

Read About

MIL-STD-461

Electromagnetic interference
(EMI)

Electromagnetic compatibility
(EMC)

Emission and susceptibility
requirements

Introduction

MIL-STD-461 establishes interface and verification requirements for the control of the electromagnetic interference (EMI) emission and susceptibility characteristics of electronic equipment and subsystems designed for or procured by the U.S. Department of Defense (DoD). This white paper supplies a summary of the standard and presents some ideas regarding ways to achieve compliant designs.

Background on MIL-STD-461

EMI (electromagnetic interference) and EMC (electromagnetic compatibility) relate to the unwanted effects in an electrical system due to electromagnetic radiation and electromagnetic conduction. The worst part of a high frequency electromagnetic signal is that it makes every conductor an antenna, in the sense that they can generate and absorb electromagnetic fields. The control of EMI is an art and science that seeks to prevent the various interdependent and independent electronic systems on military platforms from interfering with each other's normal operation.

MIL-STD-461 is concerned with specifying technical requirements for controlling EMI emissions and susceptibility at the subsystem-level and equipment-level. MIL-STD-461 is not intended to be directly applied to subassemblies of equipment such as modules or circuit cards, although these must be designed with EMI containment in mind in order for subsystem-level assemblies to conform to MIL-STD-461 requirements.

At the time of this writing, MIL-STD-461 has been issued in revisions A through F. Unlike many specifications, the release of a newer standard does not make earlier revisions unnecessary. There are still military platforms in service which were designed around MIL-STD-461A. Technology refreshes on older platforms will continue to express the EMI requirements in terms of the version of MIL-STD-461 that was in effect when the platform was first designed. In some cases, the earlier revisions are more stringent than later versions.

EMI emission and susceptibility requirements for U.S. DoD electronic equipment and subsystems are defined by MIL-STD-461.



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Comparison with commercial electronics

The use of commercial and industrial items presents a dilemma between the need for EMI control on the one hand and the desire to take advantage of existing low-cost commercial designs which may exhibit undesirable EMI characteristics on the other. For some applications of commercially developed products, such as commercial transport aircraft, EMI requirements similar to those in MIL-STD-461 are usually imposed on equipment. Most commercial aircraft equipment is required to meet the EMI requirements in RTCA DO-160 or an equivalent contractor in-house document. Later revisions to RTCA DO-160 are making the document more compatible with MIL-STD-461. Equipment qualified to revisions C, D, or E of RTCA DO-160 is often suitable for military aircraft applications.

Looking beyond aircraft, EMI requirements on most types of commercial electronic equipment are more varied and sometimes nonexistent. In the United States, the Federal Communication Commission (FCC) is responsible for regulating “Non-Licensed Radio Frequency Devices” in the commercial and residential environment to control interference to radio reception. Requirements are imposed in FCC CFR Title 47, Parts 2, 15, and 18. The FCC does not control susceptibility (referred to as immunity in the commercial community) characteristics of equipment. The most widely applied requirement is Part 15 which requires that any “digital device” comply with the conducted and radiated emission limits for commercial environments (Class A) and residential environments (Class B). These requirements are typically less stringent than military requirements of a similar type. Also, there is difficulty in comparing levels between commercial and military testing due to differences in measurement distances, different types of antennas, and near-field conditions.

MIL-STD-461 Test Name Designations

As stated earlier, MIL-STD-461 establishes interface and verification requirements for the control of the electromagnetic interference (EMI) emission and susceptibility characteristics of electronic equipment and subsystems designed for or procured by the U.S. Department of Defense. The emissions and susceptibility and associated test procedure requirements in MIL-STD-461 are designated in accordance

with an alphanumeric coding system. Each requirement is identified by a two letter combination followed by a three digit number. The number is for reference purposes only. The meaning of the individual letters is as follows:

C = Conducted	E = Emission
R = Radiated	S = Susceptibility

Conducted emissions requirements are designated by “CE---.”

Radiated emissions requirements are designated by “RE---.”

Conducted susceptibility requirements are designated by “CS---.”

Radiated susceptibility requirements are designated by “RS---.”

“---” = numerical order of requirement from 101 to 199.

Electromagnetic radiation and electromagnetic conduction are differentiated by the way an EM (electromagnetic) field propagates. Conducted EMI is caused by the physical contact of the conductors. Power supply noise is an example of conducted EMI. Radiated EMI is caused by induction (without physical contact of the conductors), meaning that electromagnetic disturbances are not confined to the surface of the emitter and will radiate away from it. Emission tests refer to a source of conducted or radiated EMI noise. Susceptibility tests refer to the effect of radiated EMI noise on a piece of equipment.

MIL-STD-461 Testing Requirements

During emission measurements, MIL-STD-461 requires that the EUT (Equipment Under Test) be placed in an operating mode which produces maximum emissions. During susceptibility testing, the EUT is placed in its most susceptible operating mode. For EUTs with several available modes (including software controlled operational modes), a sufficient number of modes must be tested for emissions and susceptibility to insure that all circuitry is evaluated. The EUT is monitored during susceptibility testing for indications of degradation or malfunction. This monitoring is normally accomplished through the use of built-in-test (BIT), visual displays, aural outputs, and other measurements of signal outputs and interfaces. The test name nomenclature explained above is used in MIL-STD-461 to specify detailed emissions and susceptibility requirements and the associated test procedures. When MIL-STD-461 is called out in an RFI or RFQ, the tests in the table below are specified individually.

TABLE 1 Emission and susceptibility requirements in MIL-STD-461F	
REQUIREMENT	DESCRIPTION
CE101	Conducted Emissions, Power Leads, 30 Hz to 10 kHz
CE102	Conducted Emissions, Power Leads, 10 kHz to 10 MHz
CE106	Conducted Emissions, Antenna Terminal, 10 kHz to 40 GHz
CS101	Conducted Susceptibility, Power Leads, 30 Hz to 150 kHz
CS103	Conducted Susceptibility, Antenna Port, Intermodulation, 15 kHz to 10 GHz
CS104	Conducted Susceptibility, Antenna Port, Rejection of Undesired Signals, 30 Hz to 20 GHz
CS105	Conducted Susceptibility, Antenna Port, Cross-Modulation, 30 Hz to 20 GHz
CS106	Conducted Susceptibility, Transients, Power Leads
CS109	Conducted Susceptibility, Structure Current, 60 Hz to 100 kHz
CS114	Conducted Susceptibility, Bulk Cable Injection, 10 kHz to 200 MHz
CS115	Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation
CS116	Conducted Susceptibility, Damped Sinusoidal Transients, Cables and Power Leads, 10 kHz to 100 MHz
RE101	Radiated Emissions, Magnetic Field, 30 Hz to 100 kHz
RE102	Radiated Emissions, Electric Field, 10 kHz to 18 GHz
RE103	Radiated Emissions, Antenna Spurious and Harmonic Outputs, 10 kHz to 40 GHz
RS101	Radiated Susceptibility, Magnetic Field, 30 Hz to 100 kHz
RS103	Radiated Susceptibility, Electric Field, 2 MHz to 40 GHz
RS105	Radiated Susceptibility, Transient Electromagnetic Field

Certain emissions apply to certain applications or certain types of platforms. The table below shows each requirement's applicability to various platform types.

TABLE 2 Requirement Applicability Matrix																		
Equipment and Subsystems Installed In, On, or Launched From the Following Platforms or Installations	CE 101	CE 102	CE 106	CS 101	CS 103	CS 104	CS 105	CS 106	CS 109	CS 114	CS 115	CS 116	RE 101	RE 102	RE 103	RS 101	RS 103	RS 105
Surface Ships	A	A	L	A	S	S	S	A	L	A	S	A	A	A	L	A	A	L
Submarines	A	A	L	A	S	S	S	A	L	A	S	L	A	A	L	L	A	L
Aircraft, Army, Including Flight Line	A	A	L	A	S	S	S	-	-	A	A	A	A	A	L	A	A	L
Aircraft, Navy	L	A	L	A	S	S	S	-	-	A	A	A	L	A	L	L	A	L
Aircraft, Air Force	-	A	L	A	S	S	S	-	-	A	A	A	-	A	L	-	A	-

TABLE 2 cntd Requirement Applicability Matrix

Equipment and Subsystems Installed In, On, or Launched From the Following Platforms or Installations	CE 101	CE 102	CE 106	CS 101	CS 103	CS 104	CS 105	CS 106	CS 109	CS 114	CS 115	CS 116	RE 101	RE 102	RE 103	RS 101	RS 103	RS 105
Space Systems, Including Launch Vehicles	-	A	L	A	S	S	S	-	-	A	A	A	-	A	L	-	A	-
Ground, Army	-	A	L	A	S	S	S	-	-	A	A	A	-	A	L	L	A	-
Ground, Navy	-	A	L	A	S	S	S	-	-	A	A	A	-	A	L	A	A	L
Ground, Air Force	-	A	L	A	S	S	S	-	-	A	A	A	-	A	L	-	A	-

Legend:

A: Applicable

L: Limited as specified in the individual sections of this standard

S: Procuring activity must specify in procurement documentation

-: Not Applicable

Design Considerations

A Commercial-Off-The-Shelf (COTS) computer often consists of a VME or OpenVPX chassis and one or more payload modules. Radiated emissions are often managed by encasing the box with metal or honeycomb shielding. Conducted susceptibility requirements are typically met by adding pre-filtering to the power supply input. Conducted emissions are filtered in the power supply, backplane and front panel connector.

One potential difficulty is the case in which filters are added in each phase of a modular design and then, when combined, produce unintended consequences. The filter designer must take a holistic, systemic view of the filter network and apply the right type and level of filtering for a given requirement.

Engaging with Curtiss-Wright

With decades of experience designing chassis for the COTS component market, Curtiss-Wright is adept at designing for subsystems that are certified to MIL-STD-461 requirements. The testing is generally performed on a prototype subsystem or at a later phase of integration by a subsystem vendor.

Curtiss-Wright sets itself apart from other rugged electronic packaging suppliers by specializing in engineered packaging solutions, primarily for government, military and aerospace applications. In addition to rugged enclosures, we also offer a range of development platforms for the latest technologies such as OpenVPX. Our standard and application-specific chassis platforms provide best-in-class thermal performance and meet the most stringent design requirements.

Author



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Summary

Curtiss-Wright product expertise includes enclosures, backplanes, accessories, and subbracks for:

- VPX (VITA 46)
- OpenVPX (VITA 65)
- VPX-REDI (VITA 48)
- VXS (VITA 41)
- VME64x
- VME
- CompactPCI (cPCI)
- Various hybrid designs

Associated services include:

- thermal management
- ultra high speed backplane signal integrity studies
- high speed backplane design
- I/O signal conditioning including filtering
- surge and lightning suppression
- thermal management
- chassis mechanical design
- program management
- SDRL data deliverables

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