IEC 61967-1

Edition 2.0 2018-12
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Integrated circuits – Measurement of electromagnetic emissions~~, 150 kHz to 1 GHz~~ –
Part 1: General conditions and definitions

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INTEGRATED CIRCUITS – MEASUREMENT OF ELECTROMAGNETIC EMISSIONS~~,~~ ~~150 kHz to 1 GHz~~ –

Part 1: General conditions and definitions

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 61967-1 has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

This second edition cancels and replaces the first edition published in 2002. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) the frequency range of 150 kHz to 1 GHz has been deleted from the title;
b) the frequency step above 1 GHz has been added to Table 1, Table 2 and to 5.4;
c) Table A.1 has been divided into two tables, and IEC 61967-8 has been added to Table A.2 of Annex A;
d) the general test board description has been moved to Annex D.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
47A/1062/FDIS	47A/1066/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61967 series, under the general title *Integrated circuits – Measurement of electromagnetic emissions*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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INTEGRATED CIRCUITS – MEASUREMENT OF ELECTROMAGNETIC EMISSIONS~~,~~ ~~150 kHz to 1 GHz~~ –

Part 1: General conditions and definitions

1 Scope

This part of IEC 61967 provides general information and definitions on the measurement of conducted and radiated electromagnetic disturbances from integrated circuits. It also provides a description of measurement conditions, test equipment and set-up as well as the test procedures and content of the test reports. Test method comparison tables are included in Annex A to assist in selecting the appropriate measurement method(s).

The object of this document is to describe general conditions in order to establish a uniform testing environment and to obtain a quantitative measure of RF disturbances from integrated circuits (IC). Critical parameters that are expected to influence the test results are described. Deviations from this document are noted explicitly in the individual test report. The measurement results can be used for comparison or other purposes.

Measurement of the voltage and current of conducted RF emissions or radiated RF disturbances, coming from an integrated circuit under controlled conditions, yields information about the potential for RF disturbances in an application of the integrated circuit.

The applicable frequency range is described in each part of IEC 61967.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

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

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

~~CISPR 25:1995, *Limits and methods of measurement of radio disturbance characteristics for the protection of receivers used on board vehicles*~~

~~ANSI C63.2:1996, *American Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz – Specifications*~~

3 Terms and definitions

For the purposes of this document, the following terms and definitions~~, taken mostly from IEC 60050(161),~~ apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
artificial network
AN
~~agreed reference load impedance (simulated), presented to the EUT by networks~~ network presenting a reference load impedance (simulated) to the DUT (e.g. extended power or communication lines) across which the RF disturbance voltage is measured and which isolates the apparatus from the power supply or loads in ~~that~~ a given frequency range

Note 1 to entry: This note applies to the French language only.

~~[IEV 161-04-05, modified]~~

3.2
associated equipment
transducers (e.g. probes, networks and antennae) connected to a measuring receiver or test generator, also transducers ~~(for example, probes, networks, and antennas) which are~~ used in the signal or disturbance transmission path between ~~an EUT~~ a DUT and measuring equipment or a (test-) signal generator

~~**3.3**~~
~~**auto sweep**~~
~~fastest calibrated sweep which a spectrum analyser will automatically select based on start frequency, stop frequency, resolution bandwidth and video bandwidth~~

3.3
broadband disturbance
broadband emission
~~emission~~ electromagnetic disturbance which has a bandwidth greater than that of a particular measuring apparatus, receiver or susceptible device

Note 1 to entry: For some purposes, particular spectral components of a broadband disturbance may be considered as narrowband disturbances.

Note 2 to entry: Emission that has a bandwidth greater than that of a particular measuring apparatus or receiver.

[SOURCE: IEC 60050-161:1990, 161-06-11, modified – Note 2 to entry and the second preferred term "broadband emission" have been added.]

3.4
common mode voltage
asymmetrical disturbance voltage
mean of the phasor voltages appearing between each conductor and a specified reference, usually earth or frame

[SOURCE: IEC 60050-161:1990, 161-04-09, modified – The word "disturbance" has been added to the admitted term.]

3.5
common mode current
~~in a cable having more than one conductor, including shields and screens, if any, the magnitude of the sum of the phasors representing the currents in each conductor [IEV 161-04-39]~~

vector sum of the currents flowing through two or more conductors at a specified cross-section of a mathematical plane intersected by these conductors

3.6
conducted emission
transient and/or other disturbance observed on the external terminals of a device during its normal operation

3.7
continuous disturbance
~~RF disturbance with a duration of more than 200 ms at the IF-output of a measuring receiver, which causes a deflection on the meter of a measuring receiver in quasi-peak detection mode which does not decrease immediately~~

electromagnetic disturbance the effects of which on a particular device or equipment cannot be resolved into a succession of distinct effects

Note 1 to entry: RF disturbance with a duration of more than 200 ms at the IF-output of a measuring receiver that causes a deflection on the meter of a measuring receiver in quasi-peak detection mode that does not decrease immediately.

[SOURCE: IEC 60050-161:1990, 161-02-11, modified – Note 1 to entry has been added.]

3.8
DUT
device under test
device, equipment or system being evaluated

Note 1 to entry: As used in this document, DUT refers to a semiconductor device being tested.

Note 2 to entry: This note applies to the French language only.

3.9
die shrink
~~amount of shrink of the mask used to produce the integrated circuit (IC) expressed as a percentage or dimensions relative to the original artwork layout (drawn size)~~

reduction of die size by using an advanced fabrication process including finer lithography node and masks

3.10
differential mode current
in a two-conductor cable, or for two particular conductors in a multi-conductor cable, half the magnitude of the difference of the phasors representing the currents in each conductor

[SOURCE: IEC 60050-161:1990, 161-04-38]

3.11
differential mode voltage
voltage between any two of a specified set of active conductors

[SOURCE: IEC 60050-161:1990, 161-04-08, modified – The second preferred term "symmetrical voltage" has been removed.]

3.12
discontinuous disturbance
electromagnetic disturbance, the effects of which on a particular device or equipment can be resolved into a succession of distinct effects

Note 1 to entry: It is recognised that this definition does not characterise the disturbance independently of the effect that it produces. As a practical matter, any measure of a disturbance should be relatable to its effect on a susceptible device.

Note 2 to entry: For counted clicks, disturbance with a duration of less than 200 ms at the IF-output of a measuring receiver, which causes a transient deflection on the meter of a measuring receiver in quasi-peak detection mode.

[SOURCE: IEC 60050-161:1990, 161-02-28, modified – Note 2 to entry has been added.]

3.13
electrically small PCB
printed circuit board~~, whose dimension is smaller~~ with length and width shorter than $\lambda/2$, for example 100 mm to 150 mm at 1 GHz

3.14
EMC
electromagnetic compatibility
ability of an~~ equipment~~ apparatus or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

~~[IEV 161-01-07]~~

3.15
electromagnetic emission
phenomenon by which electromagnetic energy emanates from a source

3.16
electromagnetic radiation
radiated emission
1) phenomenon by which energy in the form of electromagnetic waves emanates from a source into space

2) energy transferred through space in the form of electromagnetic waves

[SOURCE: IEC 60050-161:1990, 161-01-10, modified – The second preferred term "radiated emission" has been added and the Note to entry has been omitted.]

3.17
emission limit
<from a disturbing source> specified maximum emission level of a source of electromagnetic disturbance

[SOURCE: IEC 60050-161:1990, 161-03-12]

3.18
ground reference plane
flat conductive surface whose potential is used as a common reference

[SOURCE: IEC 60050-161:2014, 161-04-36, modified – The term "reference-ground plane" has been changed to "ground reference plane", the definition has been condensed and the notes to entry, omitted.]

3.19
lead frame
supporting structure for the silicon die that interfaces the external pins to the die

3.20
measuring receiver
receiver for the measurement of disturbances with different detectors

Note 1 to entry: The bandwidth of the receiver should be as specified in CISPR 16-1-1.

~~**3.22**~~
~~**multi-chip module**~~
~~**MCM**~~
~~integrated circuit whose elements are formed on or within two or more semiconductor chips that are mounted in a single package~~

~~**3.23**~~
~~**multi IC sets**~~
~~set of ICs that functions as a unit; in a higher level of integration the set could be a single IC~~

3.21
narrowband emission
~~emission which has a bandwidth less than that of a particular measuring apparatus or receiver~~

electromagnetic disturbance, or spectral component thereof, which has a bandwidth less than or equal to that of a particular measuring apparatus, receiver or susceptible device

Note 1 to entry: Emission with bandwidth less than that of a particular measuring apparatus or receiver.

[SOURCE: IEC 60050-161:1990, 161-06-13, modified – The term "narrowband disturbance" has been changed to "narrowband emission" and Note 1 to entry has been added.]

3.22
peak detector
detector, the output voltage of which is the peak value of the applied signal

[SOURCE: IEC 60050-161:1990, 161-04-24]

3.23
preamp noise floor
inherent thermal noise generated by the first stage amplifier that limits the signal resolution of the measurement system

3.24
receiver terminal voltage
antenna voltage
~~external voltage measured in dB(µV) at the input of a radio interference measuring instrument conforming to the requirements of CISPR 16-1 or ANSI C63.2~~

voltage generated by a source of radio disturbance and measured in dB (µV) by a radio disturbance measuring instrument conforming to the requirements of CISPR 16

Note 1 to entry: External voltage measured in dB (µV) at the input of a radio interference measuring instrument conforming to the requirements of CISPR 16-1-1.

[SOURCE: CISPR 25:2008, ~~3.1~~ 3.8, modified – Note 1 to entry has been added.]

3.25
reference point
specific port or point on the test set-up where the measurement of the sampled parameter is made

3.26
repetition rate
number of surges, spikes, or pulses per unit of time

3.27
radio frequency ambient
RF ambient
electromagnetic environment
totality of electromagnetic phenomena existing at a given location

[SOURCE: IEC 60050-161:1990, 161-01-01, modified – The preferred terms "radio frequency ambient" and "RF ambient" have been added and Note 1 to entry has been removed.]

3.28
shielded enclosure
mesh or sheet metallic housing designed expressly for the purpose of separating electromagnetically the internal and external environment

[SOURCE: IEC 60050-161:1990, 161-04-37, modified – The second preferred term "screened room" has been omitted.]

3.29
significant IC change
~~all~~ changes that may influence the electromagnetic emissions of an IC

Note 1 to entry: Examples include changes to a new device, new manufacturer or process line, die shrink, new package type, significant manufacturing process, internal/external clock, I/O drive capability~~, etc~~.

3.30
system gain
gain (or attenuation) of the measurement path between the reference point and the input of the RF measuring instrument

3.31
test plan
document provided by the test requester to define the tests to be carried out, the object of the testing, the DUT operating status, the conditions for the test and performance objectives

Note 1 to entry: The test plan completely guides the implementation of the test, by reference to the standard test procedure, or by detailing revisions or additions for the specific DUT.

~~**3.35**~~
~~**work bench Faraday cage**~~
~~**WBFC**~~

~~**Under consideration.**~~

4 Test conditions

4.1 General

These default test conditions are intended to ensure a consistent test environment. If other values are agreed by the users of this procedure, they shall be documented in the test report.

4.2 Ambient conditions

4.2.1 General

The following ambient conditions shall be met.

4.2.2 Ambient temperature

The ambient temperature during the test shall be 23 °C ± 5 °C for repeatability. IC emissions may vary with temperature.

4.2.3 Ambient RF field strength

The ambient RF noise level shall be at least 6 dB below the lowest emission level(s) to be measured. This shall be verified before measurements of the IC are made. The DUT shall be installed in the test set-up, as used for testing. The DUT shall not be activated (for example, the power supply voltage shall be disconnected). A scan shall be made to measure the residual noise. A description of the ambient RF noise level shall be part of the test report.

4.2.4 Other ambient conditions

All other ambient conditions that ~~may~~ can affect the result shall be stated in the individual test report.

4.2.5 IC stability over time

The functional behaviour of the IC shall be stable over time so that two measurements, separated by an interval of time, shall yield the same results within the expected variation of the measurement technique.

5 Test equipment

5.1 General

The equipment described in Clause 5 is common to all test procedures described in this document. Specific equipment shall be itemized in the individual test procedures.

5.2 Shielding

The necessary shielding depends upon the specific test method and the ambient noise level. A shielded room may be required to provide a controlled ambient noise level for emission measurements. A non-shielded set-up ~~may~~ can be used if ambient noise levels are at least 6 dB below the lowest level to be measured.

5.3 RF measuring instrument

5.3.1 General

Either measuring receivers or spectrum analysers ~~may~~ can be used (see Tables 1 and 2 for default settings). The measuring receiver, if used, shall meet the bandwidth requirements as stated in CISPR 16-1-1.

5.3.2 Measuring receiver

Table 1 – Measuring receiver bands and resolution bandwidth (RBW) default settings

Frequency range	150 kHz to 30 MHz	≥ 30 MHz ~~– 1 GHz~~
Measuring receiver RBW at 6 dB	9 kHz	120 kHz

5.3.3 Spectrum analyser

Table 2 – Spectrum analyser bands and RBW default settings

Frequency range	150 kHz to 30 MHz	≥ 30 MHz ~~– 1 GHz~~
Spectrum analyser RBW at 3 dB	10 kHz	100 kHz

5.3.4 Other RBW for narrowband emissions

Where the RF emissions can be verified as being narrowband, and the measurement technique requires a lower noise floor for resolution of the measured signals from the ambient RF noise, a reduced RBW ~~may~~ can be used.

5.3.5 Emission type, detector type and sweep speed

A determination of whether the emissions are predominately narrowband or broadband can be made by measuring at the default bandwidth and at the next narrower (one-third) increment of bandwidth. If the measured level of peak values of the spectrum is reduced by 5 dB or more when the bandwidth is reduced by one-third, then the emissions can be considered to be predominately broadband.

Examples of narrowband sources are digital ICs operated by a synchronous clock. They will typically produce a continuous emission spectrum dominated by clock harmonics and fractions. For this reason, the detector chosen will not influence the readings. The peak detector shall be used for narrowband sources.

Examples of possible broadband sources are ICs producing a non-continuous spectrum such as converters and non-synchronous logic. These devices shall be measured, preferably using the peak detector with the sweep speed set to reflect the modulation rate, according to the following formula:

$$V_s \leq \frac{2}{3} \times RBW \times f_m$$

where

V_s is the sweep speed in MHz/s;

~~*RBW*~~ f_{RBW} is the resolution bandwidth in MHz;

f_m is the modulation frequency in Hz, defined as the lowest repetition rate of a software routine or other IC operating parameter that may affect the measured RF emissions.

The sweep speed used shall be selected in such a way that a slower sweep speed will not result in a significant change in the measured emissions.

5.3.6 Video bandwidth

The video bandwidth (VBW) shall be ~~a minimum of three times the resolution bandwidth~~ at least three times the RBW when a spectrum analyser is used for measurements.

5.3.7 Verification of calibration for the RF measuring instrument

The calibration of the RF measuring instrument shall be verified by comparison with an independent calibrated instrument, traceable to a recognized standard body, if absolute levels are to be reported.

5.4 Frequency range

The recommended frequency range is 150 kHz to 1 GHz, but this may be extended if the specific procedure is usable over an extended frequency range. The range of interest may be smaller when, by function, the IC produces emissions only in that reduced range.

The applicable frequency range is described in each part of IEC 61967.

5.5 Preamplifier or attenuator

If necessary, a preamp or attenuator, either internal or external, ~~may~~ can be used. The noise figure of the preamplifier or attenuator shall be less than 10 dB. The minimum resolution for calibration of the preamplifier is 10 points per decade.

5.6 System gain

The gain (or attenuation) between the reference point and the input of the RF measuring instrument shall be verified to within an accuracy of ±0,5 dB.

5.7 Other components

The characteristics of cables, connectors and terminators ~~that are~~ not in the measurement path between the reference point and the input of the RF measuring instrument that ~~may~~ can, however, affect the measurement result, shall be verified ~~for characteristics~~ over the intended frequency range.

6 Test set-up

6.1 General

Tests shall take place according to a test plan, which shall be included in the test report. This report shall also include:

a) a circuit diagram of the application (supply decoupling, bus load, peripheral ICs, etc.);

b) a description of the PCB on which the IC is applied (layout);

c) actual operating conditions of the IC (supply voltage, output signals, etc.);

d) a description of the type of software exercising the IC(s), if applicable.

All variations shall be included in the test report. Connection to auxiliary equipment shall not influence the test results.

Other particular requirements are described in the individual test procedure.

6.2 Test circuit board

The test PCB to be used depends on the specific measurement method. The specifications of a general basic test board for this family of standards are described in ~~clause 9~~ Annex D of this document. The test PCB should be designed in accordance with these general specifications and with the additional specifications as required for the individual measurement methods. Any deviation from this description shall be stated in the individual test reports.

~~NOTE~~ For the comparison of measurement results from different devices it is necessary to use a similar PCB design, as close as possible within the same measurement method.

6.3 IC pin loading

If no other loads are required by a specific test method, the pins of the DUT shall be loaded according to the following default value table, with exceptions as noted.

Table 3 – IC pin loading recommendations

IC pin type	Pin loading
Analogue	
– Supply	As stated by the manufacturer (or as required)
– Input	10 kΩ to ground (Vss) unless the IC is internally terminated
– Output signal	10 kΩ to ground (Vss) unless the IC is internally terminated
– Output power	Nominal loading as stated by the manufacturer
Digital	
– Supply	As stated by the manufacturer (or as required)
– Input	Ground (Vss) or 10 kΩ to supply (Vdd) if impossible to ground, unless the IC is internally terminated
– Output	47 pF to ground (Vss)
Control	
– Input	Ground (Vss) or 10 kΩ to supply (Vdd) if impossible to ground, unless the IC is internally terminated
– Output	As stated by the manufacturer
– Bi-directional	47 pF to ground (Vss)
– Analogue	As stated by the manufacturer (or as required)

Pins that do not fall into any of the listed categories shall be loaded as functionally required and stated in the test report. These are recommended default values; if other values are more appropriate for a particular IC, they may be substituted for the values in Table 3 and shall be stated in the test report.

6.4 Power supply requirements – Test board power supply

The DUT shall be powered from a source with low conducted RF emissions that conform to the RF ambient requirements. If a battery is used, it shall meet the IC requirements and the voltage level shall be checked periodically to maintain a consistent operating environment. An AC power supply ~~may~~ can be used if it meets the low RF emissions requirement. All power supply lines to the DUT shall be adequately filtered according to the IC manufacturer's recommendations.

6.5 IC specific considerations

6.5.1 IC supply voltage

The supply voltage(s) shall be as specified by the IC manufacturer with a tolerance of ±5 %.

6.5.2 IC decoupling

To obtain reproducible data of measurement, appropriate decoupling should be accomplished on the test board. See ~~9.7.1~~ Clause D.9.

6.5.3 Activity of IC

Attempts should be made to fully exercise all available functions that significantly contribute to the emissions of the IC.

6.5.4 Guidelines regarding IC operation

The intent is to describe the parameters to be controlled in order to ensure test repeatability for the particular IC function or type as agreed between the manufacturer and the user.

If a programmable integrated circuit is to be tested, software that flows in a continuous loop shall be written to ensure that measurements are repeatable. The type of software used to exercise the IC (minimum, typical or worst-case) shall be documented in the test report. The IC shall be exercised using one of the following software levels:

a) minimum – implement counter function:

   used for basic tests and comparisons, see Annex B;

b) typical – normal operating or production code:

   used for representative testing, exercise microprocessor and I/O on a "normal" basis using the production code;

c) worst-case – exercise all I/O:

   used for diagnostic purposes, see Annex C.

7 Test procedure

7.1 Ambient RF noise check

Measure ambient RF noise levels to ensure that any ambient signals present are at least 6 dB below the target reference level. The ~~ambient~~ data collected shall be part of the test report. If the ambient RF noise is excessive, check the integrity of the overall system, especially the interconnecting cables and connectors. If necessary, use a shielded enclosure, a lower noise preamplifier or a narrower spectrum analyser resolution bandwidth. If the area ambient RF noise is not well known, with possible sporadic local RF sources, it is recommended to check the ambient RF noise with the unpowered test board in place and with the spectrum analyser running on maximum hold for 1 h or as required to achieve confidence in the environment.

7.2 Operational check

Energize the DUT and complete an operational check to ensure proper function of the device and normal activity (i.e. run IC test code, see 6.5.4).

7.3 Specific procedures

Follow the test technique described in the particular emission measurement procedure.

8 Test report

8.1 General

The test report shall include sufficient information to allow duplication of the measurements by another facility.

8.2 Ambient RF noise

A plot or description of the ambient ~~level~~ RF noise levels of the measurement system with the DUT unpowered shall be included in the test report.

8.3 Description of device

A description of the device (IC) being evaluated and any pertinent information that may influence the emission performance of the device shall be included in the test report (for example, IC type number, production code and date, short functional description of the device as on the data sheet). The operating frequency(ies) shall be indicated, if applicable.

8.4 Description of set-up

A description of the test set-up shall be included, with any variations from the standard set-up clearly indicated.

8.5 Description of software

The type of software used to exercise the IC, if applicable, shall be indicated. If a production code is used, the revision level shall be indicated.

8.6 Data presentation

8.6.1 General

Data shall be adjusted for any input gain or attenuation to represent the actual values appearing at the reference point, in dB (µV), for voltage measurements.

8.6.2 Graphical presentation

A graph of the measured data shall be available.

8.6.3 ~~Software for data capture~~ Measurement data

An ASCII file of the measured data shall be available.

8.6.4 Data processing

The smoothing or averaging of raw data ~~may~~ can provide a more readable format. A description of any data processing used shall be included in the test report.

8.7 RF emission limits

As this document describes measurement methods, no RF emission limits are given. Limits in general depend upon the application, the area and the country. Functional requirements and local or mandated emission requirements will define the limits.

8.8 Interpretation of results

8.8.1 Comparison between IC(s) using the same test method

Results may be directly compared as long as measurements have been carried out under the same conditions. If comparisons are intended, the devices should be running the same code (for example, the counter test code, Annex B) and the test environment should be as consistent as possible. The same test board should be used.

8.8.2 Comparison between different test methods

At the time of writing, general correlation between the specific test methods has not been established. Correlation has been demonstrated in specific cases only. Refer to Annex A.

8.8.3 Correlation to module test methods

Where sufficient data exists to establish a correlation between the measured values and the expected emissions from the IC for a given application, this shall be indicated in the specific test method (for example, component or system level tests of the product). A number of factors are involved in the translation from IC level emissions to the module or product level. In general, this IC-to-module correlation is limited to specific cases where the variables involved are controlled.

Annex A
(informative)

Test method comparison tables

Tables A.1 and A.2 compare the test methods for conducted emissions and radiated emissions, respectively.

Table A.1 – Test method comparison

Item	IEC 61967-2 TEM Cell	IEC 61967-4 1/150 Ω	IEC 61967-5 WBFC	IEC 61967-6 Magnetic probe
Measured emission type in IC	E/H field from IC	Differential and common-mode conducted emissions[a]	Common-mode conducted emissions[b]	Differential and common-mode conducted emissions[a]
Proposed frequency range	150 kHz to 1 000 MHz	150 kHz to 1 000 MHz	150 kHz to 1 000 MHz	150 kHz to 1 000 MHz
Test board for: – comparison of ICs – evaluation in application	 Mandatory Needed	 Mandatory Non-restricted[c]	 Mandatory Non-restricted	 Mandatory Non-restricted[d]
Operator dependence to reproducing measurements	No	No	No	No
Single pin voltage/ current measurable	No	Yes	No	Yes
Comparison of IC versions – in same package	Yes	Yes	Yes	Yes
IC emission source/path analysis – variation of packaging – on-chip decoupling – multiple pin power supply – I/O signal conditioning – optimized location of pins	 Yes Yes Partly Partly Partly	 Possible Yes Yes Yes Partly	 Yes Yes Yes Yes Yes	 Possible Yes Yes Yes Yes
IC qualification	Yes	Yes	Yes	Yes

[a] Differential mode voltage and common mode current

[b] Common-mode voltage and currents

[c] If 1/150 Ω connections are incorporated

[d] If suitable microstrip is incorporated

Table A.1 – Conducted emission

Item	IEC 61967-4 1 Ω/150 Ω	IEC 61967-5 WBFC	IEC 61967-6 Magnetic probe
Measured emission type in IC	Differential- and common-mode conducted emissions[a]	Common-mode conducted emissions[b]	Differential- and common-mode conducted emissions[a]
Proposed frequency range	150 kHz to 1 000 MHz	150 kHz to 1 000 MHz	150 kHz to 3 000 MHz
Test board for:			
– comparison of ICs	Mandatory	Mandatory	Mandatory
– evaluation in application	Non-restricted[c]	Non-restricted	Non-restricted[d]
Operator dependence to reproduce measurements	No	No	No
Single pin voltage/current measurable	Yes	No	Yes
Comparison of IC versions – in same package	Yes	Yes	Yes
IC emission source/path analysis			
– variation of packaging	Possible	Yes	Possible
– on-chip decoupling	Yes	Yes	Yes
– multiple pin power supply	Yes	Yes	Yes
– I/O signal conditioning	Yes	Yes	Yes
– optimized location of pins	Partly	Yes	Yes
IC evaluation	Yes	Yes	Yes

[a] Differential mode voltage and common mode current.

[b] Common mode voltage and currents.

[c] If 1 Ω/150 Ω connections are incorporated.

[d] If a suitable microstrip is incorporated.

Table A.2 – Radiated emission

Item	IEC 61967-2 TEM[a] cell and wideband TEM cell	IEC TS 61967-3 Surface scan	IEC 61967-8 IC stripline
Measured emission type in IC	E/H field from IC	E/H field from IC	E/H field from IC
Proposed frequency range	150 kHz to 2 GHz and higher (up to 18 GHz)	150 kHz to 3 000 MHz	150 kHz to 3 000 MHz
Test board for:			
– comparison of ICs	Mandatory	Mandatory	Mandatory
– evaluation in application	Needed	Needed	Needed
Operator dependence to reproduce measurements	No	No, if automated system used	No
Single pin voltage/current measurable	No	No	No
Comparison of IC versions – in same package	Yes	Yes	Yes
IC emission source/path analysis			
– variation of packaging	Yes	Yes	Yes
– on-chip decoupling	Yes	Partly	Yes
– multiple pin power supply	Partly	Partly	Partly
– I/O signal conditioning	Partly	Partly	Partly
– optimized location of pins	No	No	No
IC evaluation	Yes	No	Yes

[a] Transverse electromagnetic

Annex B
(informative)

Flow chart of a counter test code

This simple routine implements a counter function using a single 8-bit port. Every 100 µs, the port output is incremented or decremented. After 10 count cycles (256 ms), an LED output is complemented. This will provide a blinking light indication with a frequency of about 2 Hz. For consistency, equivalent loop times should be maintained. The test code flow chart is shown in Figure B.1.

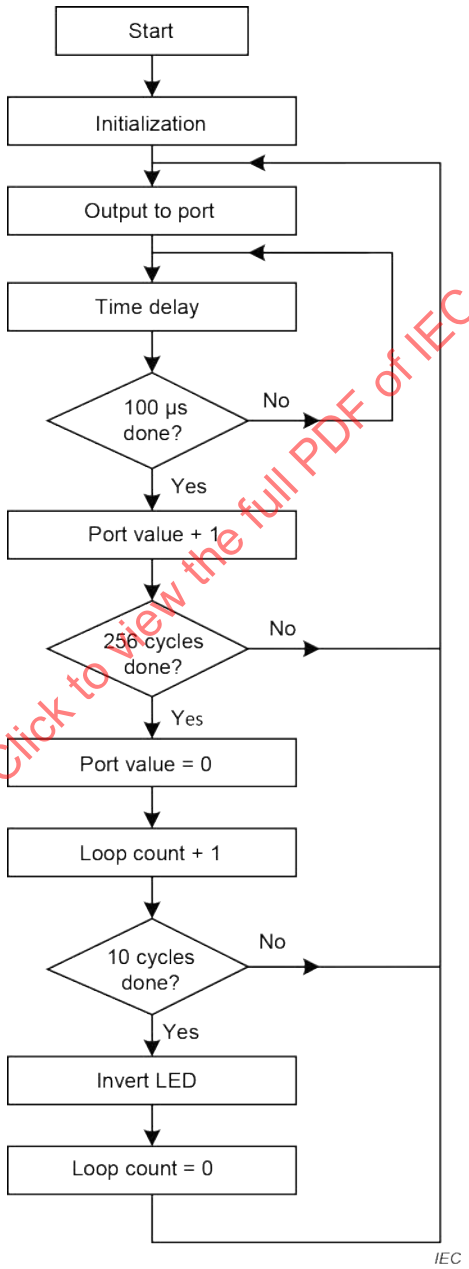


Figure B.1 – Test code flow chart

Annex C
(informative)

Description of worst-case application software

While under test, the IC shall execute software representative of that which could be found in a worst-case application. The software loop execution time shall be at least three orders of magnitude smaller than the spectrum analyser sweep period (for example, sweep = 6 s, software loop ≤ 6 ms). The following recommendations are applicable to a single IC microcontroller (MCU). They are intended as guidelines for the software writer; however, it is recognized that not all of the points are necessarily appropriate for all MCU devices:

a) the CPU should maximally exercise the internal address and data buses. Attention should be given to the bus implementation (precharged or static);

b) the test software should provide some means of indicating correct execution to the user (for example, toggling the port pin);

c) the test software should enable and exercise all on-board IC peripherals, where practical. In particular, peripherals that can generate fast periodic signals (serial peripherals, some timers) should be configured and exercised to generate these periodic signals. However, if these peripherals significantly contribute to the total radiated emission figure, then the test ~~may~~ can be performed, and results reported, with the peripherals enabled and disabled;

d) the test software should enable all internally generated clock sources that appear on any I/O pin. However, if these clocks significantly contribute to the total radiated emission figure, then the test ~~may~~ can be performed, and results reported, with the clocks enabled and disabled.

When it is impractical to execute test software (for example, when the device has no programmable memory and cannot bootstrap code into internal RAM), the test should be performed with the device held in reset. However, this test condition shall be reported with the test results.

Annex D
(informative)

General ~~basic~~ test board ~~specification~~ description

D.1 General

The purpose is to describe a universal test board. Such a board is necessary to compare the EMC performance of various ICs from different manufacturers. Constraints are given for those parameters influencing the EMC aspects.

D.2 Board description – Mechanical

The board size is $100\,^{+3}_{-1}$ mm^2. Holes may be added at the corners of the board, as shown in Figure D.1. All edges of the board shall be tinned ~~for~~ by at least 5 mm, or made conducting in order to make proper contact with the TEM ~~(transverse electromagnetic mode)~~ cell, if used. As an alternative, edges may be gold-plated.

The vias at the outer edge of the board shall be at least 5 mm away from that edge.

D.3 Board description – Electrical

The drawing in Figure D.1 shall be taken as a guide. A double layer board is proposed as a minimum requirement. However, if functionally needed, layers 2 and 3 or others may be added in between, such that a multi-layer board appears.

Layer 1 shall always be used as the ground plane. Layer 4 allows other signals, but shall be left as intact as possible, in order to be a ground plane as well. At least the area in layer 1 underneath the IC shall be left as a ground plane.

The PCB shall be made in such a way that only the IC package remains on one side (layer 1) and all other components and trace patterns remain on the opposite layer (layer 4).

D.4 Ground planes

The ground planes (layers 1 and 4) shall be interconnected by means of vias. These vias shall be placed at the following positions over the board as described in Table D.1.

Table D.1 – Position of vias over the board

Via position	Location
1	All around, at the edges of the board
2	Just outside the DUT area
3	Just inside, underneath the IC area

The ground plane at layer 1 shall be continued between vias, at position 2. As such, the ground plane at layer 1 is continued over the whole board.

If possible the same shall be done for layer 4, but the possibility to do so depends on the IC package and the space available.

D.5 Package pins

D.5.1 General

All functionally necessary components other than the IC shall be mounted on layer 4. It is therefore necessary to feed I/O and other required pins from layer 1 to layer 4. The loop areas, trace length, via placement and component orientation shall be so optimized that minimum loop areas are obtained.

D.5.2 DIL packages

These packages do not require vias, as plated-through hole pins are considered present, or established by the pins themselves.

D.5.3 SOP, PLCC, QFP packages

These packages require the use of vias. The vias should preferably be centred in the pads used for soldering the ICs. Preferably, these vias should be placed at position 3, Table D.1, to minimize the loop area involved in which the IC currents will flow.

~~**9.4.3 PGA, BGA packages**~~

~~Under consideration.~~

D.5.4 PGA packages

These packages do not require vias, as plated through-hole pins are considered present or established by the pins themselves.

D.5.5 BGA packages

These packages require the use of vias. The vias for power supply and ground interconnection should preferably be located in accordance with the manufacturer's recommendations.

D.6 Via ~~type~~ diameters

All vias at position1 shall have a hole diameter of 0,8 mm. All other vias shall have a diameter of ≥ 0,2 mm.

D.7 Via distance

~~A maximum lateral distance between vias is required for measurements up to 1 GHz.~~

- ~~Vias connecting layer 1 with layer 4 shall be at a maximum distance of 10 mm in-between.~~
- ~~Vias accompanying signal traces shall be as close as possible to those vias connecting layers 1 to 4, to create small return signal loops.~~

Via placement shall be controlled as follows for the applicable frequency range, for example, λ/10. The maximum lateral distance between vias connecting layer 1 to layer 4 (positions 1, 2 and 3) shall be 10 mm. Vias for signal traces shall be placed as close as possible to those vias connecting layer 1 to layer 4.

D.8 Additional components

All additional components shall be mounted at layer 4. They shall be placed in such a way that they do not interfere with the constraints as set for layers 1 and 4 and interconnecting vias ~~in-between~~.

D.9 Supply decoupling

D.9.1 General

To obtain reproducible data of measurement, adequate supply decoupling is required in accordance with the test board specifications. Decoupling capacitors on the test board shall be classified into two groups, as described in D.9.2. and D.9.3. The values and layout positions of the decoupling capacitors and other decoupling components shall be stated in the individual test report.

D.9.2 IC decoupling capacitors

Supply decoupling for the IC shall be in accordance with the manufacturer's recommendations. IC decoupling capacitors, if any, shall be connected to the ground plane in layer 4, underneath the IC, as described in Clause D.3 and in Figure D.1, to maintain the proper operation of the DUT. The value and layout position of a decoupling capacitor of each supply pin of the DUT may be as advised by the manufacturer, or otherwise, as long as stated in the test report.

D.9.3 Power supply decoupling for the test board

Impedance of the test board power supply may affect the measurement results if the power supply decoupling is not adequately designed. To control the supply impedance of the test board for any external power supply which may be used in the measurement, a group of decoupling capacitors shall be located on the test board. Their values and layout positions shall be as described in the individual measurement standards, or otherwise, as long as stated in the test report.

D.10 I/O load

Additional components necessary to load or activate the IC shall be mounted on layer 4, preferably directly underneath the IC package area. This includes the necessary ports to allow IC monitoring during the RF immunity test.

Dimensions in millimetres

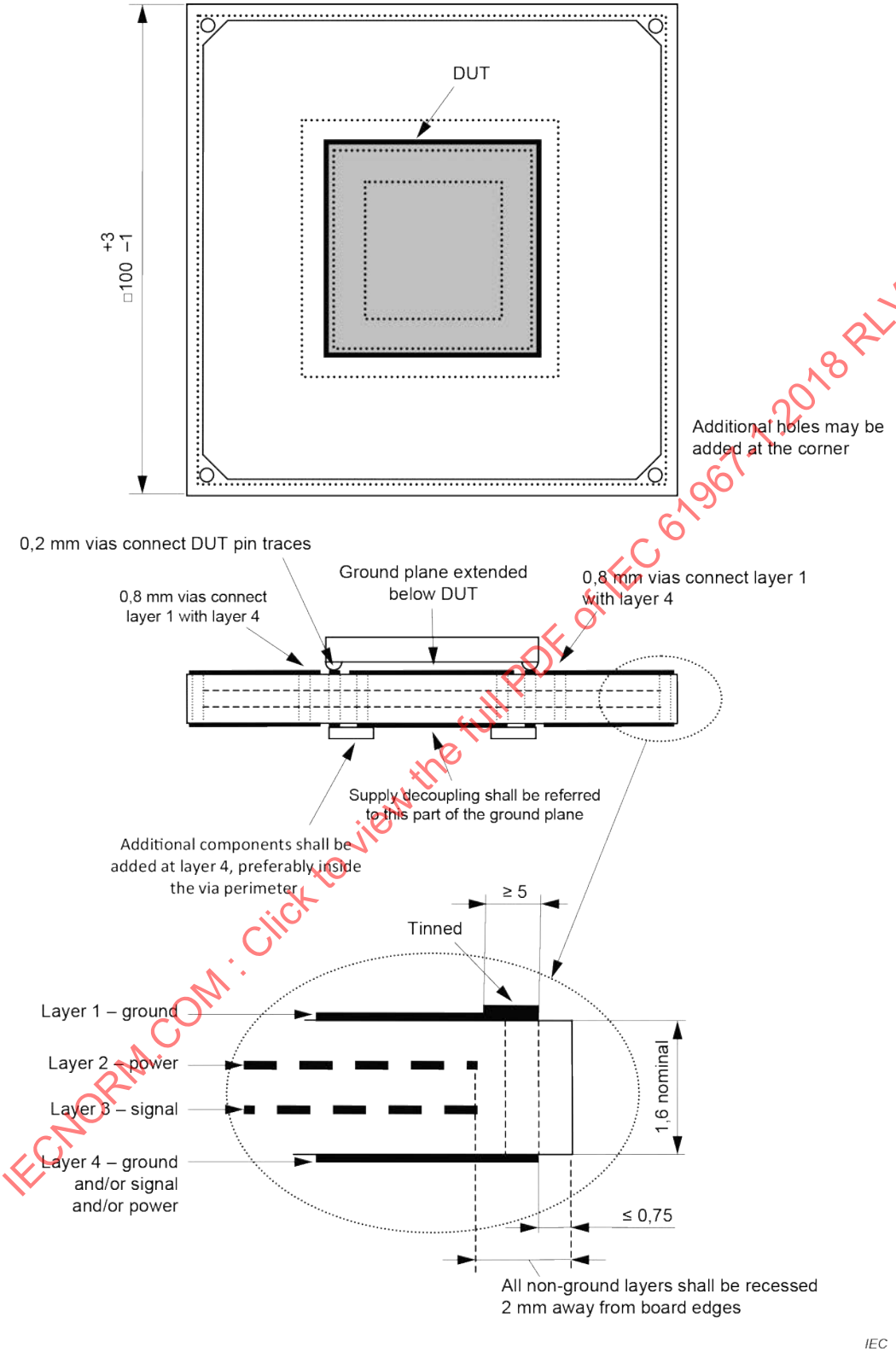


Figure D.1 – ~~General basic~~ Example of an emission test board

Bibliography

IEC 60050-161:1990, *International Electrotechnical Vocabulary – Chapter 161: Electromagnetic compatibility*

~~IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test* [1)]~~

~~IEC 61000-4-6:1996, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances inducted by radio-frequency fields* [2)]~~

IEC 61967-2: *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 2: Measurement of radiated emissions – TEM cell and wideband TEM cell method ~~(under consideration)~~*

IEC TS 61967-3: *Integrated circuits – Measurement of electromagnetic emissions~~, 150 kHz to 1 GHz~~ – Part 3: Measurement of radiated emissions – Surface scan method ~~(under consideration)~~*

IEC 61967-4, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 4: Measurement of conducted emissions, 1 Ω/150 Ω direct coupling method* [~~3~~]

IEC 61967-5, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 5: Measurement of conducted emissions – Workbench Faraday Cage method* [~~3~~]

IEC 61967-6, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 6: Measurement of conducted emissions – Magnetic probe method* [~~3~~]

IEC 61967-8, *Integrated circuits – Measurement of electromagnetic emissions – Part 8: Measurement of radiated emissions – IC stripline method*

IEC 62132-1, *Integrated circuits – Measurement of electromagnetic immunity – Part 1: General conditions and definitions*

CISPR 25:2008, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers* [1]

~~1 There exists a consolidated edition 1.2 (2001) that includes edition 1.0 and its amendments.~~

~~2 There exists a consolidated edition 1.1 (2001) that includes edition 1.0 and its amendment.~~

~~3 To be published.~~

1 Third edition (2008). This third edition was replaced in 2016 by a fourth edition CISPR 25:2016, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers*.

IEC 61967-1

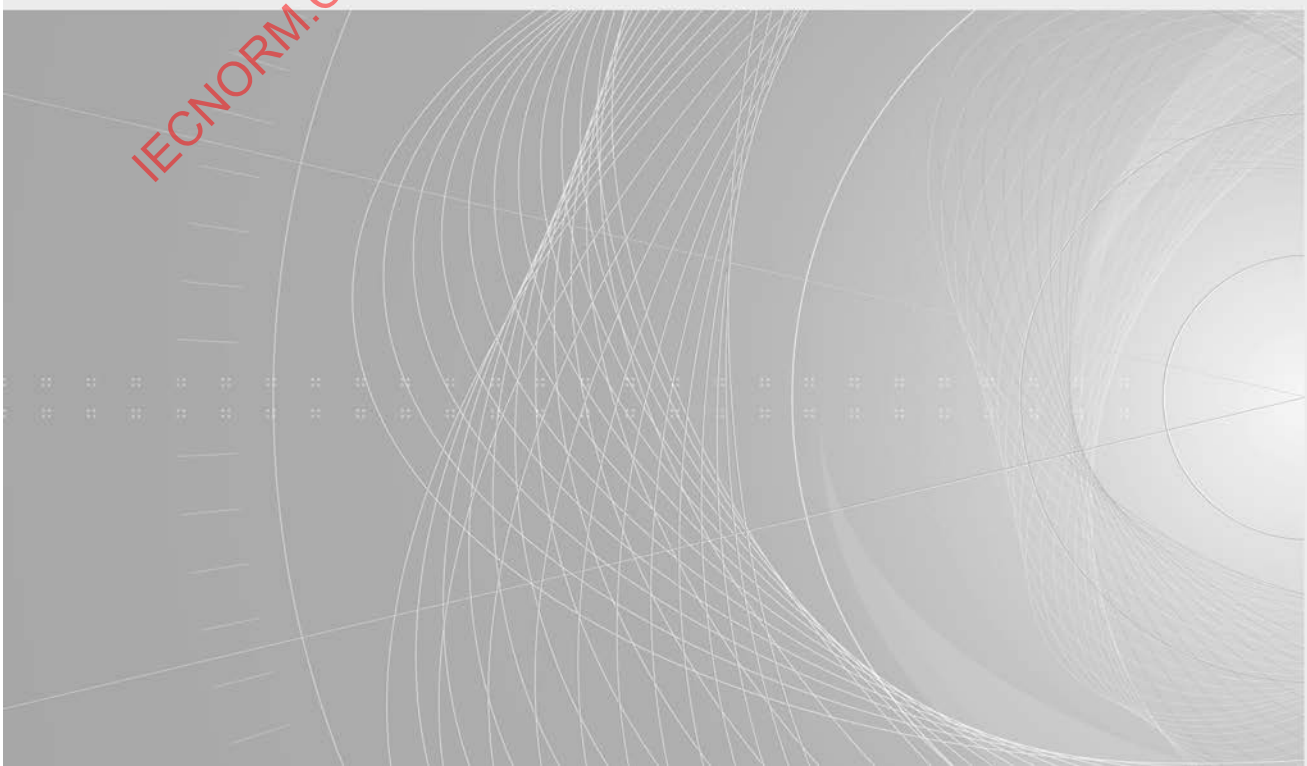
Edition 2.0 2018-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Integrated circuits – Measurement of electromagnetic emissions – Part 1: General conditions and definitions

Circuits intégrés – Mesure des émissions électromagnétiques – Partie 1: Conditions générales et définitions



IEC 61967-1:2018-12(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTEGRATED CIRCUITS – MEASUREMENT OF ELECTROMAGNETIC EMISSIONS –

Part 1: General conditions and definitions

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of 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, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). 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. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61967-1 has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

This second edition cancels and replaces the first edition published in 2002. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) the frequency range of 150 kHz to 1 GHz has been deleted from the title;
b) the frequency step above 1 GHz has been added to Table 1, Table 2 and to 5.4;
c) Table A.1 has been divided into two tables, and IEC 61967-8 has been added to Table A.2 of Annex A;
d) the general test board description has been moved to Annex D.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
47A/1062/FDIS	47A/1066/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61967 series, under the general title *Integrated circuits – Measurement of electromagnetic emissions*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

INTEGRATED CIRCUITS – MEASUREMENT OF ELECTROMAGNETIC EMISSIONS –

Part 1: General conditions and definitions

1 Scope

This part of IEC 61967 provides general information and definitions on the measurement of conducted and radiated electromagnetic disturbances from integrated circuits. It also provides a description of measurement conditions, test equipment and set-up as well as the test procedures and content of the test reports. Test method comparison tables are included in Annex A to assist in selecting the appropriate measurement method(s).

The object of this document is to describe general conditions in order to establish a uniform testing environment and to obtain a quantitative measure of RF disturbances from integrated circuits (IC). Critical parameters that are expected to influence the test results are described. Deviations from this document are noted explicitly in the individual test report. The measurement results can be used for comparison or other purposes.

Measurement of the voltage and current of conducted RF emissions or radiated RF disturbances, coming from an integrated circuit under controlled conditions, yields information about the potential for RF disturbances in an application of the integrated circuit.

The applicable frequency range is described in each part of IEC 61967.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
artificial network
AN
network presenting a reference load impedance (simulated) to the DUT (e.g. extended power or communication lines) across which the RF disturbance voltage is measured and which isolates the apparatus from the power supply or loads in a given frequency range

Note 1 to entry: This note applies to the French language only.

3.2
associated equipment
transducers (e.g. probes, networks and antennae) connected to a measuring receiver or test generator, also transducers used in the signal or disturbance transmission path between a DUT and measuring equipment or a (test-) signal generator

3.3
broadband disturbance
broadband emission
electromagnetic disturbance which has a bandwidth greater than that of a particular measuring apparatus, receiver or susceptible device

Note 1 to entry: For some purposes, particular spectral components of a broadband disturbance may be considered as narrowband disturbances.

Note 2 to entry: Emission that has a bandwidth greater than that of a particular measuring apparatus or receiver.

[SOURCE: IEC 60050-161:1990, 161-06-11, modified – Note 2 to entry and the second preferred term "broadband emission" have been added.]

3.4
common mode voltage
asymmetrical disturbance voltage
mean of the phasor voltages appearing between each conductor and a specified reference, usually earth or frame

[SOURCE: IEC 60050-161:1990, 161-04-09, modified – The word "disturbance" has been added to the admitted term.]

3.5
common mode current
vector sum of the currents flowing through two or more conductors at a specified cross-section of a mathematical plane intersected by these conductors

3.6
conducted emission
transient and/or other disturbance observed on the external terminals of a device during its normal operation

3.7
continuous disturbance
electromagnetic disturbance the effects of which on a particular device or equipment cannot be resolved into a succession of distinct effects

Note 1 to entry: RF disturbance with a duration of more than 200 ms at the IF-output of a measuring receiver that causes a deflection on the meter of a measuring receiver in quasi-peak detection mode that does not decrease immediately.

[SOURCE: IEC 60050-161:1990, 161-02-11, modified – Note 1 to entry has been added.]

3.8
DUT
device under test
device, equipment or system being evaluated

Note 1 to entry: As used in this document, DUT refers to a semiconductor device being tested.

Note 2 to entry: This note applies to the French language only.

3.9
die shrink
reduction of die size by using an advanced fabrication process including finer lithography node and masks

3.10
differential mode current
in a two-conductor cable, or for two particular conductors in a multi-conductor cable, half the magnitude of the difference of the phasors representing the currents in each conductor

[SOURCE: IEC 60050-161:1990, 161-04-38]

3.11
differential mode voltage
voltage between any two of a specified set of active conductors

[SOURCE: IEC 60050-161:1990, 161-04-08, modified – The second preferred term "symmetrical voltage" has been removed.]

3.12
discontinuous disturbance
electromagnetic disturbance, the effects of which on a particular device or equipment can be resolved into a succession of distinct effects

Note 1 to entry: It is recognised that this definition does not characterise the disturbance independently of the effect that it produces. As a practical matter, any measure of a disturbance should be relatable to its effect on a susceptible device.

Note 2 to entry: For counted clicks, disturbance with a duration of less than 200 ms at the IF-output of a measuring receiver, which causes a transient deflection on the meter of a measuring receiver in quasi-peak detection mode.

[SOURCE: IEC 60050-161:1990, 161-02-28, modified – Note 2 to entry has been added.]

3.13
electrically small PCB
printed circuit board with length and width shorter than $\lambda/2$, for example 100 mm to 150 mm at 1 GHz

3.14
EMC
electromagnetic compatibility
ability of an apparatus or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

3.15
electromagnetic emission
phenomenon by which electromagnetic energy emanates from a source

3.16
electromagnetic radiation
radiated emission
1) phenomenon by which energy in the form of electromagnetic waves emanates from a source into space

2) energy transferred through space in the form of electromagnetic waves

[SOURCE: IEC 60050-161:1990, 161-01-10, modified – The second preferred term "radiated emission" has been added and the Note to entry has been omitted.]

3.17
emission limit
<from a disturbing source> specified maximum emission level of a source of electromagnetic disturbance

[SOURCE: IEC 60050-161:1990, 161-03-12]

3.18
ground reference plane
flat conductive surface whose potential is used as a common reference

[SOURCE: IEC 60050-161:2014, 161-04-36, modified – The term "reference-ground plane" has been changed to "ground reference plane", the definition has been condensed and the notes to entry, omitted.]

3.19
lead frame
supporting structure for the silicon die that interfaces the external pins to the die

3.20
measuring receiver
receiver for the measurement of disturbances with different detectors

Note 1 to entry: The bandwidth of the receiver should be as specified in CISPR 16-1-1.

3.21
narrowband emission
electromagnetic disturbance, or spectral component thereof, which has a bandwidth less than or equal to that of a particular measuring apparatus, receiver or susceptible device

Note 1 to entry: Emission with bandwidth less than that of a particular measuring apparatus or receiver.

[SOURCE: IEC 60050-161:1990, 161-06-13, modified – The term "narrowband disturbance" has been changed to "narrowband emission" and Note 1 to entry has been added.]

3.22
peak detector
detector, the output voltage of which is the peak value of the applied signal

[SOURCE: IEC 60050-161:1990, 161-04-24]

3.23
preamp noise floor
inherent thermal noise generated by the first stage amplifier that limits the signal resolution of the measurement system

3.24
receiver terminal voltage
antenna voltage
voltage generated by a source of radio disturbance and measured in dB (µV) by a radio disturbance measuring instrument conforming to the requirements of CISPR 16

Note 1 to entry: External voltage measured in dB (µV) at the input of a radio interference measuring instrument conforming to the requirements of CISPR 16-1-1.

[SOURCE: CISPR 25:2008, 3.8, modified – Note 1 to entry has been added.]

3.25
reference point
specific port or point on the test set-up where the measurement of the sampled parameter is made

3.26
repetition rate
number of surges, spikes, or pulses per unit of time

3.27
radio frequency ambient
RF ambient
electromagnetic environment
totality of electromagnetic phenomena existing at a given location

[SOURCE: IEC 60050-161:1990, 161-01-01, modified – The preferred terms "radio frequency ambient" and "RF ambient" have been added and Note 1 to entry has been removed.]

3.28
shielded enclosure
mesh or sheet metallic housing designed expressly for the purpose of separating electromagnetically the internal and external environment

[SOURCE: IEC 60050-161:1990, 161-04-37, modified – The second preferred term "screened room" has been omitted.]]

3.29
significant IC change
changes that may influence the electromagnetic emissions of an IC

Note 1 to entry: Examples include changes to a new device, new manufacturer or process line, die shrink, new package type, significant manufacturing process, internal/external clock, I/O drive capability.

3.30
system gain
gain (or attenuation) of the measurement path between the reference point and the input of the RF measuring instrument

3.31
test plan
document provided by the test requester to define the tests to be carried out, the object of the testing, the DUT operating status, the conditions for the test and performance objectives

Note 1 to entry: The test plan completely guides the implementation of the test, by reference to the standard test procedure, or by detailing revisions or additions for the specific DUT.

4 Test conditions

4.1 General

These default test conditions are intended to ensure a consistent test environment. If other values are agreed by the users of this procedure, they shall be documented in the test report.

4.2 Ambient conditions

4.2.1 General

The following ambient conditions shall be met.

4.2.2 Ambient temperature

The ambient temperature during the test shall be 23 °C ± 5 °C for repeatability. IC emissions may vary with temperature.

4.2.3 Ambient RF field strength

The ambient RF noise level shall be at least 6 dB below the lowest emission level(s) to be measured. This shall be verified before measurements of the IC are made. The DUT shall be installed in the test set-up, as used for testing. The DUT shall not be activated (for example, the power supply voltage shall be disconnected). A scan shall be made to measure the residual noise. A description of the ambient RF noise level shall be part of the test report.

4.2.4 Other ambient conditions

All other ambient conditions that can affect the result shall be stated in the individual test report.

4.2.5 IC stability over time

The functional behaviour of the IC shall be stable over time so that two measurements, separated by an interval of time, shall yield the same results within the expected variation of the measurement technique.

5 Test equipment

5.1 General

The equipment described in Clause 5 is common to all test procedures described in this document. Specific equipment shall be itemized in the individual test procedures.

5.2 Shielding

The necessary shielding depends upon the specific test method and the ambient noise level. A shielded room may be required to provide a controlled ambient noise level for emission measurements. A non-shielded set-up can be used if ambient noise levels are at least 6 dB below the lowest level to be measured.

5.3 RF measuring instrument

5.3.1 General

Either measuring receivers or spectrum analysers can be used (see Tables 1 and 2 for default settings). The measuring receiver, if used, shall meet the bandwidth requirements as stated in CISPR 16-1-1.

5.3.2 Measuring receiver

Table 1 – Measuring receiver bands and resolution bandwidth (RBW) default settings

Frequency range	150 kHz to 30 MHz	≥ 30 MHz
Measuring receiver RBW at 6 dB	9 kHz	120 kHz

5.3.3 Spectrum analyser

Table 2 – Spectrum analyser bands and RBW default settings

Frequency range	150 kHz to 30 MHz	≥ 30 MHz
Spectrum analyser RBW at 3 dB	10 kHz	100 kHz

5.3.4 Other RBW for narrowband emissions

Where the RF emissions can be verified as being narrowband, and the measurement technique requires a lower noise floor for resolution of the measured signals from the ambient RF noise, a reduced RBW can be used.

5.3.5 Emission type, detector type and sweep speed

A determination of whether the emissions are predominately narrowband or broadband can be made by measuring at the default bandwidth and at the next narrower (one-third) increment of bandwidth. If the measured level of peak values of the spectrum is reduced by 5 dB or more when the bandwidth is reduced by one-third, then the emissions can be considered to be predominately broadband.

Examples of narrowband sources are digital ICs operated by a synchronous clock. They will typically produce a continuous emission spectrum dominated by clock harmonics and fractions. For this reason, the detector chosen will not influence the readings. The peak detector shall be used for narrowband sources.

Examples of possible broadband sources are ICs producing a non-continuous spectrum such as converters and non-synchronous logic. These devices shall be measured, preferably using the peak detector with the sweep speed set to reflect the modulation rate, according to the following formula:

$$V_s \leq \frac{2}{3} \times RBW \times f_m$$

where

V_s is the sweep speed in MHz/s;

f_{RBW} is the resolution bandwidth in MHz;

f_m is the modulation frequency in Hz, defined as the lowest repetition rate of a software routine or other IC operating parameter that may affect the measured RF emissions.

The sweep speed used shall be selected in such a way that a slower sweep speed will not result in a significant change in the measured emissions.

5.3.6 Video bandwidth

The video bandwidth (VBW) shall be at least three times the RBW when a spectrum analyser is used for measurements.

5.3.7 Verification of calibration for the RF measuring instrument

The calibration of the RF measuring instrument shall be verified by comparison with an independent calibrated instrument, traceable to a recognized standard body, if absolute levels are to be reported.

5.4 Frequency range

The recommended frequency range is 150 kHz to 1 GHz, but this may be extended if the specific procedure is usable over an extended frequency range. The range of interest may be smaller when, by function, the IC produces emissions only in that reduced range.

The applicable frequency range is described in each part of IEC 61967.

5.5 Preamplifier or attenuator

If necessary, a preamp or attenuator, either internal or external, can be used. The noise figure of the preamplifier or attenuator shall be less than 10 dB. The minimum resolution for calibration of the preamplifier is 10 points per decade.

5.6 System gain

The gain (or attenuation) between the reference point and the input of the RF measuring instrument shall be verified to within an accuracy of ±0,5 dB.

5.7 Other components

The characteristics of cables, connectors and terminators not in the measurement path between the reference point and the input of the RF measuring instrument that can, however, affect the measurement result, shall be verified over the intended frequency range.

6 Test set-up

6.1 General

Tests shall take place according to a test plan, which shall be included in the test report. This report shall also include:

a) a circuit diagram of the application (supply decoupling, bus load, peripheral ICs, etc.);

b) a description of the PCB on which the IC is applied (layout);

c) actual operating conditions of the IC (supply voltage, output signals, etc.);

d) a description of the type of software exercising the IC(s), if applicable.

All variations shall be included in the test report. Connection to auxiliary equipment shall not influence the test results.

Other particular requirements are described in the individual test procedure.

6.2 Test circuit board

The test PCB to be used depends on the specific measurement method. The specifications of a general basic test board for this family of standards are described in Annex D of this document. The test PCB should be designed in accordance with these general specifications and with the additional specifications as required for the individual measurement methods. Any deviation from this description shall be stated in the individual test reports.

For the comparison of measurement results from different devices it is necessary to use a similar PCB design, as close as possible within the same measurement method.

6.3 IC pin loading

If no other loads are required by a specific test method, the pins of the DUT shall be loaded according to the following default value table, with exceptions as noted.

Table 3 – IC pin loading recommendations

IC pin type	Pin loading
Analogue	
– Supply	As stated by the manufacturer (or as required)
– Input	10 kΩ to ground (Vss) unless the IC is internally terminated
– Output signal	10 kΩ to ground (Vss) unless the IC is internally terminated
– Output power	Nominal loading as stated by the manufacturer
Digital	
– Supply	As stated by the manufacturer (or as required)
– Input	Ground (Vss) or 10 kΩ to supply (Vdd) if impossible to ground, unless the IC is internally terminated
– Output	47 pF to ground (Vss)
Control	
– Input	Ground (Vss) or 10 kΩ to supply (Vdd) if impossible to ground, unless the IC is internally terminated
– Output	As stated by the manufacturer
– Bi-directional	47 pF to ground (Vss)
– Analogue	As stated by the manufacturer (or as required)

Pins that do not fall into any of the listed categories shall be loaded as functionally required and stated in the test report. These are recommended default values; if other values are more appropriate for a particular IC, they may be substituted for the values in Table 3 and shall be stated in the test report.

6.4 Power supply requirements – Test board power supply

The DUT shall be powered from a source with low conducted RF emissions that conform to the RF ambient requirements. If a battery is used, it shall meet the IC requirements and the voltage level shall be checked periodically to maintain a consistent operating environment. An AC power supply can be used if it meets the low RF emissions requirement. All power supply lines to the DUT shall be adequately filtered according to the IC manufacturer's recommendations.

6.5 IC specific considerations

6.5.1 IC supply voltage

The supply voltage(s) shall be as specified by the IC manufacturer with a tolerance of ±5 %.

6.5.2 IC decoupling

To obtain reproducible data of measurement, appropriate decoupling should be accomplished on the test board. See Clause D.9.

6.5.3 Activity of IC

Attempts should be made to fully exercise all available functions that significantly contribute to the emissions of the IC.

6.5.4 Guidelines regarding IC operation

The intent is to describe the parameters to be controlled in order to ensure test repeatability for the particular IC function or type as agreed between the manufacturer and the user.

If a programmable integrated circuit is to be tested, software that flows in a continuous loop shall be written to ensure that measurements are repeatable. The type of software used to exercise the IC (minimum, typical or worst-case) shall be documented in the test report. The IC shall be exercised using one of the following software levels:

a) minimum – implement counter function:

   used for basic tests and comparisons, see Annex B;

b) typical – normal operating or production code:

   used for representative testing, exercise microprocessor and I/O on a "normal" basis using the production code;

c) worst-case – exercise all I/O:

   used for diagnostic purposes, see Annex C.

7 Test procedure

7.1 Ambient RF noise check

Measure ambient RF noise levels to ensure that any ambient signals present are at least 6 dB below the target reference level. The data collected shall be part of the test report. If the ambient RF noise is excessive, check the integrity of the overall system, especially the interconnecting cables and connectors. If necessary, use a shielded enclosure, a lower noise preamplifier or a narrower spectrum analyser resolution bandwidth. If the area ambient RF noise is not well known, with possible sporadic local RF sources, it is recommended to check the ambient RF noise with the unpowered test board in place and with the spectrum analyser running on maximum hold for 1 h or as required to achieve confidence in the environment.

7.2 Operational check

Energize the DUT and complete an operational check to ensure proper function of the device and normal activity (i.e. run IC test code, see 6.5.4).

7.3 Specific procedures

Follow the test technique described in the particular emission measurement procedure.

8 Test report

8.1 General

The test report shall include sufficient information to allow duplication of the measurements by another facility.

8.2 Ambient RF noise

A plot or description of the ambient RF noise levels of the measurement system with the DUT unpowered shall be included in the test report.

8.3 Description of device

A description of the device (IC) being evaluated and any pertinent information that may influence the emission performance of the device shall be included in the test report (for example, IC type number, production code and date, short functional description of the device as on the data sheet). The operating frequency(ies) shall be indicated, if applicable.

8.4 Description of set-up

A description of the test set-up shall be included, with any variations from the standard set-up clearly indicated.

8.5 Description of software

The type of software used to exercise the IC, if applicable, shall be indicated. If a production code is used, the revision level shall be indicated.

8.6 Data presentation

8.6.1 General

Data shall be adjusted for any input gain or attenuation to represent the actual values appearing at the reference point, in dB (µV), for voltage measurements.

8.6.2 Graphical presentation

A graph of the measured data shall be available.

8.6.3 Measurement data

An ASCII file of the measured data shall be available.

8.6.4 Data processing

The smoothing or averaging of raw data can provide a more readable format. A description of any data processing used shall be included in the test report.

8.7 RF emission limits

As this document describes measurement methods, no RF emission limits are given. Limits in general depend upon the application, the area and the country. Functional requirements and local or mandated emission requirements will define the limits.

8.8 Interpretation of results

8.8.1 Comparison between IC(s) using the same test method

Results may be directly compared as long as measurements have been carried out under the same conditions. If comparisons are intended, the devices should be running the same code (for example, the counter test code, Annex B) and the test environment should be as consistent as possible. The same test board should be used.

8.8.2 Comparison between different test methods

At the time of writing, general correlation between the specific test methods has not been established. Correlation has been demonstrated in specific cases only. Refer to Annex A.

8.8.3 Correlation to module test methods

Where sufficient data exists to establish a correlation between the measured values and the expected emissions from the IC for a given application, this shall be indicated in the specific test method (for example, component or system level tests of the product). A number of factors are involved in the translation from IC level emissions to the module or product level. In general, this IC-to-module correlation is limited to specific cases where the variables involved are controlled.

Annex A
(informative)

Test method comparison tables

Tables A.1 and A.2 compare the test methods for conducted emissions and radiated emissions, respectively.

Table A.1 – Conducted emission

Item	IEC 61967-4 1 Ω/150 Ω	IEC 61967-5 WBFC	IEC 61967-6 Magnetic probe
Measured emission type in IC	Differential- and common-mode conducted emissions[a]	Common-mode conducted emissions[b]	Differential- and common-mode conducted emissions[a]
Proposed frequency range	150 kHz to 1 000 MHz	150 kHz to 1 000 MHz	150 kHz to 3 000 MHz
Test board for:			
– comparison of ICs	Mandatory	Mandatory	Mandatory
– evaluation in application	Non-restricted[c]	Non-restricted	Non-restricted[d]
Operator dependence to reproduce measurements	No	No	No
Single pin voltage/current measurable	Yes	No	Yes
Comparison of IC versions – in same package	Yes	Yes	Yes
IC emission source/path analysis			
– variation of packaging	Possible	Yes	Possible
– on-chip decoupling	Yes	Yes	Yes
– multiple pin power supply	Yes	Yes	Yes
– I/O signal conditioning	Yes	Yes	Yes
– optimized location of pins	Partly	Yes	Yes
IC evaluation	Yes	Yes	Yes

[a] Differential mode voltage and common mode current.

[b] Common mode voltage and currents.

[c] If 1 Ω/150 Ω connections are incorporated.

[d] If a suitable microstrip is incorporated.

Table A.2 – Radiated emission

Item	IEC 61967-2 TEM[a] cell and wideband TEM cell	IEC TS 61967-3 Surface scan	IEC 61967-8 IC stripline
Measured emission type in IC	E/H field from IC	E/H field from IC	E/H field from IC
Proposed frequency range	150 kHz to 2 GHz and higher (up to 18 GHz)	150 kHz to 3 000 MHz	150 kHz to 3 000 MHz
Test board for:			
– comparison of ICs	Mandatory	Mandatory	Mandatory
– evaluation in application	Needed	Needed	Needed
Operator dependence to reproduce measurements	No	No, if automated system used	No
Single pin voltage/current measurable	No	No	No
Comparison of IC versions – in same package	Yes	Yes	Yes
IC emission source/path analysis			
– variation of packaging	Yes	Yes	Yes
– on-chip decoupling	Yes	Partly	Yes
– multiple pin power supply	Partly	Partly	Partly
– I/O signal conditioning	Partly	Partly	Partly
– optimized location of pins	No	No	No
IC evaluation	Yes	No	Yes

[a] Transverse electromagnetic

Annex B
(informative)

Flow chart of a counter test code

This simple routine implements a counter function using a single 8-bit port. Every 100 µs, the port output is incremented or decremented. After 10 count cycles (256 ms), an LED output is complemented. This will provide a blinking light indication with a frequency of about 2 Hz. For consistency, equivalent loop times should be maintained. The test code flow chart is shown in Figure B.1.

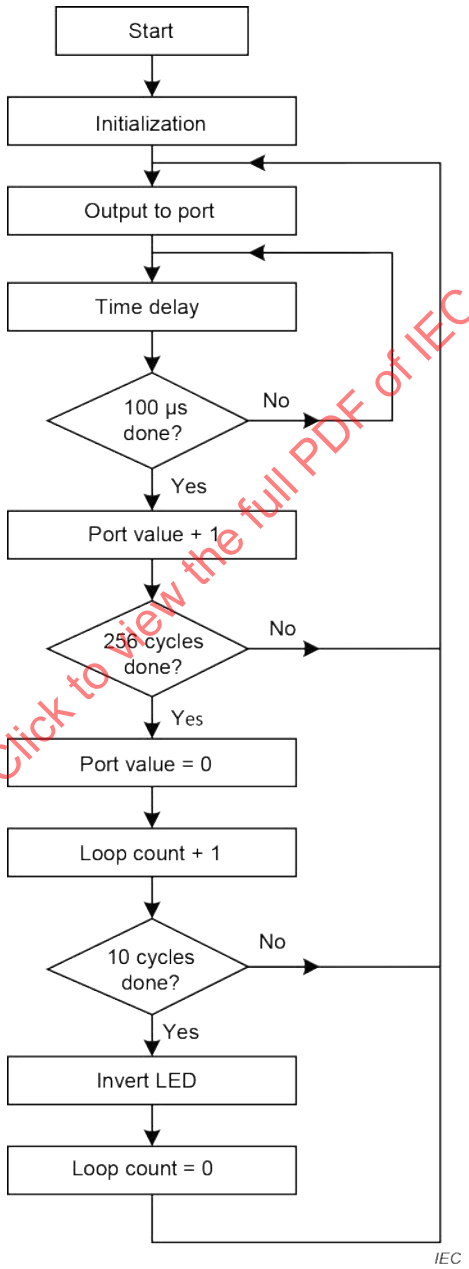

Figure B.1 – Test code flow chart

Annex C
(informative)

Description of worst-case application software

While under test, the IC shall execute software representative of that which could be found in a worst-case application. The software loop execution time shall be at least three orders of magnitude smaller than the spectrum analyser sweep period (for example, sweep = 6 s, software loop ≤ 6 ms). The following recommendations are applicable to a single IC microcontroller (MCU). They are intended as guidelines for the software writer; however, it is recognized that not all of the points are necessarily appropriate for all MCU devices:

a) the CPU should maximally exercise the internal address and data buses. Attention should be given to the bus implementation (precharged or static);

b) the test software should provide some means of indicating correct execution to the user (for example, toggling the port pin);

c) the test software should enable and exercise all on-board IC peripherals, where practical. In particular, peripherals that can generate fast periodic signals (serial peripherals, some timers) should be configured and exercised to generate these periodic signals. However, if these peripherals significantly contribute to the total radiated emission figure, then the test can be performed, and results reported, with the peripherals enabled and disabled;

d) the test software should enable all internally generated clock sources that appear on any I/O pin. However, if these clocks significantly contribute to the total radiated emission figure, then the test can be performed, and results reported, with the clocks enabled and disabled.

When it is impractical to execute test software (for example, when the device has no programmable memory and cannot bootstrap code into internal RAM), the test should be performed with the device held in reset. However, this test condition shall be reported with the test results.

Annex D
(informative)

General test board description

D.1 General

The purpose is to describe a universal test board. Such a board is necessary to compare the EMC performance of various ICs from different manufacturers. Constraints are given for those parameters influencing the EMC aspects.

D.2 Board description – Mechanical

The board size is $100\,^{+3}_{-1}$ mm^2. Holes may be added at the corners of the board, as shown in Figure D.1. All edges of the board shall be tinned by at least 5 mm, or made conducting in order to make proper contact with the TEM cell, if used. As an alternative, edges may be gold-plated.

The vias at the outer edge of the board shall be at least 5 mm away from that edge.

D.3 Board description – Electrical

The drawing in Figure D.1 shall be taken as a guide. A double layer board is proposed as a minimum requirement. However, if functionally needed, layers 2 and 3 or others may be added in between, such that a multi-layer board appears.

Layer 1 shall always be used as the ground plane. Layer 4 allows other signals, but shall be left as intact as possible, in order to be a ground plane as well. At least the area in layer 1 underneath the IC shall be left as a ground plane.

The PCB shall be made in such a way that only the IC package remains on one side (layer 1) and all other components and trace patterns remain on the opposite layer (layer 4).

D.4 Ground planes

The ground planes (layers 1 and 4) shall be interconnected by means of vias. These vias shall be placed at the following positions over the board as described in Table D.1.

Table D.1 – Position of vias over the board

Via position	Location
1	All around, at the edges of the board
2	Just outside the DUT area
3	Just inside, underneath the IC area

The ground plane at layer 1 shall be continued between vias, at position 2. As such, the ground plane at layer 1 is continued over the whole board.

If possible the same shall be done for layer 4, but the possibility to do so depends on the IC package and the space available.

D.5 Package pins

D.5.1 General

All functionally necessary components other than the IC shall be mounted on layer 4. It is therefore necessary to feed I/O and other required pins from layer 1 to layer 4. The loop areas, trace length, via placement and component orientation shall be so optimized that minimum loop areas are obtained.

D.5.2 DIL packages

These packages do not require vias, as plated-through hole pins are considered present, or established by the pins themselves.

D.5.3 SOP, PLCC, QFP packages

These packages require the use of vias. The vias should preferably be centred in the pads used for soldering the ICs. Preferably, these vias should be placed at position 3, Table D.1, to minimize the loop area involved in which the IC currents will flow.

D.5.4 PGA packages

These packages do not require vias, as plated through-hole pins are considered present or established by the pins themselves.

D.5.5 BGA packages

These packages require the use of vias. The vias for power supply and ground interconnection should preferably be located in accordance with the manufacturer's recommendations.

D.6 Via diameters

All vias at position1 shall have a hole diameter of 0,8 mm. All other vias shall have a diameter of ≥ 0,2 mm.

D.7 Via distance

Via placement shall be controlled as follows for the applicable frequency range, for example, λ/10. The maximum lateral distance between vias connecting layer 1 to layer 4 (positions 1, 2 and 3) shall be 10 mm. Vias for signal traces shall be placed as close as possible to those vias connecting layer 1 to layer 4.

D.8 Additional components

All additional components shall be mounted at layer 4. They shall be placed in such a way that they do not interfere with the constraints as set for layers 1 and 4 and interconnecting vias.

D.9 Supply decoupling

D.9.1 General

To obtain reproducible data of measurement, adequate supply decoupling is required in accordance with the test board specifications. Decoupling capacitors on the test board shall be classified into two groups, as described in D.9.2. and D.9.3. The values and layout

positions of the decoupling capacitors and other decoupling components shall be stated in the individual test report.

D.9.2 IC decoupling capacitors

Supply decoupling for the IC shall be in accordance with the manufacturer's recommendations. IC decoupling capacitors, if any, shall be connected to the ground plane in layer 4, underneath the IC, as described in Clause D.3 and in Figure D.1, to maintain the proper operation of the DUT. The value and layout position of a decoupling capacitor of each supply pin of the DUT may be as advised by the manufacturer, or otherwise, as long as stated in the test report.

D.9.3 Power supply decoupling for the test board

Impedance of the test board power supply may affect the measurement results if the power supply decoupling is not adequately designed. To control the supply impedance of the test board for any external power supply which may be used in the measurement, a group of decoupling capacitors shall be located on the test board. Their values and layout positions shall be as described in the individual measurement standards, or otherwise, as long as stated in the test report.

D.10 I/O load

Additional components necessary to load or activate the IC shall be mounted on layer 4, preferably directly underneath the IC package area. This includes the necessary ports to allow IC monitoring during the RF immunity test.

Dimensions in millimetres

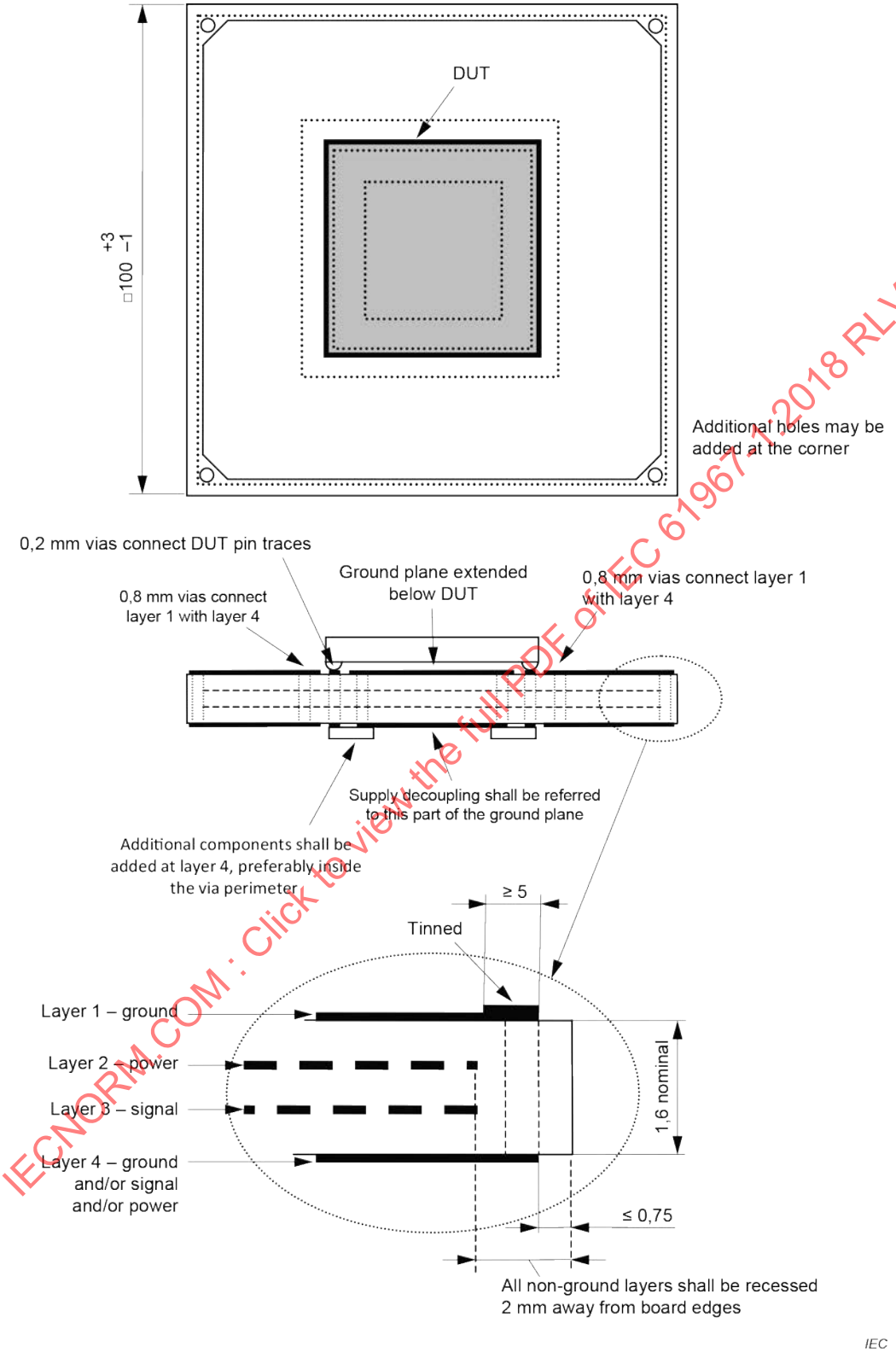

Figure D.1 – Example of an emission test board

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IEC 61967-2, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 2: Measurement of radiated emissions – TEM cell and wideband TEM cell method*

IEC TS 61967-3, *Integrated circuits – Measurement of electromagnetic emissions – Part 3: Measurement of radiated emissions – Surface scan method*

IEC 61967-4, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 4: Measurement of conducted emissions, 1 Ω/150 Ω direct coupling method*

IEC 61967-5, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 5: Measurement of conducted emissions – Workbench Faraday Cage method*

IEC 61967-6, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 6: Measurement of conducted emissions – Magnetic probe method*

IEC 61967-8, *Integrated circuits – Measurement of electromagnetic emissions – Part 8: Measurement of radiated emissions – IC stripline method*

IEC 62132-1, *Integrated circuits – Measurement of electromagnetic immunity – Part 1: General conditions and definitions*

CISPR 25:2008, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers*[1]

[1] Third edition (2008). This third edition was replaced in 2016 by a fourth edition CISPR 25:2016, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers*.

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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CIRCUITS INTÉGRÉS – MESURE DES ÉMISSIONS ÉLECTROMAGNÉTIQUES –

Partie 1: Conditions générales et définitions

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La Norme internationale IEC 61967-1 a été établie par le sous-comité 47A: Circuits intégrés, du comité d'études 47 de l'IEC: Dispositifs à semiconducteurs.

Cette deuxième édition annule et remplace la première édition parue en 2002. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) la gamme de fréquences 150 kHz à 1 GHz a été supprimée du titre;
b) un palier de fréquences au-dessus de 1 GHz a été ajouté dans le Tableau 1, le Tableau 2 et au Paragraphe 5.4;

c) le Tableau A.1 a été divisé en deux tableaux et l'IEC 61967-8 a été ajoutée au Tableau A.2 de l'Annexe A;

d) la description générale de la carte d'essai a été déplacée à l'Annexe D.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
47A/1062/FDIS	47A/1066/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 61967, publiées sous le titre général *Circuits intégrés – Mesure des émissions électromagnétiques* peut être consultée sur le site web de l'IEC.

Les futures normes de cette série porteront dorénavant le nouveau titre général cité ci-dessus. Le titre des normes existant déjà dans cette série sera mis à jour lors de la prochaine édition.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

CIRCUITS INTÉGRÉS – MESURE DES ÉMISSIONS ÉLECTROMAGNÉTIQUES –

Partie 1: Conditions générales et définitions

1 Domaine d'application

La présente partie de l'IEC 61967 fournit des informations générales et des définitions sur la mesure des perturbations électromagnétiques conduites et rayonnées par les circuits intégrés. Elle décrit également les conditions de mesure, l'appareillage et le montage d'essai, ainsi que les procédures d'essai et le contenu des rapports d'essai. L'Annexe A fournit des tableaux de comparaison des méthodes d'essai permettant de choisir la ou les méthodes de mesure appropriées.

Le présent document a pour objet de définir des conditions générales afin d'établir un environnement d'essai uniforme et d'obtenir une mesure quantitative des perturbations RF par les circuits intégrés (CI). Il décrit les paramètres fondamentaux supposés avoir une incidence sur les résultats des essais. Tout écart par rapport au présent document est consigné de manière explicite dans les rapports d'essai. Les résultats des mesures peuvent être utilisés notamment à des fins de comparaison.

La mesure de la tension et du courant des émissions RF conduits ou des perturbations RF rayonnées provenant d'un circuit intégré dans des conditions contrôlées, fournit des informations sur les perturbations RF potentielles dans une application du circuit intégré.

La gamme de fréquences applicable est décrite dans chaque partie de l'IEC 61967.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

CISPR 16-1-1, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-1: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Appareils de mesure*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
réseau fictif
AN
réseau présentant une impédance de charge de référence (simulée) au dispositif en essai (par exemple, lignes électriques ou de télécommunications prolongées) qui permet de mesurer les tensions perturbatrices RF et qui isole l'appareil de l'alimentation ou des charges à une gamme de fréquences donnée

Note 1 à l'article: Le terme abrégé "AN" est dérivé du terme anglais développé correspondant "artificial network".

3.2
équipements associés, pl
transducteurs (par exemple sondes, réseaux et antennes) connectés à un récepteur de mesure ou à un générateur d'essai; également les transducteurs utilisés dans le trajet de transmission des signaux ou des perturbations entre un dispositif en essai et un appareil de mesure ou un générateur de signaux (d'essai)

3.3
perturbation à large bande
émission à large bande
perturbation électromagnétique dont la largeur de bande est supérieure à celle d'un appareil de mesure, d'un récepteur ou d'un dispositif susceptible donné

Note 1 à l'article: Pour certaines applications, des composantes spectrales particulières d'une perturbation à large bande peuvent être considérées comme des perturbations à bande étroite.

Note 2 à l'article: Émission dont la largeur de bande est supérieure à celle d'un appareil de mesure ou d'un récepteur donné.

[SOURCE: IEC 60050-161:1990, 161-06-11, modifié – La Note 2 à l'article et le deuxième terme privilégié "émission à large bande" ont été ajoutés.]

3.4
tension en mode commun
tension de perturbation asymétrique
moyenne des phaseurs qui représentent les tensions entre chaque conducteur et une référence arbitraire, généralement la terre ou la masse

[SOURCE: IEC 60050-161:1990, 161-04-09, modifié – Le mot "perturbation" a été ajouté au terme admis.]

3.5
courant en mode commun
somme vectorielle des courants traversant deux conducteurs ou plus à une section spécifiée d'un plan mathématique entrecoupé par ces conducteurs

3.6
émission conduite
transitoire et/ou autre perturbation observée aux bornes externes d'un dispositif pendant son fonctionnement normal

3.7
perturbation continue
perturbation électromagnétique dont l'effet sur un dispositif ou un appareil donné ne peut être décomposé en une suite d'effets distincts

Note 1 à l'article: Perturbation RF d'une durée supérieure à 200 ms à la sortie de la fréquence intermédiaire d'un récepteur de mesure, provoquant une déviation de l'aiguille d'un récepteur de mesure en mode de détection de quasi-crête qui ne diminue pas immédiatement.

[SOURCE: IEC 60050-161:1990, 161-02-11, modifié – La Note 1 à l'article a été ajoutée.]

3.8
DUT
dispositif en essai
dispositif, appareil ou système soumis à une évaluation

Note 1 à l'article: Tel qu'il est utilisé dans le présent document, le dispositif en essai désigne un dispositif à semiconducteurs soumis à essai.

Note 2 à l'article: Le terme abrégé "DUT" est dérivé du terme anglais développé correspondant "device under test".

3.9
réduction de la taille d'une puce
réduction de la taille d'une puce reposant sur l'utilisation d'un procédé de fabrication avancé, notamment par une technologie de lithographie plus fine et l'emploi de masques

3.10
courant en mode différentiel
dans un câble à deux conducteurs, ou pour deux conducteurs particuliers d'un câble multiconducteur, moitié du module de la différence des phaseurs représentant les courants dans chaque conducteur

[SOURCE: IEC 60050-161:1990, 161-04-38]

3.11
tension en mode différentiel
tension entre deux conducteurs donnés d'un ensemble de conducteurs

[SOURCE: IEC 60050-161:1990, 161-04-08, modifié – Le deuxième terme privilégié, "tension asymétrique", a été supprimé.]

3.12
perturbation discontinue
perturbation électromagnétique dont l'effet sur un dispositif ou un appareil donné peut être décomposé en une suite d'effets distincts

Note 1 à l'article: Il est reconnu que cette définition ne caractérise pas la perturbation indépendamment de l'effet qu'elle produit. En pratique, il convient de rapporter toute mesure d'une perturbation à son effet sur un dispositif susceptible donné.

Note 2 à l'article: Pour les claquements dénombrés, perturbation d'une durée inférieure à 200 ms à la sortie de la fréquence intermédiaire d'un récepteur de mesure, provoquant une déviation transitoire de l'aiguille d'un récepteur de mesure en mode de détection de quasi-crête.

[SOURCE: IEC 60050-161:1990, 161-02-28, modifié – La Note 2 à l'article a été ajoutée.]

3.13
carte à circuit imprimé de petit format
carte à circuit imprimé d'une longueur et d'une largeur inférieures à λ/2, par exemple 100 mm à 150 mm à 1 GHz

3.14
CEM
compatibilité électromagnétique
aptitude d'un appareil ou d'un système à fonctionner dans son environnement électromagnétique de façon satisfaisante et sans produire lui-même des perturbations électromagnétiques intolérables pour tout ce qui se trouve dans cet environnement

3.15
émission électromagnétique
processus par lequel une source fournit de l'énergie électromagnétique

3.16
rayonnement électromagnétique
émission rayonnée
1) processus par lequel une source fournit de l'énergie vers l'espace extérieur sous forme d'ondes électromagnétiques

2) énergie transportée dans l'espace sous forme d'ondes électromagnétiques

[SOURCE: IEC 60050-161:1990, 161-01-10, modifié – Le deuxième terme privilégié, "émission rayonnée", a été ajouté.]

3.17
limite d'émission
<d'une source perturbatrice> valeur maximale spécifiée du niveau d'émission d'une source de perturbation électromagnétique

[SOURCE: IEC 60050-161:1990,161-03-12]

3.18
plan de masse de référence
surface conductrice plate dont le potentiel est utilisé comme référence

[SOURCE: IEC 60050-161:2014, 161-04-36, modifié – La définition a été abrégée et les notes à l'article ont été supprimées.]

3.19
grille de connexion
structure de soutien de la puce de silicium qui relie les broches extérieures à la puce

3.20
récepteur de mesure
récepteur destiné à la mesure des perturbations à l'aide de différents détecteurs

Note 1 à l'article: Il convient que la largeur de bande du récepteur soit conforme à la valeur spécifiée dans la CISPR 16-1-1.

3.21
émission à bande étroite
perturbation électromagnétique, ou composante spectrale d'une perturbation, dont la largeur de bande est inférieure ou égale à celle d'un appareil de mesure, d'un récepteur ou d'un dispositif susceptible donné

Note 1 à l'article: Émission dont la largeur de bande est inférieure à celle d'un appareil de mesure ou d'un récepteur donné.

[SOURCE: IEC 60050-161:1990, 161-06-13, modifié – Le terme "perturbation à bande étroite" a été remplacé par "émission à bande étroite" et la Note 1 à l'article a été ajoutée.]

3.22
détecteur de crête
détecteur qui fournit une tension de sortie égale à la valeur de crête du signal appliqué

[SOURCE: IEC 60050-161:1990, 161-04-24]

3.23
bruit de fond du préamplificateur
bruit thermique inhérent généré par le préamplificateur de premier niveau qui limite la résolution du signal du système de mesure

3.24
tension aux bornes du récepteur
tension antenne
tension produite par une source de perturbations radioélectriques et mesurée en dB(µV) par un appareil de mesure des perturbations radioélectriques conformément aux exigences de la norme CISPR 16

Note 1 à l'article: Tension extérieure mesurée en dB(µV) à l'entrée d'un appareil de mesure de brouillage radioélectrique conformément aux exigences de la CISPR 16-1-1.

[SOURCE: CISPR 25:2008, 3.8, modifié – La Note 1 à l'article a été ajoutée.]

3.25
point de référence
accès ou point spécifique sur le montage d'essai sur lequel est effectuée la mesure du paramètre échantillonné

3.26
fréquence de répétition
nombre de chocs, de pointes de tension ou d'impulsions par unité de temps

3.27
conditions ambiantes des radiofréquences, pl
conditions ambiantes des RF, pl
environnement électromagnétique
ensemble des phénomènes électromagnétiques existant à un endroit donné

[SOURCE: IEC 60050-161:1990, 161-01-01, modifié – Les termes privilégiés "conditions ambiantes des radiofréquences" et "conditions ambiantes des RF" ont été ajoutés et la Note 1 à l'article a été supprimée.]

3.28
cage de Faraday
enceinte fermée par des parois métalliques pleines ou grillagées, destinée à séparer électromagnétiquement l'intérieur et l'extérieur

[SOURCE: IEC 60050-161:1990, 161-04-37]

3.29
modification significative du CI
modification pouvant influencer les émissions électromagnétiques d'un CI

Note 1 à l'article: Les modifications apportées à un nouveau dispositif, un nouveau fabricant ou procédé, la réduction de la taille d'une puce, un nouveau type de boîtier, un changement de production important, l'horloge interne/externe, la capacité de l'unité d'entrée-sortie, en sont des exemples.

3.30
gain du système
gain (ou affaiblissement) du trajet de mesure entre le point de référence et l'entrée de l'appareil de mesure de radiofréquences

3.31
plan d'essai
document fourni par le demandeur de l'essai visant à définir les essais à effectuer, l'objet des essais, l'état de fonctionnement du dispositif en essai, les conditions d'essai et les objectifs de performance

Note 1 à l'article: Le plan d'essai guide l'intégralité de la mise en œuvre de l'essai, en faisant référence à la procédure d'essai normalisée, ou en énumérant les révisions ou les amendements concernant le dispositif en essai spécifique.

4 Conditions d'essai

4.1 Généralités

Ces conditions d'essai par défaut visent à assurer l'uniformité de l'environnement d'essai. Si les utilisateurs de cette procédure ont fixé d'autres valeurs, celles-ci doivent être indiquées dans le rapport d'essai.

4.2 Conditions ambiantes

4.2.1 Généralités

Les conditions ambiantes suivantes doivent être respectées.

4.2.2 Température ambiante

La température ambiante d'essai doit être de 23 °C ± 5 °C pour maintenir des conditions de répétabilité. Les émissions du CI peuvent varier en fonction de la température.

4.2.3 Intensité ambiante du champ de radiofréquences

Le niveau de bruit ambiant des radiofréquences doit être au moins de 6 dB inférieur au(x) niveau(x) d'émission le(s) plus bas à mesurer. Ceci doit être vérifié avant d'effectuer les mesures du CI. Le dispositif en essai doit être installé dans le montage d'essai, tel utilisé pour les essais. Le dispositif en essai ne doit pas être activé (par exemple, la tension d'alimentation doit être coupée). Le bruit résiduel doit être mesuré à l'aide d'un balayage. Le rapport d'essai doit comporter une description du niveau de bruit ambiant des radiofréquences.

4.2.4 Autres conditions ambiantes

Toute autre condition ambiante pouvant affecter le résultat doit être indiquée dans les rapports d'essai.

4.2.5 Stabilité du CI dans le temps

Le fonctionnement du CI doit être stable dans le temps de sorte que deux mesures, séparées par un intervalle de temps donné, produisent des résultats identiques dans les limites de la variation prévue de la technique de mesure.

5 Appareillage d'essai

5.1 Généralités

L'appareil décrit dans l'Article 5 est utilisé dans l'ensemble des procédures d'essai décrites dans le présent document. Un appareil spécifique doit être utilisé selon les procédures d'essai.

5.2 Blindage

Le blindage nécessaire dépend de la méthode d'essai spécifique et du niveau de bruit ambiant. Un local blindé peut être exigé pour contrôler le niveau de bruit ambiant lors des mesures d'émissions. Une installation non blindée peut être utilisée si le niveau de bruit ambiant est au moins de 6 dB inférieur au niveau le plus bas à mesurer.

5.3 Appareil de mesure de radiofréquences

5.3.1 Généralités

Des récepteurs de mesure ou des analyseurs de spectres peuvent être utilisés (voir les Tableaux 1 et 2 pour les paramétrages par défaut). Si un récepteur de mesure est utilisé, celui-ci doit être conforme aux exigences de largeur de bande de la CISPR 16-1-1.

5.3.2 Récepteur de mesure

Tableau 1 – Réglages par défaut des bandes et des largeurs de bande de résolution du récepteur de mesure

Gamme de fréquences	150 kHz à 30 MHz	≥ 30 MHz
Largeur de bande de résolution du récepteur de mesure à 6 dB	9 kHz	120 kHz

5.3.3 Analyseur de spectres

Tableau 2 – Paramétrages par défaut d'un analyseur de spectres et des largeurs de bandes de résolution

Gamme de fréquences	150 kHz à 30 MHz	≥ 30 MHz
Largeur de bande de résolution de l'analyseur de spectres à 3 dB	10 kHz	100 kHz

5.3.4 Autre largeur de bande de résolution pour les émissions à bande étroite

Lorsqu'il peut être vérifié que les émissions radioélectriques sont à bande étroite et que la technique de mesure exige un bruit de fond plus bas pour la résolution des signaux mesurés à partir du niveau de bruit ambiant des radiofréquences, une largeur de bande de résolution réduite peut être utilisée.

5.3.5 Type d'émission, type de détecteur et vitesse de balayage

Pour déterminer si les émissions sont majoritairement à bande étroite ou à large bande, des mesures peuvent être effectuées au niveau de la largeur de bande par défaut et de l'incrément le plus étroit (un tiers) suivant de la largeur de bande. Si le niveau mesuré des valeurs de crête du spectre est réduit de 5 dB ou plus lorsque la largeur de bande est réduite d'un tiers, les émissions peuvent alors être considérées comme étant majoritairement à large bande.

Les CI numériques commandés par une horloge synchrone constituent des exemples de sources à bande étroite. En général, ils produisent un spectre d'émissions continues dominé par les harmoniques et fractions d'horloge. Pour cette raison, le détecteur choisi n'influence pas les valeurs indiquées. Le détecteur de crête doit être utilisé pour les sources à bande étroite.

Par exemple, les CI produisant un spectre discontinu (tels que les convertisseurs et les circuits logiques asynchrones) constituent des sources à large bande possibles. Ces

dispositifs doivent être mesurés, préférentiellement à l'aide du détecteur de crête, la vitesse de balayage étant réglée pour correspondre à la rapidité de modulation, selon la formule suivante:

$$V_S \leq \frac{2}{3} \times RBW \times f_m$$

où

V_S est la vitesse de balayage, en MHz/s;

f_{RBW} est la largeur de bande de résolution, en MHz;

f_m est la fréquence de modulation, en Hz, définie comme la plus faible fréquence de répétition d'un logiciel ou un autre paramètre de fonctionnement du CI pouvant modifier les émissions RF mesurées.

La vitesse de balayage utilisée doit être choisie de sorte qu'une vitesse de balayage plus lente n'entraîne pas de modification significative des émissions mesurées.

5.3.6 Largeur de bande vidéo

La largeur de bande vidéo doit être au moins égale à trois fois la largeur de bande de résolution lorsqu'un analyseur de spectres est utilisé pour les mesures.

5.3.7 Vérification de l'étalonnage de l'appareil de mesure de radiofréquences

L'étalonnage de l'appareil de mesure de radiofréquences doit être vérifié en effectuant une comparaison avec un autre appareil étalonné, traçable à un organisme de normalisation reconnu, lorsque des niveaux absolus doivent être consignés.

5.4 Gamme de fréquences

La gamme de fréquences recommandée est comprise entre 150 kHz et 1 GHz, mais elle peut être étendue si la procédure spécifique est utilisable sur une gamme de fréquences étendue. La gamme prise en compte peut être plus petite lorsque, en raison de sa fonction, le CI ne produit des émissions que dans cette gamme réduite.

La gamme de fréquences applicable est décrite dans chaque partie de l'IEC 61967.

5.5 Préamplificateur ou atténuateur

Si nécessaire, un préamplificateur ou un atténuateur, interne ou externe, peut être utilisé. Le facteur de bruit du préamplificateur ou de l'atténuateur doit être inférieur à 10 dB. La résolution minimale pour l'étalonnage du préamplificateur est de 10 points par décade.

5.6 Gain du système

Le gain (ou l'affaiblissement) entre le point de référence et l'entrée de l'appareil de mesure de radiofréquences doit être vérifié à ±0,5 dB près.

5.7 Autres composants

Les caractéristiques des câbles, connecteurs et terminaisons qui ne se trouvent pas sur le trajet de mesure entre le point de référence et l'entrée de l'appareil de mesure de radiofréquences pouvant cependant influer sur le résultat de la mesure doivent être vérifiées sur la gamme de fréquences prévue.