Comparison of MIL-STD-461D/462D and MIL-STD-461C/462 Transient Test Methods

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A comparison between energy levels delivered to the EUT under different requirements confirms their congruence.

INTRODUCTION

The release of MIL-STD-461D/462D brought many changes to testing in the military E^3 field. This was true especially in the case of the various transient tests that were detailed in MIL-STD-461C/462. In MIL-STD-461D/462D, test method CS116 is meant to take the place of numerous transient requirements, including the Navy and Air Force EMP specifications, CS10, CS11, CS12, and CS13.

Since the potential for damage to the equipment under test (EUT) is so high in these tests, a comparison is warranted between the energy levels that are delivered to the EUT during a CS116 test and those levels delivered during the performance of a CS10, CS11, CS12, or CS13 test. The damage potential due to the transients injected in other test methods, such as CS115, is comparatively minor due to the short time duration of the transients in question. These methods will not be studied, although the possible interference effects due to these waveforms should not be ignored.

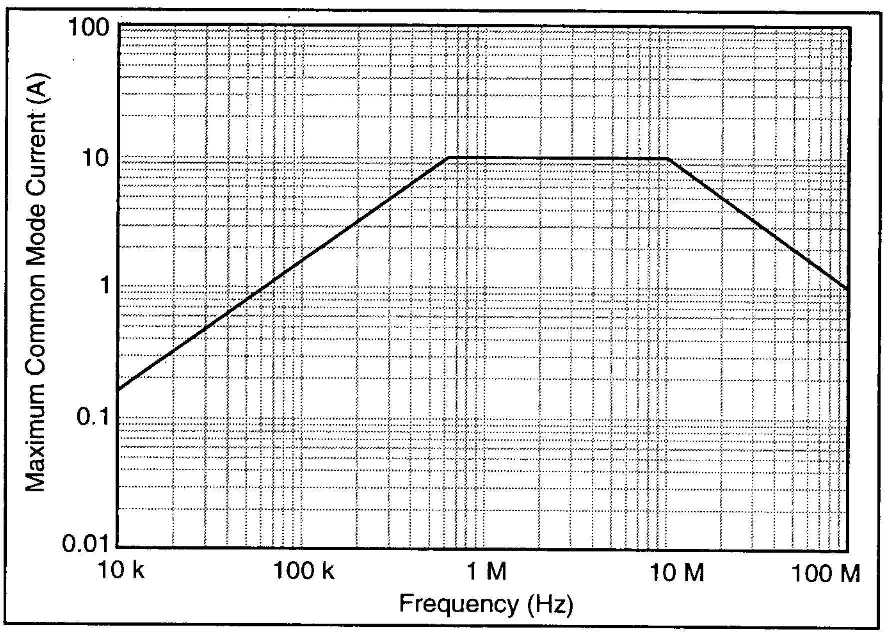

Figure 1. Current Limit for CS10/11.

ACTION INTEGRAL

In order to compare energy levels being delivered by the injection of different transient waveforms, the load through which the test current is being driven must be known. Since the comparisons being made here will be EUT independent, the action integral will be used for the energy comparisons. The action integral is a measure of the energy delivered by the test current. It is the integral of the square of the current i over the time interval of interest. The action integral AI is defined as follows:

$$AI = \int i^2 (t)\, dt \qquad (1)$$

TEST METHODS

Since the actual current driven during the test is dependent on the impedance of the EUT, the maximum current allowed in each test method will be compared for those methods under comparison. The CS10/CS11 current limit is shown in Figure 1. This limit is both a calibration limit and a test current limit. Figure 2 displays the CS12/CS13 limit. For CS12, this limit is the test

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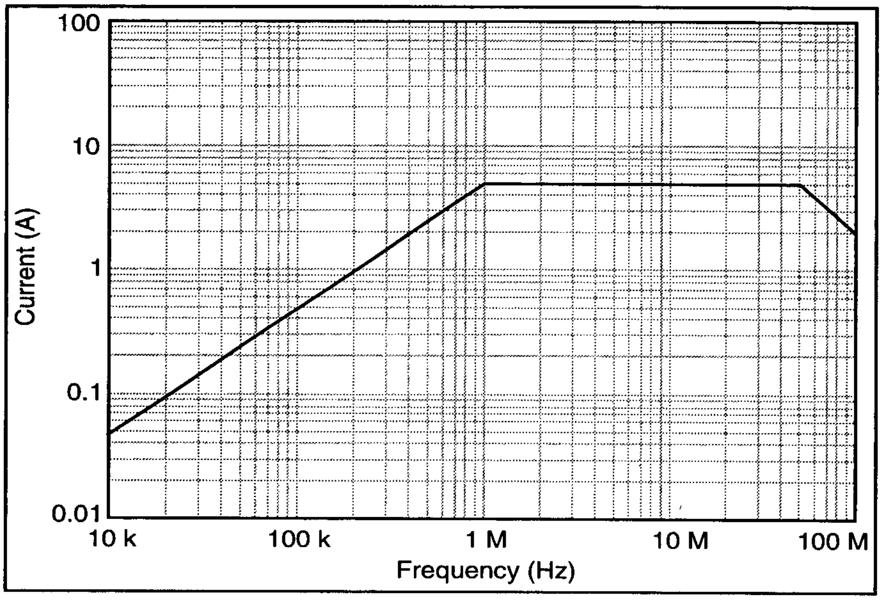

Figure 2. *Current Limit for CS12/13.*

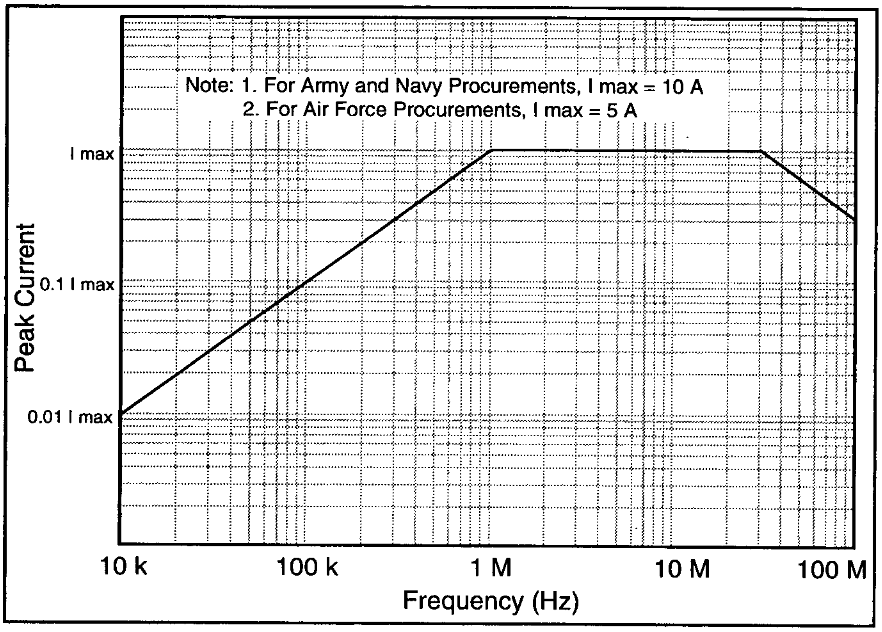

Figure 3. *Current Limit for CS116.*

current limit. For CS13, this limit is a calibration limit of the short circuit current of the transient generating system. The CS116 limit is displayed in Figure 3. This limit is both a calibration limit and a test current limit. These current levels will be used for the comparison. The waveform for these tests is that of a damped sinusoid, which may be represented by the following equation:

$$i = 1.03\, I_{peak} \sin(2\pi ft)\, e^{-\pi ft/Q} \quad (2)$$

where

- i = current (A)
- I_{peak} = peak current (A)
- f = fundamental frequency (Hz)
- t = time (s)
- Q = damping factor

CS10, CS11, and CS116 test methods have testing requirements at six mandatory fundamental frequencies, 10 kHz, 100 kHz, 1 MHz, 10 MHz, 30 MHz, and 100 MHz. CS12 and CS13 require testing at all of the above frequencies except for 30 MHz. The low frequency 10-A breakpoint in Figure 1 at 625 kHz also will be examined as this is a maximum energy point. The 50-MHz breakpoint in Figure 2 also will be studied for comparison.

CS10, CS11, and CS116 specify a damping factor of 15 ± 5, while the damping factor requirement for CS12 and CS13 is 20 ± 5. Thus, these tests specify a fairly wide tolerance of the value of the damping factor. The midpoint of the damping factor range requirement will be used for making the comparisons. The value used will be 15 for CS10, CS11, and CS116 and 20 for CS12 and CS13. For comparative purposes, a damped sinusoid waveform with a damping factor of 15 is shown in Figure 4a, while Figure 4b displays a damped sinusoid with a damping factor of 20.

During the performance of the test, the damping factor is determined by measuring the levels of various peaks of the monitored damped sinusoidal waveform. The values received are then inserted into Equation (3) in order to determine the damping factor of the waveform.

where

$$Q = \pi (N-1) \ln (I_1/I_N) \quad (3)$$

Q = damping factor
N = cycle number
I_1 = current at first peak
I_N = current at N^{th} peak

RESULTS

Solving the action integral for the damped sinusoid waveform at the frequencies, damping factors and current levels detailed above yields the results found in Table 1.

The CS116 Army and Navy specification's action integral levels meet or exceed the CS10/11 levels over the 1 MHz to 50 MHz frequency range but are lower below 1 MHz and up around 100 MHz. The CS116 Air Force specification's action integral levels are below the levels of CS12/13 over the entire test frequency range.

CONCLUSIONS

As is shown in Table 1, the CS116 Army and Navy test method action integral levels meet or exceed the action integral levels of the CS10/11 test methods at the highest levels. At low frequencies, the CS10 and CS11 test methods have higher energy levels due to slightly higher current requirements. Most failures due to overstress, however, occur around 1 MHz, where the energy levels are the highest. Although the CS116 Army and Navy requirements levels are lower than those of the CS10 and CS11 between 625 kHz and 1 MHz, testing is rarely performed in this frequency range. Most EUT critical frequencies and resonant frequencies are above 1 MHz. Above 10 MHz, the CS116 Army and Navy action integral levels are higher than the CS10/11 levels. While failures due to overstress are not common in this frequency range, the higher levels increase the change of susceptibility due to interference effects.

The action integral levels for CS116 Air Force requirements are slightly lower than those of the CS12 and CS13 levels due to the lower Q requirement and the lower current requirement at the higher frequencies. However, since the Q ranges overlap by half of their tolerance ranges, there may not be a difference in the actual damping factor received during the performance of the test. Again, while at the higher frequencies, overstress failures are not the major concern; the lower current levels, however, could lessen the chance of interference effects being produced.

Overall, the CS116 test requirement adequately covers the energy levels of the tests that it was designed to replace. Although some CS116 levels are lower, they are not significantly low enough to discredit the test method. It is important to keep in mind that all of these tests already have a built-in safety margin between testing levels and real world phenomena, that exceeds the differences encountered in this comparison.

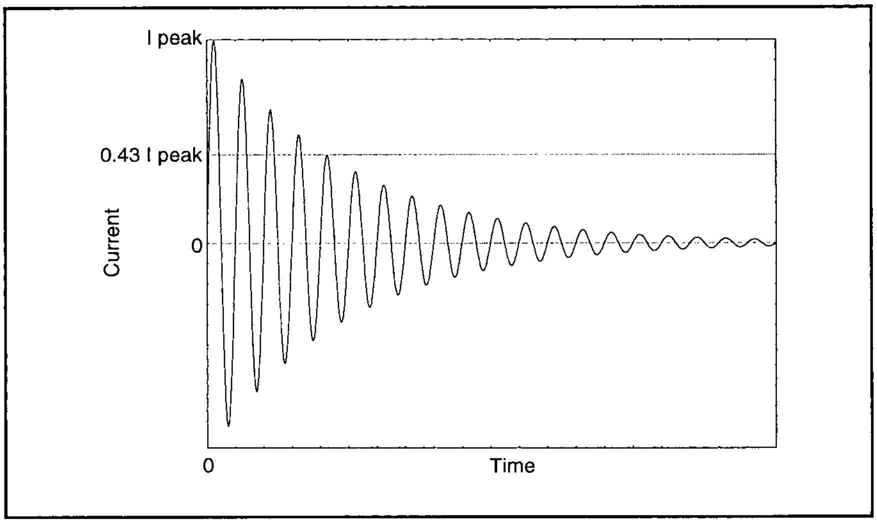

Figure 4a. *Damped Sinusoid Waveform, Q = 15.*

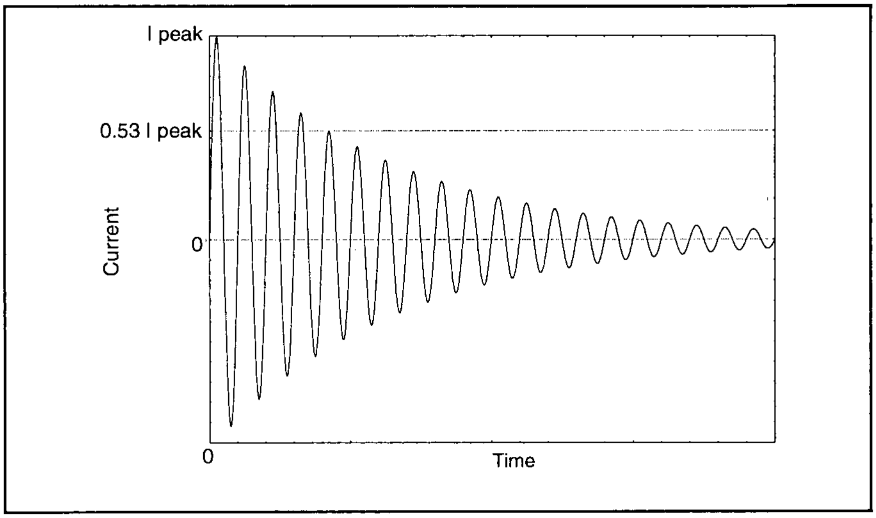

Figure 4b. *Damped Sinusoid Waveform, Q = 20.*

FREQUENCY	CS10/11	CS116/A&N	CS12/13	CS116/AF
10 kHz	$3.24\ 10^{-6}$	$1.26\ 10^{-6}$	$4.22\ 10^{-7}$	$3.16\ 10^{-7}$
100 kHz	$3.24\ 10^{-5}$	$1.26\ 10^{-5}$	$4.22\ 10^{-6}$	$3.16\ 10^{-6}$
625 kHz	$2.02\ 10^{-4}$	$7.91\ 10^{-5}$	$2.64\ 10^{-5}$	$1.98\ 10^{-5}$
1 MHz	$1.26\ 10^{-4}$	$1.26\ 10^{-4}$	$4.22\ 10^{-5}$	$3.16\ 10^{-5}$
10 MHz	$1.26\ 10^{-5}$	$1.26\ 10^{-5}$	$4.22\ 10^{-6}$	$3.16\ 10^{-6}$
30 MHz	$4.68\ 10^{-7}$	$4.22\ 10^{-6}$	$1.41\ 10^{-6}$	$1.05\ 10^{-6}$
50 MHz	$1.01\ 10^{-7}$	$9.11\ 10^{-7}$	$8.44\ 10^{-7}$	$2.28\ 10^{-7}$
100 MHz	$1.26\ 10^{-8}$	$1.14\ 10^{-7}$	$6.75\ 10^{-8}$	$2.84\ 10^{-8}$

Table 1. *Action Integral Comparisons.*

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