Application Note 2

MIL-STD-461 EMI Compliance For IPC Series DC-DC Converters

Introduction

Electromagnetic Interference (commonly referred to as EMI) refers to how various sets of circuitry in a system interact with each other, The trend of large scale integration has resulted in more "stuff" being put into the box and often results in various electromagnetic interference issues between different systems and subsystems. Management of electromagnetic interference for electronic subsystems in Hi Reliability/ Military applications is governed by MIL-STD-461. This applications note addresses compliance to revisions C, D, and E . This standard which is divided into four areas. Each of which must be dealt with by the systems design engineer to ensure overall compliance:

- Conducted Emissions
- Conducted Susceptibility
- Radiated Emissions
- Radiated Susceptibility

Summary of MIL-STD-461: 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-461D and MIL-STD-461E 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
RS103	Radiated Susceptibility, 2MHz to 40GHz, Electric Field

Conducted Emissions

IPC's DC-DC converters use switch mode or switching power conversion technology to provide high efficiency and high power density. Although switching DC-DC converters are more efficient than linear power supplies, all switch mode converters will generate some electrical noise which must be controlled. IPC DC-DC converters use advanced design techniques to help minimize this noise resulting in low input and output ripple.

Conducted emissions are generated by the DC-DC converter and conducted onto the input power lines. This noise is defined in terms of input ripple current and consists of a fundamental component, usually around 250kHz, and its harmonics.

All IPC converters have internal input filters and low input ripple on the order of 50mApp. In some applications this is sufficient. Where full compliance to MIL-STD-461 is required a discrete or off the shelf filter is required.

Careful system design is always necessary to maintain compliance. Filters should be placed at the power input to the board or enclosure. The DC-DC converters should then be placed as close as possible to the filter.

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 referenced above 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 EMI filter circuits can be placed at the output of the converter to meet this requirement.

Conducted Susceptibility

EMI filter modules attenuate both differential and common mode noise on the input power lines. Often a single filter can power several converters of different types up to its current rating. 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.

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.

IPC series DC-DC converters provide approximately 30dB of input attenuation from DC up to 1MHz. A companion EMI Filter which 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 to 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 Filter or a shunt diode added at the output. Some filters will contain the shunt diode internally. Compliance is determined if the output of the DC-DC converter is maintained within its specified dynamic limits.

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

	CE01	CE03	CE07	CS01	CS02	CS06
Standalone converter compliance	•		•	•		
Converter with filter compliance	•		•		•	[2]
Converter with filter/transient suppressor compliance	•		•		•	

	RE01	RE02	RS01	RS02	RS03
Standalone converter compliance	•		•		
Converter with filter compliance	•	•		•	
Converter with filter/transient suppressor compliance	•	•		•	

Table 2. MIL-STD-461D and MIL-STD-461E Compliance[1,3] of IPC DC-DC Converters

	CE101	CE102	CS10	CS11	CS115	CS116
Standalone converter compliance	•					
Converter with filter compliance	•		•		•	
Converter with filter/transient suppressor compliance	•		•		•	

	RE101	RE102	RS101	RS103
Standalone converter compliance				
Converter with VPT filter compliance	•		•	
Converter with VPT filter/transient suppressor compliance	•		•	

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