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Electrical equipment for measurement, control and laboratory use – EMC requirements

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL AND LABORATORY USE – EMC REQUIREMENTS

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
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6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61326 has been prepared by subcommittee 65A: System aspects, of IEC technical committee 65: Industrial-process measurement and control.

This standard cancels and replaces the first edition of IEC 61326-1 published in 1997, its amendment 1 (1998) and its amendment 2 (2000), and constitutes a technical revision.

The text of this standard is based on the following documents:

FDIS	Report on voting
65A/345/FDIS	65A/348/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

The general indications given in IEC Guide 107 have been followed.

Annexes A, B, C, D, E and F form an integral part of this standard.

The committee has decided that the contents of this publication will remain unchanged until 2003. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of July 2002 have been included in this copy.

INTRODUCTION

Instruments and equipment within the scope of this standard may often be geographically widespread and may have to operate under a wide range of environmental conditions.

The limitation of undesired electromagnetic emissions ensures that no other equipment, installed nearby, is unduly influenced by the equipment under consideration. The limits are more or less specified by, and therefore taken from, IEC and International Special Committee on Radio Interference (CISPR) publications.

However, the equipment has to function without undue degradation in a typical electromagnetic environment. The limit values for immunity specified in this standard have been chosen under this assumption. Special risks, involving for example nearby or direct lightning strikes, circuit-breaking, or exceptionally high electromagnetic radiation in close proximity, are not covered.

Complex electric and/or electronic systems require EMC planning in all phases of their design and installation, taking into consideration the electromagnetic environment, any special requirements, and the severity of failures.

ELECTRICAL EQUIPMENT FOR MEASUREMENT, CONTROL AND LABORATORY USE – EMC REQUIREMENTS

1 Scope

This International Standard specifies minimum requirements for immunity and emissions regarding electromagnetic compatibility (EMC) for electrical equipment, operating from a supply of less than 1 000 V a.c. or 1 500 V d.c. or from the circuit being measured, intended for professional, industrial-process and educational use, including equipment and computing devices for

– measurement and test;
– control;
– laboratory use;
– accessories intended for use with the above (such as sample handling equipment), intended to be used in industrial and non-industrial locations.

Computing devices and assemblies and similar equipment within the scope of information technology equipment (ITE) and complying with applicable ITE EMC standards can be used without additional testing.

Where a relevant dedicated EMC standard exists, it shall take precedence over all aspects of this product-family standard.

The following equipment is covered in this standard.

a) Electrical measurement and test equipment

This is equipment which by electrical means measures, indicates or records one or more electrical or non-electrical quantities, also non-measuring equipment such as signal generators, measurement standards, power supplies and transducers.

b) Electrical control equipment

This is equipment which controls one or more output quantities to specific values, with each value determined by manual settings, by local or remote programming, or by one or more input variables. This includes industrial process measurement and control (IPMC) equipment, which consists of devices such as:

– process controllers and regulators;
– programmable controllers (PC);
– power supply units of equipment and systems (centralized or dedicated);
– analogue/digital indicators and recorders;
– process instrumentation;
– transducers, positioners, intelligent actuators, etc.

c) Electrical laboratory equipment

This is equipment which measures, indicates, monitors or analyses substances, or is used to prepare materials.

This standard is applicable to

– equipment for use in industrial locations;
– equipment for use in laboratories or test and measurement areas with a controlled electromagnetic environment;
– test and measurement equipment which is portable and powered by battery or from the circuit being measured.

This equipment may also be used in areas other than laboratories.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2.1 General standards

IEC 60050-151:2001, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices*

IEC 60050(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 60359, *Expression of the performance of electrical and electronic measuring equipment*

IEC 61010 (all parts), *Safety requirements for electrical equipment for measurement, control, and laboratory use*

IEC 61557 (all parts), *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures*

IEEE 488.1:1987, *IEEE standard digital interface for programmable instrumentation*

IEEE 1284:1994, *IEEE standard signalling method for a bidirectional parallel peripheral interface for personal computers*

TIA/EIA-232-F:1997, *Interface between data terminal equipment and data circuit-terminating equipment employing serial binary data interchange*

2.2 Immunity standards

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques –Electrostatic discharge immunity test – Basic EMC Publication*

IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques –Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques –Electrical fast transient/burst immunity test – Basic EMC Publication*

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques –Surge immunity test*

IEC 61000-4-6:1996, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8:1993, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test – Basic EMC Publication*

IEC 61000-4-11:1994, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques –Voltage dips, short interruptions and voltage variations immunity tests*

2.3 Emission standards

IEC 61000-3-2:2000, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)*

IEC 61000-3-3:1994, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤16 A*

CISPR 11:1990, *Limits and methods of measurement of electromagnetic disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment*

CISPR 14-1:2000, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

CISPR 16-1:1999, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

CISPR 16-2:1996, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2: Methods of measurement of disturbances and immunity*

CISPR 22:1997, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

3 Definitions

For the purposes of this International Standard the definitions in IEC 60050(161) apply, together with the following.

Other definitions, not included in IEC 60050(161) and this standard, but nevertheless necessary for the application of the different tests, are given in the EMC basic publications.

3.1
type test
test of one or more samples of equipment (or parts of equipment) made to a particular design, to show that the design and construction meet one or more requirements of this standard. Statistical sampling is not required for measurement, control, and laboratory equipment

NOTE This definition is an amplification of IEV 151-04-15 to cover both design and construction requirements.

3.2
port
any particular interface of the specific device or system with the external electromagnetic environment within the scope of this standard (see figure 1 for an example of equipment under test (EUT))

NOTE I/O ports are input, output or bi-directional, measurement, control, or data ports.

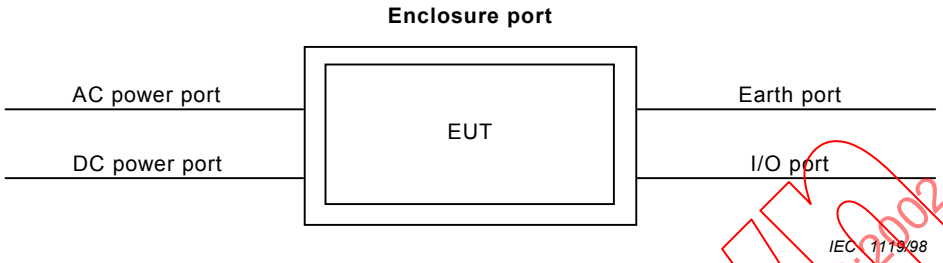


Figure 1 – Examples of ports

3.3
enclosure port
physical boundary of equipment through which electromagnetic fields may radiate or impinge

3.4
class A equipment
equipment suitable for use in establishments other than domestic, and those directly connected to a low-voltage power supply network which supplies buildings used for domestic purposes

[CISPR 11, 4.2]

3.5
class B equipment
equipment suitable for use in domestic establishments, and in establishments directly connected to a low-voltage power supply network which supplies buildings used for domestic purposes

[CISPR 11, 4.2]

3.6
long-distance lines
lines within a building which are longer than 30 m, or which leave the building (including lines of outdoor installations)

3.7
industrial locations
locations characterized by a separate power network, in most cases supplied from a high- or medium-voltage transformer, dedicated for the supply of installations feeding manufacturing or similar plants with one or more of the following conditions:

– frequent switching of heavy inductive or capacitive loads;

– high currents and associated magnetic fields;

– presence of industrial, scientific and medical (ISM) apparatus (for example, welding machines)

3.8
laboratory or test and measurement area
area that is specifically used for analysis, testing and servicing. Equipment within the scope has to be operated by trained personnel

3.9
controlled electromagnetic environment
environment usually characterized by recognition and control of EMC threats by users of the equipment or design of the installation

3.10
intrinsic error
error of a test or measuring instrument when used under reference conditions

[IEC 60359, definition 4.20, modified]

3.11
variation
difference between the indicated values for the same value of the measured quantity of an indicating or recording instrument when a single influence quantity assumes successively two different values

[IEC 60359, definition 4.21, modified]

3.12
Void

3.13
transducer with integrated signal conditioning
transducer in which all components for signal conditioning are integrated in the enclosure (see figure F.1).

3.14
transducer with remote signal conditioning
transducer whose components for signal conditioning are installed in separate enclosures (see figure F.2)

3.15
transmission link
connection between the individual components of a transducer with remote signal conditioning

3.16
nominal range
clearly specified value or upper limit of the measuring range

4 General

Equipment and systems within the scope of this standard can be subjected to various kinds of electromagnetic disturbances, conducted by power, measurement or control lines, or radiated from the environment. The types and levels of disturbances depend on the particular conditions in which the systems, subsystems or equipment are installed and operate.

Equipment such as generators, analysers, frequency meters shall fulfil the requirements under conditions defined by the manufacturer (that is without a test object connected, or connecting a 50 Ω termination to the output of a signal generator).

The manufacturer shall give information that emissions which exceed the levels required by this standard may occur when equipment is connected to a test object.

The acceptance criteria regarding the immunity requirements are structured taking into account the functionality and dependability aspects.

Equipment and individual devices of a system within the scope of this standard may also be a source of electromagnetic disturbances over a wide frequency range. These disturbances may be conducted through power and signal lines, or be directly radiated, and may affect the performance of other equipment, or influence the external electromagnetic environment.

For emissions, the objective of these requirements is to ensure that the disturbances generated by the equipment and systems, when operated normally, do not exceed a level which could prevent other systems from operating as intended. Emission limits for industrial locations are given in table 3. Emission limits for non-industrial locations are given in table 4.

To comply with this standard, no additional EMC tests are required beyond those stated here.

NOTE 1 Higher immunity levels than those specified may be necessary for particular applications (for example, when reliable operation of the equipment is essential for safety) or when the equipment is intended for use in harsher electromagnetic environments.

NOTE 2 This standard does not specify basic safety requirements such as protection against electric shock, unsafe operation, insulation co-ordination and related dielectric tests for equipment. See IEC 61010 for safety requirements.

NOTE 3 The emission limits of this standard may not, however, provide full protection against interference to radio and television reception when the measurement, control or laboratory equipment is used closer than 30 m to the receiving antenna for industrial or professional applications, and closer than 10 m for domestic and commercial applications.

NOTE 4 In special cases, for example when highly susceptible equipment is being used in close proximity, additional mitigation measures may have to be employed to reduce the influencing electromagnetic emission further below the specified limits.

NOTE 5 The manufacturer may elect to perform all tests either on a single EUT or more than one. The testing sequence is optional.

5 EMC test plan

5.1 General

An EMC test plan shall be established prior to testing. It shall contain as a minimum the elements given in 5.2 to 5.5.

It may be determined from consideration of the electrical characteristics and usage of a particular apparatus that some tests are inappropriate and therefore unnecessary. In such cases the decision not to test shall be recorded in the EMC test plan.

5.2 Configuration of EUT during testing

5.2.1 General

Measurement, control and laboratory equipment often consists of systems with no fixed configuration. The kind, number and installation of different subassemblies within the equipment may vary from system to system. Thus it is reasonable, and also recommended, not to test every possible arrangement.

To realistically simulate EMC conditions (related both to emission and immunity), the equipment assembly shall represent a typical installation as specified by the manufacturer. Such tests shall be carried out as type tests under normal conditions as specified by the manufacturer.

5.2.2 Composition of EUT

All devices, racks, modules, boards, etc. significant to EMC and belonging to the EUT shall be documented.

5.2.3 Assembly of EUT

If an EUT has a variety of internal and external configurations, the type tests shall be made with one or more typical configurations that represent normal use. All types of module shall be tested at least once. The rationale for this selection shall be documented in the EMC test plan.

5.2.4 I/O ports

Where there are multiple I/O ports all of the same type, connecting a cable to just one of those ports is sufficient, provided that it can be shown that the additional cables would not affect the results significantly.

5.2.5 Auxiliary equipment

When a variety of devices is provided for use with the EUT, at least one of each type of device shall be selected to simulate actual operating conditions. Auxiliary devices can be simulated.

5.2.6 Cabling and earthing (grounding)

The cables and earth (ground) shall be connected to the EUT in accordance with the manufacturer's specifications. There shall be no additional earth connections.

5.3 Operation conditions of EUT during testing

5.3.1 Operation modes

A selection of representative operation modes shall be made, taking into account that not all functions, but only the most typical functions of the electronic equipment can be tested. The estimated worst-case operating modes for normal application shall be selected.

5.3.2 Environmental conditions

The tests shall be carried out within the manufacturer's specified environmental operating range (for example, ambient temperature, humidity, atmospheric pressure), and within the rated ranges of supply voltage and frequency.

5.3.3 EUT software during test

The software used for simulating the different modes of operation shall be documented. This software shall represent the estimated worst-case operating mode for normal application.

5.4 Specification of performance criteria

Performance criteria for each port and test shall be specified; where possible, as quantitative values.

5.5 Test description

Each test to be applied shall be specified in the EMC test plan. The description of the tests, the test methods, the characteristics of the tests, and the test set-ups are given in the basic standards which are referred to in 6.2 and 7.2. The contents of these basic standards need not be reproduced in the test plan; however, additional information needed for the practical implementation of the tests is given in this standard. In some cases, the EMC test plan shall specify the application in detail.

NOTE Not all known disturbance phenomena have been specified for testing purposes in this standard, but only those which are considered as most critical.

6 Immunity requirements

6.1 Conditions during the tests

The configuration and modes of operation during the tests shall be precisely noted in the test report.

Tests shall be applied to the relevant ports in accordance with tables 1, A.1, B.1 or C.1, as applicable.

The tests shall be conducted in accordance with the basic standards. The tests shall be carried out one at a time. If additional methods are required, the method and rationale shall be documented.

6.2 Immunity test requirements

The immunity testing requirements are given in table 1.

Particular requirements for industrial locations are given in table A.1.

Particular requirements for laboratories or test and measurement areas with a controlled electromagnetic environment are given in table B.1.

Particular requirements for portable test and measurement equipment that is powered by battery or from the circuit being measured are given in table C.1.

For input/output circuits where the manufacturer specifies that shielded cables must be used, or that the cables must be located on conductive cable trays or in conduits, the conducted immunity requirements can be omitted within the frequency range 150 kHz to 80 MHz.

Tests for earth ports are not specified separately because they are covered by the respective basic standards:

– dedicated protection earth ports are tested as a.c. power ports;
– functional earth connections are tested as I/O-ports.

Table 1 – Minimum immunity test requirements

Port	Phenomenon	Basic standard	Test value
Enclosure	Electrostatic discharge (ESD) Electromagnetic	IEC 61000-4-2 IEC 61000-4-3	4 kV/4 kV contact/air 3 V/m
AC power	Voltage dip/short interruptions Burst Surge Conducted RF	IEC 61000-4-11 IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	1 cycle/100 % 1 kV 0,5 kV[a]/1 kV[b] 3 V
DC power[d]	Burst Surge Conducted RF	IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	1 kV 0,5 kV[a]/1 kV[b] 3 V
I/O signal/control	Burst Surge Conducted RF	IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	0,5 kV[d] 1 kV[b, c] 3 V[d]
I/O signal/control connected directly to mains supply	Burst Surge Conducted RF	IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	1 kV 0,5 kV[a]/1 kV[b] 3 V

[a] Line to line
[b] Line to earth (ground)
[c] Only in the case of long-distance lines (see 3.6)
[d] Only in the case of lines >3 m

Equipment shall not become dangerous or unsafe as a result of the application of the tests.

6.3 System and application aspects

If higher levels or tests of other phenomena under system aspects are necessary for specific applications, the immunity shall be increased or mitigation measures in the installation shall be applied.

6.4 Random aspects

The performance criterion shall be observable during the test and shall not be a random phenomenon. The duration of the test and number of tests shall be sufficient to test each function of the EUT as specified in the EMC test plan. Special care must be given to ensure that this is covered with automatic (processor) controlled EUTs.

NOTE For instance, in the case of electrostatic discharge testing of a digital device, the EUT should be exposed to at least 10 discharges at each polarity, test point and test level to exclude random effects. In case of burst testing, it may be advisable to extend the testing time to more than 1 min.

6.5 Performance criteria

The general principles (performance criteria) for the evaluation of the immunity test results are the following.

6.5.1 Performance criterion A: During testing, normal performance within the specification limits

Example 1

If electronic equipment has a central processing unit and is required to work with high reliability, the processor shall operate without any apparent degradation from the manufacturer's specification.

6.5.2 Performance criterion B: During testing, temporary degradation, or loss of function or performance which is self-recovering

Example 1

A data transfer is controlled/checked by parity check or by other means. In the case of malfunctioning, such as caused by a lightning strike, the data transfer will be repeated automatically. The reduced data transfer rate at this time is acceptable.

Example 2

During testing, an analogue function value deviates by an allowed margin. After the test, the deviation vanishes.

Example 3

In the case of a monitor used only for man-machine monitoring, it is acceptable that some degradation takes place for a short time, such as flashes during the burst application.

6.5.3 Performance criterion C: During testing, temporary degradation, or loss of function or performance which requires operator intervention or system reset occurs

Example 1

In the case of an interruption in the mains longer than the specified buffer time, the power supply unit of the equipment is switched off. The switch-on may be automatic or carried out by the operator.

Example 2

After a programme interruption caused by a disturbance, the processor functions of the equipment shall stop at a safe position and not be left in a "crashed state". Operator's decision prompts may be necessary.

Example 3

The test results in an opening of an over-current protection device which is replaced or reset by the operator.

6.5.4 Performance criterion D: Degradation or loss of function which is not recoverable due to damage to equipment, components, software, or to loss of data

For performance criteria B and C, the EUT has passed the tests if it has shown its specified immunity throughout the period of application of the test signal and, at the end of the tests, the EUT fulfils the functional requirements established in the technical product specification. The performance criteria D is normally not acceptable.

Because it is not possible to state only one performance criteria for each phenomenon, the following guidance is given:

– check the function normally fulfilled by certain equipment;
– the function of the device in relation to the phenomenon determines the performance criteria.

Examples of possible combinations are given in table 2.

Performance criteria to the different functional aspects shall be given to the user on request.

Table 2 – Example of evaluation of immunity test results

	Essential operation (functional safety)	Continuous unmonitored operation	Continuous monitored operation	Non-continuous operation
ESD IEC 61000-4-2	A	B	B	C
EM IEC 61000-4-3	A	A	A	B
Burst IEC 61000-4-4	A	B	B	B
Surge IEC 61000-4-5	A	B	B	C
Conducted RF IEC 61000-4-6	A	A	A	C
Voltage interrupts IEC 61000-4-11	A	B	C	C

NOTE For type testing, it is highly recommended that performance criteria A be chosen for all phenomena and all tests. However, performance criteria B and/or C may be accepted provided that both the specification and the test report highlight such deviation(s) for the relevant combination(s) of function and test.

7 Emission requirements

In some countries, certain control devices are legally exempted from mandatory emission requirements. Where exempted by national regulation, the emission requirements stated in this standard do not apply.

7.1 Conditions during measurements

The measurements shall be made in the operating mode in accordance with the EMC test plan (see clause 5).

NOTE The conducted emission limits covered by this standard are given on a port-by-port basis.

The description of the tests, the test methods, and the test set-ups are given in the reference standards as stated in tables 3 and 4. The contents of the reference standards are not reproduced here; however, modifications or additional information needed for the practical implementation of application of the tests are given in this standard.

7.2 Emission limits

Table 3 gives the limit values for class A equipment.

Table 4 gives the limit values for class B equipment.

Choice of table 3 or table 4 values shall be made after taking into account the intended environment and emission regulations in the areas of use.

If the equipment fulfils the limit values of table 3 but not table 4, this shall be stated in the product specification.

For equipment using ISM frequencies, see CISPR 11.

Table 3 – Emission limits for class A equipment

Port	Frequency range MHz	Limits	Reference standard
Enclosure	30 to 230	40 dB (µV/m) quasi peak, measured at 10 m distance	CISPR 16-1[a] and CISPR 16-2
	230 to 1000	47 dB (µV/m) quasi peak, measured at 10 m distance	
AC mains	0,15 to 0,5	79 dB (µV) quasi peak 66 dB (µV) average	CISPR 16-1 and CISPR 16-2
	0,5 to 5	73 dB (µV) quasi-peak 60 dB (µV) average	
	5 to 30	73 dB (µV) quasi peak 60 dB (µV) average	
[a] For alternative test site areas, see annex A of CISPR 22.			

Table 4 – Emission limits for class B equipment

Port	Frequency range MHz	Limits	Reference standard
Enclosure	30 to 230	30 dB (µV/m) quasi peak, measured at 10 m distance	CISPR 16-1[a] and CISPR 16-2
	230 to 1000	37 dB (µV/m) quasi peak, measured at 10 m distance	
AC mains[b]	0 to 0,002	As specified in the reference standard	IEC 61000-3-2 IEC 61000-3-3
	0,15 to 0,5	66 dB (µV) to 56 dB (µV) quasi peak 56 dB (µV) to 46 dB (µV) average Limits decrease linearly with log. of frequency	CISPR 16-1 and CISPR 16-2
	0,5 to 5	56 dB (µV) quasi peak 46 dB (µV) average	
	5 to 30	60 dB (µV) quasi peak 50 dB (µV) average	
[a] For alternative test site areas, see annex A of CISPR 22. [b] For discontinuous disturbances, see CISPR 14-1.			

8 Test results and test report

The test results shall be documented in a comprehensive test report with sufficient detail to provide for test repeatability.

The test report shall contain the following minimum information:

– EUT description;
– EMC test plan;
– test data and results;
– test equipment and set-up.

Annex A
(normative)

Immunity test requirements for equipment intended for use in industrial locations

This annex applies to instruments and equipment that are intended for installation in industrial locations (it covers all equipment that may be used in close proximity to high-level sources of disturbances).

NOTE Equipment not specifically designed for use in industrial locations may be used by controlling the EMC environment throughout installation and/or usage.

Table A.1 – Immunity test requirements for equipment intended for use in industrial locations

Port	Phenomenon	Basic standard	Test value
Enclosure	Electrostatic discharge (ESD) EM field Rated power frequency magnetic field	IEC 61000-4-2 IEC 61000-4-3 IEC 61000-4-8	4 kV/8 kV contact/air 10 V/m 30 A/m[e]
AC power	Voltage dip/short interruptions Burst Surge Conducted RF	IEC 61000-4-11 IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	0,5 cycle, each polarity/100 % 2 kV 1 kV[a]/2 kV[b] 3 V[f)]
DC power[g]	Burst Surge Conducted RF	IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	2 kV 1 kV[a]/2 kV[b] 3 V[f]
I/O signal/ control	Burst Surge Conducted RF	IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	1 kV[d] 1 kV[b, c] 3 V[d, f]
I/O signal/ control connected directly to power supply network	Burst Surge Conducted RF	IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	2 kV 1 kV[a]/2 kV[b] 3 V[f]

[a] Line to line

[b] Line to ground

[c] Only in the case of long-distance lines (see 3.6)

[d] Only in the case of lines > 3 m

[e] Only to magnetically sensitive equipment. CRT display interference is allowed above 1 A/m.

[f] The test level for the conducted r.f. test is lower than the level for the radiated r.f. test because the conducted r.f. test simulates the resonance condition at each frequency and is thus a more severe test.

[g] DC connections between parts of equipment/system which are not connected to a d.c. distribution network are treated as I/O signal/control ports.

Annex B
(normative)

Immunity test requirements for equipment used in controlled EM environments

Equipment covered within this annex is intended for use in laboratories or test and measurement areas with a controlled electromagnetic environment.

The manufacturer shall state that equipment fulfilling the requirements in table B.1 is designed to operate in a controlled electromagnetic environment, i.e. where r.f. transmitters such as mobile telephones may not be used in close proximity.

NOTE 1 In general, analysis, test and service laboratories have controlled EMC environments, and personnel in these areas are usually trained to be able to interpret results. Hence, the test values shown in table B.1 are relaxed from those in table 1.

NOTE 2 If r.f. transmitters are used in close proximity, they may disturb equipment within the scope of this standard.

Table B.1 – Immunity test requirements for equipment used in controlled EM environments

Port	Phenomenon	Basic standard	Test value
Enclosure	Electrostatic discharge (ESD) EM field	IEC 61000-4-2 IEC 61000-4-3	4 kV/8 kV contact/air 1 V/m
AC power	Voltage dip/short interruptions Burst Surge Conducted r.f.	IEC 61000-4-11 IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	0,5 cycle, each polarity/100 % 1 kV 0,5 kV[a]/1 kV[b] 1 V
DC power[c, d]	Burst Surge Conducted r.f.	IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	1 kV Not required 1 V
I/O signal/ control	Burst Surge Conducted r.f.	IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	0,5 kV[c] Not required 1 V[c]
Measurement I/O[c]	Burst Surge Conducted r.f.	IEC 61000-4-4 IEC 61000-4-5 IEC 61000-4-6	X[e] Not required X[e]

[a] Line to line.

[b] Line to ground.

[c] Only in the case of lines > 3 m

[d] DC connections between parts of equipment/system which are not connected to a d.c. distribution network are treated as I/O signal/control ports.

[e] The rated disturbance values shall be stated in the product specification by the manufacturer.

Annex C
(normative)

Immunity test requirements for portable test and measurement equipment

Equipment covered within this annex is portable test and measurement equipment that is powered by battery or from the circuit being measured. Equipment that can be operated while charging is excluded from this annex.

NOTE 1 Test and measurement instruments within the scope of this standard can be used in a wide range of locations but by personnel capable of interpreting the results obtained. If these instruments are connected to a mains supply, it is normally only by their test or measurement leads and only for a short duration of the test. Hence, the test values shown in table C.1 are relaxed from those in table 1.

NOTE 2 If r.f. transmitters are used in close proximity, they may disturb equipment within the scope of this standard.

Table C.1 – Immunity test requirements for portable test and measurement equipment

Port	Phenomenon	Basic standard	Test value
Enclosure	Electrostatic discharge (ESD) EM field	IEC 61000-4-2 IEC 61000-4-3	4 kV/8 kV contact/air 3 V/m

There are no further requirements for the mains chargers used by the products within the scope of this standard.

Annex D
(normative)

Test configurations, operational conditions and performance criteria for sensitive test and measurement equipment for EMC unprotected applications

D.1 General

In addition to the requirements of this standard, this annex specifies more detailed test configurations, operational conditions and performance criteria for equipment with test and measurement circuits (both internal and/or external to the equipment) that are not EMC protected for operational and/or functional reasons, as specified by the manufacturer.

Examples of such equipment include, but are not limited to, oscilloscopes, logic analysers, spectrum analysers, network analysers, digital multimeters (DMM) and board test systems.

The manufacturer specifies the environment for which the product is intended to be used and utilizes the corresponding test level specifications in this standard.

D.2 Test configurations

D.2.1 I/O ports for test and measurement purposes (T&M ports)

Test and measurement (T&M) input ports shall be capped and shorted unless this leads to an operating condition unsuitable for measuring the emission and immunity performance of the product. In this case, an appropriate input signal shall be applied.

Test and measurement (T&M) output ports not needed to evaluate the essential functions of the EUT shall be capped and/or terminated.

NOTE 1 Probes and/or test leads to be used with the test and measurement ports do not need to be connected. Such test leads can vary substantially from one application to another and are often connected to equipment that has the covers removed and may be in various stages of disassembly to provide access to test points inside. Connected test leads may increase emissions and/or reduce immunity in certain applications.

NOTE 2 Capped means locally covered in a screening manner.

D.2.2 Auxiliary equipment

Auxiliary equipment necessary for the normal operation of the equipment under test (EUT) shall be included as part of the equipment to be tested.

D.3 Operational conditions

When both battery and a.c. options are available, both modes of operation shall comply.

D.3.1 Oscilloscopes

The oscilloscope ports shall be set for maximum sweep speed, maximum sensitivity and continuous acquisition mode unless other modes are known to provide worst-case emission or immunity results within normal applications.

D.3.2 Logic analysers

The logic analyser shall be set for data analysis modes during emissions testing and continuous data acquisition mode during immunity testing unless other modes are known to provide worst-case emission or immunity results within normal applications.

D.3.3 Digital multimeters (DMM)

Typical set-ups include: peak detect, maximum sensitivity (usually auto-range, if available, will suffice) and continuous acquisition mode.

D.3.4 Other equipment

For equipment not mentioned in D.3.1 to D.3.3, the following philosophy shall apply.

A selection of representative operation modes shall be made, taking into account that not all functions, but only the most typical functions of the equipment can be tested. The estimated worst-case operating modes for normal application shall be selected.

D.4 Immunity test conditions – Performance criteria

D.4.1 Tests with transient electromagnetic phenomenon

During testing, the EUT may have temporary degradation or loss of function or performance which is self-recovering. Self-recovery times greater than 10 s shall be specified by the manufacturer. Trigger functions shall not be evaluated. No change in actual operating state or loss of stored data is allowed.

Electrostatic discharges shall be applied to the housing shield, but not to the inner pins of shielded port or cable connectors. Examples include: BNC, D-subminiature, IEEE 488 (GPIB), RS232 and IEEE 1284-B (parallel printer port).

D.4.2 Tests with continuously present electromagnetic phenomenon

No visual degradation of parameters of the EUT is allowed during application of the test except as specified by the manufacturer.

No test for power frequency magnetic field is required.

D.5 Typical product specific immunity test parameters

D.5.1 Oscilloscopes

Typical parameters observed during immunity testing include trace width deviation, trace offset and display noise.

D.5.2 Logic analysers

Typical parameters observed during immunity testing include logic analyser functional operations that may cause system lock-up or change of function or mode.

D.5.3 Digital multimeters (DMM)

Typical parameters observed during immunity testing include the displayed measurement value.

Annex E
(normative)

Test configurations, operational conditions and performance criteria for portable test, measuring and monitoring equipment used in low-voltage distribution systems

E.1 General

In addition to the requirements of this standard, this annex specifies more detailed test configurations, operational conditions and performance criteria for equipment which is

– used for testing, measuring or monitoring of protective measures in low-voltage distribution systems, and;
– powered by battery and/or from the circuit measured, and;
– portable.

Examples of such EUT include, but are not limited to, voltage detectors, multimeters, insulation testers, earth continuity testers, earth resistance testers, loop impedance testers, RCD-testers and phase sequence testers as defined in IEC 61557.

The manufacturer specifies the environment for which the product is intended to be used, and utilizes the corresponding test levels in this standard.

E.2 Test configurations

E.2.1 Test and measurement I/O ports

Test and measurement ports shall be connected with test leads recommended or supplied with the EUT. Where the test leads are unspecified, typical test leads shall be used. The test leads shall be connected and arranged in a typical configuration for each operation mode, according to figure E.1

If the test leads recommended or supplied are longer than 1 m each one should be bundled up so that the test or measurement object is in a (horizontal) distance of 1 m to the EUT.

The test leads shall be arranged 0,1m apart in a horizontal position on the test table.

Auxiliary equipment (AE) required for generating or monitoring the test object signal shall be connected according to figure E.1 via two EM-clamps as described in IEC 61000-4-6, figure A.3, and/or further decoupling networks.

Voltage measurements shall be made with a 1 000 × (1 ± 10 %) ohm resistor (test object) connected in series with one of the test leads as shown in figure E.2. Current measurements shall be made with a 100 × (1 ± 10 %) ohm resistor (test object) connected in parallel with the test leads as shown in figure E.3.

For other measurements the test object shall be specified by the manufacturer and documented in the test report.

E.2.2 Operational conditions

Test and measurement equipment shall be set to the most sensitive ranges or combination of ranges unless other ranges are known to provide worst-case immunity results within normal application. Each function of multifunctional equipment shall be tested separately.

E.3 Immunity requirements-performance criteria

E.3.1 Electrostatic discharge

Test levels according to annex C, performance criterion B.

Electrostatic discharge shall be applied to the housing, to the terminals of the EUT and to the coupling planes, but not to the inner pins of shielded port or cable connectors (for example, BNC, D-subminiature, IEEE 488 (GPIB), RS232, IEEE 1284-B (parallel printer port), etc.).

E.3.2 EM-field

Test levels according to annex C starting at 80 MHz during testing normal performance within the specification limits. This includes that variations are allowed outside the maximum intrinsic error documented in the technical data of the user's manual. The variations shall be limited to five times the intrinsic error but not more than ±20 % of the measured value when measured at between 50 % and 100 % of full scale. If the maximum dimension of the equipment enclosure is < 0,3 m, the test is performed from only one side in accordance with figure E.1 and noted in the test report.

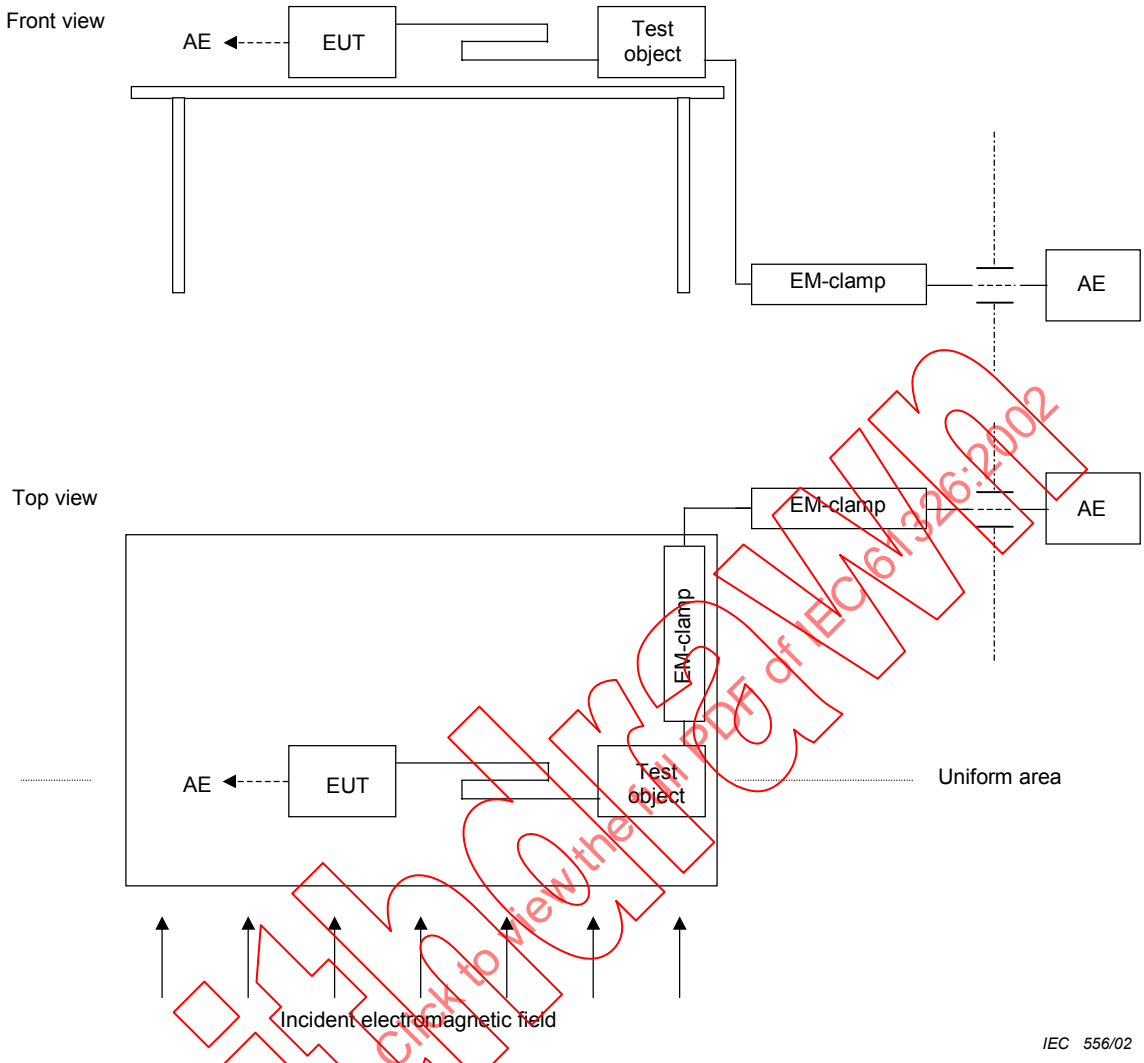
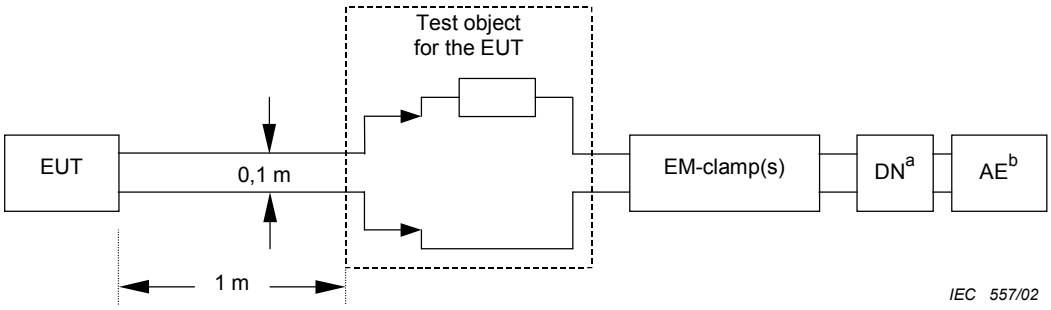
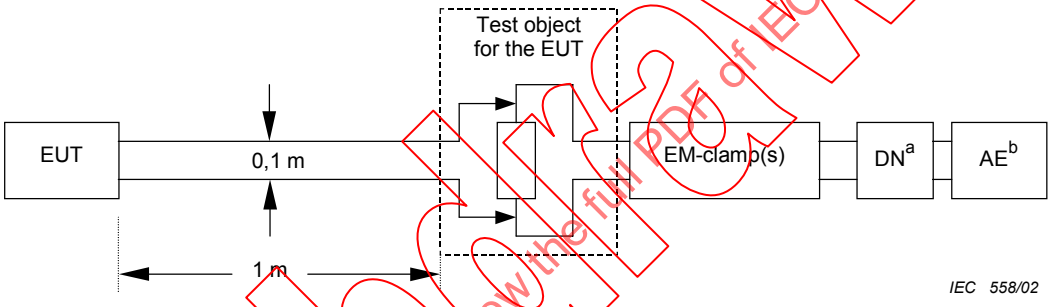


Figure E.1 – Test set-up for portable test, measuring and monitoring equipment based on IEC 61000-4-3



[a] Decoupling network (if necessary)
[b] For example, voltage source

Figure E.2 – Example of connection details for voltage measurements



[a] Decoupling network (if necessary)
[b] For example, current source

Figure E.3 – Example of connection details for current measurements

Annex F
(normative)

Test configurations, operational conditions and performance criteria for transducers with integrated or remote signal conditioning

F.1 General requirements

F.1.1 General considerations

In addition to the requirements of this standard, this annex specifies more detailed test configurations, operational conditions and performance criteria for transducers with integrated or remote signal conditioning.

This annex applies only to transducers characterized by their ability to transform with the aid of an auxiliary energy source a non-electric quantity to a process-relevant electrical signal, and to output the signal at one or more ports. The standard includes transducers for electrochemical and biological measured quantities.

The transducers covered by this annex may be powered by d.c. or a.c. voltage and/or by battery or with internal power supply.

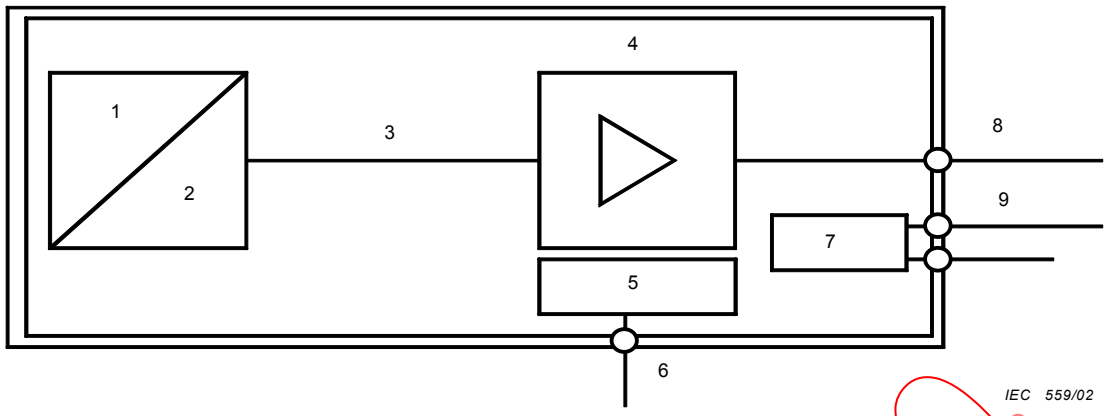
Transducers referred to by this annex comprise at least the following items (see figures F.1 and F.2):

– one or more elements for transforming a non-electrical input quantity to an electrical quantity;
– a transmission link for transferral of the electrical quantity to a component for signal conditioning;
– a unit for signal conditioning that converts the electrical quantity to a process-relevant electrical signal;
– an enclosure for enclosing the above-stated components fully or in parts.

Transducers referred to by this annex may also have the following items (see figures F.1 and F.2):

– a communication and control unit;
– a display unit;
– control elements such as keys, buttons, switches, etc.;
– transducer output signals are clearly assigned to the input signals;
– transducers with signal conditioning which may be integrated or remote.

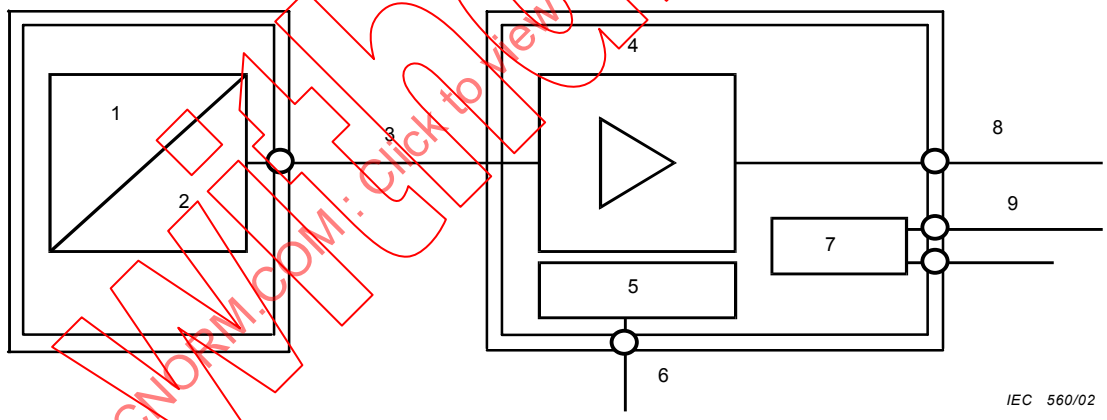
The manufacturer specifies the environment for which the product is intended to be used and utilizes the corresponding test levels in this standard.



Key

1 Non-electrical quantity
2 Electrical quantity
3 Transmission link
4 Signal conditioning
5 Communication and control unit
6 Input/output ports
7 Power supply
8 Signal port
9 AC/d.c. port

Figure F.1 – Example of a transducer with integrated signal conditioning



Key

1 Non-electrical quantity
2 Electrical quantity
3 Transmission link
4 Signal conditioning
5 Communication and control unit
6 Input/output ports
7 Power supply
8 Signal port
9 AC/d.c. port

Figure F.2 – Example of a transducer with remote signal conditioning

F.1.2 Test configurations

A system for monitoring the behaviour of the EUT and for registering the output values shall be designed in such a way that the electromagnetic compatibility characteristics of the EUT are not impaired. The input impedance of the monitoring system shall correspond to the terminating impedance of the transducer, specified by the manufacturer. The distance between the monitoring system and the EUT should be at least 1,5 m.

The measurement uncertainty and the bandwidth of the monitoring system shall be adapted to the characteristics of the transducer.

Transmission links are considered as separate input and output lines.

The tests shall be conducted in compliance with the environmental conditions for the transducer specified by the manufacturer, and using the specified supply voltage.

In the case of battery-operated transducers that can also be used when connected with a power supply, both operating modes (stand-alone and externally supplied) shall be tested.

In cases in which the manufacturer's installation instructions stipulate the use of external protective equipment or particular protective measures that are explicitly stated in the operating manual, the test requirements given in this annex shall be applied for use together with the external protective equipment or measures.

F.1.3 Operational conditions

Transducers shall be operated during the test with all lines connected, provided the ports do not have functions that contravene the definition of a transducer's function. Configurations with alternative ports shall be tested separately.

Transducers shall be set to the most sensitive ranges or combination of ranges unless other ranges are known to provide worst-case immunity results within normal application.

Only operational functions compliant with the specified use under the nominal conditions are permitted. Defined functions that cannot be set under electromagnetic compatibility test conditions shall be simulated by appropriate measures. This shall be done in such a way that the electromagnetic compatibility behaviour of the transducer is not affected.

Measurement and supply circuits shall be grounded in accordance with the manufacturer's specifications. If no such specifications are given, the tests shall be carried out with the circuits grounded and with the circuits ungrounded.

F.1.4 Performance criteria

The performance criteria are used to assess the defined functions of a transducer under the effects of external electromagnetic disturbances. Since a transducer is often part of a chain of functions in a large process, effects on the overall process due to malfunctions of a transducer caused by external interference factors cannot be predicted without great difficulty. For this reason it is particularly important that the behaviour of transducers under the influence of electromagnetic disturbances is described with performance criteria by the manufacturer.

The main function of a transducer is to transform a non-electrical quantity into a process-relevant signal as shown in figures F.1 and F.2. Different performance criteria may be used for other functions that are not relevant to the process.

Table F.1 classifies the permissible effects of a disturbance on the functions of a transducer (performance criteria).

Table F.1 – Performance criteria for the different functions

Function	Phenomena		
	IEC 61000-4-3 IEC 61000-4-6 IEC 61000-4-8	IEC 61000-4-2 IEC 61000-4-4 IEC 61000-4-11	IEC 61000-4-5
Main function	The deviations during the test are within the limit values for measurement uncertainty specified and documented by the manufacturer	The deviations during the test are within the limit values for additional measurement uncertainty specified and documented by the manufacturer	The deviations during the test may be outside the limit values for measurement uncertainty specified and documented by the manufacturer. After the test the measured values are within the specified measurement uncertainty range
Process-relevant communication	Communication as intended	Temporary interference of the communication is permitted during the test. However, it shall not cause any malfunction	Temporary interference of the communication that does not cause any malfunction is permitted during the test
Communication not relevant to the process	Communication as intended	Temporary interference of the communication is permitted during the test. However, it shall not affect the main function	Temporary interference of the communication that does not cause any malfunction is permitted during the test
Alarm function	No malfunctions permitted		
Limit values not relevant to the process	No malfunctions permitted within the switching tolerances defined and documented by the manufacturer		Temporary loss of function is permitted during the test

F.1.5 General test parameters

After or during each test, the function of the transducer shall be tested.

Power inputs for voltages up to 75 V d.c. or voltages up to 50 V a.c. that are fed in a single cable together with the input and output lines are tested as input and output lines.

Power inputs for voltages up to 75 V d.c. or voltages up to 50 V a.c. with superimposed output signals (for example, 4-20 mA current loop with two-wire technology) are also tested as input/output lines.

The transmission link of a transducer with remote signal conditioning is tested as an input/output line.

Any insulation resistance requirements shall be checked after ESD, fast transient (burst) and surge tests. If the manufacturer's specifications are not satisfied, the transducer is deemed to have failed the EMC tests.

F.2 Transducers for measurement of tension and compressive forces (force transducers)

F.2.1 General considerations

In addition to the requirements of the main part of this standard and of clause F.1, this subclause describes particular EMC requirements for force transducers that permit static measurement quantities.

Force transducers comprise at least the following components:

- a deflection unit that records mechanical forces as input quantities;
- one or more converting elements for generating electrical signals proportional to the mechanical input quantities;
- a measurement signal amplifier for processing the electrical signals into process-relevant signals.

F.2.2 Test configuration

The force transducer shall be tested in the position specified by the manufacturer (see figure F.3).

If no installation position is specified by the manufacturer, the transducer shall be positioned in such a way that the force is applied vertically.

The grounding of the power supply and force transducer shall comply with the manufacturer's specifications. If none are given, the power supply for voltages less than 60 V d.c. shall be grounded and the transducer shall be tested both grounded and insulated to ground.

The device under test shall be connected with the functional ground port only at the terminals on the deflection unit intended for that purpose.

If the ports are implemented in the form of plug-in connectors and if they have a terminal for a cable shield, then the shield shall be connected with the functional ground port. Preinstalled cable connectors with shielding shall be connected accordingly.