

EMC IMMUNITY MEASUREMENTS IN APPLIED INDUSTRIAL SETTINGS: STANDARDS AND PRACTICES

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Abstract

The basic requirement for the reliable operation of modern electronic devices is electromagnetic compatibility (EMC), which focuses on the examination of the proper operation and interaction of electrical devices with each other, in this case we examine the interference tolerance (immunity) against radiated radio frequency field strength. This article presents the measurement, requirements for equipment used in commercial and residential environments, with particular attention to the requirements of the MSZ EN IEC 61000-4-3 standard. The analysis covers the different field strength test levels, the frequency ranges between 200 MHz and 1 GHz, and the use of anechoic chambers and special antennas essential for the measurement. The study details the measurement process from the generation of interference signals to the functional verification of the equipment under test (EUT). The aim of the summary is to provide developers with a comprehensive overview of the standardization processes and the methodology for successful conformity tests.

Keywords: EMC, radiated interference, immunity test

1. Introduction

The basic concepts of EMC are contained in MSZ IEC 1000-1-1. EMC is the ability of devices and systems to function in their electromagnetic environment without impairment or problems. Electromagnetic compatibility ensures that the operation does not affect the electromagnetic environment to such an extent that it adversely affects the operation of other devices and systems. According to Directive 2004/108/EC of the European Parliament and of the Council: “The ability of an equipment or system to function satisfactorily in its (its) electromagnetic environment without exposing other equipment in its environment to unacceptable disturbances.” (MSZ IEC 1000-1-1)

The purpose of applying electromagnetic compatibility measures is to ensure that various elements of electronic equipment can operate in close proximity to each other without causing undue interference. (MSZ IEC 1000-1-1)

Interference that causes performance degradation is known as electromagnetic interference (EMI). This interference needs to be reduced to ensure that different electrical equipment is compatible and can operate in the presence of each other. EMC has two main components, on the one hand, emissions, where EMI emissions refer to the production of unwanted electromagnetic energy. These need to be reduced below certain acceptable limits to ensure that they do not cause any disturbance to other

equipment. On the other hand, susceptibility and immunity, where the susceptibility of an electronic item to EMI is how it reacts to unwanted electromagnetic energy.

2. Measurement laboratories, measurement sites

Standard tests and measurements usually impose requirements on the equipment, the dimensions of the test space, interference immunity, etc., due to which the majority of measurements can only be performed in special test sites designed for this purpose.

Depending on the task, the on-site options for tests may be the following:

- Simple test room
- Final installation site of the equipment
- Open-air OATS (Open Area Test Site)
- Shielded room
- Open-air stripline test sites are used for high-frequency measurements (Rejtő, 2006).

3. EMC Measurements

Electrical instruments have developed significantly in recent times. This development is reflected in both software and hardware features. The latest measurement software has an easy-to-use interface. The measurement programs include current legislation, regulations, and the possibility of continuous updating (Rejtő, 2006).

In order to conduct measurements, special purpose instruments, various sensors, antennas, power supplies, and other special devices are required, as well as a clamp, rotary table, antenna, lifting stand, and other infrastructure equipment.

Radiated immunity testing is based on modeling the effect of electromagnetic fields on the operation of electronic devices. Electromagnetic waves can induce interference voltages and currents through the circuits and conductors of the device, which can result in malfunction or complete shutdown.

The purpose of the tests is to determine what differences can be experienced in the operation of the device as a function of field strength and frequency.

3.1. EMC Meters

- Measuring receivers, spectrum analyzers
- Utility networks: standard topologies, impedance frequency response, interference signal output and input, control and calibration measurement of utility networks
- Current transformer (Current Probe/Current Clamp) for control and calibration measurements; use during conducted interference emission and immunity measurements
- Wave coupler for conducted interference immunity measurements; device for control and calibration measurements
- Signal sources, amplifiers
- Near-field measuring devices (FIEK Laboratory tests)

3.2. Standard required for performing immunity measurement

IEC 61000-4-3 is an EMC standard. It specifies immunity requirements for electrical and electronic equipment to radiated electromagnetic energy. It specifies test levels and the required test procedures. The aim of the standard is to establish a common reference for assessing the immunity of electrical and

electronic equipment to radiated radio frequency electromagnetic fields. The test method describes a consistent method for assessing the electromagnetic immunity of an equipment or system to RF electromagnetic fields from RF sources other than those in the immediate vicinity of the EUT. Almost all electrical and electronic equipment is covered by the standard. As this standard is a basic EMC publication, its application is not possible without a product standard.

Most EMC product standards refer to IEC 61000-4-3 for testing immunity to radiated RF fields. Some of these standards include: CISPR 35, EN 55035, IEC 61547, EN 61547, IEC 60601-1-2, EN 60601-1-2, IEC 61000-6-1, EN 61000-6-1, IEC 61000-6-2 and EN 61000-6-2. Almost all commercial products are tested for radiated immunity according to IEC 61000-4-3 in conjunction with the higher-level product standard. The test levels and performance criteria are specified in the product standards. IEC 61000-4-3 is the radiated immunity test standard for short.

The product standards list the test names. The most commonly used names are:

- Radiated immunity
- Immunity to radiated RF fields
- RF field radiated immunity tests

From the point of view of product use, we distinguish the type of use (EN 55011).

1. Class A: Connected to an industrial network
2. Class B: Connected to a residential network
3. Group 1: Does not emit RF signals during operation
4. Group 2 emits RF signals during operation (e.g.: Microwave oven)

All of the above test names indicate the same test: a field is applied to the EUT and its performance is verified (IEC 61000-4-3).

Table 1. The IEC 61000-4-3:2020 standard defines five test levels (IEC 61000-4-3)

Level	Test field strength (V/m)
1	1
2	3
3	10
4	30
x	Special

The table lists the levels of radiated radio frequency immunity tests within the scope of electromagnetic compatibility (EMC) (usually based on the IEC 61000-4-3 standard). The levels shown in the table (Table 1) indicate different levels of disturbance from low level (1) to special requirements or customer requirements (X).

IEC 61000-4-3:2020 specifies tests in the frequency range above 80 MHz, limited only by the capabilities of the test instruments. The frequencies or frequency ranges selected by product committees for testing may be limited to those at which intentional RF emitting devices actually operate. Product committees may require a specific test level and modulation type (as an alternative to 80% AM). If the product is intended to meet the requirements of only certain countries, the test may be reduced to the frequency bands designated for digital mobile phones and other intentional RF emitting devices in those countries.

The starting frequency may be 80 MHz, the stopping frequency may be 1, 6, 18 GHz or higher. The upper frequency for this test is specified in the product standards (IEC 61000-4-3).

4. The role of commercial applications

4.1. Ensuring interference immunity of electronic devices

One of the most important goals of commercial EMC radiated immunity testing is to ensure the reliable operation of consumer and industrial electronic devices in the electromagnetic environment. Devices such as smartphones, routers, automotive electronic systems, and medical equipment are all susceptible to EMI and must undergo rigorous EMC testing.

4.2. Automotive and aircraft electronics applications

Modern vehicles and aircraft contain a large number of electronic modules that are sensitive to electromagnetic interference. EMC radiated immunity tests ensure that these devices operate properly in environments where strong radio frequency radiation occurs (Testups Hungary Electronics).

4.3. Industrial automation and IoT devices

With the increasing industrial automation and the proliferation of IoT (Internet of Things) devices, the importance of EMC testing continues to grow. Wireless communication between smart devices is susceptible to electromagnetic interference, so EMC radiated immunity tests are essential for reliable operation.

5. The commercial radiated immunity test

5.1. Purpose of test

The purpose of the test is to ensure that the electronic device or apparatus under test is not susceptible to environmental electromagnetic interference and will operate properly in environments where such interference may occur. This allows regulatory authorities (e.g. in the European Union to comply with EMC directives) and manufacturers to ensure that the device does not cause interference to other equipment or will not have a disruptive effect on the operation of other equipment before the device is placed on the market (EUROLAB Laboratory Services).

5.2. Testing procedure

The device is placed in a specific test environment that provides favorable conditions for electromagnetic radiation. This is often done in an electromagnetic anechoic chamber, where the device is oriented in the direction of the radiated electromagnetic waves.

The field strength required to perform the test is generated using a calibrated RF (radio frequency) antenna, one of the most important tools. The frequency and power level are set according to the given standard and test requirements. During the test, the device is tested at different frequencies (usually from 80 MHz to 1 GHz, 1 GHz–6 GHz), as different electromagnetic interferences can occur at different frequencies. The test spectrum is often defined by the given device and industry standards (MSZ IEC 1000-1-1). During the test, the device is monitored to see if the normal operation of the device is

interrupted or malfunctions due to the radiated electromagnetic field. Any malfunctions or disturbances of the device (e.g. freezes, faulty signals, or malfunctions) are recorded

Radiation Modes: The device can be tested with different types of interference:

- ☐ Direct radiation (when the device is directly exposed to radiation)
- ☐ Reflected radiation (when radiation is reflected from surrounding surfaces).

6. Tools used for measurement

The rack cabinet houses the BBA150 (Figure 1) is a broadband amplifier designed for various radio frequency (RF) applications. Its frequency range can be from 4 kHz to 6 GHz. This amplifier is particularly suited for use in laboratory and industrial environments where signal amplification is required across a wide frequency range. The NRX Power Meter (Figure 2) is an advanced precision instrument designed for measuring radio frequency (RF) power. It is widely used in both laboratory and industrial environments where accurate and reliable power measurement is essential. The SMCV100B (Figure 3) is an advanced vector signal generator primarily used in telecommunications, radio frequency (RF), and broadcast applications. This device is capable of generating various modulation formats and signals, making it an ideal tool for engineers working in development, testing, and research.



Figure 1. BBA150 broadband amplifier



Figure 2. NRX power meter



Figure 3. SMCV100B vector signal generator

The R&S®ESR 26 (Figure 4) is an EMI test receiver designed for measuring electromagnetic interference (EMI) using classic step-by-step scans or ultrafast FFT-based time domain scans. It also functions as a powerful signal and spectrum analyzer. The receiver features real-time spectrum analysis with a wide range of diagnostic tools for detailed analysis of interference signals and their characteristics. These tools enable users to detect hidden or intermittent emissions and analyze their causes. The R&S®ESR features intuitive menus on a user-friendly touchscreen. Its compact dimensions, low weight, an optional heavy-duty enclosure, and an optional DC power supply make the R&S®ESR the ideal choice for mobile use (www.rohde-schwarz.com).



Figure 4. ESR 26 EMI test receiver

The HL562e antenna (Figure 5) is a specific device used for measuring EMC immunity, especially for testing the effect of radiated electromagnetic fields. The HL562e type antenna is usually a dipole antenna that provides optimal performance for measuring the radiation of electromagnetic waves in various frequency ranges.



Figure 5. HL562E antenna

7. Evaluation of results

A device can be considered compliant based on the test if it can withstand the specified level of electromagnetic radiation without any significant change in its operation, or if the effects of the disturbances remain within the permitted limits. The commercial product under test was tested in the frequency range of 200 MHz–1 GHz. The standard requires a field strength of 10 V/m for these measurements. The receiver may deviate from this, in this series of measurements, which also included the measurement shown in the picture, we tested the product at electric field strengths of 7 V/m, 9 V/m, 10 V/m, 12 V/m and 15 V/m. The product shown in the picture was tested in the presence of a field strength of 7 V/m.

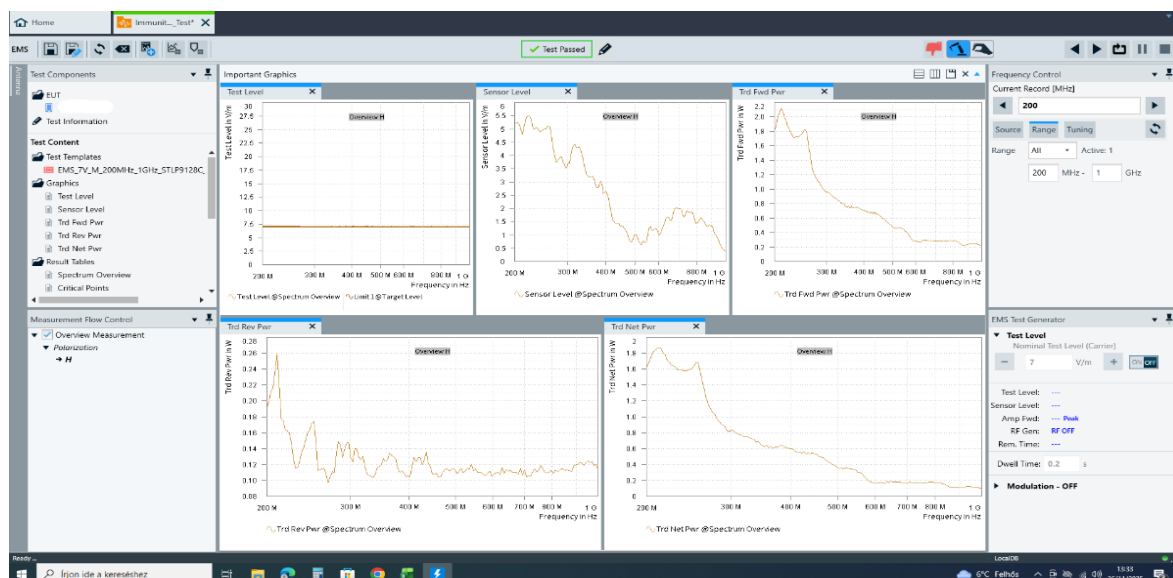


Figure 6. Measurement program while running TEST PASSED

The measurement was successful, the product withstood the field strength of 7 V/m radiated onto it without any errors in a horizontal antenna position. The measurement is shown in Figure 6.

If disturbances occur in the operation of the device during the test, the manufacturer or developer must modify the device to comply with EMC regulations. The tested commercial product was tested in the frequency range between 80 MHz–200 MHz. This measurement is also part of the previous measurement series. This measurement was carried out using a field strength of 15 V/m.

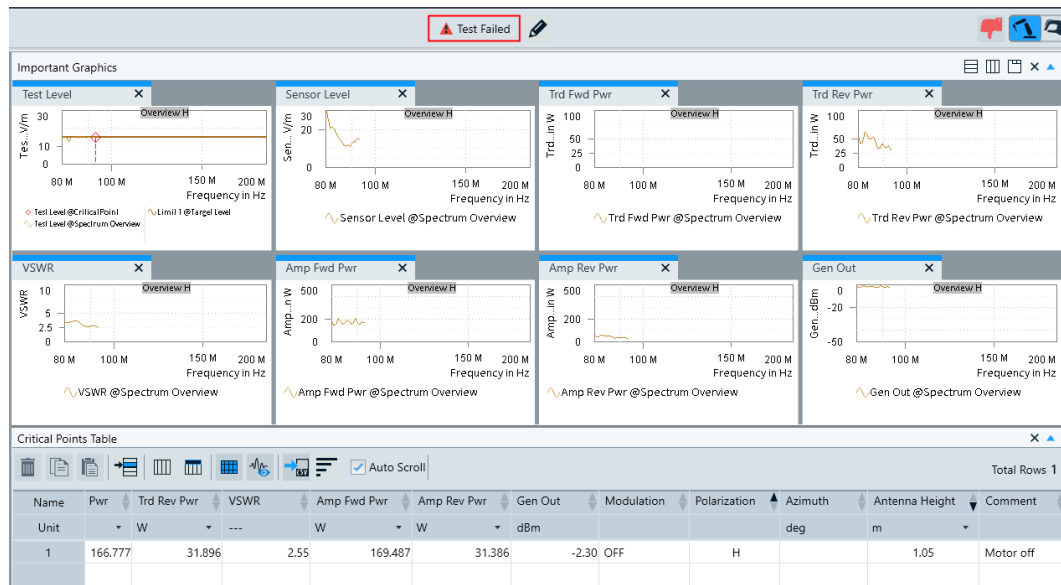


Figure 7. Measurement program while running TEST FAILED

Unfortunately, the product to be measured stopped at a frequency of 93 MHz. It did not start further. After detecting the error phenomenon, at a critical point, the comment field was marked as motor off. The measurement is shown in Figure 7.

8. Conclusions

Which level did the device pass during the test:

- Criteria 'A' (Pass): The device worked continuously during and after the test, without any problems.
- Criteria 'B': The problem was a temporary error (e.g. display flashing, data transfer slowdown), but after the problem disappeared, the simple operation error was restored.
- Criteria 'C': The device stopped or froze and can only be restored by user intervention (e.g. restart, reset).
- Criteria 'D' (Fail): The device suffered permanent damage or data loss. (www.mpbelectronic.com)

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