APPLICATION NOTE

MIL-STD-461 Compliance for VPT DC-DC Converters

DC-DC CONVERTERS AND ACCESSORIES

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Introduction

The control of electromagnetic interference for electronic subsystems is governed by MIL-STD-461 for the US Department of Defense. This document details compliance to revisions C and D-G. The standard is divided into four areas, each of which must be dealt with by the systems designer to ensure overall compliance:

MIL-STD-461C Requirements

- CE01 Conducted Emission, 30Hz TO 20kHz, Power Leads
- CE03 Conducted Emission, 20kHz to 50MHz, Power Leads
- CE07 Conducted Switching spikes
- CS01 Conducted Susceptibility, 30Hz to 50kHz, Power Leads
- CS02 Conducted Susceptibility, 50kHz to 400MHz, Power Leads
- CS06 Conducted Susceptibility, Spike, Power Leads
- RE01 Radiated Emission, 30Hz to 30kHz, Magnetic Field
- RE02 Radiated Emission, 30kHz to 10GHz, Electric Field
- RS01 Radiated Susceptibility, 30Hz to 30kHz, Magnetic Field
- RS02 Radiated Susceptibility, Magnetic Induction Fields
- RS03 Radiated Susceptibility, 14kHz to 10GHz, Electric Field

MIL-STD-461 D-G Requirements

- CE101 Conducted Emissions, Power Leads, 30Hz TO 10kHz
- CE102 Conducted Emission, Power Leads, 10kHz to 10MHz
- CS101 Conducted Susceptibility, Power Leads, 30Hz to 150kHz
- CS114 Conducted Susceptibility, Bulk Cable Injection, 10kHz to 200MHz
- CS115 Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation
- CS116 Conducted Susceptibility, Damped Sinusoidal Transients, Cables and Power Leads, 10kHz to 100MHz
- RE101 Radiated Emission, 30Hz to 100kHz Magnetic Field
- RE102 Radiated Emission, 10kHz to 18GHz, Electric Field
- RS101 Radiated Susceptibility, 30Hz to 100kHz Magnetic Field

Some systems are governed by similar standards including RTCA DO-160D for civilian aircraft, and DEF STAN 59-41 for the United Kingdom Ministry of Defense.

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Conducted Emissions

VPT's DC-DC converters use modern switch-mode or switching power conversion technology to provide high efficiency and a small size. All switch-mode DC-DC converters inherently generate some switching noise. VPT DC-DC converters use advanced design techniques to minimize this noise, offering both low input and output ripple.

Conducted emissions requirements govern noise generated by the DC-DC converter and conducted on to the input power lines, usually 28V. This noise is defined in terms of input ripple current and consists of a fundamental component, usually around 500kHz, and its harmonics. All VPT DC-DC converters have internal input L-C filters and have low input current ripple on the order of 50mApp. In some applications this is sufficient. Where full compliance to MIL-STD-461C-G is required, VPT offers several hybrid EMI filter options which are listed in table 1 and Hi-Rel COTS EMI filters options in table 2:

Function	Product
EMI Filter modules	DVMSA28, DVMA28/50, DVMH28, DVMC28/50, DVME28/50, DVMD28/50, SVRMH28, SVRMC28, SVRME28
EMI filter / transient suppression modules	DV704A, DVMN28
DC-DC converters with integral EMI filter	DVEHF28, DVETR28, DVETR28, DVST28

Table 1. DV and SVR Filter Products.

Function	Product
EMI Filter modules	VPTF1-28, VPTF3-28, VPTF10-28, VPTF20-28, VXRF2-28, VXRF5-28, VXR10-28, VXRF20-28 VXRF50-28, VSCF1-28, VSCF3-28, VSCF10-28
EMI filter / transient suppression modules	VPTc10-28, VPTi10-28
Precondition Module / Regulated Bus Converter	VPTPCM-12, VPTHVM-270

Table 2: VPT, VXR, and VSC Filter Products

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The EMI filter modules attenuate both differential and common mode noise on the input power lines. One filter can power several converters of different types up to its current rating. Recommended filters for a given system power are listed in Table 3 for Mil Temp DV and SVR and Table 4 for COTS. DV series EMI filters are recommended for use with DV, SV, and SVL series DC-DC converters. SVR series EMI filters are recommended for use with SVR series converters. For higher power levels, the system can be divided with several converters per filter, or filters of like types can be paralleled for higher current.

Recommended Filter	Rated Current (Amps)
DVMA50	0.5
DVMSA28	0.8
DVMA28	1.0
DVMH28	2.0
SVRMH28	2.0
DV704A	2.0
DVMC50	2.0
DVMC28	4.0
SVRMC28	4.0
DVMD50	4.0
DVMD28	7.0
DVME50	8.0
SVRME28	10.0
DVME28	15.0

Table 3. Mil Temp DV and SVR EMI Filters

Recommended Filter	Rated Current (Amps)
VPTF1-28	1.0
VSCF1-28	1.0
VXRF2-28	2.0
VPTF3-28	3.0
VSCF3-28	3.0
VXRF5-28	5.0
VSCF10-28	10.0
VPTF10-28	10.0
VXRF10-28	10.0
DVMN28	10.0
VPTF20-28	20.0
VXRF20-28	20.0
VXRF50-28	50.0

Table 4. COTS Filter Rated Current

Careful system design is always necessary to maintain compliance. In general the filter should be placed at the power input to the board or enclosure. The DC-DC converter should then be placed as close as possible to the filter. Ideally the system should be setup in a straight line. However, if this not possible use CASE ground to shield power lines from each other. Some tradeoff in the placement usually occurs, but it is important to keep the filtered input lines away from any noise sources. Typical noise sources which should be avoided include the converter output lines and any high-speed digital circuitry.

Occasionally, CE03 or CE102 may be required on the DC output of the DC-DC converter. Additional filtering will be needed, including both common and differential mode filters. In some cases VPT's EMI filter modules can be placed at the output of the converter to meet this requirement.

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Conducted Susceptibility

Electronic circuits not only generate noise but also can be susceptible to noise generated elsewhere. Conducted susceptibility requirements define various noise sources which when conducted on the power lines should not cause degradation or malfunction of the system. Conducted susceptibility is tested on the input power leads only. The control or output leads may require additional external protection if they are to meet these requirements as well.

VPT's DC-DC converters provide approximately 30dB of input attenuation from low frequency up to 1MHz. An input filter as described in Table 1 provides additional attenuation above 10kHz for CS01 and CS101, and up to several hundred MHz as required by CS02, and CS114. The DC-DC converter is determined to comply with these requirements if the output voltage is maintained within its total static regulation limits.

The input filter also contains significant capacitance which filters the higher voltage and short duration transients of CS06, CS115, and CS116 to safe levels. The 0.15µs spike of CS06 has a low impedance, but is of such short duration that it is effectively filtered. The same is true for the impulse excitation of CS115. The damped sinusoidal transient of CS116 has a much higher source impedance, such that the voltage seen by the filter is much smaller than the calibration voltage, and it too will be filtered to acceptable levels. Compliance is determined if the output of the DC-DC converter is maintained within its specified dynamic limits.

For longer duration input voltage transients such as the CS06 spike requirement with pulse width greater than 0.15µs, a transient suppression module is required. The source impedance is low and the duration long enough such that an EMI filter alone is not sufficient to protect the converter. The transient suppressor blocks the spike, limiting the voltage seen by the converter to a safe level. To protect against negative transients, a series diode should be added at the input of the DV704A or a shunt diode added at the output. The DVMN28 contains the shunt diode internally. Compliance is determined if the output of the DC-DC converter is maintained within its specified dynamic limits. The VPTc10-28 and VPTi10-28 provide voltage transient protection and reverse polarity protection and both products are compatible with the DV and VPT series converters.

For sensitive loads, where the specified performance is not sufficient to avoid system upset, additional capacitance can be added at the input or output of the DC-DC converter. Significant capacitance added at the input should be appropriately damped.

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Radiated Emissions

Radiated emissions requirements govern the electric and magnetic fields emitted by a subsystem. Compliance should be tested at the completed subsystem level, and is heavily dependent on the system design, especially the grounding, shielding, and cabling. VPT's hermetic hybrid DC-DC converters have six-sided metal packages which limit high frequency emissions from the converter itself. Most radiation usually emanates from the input cabling or load circuitry, and that is where careful system design is essential. For the VSC, VPT, and VXR series converters the metalized V-SHEILD packaging reduces high frequency emissions. The fundamental switching frequency of VPT DC-DC converters is above 300kHz, with no noise source in the range of RE01 or RE101. An input filter as described in Tables 1 and 2 will provide sufficient filtering of the input lines to meet RE02 and RE102. In cases where there is an outage, a ferrite EMI bead on the input or output lines usually brings the system back into compliance.

Radiated Susceptibility

Radiated susceptibility requirements dictate electric and magnetic field levels which should not cause degradation or malfunction of a system. As with emissions, potential problem areas include input cables and output circuitry. An input filter as specified in Tables 1 and 2 for the input power lines is required for compliance. If the load circuitry is not enclosed or shielded, or if testing is performed on output or signal cables, additional filtering may be required on those outputs and signals.

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	CE01	CE03	CE07	CS01	CS02	CS06
Standard Converter Compliance	•		•	•		
Converter with VPT Filter Compliance	•	•	•	•	•	•[2]
Converter with VPT Filter/Transient Suppressor Compliance	•	•	•	•	•	•

	RE01	RE02	RS01	RS02	RS03	
Standard Converter Compliance	•		•			
Converter with VPT Filter Compliance	•	•	•	•	•	
Converter with VPT Filter/Transient Suppressor Compliance	•	•	•	•	•	

Table 5. MIL-STD-461C Compliance[1] of VPT DC-DC Converters.

	CE101	CE102	CS101	CS114	CS115	CS116
Standard Converter Compliance	•					•
Converter with VPT Filter Compliance	•	•	•	•	•	•
Converter with VPT Filter/Transient Suppressor Compliance	•	•	•	•	•	•

	RE101	RE102	RS101	RS103		
Standard Converter Compliance	•		•	•		
Converter with VPT Filter Compliance	•	•	•	•		
Converter with VPT Filter/Transient Suppressor Compliance	•	•	•	•		

Table 6. MIL-STD-461D-G Compliance[1, 3] of VPT DC-DC Converters.

1. Proper system design necessary to maintain radiated compliance
2. For pulsewidth t≤0.15us
3. CS114 curve 3. CS116 for Air Force Procurements

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Conclusion

The EMI performance of VPT's standard DC-DC converters and EMI filters has been documented, including both emissions and susceptibility. This characterization of standard module performance enables simplified system design where compliance to MIL-STD-461 is required.

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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