WHITE PAPER

EMI/EMC TEST REQUIREMENTS FOR MILITARY AND COMMERCIAL APPLICATIONS

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COMPARING EMI/EMC TEST REQUIREMENTS FOR MILITARY AND COMMERCIAL APPLICATIONS

EMI/EMC OVERVIEW

Technology is embedded into nearly every aspect of the modern life. Advancements in electronic technology are transforming the world rapidly—and the implications are widespread. From simplifying tasks and eliminating communication barriers to delivering entertainment and executing highly complex functions, technology is everywhere. As the widespread adoption of electronic technology continues at a rapid pace, however, the risk of electromagnetic inference increases in a variety of different settings. Depending on the type of product or system, electronic interference can have catastrophic consequences. As a result, it is critical that electronic devices and complex electronic systems do not interfere with the operation of other products within their intended installation environment. The good news is that Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) testing are designed to mitigate such risks, thereby ensuring that products operate as intended in real world environments. The following pages provide insights into the areas below:

- Different EMI/EMC Test Categories
- Military Versus Commercial Test Requirements
- Common Issues with MIL-STD-461G CE101 & CE102

UNDERSTANDING EMI/EMC TEST CATEGORIES

Product compliance tests are developed to simulate real-world environments. The two common types of test categories are immunity and susceptibility tests and emissions tests, respectively. Immunity and susceptibility tests evaluate the ability to operate as intended when subjected to external electromagnetic environments. These tests often encompass the following:

- Radiated Electromagnetic Fields
- Conducted Electromagnetic Voltages and Currents
- Surges, Switching Transients, and Lightning
- Power Quality (Dropouts, Sags, and Variations)

Emissions tests on the other hand ensure that proper EMI controls have been implemented, thus minimizing the potential for operational interference of nearby equipment.

- Radiated EM emissions
- Conducted EM emissions

DIFFERENCES BETWEEN MILITARY AND COMMERICAL TESTING

EMI/EMC test standards can vary among industries; however, the greatest discrepancy in test criteria is between military and commercial devices and systems. Although modern industry test standards tend to address similar EMI/EMC concerns, sometimes resulting in overlapping test conditions, there is often variability. The electromagnetic environment of each installation platform and its effects on locally installed equipment, for example, can be quite different. These variances result in changes to test conditions, which can range from differences in limits, levels, frequencies, and other variables. The scope of the variances causes gaps, which are considered risk areas, thus requiring testing to ensure compliance.

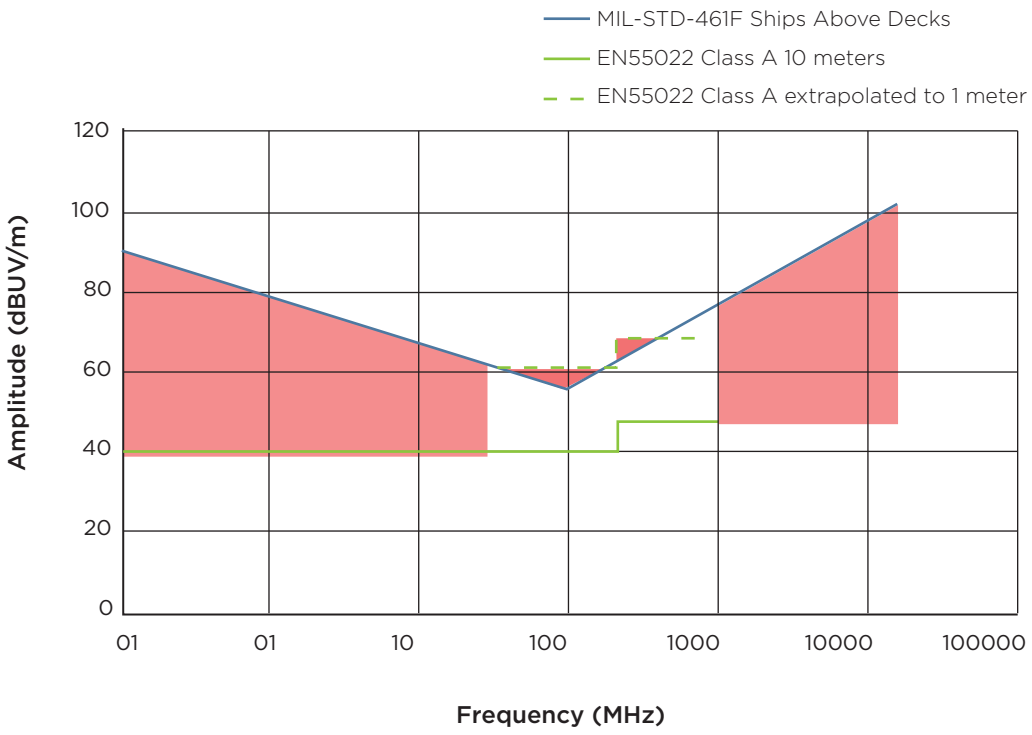
Commercial Off the Shelf (COTS)

The integration of Commercial Off the Shelf (COTS) equipment in the Department of Defense (DoD) has been increasing exponentially. The shift is understandable. COTS equipment is more cost-effective and is beneficial for improving deployment time. Importantly, however, is that COTS equipment is generally not designed or intended for combat

electromagnetic environments. COTS equipment is commonly qualified to commercial industry standards—and not MIL-STD requirements. Although an occasional risk analysis assessment and certain test requirements are waived to support rapid deployments, this is not common practice. In most cases, therefore, COTS equipment will require some modification to meet MIL-STD test criteria. The following table provides a synopsis between commercial test standards for COTS equipment and MIL-STD-461—the DoD interface standard that outlines criteria for electromagnetic interference characteristics.

MILITARY REQUIREMENTS (MIL-STD-461)	COTS REQUIREMENTS (IEC/EN/CISPR)
RE101 MAGNETIC FIELD EMISSIONS 30 HZ – 100 KHZ	NO EQUIVALENT TEST REQUIRED
RE102 ELECTRIC FIELD EMISSIONS 10 KHZ – 18 GHZ	**CISPR 16 ELECTRIC FIELD RADIATED EMISSIONS** 30 MHZ – 1 GHZ
CE101 CONDUCTED EMISSIONS (CURRENT) POWER LEADS ONLY 30 HZ – 10 KHZ	**IEC 61000-3-2 CURRENT HARMONICS <16AMPS** **IEC 61000-3-12 CURRENT HARMONICS <75AMPS** FUNDAMENTAL TO 50TH HARMONIC
CE102 CONDUCTED EMISSIONS (VOLTAGE) POWER LEADS ONLY 10 KHZ – 10 MHZ	**CISPR /IEC/EN CONDUCTED EMISSIONS** **POWER** 150 KHZ – 30 MHZ **COMMUNICATIONS (I/O)** 150 KHZ – 30 MHZ

The differences between the radiated emissions electrical field for military and commercial items are significant. Key areas of difference include frequency range, measurement distance, resolution BW, and peak versus quasi peak. In addition, there are further considerations, including Input power, mode(s) of operation, and equipment configuration. The following graph provides a radiated emissions electric field comparison between MIL-STD-461 and EN55022 standards.



COMMON ISSUES WITH MIL-STD-461G CE101 & CE102

Military test standards are often more rigid than commercial requirements –and they change from time to time. As a result, manufacturers are presented with a variety of challenges when testing a product to MIL-STD requirements. The most common issues that are encountered are listed below:

- Current Harmonic Control
- Full Load Testing
- Filter Modifications
- Variable Frequency Drives

CURRENT HARMONIC CONTROL

Current harmonics emissions produced by a COTS UPS, and other power conversion technologies, have commonly encountered problems meeting CE101 while previously complying with the IEC's 61000-3-2, or 3-12 harmonics control criteria. The CE102 ≥ 1kVA limit was derived from MIL-STD 1399 section 300A Shipboard and submarine power quality requirements. Although the limit is relaxed based on the fundamental current draw, it regulates single harmonic currents to 3% from the 2nd to the 32nd.

FULL LOAD TESTING

UPS manufacturers will typically test and qualify their equipment independently at full load. Internal inductive filtering is sized to provide adequate harmonic control at the highest rating of the supply without causing significant voltage drop. Defense System integrators will test their subsystem at full load, which is usually at a percentage that is lower than the UPS full load. What does this mean? The lower the current draw, the lower the harmonic control provided by the internal inductor. Specifically, active current draws >1kVA, but less than 65% of the UPS rating, thus explaining why they commonly struggle meeting the MIL-STD-461G-CE101 test criteria.

FILTER MODIFICATIONS

Filter modifications can also cause issues. Simply put, filter modifications can be big, heavy, and expensive. In addition, the modifications can cause a variety of other EMI/EMC test issues, often pertaining to MIL-STD-461G RE101, which is used to verify that magnetic field emissions.

VARIABLE FREQUENCY DRIVES

Motor controllers and variable frequency drives, which modifies frequency and voltage to match output requirement, are a source of conducted interference. Carrier frequencies are generally found between 4 kHz & 22 kHz. CE Mark Compliance and Federal Communications Commission (FCC) testing starts at 150 kHz. MIL-STD-461 testing, however, starts at 10 kHz. Input filtering loss pass cutoff is usually tuned for 150 kHz allowing carrier frequency to freely conduct back onto the utility. Filter modifications or replacements typically occur during qualification testing.

The following table highlights key differences between military and commercial test requirements:

MIL-STD-461	IEC/EN/CISPR
RS101 MAGNETIC FIELD SUSCEPTIBILITY 30 HZ – 100 KHZ	**IEC 61000-4-8 POWER FREQUENCY MAGNETIC FIELD** 50 HZ – 60 KHZ
RS103 ELECTRIC FIELD SUSCEPTIBILITY 2 MHZ – 18 GHZ UP TO (40 GHZ)	**IEC 61000-4-3 ELECTRIC FIELD RADIATED IMMUNITY** 80 MHZ – 2.7 GHZ
CS101 CONDUCTED SUSCEPTIBILITY (VOLTAGE RIPPLE) POWER LEADS ONLY 30 HZ – 150 KHZ	**IEC 61000-4-13** 16 HZ – 2.4 KHZ **IEC 61000-4-16** 15 HZ – 150 KHZ
CS114 CONDUCTED SUSCEPTIBILITY **POWER (4 KHZ) 10 KHZ – 200 MHZ** **COMMUNICATIONS(I/O)10 KHZ – 200 MHZ**	**IEC 61000-4-6 CONDUCTED IMMUNITY** **POWER** 150 KHZ – 80 MHZ **COMMUNICATIONS (I/O)** 150 KHZ – 80 MHZ
CS106 TRANSIENT SUSCEPTIBILITY POWER LINES ONLY	**IEC 61000-4-5 ELECTRICAL SURGES** ALL LINES
CS115 IMPULSE EXCITATION ALL LINES	**IEC 61000-4-4 ELECTRICAL FAST TRANSIENTS** ALL LINES
CS116 DAMPED SINUSOIDAL TRANSIENTS ALL LINES 10 KHZ – 100 MHZ	**IEC 61000-4-12 DAMPED SINUSOIDAL TRANSIENT** ALL LINES 100 KHZ RING WAVE
RS105 ELECTROMAGNETIC PULSE (EMP) 50 KV 2/50NS	**IEC 61000-4-9 MAGNETIC PULSE 50/60HZ TO 50 KHZ** **IEC 61000-4-10 DAMPED SINUSOIDAL MAG. PULSE** 100KHZ & 1 MHZ
CS118 PERSONNEL BORNE ELECTROSTATIC DISCHARGE 2 KV – 15 KV AIR AND CONTACT DISCHARGE 150 PF, 330 Ω	**IEC 61000-4-2 ELECTROSTATIC DISCHARGE (ESD)**

INSIGHTS FROM INDUSTRY EXPERTS

When thinking about EMI/EMC testing, it is important to connect with industry experts to get the latest insights. By talking with top experts, customers can reduce cost, accelerate time-to-market, and mitigate risks. With 28 test laboratories in North America, NTS boasts the most EMI/EMC chambers on the continent—and it offers easy access to world-renowned test experts. In fact, NTS EMI/EMC experts sit on advisory boards, speak at conferences, and author technical papers. Contact us today at 800.270.2516 or visit us at www.nts.com—and discover what it means to test to a higher standard.

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