Electromagnetic Susceptibility Measurement of Military Radio Electronic Equipment

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***Abstract*—Whereas the EMC of a piece of equipment represents a requirement which must be fulfilled according to the applicable EMC standards, in order not to disturb the functionality of other devices, the EMS of that equipment has the same importance, since its prime purpose is to perform and to achieve the scope for which it was designated. Thus, the measurement of the equipment's EMS became an important aspect to be considered by any manufacturer, because, on the opposite side, any buyer will be very focused to check, before buying, the compliance of equipment with the Standards provisions on EMS matter. This article provides a synthetic updated overview of the main aspects related with the EMS test conditions, test methods and results interpretation, from the Military Standards prospective.**

***Index Terms*—anechoic chamber, conducted susceptibility, electromagnetic disturbances, immunity thresholds, radiated susceptibility, reverberation chamber, test requirements.**

I. Introduction

According to IEC 60050 – International Electrotechnical Vocabulary, electromagnetic susceptibility (EMS) represents the inability of a device, equipment, or system to perform without degradation in the presence of an electromagnetic disturbance. Also, this regulation notes that susceptibility is a lack of immunity which is the ability of a device, equipment, or system to perform without degradation in the presence of an electromagnetic disturbance [1].

Having seen these definitions, it is clearly understood the need for a superior immunity of a device and a less possible susceptibility to the electromagnetic interferences (EMI).

In order to achieve this goal, the manufacturers pay a lot of efforts to improve the design methods and to produce radio electronic equipment which comply with the EMS Standards requirements.

On the other hand, the authorities struggle to develop more and more precise rules and test methods to control the EMS of a product. These rules and methods are included in civilian and military standards and publications. Speaking about civilian immunity standards, the IEC 61000-4 series of immunity standards, Electromagnetic Compatibility—Testing and Measurement Techniques, consists of 21 generic test methods developed to address upsets and malfunctions in electrical and electronic device. It represents the main international reference which provides us with a complete and detailed frame of criteria, rules and immunity test methods, applicable to a large number of situations and electromagnetic disturbances [2].

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Within the military field, MIL-STD-461G issued on December 11, 2015, is the main standard which describes the requirements for the control of electromagnetic interference characteristics of subsystems and equipment [3].

Both above mentioned regulations approach the EMC/EMS problematics by using four main terms: emissions, susceptibility, conducted and radiated (when speaking about electromagnetic disturbances). Starting from these terms, MIL-STD-461G establishes detailed verification requirements, limits and test methods related to four main domains:

- Conducted emissions (CE);
- Conducted susceptibility (CS);
- Radiated emissions (RE);
- Radiated susceptibility (RS) [3].

To "measure" the EMS of a device is somehow an inappropriate expression. In fact, this means to determine the maximum threshold level of a signal that will be applied to the equipment under test (EUT), without it exhibiting any malfunction, degradation of performance, or deviation from specified indication, beyond the tolerances indicated in the individual EUT specification [3].

The problematic related with the CS and RS measurement for military radio electronic equipment will be briefly addressed in the following paragraph.

II. Measurement of the Conducted Susceptibility

Before approaching each of the above-mentioned domains, MIL-STD-461G establishes the verification requirements (measurement tolerances, shielded enclosures, RF absorber material, ambient electromagnetic level, ground plane, power source impedance, general test precautions, EUT test configurations, operation of EUT, use of measurement equipment and calibration of measuring equipment).

In order to prevent the interaction between external environment and EUT, the measurement of its susceptibility shall be performed inside shielded enclosures, usually anechoic or semi-anechoic chambers. This requirement becomes an issue when a large military item must be tested. Due to the volume and weight of such equipment, a semi-anechoic chamber will be usually used. This is a special built facility which must meet the applicable standards requirements (EN 50147-1/IEEE 299 for shielding performances, IEC/EN 61000-4-22 for EMC/EMS tests, CISPR 16-1-4 for NSA and SVSWR, CISPR 22 for AN). For example, for military applications, the ambient electromagnetic level inside of the shielded enclosure shall be at least 6 dB below the allowable specified limits [3]. Also, there are clear requirements for the RF absorber

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material (carbon impregnated foam pyramids, ferrite tiles, and so forth), in terms of the absorption at normal incidence. This parameter has different values depending on frequency (6 dB from 80 MHz to 250 MHz and 10 dB above 250 MHz).

There are, also, strict rules regarding the componence of the test equipment and location of each device.

The CS measurement implies the verification of device's behavior when subjected to conducted disturbances generated as test signals with known parameters (voltage levels, frequencies, modulation).

In case of military equipment, the CS measurement is performed for 10 different requirements:

1) CS101, power leads;
2) CS103, antenna port, intermodulation;
3) CS104, antenna port rejection of undesired signals;
4) CS105, antenna port cross modulation;
5) CS109, structure current;
6) CS114, bulk cable injection;
7) CS115, bulk cable injection, impulse excitation;
8) CS116, damped sinusoidal transients on cables and power leads;
9) CS117, lightning induced transients, cables and power leads;
10) CS118, personnel borne electrostatic discharge [3].

The associated test procedures consist of three steps (turning on the measurement equipment, calibration and EUT testing), which are almost the same for all the above-mentioned requirements, excepting *CS103, CS104, CS105* and *CS109*. Also, these three steps are applied for the RS measurement, as we will see in chapter III.

It is very important to mention that the test procedures included in the standards are generic test methods and can be adapted as necessary for each application [3].

The electromagnetic disturbances conducted throughout the power leads are mainly represented by ripple voltages associated with allowable distortion of power source voltage waveforms (DC offset, harmonics, interharmonics, notching or noise). In case of *CS101* requirement, the componence of the test equipment consists of:

- Signal generator;
- Power amplifier;
- Oscilloscope or measurement receiver;
- Coupling transformer;
- Capacitor, 10 μF;
- Isolation transformer for oscilloscope use or transducer for measurement receiver use;
- Resistor, 0.5 ohm;
- LISNs (Line Impedance Stabilization Network) [3].

CS 101 requirement is applicable from 30 Hz to 150 kHz, for equipment and subsystems AC and DC power leads [3]. For DC powered equipment, CS101 is required over the entire 30 Hz to 150 kHz range. For AC powered equipment, CS101 is only required from the second harmonic of the equipment power frequency (100 Hz for 50 Hz equipment) to 150 kHz. The voltage levels of the applied signals depend on the nominal EUT source voltage: for voltages of 28 Volts and below, the level of signals will be between 96.5–126 dBμV; for voltages above 28 Volts, the signal level will be 106.5–136 dBμV. While maintaining the required signal level, the required frequency range is scanned at a rate of 0.0333 f_0/sec, with a maximum scan step of $0.05\, f_0$, where f_0 represents the tuned frequency of the signal source. This scanning process is performed for each power lead. The degradation of EUT performance is monitored in order to determine the threshold level when this occurs.

The following three requirements apply to receivers to assess their performance degradation produced by the RF signals arriving at the receiver antenna port.

Because of the large variety of receiver designs being developed, there are no standard test procedures general applicable, so, for each tested equipment, the test procedure may be tailored, while maintaining the basic concept of the guidance provided by the standard [4]. Examples of basic steps for testing procedures performed for the following three requirements, provide by the specialized literature are presented below.

CS103 is a requirement applicable from 15 kHz to 10 GHz for equipment and subsystems, such as communications receivers, RF amplifiers, transceivers, radar receivers, acoustic receivers and electronic warfare (EW) receivers.

It is very known that intermodulation is a phenomenon which occurs at the entrance of non-linear equipment, by overlapping two or more signals with different frequencies, producing a signal with a different frequency at the exit of that equipment. The intermodulation products could be [5]:

- Second order: 2f1, 2f2, f1±f2;
- Third order: 2f1-f2; 2f1+f2; 2f2-f1; 2f2+f1;
- Superior order.

The concept of this requirement is to combine two out-of-band signals and apply them to the antenna port of the receiver, while monitoring it for an undesired response [3]. One of the signals is modulated with the modulation expected by the receiver (normally, phase or frequency modulation are preferred due to a superior protection to intermodulation products, instead of amplitude modulation). Of course, this signal has to have higher amplitude than the EUT specified sensitivity. The second signal is a continuous wave (CW).

Both signals are modulated and successively applied to the EUT, at the minimum required level to obtain a normal operation of the EUT. This represents the tuned frequency of the EUT (f_0). Then, the first signal is applied, while the second signal is off. The frequency of the first signal is increased until the normal operation of the EUT is lost. This frequency is recorded as f_1. The difference between f_1 and the EUT tuned frequency (f_0) is noted as Δf.

The second signal is applied at a $f_1 + \Delta f$ frequency and an amplitude which allows a normal EUT operation. The above-mentioned frequency is scanned, while monitoring the EUT for indications of susceptibility. If the intermodulation is present, the levels of both signals will be decreased until the normal EUT operation is restored. These amplitudes are recorded.

The difference between EUT minimum required level for a normal operation (sensitivity level) and the last recorded level of the first signal represents the intermodulation rejection.

For the receivers that process a very specialized type of modulation, which would never be expected on an out-of-band

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signal, a third signal can be used at the fundamental [3].

The rejection level requirement depends on the individual procurement specification. For instance, the rejection requirement is 66 dB within the tuning range and 80 dB outside the tuning range.

CS104 is a requirement applicable from 30 Hz to 20 GHz for all types of equipment above mentioned al *CS103* requirement. The intent of this requirement is to control the response of EUT to signals outside its intentional pass band that can produce spurious responses. The ability of a receiver to reject other than the tuned frequency is a measure of receiver performance [3].

The basic concept is to apply one or two out-of-band signals to the antenna port of the receiver while monitoring the receiver for degradation [3].

In case of applying a single signal, this is set at EUT tuned frequency, modulated and having an amplitude which allows a normal operation of the EUT. The required frequency range is scanned by increasing the signal frequency until the upper test end frequency is reached, while monitoring the EUT for spurious responses. If susceptibility occurs, the signal amplitude will be lowered, until the EUT normal operation is restored. The signal level and frequency are recorded.

The rejection is determined by subtracting the signal amplitude from the EUT normal operation amplitude.

In case of applying two signals, the following steps are usually performed:

- First signal is modulated and set at the EUT tuned frequency, then it is amplified until the EUT normal operation is reached; the signal amplitude is recorded;
- The first signal is turned off;
- The second signal is modulated and set at the EUT tuned frequency, then it is amplified until the EUT normal operation is reached; the signal amplitude is recorded;
- While keeping the second signal applied, but unmodulated, the first signal is modulated and applied at the EUT tuned frequency and amplified until EUT normal operation is reached;
- The required frequency range is scanned by increasing the frequency of the second signal to the upper limit of the range, while monitoring the EUT for indications of susceptibility;
- If spurious response is observed and it is not an intermodulation product, the amplitude of second signal will be decreased, until the disapperance of that spurious response; the signal amplitude and frequency are recorded;
- The rejection is determined by subtracting the second signal amplitude from the EUT normal operation amplitude;
- Repeat the above-mentioned steps, but with the first signal modulated and with the second signal unmodulated.

The outcome of testing the CS to antenna port rejection of undesired signals is a test report which includes data regarding the sensitivity of the receiver, the levels of the signal sources, frequency range swept, operating frequencies of the receiver, degree of rejection and frequencies and threshold levels associated with any responses.

CS105 requirement is applicable from 30 Hz to 20 GHz only for receivers that normally process amplitude-modulated RF signals. Cross modulation may exist when a strong carrier is within the same band as the desired frequency [3].

The intent of this requirement is to control the response of antenna-connected receiving subsystems to modulation being transferred from an out-of-band signal to an in-band signal. This effect results from a strong, out-of-band signal near the operating frequency of the receiver that modulates the gain in the front-end of the receiver and adds amplitude varying information to the desired signal. In order to proper test for cross modulation response, the bandpass characteristics of the receiver must be known for determining frequencies near the receiver fundamental that will be excluded from the test.

The test procedure implies the use of two signals and the performance of the following steps:

- First signal is modulated and set at the EUT tuned frequency, then it is amplified until the EUT normal operation is reached; the signal amplitude and frequency are recorded;
- The first signal is turned off;
- The second signal is modulated and set at the EUT tuned frequency, then it is amplified until the EUT normal operation is reached; the signal amplitude and frequency are recorded;
- First signal, modulated, is applied and then it is amplified until the EUT normal operation level + 10 dB;
- Modify the frequency of the second signal above and below the EUT tuned frequency to the upper and lower end frequencies, while monitoring the EUT performance;
- If susceptibility is observed, confirm that the cause is cross-modulation by removing the modulation of the first signal. If susceptibility disappears, the cause is cross-modulation;
- If susceptibility is observed, lower the amplitude of the second signal until susceptibility is not present and record the amplitude of the signal;
- The rejection is determined by subtracting the second signal amplitude from the EUT normal operation amplitude.

CS109 requirement is applicable from 60 Hz to 100 kHz for equipment and subsystems that have an operating frequency of 100 kHz or less and an operating sensitivity of 1 μV or better (such as 0.5 μV). Handheld equipment is exempt from this requirement [3]. The potential threat is to equipment with metal chassis attached to the metal structure of a platform. Current from power generation and distribution, power frequency harmonics and low frequency transmitters that are coupled to the platform structure may flow through the equipment metal chassis and induce voltages into the equipment. The induced voltage may interfere with the performance of the equipment [6].

A dedicated test procedure is used to verify the ability of the EUT to withstand structure currents with values between 60 to 120 dBμA. Calibration is not required for this test procedure assuming that the current probe and measurement receiver are calibrated.

The EUT is placed on a non-conductive surface, in order to enable a single point ground to be established. Chassis isolators may be incorporated to prevent current flow across the sensitive surface [6].

A set of test points (where the generated currents will be applied) is selected, mandatory on each surface of the EUT. Armored cables, shielded cables and conduit terminated at the EUT are also classified as test points. The conductors used to apply the currents must be perpendicular to surface for at least 50 cm [3].

The measurement results are presented in a table format, showing the mode of operation, susceptible frequency, current threshold level, current limit level, and susceptible test points.

CS114 requirement is applicable from 10 kHz to 200 MHz for all interconnecting cables, including power cables and is used to verify the ability of the EUT to withstand RF signals coupled onto EUT associated cabling. Although the name implies that the test is associated with conducted interference, the test is performed to evaluate radiated susceptibility coupled into the equipment via the exposed wiring [6].

Current injection probes are pre-calibrated to the appropriate limit and modulated according to the test procedure (with 1 kHz pulse modulation). The calibration limits are represented by five limit curves (first one: 37-77 dBμA, last one: 69-109 dBμA), applicable depending on the platform type where the equipment is located, arm forces category and frequency range. After the calibration process, the probes are placed on the cable selected for test.

Any susceptibility thresholds that were determined along with their associated frequencies are documented.

Comparing with the previous revisions of the standard, MIL-STD-461G introduces an augmentation of the measurement system integrity check, since the current must be measured using a current probe that does not require periodic calibration.

CS115 requirement is applicable to all aircraft, space, and ground system interconnecting cables, including power cables. The requirement is also applicable to surface ship and submarine subsystems and equipment.

Testing is very similar with CS114, with the differences that a pulse generator is used instead of the RF signal source and an oscilloscope is used instead of the measurement receiver. The ability of the EUT to withstand impulse signals coupled onto EUT associated cabling is verified. The applied trapezoidal pulse has rise and fall time less than 2 ns, minimum width of 30 ns, repetition rate 30 Hz and amplitude at 4.5 Amperes. Any susceptibility thresholds that were determined are documented. The objective of these tests is to protect equipment from fast-rise and fall-time transients that may be present because of internal and external switching functions. The impact of these switching functions on the surrounding environment is the generation of electromagnetic disturbances that could assault equipment directly and indirectly. Direct effects of these disturbances can occur through coupling into internal circuitry, coupling through the AC/DC power source, or equipment enclosure. Indirect effects can occur through coupling into signal and power leads.

CS116 requirement is applicable from 10 kHz to 100 MHz for all interconnecting cables, including power cables, and individual high side power leads. The purpose is to evaluate the EUT's ability to withstand the damped sinusoidal wave transients often associated with lightning or electrical switching operations [6].

A damped sine transient, having peak current at 1st cycle at 10 Amperes and damping factor 15±5, is applied. Compliance shall be demonstrated at the following frequencies: 0.01, 0.1, 1, 10, 30, and 100 MHz. The test signal repetition rate shall be no greater than one pulse per second and no less than one pulse every two seconds. The pulses are applied for a period of five minutes, at a repetition rate of 1-2 seconds. For polyphase power systems, individual phase leads are tested.

Any susceptibility thresholds and the associated frequencies that were determined for each connector and power lead are documented.

An important aspect to be mentioned is that if the current is excessive and the characteristic impedance of the circuit is low or unknown, the calibration setting appliance could damage the EUT. For this reason, in such situation, the standard allows to lower the current level [6].

CS117 requirement is a new introduced requirement, comparing with the previous revisions of MIL-STD-461 Standard. It has a limited applicability, usually related to safety-critical equipment interconnecting cables, including complete power cables, and individual high side power leads. The purpose is to evaluate the EUT's ability to withstand lightning induced transients coupled onto the cables [3].

The EUT is subjected to the levels and lighting transients (Multiple Stroke and Multiple Burst) supplemented by the six waveforms and timing precisely established by the standard [6].

Multiple stroke testing applies an initial transient at the designated level, followed by thirteen subsequent transients at a decreased level over a period of up to 1.5-seconds. Ten multiple stroke applications are applied with up to 5-minutes between each application [6].

Multiple burst testing applies a group of twenty transients with 50 to 1000 µS between transients with 3-sets of bursts spaced between 30 and 300 mS. Burst groups are applied every 3-seconds for a minimum of 5-minutes [6].

Comparing *CS117* requirement with a widely-known requirement of Radio Technical Commission for Aeronautics, namely RTCA DO-160-Section 22.0, few differences are coming up:

- No pin or ground injection tests are required in CS 117, but only cable induction, due to the fact that pin injection tests are damage tests;
- No Single Stroke (SS), are required in CS 117, but only MS and MB;
- CS 117 has only two levels, internal and external;
- CS 117 represent only a part of RTCA DO-160G-S 22 test requirement and applies to military aircraft and surface ships which have cables routed above deck;
- CS117 is not intended to address physical effects, but only disturbance of functionality [7].

CS118 requirement is also a new introduced one, being applicable to electrical, electronic, and electromechanical subsystems and equipment that have a man-machine interface. The concept of this requirement is to simulate

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ESD (Electrostatic Discharge) caused by human contact and test points are chosen based on most likely human contact locations. Multiple test locations are based on points and surfaces which are easily accessible to operators during normal operations. Typical test points would be keyboard areas, switches, knobs, indicators, and connector shells as well as on each surface of the EUT [8].

There are two test situations for the EUT: contact discharge (at ± 8 kV) and air discharge (at four test levels: ±2 kV, ± 4 kV, ± 8 kV, and ±15 kV, not only at the 15 kV limit, as per RTCA DO-160-S25; this is because air discharge current waveforms can have higher amplitudes at lower potentials, due to smaller arc distances and hence lower arc resistance) [9].

Air discharge is required only if the contact discharge cannot be applied. Five positive and five negative discharges are applied at each test point [6]. Between discharges, the residual charge must be removed, by grounding the test point through a resistor.

ESD represent an important issue within the military field where the majority of the military systems are controlled/operated by electronic microchips – so sensitive components to ESD. That's why, ESD testing, classifying, labeling and handling represent important and systematized activities for the military equipment.

III. Measurement of the Radiated Susceptibility

RS measurement implies the verification of device's behavior when subjected to radiated disturbances generated as test signals.

For military equipment, the RS measurement implies the performance of test activities related to 3 requirements:

1) RS101, magnetic field;
2) RS103, electric field;
3) RS105, transient electromagnetic field.

RS101 requirement is applicable from 30 Hz to 100 kHz for equipment and subsystem enclosures, including electrical cable interfaces. The EUT is subjected to local magnetic fields produced with a small coil (loop) located firstly at 5 cm from each face of the EUT and then, repositioned successively to a location in each 30 by 30 cm area on each EUT face and also, each interface connector. The magnetic fields strength is between 110 and 183 dBpT. The goal is to generate field leakage inside of the EUT and to observe the moment when an abnormal behavior is exhibited, in order to register the threshold and the frequency of that magnetic field.

MIL-STD-461G provides an alternative test procedure – AC Helmholtz coil, provided that the EUT size versus coil size constraints can be satisfied. It is very known the fact that a Helmholtz coil consists of a pair of near identical circular magnetic coils that are placed symmetrically along a common axis, and separated by a distance equal to the radius of the coil. Each coil carries an equal electric current in the same direction, to create a uniform magnetic field between the two coils. The EUT is placed between radiating loops of the Helmholtz coil, by providing minimum 5 cm between EUT and each radiating loop.

The Helmholtz coil alternative method is very useful in RS testing of a common size EUT and provides the distinct advantage of a complete testing in the plane with only one frequency scan [10]. For a complete exposure, the EUT is rotated in three orthogonal planes.

RS103 requirement is applicable for equipment and subsystem enclosures and all interconnecting cables. The requirement is applicable as follows:

a. 2 MHz to 30 MHz, Army, Navy and optional for all others;
b. 30 MHz to 18 GHz, All,
c. 18 GHz to 40 GHz, Optional (according to the procurement requirements) [3].

The EUT is subjected to the radiated electric fields with magnitudes between 5 and 200 V/m, depending on the frequency range, platform type and armed forces category.

An important aspect established by the standard is the test setup. In this respect, the transmitting antennas shall be placed one meter or greater from the test setup boundary. Between 2 MHz and 200 MHz, this placement depends on the test setup boundary size which can be below or over 3 meters and includes the EUT and the 2 meters of power leads. Starting with 200 MHz and above, multiple antenna positions may be required, especially for large test items, in order to provide a complete coverage within the radiating antenna 3 dB beam width. In the 200 MHz to 1 GHz frequency range the antenna positioning should expose the EUT plus 35 cm of cable at the EUT end of the cable. Above 1 GHz the position includes the EUT plus 7 cm of cable. The source signal is modulated to 1 kHz square pulse modulation. The testing is performed over the required frequency range, firstly with the transmit antenna vertically polarized and then horizontally polarized. Circularly polarized fields are not acceptable [3].

MIL-STD-461G provides an alternative test procedure – reverberation chamber (mode-tuned), which may be used over the frequency range of 200 MHz to 40 GHz. The lower frequency limit is dependent on chamber size.

The reverberation chamber provides an advantage in exposing all EUT faces simultaneously and creating very high-level fields with relatively low power amplifiers [6].

It is very known the fact that a reverberation chamber is a shielded enclosure with highly reflective surface walls, or resonant cavity for RF testing, which has a paddle or tuner for stirring the field inside it. There are two modes of reverberation testing methods: "mode-tuned" and "mode-stirred" depending on the movement type of the paddle (stepped or continuous). In mode-tuned method, the paddle (tuner) is placed to successive positions where the electrical field is applied for a sufficient time to simultaneously radiate all sides of the EUT. The number of tuner positions depends on the frequency range and chamber dimensions and could be from 12 to 50.

The EUT shall be placed at least one meter from the chamber walls, the tuner and antennas (transmitting one and receiving one) and is subjected to the same electrical fields as in *RS103* case. The same antennas used for calibration are used for EUT testing. Speaking about calibration, there are two procedures for the receiving antenna and for the electric field probe, in order to establish the electric field strength that will be created inside the chamber when a fixed amount of RF energy is injected into the chamber. The calibration of the test equipment is a very important factor to be considered, in order to obtain accurate test results. For instance, the use of broadband transmitting antenna, which normally has a better gain at higher frequencies, in addition with the use of field probe, which is also a broadband receiving device and cannot distinguish between fundamental or harmonics, leads to errors in the measurement process. This is the reason why the electric field probe calibration must be performed according to IEEE 1309 provisions.

RS105 requirement is applicable to equipment and subsystem enclosures which are exposed to the external electromagnetic environment. The basic concept is to demonstrate the ability of the EUT to withstand the fast rise time, free-field transient environment of EMP, that is applied to all three axes of the EUT, at least 5 times, at the rate of no more than one pulse per minute. The peak field strengths 50 kV/m with a tolerance of +6 dB / 0 dB and the rise-time is between 1.8 ns and 2.8 ns, while the full with half maximum is 23 ± 5 ns.

Before testing the EUT, a calibration process is performed, in order to verify the pulse waveform and level at five points defining the EUT boundary (four corners and the center). Measurements of the field are made with D-dot (electric field) or B-dot (magnetic field) sensors to capture the level and rate of change of the transient pulse at each of the five points [6].

In order to avoid the burnout of the EUT, the test is performed firstly at 10% of the specified limit, and then the amplitude is increased in 2 or 3 steps until the limit is reached. During the test procedure, the EUT is 180 degrees rotated.

To ensure a proper uniform field distribution area, *RS105* requires that transmission line length and width are at least twice that of the EUT and at least three times the height [11].

RS105 requirement is applicable only for EUT and not for its associated cabling which must be kept as short as possible and oriented in a specific manner (routed in shielded conduit and/or underneath the ground plane), in order to minimize coupling to the EMP fields.

MIL-STD-461G is the main military standard which establishes the framework for testing rules and activities at the equipment and subsystems level.

Usually, the equipment and subsystems are components of the military systems.

At the systems level, from the EMC/EMI/EMS prospective, another important military standard represents the main reference document: *MIL-STD-464 C* [12].

Its provisions establish the interface requirements for electromagnetic environmental effects and verification criteria for complete systems.

These rules encompass, in addition with important EMC/EMI aspects, requirements for the electromagnetic vulnerability (EMV), electromagnetic pulse (EMP) and electrostatic discharge (ESD).

By checking these rules, an important similitude with the requirements included in MIL-STD-461G can be observed, which leads to the conclusion that the fulfilment of the EMS requirements at the subsystem level is almost a warranty of a full EMS compliance, at the system level.

IV. CONCLUSION

Along with the high battle performances, an improved level of the electromagnetic immunity remains one of the most important characteristics of military equipment. Thus, the electromagnetic susceptibility assessment for that equipment remains a priority for any purchasing authority which will check very carefully if the product has been completely tested according to the latest applicable standards. For this reason, during the acceptance tests phase, the buyer will assign a committee to attend the test and supervise its performance. The committee members must be very familiar and updated with the latest applicable standard provisions, in order to properly asses the capacity of the product to satisfy technical and operational requirements of the army.

The article summarizes the main aspects related with the electromagnetic susceptibility assessment, provided by the military standard in force and presents examples of test procedures described within the specialized literature.

Nevertheless, for details and specific needs for clarification, a thorough study of the standard provisions is highly indicated.

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