EMC In Action

Managing Electromagnetic Interference For Safer, More Successful Products

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Contents

Executive Summary

If you think electromagnetic compatibility (EMC) testing sounds mundane, think again. Under certain circumstances, it can be a matter of life-and-death. In fact, the world's deadliest aviation accident in history[1] was caused by electromagnetic interference (EMI) that could have been avoided.

On a foggy day in 1977, overlapping radio signals blocked communications between two jumbo jets and the control tower at Tenerife airport. By the time the pilots realized the danger, it was too late. The two aircrafts collided on the runway and 583 people died.

Fast forward 40 years, and the potential for EMI to tragically disrupt technology has never been higher. For example, imagine a poorly shielded computer CPU emitting radiations interfering with the communication signals of a mobile phone. Annoying if you are chatting with a friend, but a critical concern when calling an ambulance for a heart attack victim.

Fortunately, there are many ways that manufacturers can protect radio receivers and other devices from interference and mitigate EMI phenomena. The key to achieving this is called Electromagnetic Compatibility (EMC). Which simply means ensuring that equipment functions to standards set out by regulatory authorities, without introducing intolerable electromagnetic emissions to disturb anything else in that environment.

This whitepaper is designed to explore the market requirements and technical issues involved in EMC testing. It will help you confirm that your products are in compliance with the legal requirements in the markets in which you currently operate or may be planning to enter. And it will also outline how to gain increased security in terms of product liability and improve your market position with tested products.

1 - https://en.wikipedia.org/wiki/Tenerife_airport_disaster

Introduction to EMC Testing

All electric and electronic devices emit and receive electromagnetic waves, which can interfere with other electrical or electronic equipment. To prevent harmful interferences, electric devices have to adhere to EMC guidelines.

Most countries have regulations to ensure that electrical products available in their markets are built to deliver suitable EMC performance. That means not creating interference that can affect other equipment, as well as providing some level of immunity to external disturbances. And it is up to manufacturers of electrical equipment to adhere to these regulations and make sure that their products are EMC compliant.

Example of EMC regulations:

COUNTRY	EMC REGULATION
European Union	EMC Directive 2014/30/EU
United States	FCC Part 15 Subpart B
Australia	Radio communications (Electromagnetic Compatibility) Standard 2008
Japan	Den-An Law, VCCI Rules
Vietnam	Circular No. 11/2012/TT-BKHCN, Circular No. 05/2014/TT-BTTTT

Note: Depending on the type of equipment, other regulations may be applicable in addition to (or instead of) the ones mentioned here.

SECURING EMC SUCCESS

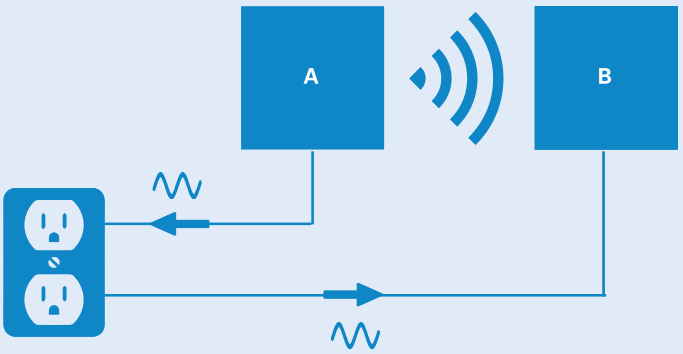
The best way to produce EMC compliant equipment is to start early, and follow EMC best practices during the design process. However, manufacturers also need to verify the effectiveness of their designs by testing prototypes for EMC.

The testing is done in an EMC laboratory. Two types of phenomena are considered: electromagnetic interference (EMI) and electromagnetic susceptibility (EMS). EMI is related to the electromagnetic radiation emitted by a product, whereas EMS describes the behavior of a product when subjected to electromagnetic disturbances coming from the environment.

Both factors are important. Together, they can mean the difference between a potentially dangerous device that cannot find a market, or a successful, highly-profitable product that takes the world by storm.

Understanding Electromagnetic Interference (EMI)

The electromagnetic emissions produced by electrical devices are propagated in two ways – radiated through the air or conducted along power lines or signal cables. While both can cause disturbances to the environment, they are normally assessed separately.



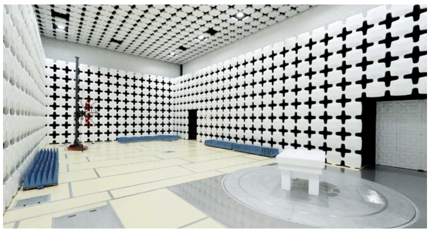
This picture shows how apparatus A may affect apparatus B via radiated or conducted electromganetic disturbances.

RADIATED EMISSIONS

Electromagnetic emissions radiated through the air are usually measured by an antenna located between three and ten meters from the device, which is referred to as the equipment under test (EUT). During testing, the EUT is rotated through 360 degrees while instruments record the emission levels at different turntable angles and antenna heights. The measurements can be performed in different kinds of test sites, even outdoors. But, the most accurate results are usually obtained when testing is done in a semi-anechoic chamber.

A semi-anechoic chamber is a large, specially shielded room, where the walls and ceiling are covered by materials that absorb electromagnetic radiation. The combination of shielding and absorbers reduce the level of environmental EM noise and prevent unwanted reflections from EM waves on the walls and ceiling. This means that the test only records relevant radiated signals produced by the EUT, enabling a precise evaluation.

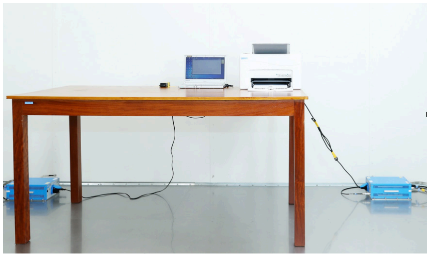
Radiated emission tests usually measure frequencies from 30 MHz to 1 GHz, and sometimes even higher. The results are compared to the limits listed in the relevant regulation in order to verify the compliance of the product.



CONDUCTED EMISSIONS

While radiated emissions are all around, conducted emissions are different. They travel across whatever a device is connected, which means they can potentially affect any other device plugged into the same infrastructure. Conducted emissions testing measures the level of electromagnetic noise that the EUT propagates across connected equipment, including mains electricity wiring, telephone networks or LANs.

During a test, the power and telecommunication cables of the EUT are connected to an instrument that measures the level of electromagnetic noise – typically between 150 kHz and 30 MHz – which the EUT generates. The results are compared with the specifications set out in the applicable regulation to determine the compliance of the product.



Getting to Grips with Electromagnetic Susceptibility (EMS)

Technology is everywhere. But some devices can be more sensitive to electromagnetic effects than others. That's where electromagnetic susceptibility testing comes in. It assures market regulators and end users alike that a product can withstand a certain amount of electromagnetic disturbance without suffering unwanted consequences.

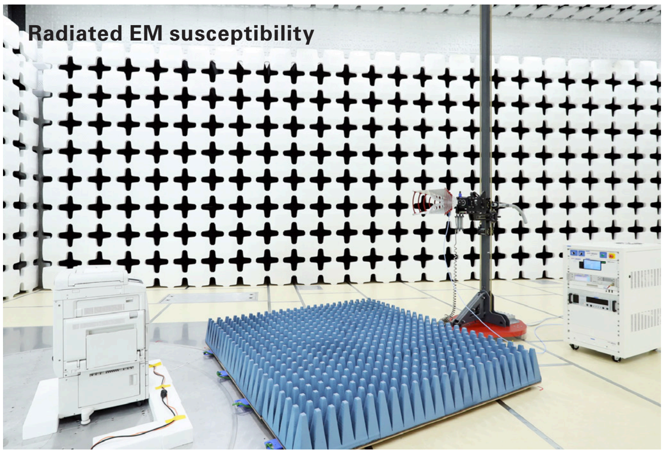
EMS testing takes a variety of forms that reflect the different types of electromagnetic disturbances. The most common EMS tests are:

ELECTROSTATIC DISCHARGES (ESD)

Have you ever felt an electric shock when touching a car door? That's an electrostatic discharge, or ESD. And, while it is relatively harmless to human beings, the high voltages involved – sometimes up to several kilovolts – can damage sensitive electronic equipment.

The immunity of electrical equipment to ESD is verified with an ESD simulator. The operator applies ESD pulses to all parts of a product that could be touched by a user. This checks whether such discharges will affect the proper operation of the device.


Electrostatic discharges


Radiated EM susceptibility

RADIATED EM SUSCEPTIBILITY

The world is filling up with equipment emitting intentionally wireless signals. From TV and radio stations to cell phones, walkie-talkies, traffic radar, RFID readers and, of course, Wi-Fi and Bluetooth transmitters. Unfortunately, the radio waves from these devices can produce interference and cause electrical and electronic devices to malfunction.

It is important to verify that equipment can withstand EM radiation before it goes on the market. This is done by exposing the product to electromagnetic signals of various frequencies – usually ranging from 80 MHz to 2.7 GHz – using an antenna connected to a signal generator.

ELECTRICAL FAST TRANSIENT BURSTS

Electrical fast transient bursts (EFT/B) are a series of fast repeat pulses that may be generated when a device switches inductive loads in the electric network. For example, when an electric motor is turned on or off, sparking will briefly occur inside the electrical switch. These sparks will cause transient disturbances to propagate through power or signal cables. While these pulses are very short, they can have an amplitude of several kilovolts in most severe cases.

The vulnerability of electrical equipment to EFT/B is verified by connecting its power and signal cables to a pulse generator via a coupling network or a capacitive coupling clamp, and by injecting a series of test disturbances.

SURGES

Surges are unpredictable. They are often caused by lightning strikes or accidental overvoltages during switching events in the power distribution system. And they propagate through power cables that are connected to buildings – from homes and offices to schools and hospitals.

Because surge pulses can have an amplitude of several kilovolts with high energy, they can damage or destroy electrical equipment not fitted with surge protection components.

Surge resilience testing is done by connecting the equipment to a surge generator. Test pulses are usually injected to the power ports and also to telecommunication ports that may connect to outdoor cables.

CONDUCTED LOW FREQUENCY EM SUSCEPTIBILITY

On their own, low frequency electromagnetic waves have little impact on smaller devices. But, they can be captured by long cables, which enables them to affect electrical devices through any wiring they may be attached to.

A conducted low frequency EM susceptibility test is an extension of the radiated EM susceptibility test, but it focuses on frequencies lower than 80 MHz. Because generating radiated signals with long wavelength would require big antennas, it is easier to simulate the effects of such signals in a conducted manner. This is done by injecting EM noise – from 150 kHz to 80 MHz – directly into the cables of the EUT with a signal generator and a coupling device.

POWER FREQUENCY MAGNETIC FIELDS

Every electrical device connected to the AC mains network operates at a specific power frequency – either 50 Hz or 60 Hz, depending on the country. At such frequencies, the electric current inside power cables generates magnetic fields that can affect sensitive equipment.

To find out whether a product performs well under such conditions, it is tested by being placed in the middle of a large inductive coil – typically 1 x 1 m or 2 x 2 m – generating a magnetic field of 50 Hz or 60 Hz.

VOLTAGE DIPS AND INTERRUPTIONS

Voltage dips and interruptions are caused by faults in the electric network. They can range from a few percent up to 100%, and last a few milliseconds or a few seconds.

The ability of electrical equipment to withstand such unpredictable events can be verified by connecting the power cable of the EUT to a generator that produces the required voltage variations.

EFT/B, surges, and voltage dips and interruptions

Information Technology Equipment

Information Technology Equipment (ITE) is a special category of electrical products from the EMC point of view, as it is more likely than many other device categories to be affected by, or to cause, electromagnetic interference.

Due to its complex construction and to the interdependencies of components, an EMC failure at any level of an ITE product could generate serious performance degradations, such as:

- Corruption or loss of stored data
- Incorrect input/output signals
- Flickering, blurred, or distorted images on display
- Error message, misbehaving or freezing software
- Permanent damage (especially in case of ESD or surge)

An increasing number of ITE relies furthermore on wireless connectivity for its operation, making it more vulnerable to electromagnetic disturbances. Miniaturisation of ITE is an additional EMC challenge, as small ITE devices like smartphones can be easily carried around. They are therefore more likely to be located time to time close to other apparatus which may cause, or suffer from, electromagnetic interference.

An example of EM interference phenomenon that many people may observe at home is the fact that Wi-Fi devices operating at 2.4 GHz may experience degradations of their wireless performance in the vicinity of a microwave oven. Microwave ovens operate indeed at 2.4 GHz, too, with high power, which makes them likely to cause disturbances to nearby Wi-Fi equipment.

In order to be able to operate adequately in various kinds of electrognetic environments – and to comply with EMC regulations – ITE products require a great care in their conception. They are thus a good illustration of why EMC is nowadays more relevant than ever.

The Best Time to Test

Manufacturers should consider testing electrical products for EMC at three different stages: during development, at final prototyping and during mass production.

Testing a product from time to time during development helps to identify potential EMC problems at an early stage. This allows for better control of the development schedule (and cost) of new products.

Testing a product at the final prototype stage demonstrates that it is fully compliant with relevant EMC regulations before starting mass production. The test site will issue a test report, which can be used to prove the compliance of the product to the market regulator or to the manufacturer's business partners.

Finally, the testing of a random selection of samples from the mass production line is part of a manufacturers' quality control procedure. It is used to verify that small variations that may occur during manufacturing process have not adversely affected the EMC performance of the products.

KEEPING CONTROL

Putting non-compliant products on the market is a risky business. The impact of electromagnetic disturbances can range from a minor inconvenience to a major safety hazard. Non-compliance can also lead to penalties or sales restrictions imposed by the market regulator, depending on the problem severity.

Taking corrective actions after a product has been launched on the market is complicated and can be costly for the manufacturer. So it makes sound commercial sense to put efficient procedures in place so that the EMC performance of products is always under control.

EXAMPLES OF GLOBAL EMC STANDARDS

EMC regulations vary from country to country. The table here below gives an overview of some common EMC standards.

PRODUCT CATEGORY	INTERNATIONAL STANDARDS	EUROPEAN STANDARDS	US STANDARDS
Household appliances	CISPR 14-1 CISPR 14-2	EN 55014-1 EN 55014-2	
Information technology equipment	CISPR 24 CISPR 32	EN 55024 EN 55032	
Residential equipment	IEC 61000-6-1 IEC 61000-6-3	EN 61000-6-1 EN 61000-6-3	FCC Part 15B ANSI C63.4
Industrial equipment	IEC 61000-6-2 IEC 61000-6-4	EN 61000-6-2 EN 61000-6-4	
Laboratory equipment	CISPR 11 IEC 61326-1	EN 55011 EN 61326-1	
Medical equipment	CISPR 11 IEC 60601-1-2	EN 55011 EN 60601-1-2	CISPR 11 IEC 60601-1-2
Equipment connected to public low-voltage distribution system	IEC 61000-3-2 IEC 61000-3-3	EN 61000-3-2 EN 61000-3-3	
Radio equipment operating in 2.4 GHz and 5 GHz bands		EN 300 328 EN 301 489-1 EN 301 489-17 EN 301 893	FCC Part 15C FCC Part 15E ANSI C63.10

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Expert Profile

THIMO SAUTER
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TÜV RHEINLAND VIETNAM

Thimo Sauter began his career in 2007 as a Project Engineer at TÜV Rheinland Japan. He contributed to the development of EMC and radio testing services at the Global Technology Assessment Center in Yokohama. In 2011 he qualified as TCB/FCB for the certification of wireless products according to FCC rules (USA) and ISED regulations (Canada).
In 2015, he moved to Vietnam to establish TÜV Rheinland's new EMC laboratory in Hung Yen Province.
He has held the position of EMC Laboratory Manager since 2016.
He holds a Master's degree in Physics from the Swiss Federal Institute of Technology in Lausanne (EPFL).

Getting EMC Precisely Right with TÜV Rheinland's Testing, Certification and Market Access Services

As an authorized testing and certification body and international service provider, TÜV Rheinland offers a flexible range of EMC services to support companies meet all of the applicable legal requirements.

TÜV Rheinland can help manufacturers to get their EMC "Precisely Right" by:

- Enabling compliance with legal requirements in various countries
- Receiving conformity evaluations from an independent third party
- Benefitting from short test times and extensive experience
- Gaining increased security in terms of product liability
- Improving market position with tested products

TÜV Rheinland's state-of-the-art EMC test facilities include specialized infrastructure, such as large-scale anechoic chambers that create an ideal testing environment. This enables the laboratories to precisely evaluate the EMC performance of a wide range of products, from information technology equipment (ITE) to industrial, scientific and medical equipment. Additionally, they offer testing services for radio apparatus, such as Wi-Fi and Bluetooth devices.

TÜV Rheinland also provides valuable market access services to support manufacturers and importers/exporters of electrical equipment with EMC certification for various markets all over the world – such as Notified Body certification for the European Union or CR Mark certification for the Vietnamese market, and more.

Furthermore, TÜV Rheinland's Certipedia certificate database and its internationally recognized EMC test mark enable manufacturers to quickly and easily prove to clients, end-user customers, or any other interested parties, that their products are EMC compliant. At any time with just one smartphone scan, they can access essential certification program characteristics via a customized QR code.

To find out more about EMC testing and prove that your products are fully compliant, contact TÜV Rheinland.

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