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An Introduction to Electromagnetic Compatibility (EMC) Standards

In the design of power systems, engineers have long considered how to minimize the potential for causing interference with the operation of sensitive electronic equipment. Such interference could occur when electromagnetic fields or transient events associated with the operation of the power system interact with this equipment, overcoming the desired signals and causing system malfunctions. The ability of electrical or electronic equipment to function satisfactorily in its intended operating environment without causing electromagnetic disturbances that adversely affect other equipment is known as electromagnetic compatibility (EMC). The recent proliferation of microprocessors in applications ranging from computers to delicate medical equipment has greatly increased both the incidence and seriousness of EMC problems. To provide guidelines on how to reduce electromagnetic interference, several professional organizations are working on EMC standards.

This EPRI Resource Paper was written to increase energy providers' awareness of EMC Standards. It is intended to provide an introduction to EMC standards and related topics that may be of use to power engineers in practical matters, such as evaluating and dispatching customer complaints, or applying EMC Standards in the conduct of their business. The insights derived may be useful for understanding the nature and sources of customer EMC problems and the appropriate testing standards, evaluating vendor claims or power equipment testing requirements, or enhancing the installed reliability of provider or customer equipment.

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Background

The earliest power system EMC problem was interference with the telephone system from magnetic coupling to the telephone lines. Later, interference with AM broadcast receivers from high-voltage corona or gap discharges became a serious issue. More on EMC history is given in Appendix A. Today, attention has shifted to interference involving hand-held radios, power lines located along railroad rights of way, and potentially sensitive electronic systems.The original EMC problems were "mitigated" using methods such as reconfiguring the architecture of the telephone system to minimize magnetic coupling, reducing corona discharges on high voltage transmission lines and repairing gap discharges on distribution lines to minimize electromagnetic interference (EMI). In the process of mitigating them, however, it was recognized that the development of industry wide standards for measurement and design would be of great benefit. New problems have emerged and are bringing the issue of EMC to the attention of Energy companies once more. Consider some of these real-world EMC problems:

- Hand-held radios used by power personnel have interfered with the operation of microprocessor relays and caused malfunction of distribution circuit breakers.
- Electromagnetic fields from power lines located along railroad easements have caused malfunction of railroad signaling systems.
- Electromagnetic fields from spark discharges on distribution lines near airports have interrupted communication between the control tower and airplanes on landing approaches.
- Electromagnetic fields from currents injected into the power system by power electronic controllers, known collectively as Flexible AC Transmission System (FACTS) devices, have caused false blocking signals on relay communication systems using a power line carrier (PLC).
- 50/60 Hz Magnetic fields near power facilities have affected certain CRT displays, causing complaints.
- Power line wide-band communications (Internet access) systems have caused interference with licensed government and amateur radio communications services.

Many new types of EMC problems are not well understood and effective methods to mitigate them have not yet been developed. In the process of resolving these issues, it is important to understand existing EMC standards that may be relevant and their application to real problems. Standards provide guidance in implementing uniform testing techniques for controlling EMI and ensuring compatibility of control equipment used in the generation and transmission of electric energy.

Also contributing to new EMC problems is the changing electromagnetic environment of the power system. Higher voltage transmission, for example, has resulted in more corona and higher currents on transmission and distribution lines have caused higher magnetic fields. In addition, maintenance and staffing reductions have contributed to more difficulty with locating and repairing arcing sources on the distribution lines. The use of power electronic devices has resulted in more intense electromagnetic fields at higher frequencies. Also, proposed wide-band power line communications systems may generate additional high frequency electromagnetic fields.

Power companies should thus be concerned about EMC standards because they will help resolve EMC problems in their generating plants and power delivery facilities. Standards will also help ensure that equipment made available by vendors meets industry EMC requirements.

The Role of Standards in Resolving EMC Problems

Over the years, power companies' involvement in the development of standards has been through organizations such as the IEEE, ANSI, CISPR and the IEC. These efforts have yielded standards for the measurement and limitation of radio noise and on the susceptibility of microprocessor-based relays to RF fields. Already these efforts have played a large role in mitigating power transmission EMC problems.

In parallel with these efforts, numerous other industry-specific EMC standards have been developed. Originally, standards were written by and for the military and their contractors. They were interested, for example, in the compatibility of radios and vehicles or radar systems and sensitive receivers. In more recent years, however, the use of European EMC standards for conformity testing of commercial products has increased dramatically. The European Union (CE mark) requirements have driven the implementation of EMC standards requiring immunity (interference tolerance) testing for commercial products bound for Europe.

Energy Provider EMC Issues

Energy provider EMC problems are mainly related to two issues: First, the electromagnetic emissions caused by operation of the power system that might cause "harmful interference," and second the immunity of power control and communications equipment to the electromagnetic disturbances from the environment in which it operates. Standards and other reference documents that apply to both types of issues have been written and are discussed here.

Power Frequency Emissions

The operations of generating and distributing electric energy produce electric and magnetic fields that may interfere with the normal functioning of provider or customer equipment. They may disrupt systems such as cathode ray tube (CRT) computer monitors, photolithography systems or electron microscopes. These power frequency fields may also cause malfunction of railroad signaling systems. Railway EMC concerns are covered in the European Standard series EN 50121 and the "Blue Book" of the American Railway Engineering and Maintenance-of-Way Association (AREMA) (1)(2). These references are useful for designing power lines to be compatible with railroad signaling and communication operations.

Harmonic Frequency Emissions

Nonlinear loads may cause voltages and currents and their resultant electric and magnetic fields to occur at low-order harmonic frequencies. These currents are well known sources of transformer damage and their associated fields can couple into interference receptors such as analog telephone systems.

The management of harmonic frequency currents and their fields is one aspect of "power quality" (PQ). Although power quality is not EMC, the two topics are related. Power quality is generally restricted to outages and low frequency disturbances (< 9 kHz) that are conducted to equipment through the electricity lines. EMC is considered to be wider bandwidth disturbances that reach "victim" equipment through electric and magnetic field coupling. These coupling paths may also relate to safety concerns due to grounding systems. In the US, the quality of power is monitored in accordance with IEEE-1159-1995. (3) In Europe, EN 50160-1999 addresses the important characteristics of the voltage at the customer's terminals in public low-voltage (LV) and medium-voltage (MV) distribution systems. (4)

Transient Emissions & Immunity

Transient currents and fields are caused by distribution switching operations or lightning induced effects. These events may interfere with the operation of distribution equipment and are the subject of several EMC Standards. There are no regulated limits on the transient electromagnetic fields or voltages in power plants and substations. However, guidance on acceptable equipment immunity levels can be found in CIGRE 36.04 and IEC 61000-6-5. (5) (6) Table 5 shows the transient immunity tests that ensure functional reliability of energy production and distribution equipment by testing to immunity types and levels of susceptibility from realistic simulations of the hostile power environments.

Radio Frequency Emissions

The power system may also generate radio frequency interference (RFI), which can interfere with the operation of communication and navigation systems, long or medium wave radio and television broadcast, aeronautical beacons, amateur radio and aircraft communication. Table 4 shows standards for common power system emitters, including corona from HV transmission lines, "tracking" or "scintillation" across the surface of contaminated string insulators, and gap discharges (arcing) from imperfections in the LV distribution hardware. Other emitters include HVDC converters, VAR compensation equipment or FACTS devices—which may produce RFI up to a few MHz—power line carrier (PLC) systems, and recently proposed systems for providing consumer broadband services via power lines.

Legal Implications

Normally operating power systems are defined as "incidental radiators," in Part 15 of the US government telecommunications regulations (47CFR15). (Power systems do not radiate RF energy as an intended aspect of power system operation, but rather "incidentally" as a by-product of their operation.) (7) As a result, "harmful interference" as defined in 47CFR15 must be avoided. The Federal Communications Commission (FCC) defines such harmful interference as "any emission, radiation, or induction that endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunications service operating in accordance with this chapter." According to the Commission, "The operator of a radio frequency device shall be required to cease operating the device upon notification by a Commission representative that the device is causing harmful interference. Operation shall not resume until the condition causing the harmful interference has been corrected."

This standard normally applies to power line emissions from incidental sources, such as corona or gap discharges. In the case of corona, transmission lines are designed to reduce the associated noise to acceptable levels. Gap discharges usually occur in aging systems and are addressed by preventative maintenance and mitigation of the arcing problems as they occur. Standards for this type of interference are usually related to line design and measurement issues rather than the setting of limits, such as IEEE-430 (1992) and CISPR 18-2 (1996-12). (8)(9) A major exception to this is the Canadian Standard CAN3-C108.3.1-M84, which sets limits for RFI from corona at the edge of the right-of-way. (10)

When the power system is used as a "carrier current" for communications, 47CFR15 defines the power line as an "unintentional radiator" and provides specific limits on emissions. In addition, there are several European national standards, of which the UK Draft MPT 1570 standard, "Radiation Limits and Measurement Standard," is one example. (11) The limits contained in these standards could present severe constraints on the operation of wide-band power line communication systems.

Other Emissions

Energy provider-owned microwave systems and hand-held radios and non-power communications systems mounted on leased tower space must be considered as sources of EMI because they are often used near sensitive provider-owned control and communication systems. (The standards that apply to these devices relate to human exposure limits and are not discussed here.)

Although unintended, transmission towers and overhead grounding systems may also act as "parasitic" sources that reradiate other signals. This effect can cause the radiation patterns of AM broadcast antennas to be modified (12) and can degrade signals from the nationwide differential global positioning system (NDGPS) network.

Immunity in the Power Systems Environment

Energy companies often depend upon equipment that may not be immune to the electric and magnetic environment generated by the power system itself. Examples include CRT monitors and magnetic fields (covered in EN55024), (13) distribution relays and susceptibility to RF fields from hand held radios (covered in ANSI C37.90), (14) or control instrumentation in substations that may be susceptible to the operation of contactors or circuit breakers. The immunity standards that apply to such equipment are shown in Table 5. It is important that equipment acquired for use in these environments be tested for immunity to the typical interference threats found in the substation environment.

In Europe, an EMC Directive addressing electromagnetic compatibility between the power emissions sources and the customers' equipment (89/336EEC) was enacted in 1992. The "harmonized" standard for power quality used throughout Europe (EN50160) states: "It should be noted that this question is addressed directly by other standards, already published or in preparation: Emission standards govern the levels of electromagnetic disturbances which customers' equipment may be allowed to generate. Immunity standards set down disturbance levels that the equipment should be capable of tolerating without undue damage or loss of function. A third set of standards, for electromagnetic compatibility levels, has the function of enabling coordination and coherence of the emission and immunity standards, with the overall objective of achieving electromagnetic compatibility." (4)

Table 1
Types of EMC Tests

	Emissions	Immunity
Conducted	1	3
Radiated	2	4

The Structure of EMC Standards

EMC Standards are structured around prescribed tests for conducted (e.g. through wires) and radiated (through space) effects. What comes out of a product is measured by emissions tests. What is imposed onto a product is referred to as immunity, or susceptibility, testing. The four quadrants shown in Table 1 represent the four major types of EMC tests:

1. Conducted Emissions (samples RF noise voltages "kicked-back" into the power lines)
2. Radiated Emissions (uses antennas to measure RF "leakage" & re-radiation from wires)
3. Conducted Immunity (imposes interference into wires)
4. Radiated Immunity (radiates electromagnetic waves onto the product)

These types of tests are performed using EMC Standards to guide the test engineers. In the US, the concept of "harmful interference" applies, and conducted emissions and radiated emissions testing (against CISPR limits) on typical electronics is required, which limits the amount of EMI emitting from these items. Products must withstand interference and operate safely, and must not cause harmful interference (items 1&2 above). (7)

Figure 1. CE Mark

In Europe, the EMC Directive (89/336EEC) addressed all products that may cause emissions or whose performance may be affected by electromagnetic interference. The "Essential Requirements" of the Directive were that products not disturb radio, telecommunications, or other products (emissions limits) and that they have adequate levels of intrinsic immunity to interference to operate as intended (immunity requirements). The Directive also requires the application of the "CE Mark" for all consumer, commercial, industrial, scientific, or medical electronic products—virtually all electrical and electronic products or installations (Figure 1).

The presence of this Mark is a legal statement indicating that the product meets the Essential Requirements of the Directive and that "harmonized" standards were used to assess the product for conformity to emissions and immunity (susceptibility) requirements. (In other words, it was tested in all four quadrants of Table 1.) Full EMC compatibility is more likely to be assured, however, by the addition of related immunity tests, because customers often regard "reliability" as the most important feature of a product and identify a product that is more "immune" from interference as a more reliable product.

The E.U. standards structure is thus based on a hierarchy of Basic, Generic, and Product Standards, as shown in Figure 2:

1. Basic Standards describe the phenomena we're trying to simulate, like the damaging effects of ESD or lightning, or how to measure radio emissions coming from products.

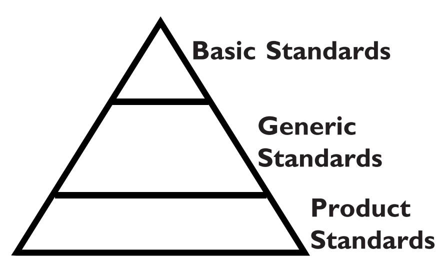


Figure 2. European Standards Structure

2. Generic Standards describe the genre (location) where the product will be used, such as consumer or commercial versus heavy industrial settings.
3. Product Standards describe the mixture of emissions and immunity tests to be applied to a particular product type, often industry-specific.

When the EMC Directive was published in 1992, many product standards had not yet been written, and the affected manufacturers used the generic standards for guidance in the application of tests. The generic standards simply covered emissions & immunity testing in light industrial and heavy industrial product locations (genres).

As product standards were written, they focused on six major product areas:

1. Industrial, scientific, & medical (ISM) products (15)
2. Industrial process, measurement, & control (IPM&C) products (16)
3. Broadcast receivers & consumer electronics
4. Tools & appliances
5. Lighting equipment
6. Information technology equipment (ITE), such as computers and telephone products (17)

Table 2 provides details on MIL, US and EU Standards used to assess these types of products.

Emissions testing for these products tries to limit the amount of EMI (interference or radio leakage) radiated into the environment. The Generic Standards of the 1990s required that a product be tested for conducted & radiated emissions related to CISPR limits. (15)(17) Conducted emissions testing imposes limits for the amount of voltage a product may inject back into its power lines, which can cause re-radiation from those lines or other harmful effects. Conducted emissions limits for IPM&C products (16) are shown in Figure 3 for Class A (industrial) products. To compare actual product performance to the EMI limits, radiated emissions are measured on an open area test site (OATS) or suitable anechoic chamber and compared to limits such as that shown in Figure 4.

Immunity standards attempt to ensure EMC compatibility between a product and the environment in which it is used. The Generic Standards of the 1990s required immunity testing for radiated and transient immunities. Radiated immunity was mandated from 26–500 MHz without modulation at field strengths as high as 10 V/m at 3 meters distance. This Standard has now been changed to 80–1000 MHz with AM modulation and cell-phone (pulsed) modulation to more accurately simulate modern RF environments. (19)(13)

Table 2
EMC Standards Matrix

Type of Disturbance	**Emissions**	**Immunity**
Conducted RF (wires)	MIL, US, EU	MIL, **EU**
Radiated RF (air)	MIL, US, EU	MIL, EU
Power-line related	**EU, Harmonics**	**EU, Magnetic fields**
	EU, Flicker	**EU, Dips & interrupts**
Electrostatic Discharge		EU
Electrical Fast Transient		EU
Surge		**EU**

Additional Standards Required After 2001

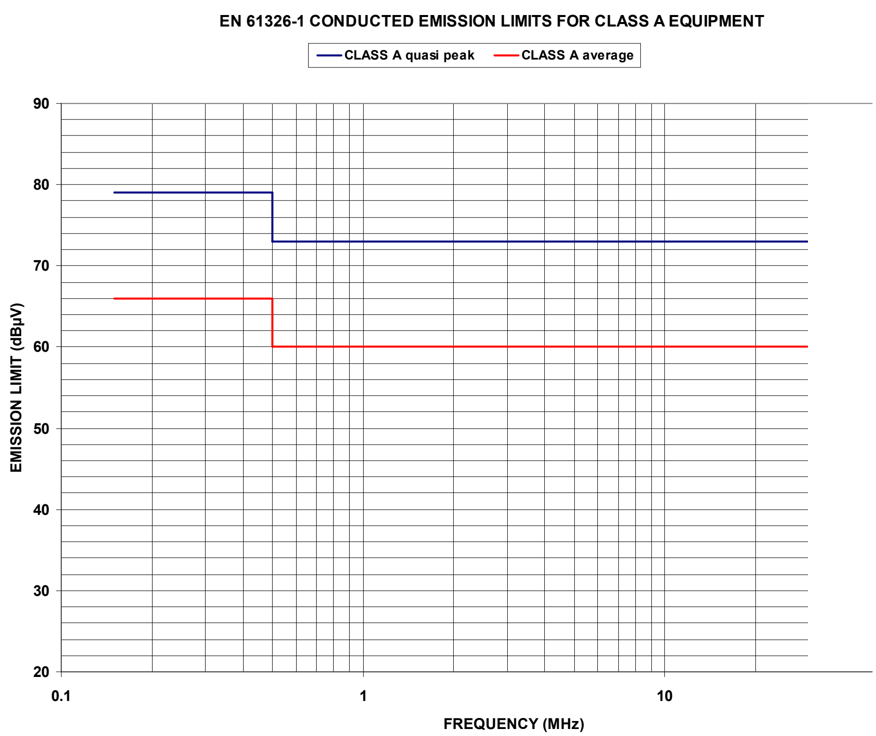


Figure 3. Limits for Conducted Emissions

Since this test required intentionally transmitting RF energy, it was necessary to conduct such radiated immunity testing within a shielded fully anechoic chamber, without outside radio leakage or internal reflections, as shown in Figure 5. Testing for transient immunity, in the form of electrostatic discharge (ESD) and electrical fast transient (EFT), was also required. (18) (20)

ESD testing required an appropriate simulator (ESD "gun") with plate antenna and accessories for floor standing or table top products. Newer versions of this standard require the direct injection of sub-nanosecond voltages up to 8 kV, and air discharges to 15 kV,as shown in Figure 6. The IEC 61000–4-2 Standard (18) requires the use of this "contact mode" method to ensure repeatable testing results on metal encased products.

EFT (or burst) testing simulates the rush of arcs that repeatedly form and extinguish when a magnetic field collapses across the opening contacts of a switch. This "showering arc" or "burst" of short rise-time, short duration pulses is problematic for products using microprocessors. In poorly decoupled products, the noise pulses are mistaken for data or timing information, and product latch-up is a common result. The immunity standard requires common-mode testing on power and I/O lines, at repetition rates from 2.5–5.0 kHz. Many nondestructive field failures can be simulated in the laboratory by using higher repetition rates, (20) and the Guide on EMC in Power Plants and Substations prepared by the CIGRE Working Group 36.04 in 1997 calls out various repetition rates up to 1 MHz. (5)

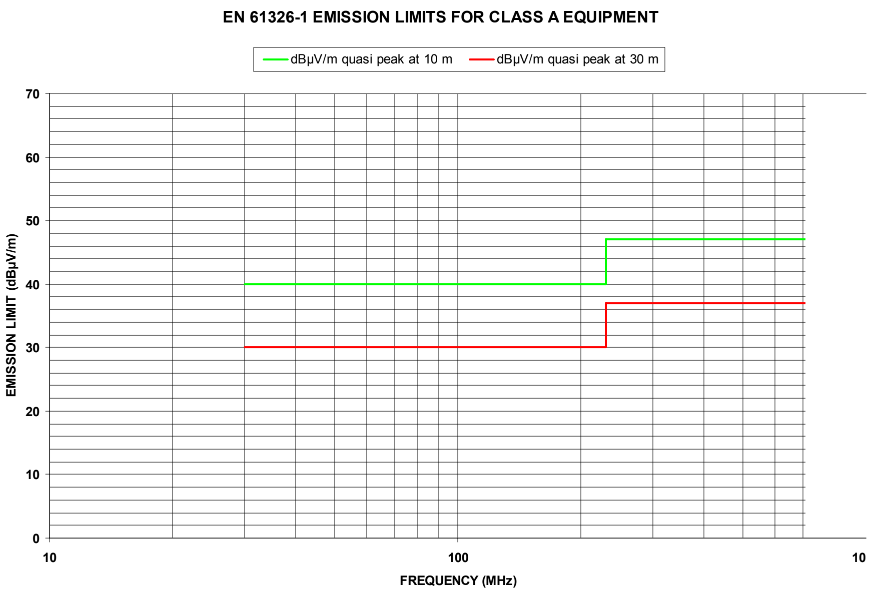


Figure 4. Limits for Radiated Emissions

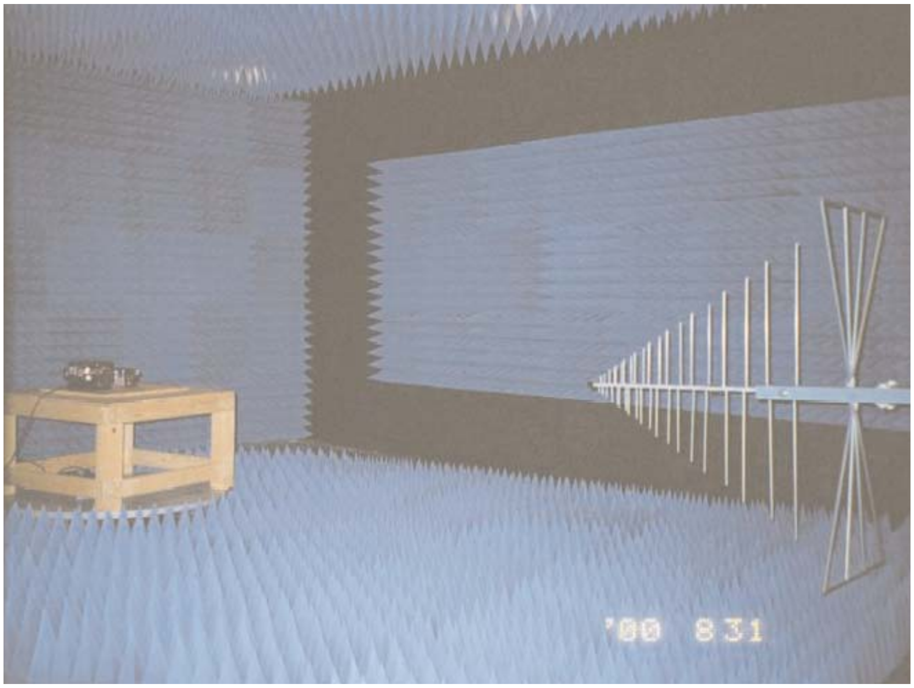


Figure 5. Fully-Anechoic Chamber

Compliance & Enforcement

Compliance with the CE Marking requirements for intentional radiators—those products that intentionally transmit RF energy when being used—mandates the Type Acceptance Route to market. This route imposes testing by a recognized or accredited laboratory and/or submission of product samples to the appropriate national authorities. For unintentional radiators—those products that may accidentally emit RF energy (the vast majority of consumer and commercial items)—there are two routes to conformity with the essential requirements of the EMC Directive.

1. Standards Route – for simple products that will pass all the "harmonized" tests in their product standard
2. Technical Construction File – for products where :
   - There is no harmonized European EMC Standard;
   - Standards exist, but can only be applied in part;

- Testing to harmonized Standards is not practical, due to size, location, etc.;
- A large number of product variations makes testing each combination impossible;
- Other recognized EMC Standards were used, such as MIL-STD, etc.

Enforcement of the E. U. Directive rests with each national authority. In the UK, for example, the trading standards departments of the local authorities can levy civil penalties of three months and/or £5,000, or both. Competitors typically provide good leads on where violations are occurring. In the US, trade show exhibits are scanned by the FCC to detect "harmful interference," and products are also acquired and tested by the Commission. In both markets, complaints drive the enforcement process, with authorities launching an investigation after a complaint from a user or a competitor comes in. The data in Europe are archived by the manufacturer's representative or legal agent. In the US, the data are required to be on file with the manufacturer. In either case, only a national authority can compel the delivery of the test data. In most cases, a manufacturer issues a "Declaration of Conformity" stating which standards were used to test the product and to establish compliance with the essential requirements of the EMC Directive in Europe, or with due diligence and good manufacturing practice for self-declaration in the US.

Large manufacturers typically utilize their own in-house EMC Qualification testing facilities, and smaller firms often use third-party test houses for assessing conformity. In either case, many manufacturers will attempt some "pre-qualification" testing at their plants to quantify their EMC concerns and evaluate the effectiveness of any modifications. Often, such equipment is low-cost and non-compliant, but still useful. Some firms use a non-conforming test site—such as their laboratory test floor—and clever engineers can implement non-standard uses for immunity test equipment to expose design weaknesses.

Some of these test laboratories have mutual recognition agreements with accrediting firms in other jurisdictions. Many of these testing bodies also offer private labels, or "marks," which reflect the levels of testing undertaken. While not replacing the CE Mark or its legal responsibilities, these "marks" could indicate the testing types, levels, and performance criteria to which the product was subjected.

Product Examples

Three common power-measuring instruments illustrate the recent regulatory burden for manufacturers of industrial process, measurement, and control (IPM&C) instruments bound for Europe in the 1990s. (16) This classification would include such common items as portable oscilloscopes, hand-held DVM's, and common panel meters used in power control settings. The testing burdens for these types of instruments are shown in Table 2. Conducted emissions and radiated emissions are required in the US and Europe and in some smaller markets as well. Products

Table 3
Performance Criteria During Immunity Testing

Type A	EUT performs normally during the test.
Type B	EUT performs normally after the test, without loss of stored data or change in operational mode. Performance degradation is allowed during the test.
Type C	A & B apply, but normal performance after the test requires operator intervention.
Type D	Non-recovering failure (damage).

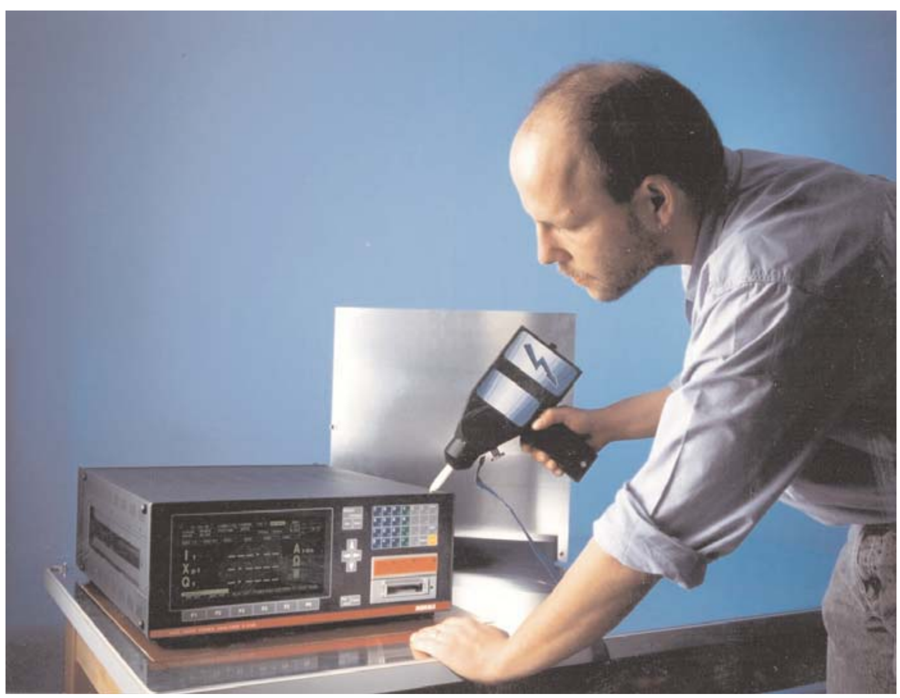


Figure 6. Table-top ESD Testing

Table 4
EMC Emissions Standards

EN55011(1991)	**Emissions from Industrial, Scientific, & Medical equipment**
EN55013(1998)	Emissions from Broadcast Receivers
EN55013(1998)	Emissions from Broadcast Receivers
EN55014(1993)	Emissions from household appliances and tools
EN55015+A2(1999)	Emissions from lighting equipment
CISPR 18-2(1996)	Emissions from overhead power lines & HV equipment
EN55022(1998)	**Emissions from Information Technology Equipment**
IEEE 430(1992)	Emissions from overhead power lines & substations
MIL-STD-461E	Radiated & Conducted Emissions from U.S. military products
FCC (47CFR15)	Emissions from U.S. commercial electronics
EN61000-3-2(1995)	**Conducted harmonic emissions from products drawing up to16AMPS**
EN61000-3-3(1995)	**Voltage fluctuations (flicker) emissions from products up to 16AMPS**

Figure 7. Level-setting Procedure

bound for Europe (CE-marked) and many other high-quality products are subjected to immunity testing as well.

Equipment purchased by energy companies is often sold in Europe and tested according to the product standard for the IPM&C equipment (IEC 61326-1). However, energy providers have also recognized that these requirements may not be sufficient to guarantee immunity in the power station and substation environments, which are both different and more severe. For this reason, IEC Standard 61000-6-5 has been developed to specify additional tests that more closely mimic the power station and substation environment (the Basic Standards within IEC 61000-6-5 are shown in bold in Table 5). All Immunity testing is carried out while monitoring the performance of the equipment under test (EUT.) In order to fully specify an immunity test and get consistent results, it is necessary to quantify the EUT performance criteria during immunity testing. The European Immunity Standards use the definitions in Table 3.

Only CE-marked products or those designed to meet the highest standards are generally tested for immunity at all, and this testing is not required for many markets, such as consumer products in the US or Asia. The question thus arises, Is such "commercial grade" equipment good enough for power system environments? Probably not. In practical terms, only products that are CE-Marked should be considered for heavy industrial or professional use, because the cost of down time is just too great. For this reason, many manufacturers voluntarily test their products for immunity, even if they are not shipping them to Europe.

A practical approach to ensuring compatibility and reliability at power plants and transmission substations levels is provided by the Guide on EMC in Power Plants and Substations prepared by the CIGRE Working Group 36.04 in 1997. (5) Aspects of this approach include:

- Characterize worst-case disturbances, then choose reasonable immunity levels;
- Ensure that no level of distur-

bance above the threshold level can arise;

- Specify acceptance criteria for each function of automation and control systems;
- Specify the equipment and installation practices to provide the immunity levels required;
- Specify the tests to verify that these goals have been achieved

The CIGRE survey of standardized procedures used to carry out the tests is based on IEC 1000-4-x series of immunity tests. The EMC Standards cited by the CIGRE Guide on EMC in Power Plants and Substations are highlighted in Table 4 (Emissions) and Table 5 (Immunity.) In Europe, these standards are also cited in IEC 61000-6-5, Immunity for power station and substation environments. (6)

"New" EMC Standards

For CE Marking in 2001, six new standards were added to those previously discussed—four immunity standards and two emissions standards, shown highlighted in Table 2. These standards include:

1. Surge–Modern buildings often feature lightning rods for the dissipation of energy from "direct" lightning strikes, but the electromagnetic effects of these events are destructive to wire-connected products within about five miles. To simulate the damage inflicted by these "indirect" strikes, IEC 61000-4-5(1995) describes methods, waveforms and energy levels for testing power, I/O and telecoms lines. (21)
2. Conducted RF Voltages–With the increasing density of RF emitters, the ability of cabling bundles to withstand immersion in RF fields from intentional transmitters is crucial. IEC 61000-4-6(1996) details test equipment and methods for simulating the effects of external transmitters inducing modulated RF voltages onto power and I/O lines. Voltages are usually applied with Coupler Decoupler Networks (CDN's) for most common lines, and the level of interference is established with a level-setting procedure shown in Figure 7. (22)
3. Power line Magnetic Fields–With increasing reliance on computers and telecommunications equipment, their resistance to power line magnetic fields is essential when they are installed near power distribution equipment or other magnetic sources. IEC 61000-4-8 (2001) uses induction coils to produce a 50-60 Hz H-field that is brought near a product or into which a product is placed. (23)
4. Power Dips & Interrupts–Some products are more sensitive than others are to momentary interruptions or longer perturbations on their power inputs. IEC 61000-4-11 (2001) simulates both rapid, short sub-cycle dips and the longer, slower interruptions seen in motor intensive locations. (26)

Table 5
EMC Immunity Standards

EN50082-1(1997)	Generic immunity; residential, commercial, & light industrial locations
EN55014-2(1997)	Immunity of household appliances and tools
EN55020(1994)	Immunity of broadcast receivers
EN55024(1998)	Immunity of Information Technology Equipment
MIL-STD-461E	Radiated & Conducted Immunity for U.S. military products
IEC61000-4-2(1999)	**Immunity to electrostatic discharge**
IEC61000-4-3(1998)	**Immunity to radiated RF electromagnetic fields**
IEC61000-4-4(1995)	**Immunity to electrical fast transient (burst)**
IEC61000-4-5(1995)	**Immunity to indirect lightning strike (surge)**
IEC61000-4-6(1996)	**Immunity to conducted disturbances from RF fields**
IEC61000-4-8(2001)	**Immunity to power frequency magnetic fields**
IEC61000-4-9(2001)	**Immunity to pulsed magnetic fields**
IEC61000-4-10(2001)	**Immunity to damped oscillatory magnetic fields**
IEC61000-4-11(2001)	**Immunity to voltage dips & fluctuations on AC mains**
IEC61000-4-12(2000)	**Immunity to oscillatory waves**
IEC61000-4-13(Ed. 1)	**Immunity to harmonics & inter-harmonics at AC power ports**
IEC61000-4-16(1998)	**Immunity to conducted disturbances from 0-150 kHz**
IEC61000-4-17(1999)	**Immunity to ripple on DC power inputs**
IEC61000-4-27(2000)	Immunity to phase imbalance
IEC61000-4-28(1999)	Immunity to power frequency variations
IEC61000-4-29(2000)	Immunity to voltage dips & fluctuation on DC mains

5. Power line Harmonic Emissions–Switched-mode power supplies commonly used in modern computer equipment draw short pulses of current at the tips of the applied line voltage. This non-sinusoidal current is rich in harmonics of the fundamental line frequency, and these high-order currents can be harmful in power distribution networks. This "emission" is addressed in EN 61000-3-2 (1995), which establishes test methods and limits for these harmonic currents for single-phase products drawing 16 AMPS or less. (33)
6. Power line Flicker Emissions–Variations in the current demand of electrical and electronic products can cause the line voltage to sag, and if these demands are recurring, the lights can "flicker" or vary in brightness. This annoyance is more dangerous at frequencies and intensities that can precipitate seizures in some susceptible individuals. These variations in brightness, and their cause, variations in load, are addressed in EN 61000-3-3 (1995) using a stable laboratory AC supply, reference impedance and a "flickermeter." (34)

More "power tolerance" tests are slated for implementation in the future. Typically, a few years pass between groups of new standards, and two groups have been implemented from 1992-2001 in Europe. The first group was mandated in 1995, and the second group in 2001. Some of the new standards awaiting "harmonization" by CENELEC include:

1. Pulsed magnetic field immunity–IEC 61000-4-9(2001) uses the same induction coils as IEC 61000-4-8 to expose the product to pulsed (unipolar) magnetic fields by connecting the Combination Wave surge generator used in IEC 61000-4-(1995) to the induction coil. (24)
2. Damped oscillatory magnetic field immunity–IEC 61000-4-10(2001) uses a 100 kHz period "ring wave" generator driving the induction coil to produce changing polarities of magnetic fields. These can result from power switching operations. (25)
3. Oscillatory wave immunity–IEC 61000-4-12(1995) requires 100 kHz and 1 MHz damped oscillatory waveforms (27)
4. Harmonics, Interharmonics, & Mains Signaling–IEC 61000-4-13 (2001 Ed. 1) specifies testing for the immunity or "tolerance" of products to power frequency harmonics, interharmonics, and mains signaling (PLC) interference. (28)
5. Conducted disturbances from 0–150 kHz–IEC 61000-4-16(1998) indicates methods and limits for simulating conducted disturbances in the frequency range of DC to 150 kHz on power lines. (29)
6. Unbalance, immunity test–IEC 61000-4-27(2000) supplies information on the testing of products for tolerance to unbalanced conditions on the power mains. (30)
7. Variation of power frequency–IEC 61000-4-28(1999) specifies test conditions and performance criteria for "power tolerance" testing of products subjected to variations in the power frequency. (31)
8. Voltage dips, interruptions, & variations on DC power–IEC 61000-4-29(2000) gives test conditions and criteria for evaluating equipment subjected to assorted variations on the DC input power mains (32)

Summary

With the increasing speed and proliferation of sensitive electronics, coupled with ever more low-power wireless applications, the problems associated with EMC will only get worse unless appropriate standards are provided. Understanding the EMC Standards used to evaluate products for "reliability" helps power personnel choose equipment for their facilities that will ensure compatibility, and helps them assist customers in procuring equipment that is tolerant to outside interference. Service providers use power quality standards to measure the quality of the "product" they produce, but these standards are only an indication that the source, transmission medium, and load are compatible with each other. Understanding EMC standards helps utility personnel build and maintain reliable installations that produce good quality output, and helps them in their interactions with customers. (35)

Supplier- and consumer-side EMC characterization and testing is important, since they assure compatibility between the equipment of producers and consumers of electric energy. Currently, immunity testing is only required in Europe, but that is changing. Already, in the power, military and medical industries in the US, the push is on to implement a variety of immunity tests to ensure reliability and minimize risk.

Providers tasked with building or modifying generation or substation facilities are using CIGRE 36.04 and IEC 61000-6-5 to guide them in specifying and testing products that contribute to the installed reliability of the facility, not detract from it. These standards are based on the "Basic Standards" of the European Union, the most widely used and respected EMC standards currently in circulation, and test equipment is widely available for them. (5) (6)

Providers also want to offer customers the best quality product possible, and power quality standards are used to measure it. Providers can also help customers tolerate certain amounts of imperfection in the power delivered to them, as measured by new "Power Tolerance" tests. In fact, both power quality and power tolerance testing is required to ensure (EMC) between providers and their customers.

EMC Standards Organizations

North American EMC standards are published by the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), the Federal Communications Commission (FCC), and the Canadian Standards Association (CSA). European EMC standards are developed for CENELEC (the European Committee for Electrotechnical Standardization) and are harmonized across Europe based on existing IEC and/or CISPR standards. There are similarities between international and US standards. Emissions tests are required by both. Immunity tests are required in Europe and used for high-reliability applications in the US.

ANSI–The American National Standards Institute administers and coordinates the U.S. voluntary standardization and conformity assessment system. ANSI was founded in 1918 by five engineering societies and three government agencies and functions as a private non-profit membership organization. The primary ANSI standards for EMC are contained in the C63 series of standards.

CSA–The Canadian Standards Association is a non-profit, private, member-based association that develops standards. The CSA does recognize certain standards promulgated by other organizations. These "endorsed standards" are non-Canadian standards that have been reviewed by CSA and are approved for use in Canada.

CENELEC–The European Committee for Electrotechnical Standardization (Comite Europeen de Normalisation Electrotechnique) was established in 1973 as a non-profit organization. CENELEC has been mandated by the European Commission (EC) to adopt (harmonize) the standards necessary to show conformity with the Essential Requirements of the EMC Directive. CENELEC has the responsibility for producing harmonized European EMC standards and adopts proposed IEC standards as written or rejects them for a new EN standard. CENELEC Technical Committee TC210 is responsible for EMC standards (previously this was TC110). According to a 1991 agreement, the IEC has primary responsibility for the development of standards. When CENELEC identifies the need for an EMC standard, it asks the IEC to develop it. If the IEC is not in a position to carry out the requirements, CENELEC will perform the work itself.

CISPR–The International Special Committee on Radio Interference (Comite International Special Des Pertubations Radioelectriques) was set up in 1934 with the object of reaching worldwide agreement on control of radio interference and thus avoiding barriers to trade. CISPR covers the frequency range from 9 kHz to 400 GHz. It is a special committee of the International Electrotechnical Commission (IEC) differing from IEC's normal technical committees in that it has a wider membership. Technical committees are made up of national representatives from IEC member countries.

ETSI–The European Telecommunications Standards Institute is a non-profit organization established to produce telecommunications standards concerning telecom and radio transmitting equipment.

FCC–The Federal Communications Commission is an independent agency of the US Federal Government and is directly responsible to Congress. The FCC was established by the Communications Act of 1934 and is charged with regulating interstate and international communications by radio, television, wire, satellite, and cable. The FCC also allocates bands of frequencies for non-government communications services (the NTIA allocates government frequencies). The general EMC requirements in the US are set by the FCC. The Code of Federal Regulations (CFR) Title 47, Part 15 covers radio frequency devices capable of emitting RF energy in the range of 9 kHz to 200 GHz. Testing should be done in accordance with ANSI C63 standards.

IEC–The International Electrotechnical Commission (IEC), largely through its CISPR committee (established in 1934) generates EMC standards that address emissions, and through TC-77 (established in 1973) addresses immunity requirements and test procedures. The IEC works closely with CENELEC and the International Organization for Standardization (ISO).

ITU–The International Telecommunications Union is responsible for international frequency allocations and radio frequency spectrum management.

IEEE–The Institute of Electrical and Electronics Engineers was founded in 1884 and is the world's largest technical professional society. IEEE promulgates standards that apply to many subjects, including EMC topics in cooperation with ANSI.

ISO–The International Organization for Standardization is a worldwide federation of national standards bodies from about 140 countries. ISO is a non-governmental organization established in 1947 to promote the development of standardization and related activities. The work of ISO results in international agreements that are published as International Standards.

MIL-STD–US Military Standards are prepared by EMC personnel of the US Army, Navy, and Air force. The EMC requirements of the military are different from commercial needs and the Tri-Service EMC Committee revises and updates EMC standards as necessary. Military standards are generally more elaborate and tend to be more stringent than their non-military commercial or civilian counterparts. The primary military EMC standard is MIL-STD 461E, which covers EMC methods and limits. The basic concepts of MIL-STD-461 have been adopted by several non-US military organizations and also influence national and international standardization efforts.

NTIA–The National Telecommunications and Information Administration is an agency of the US Department of Commerce. The NTIA manages the Federal Government's use of the radio frequency spectrum and allocates government frequencies (the FCC allocates non-government frequencies).

Official Journal of the European Communities–The OJEC is published every day in all eleven official languages of the European Union (EU), containing material on legislation, information, and notices. An EMC standard is deemed to be "harmonized" once it has been published in the OJEC.

References and additional reading

(1) ENV50121-1: 1999 Railway applications–Electromagnetic Compatibility - Part 1 - General, The European Committee for Electrotechnical Standardization, 1st ed. Brussels, CENELEC 1999

(2) "Principles and Practices for inductive coordination of electric supply and railroad communication/signaling systems," Association of American Railroads and Edison Electric Institute, Joint Committee on Inductive Coordination, Washington DC and New York, 1977

(3) IEEE Std 1159-1995 IEEE Recommended Practice for Monitoring Electric Power Quality, Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York

(4) EN50160:1999 Voltage Characteristics of electricity supplied by public distribution systems, 1st ed. Geneva, IEC, 1999

(5) Guide on EMC in Power Plants and Substations. Prepared by CIGRE Working Group 36.04 (EMC within power plants and substations), 1997

(6) IEC 61000-6-5 (1999-03): Electromagnetic Compatibility (EMC) - Part 6-5: Generic standards - Immunity for power station and substation environments (CD). Geneva, International Electrotechnical Commission, 1999

(7) Code of Federal Regulations, Title 47, Volume 1, Part 15 - Radio Frequency Devices U.S. Govt. Printing Office, revised October 1, 1999 47CFR15.33 pages 664-665

(8) IEEE Standard 430, 1992 Standard Procedures for the Measurement of Radio Noise from Overhead Power Lines and Substations, IEEE, Inc. 345 East 47th St, New York, NY

(9) IEC / CISPR 18-2, Radio interference characteristics of overhead power lines and high voltage equipment, Amendment 2. 1996-12

(10) CAN3-C108.3.1-M84, 1984 Limits and Measurement Methods of Electromagnetic Noise from AC Power Systems, 0.15 - 30 MHz, Canadian Standards Association, Ontario, Canada

(11) Draft MPT 1570, Radiation Limits and Measurement Standard, Radiocommunications Agency, London, February 2000

(12) IEEE Standard 1260, "Guide on the Prediction, Measurement and Analysis of AM Broadcast Reradiation by Power Lines." 1996

(13) EN55024:1998 Electromagnetic Compatibility (EMC) - Immunity of Information Technology Equipment (ITE) The European Committee for Electrotechnical Standardization, 1st ed. Brussels, CENELEC 1998

(14) IEEE Std C37.90.2-1995 IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers, IEEE, Inc., New York

(15) EN55011:1998 Electromagnetic Compatibility (EMC) - Emissions from industrial, scientific and medical (ISM) equipment The European Committee for Electrotechnical Standardization, 1st ed. Brussels, CENELEC 1998

(16) EN61326-1:1997 Electromagnetic Compatibility (EMC) - Emissions and Immunity for Equipment for Measurement, Control, and Laboratory use The European Committee for Electrotechnical Standardization, 1st ed. Brussels, CENELEC 1997

(17) EN55022:1998 Electromagnetic Compatibility (EMC) - Emissions from information technology equipment (ITE) The European Committee for Electrotechnical Standardization, 1st ed. Brussels, CENELEC 1998

(18) IEC 61000-4-2 (1999-05): Electromagnetic Compatibility (EMC) - Part 2: Testing and measurement techniques–Electrostatic discharge immunity test 1st ed. Geneva, International Electrotechnical Commission, 1999

(19) IEC 61000-4-3 (1998-11): Electromagnetic Compatibility (EMC)–Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test 1st ed. Geneva, International Electrotechnical Commission, 1998

(20) IEC 61000-4-4 (1995-01): Electromagnetic Compatibility (EMC)–Part 4: Testing and measurement techniques–Section 4: Electrical fast transient/burst immunity test 1st ed. Geneva, International Electrotechnical Commission, 1995

(21) IEC 61000-4-5 (1995-02): Electromagnetic Compatibility (EMC)–Part 4: Testing and measurement techniques - Section 5: Surge immunity test 1st ed. Geneva, International Electrotechnical Commission, 1995

(22) IEC 61000-4-6 (1996-04): Electromagnetic Compatibility (EMC)–Part 4: Testing and measurement techniques–Section 6: Immunity to conducted disturbances, induced by radio-frequency fields 1st ed. Geneva, International Electrotechnical Commission, 1996

(23) IEC 61000-4-8 (2001-03): Electromagnetic Compatibility (EMC)–Part 4-8: Testing and measurement techniques–Power frequency magnetic field immunity test 1st ed. Geneva, International Electrotechnical Commission, 2001

(24) IEC 61000-4-9 (2001-03): Electromagnetic Compatibility (EMC)–Part 4-9: Testing and measurement techniques–Pulse magnetic field immunity test 1st ed. Geneva, International Electrotechnical Commission, 2001

(25) IEC 61000-4-10 (2001-03): Electromagnetic Compatibility (EMC)–Part 4-10: Testing and measurement techniques–Damped oscillatory magnetic field immunity test 1st ed. Geneva, International Electrotechnical Commission, 2001

(26) IEC 61000-4-11 (2001-03): Electromagnetic Compatibility (EMC)–Part 4: Testing and measurement techniques–Section 11: Voltage dips, short interruptions and voltage variations immunity tests 1st ed. Geneva, International Electrotechnical Commission, 2001

(27) IEC 61000-4-12 (1995-05): Electromagnetic Compatibility (EMC)–Part 4: Testing and measurement techniques–Section 12: Oscillatory waves immunity test. Basic EMC Publication 1st ed. Geneva, International Electrotechnical Commission, 1995

(28) IEC 61000-4-13 (Ed. 1.0): Electromagnetic Compatibility (EMC)–Part 4-13: Testing and measurement techniques–Harmonics and interharmonics including mains signaling at a.c. power port, low frequency immunity tests - Basic EMC Publication 1st ed. Geneva, International Electrotechnical Commission, 2001

(29) IEC 61000-4-16 (1998-01): Electromagnetic Compatibility (EMC)–Part 4-16: Testing and measurement techniques–Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz 1st ed. Geneva, International Electrotechnical Commission, 1998

(30) IEC 61000-4-27 (2000-08): Electromagnetic Compatibility (EMC)–Part 4-27: Testing and measurement techniques–Unbalance, immunity test 1st ed. Geneva, International Electrotechnical Commission, 2000

(31) IEC 61000-4-28 (1999-11): Electromagnetic Compatibility (EMC)–Part 4-28: Testing and measurement techniques–Variation of power frequency, immunity test. 1st ed. Geneva, International Electrotechnical Commission, 1999

(32) IEC 61000-4-29 (2000-08): Electromagnetic Compatibility (EMC)–Part 4-29: Testing and measurement techniques–Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests 1st ed. Geneva, International Electrotechnical Commission, 2000

(33) EN61000-3-2:1995 Electromagnetic Compatibility (EMC)–Part 3: Limits - Section 2: Limits for harmonic current emissions The European Committee for Electrotechnical Standardization, 1st ed. Brussels, CENELEC 1995

(34) EN61000-3-3:1995 Electromagnetic Compatibility (EMC)–Part 3: Limits - Section 3: Limitation of voltage fluctuations and flicker in low-voltage supply systems The European Committee for Electrotechnical Standardization, 1st ed. Brussels, CENELEC 1995

(35) Power System Electromagnetic Compatibility, EPRI Resource Paper, M. Silva, F. Young, and R. Olsen, December, 2000.

(36) Curtis, Leslie E. "Electrical Interference in Motor Car Receivers," Proceedings of the Institute of Radio Engineers, vol. 20 no. 4, April 1932, p. 674

(37) The History of Military EMC Specifications, Warren Kesselman, Herbert Mertel, IEEE-EMC Society Summer 2000 Newsletter

(38) Paul, C.R. Introduction to Electromagnetic Compatibility. New York: John Wiley & Sons, 1992.

Appendix A: History of EMC Standards

The 1930s introduced AM broadcast radio to many people, and with the rising use of electric motors, railroads, and signs, more EMI problems appeared. The Proceedings of the Institute of Radio Engineers (IRE) addressed vehicle EMI problems in 1932. (36) The IEC recommended in 1933 that an "International Special Committee on Radio Interference" (CISPR) be formed to quantify the emerging EMI problems and describe interference measuring equipment for the 150 kHz – 1.605 MHz range. At the CISPR meeting in 1934, it was agreed that the tolerable limits for interference would preserve a 40 dB signal-to-noise ratio when receiving the reference 1m V/M field strength modulated to 20%. (37) Radiated emissions testing was initially addressed, but voltages "leaking" from power cords, polluting the unfiltered power network and re-radiating into space mandated that conducted emissions testing be addressed as well.

In 1934 the US Army Signal Corps issued SCL-49, "Electrical Shielding & Radio Power Supply in Vehicles." From 1934-1939 CISPR issued Reports RI 1-8 specified receivers, field strength measurements and artificial mains networks (AMN or LISN) to stabilize the impedance of the power being supplied, so as to allow consistent voltage measurements. (37)

The need for EMC increased during World War II because of the growing numbers of electronic devices, such as radios, navigation receivers, and radars. Reports of interference on airplanes between radios and navigation equipment were handled on a case-by-case basis. EMC was made more urgent with the deployment of life-critical guidance, communication, and sonar and radar applications that tracked enemy ship, submarine, air and terrestrial locations. The earliest developments in Military EMC Standards were driven by vehicle EMI problems. (Figure 8) In 1942, The US Army Signal Corps issued 71-1303, later modified into JAN-I-225 in 1945.

CISPR met again after the War in 1946, and issued standards on conducted interference measurement techniques and recommended emissions limits and an artificial mains network (LISN) for the widely used broadcast band. (37) Post-war projects centered on radio noise from transmission lines, and EEI (Edison Electric Institute) and EPRI (Electric Power Research Institute) extended this work to the 1000 kV range. (35) Several national EMC organizations were also formed after the war, with technical committees to develop new standards.

EMC problems increased rapidly with the introduction of solid-state electronics, beginning with the bipolar transistor in the 1950s and the integrated circuit (IC) "chip" in the 1960s. The FCC licensed Citizen's Band (CB) radio in the early 1960's, with a resulting increase in incidents of EMI. (38)

Microprocessors were introduced in the 1970's. Apple Computer introduced the Apple II in 1976, and Radio Shack responded with the TRS-80 in 1977, the same year power interference with railroad signaling was addressed (in September 1977.) (2) As computers became more common, commercial EMC standards were urgently needed and, in 1979, the FCC mandated CISPR emissions limits for "digital devices" in response to increasing reports of radio, TV, and aircraft navigation interference from digital electronics. (Figure 3, Figure 4) The IBM-PC was introduced August 12, 1981 and the effect of power frequency magnetic fields on computer monitors became the subject of growing complaints. (38)

Figure 8. Jeep plant

The end of the Cold War, softening demand for military hardware, and the integration of the European Union (EU) in the 1990's began to shift emphasis away from MIL-STD 461 towards consumer, commercial, and light industrial equipment covered under the EMC Directive 89/336EEC of the EU. These European standards became the underlying methodology for high quality, "world designed" products, which could be shipped to all regulated markets.

Appendix B: Glossary

Anechoic Chamber – a test room that has walls and ceiling covered with anechoic absorber or radio-absorbent material (RAM) to prevent reflected radio waves during an EMC test

Arcing – the current flow across an ionized air gap

Basic Standard – describes the phenomena that are being simulated, such as electrostatic discharge or surge

Burst – Electrical Fast Transient (EFT) - simulates the rush of "showering arcs" that repeatedly form and extinguish when a magnetic field collapses across the opening contacts of a switch

Common Mode Current – a current flowing in the same direction along all conductors in a circuit, including the shield.

Compatibility Level – the specified electromagnetic disturbance level used as a reference level for coordination in the setting of emission and immunity limits. By convention, the compatibility level is chosen so that there is only a small probability that the actual disturbance level will exceed it. Frequently, the 95% probability level is defined as the compatibility level.

Conduction – a coupling method by direct wire connection

Coupling – the transfer or pick-up of electromagnetic energy from one circuit to another by radiation, induction, or conduction (or all three)

Current Probe – a transducer that converts current through its primary opening into voltage at its output, for the measurement of current spectra in conductors

Decibel (dB) – a numerical expression of the relative difference between a quantity and a reference level

Declaration of Conformity – a legal statement accompanying a product staing its conformity with the "essential requirements" of the EMC Directive

Dips – short, sub-cycle reductions in power input voltage (see Interrupts) (IEC 61000-4-11)

Electrical Fast Transient (EFT) (Burst) – simulates the rush of "showering arcs" that repeatedly form and extinguish when a magnetic field collapses across the opening contacts of a switch

EMC – Electromagnetic Compatibility- the ability of electrical or electronic equipment to function satisfactorily in its intended electromagnetic operating environment without causing undesirable or intolerable electromagnetic disturbances to other equipment or systems. Also, the engineering discipline of studying, analyzing, and solving electromagnetic interaction problems.

EMI – Electromagnetic Interference – the impairment of the performance of equipment or systems caused by an unwanted electromagnetic disturbance

Emission – Electromagnetic energy that travels outside the bounds of the initiating device as conducted energy or radiated energy, or both

EN – Euronorms (European Standards) – Adopted standards have an EN prefix. Prior to adoption, HD a harmonized document, prEN is a preliminary or provisional EN standard, and ENV is a temporary (voting copy) EN standard.

ESD – Electrostatic discharge – the energy released by the flow of electric current, usually resulting from the mechanical separation of electric charge. ESD can damage sensitive equipment and create impulsive electromagnetic energy.

Essential Requirements – the EMC Directive mandates that a product not disturb other products and that it have intrinsic immunity to outside interference to enable it to operate as intended

European EMC Directive – 89/336/EEC was adopted in 1989. This Directive sets out the legal requirements on EMC for all electric or electronic equipment to be placed or used in the Common Market/European Economic Area. The European legislation covers emissions as well as immunity and came into effect in 1992. An amending Directive (92/31/EEC) was adopted in 1992, which introduced a transitional period that ended on December 31, 1995. Enforcement of the EMC Directive is the responsibility of government-appointed authorities in individual countries.

EUT – Equipment Under Test – a device or system (and its associated cables) used for EMC testing that is representative of a product to be marketed

Flicker – an emission from a product whose variance in current demand causes a corresponding variance in the luminance of incandescent lamps connected in parallel, regulated under EN 61000-3-3

Gap discharge – electrical arcing caused by loose or broken hardware in the distribution power system

Generic Standards – EMC Standards that call for testing based on the location where the product would be used, such as commercial or heavy industrial locations

Harmonic Emissions – an emission from a product that does not draw sinusoidal current, and hence produces harmonic currents that enter the power system wiring, regulated under EN 61000-3-2

Immunity – the ability of a device or system to perform satisfactorily in the presence of a specific interfering electromagnetic environment

Incidental Radiator – a device that incidentally generates radio-frequency energy during the course of its operation, although its not intentionally designed to do so

Induction – a process by which electromagnetic energy is transferred from a source to a nearby parallel conductor or circuit

Interrupts – cessation of electrical service for several seconds, which may cause rotating machines to generate smooth, slow voltage changes (IEC 61000-4-11)

Line Impedance Stabilization Network (LISN or AMN) – sets the RF impedance of the power line and derives a sample of the noise voltages being ejected from the mains of the EUT

OATS – Open Area Test Site – used for conformance testing for radiated emissions. Reflected radio frequency waves are a problem and no objects, structures, or wires should be in the area. A good site should also have very low ambient RF levels in the test frequencies of interest. Requirements for OATS certification are detailed in CISPR 16.1 and ANSI C63.4

Performance Criteria – standardized guidance on the evaluation of the performance of an EUT while it is being subjected to Immunity tests

Product Standard – the Standard that should be used for the guidance on testing of a particular type of finished product, if not available use a Generic Standards or TCF filing instead

Receptor – a circuit, device or system (victim) that may suffer interference due to noise

Re-Radiation – indirect transmission of RF energy across open space, using wiring or other structures as secondary antennas

Shielded Enclosure – a room shielded from external radio frequency electromagnetic waves with filtered power to facilitate EMC testing of equipment (also called a "Faraday cage or screened room")

Surge – lightning strike simulation testing on power and I/O lines, typically to IEC 61000-4-5

Susceptibility – the threshold for interference in a device or system

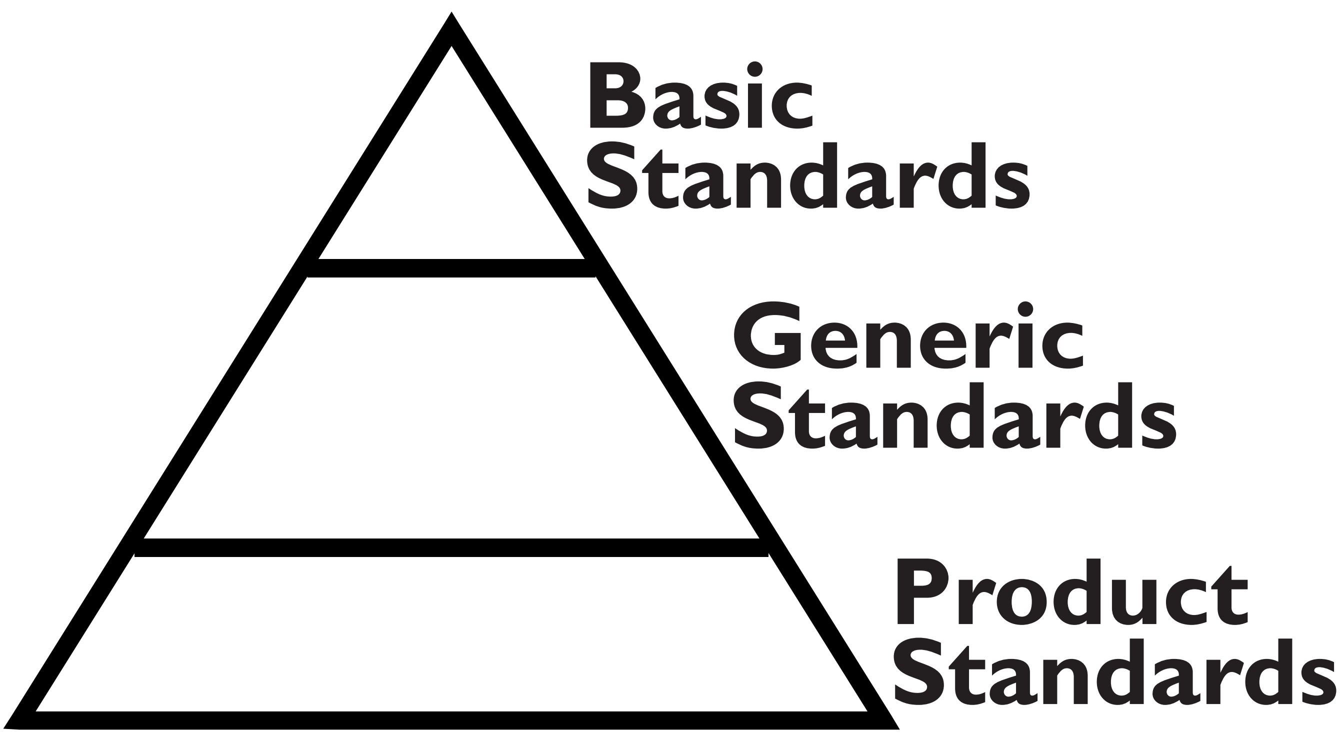
Technical Construction File (TCF) – used to demonstrate EMC compliance where:

- There is no harmonized European Standard
- Standards exist, but can only be applied in part
- Testing to harmonized Standards is not practical due to size, location, etc.
- The large number of product variations makes testing all combinations impossible
- Other recognized EMC Standards were used, such as MIL-STD, etc.

In the past, the TCF Route to Market required the use of a "Competent Body" but that may change towards Self-Declaration in the future.

Unintentional Radiator – a device that incidentally generates radio-frequency energy during the course of its operation although its not intentionally designed to do so (Incidental radiator)

The following illustrations are provided as aids to making overhead or 35 mm transparencies.


Basic
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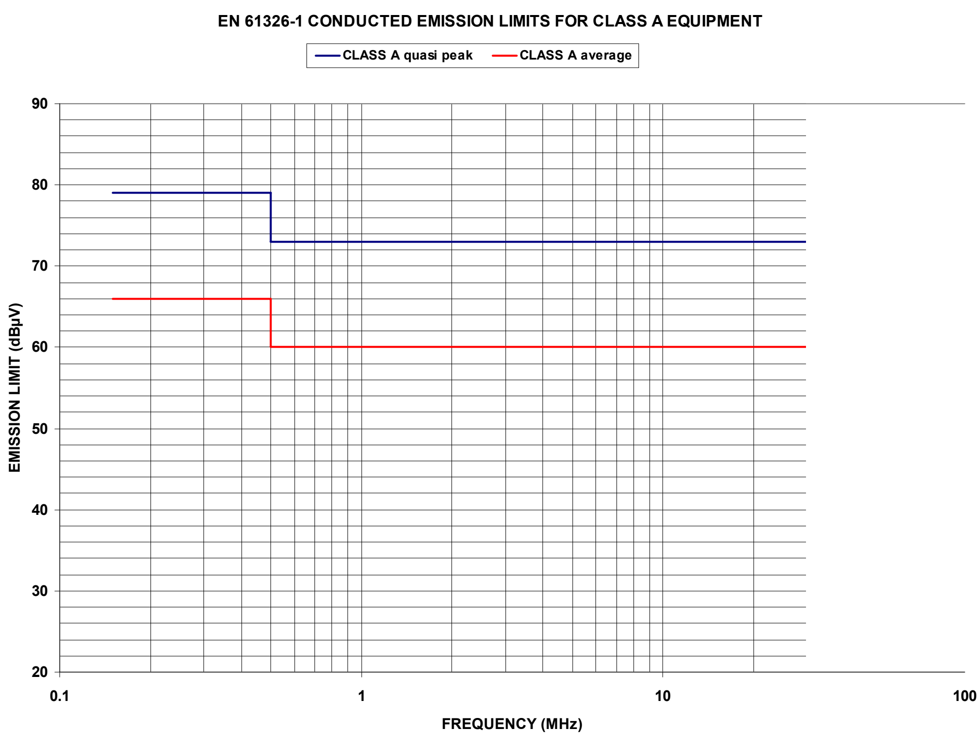
EN 61326-1 CONDUCTED EMISSION LIMITS FOR CLASS A EQUIPMENT
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CLASS A average
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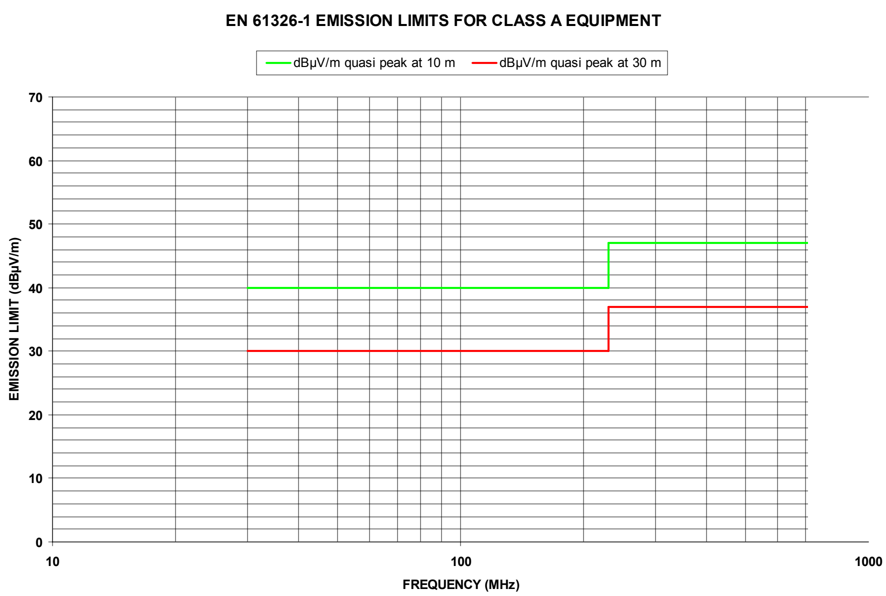
FREQUENCY (MHz)


EN 61326-1 EMISSION LIMITS FOR CLASS A EQUIPMENT
dBµV/m quasi peak at 10 m
dBµV/m quasi peak at 30 m
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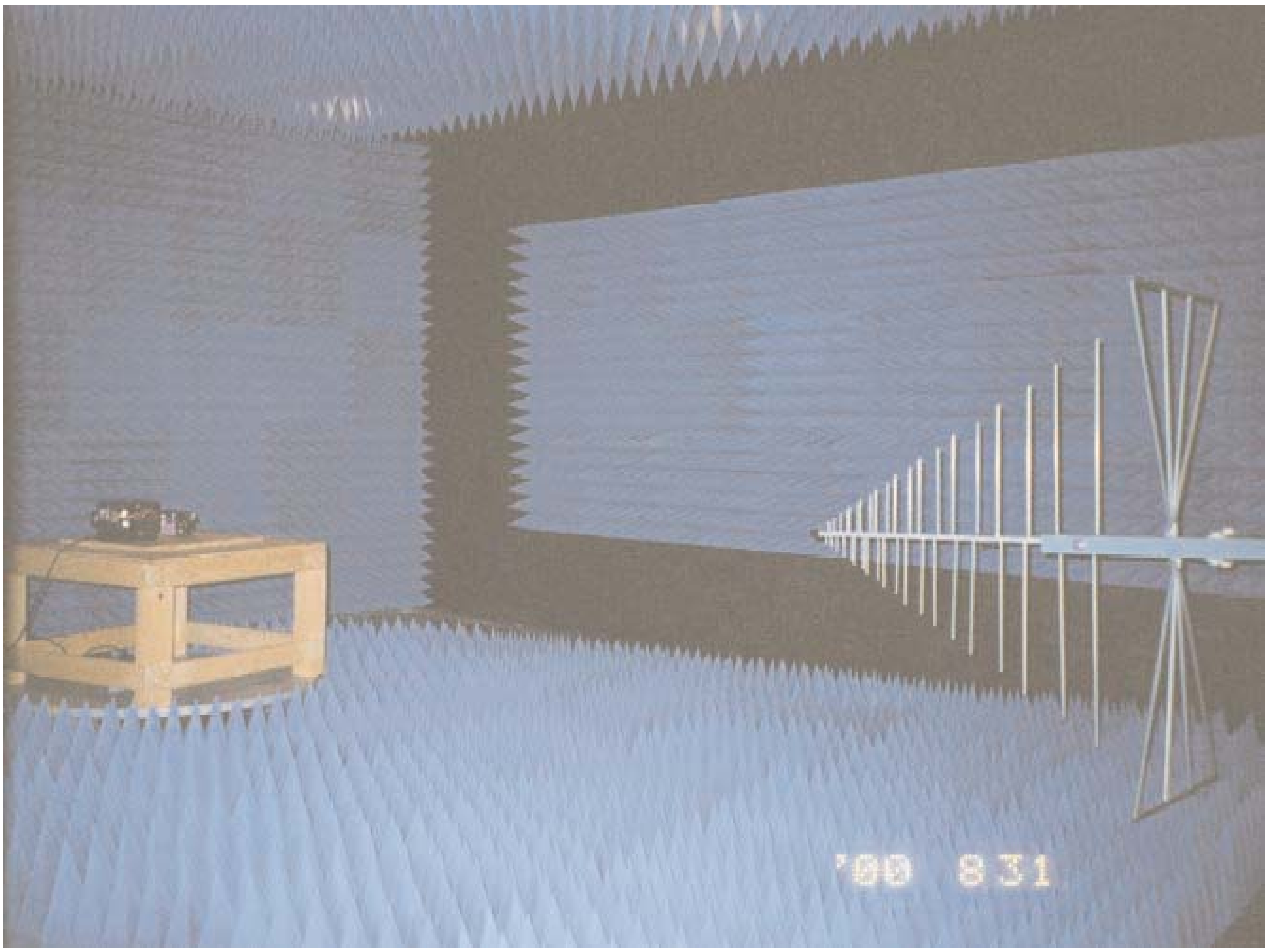
FREQUENCY (MHz)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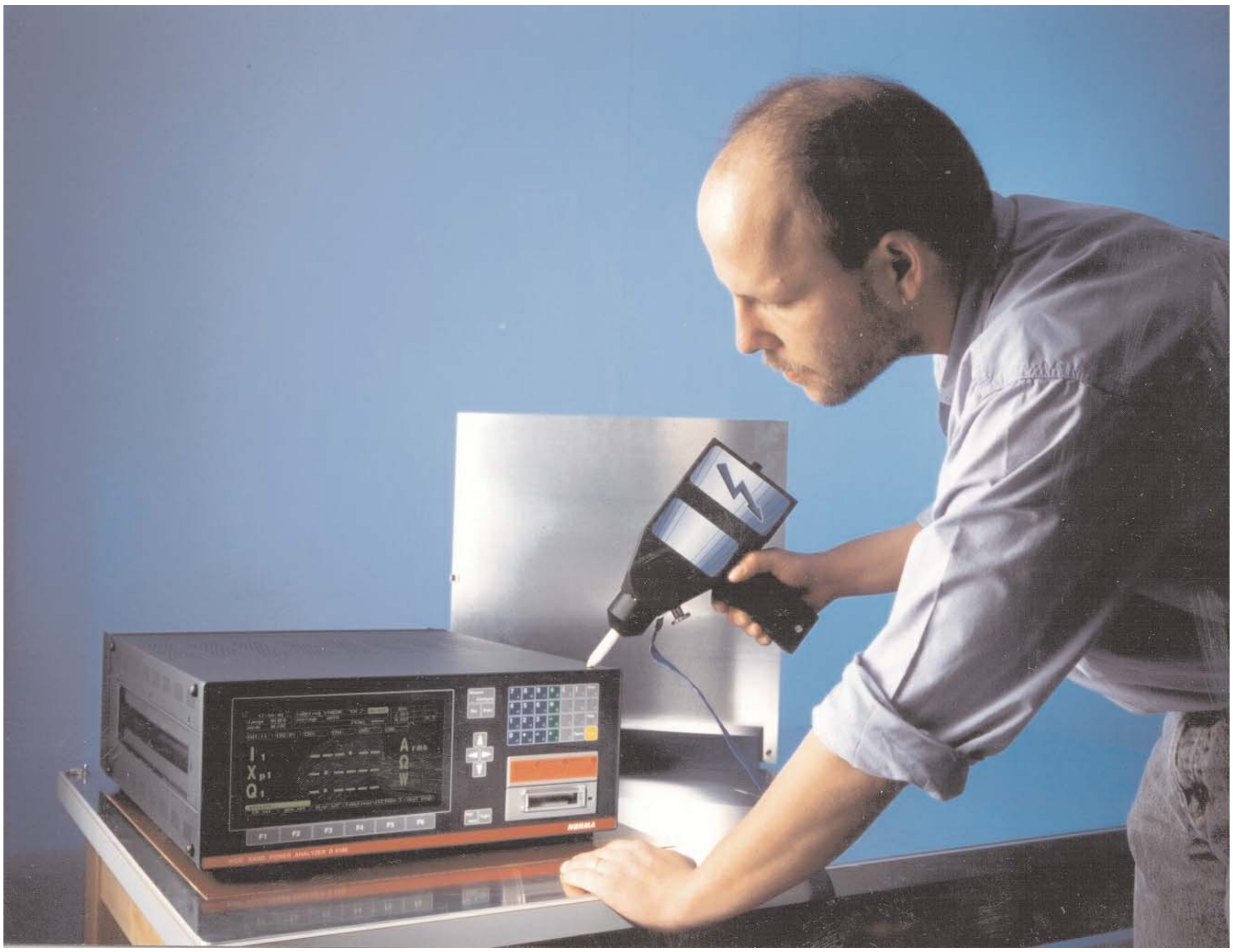


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