EMC Management & Lab Accreditation

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Abstract— EMC is the ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable disturbances into that environment or into other equipment. The methods of coupling electromagnetic energy from a source to a receptor can be done in four categories – Conducted, Inductively, Capacitively coupled and radiated. Emphasis is placed upon an intersystem approach to the improvement of the overall electromagnetic environment. There are a plethora of tests which are done under EMC is Emissions and Immunity– Radiated & Conducted (PLCE and SLCE), Radiated & Conducted, Immunity, ESD, EFT/B, Surge, VDI, Magnetic and Flickers.

This paper provides the overview of all the EMC testing's, EMC Management, Laboratory Accreditation, Standards, different EMC Chambers and Legal issues of EMC.

Keywords— EMC, RE (Radiated Emissions), CE (Conducted Emissions), ESD (Electrostatic discharge), EFT/B (Electric Fast Transient/Burst), PLCE (Power Line Conducted Emission), SLCE (Signal Line Conducted Emissions), VDI (voltage dips and Interruptions).

INTRODUCTION

When we hear "EMC" or its longer version, "electromagnetic compatibility", it suggests elaborate anechoic chambers with pretty tiles, highly-specialized antennae, sophisticated EMI receivers, copper and more copper, and a thicket of regulations. We all are concerned with electromagnetic compatibility because we face specific problems in our own specialized areas. In addition to this, natural environment, intentional electromagnetic threats are also now emerging to which unprotected systems will be vulnerable. The environment itself is also a pertinent factor because its characteristics influence the electromagnetic energy present within it. The fundamental work of strategic nature in EMC is required now to support emerging technologies and prevent new threats. A European technology Network on Sustainable Electromagnetic Environments (ETN-SEE) has been established to facilitate, coordinate, and accelerate the development and acceptance of technologies which will create an electromagnetic friendly and secure society in the future. Electromagnetic compatibility invariably has two aspects. For any incompatibility to exist there must be a source of interference. If either of these is absent, there is no EMC problem. Electromagnetic Interference (EMI) has become a major problem for circuit designers, and it is likely to become even more severe in the future. As circuitry has become smaller and more sophisticated, more circuits are being crowded into less space, which increases the probability of interference. Interference is the undesirable effect of noise. If a noise voltage causes improper operation of a circuit, it is interference. Noise cannot be eliminated, but it can be reduced in magnitude. An EMI filter is designed to attenuate one or more specific frequencies in order to provide electromagnetic compatibility of an electronic device while in the presence of an electromagnetic emitter operating at the same or similar frequencies.

EMISSIONS AND IMMUNITY TESTS

Radiated Emissions:

Radiated Emissions testing involves measuring the electromagnetic field strength of the emissions that are unintentionally generated by the system. The electromagnetic waves don't extend out from the system in a spherical pattern. The emissions tend to be pretty directional, so in the test lab, we can just vary the height of the receiving antenna. The antenna picks up both the signal direct from the system and from the ground. The types of Antennas used for Radiated Emissions are more than three types. Bilog Antenna (30MHz-1GHz), Horn Antenna (1-18GHz) and Fixed Gain Horn Antenna (18-40GHz) are mainly used.

Performing radiated emissions measurements is not as straightforward as performing conducted emissions measurements. The complexity of the ambient environment is added which could interfere with measuring the emissions from a DUT. There are some methods that can be used to discriminate between ambient environment and signals from the DUT. Testing in a semi-anechoic chamber can simplify and accelerate measurements because the ambient signals are no longer present. Chambers are an expensive alternative to open area testing. If the device is placed on a turntable, rotate the device while observing a signal in question. If the signal amplitude remains constant during device rotation, then the signal is more likely to be an ambient signal. Signals from a DUT usually vary in amplitude based on its position.

Conducted Emissions:

Conducted RF emissions are electromagnetic disturbances (noise voltages and currents) caused by the electrical and electronic activity in an item of equipment and conducted out of that equipment along its interconnecting cables, such as power, signal or data cables. The conducted disturbances in a conductor, emitted by one item of equipment, can couple directly into another item of equipment that is connected to the same conductor. Conducted disturbances are also radiated from the conductors they travel along, as both electric and magnetic waves, and in this sense, the conductor is acting as an 'accidental transmitting antenna'. A very common frequency range called out by conducted emissions standards is 150 kHz to 30 MHz. We have two different emission testing under Conducted Emission Testing, they are – 1) PLCE (tested on power ports) and 2) SLCE (tested on telecommunication ports).

Power Line Conducted Emissions – CE limit are imposed on power lines primarily to protect other equipment that shares the power lines. The ripple caused by emissions from multiple devices on the line can at times be additive. In the power line conducted emission test, EUT is the interference resource and the equivalent circuits of parallel transmission lines.

Signal Line Conducted Emissions – CE limits on signal lines apply to the entire cable bundle and are intended to control low-frequency radiation produced by cabling harnesses.

Radiated and Conducted Immunity/Susceptibility:

Radiated Immunity test is intended to see how well our EUT performs when it is encountered with different types of electromagnetic field disturbances in normal usage. A signal generator feeds a modulated sine wave to a broadband RF power amplifier. The output of the amplifier is connected to a transducer, which turns the varying conducted voltage into a varying radiated electromagnetic field. For RS test, we use Log periodic Antenna and Horn Antenna. The compliance testing for radiated immunity for commercial products is based on the international standard, IEC 61000-4-3, and is performed from 80 to 1,000 MHz at e-field levels from 3 to 20 V/m, depending on the production environment or application. The RF signal is generally modulated by a 1,000 Hz Amplitude Modulation sine wave modulation set to 80% for commercial testing, and short duration (as little as 1%) pulsed modulation for military and aerospace testing. The modulation is designed to test for "audio rectification" issues.

Testing should be performed in a configuration, close to actual conditions in which the EUT will be used. A metallic grounding plane is not required, but the EUT should be placed on a non-metallic, non-conductive material. The required wiring length required for the EUT is less than 3m, then the specified length should be used. The required length is longer, a minimum of 1m of cable should be exposed to the RF field, and excess cables should be bundled in the center of the cable in lengths of 30-40cm.

Conducted Susceptibility is to test the immunity to conducted disturbances induced by radio-frequency fields. It is used to stimulate the normal voltage and current environment of external power and signal cables. We can have both capacitive and inductive coupling when the cables are bundled together. The different transducers that are used in CS test are CDNs, BCI Probe, EM Clamp and direct voltage injection. This test simulates adjacent cabling by injecting a common mode disturbance into your cabling using a transducer. The compliance testing for conducted immunity is based on international standard, IEC 61000-4-6, and it is performed to test the requirement of electrical and electronic equipment to electromagnetic disturbances coming from intended RF transmitters in the 9 kHz - 80 MHz frequency range.

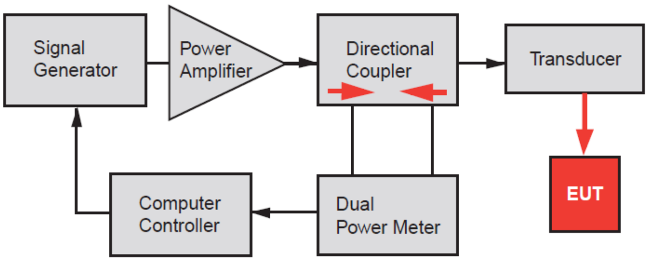

Figure 1: Conducted Immunity Test Setup

The frequency range is swept from 150 kHz to 80MHz, using the signal levels established during the settling process, and with disturbance signal 80% amplitude modulated with a 1 kHz sine wave, pausing to adjust the RF signal level or to change coupling devices as necessary. Where the frequency is swept incrementally, the step size shall not exceed 1% of the preceding frequency value. The dwell time of the amplitude modulated carrier at each frequency shall not be less than the time necessary for the EUT to be exercised and to respond, but shall in no case be less than 0.5s. The sensitive frequencies shall be analyzed separately.

ESD (Electrostatic Discharge):

An electrostatic discharge test is a common form of EMC immunity test. ESD involves in applying the discharges to any areas of the EUT which are normally accessible to a human touch. An ESD test has two discharge pins i.e. 1) Air and 2) Contact. In air discharge, the tip is blunt which is charged up to full voltage. When the air discharge tip is moved closer to the conductive surfaces of the EUT with a sufficiently large potential difference, a spark will arc across to the device. In contact discharge, the uncharged sharp tip gets in contact with a point on the EUT. When the trigger is applied to the ESD simulator, the tip is charged that discharges the energy through the EUT. ESD can attack via two paths – conduction (direct) and electromagnetic radiation (indirect). The indirect effects are real, and I've seen indirect ESD induced failures occur up to 20 feet away. These multiple paths often mean multiple design fixes. For the direct effects, filters/transient protection are used for vulnerable inputs/outputs, while ferrites or other current limiting are used for power/ground paths. For the indirect effects, high-frequency shielding is used. Damage is common when ESD is injected on an unprotected I/O pin – digital, analog, or even power. Circuits vulnerable to ESD damage include I/O or any other lines directly connected to the outside world. Circuits vulnerable to ESD upset include resets, interrupts, and controls. Unwanted resets are very common with ESD — so common that we routinely add protection to these devices. Even power circuits are vulnerable. I have seen ESD shut down power supplies due to ESD upsetting power protection circuits.

EFT/B, Surge, and VDI:

The repetitive fast transient test with bursts consisting of a number of fast transients, coupled into the power supply, control and signal ports of electrical and electronic equipment. Significant for the test are the short rise time, the repetition rate and the low energy of the transients. EFT is done in two coupling methods. They are – 1) Direct and 2) Capacitive. Indirect coupling for power ports, the EFT disturbances are injected directly onto the relevant signals with a carefully defined source impedance. In capacitive coupling, the signals are fed through a capacitive coupling clamp, which couples the disturbance to the cables. The International standard for EFT/B test is IEC-61000-4-4. Test voltages of up to 4 kV in positive and negative polarities are applied to the A/C power leads and up to 2 kV is applied to the I/O cables. The test voltages are at a 5 kHz pulse repetition frequency and applied for 60 seconds to each power supply terminal including protective earth and every combination of these terminals. The coupling clamp is used to apply up to 2 kV to the I/O cables.

Surge is usually applied to AC (or DC) power input ports, but in some cases, it is also applied to the I/O ports. The surge pulses are coupled directly to the signals via defined source impedance. The coupling network is usually contained inside an immunity test system along with a decoupling network which helps to protect the power supply or auxiliary equipment. Surge coupling mechanisms are described in two modes: 1) Common mode 2/10 us, 6kV open-circuit voltage, 100 amp short-circuit current. (Longitudinal surge), 2) Differential mode 2/10 us, 1kV open-circuit voltage, 100 amp short-circuit current (metallic surge). In common mode surge, all the conductors in the cable develop the same instantaneous voltage with respect to earth ground. There is no voltage difference between any two conductors in the cable. The majority of surges that affect communication cables are common mode surges.

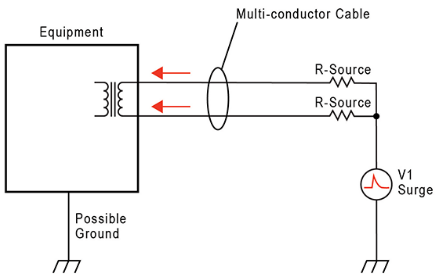

Figure 2: Common surge mode

When considering common mode surge, it is important to understand that if there is no path for surge current to exit the equipment, no surge current can flow. Similarly, even if there is a path that contains an isolation barrier that is stronger than the applied surge voltage, no current can flow, and this strategy particularly works very well for Ethernet ports.

In differential mode surge, a surge voltage appears between the individual conductors in a multi-conductor cable. The surge current will attempt to enter the equipment on one of the cable conductors and exit the equipment on another conductor in the same cable.

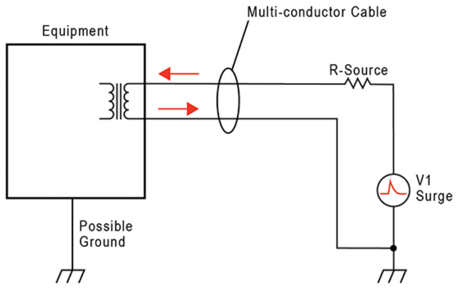

Figure 3: Differential surge mode

VDI test is normally used to simulate voltage dips and short brownouts on AC or DC power supplies. This test allows us to know whether the EUT works properly with the power supply fluctuations. IEC 61000-4-11 defines the immunity test methods and range of preferred test levels for electrical and electronic equipment connected to low-voltage power supply networks for voltage dips, short interruptions, and voltage variations. This standard applies to electrical and electronic equipment having a rated input current not exceeding 16 A per phase, for connection to 50 Hz or 60 Hz A.C. networks.

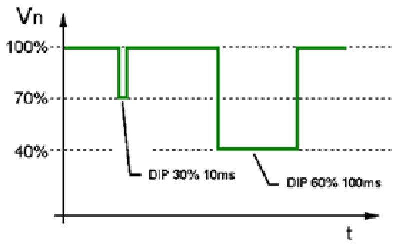

Figure 4: Dips for a period in the order of a millisecond.

Voltage dips and short interruptions are caused by faults in the network, in installations or by a sudden large change of load. Voltage variations are caused by the continuously varying loads connected to the network. The EUT is tested for test levels of 30%, 60% and >95% below the rated voltage for the equipment. The duration of the dips/interruptions are 10ms, 100ms and 5000ms respectively. Five dips are performed for each test level at a rate of one dip per minute. The changes in supply voltage occur at zero crossing of the voltage. A test level of 0% corresponds to a total supply voltage interruption.

Harmonics and Flickers:

Flicker and harmonics testing are another forms of emissions testing. These EMC tests are usually performed to the EN61000-3-2 and EN61000-3-3 standards respectively. In

Europe, these are considered to be 'horizontal' standards, which means that they apply to almost all types of electronic or electrical equipment that enter the EU. Harmonics is current testing, which is usually associated with switch mode power converters and other non-linear loads. The harmonics load on local power supplies is reduced, which helps to avoid overheating and increases efficiency. The test setup for measuring harmonic currents is very similar, only a sense resistor is added in series. By measuring the dynamic current consumption across the frequency range of interest, the analyzer is able to calculate the current consumption of the power supply harmonics.

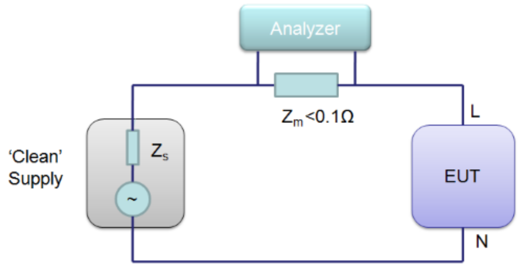

Figure 5: Harmonics Current measurement circuit.

Flicker is voltage testing that is caused arcing between contacts which in turn would cause nearby lamps sharing the same power supply to flicker. In figure 6, all the analyzer is measuring the voltage across the EUT. There is a calibrated complex source impedance, so the analyzer can work out the voltage fluctuations across a range of frequencies.

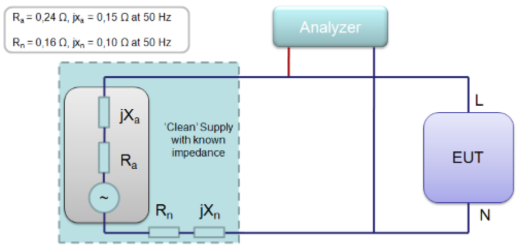

Figure 6: Flicker measurement circuit.

Pass/Fail Criteria:

When performing all the EMC Immunity tests, we have to evaluate whether the product passes or fails each EMC immunity test. They need to monitor your equipment during and after each test and watch for any changes to the behavior or operation. The performance of the product usually falls into categories A, B, C, and D.

- Criteria A: It is considered perfect, which means our product performs normally and within specifications, usually in the product manual, during and after the test. So essentially nothing bad happens to the product.
- Criteria B: The product may have a temporary loss of function of performance which ceases after the applied disturbance ceases. So after the test finishes, the equipment under test recover to its normal performance without operator intervention.

- Criteria C: It is the same as Criteria B, but the operator intervention is required. So maybe the EMC phenomena reset the device and we need to power it back on manually.

- Criteria D: There is a loss of degradation of performance which is not recoverable, owing to damage to the hardware or loss of data. So basically in some way the test has trashed the product. It might have fried some components or caused corruption of some data.

EMC MANAGEMENT AND METHODOLOGIES

To facilitate assurance of achieving compatibility, an EMC management lifecycle for every project is required. Each phase of the project lifecycle can be termed Definition, Requirement, Tendering, Design, Manufacture, Installation, Commissioning, and Operations & Maintenance.

A. Definition Phase

In this phase, the potential impact of EM interference between different electrical and electronic systems in the pre-defined electromagnetic environment is accessed and identified.

B. Requirement Phase

In this phase, the general EMC management and specific EMC technical requirements applicable to the project is formulated.

C. Tendering Phase

During this stage, EMC competence of the tenders is assessed based on their technical abilities to comply with the specific EMC requirements. Upon completion of the EMC assessment, the relevant project leaders should be advised of the results to enable them to finalize their overall assessment.

D. Design Phase

In the Design phase, EMC design progress, and compliance with requirements of each sub-system should be monitored. The design submissions include EMC Management Plan, EMC Test Specification, EMC Test Reports or Certificates and EMC Design Review.

E. Manufacture Phase

All EMC design should be completed with each system with the compliance requirements. Based on the proven designs, manufacturing of the system hardware is commenced.

F. Installation Phase

To make certain system design integrity, good EMC installation is practiced.

G. Commissioning Phase

During this phase, the identification of all necessary EMC interface and integration tests for each component of the system should be carried out.

H. Operation & Maintenance Phase

The operators & maintainers monitor the performance of the system. Enhancement of the EMC Compliance Matrix should be revised which will facilitate the preparation of the EMC specifications for the future system upgrade.

EMC management mode enables the interpretation of role definition and the management required in each phase of the project is to manage the EMC assurance in a large-scale project.

LABORATORY ACCREDITATION

Since 1990, the accreditation of EMC laboratories has become increasingly important in many parts of the world. The compliance of most of the electronic products with national and international electromagnetic compatibility (EMC) requirements is to be determined and documented. Qualified test laboratories can help reduce the test and approval periods, especially when regulatory authorities accept test data and reports documented without further evaluations. For example, in the US, an EMC test laboratory is accredited by A2LA (American Association for Laboratory Accreditation), NVLAP (National Voluntary Laboratory Accreditation Program). A2LA works with government and industry to serve as a resource on issues of quality and competence, provides technical expertise and recommendations on approaches to oversight, and helps to ensure conformance with established policies and requirements through accreditation.

Accreditation of US EMC test laboratories to the foreign standards serves as a basis for their recognition by the foreign regulatory authority as a conformance assessment body (CAB). Accreditation provides a formal recognition to competent EMC testing laboratories based on the authentication of the enforcement of a quality system in the laboratory (in accordance with ISO/IEC 17025) and the determination of a minimum level of technical proficiency to perform the EMC tests. There are four distinct groups that benefit from accreditation in general: EMC laboratories, users of laboratory testing services, regulatory authorities (private and public entities that require quality test data to operate), and the public. Accreditation has a positive impact on the public by stimulating higher standards of quality within EMC testing laboratories. Manufacturers also gain efficiency because of accreditation as they do not have to perform their own on-site assessments. Manufacturers who have in-house EMC testing capabilities can reduce or eliminate the overhead costs by using external accredited laboratories with the assurance of technical proficiency. Laboratory accreditation uses criteria and procedures specifically developed to determine technical competence. Qualified technical assessors conduct a thorough evaluation of all factors in a laboratory that affects the production of test or calibration data. Very often these criteria are based on ISO/IEC 17025, which is used for evaluating EMC test laboratories throughout the world.

Mutual recognition arrangements (MRAs), are crucial in enabling test and calibration data which are accepted by the countries. MRAs rely on accreditation as a basis for establishing technical competence and building regulator confidence. The accreditation bodies are responsible for accrediting competent conformity assessment bodies (CABs) in accordance with international standards and to the importing party's technical requirements. In the United States, NIST (National Institute of Standards and Technology) currently lists A2LA, ANAB (ANSI-ASQ National Accreditation Board), and NVLAP as acceptable for use by MRAs for EMC and telecommunications test laboratories (ISO/IEC 17025). Both A2LA and ANSI are recognized through the National Voluntary Conformity Assessment Systems Evaluation (NVCASE) Program as accreditors of certification bodies (ISO/IEC Guide 65). ISO/IEC 17025 allows laboratories to implement a sound quality system and demonstrate that they are technically competent and produce valid and reliable results.

The accreditation of EMC test laboratories around the world becomes more important with the globalization of trade and the proliferation of electronic and electric products in all aspects of life. Regulatory authorities in many countries have changed product approval processes for various product categories and now allow manufacturers to determine and declare product compliance with applicable standards. Qualified EMC test laboratories can now test products in accordance with foreign requirements/standards and prepare test reports that serve as the basis for product approval in foreign markets. EMC test laboratories must demonstrate their technical proficiency to perform these tests and also establish a quality framework that allows testing under repeatable and consistent conditions. The laboratory accreditation process (applied by recognized accreditation bodies), based on the generally accepted standard ISO/IEC 17025, allows test laboratories to obtain this independent determination and documentation of technical proficiency in the technical field of EMC.

From my experience, few things that I can share about ISO 17025 Accreditation. ISO 17025 is mainly applicable for testing and calibration laboratories. Normally the process of ISO 17025: 1) Scope, 2) Normative References, 3) Terms and Definitions, 4) Management Requirements and 5) Technical Requirements. In Scope, meet general requirements a laboratory has to meet to be considered competent. In Normative references, general terms and their definitions concerning standardization and other quality systems like installation, designing and development are done. Terms and Definitions are for the purpose of International standards such as shall, should, policy, procedure, documents, quality system and recording of the product is done in the process or not. Quality control data shall be analyzed where they are found to be outside pre-defined criteria, the planned action shall be taken to correct the problem and to prevent incorrect results from being reported. Under Management Requirements we ensure that the quality system, document control, review of requests, tenders, service to the client, purchasing services and suppliers, correction, prevention and management reviews are performed. Finally, under technical requirements, environmental conditions. Test methods, validations, sampling, traceability and reporting the results are completed. Therefore, the ISO 17025 pass level is 80%. The newer version of ISO/IEC 17025 calls out requirements for impartially stating that the laboratory management must commit to impartially and that the laboratory must ensure impartially in all its activities and not allow commercial, financial or other pressures to compromise impartially. Impartially is the principle that decisions are based on objective evidence obtained during the performance of the laboratory's activities, not on the basis of bias or prejudice caused by the influence of different interests of individuals or other involved parties.

EMC STANDARDS

Standards were created to provide a method of testing products so that different test facilities could compare test data. Without standards, each test lab or manufacturer was performing testing of products to their own methods and limits. The major worldwide standards for the EMC sector are IEC (International Electrotechnical Commission) standards and CISPR (Comité international spécial des perturbations radioélectriques) standards. IEC standard defines the input from the country organizations as they are trade consensus. CISPR addresses at 9 KHz and also 18-40GHz. CISPR is the standard that presents several test methods, with suggested limits, to evaluate the level of radiated emissions from a component designed for installation. CISPR is subdivided into three categories. They are 1) Basic standards 2) Generic standards 3) product standards. The basic standards tell us what actually the procedure is, but, it doesn't explain at which level the product should be tested. Generic standards are applied when the product doesn't have its specific standards but, explains how to perform the test. Product standards are the product group's i.e. medical, household equipment's and explains which test should be performed t what level on each equipment. CISPR 11 is widely used international standard for EMC within Europe for electromagnetic emissions or disturbances from Industrial, Scientific, and Medical, ISM, Equipment. CISPR 11 applies to a very wide variety of equipment including everything from Wi-Fi systems, and microwaves through to arc welders, all of which fall into the industrial, scientific and medical category that can use the ISM license-free bands like 2.4 GHz.

CISPR 16 is a series of fourteen publications specifying equipment and methods for measuring radio disturbances and immunity of voltages and currents in the frequency range 9 kHz to 1GHz. CISPR 16 is split into four distinct parts with an overall number of fourteen different elements i.e. CISPR 16-1, CISPR 16-2, CISPR 16-3 and CISPR 16-4. CISPR 16-1 consists of five parts which specify voltage, current, and field measuring apparatus. CISPR 16-2 specify the methods for measuring high-frequency EMC phenomena. It addresses both EMC disturbances and immunity. CISPR 16-3 is basically a technical report rather than a standard and it contains specific technical reports and information on the history of CISPR. CISPR 16-4 consists of five parts and contains information related to uncertainties, statistics and limit modeling. CISPR 22 is widely used standard for electromagnetic compatibility within Europe for Information Technology Equipment, ITE.

CISPR 22 differentiates between Class A and Class B equipment and it gives figures for conducted and radiated emissions for each class. CISPR 22 requires certification over the frequency range of 0.15 MHz to 30 MHz for conducted emissions. CISPR 22 has no specified limits for frequencies above 1.0 GHz, and CISPR limits are provided in dBμV, while the FCC limits are specified in μV. In terms of similarities, the conducted and radiated emission limits specified in CISPR 22 and FCC Part 15 are similar.

The tables below give a summary of the field strength limits for conducted and radiated emissions of CISPR 22 standard.

Table 1: CISPR 22 CLASS A Conducted EMI Limit:

The frequency of Emission (MHz)	Conducted limit (dBuV)	
	Quasi-peak	Average
0.15-0.50	79	66
0.50-30.0	73	60

Table 2: CISPR 22 CLASS B Conducted EMI Limit:

The frequency of Emission (MHz)	Conducted limit (dBuV)	
	Quasi-peak	Average
0.15-0.50	66 to 56	56 to 46
0.50-30.0	56	46
5.00-30.0	60	50

Table 3: CISPR 22 CLASS A 10-meter Radiated EMI Limit:

The frequency of Emission (MHz)	Field Strength Limit (dBuV/m)
30-88	39
88-216	43.5
216-960	46.5
above 960	49.5

Table 4: CISPR 22 CLASS B 3-metre Radiated EMI Limit:

The frequency of Emission (MHz)	Field Strength Limit (dBuV/m)
30-88	40
88-216	43.5
216-960	46
above 960	54

FCC Part 15 is a Code of Federal Regulations, Title 47, Part 15, 47 CFR 15. Title 47 regulates everything from spurious emissions to unlicensed low-power broadcasting in the USA. Part 15 of the FCC Title 47 is often just called FCC part 15 and it relates to EMC. The FCC Part 15 rules and regulations have been designed to align with the European CISPR regulations.

The scope of FCC Part 15 is split into three sections as follows:

- FCC Part 15A: This section sets out the regulations under which an intentional, unintentional, or incidental radiator may be operated without an individual license. It also contains the technical specifications as well as the administrative requirements and other conditions relating to the marketing of FCC Part 15 devices.

- FCC Part 15B: This covers the operation of an intentional or unintentional radiator that is not in accordance with the regulations in this part must be licensed according to the provisions of section 301 of the US Communications Act of 1934.

- FCC Part 15C: Unless specifically exempted, the operation or marketing of an intentional or unintentional radiator that is not in compliance with the administrative and technical provisions, including prior FCC authorization or verification, as appropriate, is prohibited under section 302 of the US Communications Act of 1934.

There are two classes of the device for FCC Part 15:

- Class A digital device: Within FCC Part 15, a Class "A" digital device is one that is used in a commercial, industrial or business environment.

- Class B digital device: Within FCC Part 15, a Class "B" digital device is used in a residential or domestic environment. Examples of devices in this category may be personal computers, calculators, and similar electronic devices that are marketed for use by the general public.

One of the major elements of this was the EMC Directive - 89/336/EC. EMC standard applied to all equipment that was placed on the market of users within the EC. The EMC Directive from the EC (European Commission) was ground-breaking in terms of EMC standards and legislation as it was the first time that limits had been placed on the immunity of the equipment to interference as well as its emissions. The EMC Directive has moved onwards and is now a well-established EMC standard.

EMC CHAMBERS

A Chamber is used for EMC and RF (Wireless) testing. The word ‘anechoic’ more or fewer means ‘without echo.’ An anechoic chamber is designed to absorb reflections of waves within the chamber rather than have them bounce off the walls which can cause echo. If these chambers are designed and assembled correctly, they can keep the waves entering from the chamber i.e. they provide shielding from outside interference. There are many types of anechoic chambers that are designed for different applications. Some of the most common uses and types are for things like audio recording, radiated emissions testing, radiated immunity testing, wireless transmitter (RF) testing, antenna testing and specific absorption rate (SAR) testing. Audio chambers are the odd man out here because they deal with absorption of sound waves rather than electromagnetic energy which is common to all the other types of chambers.

Semi-Anechoic Chamber: An anechoic chamber is an RF shielded room whose walls and ceiling have been covered with microwave absorbers and ferrites. Ferrites are used for low frequencies for continuous matching between the impedance of interior of the chamber and the impedance of the shielded walls. The most common type of EMC testing chamber by far is the semi-anechoic chamber. The word ‘semi’ indicates that it’s only partially able to absorb electromagnetic energy and one of the reasons for that is, the floor of the chamber is reflective rather than absorptive. The test distance for the semi-anechoic chamber is 3m, 5m, and 10m. A semi-anechoic chamber is a room where sound reflections only come from the floor because the walls and ceiling are absorbent. The solid floor makes this room much easier to work in than the anechoic chamber because equipment can be stood on the solid floor. We often put absorbent material on the floor to reduce floor reflections.

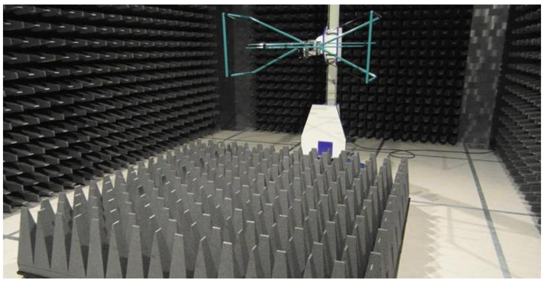

Figure 7: Semi-Anechoic Chamber

Full-Anechoic Chamber: The main purpose of a fully anechoic chamber is to perform full compliance measurements of radiated emission and immunity. The full anechoic chamber is a multi-functional EMC test facility for commercial and telecom testing. The combination of the pan-type 2mm galvanized panel system, parallel closing RF shielded doors and polystyrene hybrid absorbers on the walls, floor and ceiling create a high performance controlled electromagnetic environment that complies with international immunity and emission test standards. The FAR test volume is measured at three levels, bottom, middle and top, with a fixed position for the receive antenna. The two methods for FAR validation are the reference site method (RSM) for path lengths of 3 and 5 meters and traditional NSA for 5 and 10-meter distances. The RSM is required in the shorter paths in order to reduce coupling or near-field effects related to biconical receive antennas.

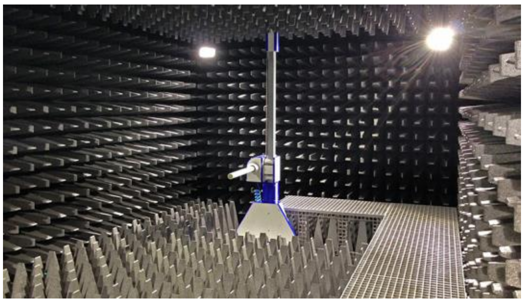

Figure 8: Full-Anechoic Chamber

OATS (Open Area Test Site): In OATS is preferable to the SAC because there are no walls in the vicinity of the measurement area. Even with plenty of absorbing material on the walls of a SAC, there will still be a portion of the wave energy that gets through the absorber and reflects back off the metallic surface of the chamber wall. An Open Test Area Site is a 3m and 10m emissions test range. The receiving measurement antenna, in that case, picks up the wave coming from the equipment under test (EUT), the reflection off the floor and the partial reflection off one or more walls.

Figure 9: OATS (Open Area Test Site)

GTEM (Gigahertz Transmissive Electromagnetic cell): GTEMs are used to measure radiated emissions for FCC part 15B and 18 devices (with some caveats) and perform radiated immunity testing according to IEC61000-4-3. The two main downsides of a GTEM are the limited EUT size and the measurement error at lower frequency ranges (approximately under 200 MHz). The GTEM cell is a frequency extended variant of the traditional TEM (Transverse Electro-Magnetic) cell. It is designed for EMC applications, calibration of antennas/field probes, test and measuring of mobile phones and screening measuring of material.

Figure 10: GTEM cell

Reverberation Chamber: An electromagnetic reverberation chamber (RVC) is a chamber which is made to resonate. They are predominantly used as a cavity resonator to perform radiated immunity testing. Due to the high Q-factor of the chamber and the almost complete reflectivity of the walls and floor, an electromagnetic field of a given strength can be created using a much smaller power amplifier compared to that needed in a SAC.

Figure 11: Reverberation Chamber

RF Shielded Room: An RF shielded room forms the basis for a semi-anechoic chamber. It is a well-sealed metal box which offers electric and magnetic field shielding effectiveness over a given range of frequencies. RF Shielded rooms provide RF quiet environment in which to conduct different application tests such as EMC, wireless technology on automotive or military vehicles, MRI scans, etc. These rooms are built with Smart shield TM modular RF shielding, electromagnetic pulse protection EMPP shielding, TEMPEST (secure communications) shielding and architectural shielding full systems.

Figure 12: RF Shielded Room

LEGAL EMC ISSUES

Traditionally, EMC and EMI issues are solved in the EMC lab, often without getting a full understanding of the underlying effects. The root causes of electromagnetic resonance, effects the product, enabling fast design cycles and high product quality. To reduce the EMC issues, power chokers are used with inverters. In general, one choke is used for each phase of an inverter. Currents flowing through these chokes are in the range of a few amps. Electric and magnetic losses lead to heat generation, and this heat can affect the performance and reliability of inverters. The denser the individual components of an inverter are packed together, the more critical heat management is. AC Inverters use a fast switching PWM (Pulse Width Modulation) technique to create a variable frequency AC Output to the connected motor. The fast switching of the output of the drive when connected with long motor cables results in a reflected voltage at the motor which can be up to three times the AC supply voltage. Output chokes help to reduce this peak voltage, and increase the rise time, to reduce the stress applied to the motor insulation and prevent damage. Currents flowing through these chokes are in the range of a few amps.

Electric and magnetic losses lead to heat generation, and this heat can affect the performance and reliability of inverters. The denser the individual components of an inverter are packed together, the more critical heat management is. Some EMC issues are caused by poor grounding and shielding i.e. quieting the sources of interference, inhibiting coupling paths and hardening the potential victims. The issues with shielded enclosures are when the longest dimension approaches half wavelength. There are three main issues of concern for wound (inductive) components which control stray magnetic fields, the variability of their parameters with current and temperature, and their resistivity. While performing EMC tests, the test setup, including the layout of the equipment, the cable used, cable length, supporting equipment, etc. shall follow the relevant EMC standards. Sometimes, we need to maintain the exact length of the cables that are connected to the system to simulate the actual operating conditions of the equipment in its applications.

FUTURE EMC

Today, the trends of the past 20 years are continuing. Computing devices are getting denser, faster, more complex and more pervasive, creating new challenges for the EMC engineer. At the same time, advances in electromagnetic analysis and available design possibilities are revolutionizing the methods used to ensure compliance with EMC requirements. Newer technologies are more likely to cause an EMI disruption that could cause functional degradation to another system with low levels of immunity protection. Mixed-signal components (digital and analog) are both used on printed circuit boards, yet during the design process hardware engineers are concerned with functionality as per market specifications. Digital devices may emit EMI that could interfere with the operation of other electrical devices and systems. Newer technologies are in general more likely to cause an EMI disruption or induce an event that could cause functional degradation to another system with low levels of immunity protection.

Government and industry conventions, the test procedures related to electromagnetic compatibility continue to be introduced and updated on a regular basis. Nevertheless, the rapid pace of technical innovation basically ensures that regulations alone will never be sufficient to guarantee the safety and compatibility of electronic systems. This makes it more important than ever to address electromagnetic compatibility issues early in the design, rather than “fixing” a product after it fails to meet a given requirement. Understanding the nature of EMI in a real-life environment and how to deal with it can help users to make their processes and equipment much more effective and error-free, and their sensitive devices better protected from EMI-caused electrical overstress. EMC engineers should be educated in Hazard Based Safety Engineering (HBSE) which addresses functional safety along with hazard and risk assessments. As of today, only a few engineers are aware of a new HSBE standard (IEC 62368-1) that may eventually replace certain UL, CSA, IEC and EN product safety standards.

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