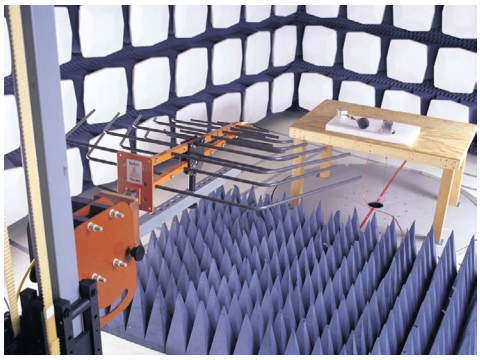
EMC Standards Overview



Electromagnetic Compatibility (EMC) can be defined as the ability of systems, equipment, and devices that utilize the electromagnetic spectrum to operate in their intended operational environments without suffering unacceptable degradation or causing unintentional degradation. Threats to a system can be both naturally-occurring and man-made and can be categorized into 4 types of tests: Radiated Immunity, Radiated Emissions, Conducted Immunity and Conducted Emissions. The limits and levels used for these tests are defined in various standards and adopted by various organizations. It is imperative that products meet the requirements set forth in these standards because public safety, among other things, relies on the products to perform as intended.

With so many different categories of components and systems with their own specific needs in terms of EMC, it is no surprise that there are a significant number of EMC test standards. Unfortunately, keeping track of and knowing which standard to use can be a difficult task. This document serves as a guide to familiarizing yourself with some of the more common standards used across the industry.

1.0 Major International Standards Organizations

To maintain the many standards relating to EMC testing, a number of organizations, both domestic and foreign, serve as the governing body for different categories of standards.

2.0 International Electrotechnical Commission (IEC)

The IEC is an international organization which prepares and publishes International Standards for all electrical, electronic and related technologies (1). Included in this broad description are standards specific to EMC. They are broken into three categories:

- Basic Standards
  - Basic EMC Standards give general rules achieving EMC. These standards serve as reference, including descriptions of the electromagnetic disturbance under question as well as suggested limits that must be adhered to. Therefore, they cannot be applied to a specific product or system.
- Generic Standards
  - These standards pertain to a specific environment. They include EMC requirements and test procedures and are applicable to any and all products that would need to operate in the described environment.
- Product Standards
  - Product Standards apply to specific products or product families and define test procedures and EMC limits relating to these products.

The IEC has formed and oversees a number of committees which are responsible for defining EMC standards. These standards are either adopted in whole or harmonized with national standards by various governing bodies throughout the world. The two major committees are the International Special Committee on Radio Interference (French title acronym is CISPR) and Technical Committee 77 (TC 77).

CISPR's principal task is at the higher end of the frequency range, from 9 kHz upwards, preparing standards that offer protection of radio reception from interference sources such as electrical appliances of all types, the electricity supply system, industrial, scientific and medical (ISM) RF, broadcasting receivers (sound and TV) and, increasingly, IT equipment (ITE) (2). CISPR typically develops Product Standards for both immunity and emissions.

The other major committee, TC 77, primarily develops Basic and Generic EMC publications with a focus on immunity EMC requirements and environments, though TC 77 does also produce product-family standards covering low-frequency emissions and product immunity standards. TC 77 is broken into three subcommittees:

- SC 77A focuses on low-frequency (up to and including 9 kHz) phenomena
- SC 77B focuses on high-frequency continuous and transient phenomena, including electrostatic discharge (ESD)
- SC 77C focuses on high-power transients such as those resulting from high-altitude electromagnetic pulses (HEMP)

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Examples of common IEC and CISPR standards are given in Tables 1 and 2, respectively.

Table 1: Common IEC Standards

Document Number	Subject
IEC 61000-1-X	General Requirements
IEC 61000-2-X	Environments (Description, Classification and Compatibility Levels)
IEC 61000-3-X	Limits (Emissions and Immunity)
IEC 61000-4-X	Testing and Measurement Techniques
IEC 61000-5-X	Installation and Mitigation Guidelines
IEC 61000-6-X	Generic Standards
IEC 60601-X-X	Medical Electrical Equipment
IEC 61326-X-X	Electrical Equipment for Measurement, Control and Laboratory Use

Table 2: Common CISPR Standards

Document Number	Subject
CISPR 11	General Requirements
CISPR 12	Environments (Description, Classification and Compatibility Levels)
CISPR 13	Limits (Emissions and Immunity)
CISPR 14-1	Testing and Measurement Techniques
CISPR 14-2	Installation and Mitigation Guidelines
CISPR 20	Generic Standards
CISPR 22	Medical Electrical Equipment
CISPR 24	Electrical Equipment for Measurement, Control and Laboratory Use
CISPR 321[1]	Electromagnetic compatibility of multimedia equipment - Emission requirements
CISPR 352[2]	Electromagnetic compatibility of multimedia equipment - Immunity requirements

[1]At the time of release of this app note, CISPR 32 replacing CISPR 13 and CISPR 22

[2]At the time of release of this app note, CISPR 35 replacing CISPR 20 and CISPR 24

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3.0 International Organization for Standardization (ISO)

A sister organization to the IEC, ISO also is an international organization which develops and publishes international standards. Like IEC, ISO develops standards for a multitude of applications, which include EMC. Where the IEC focuses solely on electrotechnical standardization, ISO goes further by not limiting themselves to one field. ISO standards can be found in nearly any discipline throughout the world, including (but not limited to) sustainable development, food, water, cars, climate change, etc.

Though EMC is only a small part of ISO's reach, they still interact closely with the IEC in terms of EMC and are still recognized as an industry leader in EMC standards development. For example, ISO 11451-X and ISO 11452-X are widely used and relied-upon in the international automotive industry.

4.0 International Telecommunication Union (ITU)

Another sister organization to the IEC (as well as ISO), ITU develops technical standards which focus on telecommunication networks and technology, thus allowing these products to interact without interfering with each other. This effort goes hand-in-hand with EMC as limiting emissions from electronic products will prevent interference of the aforementioned networks and technology. Again, the ITU maintains close connection with IEC and ISO to ensure commonality.

5.0 Major European Standards Organizations

European Committee for Electrotechnical Standardization (CENELEC)

Within the European Union, CENELEC is responsible for electrotechnical standardization. CENELEC develops voluntary standards, but primarily adopts (in part or entirely) international standards, often times IEC and CISPR standards, as European norm (EN). This is done by publishing the standard in the Official Journal of the European Union and Directive 2004/108/EC. The main objective of Directive 2004/108/EC is to regulate the compatibility of equipment regarding EMC (4). Once these standards are published, applicable products are required, by law, to comply. The standards are also given an 'EN' number once published. For example, many of the published CISPR documents are renamed 'EN 550XX' where 'XX' is the CISPR document number (CISPR 11 becomes EN 55011, CISPR 12 becomes EN 55012, etc.). Finally, by showing compliance to all of the applicable standards per Directive 2004/108/EC, a product can apply for and receive a CE mark, thus allowing its sale in European countries.

It should be noted that, although Directive 2004/108/EC is effective as of the release date of this Application Note, Directive 2014/30/EU was published on April 18th 2014 and will go into force on April 20th 2016, thus repealing Directive 2004/108/EC.

European Telecommunications Standards Institute (ETSI)

As its name implies, ETSI produces globally-applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, broadcast and internet technologies (5). As with the ITU, ETSI's goal is to allow the interaction of ICT equipment without any unwanted interference. Typically, ETSI EMC standards can be recognized by having a document number with this format: EN 300 XXX.

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6.0 Major North American Standards Organizations

United States of America Department of Defense (DoD)

Within the DoD lies the Defense Standardization Program (DSP). The DSP is responsible for developing a large variety of standards, specifications, handbooks and other documents for a wide range of applications. In terms of EMC, the two most common military standards are MIL-STD-461 and MIL-STD-464. Both documents describe a comprehensive array of immunity and emissions test methods and requirements (see Table 3 for the current list of MIL-STD-461 tests). The main difference between the two is that MIL-STD-461 is intended for controlling and demonstrating EMC on assemblies and subsystems and MIL-STD-464 focuses on total systems.

Despite the intended application being for military use, both of these documents are free and available to the public. In fact, many countries around the world have adopted MIL-STD-461 and MIL-STD-464 for use in testing their military products for EMC.

Table 3: Required MIL-STD-461 Tests

Requirement	Description
CE101	Conducted Emissions, Power Leads. 30 Hz to 10 kHk
CE102	Conducted Emissions, Power Leads. 10 kHk to 10 MHz
CE106	Conducted Emissions, Antenna Terminal, 10 kHk to 40 GHz
CS101	Conducted Susceptibility, Power Leads, 30 Hz to 150 kHz
CS103	Conducted Susceptibility, Antenna Port, Intermodulation, 15 kHz to 10 GHz
CS104	Conducted Susceptibility, Antenna Port, Rejection or Undesired Signals, 30 Hz to 20 GHz
CS105	Conducted Susceptibility, Antenna Port, Cross-Modulation, 30 Hz to 20 GHz
CS109	Conducted Susceptibility, Structure Current, 60 Hz to 100 kHz
CS114	Conducted Susceptibility, Bulk Cable Injection, 10 kHz to 200 MHz
CS115	Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation
CS116	Conducted Susceptibility, Damped Sinusoidal Transients, Cable and Power Leads, 10 kHz to 100 MHz
RE101	Radiated Emissions, Magnetic Field, 30 Hz to 100 kHz
RE102	Radiated Emissions, Electric Field, 10 kHz to 18 GHz
RE103	Radiated Emissions, Antenna Spurious and Harmonic Outputs, 10 kHz to 40 GHz
RS101	Radiated Susceptibility, Magnetic Field, 30 Hz to 100 kHz
RS103	Radiated Susceptibility, Electric Field, 2 MHz to 40 GHz
RS105	Radiated Susceptibility, Transient Electromagnetic Field

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7.0 Federal Communications Commission (FCC)

The FCC regulates interstate and international communications by radio, television, wire, satellite and cable in all 50 states, the District of Columbia and U.S. territories. An independent U.S. government agency overseen by Congress, the commission is the United States' primary authority for communications law, regulation and technological innovation (6). For purposes of EMC, the FCC can be considered analogous to the ITU and ETSI in that these organizations (FCC included) concern themselves with communication interference from ICT products and thus require these products to undergo emissions testing.

The methods and limits of this testing are given in Code of Federal Regulations (CFR) Title 47 Part 15 which is free and available to the public. Depending on the type of device being tested, there are four methods of equipment authorization. These include:

- Verification
- Declaration of Conformity (DoC)
- Certification through the FCC
- Certification through Telecommunications Certification Body (TCB)

Details on what type of authorization is required for a certain device type and the necessary steps to achieve authorization can be found online through the Office of Engineering and Technology (OET).

8.0 American National Standards Institute (ANSI)

ANSI is an American organization that publishes standards for a wide range of applications over a wide range of product types. For EMC, ANSI has developed its own independent standards, as well as adopted international standards for recognition in the United States. ANSI is also deeply involved in accrediting programs that assess conformance to standards, including various ISO systems. ANSI is the US input to IEC and oversees the US National Committee and Technical Advisory Groups. An example of the breadth of ANSI's involvement in accreditation is in Normalized Site Attenuation (NSA), found in ANSI C63.4. T his is a measure of the attenuation of signals propagated over a site and compared with the theoretical attenuation of these signals over an ideal site. Many of the world's EMC standards reference ANSI's NSA method for determining the quality of the chamber intended to be used for EMC testing.

9.0 Lifecycle of EMC Standards

Technology, products, test methods and requirements are constantly evolving, so to keep up, EMC standards must adapt and adhere to these changes. As can be expected, with so many different standards and standards organizations in the world, there are varying lifecycle procedures and durations associated with these different standards. However, most follow the same general process. For the sake of brevity, we will provide an overview of the lifecycle of an IEC publication (7).

- The first stage in developing a new IEC publication is known as the Preliminary Stage. This stage is used when all of the details needed to fully realize a new publication have not yet been collected. This stage also applies to work items that have no target date. Depending on the subject of the work item, this stage can have a long duration.
- Once all of the preliminary development for a standard is complete, the next step in producing a new IEC publication is to create a New Work Item Proposal (NP). This is known as the Proposal Stage. By submitting an NP to the IEC, the requestor is alerting the IEC that there is a need for a new standard, an update to an existing standard or a technical specification. If the NP is approved, the document moves to the Preparatory Stage.
- In the Preparatory Stage, a Working Draft (WD) of the new or updated publication is prepared. Once the WD is complete, it moves to the Committee Stage.
- In the Committee Stage, the document is submitted as a Committee Draft (CD) to the National Committees for comment and will be available for 12 months. Here, comments from the various committees are returned to the document originator and compiled.
- Next, the document moves to the Enquiry Stage where a Committee Draft for Vote (CDV) is submitted to the National Committees. This is the final opportunity for technical comment. If the document receives a majority vote, a revised version of the document, with incorporated comments, will be submitted for Final Draft International Standard (FDIS) processing. Note that if a CDV is approved unanimously, the document moves straight to publication.
- In the Approval stage, the FDIS (with incorporated comments) is circulated for vote. If it receives a majority positive vote, the FDIS is published.

While there is not necessarily a defined lifecycle duration from standard to standard, once a standard is approved, a stability date is assigned. Typically, this stability date is at least 5 years.

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10. What Version of the Standard Should I Use?

With so many standards constantly evolving and changing, it is imperative to know which version of the required standards you should be testing to. Two general rules of thumb can be stated. If military testing is required, ensure that you test to the exact revision stated in the contract. Often times, military contracts will require products to be tested to outdated versions of military standards, so, unless there is a clause within the contract or there is customer permission in place to test to a standard other than what is listed in the contract, test to exactly what the contract dictates.

On the other hand, if a product is required to be tested to commercial standards (IEC, EN, FCC, etc.), two things need to be taken into account. If the product is being tested to a product family standard, then the product must be tested to the individual test standard versions listed in the product family standard. Otherwise, always test to the latest version of the standard(s) in question. This is required by Directive 2004/108/EC, as well as other organizations such as the FCC. Because of this, it is important to be cognizant of the latest standards immediately prior to any test that is to be performed. Additionally, when new versions of standards are released, an evaluation must be done to determine whether a product tested to the previous standards meets the updated requirements. If the product does not meet the new requirements, a redesign is required, and then a retest will need to be performed in a timely fashion to show compliance of the new design. Some organizations, such as the FCC, will sanction fines for products that are non-compliant to the current standard.

11. Major Product Segments and Their Standards

- Automotive
  - ISO, Soceity of Automotive Engineers (SAE) and CISPR
  - Many auto manufacturers have developed their own standards
- Aviation
  - RTCS DO-160, EUROCAE/ED-14G
- Military
  - MIL-STD-461, MIL-STD-464, DEF STAN
- Medical
  - IEC 60601
  - US FDA and EU Directive
- Instrumentation, Scientific, Medical (ISM)
  - IEC, CISPR and FCC Standards
- Multimedia
  - Information Technology - FCC, CISP 22 (emissions) & 24 (immunity)
  - Audio Video - FCC, CISPR 13 (emissions) & 20 (immunity)
  - Combined - FCC, CISPR 32 (emissions) & 35 (immunity

Conclusion

For over 40 years, AR RF/Microwave Instrumentation has been providing numerous RF amplifiers, antennas, systems, and other equipment for use in testing a myriad of components and systems for EMC. As such, AR has vast experience in designing test solutions for many of the standards governing EMC compliance. Furthermore, AR is at the forefront of standards development as it has representatives on several national and international standards committees. While this application note has provided a cursory glance at the breadth of EMC standards in today's industry, there are many details that have been left untouched. If you would like to learn more, feel free to contact one of our applications engineers at 800-933-8181.

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