, uses tin/lead solder, restricts the use of fine-pitch components, and utilizes a conformal coating. Epoxy-encapsulated VPT products offer additional tin whisker mitigation.

COMPLIANCE. When a DC-DC converter is designed for a critical application, it will be required to comply with system specifications. Common electrical specifications for DC-DC converters are MIL-STD-461 for EMI, MIL-STD-704 for aircraft electrical power, and MIL-STD-1275 for military vehicle power. Always select DC-DC converters that are designed to meet these specifications from the outset, with such features as wide input voltage ranges, high transient ratings, and accessory products, including EMI filters, transient suppressors, and line conditioners. Both VPT and VXR Series products are designed to meet MIL-STD-704 input voltage requirements and, when used with a VPT or VXR EMI filter, will meet MIL-STD-461C-G and DO-160 conducted emissions requirements. The VXR Series can meet many MIL-STD-1275 requirements. For more information on MIL-STD-461C-G compliance, please refer to the "MIL-STD-461 Compliance for VPT DC-DC Converters" application note.

QUALIFICATION: Hi-Rel COTS are usually qualified to a manufacturer-specific qualification plan which can include both military and commercial standards. Typical standards used for qualification include MIL-STD-883, MIL-STD-810, MIL-STD-202, and JESD-22. Without a governing military standard, the manufacturer's qualification plan is critical. Look for a qualification plan which includes temperature cycling, mechanical shock, random vibration, and

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

a steady-state temperature humidity life test. For more information, refer to the "VPT Series DC-DC Converters and Power Accessory Modules" application note.

QUALITY SYSTEM: Hi-Rel COTS are assembled to commercial standards such as J-STD-001 and IPC-A-610. The manufacturer should have a quality system that is certified to ISO-9001, but experience with higher quality levels or additional certifications will directly benefit product quality. The manufacturer should also have an aggressive counterfeit parts control plan.

There is one more important point to consider when selecting COTS DC-DC converters. COTS does not imply using a commercial or telecom DC-DC converter outside of its recommended operating range, whether that range is voltage, temperature, or another parameter. It also does not intend the up-screening of commercial DC-DC converters. Up screening, where a device is screened for use beyond its design limits, requires detailed knowledge of its internal stresses. Either of these practices can result in compromised system reliability because of designing without margin or violating component electrical derating or thermal ratings. Qualification failures, compliance issues, field failures due to vibration and temperature cycling, and erratic operation at cold temperatures are typical examples of what can happen when a product is used outside its intended application. Instead, use a Hi-Rel COTS DC-DC converter specifically designed for avionics, military, or other rugged applications.

The VPT and VXR Series of Hi-Rel COTS DC-DC converters are based on VPT's MIL-PRF-38534 hybrid converter designs with 20 years of heritage. The VPT and VXR Series blends proven electrical designs with commercial components and assembly techniques in a rugged package, passes a rigorous environmental qualification, and offers a reliable solution for cost-sensitive applications. Qualification reports for our VPT and VXR Series products are available. Contact your local VPT sales representative to request one.

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

Defining True Mil-Spec DC-DC Converters

A true military-grade DC-DC converter is defined as a Mil-Spec component. The governing specification for DC-DC converter modules is MIL-PRF-38534, General Specification for Hybrid Microcircuits. MIL-PRF-38534 certification is granted and audited by the Defense Logistics Agency (DLA) Land and Maritime, formerly DSCC, an agency of the US Department of Defense. A true military-grade DC-DC converter will be qualified to this specification and listed on a Standard Microcircuit Drawing (SMD). A true military-grade EMI filter will be listed on a DLA Land and Maritime Drawing.

MIL-PRF-38534 governs not only the product but the components, materials, and processes used to build it. This means the converter is built on a DLA-qualified manufacturing line, it has passed a DLA-approved qualification, and it is available to a DLA SMD. This strict process ensures that quality is built into the product from the start, not added later.

Mil-Spec DC-DC converters, governed by MIL-PRF-38534, are the default choice for any critical reliability application. Class H is the “go to” quality level for any application which imposes harsh environmental conditions or is required for high-reliability platforms. Examples of these would include flight-critical avionics, UAVs, ground systems, ground vehicles, missile systems, first-stage space (suborbital), launch vehicles, shipboard, submarine, downhole, high temperature, undersea, high altitude, and other similar applications. An example application is shown in Figure 1.

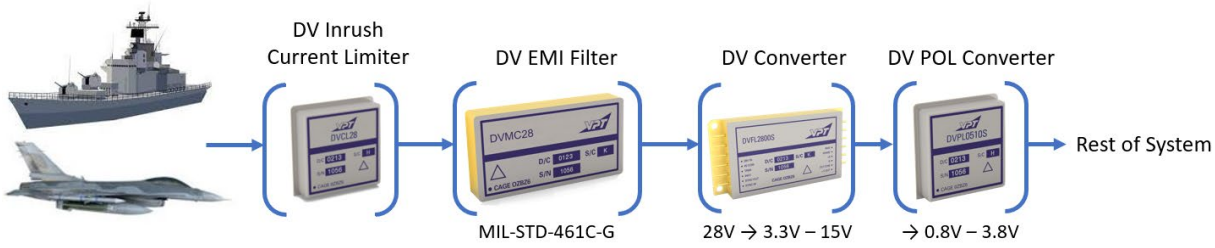

Figure 1: Military-grade DV hybrid Application Example

The military-grade DC-DC converter brings several additional characteristics above what you will find in a COTS-grade product. MIL-PRF-38534 dictates these, and they can drastically increase the long-term reliability of the system. These qualities are highlighted in the coming paragraphs.

WIDE TEMPERATURE RANGE: MIL-PRF-38534 Class H devices are specified to operate continuously over the full military temperature operating range of -55°C to +125°C. High-temperature operation is enabled with bare die power semiconductors and high thermal

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

conductivity ceramic and metal packaging. If your application requires the full military temperature range of operation, be sure your product selection does not include plastic-encapsulated ICs. While many manufacturers claim a full military temperature operating range, true continuous full-power 125°C operation is impossible to achieve with plastic-encapsulated ICs and PCB construction. To rate a PCB-constructed product produced with plastic ICs will result in exceeding the junction temperatures of these ICs and jeopardizes long-term reliability. Using bare die on a ceramic package ensures die junction temperature ratings are met with margin providing a true full military temperature-rated DC-DC converter. This can be achieved because bare die junction temperature ratings are generally 150°C or more. When specifying converters for this temperature range, ensure your supplier does not derate the power to 125°C. VPT hybrid converters operate at full power at 125°C then derate linearly from full power to no power from 125°C to 135°C (case/packaging temperature). For more information, please refer to the "Thermal Considerations for Hybrid DC-DC Power Converters" application note.

HERMETIC PACKAGING: Qualified hybrid DC-DC converter modules are hermetically sealed, usually in welded metal packages with glass or ceramic seals. Hermeticity protects internal semiconductor devices from moisture-related failures. Hermeticity is verified by MIL-STD-883 Method 1014 for fine and gross leak. Internal water vapor is monitored using MIL-STD-883 Method 1018. Hermeticity also allows the device to tolerate liquid cleaning processes during assembly. A true hermetic package should not be confused with packages that appear hermetic or with datasheets using ambiguous terms such as "sealed" or "near hermetic" that do not meet the hermetic conditions defined in MIL-STD-883.

NO PURE TIN: MIL-PRF-38534 specifically prohibits the use of internal and external pure tin finishes with >97% tin, which can produce tin whiskers. Ensure the manufacturer has in place an aggressive program to screen components and eliminate pure tin.

COMPONENT ELEMENT EVALUATION: All materials and components used in DV Series DC-DC converter products are evaluated in accordance with MIL-PRF-38534 to verify they meet their specifications and are suitable for the intended application. Element evaluation differs from qualification in that it is performed on each lot of material.

QUALIFICATION: True military DC-DC converter modules are qualified in accordance with MIL-PRF-38534. Test methods are dictated by MIL-STD-883. The qualification is reviewed, and final approval is given by DLA. This type of qualification differs from that of a commercial manufacturer, where the test plan and final approval are self-determined. Upon successful qualification, the DC-DC converter can be put on a DLA-controlled SMD.

QUALIFIED MANUFACTURING LINE: The qualified DC-DC converter will be built by a QML-listed manufacturer on a qualified manufacturing line. All processes used in the manufacture of the product are qualified and audited by DLA.

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

At the Mil-Spec quality level, manufacturers are certified to ISO-9001 and, above that, to MIL-PRF-38534. A counterfeit parts control plan is required. Regarding the products themselves, optocouplers are generally not used at this level, and fixed frequency and full six-sided metal shielding are standard. Mil standard compliance regarding EMI and input voltage range and transient capability is also standard for this level of product.

MIL-PRF-38534 qualified DC-DC converters can often be procured to a manufacturer datasheet with reduced screening. This option can take advantage of the qualified manufacturing line and processes and the reliability of the hermetic hybrid construction without full Mil-Spec compliance, and therefore at a reduced cost.

VPT's hermetic hybrid DV Series of Avionics / Military DC-DC Converters are built on a DLA-certified manufacturing line and are fully qualified to MIL-PRF-38534 Class H and K. VPT continues to push the technology envelope for hybrid DC-DC converters with high efficiency, low voltage point of load DC-DC converters, high-efficiency isolated converters with synchronous rectification, higher power densities, lower noise, better regulation, and a continued release of new product technologies.

Defining Space Grade DC-DC Converters

Space-level DC-DC converters, radiation tolerant or radiation hardened, are governed by MIL-PRF-38534. This type of hybrid DC-DC converter comes with the same characteristics found on a True Mil-Spec DC-DC converter, such as hermeticity, no tin, made in a manufacturing facility to MIL-PRF-38534 Class H and Class K, and a wide temperature range. VPT's space-grade hybrid converters are characterized for Total Ionizing Dose performance, including Enhanced Low Dose Rate Sensitivity and for Single Event Effects according to VPT's radiation hardness assurance (RHA) plan is certified by DLA to MIL-PRF-38543 Appendix G. Space-level hybrid DC-DC converters, SV, SVL, and SVR Series, are available on SMDs. The SV Series is available to be procured under Class H. SVL, and the SVR Series can be procured to Class H or Class K. An example space-grade application is shown below in Figure 2.

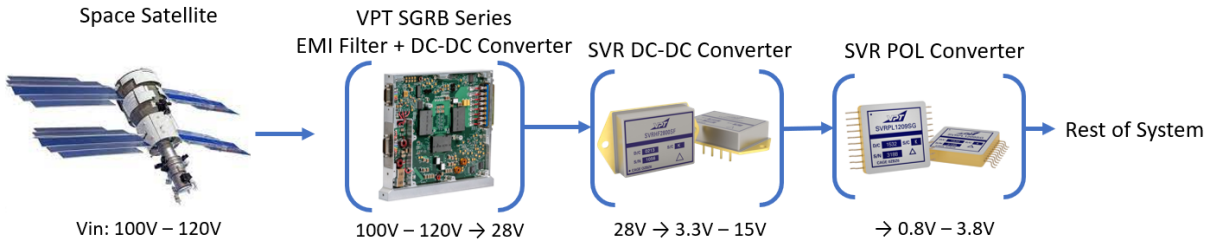

Figure 2: Space-Grade (SVR and SGRB) Application Example

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

Space-grade DC-DC converters are intended for space applications, including satellites, launch vehicles, and other spacecraft from low Earth orbit (LEO) to deep space for both commercial and military applications. Typical characteristics of space-grade DC-DC converters include:

TOTAL IONIZING DOSE (TID) RADIATION: All space applications will require some level of TID radiation guarantee. TID radiation is affected by shielding. For low Earth orbits where the DC-DC converter is adequately shielded, a 30krad(Si) guarantee is often sufficient. For higher orbits or longer missions, a 60krad(Si) with ELDRS or 100krad(Si) with ELDRS guarantee may be required. VPT's space-qualified hybrid converters, the SV and SVL Series converters, are radiation hardened to 60krad(Si) with ELDRS. The SVR Series converter line is guaranteed to 100krad(Si) with ELDRS. TID performance is verified by VPT with component test data or guarantees, worst-case analysis, and test data on the complete DC-DC converter. Test reports are available to VPT customers at no cost. Contact your local VPT sales representative to obtain a radiation report.

ENHANCED LOW DOSE RATE SENSITIVITY (ELDRS): TID testing is normally performed at high dose rates to shorten test time and reduce test costs. Testing at lower dose rates, closer to those seen in actual space environments, has shown increased sensitivity to radiation in some components, especially bipolar technologies. Modern space programs will almost certainly have an ELDRS requirement, usually to the same level as the TID requirement. ELDRS performance is proven through testing and analysis. VPT has performed extensive ELDRS verification on all space-grade DC-DC converters.

PROMPT DOSE: Prompt dose requirements are generated by thermal nuclear events. Contact your local VPT sales representative for guidance on which VPT space products may meet prompt dose application requirements.

SINGLE EVENT EFFECTS (SEE): Single-event effects are caused by energetic particles which interact with the semiconductors internal to the DC-DC converter. SEE cannot be shielded and must be dealt with in the DC-DC converter design itself. There are many types of SEEs that can negatively impact switch-mode power supplies in space environments. Single-event transients (SET), single-event upsets (SEU), single-event functional interrupts (SEFIs), single-event gate rupture/burnout (SEGR/SEB), and single-event latch-ups (SEL) are the different types of SEE failures space power supplies can experience if not designed to withstand the correct level of radiation of that space environment. SEFIs and SEUs are digital errors where a bit or bits are changed and can lead to more serious failures if it occurs in the device's control operation. SEGR/SEB are considered catastrophic events because these events cause hard failures to occur in critical active components inside a DC-DC converter. SELs, when the maximum current is not limited or the product is not designed in a way to mitigate SELs, can cause catastrophic failures. Depending on the amount of current dissipated and product design, SELs can sometimes be a non-destructive event. A SEE rating of 44 MeV/mg/cm^2 covers most particles

that a spacecraft may encounter in its lifetime and is sufficient for most programs. A SEE rating of 85 MeV/mg/cm^2 covers essentially all particles spacecraft will encounter during its lifetime. SEE performance is verified primarily with the qualification of the complete DC-DC converter. Testing should include high temperature latch-up testing.

NO OCTOCOUPLERS: Although isolation of the feedback control in a DC-DC converter can be accomplished with an optocoupler operating in the linear region, the LED within an optocoupler is sensitive to displacement damage from proton radiation. A reliable space-grade DC-DC converter will not use optocouplers. VPT uses a proprietary magnetic feedback technology that is insensitive to radiation effects.

WORST CASE AND RADIATION ANALYSIS: A guarantee of end-of-life post-radiation performance of the DC-DC converter is usually required. The manufacturer will have completed a detailed worst-case analysis for circuit performance, including both end-of-life and radiation effects. Radiation degradation of components is fed into analytical and simulation models to predict post-radiation performance. Extreme value, root sum square, and Monte Carlo analysis methods are used. VPT space hybrids have module-level WCAs available for purchase.

MIL-PRF-38534 SCREENING LEVELS: Space-grade hybrid DC-DC converters are procured to MIL-PRF-38534 Class K or H. Class K converters offer additional element evaluation and additional screening beyond Class H. Furthermore, Class K DC-DC converters are in full compliance with the latest version of MIL-PRF-38534 revision L and come with an SMD. Revision L of MIL-PRF-38534 was implemented in June 2020 and required enhanced element evaluation than previous revisions of MIL-PRF-38534. MIL-PRF-38534 revision L is very similar to Aerospace TOR Requirements. Any VPT hybrid DC-DC converter that can be built to the new revision L can also meet Aerospace TOR Requirements. This has caused lead times and costs to increase for Class K parts. VPT understands many customers and programs that do not want to take on the increased cost and time and would rather receive products built to the previous revision of MIL-PRF-38534 revision K. Therefore, VPT offers -KL1 parts, which are evaluated to the requirements of MIL-PRF-38534 revision K and previous revisions. -KL1 parts do not come with an SMD number or MIL-PRF-38534 certification mark and are marked with -KL1 instead of -K. VPT has complete traceability to the product serial number of every element and material used in the product down to the supplier manufacturing lot number (wafer number for active components). Therefore, VPT can specify which products contain residual (rev K) or enhanced element-evaluated components (rev L). The SV, SVL, and SVR Series converters can be procured to -KL1 screening level. Furthermore, VPT offers compatible EMI filters for our space-grade isolated DC-DC converters.

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

SGRB DC-DC Converters

The SGRB Series product line is designed to operate in the most demanding commercial, military, and scientific space missions. VPT's SGRB DC-DC converters are PCB-based products equipped with the latest GaN technology and with an integrated EMI filter. The SGRB Series converters can operate continuously between -35°C to 85°C. TID performance is to 100krad(Si), including ELDRS, and SEE performance is to 85 MeV/mg/cm^2 with transients fully analyzed for cross-section and magnitude. Radiation hardness is guaranteed by converter level analysis and radiation lot acceptance testing (RLAT) of all sensitive semiconductor parts used in the converter. Moreover, ELDRS effects are considered for all bipolar ICs used in the SGRB. Radiation hardness testing for TID, SEE, and various space environmental conditions are guaranteed under the processes and procedures outlined in VPT's DLA-approved RHA plan. Radiation and MTBF reports are available; please contact your local VPT sales representative to obtain one.

VPT's SGRB power converter can be used in a variety of high-power space applications. An SGRB converter alone can provide either 400W or 420W of total output power and can be shared to meet higher power requirements. The SGRB converter operates at a higher input voltage. Specifically, the product can meet the 100V and 120V input voltage requirements. High efficiency is achieved on all SGRB converters using GaN technology. Protection features on the SGRB converter include overvoltage protection, current limit and short circuit protection, and power supply telemetry. These converters also feature undervoltage lockout and very low output noise/ripple.

Defining Space COTS DC-DC Converters

VPT's high-reliability space COTS, the VSC Series, are designed to meet the requirements for suborbital and low Earth orbit (LEO) applications. Suborbital and LEO applications are defined to be between 100km to 3000km above the Earth's surface. Radiation tolerance is ensured by VPT's in-house space COTS RHA plan. The VSC uses radiation lot acceptance tested (RLAT) components to guarantee radiation performance. The VSC Series radiation performance is guaranteed to 30krad(Si) for TID, including ELDRS and SEE performance to 30 MeV/mg/cm^2. Internal designs are based on the proven high-reliability VPT Series COTS. For more information regarding the VSC Series product line, please refer to the "VSC Series Space COTS DC-DC Converters and Power Accessory Modules" application note.

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

Conclusion

It can be difficult to determine the quality specifications listed in the manufacturer's datasheets, but it is critical to do so when selecting the right level of DC-DC converter for your application. To optimize your system reliability and control costs, it is important to fully understand the products you plan to utilize in your design. Temperature range, performance specs, Mil-Spec compliance and quality systems must be considered. Design heritage and program heritage are also important factors to review. Select a reputable manufacturer with proven experience in high-reliability applications. Choose Hi-Rel COTS for cost-sensitive applications, a MIL-PRF-38534 Class H qualified DC-DC converter for critical avionics, or a Class K radiation-hardened hybrid with an ELDRS guarantee for your next space mission. VPT is the only QML-listed manufacturer which offers every quality level of DC-DC converter from COTS to space. VPT understands your next mission and offers three distinct product lines to ensure you receive the reliability and performance optimized for your application.

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:

Phone: (425) 353-3010
Fax: (425) 353-4030
E-mail: vptsales@vptpower.com
Website: www.vptpower.com

Sales & Marketing Headquarters:
19909 120th Avenue NE
Suite 102
Bothell, WA 98011

Company Headquarters:
1971 Kraft Drive
Blacksburg, VA 24060

Appendix A

Please see the table below for the differences and similarities between Hi-Rel COTS Series and Avionics/Military Series DC-DC converters offered by VPT.

Parameter	Hi-Rel COTS Series	Avionics/Military Series
VPT Product Family	VPT and VXR Series	DV Series
Operating Temperature Range	-55°C to +100°C (VPT Series) -55°C to +105°C (VXR Series)	-55°C to +125°C
Environmental Screening	Rugged environmental based on MIL-STD-883 test methods	To MIL-PRF-38534 Class H and Class K
Packaging	Six-sided metal package or epoxy-encapsulated V-Shield.	100% hermetic metal packaging
Screened Components	No	Yes
Materials	Tin whisker mitigation strategy, anti-counterfeit materials policy	No pure tin, anti-counterfeit materials policy
Optocouplers	No	No
Fixed Switching Frequency	Yes	Yes
Radiation Tolerance	N/A	N/A
On DLA SMDs	N/A	Yes
Typical Compliances and Certifications	• MIL-STD-1275 • MIL-STD-704A-F input voltage requirements • MIL-STD-461C-G when used with a COTS EMI Filter • *RTCA/DO-160 Section 16 • *RTCA/DO-160 sections 18 and 21 when used with a VXR EMI filter. • DEF-STAN 59-411 • Testing to JESD22, MIL-STD-810, MIL-STD-883, J-STD-001, ISO-9001 • IPC-A-610 manufacturing	• Products available qualified to MIL-PRF-38534 Class H and Class K • MIL-PRF 38534 Class H and Class K certified manufacturing facility • MIL-STD-704A-F input voltage requirements • DO-160 • MIL-STD-883 environmental screening • MIL-STD-461C-G when used with a Hybrid EMI filter

*Only applicable to the VXR Series DC-DC Converters and EMI filters

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com

Appendix B

Please see the table below for the differences and similarities between Space COTs, Space Grade, and SGRB Series DC-DC converters VPT offers.

Parameter	Space COTS	Space Grade Converters	SGRB Series Converters
VPT Product Family	VSC Series	SV, SVL, and SVR Series	SGRB Series
Operating Temperature Range	-55°C to +100°C	-55°C to +125°C	-35°C to +85°C
Input Nominal Voltage	28Vdc	28Vdc; 50Vdc available on SVL50 Series products	100Vdc and 120Vdc
Integrated EMI Filter	No	No	Yes
Environmental Screening	Rugged environmental based on MIL-STD-883 test methods	To MIL-PRF-38354 Class H and Class K	Please refer to the SGRB datasheets for more information
Packaging	Epoxy-encapsulated with low outgassing	100% hermetic metal packaging	Aluminum case and cover with nickel plating
Screened Components	No	Yes	Yes
Materials	Tin whisker mitigation strategy, anti-counterfeit materials policy	No pure tin, anti-counterfeit materials policy	No pure tin, anti-counterfeit materials policy
Optocouplers	No	No	No
Fixed Switching Frequency	Yes	Yes	Yes
Radiation Tolerance	Guaranteed to 30krads(Si), including ELDRS for TID; 30 MeV/mg/cm^2 for SEE	Guaranteed to 60 and 100krads(Si), including ELDRS for TID; 44 and MeV/mg/cm^2 for SEE	Guaranteed to 100krads(Si), including ELDRS for TID; 85 MeV/mg/cm^2 for SEE
On DLA SMDs	N/A	Yes	N/A
Typical Compliances and Certifications	• VPT's internal Radiation Hardness Assurance (RHA) Plan • Radiation Lot Acceptance Testing (RLAT) components • MIL-STD-704A-F input voltage requirements • Manufactured in facility certified to ISO9001, J-STD-001, and IPC-A-610 • MIL-STD-883 environmental screening • MIL-STD-461C-G when used with a Hybrid EMI filter	• Products available qualified to MIL-PRF-38534 revision L Class H and Class K • -KL1 screening option available (Meets MIL-PRF-38534 revision K and previous revisions) • VPT's Radiation Hardness Assurance (RHA) Plan certified by DLA to MIL-PRF-38534 Appendix G • MIL-PRF-38534 element evaluated components. • MIL-STD-704A-F input voltage requirements • MIL-PRF-38534 Class H and Class K facility manufacturing • MIL-STD-883 environmental screening • MIL-STD-461C-G when used with a Hybrid EMI filter	• VPT's internal Radiation Hardness Assurance (RHA) Plan • Manufactured in facility certified to ISO9001, J-STD-001 (Space Addendum), and IPC-A-610 • Designed in line with EEE-INST-002

Sales Information: (phone) 425-353-3010 • (fax) 425-353-4030 • vptsales@vptpower.com • www.vptpower.com