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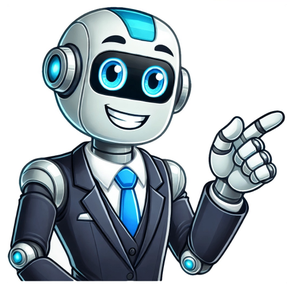

Electromagnetic compatibility testing

EMC TESTING: THE BEGINNER'S GUIDEStart Here: Beginner's Guide To EMC New to EMC (electromagnetic compatibility) testing? Need to polish up your knowledge? This beginner's guide to EMC gives the concise information you need to identify, prepare for and ultimately pass EMC testing. In this guide, you'll learn how to find the EMC standards that apply to your product, what the emissions and immunity tests are that you'll need to pass, how to prepare for testing, how to find good EMC test labs, typical pricing and much more. The beginner's guide to EMC is an in-depth tutorial on all aspects of EMC testing. This guide covers the fundamentals of everything you need to know to be able to navigate, prepare for and pass EMC testing. Here's what we'll cover in this chapter:Learn what electromagnetic compatibility (EMC) testing isDiscover the poor first time pass rate averageThe 5 reasons manufacturers care about EMC testingThe history and future of EMC testingRead on below!What is Electromagnetic Compatibility (EMC) Testing?Electromagnetic Compatibility (EMC) testing is the process of evaluating an electronic device to ensure it does not emit an excessive amount of electromagnetic interference (EMI), and that it can operate correctly in the presence of EMI in its environment. These emissions—both radiated and conducted—must fall within defined regulatory limits to avoid interference with other equipment. EMC testing includes two core objectives: Emissions Testing – Ensuring your device does not generate unwanted interference. Immunity Testing – Confirming your device continues functioning as intended when exposed to external electromagnetic disturbances. Most countries require products with electronics to pass EMC testing before they can be legally sold. Tip: The term "electromagnetic compatibility" refers to a device's ability to function satisfactorily in its electromagnetic environment without introducing intolerable interference to anything in that environment. Before diving into testing preparation, it’s helpful to know what types of tests your product is likely to undergo. Below is a high-level overview of the main EMC emissions and immunity tests. These are covered in much more detail in later chapters. Emissions Tests Radiated Emissions (EMI) Tests: Measures electromagnetic energy unintentionally emitted into the air. Tested in an anechoic or semi-anechoic chamber using antennas. Conducted Emissions Tests: Measures unwanted RF energy that travels along power or signal lines, typically below 30 MHz. Immunity Tests Each test applies differently depending on the product category and the standards it must meet. These tests are typically defined in standards like IEC 61000-4-x and CISPR 11/22/32. We rely on a finite electromagnetic spectrum for radio, wireless communications, satellite navigation, and more. Even unintended emissions from electronic circuits can pollute these frequencies, causing cross-interference. 2. Safety in Critical Systems Failures in devices due to EMI can cause serious harm, especially in sectors like medical, military, automotive, and aerospace. EMC standards are built to safeguard the performance of safety-critical equipment. 3. Product Performance and Reliability EMC issues can degrade sensitive electronics, from sensor readings to wireless signals. Thorough EMC testing helps identify and resolve interference sources early—improving product reliability and reducing returns. 4. Regulatory Compliance & Legal Risk Regulators such as the FCC (US), CE (EU), ISED (Canada), and others enforce EMC standards. Non-compliance can lead to fines, product recalls, and even bans on market entry. 5. Market Access & Customer Trust Passing EMC tests ensures smoother certification and faster time-to-market. It demonstrates professionalism and builds trust with distributors and customers worldwide. Only ~50% of products pass EMC testing the first time, according to one of the largest studies by Intertek Labs. A failed test can delay time-to-market by days or months, making proper preparation critical. In this guide, we’ll show you: How to determine applicable EMC standards The typical emissions and immunity tests How to prepare effectively (including pre-compliance testing) What labs look for—and how to choose the right one Pricing ranges for different regions and products 1882 (Germany): First known EMC regulation for telegraph systems 1899 (UK): The Lighting Clauses Act to stop lamps from interfering with neighbors’ lighting 1938 (US): FCC emission rules for transmitters 1989 (US): Standardization of general-purpose emission limits 1992 (EU): Introduction of the EMC Directive to harmonize compliance across member countries EMC rules have evolved in response to real-world problems—protecting both the spectrum and user safety. Driven by IEC efforts, more countries are aligning with international standards (e.g., CISPR, IEC 61000 series). 2. Expansion of Immunity Testing Regions like Australia, New Zealand, and parts of Asia are moving toward the EU model that mandates both emissions and immunity testing. 3. Stricter Test Lab Accreditation Governments now require labs to be accredited (e.g., FCC rules for US transmitter certification). Smaller labs may be phased out in favor of those with deeper compliance capabilities. 4. Increased Testing Costs and Complexity As test requirements increase, manufacturers should expect longer test cycles and more detailed planning to meet both emissions and immunity thresholds. This guide is just the beginning. To fully understand how to prepare your product for successful EMC testing and global compliance, continue reading the rest of the guide: Each chapter is designed to walk you through the entire process with practical tips, expert advice, and actionable tools to help you succeed. That's it for the first part of the beginner's guide to EMC. Remember to share this with any friends or colleagues that will find it valuable. Also leave any comments or questions below! Cookie consent(s) We use cookies to personalize content and ads, provide social media features, and analyze traffic. This is done only with your explicit consent. By clicking "ACCEPT ALL," you agree to the processing and sharing of your data with our partners for social media, advertising, and analytics, including in third countries in accordance with Art. 49(1)(a) GDPR and Art. 17(1)(a) FADP (Switzerland). There is a risk that your data may be monitored by authorities without legal recourse. You can change or revoke your consents at any time in the data privacy settings . Settings DEKRA evaluates the applicable Electromagnetic Compatibility (EMC) requirements that an electronic device or component has in order to comply with national and international standards and requirements. DEKRA’s Electromagnetic Compatibility (EMC) Testing services apply to all electronic devices and components. Our EMC testing services are specifically designed to provide proof that our customers’ products are immune to any electromagnetic interference (Immunity) and that they are not radiating above certain levels of energy that might be harmful to users or to the environment (Emissions). EMC is everywhere! Literally speaking in products, but also in DEKRA's global network. Find our EMC labs around the globe: DEKRA’s global network of testing laboratories and specialized EMC experts help our customers to test their products for electromagnetic compatibility according to international standards both in our laboratories and on-site. Our experts specify the samples and documentation needed, book the test facilities to perform the necessary testing and inform customers on the progress and results of tests. We ensure that all of our customers’ products are fully compliant with all the applicable or requested EMC requirements in each market, ensuring market access and success with minimum interference.Household appliancesPower toolsElectric toysLighting productsConsumer electronicsIT and Office equipmentAudio and video equipmentTelecom equipmentSmart home devicesWearable devices and wireless productsIndustrial, scientific and medical devicesMeasurement and laboratory equipmentElectric component (electronic switch, dimmer, etc.)Power supplies and Electronics (batteries, UPS, PV inverters, ...) Electromagnetic compatibility (EMC) testing measures an electrical product’s ability to function satisfactorily in its intended electromagnetic environment without generating intolerable electromagnetic disturbances to anything in that environment. EMC differs from other safety aspects because the electromagnetic phenomena exist in the normal use environment of all electrical equipment. Product EMC testing is performed at the design, development and production stages to ensure that all products are safe before reaching the end-user. The test evaluates the correct selection of components and the proper construction following the requirements of the relevant EMC standards. EMC type tests are usually much more stringent than routine production tests as they intend to verify a product’s safety design. Also, during EMC testing, the product sample must be energised. If a product doesn’t pass the EMC testing procedure, the manufacturer has two options: Provide the testing laboratory with a new sample on which all relevant tests are to be performed againMake all the necessary repairs and modifications on the already tested sample and have the lab repeat only the sequence of EMC tests that the sample failed. In addition, EMC testing is required for obtaining international approvals and product certification marks for electrical products. For instance, electrical products must pass EMC testing and comply with the EMC Directive 2014/30/EU to obtain CE marking approval for the EU market. This section focuses on the main tests for achieving EMC compliance. Radiated Emissions (EMI) tests Radiated emissions testing measures the electromagnetic field strength of the emissions unintentionally produced by the electrical product. These emissions are inherent to the currents and switching voltages within any digital circuit. To perform the EMI tests, the following equipment is often needed: EMI receiver, preselector and QP adapterTurntableRB coaxial cableAttenuatorHigh pass filterBroadband linearly polarised antennaOpen area test site and full anechoic chamber The test procedure includes several steps, as follows: Performing a preliminary measurement inside an anechoic chamber to characterise the product samplePerforming test and limits comparison in an open area test site with the sample placed on a remotely controlled turntableLoading the specification limits and applicable correction factors to the EMI receiverMaximising the readings by adjusting the turntable azimuth between 0– 360 °, the antenna height between 1– 4 meters, and antenna polarisationEvaluating the emissions from the product using appropriate methodsEmission level = Reading Value + Ant. Factor + Cable LossRecording the output of the preliminary measurementRecording the emissions levels on the frequency range in tables and spectral plots using the preliminary measurement information. Before submitting a sample to a test lab for this type of EMC testing, manufacturers must ensure proper product design. A minor issue, such as noise on the cabling, will fail the radiated emissions test. Conducted Emission tests Conducted emissions testing measures the portion of electromagnetic energy created by a product and conducted onto the power supply cord. The test aims to verify that these emissions comply with specified limits in relevant EMC standards, usually from 150 kHz to 30 MHz. To perform the conducted emissions tests, the following equipment is often needed: EMI receiverAMN (artificial mains network) for the sample and any additional-peripheral equipmentTerminationGround planeCurrent probeCoaxial cableIsolation transformerFilter. The test procedure includes several steps, as follows: Emission level = Reading value + Correction factorCorrection Factor = Cable loss + Insertion loss of LISNMargin value = Emission level – LimitInvestigating the frequency spectrum from 0.15 MHz to 30 MHzConnecting all interface ports to the appropriate peripheral units via specific cables and recording any relevant information (e.g. cables’ data)Recording the emissions levels in the frequency range of 150 kHz– 30 MHz in tables and spectral plots. Failing the conducted emissions testing is not uncommon for products with a pre-certified external AC-DC power adapter. Power supplies are often supposedly compliant, but when re-tested, they become non-compliant because of hardware changes since the initial compliance testing or flaws with the original testing. Keep track of your suppliers’ compliance status using the supplier portal for EU and SCIP compliance. Flicker tests Flicker testing is another form of emissions testing. It helps determine if the product sample produces fluctuating load in the branch circuit causing RMS voltage fluctuations with flickers. To perform this type of EMC testing, the following equipment is often needed: Power sourceFlicker meterImpedance networkVoltage fluctuation meter. The test procedure includes as follows: Determining acceptable values and relative voltage change characteristicsMeasuring the RMS voltage fluctuations on the ac mains caused by the sampleEvaluating the flicker severity using appropriate methods and recording the outputMeasuring the relative voltage changes and determining if the total accuracy is better than ±8%. Radiated RF electromagnetic immunity tests The radiated RF electromagnetic immunity test measures the performance of the product’s immunity to radiated RF electromagnetic field disturbances for simulating the interference of transmitted electromagnetic waves. This test required the following equipment: Signal generatorRF power amplifierFunction generatorBiconical antenna and log-periodic antennaMillivoltmeterIsotropic “E” field probeDual directional couplerPower amplifierField sensorAnechoic chamber or semi-anechoic chamberAbsorbersRF coaxial cableCCD and a monitor for CCD. During the test, the product sample is subjected to a field of 3V/m, and amplitude modulated 80% by a 1-kHz sinusoidal signal. And the radiated field is applied in vertical and horizontal polarisation using appropriate antennas. The test is performed in an anechoic or semi-anechoic chamber. Electrostatic discharge immunity tests This form of EMC testing evaluates the performance of the immunity to electrostatic discharges at the enclosure, accessible ports and other similar areas of the product sample. The following equipment must be provided to perform electrostatic discharge immunity testing: ESD simulatorOscilloscopeHorizontal coupling planeVertical coupling planeDischarge electrodeDischarge return cableBleeder resistorsInsulating support. The test procedure includes three main steps. First, applying potentials of ±2 kV, ±4 kV, ±8 kV, and ±15 kV (or others specified in the relevant EMC standards) near each applicable test point (air discharges are applied to insulating surfaces). Secondly, applying potentials of ±2 kV, ±4 kV, ±6 kV, and ±8 kV (or others specified in the relevant standards) to each applicable test point (contact discharges are applied to conductive surfaces and coupling planes). Lastly, performing indirect discharge using the direct contact ESD test tip. In this regard, potentials of ±2 kV, ±4 kV, ±6 kV, and ±8 kV (or other specified in safety standards) are applied to the centre of the vertical edge of the coupling plane at a distance of 0.1m from the outer casing of the product sample to each applicable test point. Surge immunity test Surge immunity testing evaluates the performance of the equipment’s immunity to surge disturbances. Three pieces of equipment are needed to perform this test – surge wave generator, coupling/decoupling network and reference ground plane. The test procedure includes several steps: Applying test voltages in a synchronised way to the voltage phase at zero-crossing and peak value of the A.C. voltage wave (both, positive and negative).Applying the surge to the equipment’s power supply terminals via the capacitive coupling decoupling network.Testing at least five positive and five negative discharges at selected points of the power supply (0°, 90°, 180°, and 270° of the sine wave). Magnetic field immunity test This form of EMC testing measures the performance of the immunity of an electrical product to magnetic field disturbances. The test requires the use of the following equipment: Test generatorMagnetic field probe and testerDecoupling networkSquare coil or another inductive coilBack filter. During the test, the equipment is subjected to a continuous magnetic field by use of an induction coil. Afterwards, the induction coil is rotated by 90° to expose the product to the test field with different orientations. Three orthogonal planes are tested. Lastly, the dwell time at each frequency is measured and should be at least equal to the time the product needs to respond. Electrical fast transient (EFT) immunity test This test helps evaluate the performance of the product’s immunity to electrical fast transient disturbances. The equipment needed for the test is as follows: Burst generatorCoupling decoupling networkReference ground plane, capacitive clampInterconnection cable33 nF capacitor probe for direct injection. During the test, an EFT test signal is applied to the neutral and ground lines of the product sample’s mains input at a distance of 1 meter from the sample. The test signal voltage is applied for 1 minute to each line in negative and positive polarities. The same test signal is also applied to the signal lines connected to the product unit. Harmonic tests Harmonic testing measures the harmonic current requirements of an electrical product. By limiting the harmonic current requirements, the harmonic load on local power supplies is decreased, which helps avoid specific electrical product hazards (e.g. overheating) and increases efficiency. Share — copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt — remix, transform, and build upon the material for any purpose, even commercially. The licensor cannot revoke these freedoms as long as you follow the license terms. Attribution — You must give appropriate credit , provide a link to the license, and indicate if changes were made . You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use. ShareAlike — If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original. No additional restrictions — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation . No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. The EMC Directive - officially named Electromagnetic Compatibility (EMC) Directive 2014/30/EU of the European Parliament and of the Council – ensures that electrical and electronic equipment does not generate electromagnetic disturbance, or is not affected by electromagnetic disturbance. The legislation sets out limits for electromagnetic emissions from equipment, so that mediums such as telecommunication, radio, and other equipment are not disturbed. It also concerns the immunity of equipment to interference, aiming to protect this equipment from disturbance by radio emissions when it is in use. You can download the full version of the EMC Directive here – it runs to 28 pages. We have created this guide to highlight some of its most important elements. What does the EMC Directive cover? The EMC Directive is focused on regulating the compatibility of equipment in relation to electromagnetic fields. Its main objectives are to ensure that: Equipment (apparatus and fixed installations) needs to comply with EMC requirements when it is placed on the market and/or taken into service. The application of good engineering practice is required for fixed installations, with the possibility that competent authorities of Member States may impose measures in instances of non-compliance. The EMC Directive covers the majority of finished mains or battery-powered electrical products. Exceptions to the guide include sub assemblies and components without an intrinsic function, (i.e. they are only of use when combined with other components). There are also some exceptions which are already covered in other directives, including; medical devices; communications equipment; road vehicles; agricultural vehicles; and military equipment. Who enforces the EMC Directive? In the UK, the EMC Directive is officially implemented by The Electromagnetic Compatibility Regulations 2006. These regulations are enforced by the Trading Standards and Ofcom. The Health and Safety Executive can take part in investigations into non-compliant products, as can the Department of Trade and Industry’s radiocommunication agency, and the British Approvals Board for Telecommunications. What are the penalties for non compliance? Businesses which are found to be supplying non-compliant equipment face a maximum penalty of three months' imprisonment, or a £5,000 fine. Typically, manufacturers are asked to replace or recall apparatus which is found to be non-compliant. The sale of apparatus which is found to be non-compliant can be suspended or banned by the relevant authority. Key EMC Directive responsibilities for manufacturers Assessments for EMC Directive conformity There are five classes of assessments which have the purpose of testing for EMC Directive conformity: Radiated emissions - Checks to ensure that the product does not emit unwanted radio signals. Conducted emissions - Checks to ensure the product does not send out unwanted signals along its supply connections and connections to any other apparatus. Radiated susceptibility - Checks that the product can withstand a typical level of electromagnetic pollution. Conducted susceptibility - Checks that the product can withstand a typical level of noise on the power and other connections. Electrostatic discharge - Checks that the product is immune to a reasonable amount of static electricity. Routes to EMC Directive compliance There are two conventional routes to confirming compliance with the EMC Directive: 1. Standards Route The electrical products which many manufacturers produce are of no concern in relation to the EMC Directive, and in these cases organisations are able required to take a logical approach to the requirements, which is known as the Standards Route. This way of complying with the EMC Directive allows the manufacturer themselves to compare the performance of their equipment with the harmonised standards set out in the Directive. If they are sure that the standards have been met, manufacturers can make a Declaration of Conformity. In these cases, testing can sometimes be required, but is not mandatory. 2. Technical Construction File With electrical products for which there are no harmonised standards, or when testing must be conducted outside the confines of the manufacturer’s site in order to demonstrate compliance, the manufacturer is required to put together a Technical Construction File. The results of these assessments, along with the other information in the Technical Construction File, are then audited in order to assure that the electrical products comply with the EMC Directive. A Technical Construction File typically contains information such as; a general description of the equipment; design and drawings of the equipment; proof (if any) of compliance with harmonised standards; in the absence of standards, a description and proof of how the requirements of the Directive have been met; details on assessments made; a Declaration of Conformity. CE marking CE marking provides manufacturers with a way to make a visible declaration that electrical products comply with the EMC Directive. CE marking is a required form of EMC Directive compliance which accompanies a Declaration of Conformity. It also confirms that electrical products have free circulation within the European Economic Area. You can rely on IES to provide comprehensive CE marking, including all relevant testing, as part of our integrated EMC Directive compliance service. Electromagnetic fields (EMF) safety Manufacturers which operate a site which uses high voltage applications need to consider EMF safety. Read about IES’s EMF testing service here. A trusted partner for EMC Directive conformity IES offers offer the option of conformity assessments being carried out at your site, or at our own facility, as well as guidance on Technical Construction File compilation and CE marking to declare conformity to the EMC Directive. Read more on our comprehensive service for EMC Directive compliance, or get in touch to discuss your requirements. Element is the proven leader in EMI and EMC testing, compliance, and certification. We provide accredited electromagnetic compatibility services, helping you to meet regulatory requirements, and improve the performance and safety of products and devices through our global laboratories. Our network of laboratories supports you with testing programs that deliver a full range of certification and validation services to meet your unique testing needs. We provide EMC and EMI testing for a wide range of critical industries, delivered through some of the largest testing facilities in the US, UK, and Germany. What is EMC testing? Electromagnetic capability testing, known as EMC testing, measures the ability of electronic equipment, product, or devices to function satisfactorily without intolerable electromagnetic disturbances to anything within their electromagnetic environments. You can demonstrate EMC compliance when the device tests successfully and meets the EMC requirements for the target market, which leads to EMC certification. It is essential to test your products to ensure they meet the regulatory requirements; EMC certification is a mandatory requirement for a number of global markets. In addition to product safety and wireless coexistence, considering EMC principles in the early stages of the product development cycle will help to improve performance, reduce the risk of redesign, and mitigate unnecessary costs. EMC testing solutions Our EMC testing covers a broad range of products from small wearable technologies and implantable devices to large capital items or even in-situ installations. Helping all industries get their products to market faster, including medical or automotive industries where failure is not an option. EMC testing services Offering a wide range of services, we support our customers: EMC advice and guidance Pre-test capabilities EMC pre-compliance testing Wireless testing Global approvals and certifications EMI & EMC standards EMC calibration EMC test reports EMI & EMC certification Global market access