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Integrated circuits — Measurement of electromagnetic emissions

Part 8: Measurement of radiated emissions — IC stripline method

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The UK participation in its preparation was entrusted to Technical Committee EPL/47, Semiconductors.

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Foreword

The text of document 47A/868/FDIS, future edition 1 of IEC 61967-8, prepared by SC 47A, "Integrated circuits", of IEC TC 47, "Semiconductor devices" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61967-8:2011.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2012-06-15
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2014-09-15

This standard is to be used in conjunction with EN 61967-1.

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050-131	-	International Electrotechnical Vocabulary (IEV) - Part 131: Circuit theory	-	-
IEC 60050-161	-	International Electrotechnical Vocabulary (IEV) - Chapter 161: Electromagnetic compatibility	-	-
IEC 61000-4-20	-	Electromagnetic compatibility (EMC) - Part 4-20: Testing and measurement techniques - Emission and immunity testing in transverse electromagnetic (TEM) waveguides	EN 61000-4-20	-
IEC 61967-1	-	Integrated circuits - Measurement of electromagnetic emissions, 150 kHz to 1 GHz - Part 1: General conditions and definitions	EN 61967-1	-
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	EN 61967-2	-

CONTENTS

INTEGRATED CIRCUITS – MEASUREMENT OF ELECTROMAGNETIC EMISSIONS –

Part 8: Measurement of radiated emissions – IC stripline method

1 Scope

The measurement procedure of this part of IEC 61967 defines a method for measuring the electromagnetic radiated emission from an integrated circuit (IC) using an IC stripline in the frequency range of 150 kHz up to 3 GHz. The IC being evaluated is mounted on an EMC test board (PCB) between the active conductor and the ground plane of the IC stripline arrangement.

2 Normative references

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

IEC 60050-131: *International Electrotechnical Vocabulary (IEV) – Part 131: Circuit theory*

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

IEC 61967-1: *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 1: General conditions and definitions*

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 61000-4-20*: Electromagnetic compatibility (EMC) – Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61967-1, IEC 60050-131 and IEC 60050-161 as well as the following apply.

3.1
transverse electromagnetic (TEM) mode
waveguide mode in which the components of the electric and magnetic fields in the propagation direction are much less than the primary field components across any transverse cross-section

3.2
TEM waveguide
open or closed transmission line system, in which a wave is propagating in the transverse electromagnetic mode to produce a specified field for testing purposes

3.3
IC stripline
TEM waveguide, consisting of an active conductor placed on a defined spacing over an enlarged ground plane, connected to a port structure on each end and an optional shielded enclosure

NOTE This arrangement guides a wave propagation in the transverse electromagnetic mode to produce a specific field for testing purposes between the active conductor and the enlarged ground plane. As enlarged ground plane the ground plane of the standard EMC test board according to IEC 61967-1 should be used. An optional shielding enclosure may be used for fixing the IC stripline configuration and for shielding purposes. This leads to a closed version of the IC stripline in opposite to the open version without shielding enclosure. For further information see Annex A.

3.4
two-port TEM waveguide
TEM waveguide with input/output measurement ports at both ends

3.5
characteristic impedance
magnitude of the ratio of the voltage between the active conductor and the corresponding ground plane to the current on either conductor for any constant phase wave-front

NOTE The characteristic impedance is independent of the voltage/current magnitudes and depends only on the cross sectional geometry of the transmission line. TEM waveguides are typically designed to have 50 Ω characteristic impedance. For further information and equation to stripline arrangements, see Annex A.

3.6
primary (field) component
electric field component aligned with the intended test polarization

NOTE For example, in IC stripline, the active conductor is parallel to the horizontal floor, and the primary mode electric field vector is vertical at the transverse centre of the IC stripline.

4 General

This test method is based on the TEM wave guide measurement principle according to IEC 61000-4-20. A stripline set-up is used to measure the RF emission of ICs. The RF voltage at the stripline port is related to the electromagnetic radiation potential of the IC and will be measured using a spectrum analyzer or measuring receiver. The intent of this test method is to provide a quantitative measure of the RF emissions from ICs for comparison or other evaluation.

5 Test conditions

5.1 General

The test conditions shall meet the requirements as described in IEC 61967-1. In addition, the following test conditions shall apply.

5.2 Supply voltage

The supply voltage shall be as specified by the IC manufacturer. If the users of this procedure agree to other values, they shall be documented in the test report.

5.3 Frequency range

The effective frequency range for the IC stripline is 150 kHz to 3 GHz. The range is limited by its Voltage Standing Wave Ratio (VSWR) characteristics (≤ 1,25).

6 Test equipment

6.1 General

The test equipment shall meet the requirements as described in IEC 61967-1. In addition, the following test equipment requirements shall apply.

6.2 RF measuring instrument

A spectrum analyzer or EMI receiver shall be used. The resolution bandwidth shall be 9 kHz for EMI receivers or 10 kHz for spectrum analyzers in the frequency range from 150 kHz to 30 MHz and respectively 120 kHz or 100 kHz above 30 MHz according to IEC 61967-1. Measurements shall be made with a peak detector and presented in units of dBμV [for 50 Ω system: (dBm readings) + 107 = dBμV]. For spectrum analyzers, the frequency band of interest shall be swept in calibrated or coupled mode (auto sweep).

6.3 Preamplifier

Optionally, a 20 dB to 30 dB gain, low noise preamplifier might be used. If used, the preamplifier shall be connected directly to the measurement port of the IC stripline using the appropriate 50 Ω coaxial adapter.

6.4 IC stripline

TEM waveguide, consisting of an active conductor placed on a defined spacing over an enlarged ground plane, connected to a port structure on each end and an optional shielded enclosure. The spacing between active conductor and ground plane of the IC stripline has a default value of 6,7 mm. Other spacing can be used but has to be noted in the test report.

NOTE A conversion factor allows comparisons between IC stripline arrangements with different spacing between active conductor and ground plane (see Annex A).

This IC stripline arrangement guides wave propagation in the transverse electromagnetic mode to produce a specific field for testing purposes between the active conductor and the enlarged ground plane which is preferably the ground plane of a standard EMC test board according to IEC 61967-1. The EMC test board controls the geometry and orientation of the operating IC relative to the IC stripline and eliminates any connecting leads within the IC stripline (these are on the backside of the board, which is opposite to the IC stripline). An optional shielding enclosure may be used for fixing the IC stripline configuration and for shielding purposes. This leads to a closed version of the IC stripline as opposed to the open version without shielding enclosure.

For further information, see Annex A.

6.5 50 Ω termination

A 50 Ω termination with a VSWR less than 1,1 over the frequency range of measurement is recommended for the IC stripline 50 Ω port not connected to the RF measuring instrument.

6.6 System gain

The gain (or attenuation) of the measuring equipment, without the IC stripline, shall be known with an accuracy ±0,5 dB. The gain of the RF measurement system shall remain within a 6 dB envelope for the frequency range of interest.

7 Test set-up

7.1 General

The test set-up shall meet the requirements as described in IEC 61967-1. In addition, the following test set-up requirements shall apply.

7.2 Test configuration

See Figure 1 for IC stripline test configuration. One of the 50 Ω ports is terminated with a 50 Ω load. The remaining 50 Ω port is connected to the spectrum analyzer through the optional preamplifier. For further information and cross section view of the IC stripline arrangement, see Annex A.

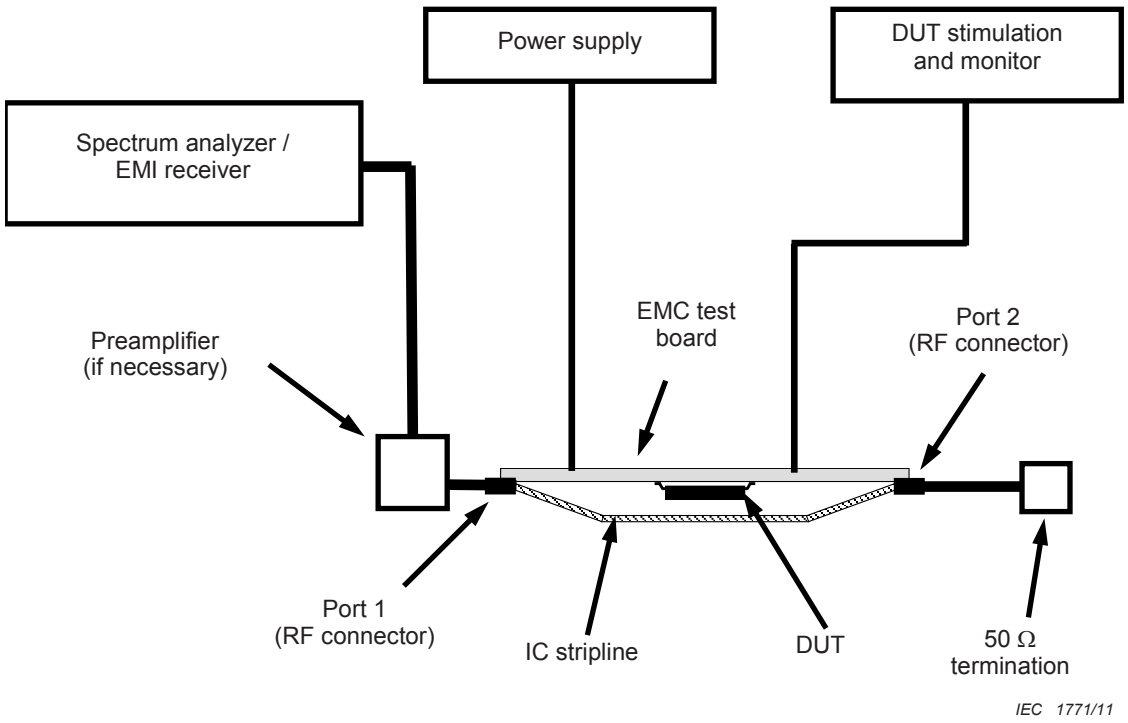

Figure 1 – IC stripline test set-up

7.3 EMC test board (PCB)

The DUT shall be mounted on a PCB according to IEC 61967-1 and in this standard. In cases where IEC 61967-1 and this standard are in conflict, the requirements of this standard shall apply.

The EMC test board is provided with the appropriate measurement or monitoring points to ensure the correct DUT operation. It controls the geometry and orientation of the DUT relative to the active conductor and eliminates in case of a closed version of the IC stripline any connecting leads within the housing (these are on the backside of the board, which is outside the housing).

8 Test procedure

8.1 General

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

8.2 Ambient conditions

The definitions for ambient temperature and general condition of IEC 61967-1 are valid.

The ambient RF noise level shall be verified to be at least 6 dB below the lowest emission level(s) to be measured. The DUT shall be installed in the test set-up, as used for testing. The DUT shall not be activated (e.g. power supply voltage disabled). A scan shall be made to measure the ambient noise. A description of the ambient shall be a part of the test report.

If the measured noise floor is excessive, e.g. due to external ambient noises or the noise floor of the measurement system itself, shielded enclosure should be used. The noise floor measurement system can be improved by using a lower noise preamplifier.

8.3 Operational check

Energize the DUT and complete an operational check to assure proper function of the device (i.e. run IC test code).

8.4 Verification of IC stripline RF characteristic

For verification of the IC stripline RF characteristic the VSWR value of the empty IC stripline with a 50 Ω-load termination at the second port shall be measured and documented in the test report. The value shall be lower than 1,25.

Optionally it is recommended to check the DUT-loaded IC stripline. In this case, the IC stripline resonances shall be verified with unpowered DUT in accordance to IEC 61000-4-20.

$$A_{tloss} = \left| 10 \times \lg\left(\frac{P_{refl}}{P_{fwd}} + \frac{P_{output}}{P_{fwd}} \right) \right| \leq 1\ dB \tag{1}$$

where

A_{tloss} is the transmission loss of loaded IC stripline (dB);

P_{refl} is the reflected power at input port (W);

P_{fwd} is the forward power at input port (W);

P_{output} is the measured power at output port (W).

Measurements carried out at frequencies where the VSWR and losses A_{tloss} exceed the maximum tolerated values shall be ignored.

8.5 Test technique

With the EMC test board energized and the DUT being operated in the intended test mode, measure the RF emissions over the desired frequency band.

When using a spectrum analyzer, enable the “Max Hold” function and allow the analyzer to perform a minimum of three sweeps while the IC code loop executes. The sweep time shall be much greater than the IC code loop execution time.

NOTE The “Max Hold” setting on a spectrum analyzer maintains the maximum level of each trace data point and updates each point if a new maximum level is detected in successive sweeps.

When using a receiver, the dwell time for each test frequency shall be greater than or equal to two times the IC code loop execution time and record the maximum level detected.

Four separate emissions measurements are performed resulting in four sets of data. The first measurement is made with the EMC test board mounted in an arbitrary orientation in the test setup. The second measurement is made with the EMC test board rotated 90 degrees from the orientation in the first measurement. For each of the third and fourth measurements, the EMC test board is rotated again to ensure emissions are measured from all four possible orientations. The four sets of data shall be documented in the test report.

9 Test report

9.1 General

The test report shall be in accordance with the requirements of IEC 61967-1. In addition, the following test report requirements shall apply.

9.2 Measurement conditions

All measurement conditions shall be documented in the test report.

10 IC Emissions reference levels

IC emissions acceptance levels, if any, are to be agreed upon between the manufacturers and the users of ICs and may be selected using the reference level scheme in Annex B. These reference levels apply to measurements over the frequency range of 150 kHz to 3 GHz in units of dBμV.

Annex A
(normative)

IC stripline description

A.1 General

The IC stripline offers a broadband method of measuring either immunity of a DUT to fields generated within the IC stripline or radiated emission from a DUT placed within the IC stripline. It eliminates the use of conventional antennas with their inherent measurement limitations of bandwidth, non-linear phase, directivity and polarization. The IC stripline is a special kind of transmission line that propagates a TEM wave. This wave is characterized by transverse orthogonal electric (E) and magnetic (H) fields, which are perpendicular to the direction of propagation along the length of the IC stripline or transmission line. This field simulates a planar field generated in free space with impedance of 377 Ω. The TEM mode has no low frequency cut-off. This allows the IC stripline to be used at frequencies as low as desired. The TEM mode also has linear phase and constant amplitude response as a function of frequency. This makes it possible to use the IC stripline to generate or detect the field intensity in a defined way. The upper useful frequency for an IC stripline is limited by distortion of the test signal caused by resonances and multi-moding that occur within the IC stripline. These effects are a function of the physical size and shape of the IC stripline.

The IC stripline is of a size and shape, with impedance matching at the input and output feed points of the IC stripline that limits the VSWR to less than 1,25 up to its rated frequency. In principle there are two versions of IC stripline possible – open and closed version. The open version uses the common stripline configuration (Figure A.1). At the closed version a shielding case is added (Figure A.2). The active conductor of the IC stripline is tapered at each end to adapt to conventional 50 Ω coaxial connectors. The requested EMC test board can be based on a TEM cell board according to IEC 61967-1. The first resonance is demonstrated by a high VSWR over a narrow frequency range. An IC stripline verified for field generation to a maximum frequency will also be suitable for emission measurements to this frequency.

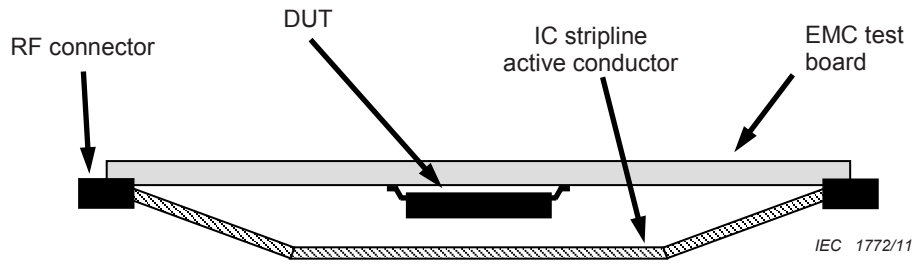

Figure A.1 – Cross section view of an example of an unshielded IC stripline

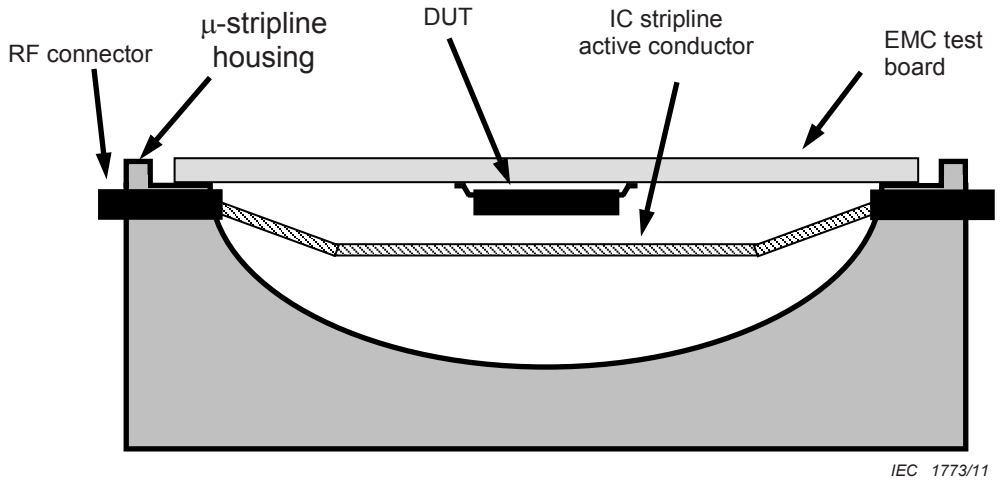

Figure A.2 – Cross section view of an example of an IC stripline with housing

The maximum usable DUT size is limited by the IC stripline dimensions. The ratio of DUT package height to IC stripline height is recommended to one third but shall not exceed one half according to IEC 61000-4-20. In x-y dimension the package shall not exceed the width of active conductor by more than 10 %.

NOTE 3 D field simulations have shown that an uniform field (not more than +0 dB and not less than -3 dB) is present outside the active conductor width geometrical boundary up to a package size which exceeds the width of the active conductor by 10 % at a half of active conductor height [4][1].

The limitation values for the 6,7 mm IC stripline for example are given in Table A.1 and Table A.2. The active conductor width for the closed version is dependent on the distance between active conductor and housing. The complete setup has to fulfill the requirements of 8.4.

Table A.1 – Maximum DUT dimensions for 6,7 mm IC stripline open version

	Active conductor 6,7 mm IC stripline open version	DUT
z dimension (height)	6,7 mm	≤3,35 mm
x-y dimension (width)	33 mm	≤36,3 mm

Table A.2 – Maximum DUT dimensions for 6,7 mm IC stripline closed version

	Active conductor 6,7 mm IC stripline closed version	DUT
z dimension (height)	6,7 mm	≤3,35 mm
x-y dimension (width)	24 mm	≤26,4 mm

NOTE The 24 mm width of the closed version stripline is related to the stripline height and shielding design with shape and distance to achieve the stripline characteristic defined in 8.4.

A.2 Characteristic impedance of stripline arrangements

The nominal, characteristic impedance of an open version of IC stripline can be calculated as follows [3], if $1 < w/h \leq 10$

[1] *Figures in square brackets refer to the Bibliography.*

$$Z = \frac{120\pi}{\frac{w}{h} + 2{,}42 - 0{,}44\frac{h}{w} + \left[1 - \frac{h}{w}\right]^6} \quad \text{(A.1)}$$

where

Z is the characteristic impedance (Ω), typical 50 Ω;

w is the width (m) of active conductor ;

h is the height (m) between the active conductor and ground plane.

For the closed version of the IC stripline the influence of housing has to be taken into account. This correction depends on the housing geometry. For spherical housing surface an analytical formula for the characteristic impedance cannot be provided, empirical investigations are necessary. The characteristic impedance of those stripline arrangements have to be verified by measurement.

A.3 Conversion for different active conductor heights

A conversion factor (X) to correlate measuring results of IC striplines with different heights to the default IC stripline height of 6,7 mm can be calculated by:

$$X = 20 \times \lg\left(\frac{h_1}{h_2}\right) \quad \text{(A.2)}$$

where

X is the conversion factor (dB) to IC stripline 6,7 mm height type results;

h_1 is the active conductor height of specific type;

h_2 is the active conductor height of 6,7 mm type .

For example the conversion factor for a 8 mm IC stripline is X = 1,54 dB. That means 1,54 dB has to be added to the measured voltage in dBμV at the measurement port of the 8 mm height IC stripline.

A.4 Example for IC stripline arrangement

An example for IC stripline with housing is given in Figure A.3. The housing x-y dimensions are defined by the used EMC test board (IEC 61967-1: 100 mm × 100 mm). The housing in z direction shall be as far as possible from the active conductor but avoid resonances and multi-moding in the frequency range of interest.

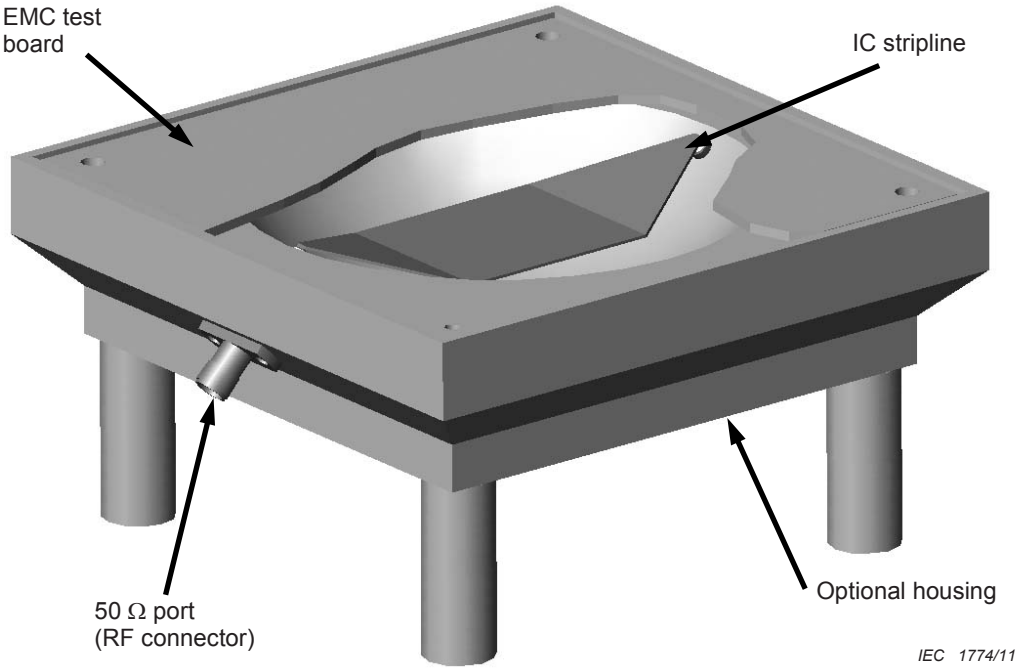

Figure A.3 – Example of IC stripline with housing

Annex B
(informative)

Specification of emission levels

B.1 Scope

This annex provides a method of specifying the emission level profiles of integrated circuits.

B.2 General

This annex is not a product specification. However, using the concept described in this standard and by careful application and agreement between the manufacturer and the user, it is possible to develop a description of the RF emissions behavior for a specific integrated circuit in one of three (x-y-z) field orientations.

B.3 Specification of emission levels

The diagram in Figure B.1 represents a scheme that facilitates classification of emission levels for ICs. In order to be able to use the classification as defined in IEC 61967-2 values are to be calculated using the Equation (B.1):

$$A = B + 20 \times \lg\left(\frac{h_{IC\ Stripline}}{h_{\mu TEM}}\right) \quad \text{(B.1)}$$

where

A is the converted result for comparison with reference levels;

B is the measurement result ;

$h_{\mu TEM}$ is the septum height μTEM cell 45 mm (default);

$h_{IC\ stripline}$ is the active conductor height 6,7 mm (default) .

B.4 Presentation of results

The typical description of the maximum emission level consists of two letters and one number always following the same sequence. If one of the three slopes is not needed, the corresponding letter or number will be omitted.

The first character shall be a capital letter indicating the position of the horizontal line with zero dB/decade slope. The second character shall be a number indicating the position of the -20 dB/decade slope. The third character shall be a small letter indicating the position of the -40 dB/decade slope.

Such defined maximum emission levels with the described notation offer a standardized way to communicate maximum emission levels unambiguously.

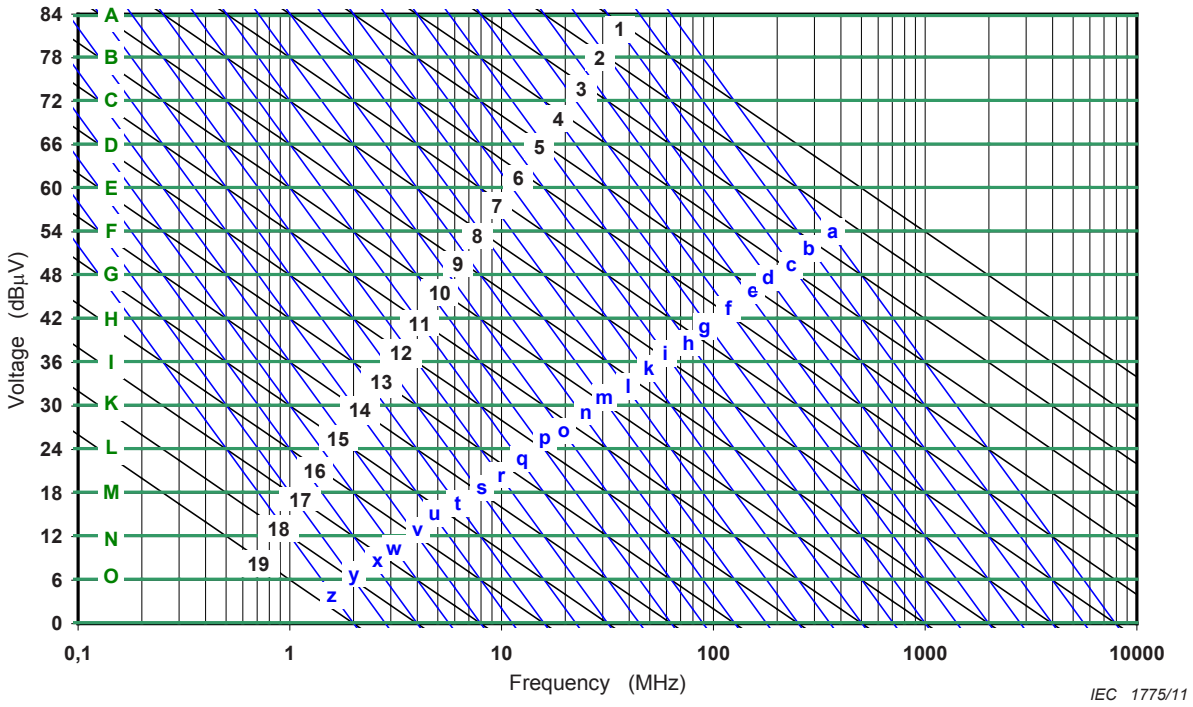

Figure B.1 – Emission characterization levels

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[3] M. V. Schneider, *Microstrip Lines for Microwave Integrated Circuits* The Bell System Technical Journal, vol. 48, pp. 1421–1444, May 1969

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