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Electronic devices, ranging from navigation to braking and lane assistance. EMC ensures that these systems function seamlessly and do not interfere with one another or other nearby devices, contributing to safer and more reliable transportation for drivers and passengers.
Electromagnetic Compatibility (EMC)?
Electromagnetic Compatibility (EMC) is the ability of electrical and electronic systems or devices to operate without causing interference to other systems or protection from external interference. Why is Electromagnetic Compatibility important? EMC is important as it ensures the reliable operation of electronic devices. It ensures that electronic systems can operate in their intended environment without causing distortions or disruptions to other nearby devices, and also provides protection from external electromagnetic interference that might affect their performance. What are the types of Electromagnetic Interference (EMI)? Types of EMI include conducted interference, radiated interference, continuous EMI, and intermittent EMI. Conducted EMI occurs through electrical conductors, while radiated EMI is transmitted through the air. Continuous EMI is a constant source of disturbance, while intermittent EMI occurs in irregular intervals or bursts. What are the key components of EMC testing? Key components include Emissions testing and Immunity testing. Emissions testing measures the amount of electromagnetic energy radiated or conducted by a device, ensuring it does not exceed the defined limits. Immunity testing ensures a device can function properly in the presence of EMI, by verifying its resistance to external disturbances like electromagnetic fields and voltage surges. How can I ensure my electronic device meets EMC requirements? Ensuring EMC compliance involves several steps like: understanding the relevant standards, designing the device with EMC principles in mind, testing during the development stages, and using a certified laboratory for final evaluation. Following these steps and adhering to best practices can help your device achieve compliance with EMC requirements.
Related Technology Terms
EMI (Electromagnetic Interference)
EMC Testing (Electromagnetic Compatibility Testing)
EMC Standards (Electromagnetic Compatibility Standards)
EMC Design (Electromagnetic Compatibility Design)
RF Shielding (Radio Frequency Shielding)
Sources for More Information
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This text is machine translated. In order to better understand electromagnetic compatibility, let's revisit the example mentioned at the beginning with the racetrack and the television. The flying sparks during current transmission at the sliding contacts generate very high voltage peaks. These can spread back into the power grid via the conductors in the rails and the transformer. At the same time, the current in the conductors in the rails and the contact conductors in the rails and the contact cables of the transformer act like antennas, so that the high-frequency components of the voltage peaks are emitted as electromagnetic radio waves. As a result, the interference with the television was mostly via the power grid and partly via direct radio radiation. Thanks to the minimal interference emission and maximum interference immunity, the simultaneous interference-free operation of many devices and systems is possible without any problems. Even in the smallest of spaces and in the same electromagnetic environment. The various requirements of the DIN VDE regulations on EMC have since been incorporated into the European standards (EN standards) and international standards (IEC). The three letters EMI are often used in connection with EMC. The abbreviation EMI stands for Electromagnetic Interference, among other things. Interference is the superposition of waves, whereby the waves can amplify or cancel each other out depending on their phase position. Electromagnetic interference describes an operational disturbance caused by the electromagnetic field of an external source in an electronic device. Natural sources of interference include, for example, solar radiation or electrostatic discharges (lightning). Man-made sources include power lines, electrical devices and radio transmitters. In order for two systems to interact with each other, there must be a connection or transmission. Experts then speak of a coupling that exists between the interference source (transmitter) and the interference sink (receiver). Depending on how the systems are mechanically constructed, the coupling can take place in different ways: The reduction or suppression of EMI and RFI interference is a very complex issue that must be taken into account during the development of a product. Otherwise, there is a risk that the product will fail the final EMC test and a cost-intensive redesign of the finished device will be necessary. In this case, it is then necessary to check exactly which interference faults occur at which points and how this can be prevented. For appliances that have a mains connection cable, so-called interference suppression filters are used. These main filters are located directly at the input of the power line and contain specially tuned coils and capacitors. This prevents the interference generated in the appliance from reaching the outside power cable. At the same time, the mains filters ensure that any interference can enter the appliance via the mains connection cable. In accordance with the standards EN IEC 61000-6-1:2019 and EN IEC 61000-6-2:2019, a distinction is made between two classes for high-frequency devices that unintentionally emit high-frequency fields: EMC class A for use in industrial environments EMC class B for use in or in the immediate vicinity of residential, commercial and industrial areas The EMC Machinery Directive (2003/42/EC) applies to machines with electrical or electronic components that cause electromagnetic emissions or are exposed to interference radiation in the form of electromagnetic fields. The measurement methods and test setups used are always tailored to the device to be tested and can vary greatly. Irrespective of this, a passed EMC test can serve as the basis for CE marking if required. As the EU Directive 2014/30/EU (EMC Directive) on compliance with EMC requirements does not have the character of a law, the EU member states had to convert the EMC Directive into a national law. In Germany, the Electromagnetic Compatibility Act (EMVG) was therefore passed in 2016. This law is binding for manufacturers, distributors and dealers. Like the EMC Directive, the EMC Act does not contain any technical specifications regarding the permissible limit values. These are laid down in the various standards that must be applied. Even if it is not currently mandatory, EMC tests should definitely be carried out prior to market launch. This is because if a non-EMC-compliant or EMC-compliant product emits an excessively strong electromagnetic interference signal, the authorities will demand that the defect be rectified quickly. This then affects the devices on the market as well as the entire stock. If the request is not complied with immediately, there is a risk of high fines, product recalls and sales bans. If there is an immediate danger to life and limb, the affected appliances will even be destroyed. The Electromagnetic Compatibility (EMC) Directive 2014/30/EU is one of the key pieces of legislation that governs the placement of electrical and electronic equipment on the European market. Its purpose is to ensure that equipment does not generate electromagnetic disturbances or is not adversely affected by them. It's also one of several directives that fall under the umbrella of the CE marking requirements. For most electrical and electronic products sold within the European Economic Area (EEA), demonstrating compliance with the EMC Directive is a mandatory part of the CE marking process. This guide explains what the EMC Directive covers, who it applies to, what testing and documentation are required, and how to demonstrate full compliance to support CE marking. You can download the full version of the EMC Directive here. What is the EMC Directive, and which equipment does it apply to? The EMC Directive is a European regulation that ensures the electromagnetic compatibility of electrical and electronic equipment. It applies to both apparatus (finished, market-ready products) and fixed installations (permanently installed equipment within a defined site). The directive has two core objectives: To prevent electrical and electronic equipment from generating electromagnetic disturbances that interfere with telecommunications, radio, and other equipment. To ensure that equipment is immune to electromagnetic interference, so it can operate reliably in its intended environment. The EMC Directive applies to the majority of mains- or battery-powered products. However, it does not apply to subassemblies or components that do not have an intrinsic function (e.g. they are only functional when part of a larger system). Some categories are also regulated by separate directives, including: Medical devices Communication equipment Road and agricultural vehicles Military equipment Who's responsible for EMC compliance? Manufacturers are primarily responsible for ensuring products meet the EMC requirements. However, importers and distributors also have legal obligations. Importers must ensure products carry the CE mark and are accompanied by appropriate documentation. Distributors must verify that products are correctly labelled and compliant before placing them on the market. All economic operators must cooperate with national authorities to provide access to conformity documentation and assist in corrective actions if needed. Who enforces EMC, and what are the penalties for non-compliance? In the UK, the EMC Directive is implemented through the Electromagnetic Compatibility Regulations 2016. Enforcement authorities, such as Trading Standards and Ofcom, oversee compliance. Penalties for non-compliance can include: A fine of up to £5,000 Imprisonment for up to three months Mandatory recall or withdrawal of non-compliant products from the market Find out more in the UK Government's statutory guidance here. How do you carry out testing against the EMC Directive? To demonstrate EMC Directive conformity, manufacturers must test their equipment for both electromagnetic emissions and immunity. There are five key assessment classes, each targeting specific risks: Radiated emissions: Ensures the equipment does not emit disruptive radio signals. Conducted emissions: Ensures signals are not unintentionally transmitted via supply or connection lines. Radiated susceptibility: Checks the equipment's ability to function in a standard electromagnetic environment. Conducted susceptibility: Verifies that equipment remains functional when subjected to interference through power or signal connections. Electrostatic discharge: Tests the product's resistance to static discharge during normal handling or operation. Before testing begins, manufacturers must ensure the equipment is: Fully assembled and functional Connected to its usual operating systems Running in normal production mode Energised with any required DC or RF power sources In some cases, where product design or performance requires it, manufacturers may voluntarily engage a Notified Body to carry out EMC assessments. While this is not mandatory under the EMC Directive, it can help de-risk compliance for more complex or high-stakes products. What documentation do you need? Under the EMC Directive, manufacturers are required to establish technical documentation that demonstrates the conformity of their equipment with the directive's essential requirements. This documentation must be sufficiently detailed to allow for the assessment of the product's compliance and should encompass all relevant aspects of design, manufacture, and operation. The technical documentation should include: A general description of the equipment Design and manufacturing drawings, along with schemes of components, sub-assemblies, and circuits Explanations are necessary for understanding the drawings and the operation of the equipment A list of harmonised standards applied in full or in part, and where these standards have not been applied, descriptions of the solutions adopted to meet the essential requirements Results of design calculations, the examinations carried out, etc The manufacturer must keep this documentation for 10 years after the equipment is placed on the market and should make it available to the competent national authorities upon request. It's important to note that while the EMC Directive allows manufacturers to self-assess their products, involving a Notified Body can be beneficial, especially for complex products or when harmonised standards are not fully applied. A Notified Body can provide an independent assessment of the technical documentation and the conformity of the product. How does EMC fit into CE marking regulations? Many electrical and electronic products placed on the European market fall under more than one EU directive. While the EMC Directive ensures electromagnetic compatibility, it doesn't cover all safety or performance aspects of a product. For example, equipment may also fall under the Low Voltage Directive or the Machinery Directive, as well as EMC. In these cases, the manufacturer must: Identify all applicable directives based on the product type, intended use, and environment Ensure the product meets the essential requirements of each directive, which may include safety, energy efficiency, or hazardous substance restrictions Compile a single technical file that covers the conformity assessment evidence for all applicable directives Draft a single Declaration of Conformity (DoC) that references each relevant directive and harmonised standard Affix the CE mark, which symbolises compliance with all relevant EU legislation, not just one Note that, the CE mark does not indicate conformity with a single directive. It represents compliance with all EU legislation applicable to the product. Download our free guide here for more information on complying with CE regulations. Comply with the EMC Directive with total confidence Our start-to-finish EMC testing service for large and medium-sized capital equipment covers every step of the process, from testing against relevant measures to compiling your technical documentation and addressing remedial actions. See our EMC testing service page here to learn more. Electrical engineering concept Anechoic RF chamber used for EMC testing (radiated emissions and immunity). The furniture has to be made of wood or plastic, not metal. Log-periodic antenna measurement for outdoors Electromagnetic compatibility (EMC) is the ability of electrical equipment and systems to function acceptably in their electromagnetic environment, by limiting the unintentional generation, propagation and reception of electromagnetic energy which may cause unwanted effects such as electromagnetic interference (EMI) or even physical damage to operational equipment.[1][2] The goal of EMC is the correct operation of different equipment in a common electromagnetic environment. It is also the name given to the associated branch of electrical engineering. EMC pursues three main classes of issue. Emission is the generation of electromagnetic energy, whether deliberate or accidental, by some source and its release into the environment. EMC studies the unwanted emissions and the countermeasures which may be taken in order to reduce unwanted emissions. The second class, susceptibility, is the tendency of electrical equipment, referred to as the victim, to malfunction or break down in the presence of unwanted emissions, which are known as Radio frequency interference (RFI). Immunity is the opposite of susceptibility, being the ability of equipment to function correctly in the presence of RFI, with the discipline of "hardening" equipment being known equally as susceptibility or immunity. A third class studied is coupling, which is the mechanism by which emitted interference reaches the victim. Interference mitigation and hence electromagnetic compatibility may be achieved by addressing any or all of these issues, i.e., quieting the sources of interference, inhibiting coupling paths and/or hardening the potential victims. In practice, many of the engineering techniques used, such as grounding and shielding, apply to all three issues. The earliest EMC issue was lightning strike (lightning electromagnetic pulse, or LEMP) on ships and buildings. Lightning rods or lightning conductors began to appear in the mid-18th century. With the advent of widespread electricity generation and power supply lines from the late 19th century on, problems also arose with equipment short-circuit failure affecting the power supply, and with local fire and shock hazard when the power lines were struck by lightning. Power stations were provided with output circuit breakers. Buildings and appliances would soon be provided with input fuses, and later in the 20th century miniature circuit breakers (MCB) would come into use. It may be said that radio interference and its correction arose with the first spark-gap experiment of Marconi in the late 1800s.[3] As radio communications developed in the first half of the 20th century, interference between broadcast radio signals began to occur and an international regulatory framework was set up to ensure interference-free communications. Switching devices became commonplace through the middle of the 20th century, typically in petrol powered cars and motorcycles but also in domestic appliances such as thermostats and refrigerators. This caused transient interference with domestic radio and (after World War II) TV reception, and in due course laws were passed requiring the suppression of such interference sources. ESD problems first arose with accidental electric spark discharges in hazardous environments such as coal mines and when refuelling aircraft or motor cars. Safe working practices had to be developed. After World War II the military became increasingly concerned with the effects of nuclear electromagnetic pulse (NEMP), lightning strike, and even high-powered radar beams, on vehicle and mobile equipment of all kinds, and especially aircraft electrical systems. When high RF emission levels from other sources became a potential problem (such as with the advent of microwave ovens), certain frequency bands were designated for Industrial, Scientific and Medical (ISM) use, allowing emission levels limited only by thermal safety standards. Later, the International Telecommunication Union adopted a Recommendation providing limits of radiation from ISM devices in order to protect radiocommunications. A variety of issues such as sideband and harmonic emissions, broadband sources, and the ever-increasing popularity of electrical switching devices and their victims, resulted in a steady development of standards and laws. From the late 1970s, the popularity of modern digital circuitry rapidly grew. As the technology developed, with ever-faster switching speeds (increasing emissions) and lower circuit voltages (increasing susceptibility), EMC increasingly became a source of concern. Many more nations became aware of EMC as a growing problem and issued directives to the manufacturers of digital electronic equipment, which set out the essential manufacturer requirements before their equipment could be marketed or sold. Organizations in individual nations, across Europe and worldwide, were set up to maintain these directives and associated standards. In 1979, the American FCC published a regulation that required the electromagnetic emissions of all "digital devices" to be below certain limits.[3] This regulatory environment led to a sharp growth in the EMC industry supplying specialist devices and equipment, analysis and design software, and testing and certification services. Low-voltage digital circuits, especially CMOS transistors, became more susceptible to ESD damage as they were miniaturised and, despite the development of on-chip hardening techniques, a new ESD regulatory regime had to be developed. From the 1980s on the explosive growth in mobile communications and broadcast media channels put huge pressure on the available airspace. Regulatory authorities began squeezing band allocations closer and closer together, relying on increasingly sophisticated EMC control methods, especially in the digital communications domain, to keep cross-channel interference to acceptable levels. Digital systems are inherently less susceptible than analogue systems, and also offer far easier ways (such as software) to implement highly sophisticated protection and error-correction measures. In 1985, the USA released the ISM bands for low-power mobile digital communications, leading to the development of Wi-Fi and remotely-operated car door keys. This approach relies on the intermittent nature of ISM interference and use of sophisticated error-correction methods to ensure lossless reception during the quiet gaps between any bursts of interference. "Electromagnetic interference" (EMI) is defined as the "degradation in the performance of equipment or transmission channel or a system caused by an electromagnetic disturbance" (IEV 161-01-06) while "electromagnetic disturbance" is defined as "an electromagnetic phenomenon that can degrade the performance of a device, equipment or system, or adversely affect living or inert matter (IEV 161-01-05). The terms "electromagnetic disturbance" and "electromagnetic interference" designate respectively the cause and the effect.[1] Electromagnetic compatibility (EMC) is an equipment characteristic or property and is defined as "the ability of equipment or a system to function satisfactorily in its electromagnetic environment without unacceptable electromagnetic disturbances to anything in that environment" (IEV 161-01-07).[1] EMC ensures the correct operation, in the same electromagnetic environment, of different equipment items which use or respond to electromagnetic phenomena, and the avoidance of any interference. Another way of saying this is that EMC is the control of EMI so that unwanted effects are prevented. Besides understanding the phenomena in themselves, EMC also addresses the countermeasures, such as control regimes, design and measurement, which should be taken in order to prevent emissions from causing any adverse effect. Main article: Electromagnetic interference
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