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ETSI Guide

Electromagnetic compatibility and Radio spectrum Matters (ERM); Measurement uncertainties and test methodologies from 1 GHz to 40 GHz

Reference

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Contents

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Foreword

This ETSI Guide (EG) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the ETSI standards Membership Approval Procedure.

1 Scope

The present document has been developed to provide a central resource for measurement uncertainties and associated test methods above 1 GHz for use by Technical Committees producing testing standards for radio communications equipment. The present document is divided into three distinct parts. The first part covers measurement uncertainty requirements and the process of calculation of the uncertainty for each test parameter. The second part covers the radiated RF test methods and the third part covers the conducted RF test methods.

The present document is further divided into ElectroMagnetic Compatibility (EMC), ElectroMagnetic Field (EMF) and Radio Parameter (RP) testing, each section further divided by the relevant radio technology.

The following radio technologies are covered by the present document:

a) general radio equipment (including broadcast equipment);

b) aeronautical radio equipment;

c) satellite radio equipment;

d) fixed link radio equipment point-to-point and point-to-multipoint;

e) maritime radio equipment;

f) radio equipment used in the transport sector; and

g) associated ancillary equipment.

Wherever possible all test methods are based on published references from the International Telecommunications Union Radio Sector (ITU-R), the International Maritime Organization (IMO) and regional Standards Development Organizations (SDOs). The measurement uncertainty requirements are based on International Standards and technology sector interpretations and implementations.

Annex A contains a list of test stimuli and environment definitions that are used within the main part of the present document.

WARNING: RF power levels encountered during some of the tests methods in the present document may lead to test personnel being exposed to RF levels above International limits for occupational exposure to ElectroMagnetic Fields (EMF). EMF is regulated by a variety of voluntary and legal limits. Sufficient test facility controls should be implemented to ensure that personnel are not exposed to EMF above the relevant limits for the transmitter frequency.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

[1] ETSI TR 102 273-1-1 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties Part 1: Uncertainties in the measurement of mobile radio equipment characteristics; Sub-part 1: Introduction".

[2] ETSI TR 102 273-1-2 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 1: Uncertainties in the measurement of mobile radio equipment characteristics; Sub-part 2: Examples and annexes".

[3] ETSI TR 102 273-2 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 2: Anechoic chamber".

[4] ETSI TR 102 273-3 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 3: Anechoic chamber with a ground plane".

[5] ETSI TR 102 273-4 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 4: Open area test site".

[6] ETSI TR 102 273-5 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 5: Striplines".

[7] ETSI TR 102 273-6 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 6: Test fixtures".

[8] ETSI TR 102 273-7 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 7: Artificial human beings".

[9] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

[10] UKAS LAB 24: "Measurement Traceability and Calibration in the Mechanical Testing of Metallic Materials".

[11] CISPR 16-4: "Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-2: Uncertainties, statistics and limit modelling - Uncertainty in EMC measurements".

[12] CISPR 16-1: "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1: Radio disturbance and immunity measuring apparatus".

[13] ISO/IEC 17025 (2005): "General requirements for the competence of testing and calibration laboratories".

[14] CENELEC EN 50392: "Generic standard to demonstrate the compliance of electronic and electrical apparatus with the basic restrictions related to human exposure to electromagnetic fields (0 Hz - 300 GHz)".

[15] ETSI TS 102 321: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Normalized Site Attenuation (NSA) and validation of a fully lined anechoic chamber up to 40 GHz".

[16] ETSI EN 301 489 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements".

[17] CISPR 22: "Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement".

[18] CENELEC EN 55022: "Limits and methods of measurement of radio disturbance characteristics of information technology equipment".

[19] ETSI TR 102 215: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Recommended approach, and possible limits for measurement uncertainty for the measurement of radiated electromagnetic fields between 1 GHz and 300 GHz".

[20] CENELEC EN 61000-4-3: "Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test".

[21] ISO 9000: "Quality management systems -- Fundamentals and vocabulary".

[22] ITU-T Recommendation O.153: "Basic parameters for the measurement of error performance at bit rates below the primary rate".

[23] ETSI EG 202 373: "Electromagnetic compatibility and Radio spectrum Matters (ERM);Guide to the methods of measurement of Radio Frequency (RF) fields".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

accuracy: in relation to the measured value defined in clause 4.2 of TR 102 215 [19]; it has also been used in the rest of the document in relation to test instrumentation

antenna: part of a transmitting or receiving system that is designed to radiate or to receive electromagnetic waves

antenna factor: quantity relating the strength of the field in which the antenna is immersed to the output voltage across the load connected to the antenna

NOTE: When properly applied to the reading of the measuring instrument, yields the electric field strength in V/m or the magnetic field strength in A/m.

antenna gain: ratio of the maximum radiation intensity from an (assumed lossless) antenna to the radiation intensity that would be obtained if the same power were radiated isotropically by a similarly lossless antenna

confidence level: probability of the accumulated error of a measurement being within the stated range of uncertainty of measurement

correction factor: numerical factor by which the uncorrected result of a measurement is multiplied to compensate for an assumed systematic error

directivity: ratio of the maximum radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions (i.e. directivity = antenna gain + losses)

error (of a measuring instrument): indication of a measuring instrument minus the (conventional) true value

NOTE: See clause 4.2 of TR 102 215 [19].

error of measurement (absolute): result of a measurement minus the true value of the measurand

NOTE: See clause 4.2 of TR 102 215 [19].

error (relative): ratio of an error to the true value

free field: field (wave or potential) that has a constant ratio between the electric and magnetic field intensities

free space: region free of obstructions and characterized by the constitutive parameters of a vacuum

impedance: measure of the complex resistive and reactive attributes of a component in an alternating current circuit

impedance (wave): complex factor relating the transverse component of the electric field to the transverse component of the magnetic field at every point in any specified plane, for a given mode

isotropic radiator: hypothetical, lossless antenna having equal radiation intensity in all directions

measurand: quantity subjected to measurement

measuring system: complete set of measuring instruments and other equipment assembled to carry out a specified measurement task

shielded enclosure: structure that protects its interior from the effects of an exterior electric or magnetic field, or conversely, protects the surrounding environment from the effect of an interior electric or magnetic field

test method: a clause or subclause in a standard that includes a definition statement, a test procedure, applicable limits and maximum allowable measurement uncertainty

NOTE: For the purposes of the present document the clause for applicable limits is not included but should be included in standards.

test procedure: clause or subclause in a standard that gives a set of steps to be followed to measure a specific measurand (or parameter in the case of protocol testing)

uncertainty: parameter, associated with the result of a measurement, which characterizes the dispersion of the values that could reasonably be attributed to that measurement

3.2 Symbols

For the purposes of the present document, the following symbols apply:

°C	degrees Centigrade
cm	centimetres
σ	standard deviation
dB	deciBel
GHz	GigaHertz
MHz	MegaHertz
mV	milliVolt

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AF	Audio Frequency
DC	Direct Current
e.m.f	electromotive force
EIRP	Equivalent Isotropically Radiated Power
EMC	ElectroMagnetic Compatibility
EMF	ElectroMagnetic Field
ERP	Effective Radiated Power
EUT	Equipment Under Test
IMO	International Maritime Organization
ITU-R	International Telecommunications Union Radio Sector
NRA	National Regulatory Authority
OATS	Open Area Test Site
R&TTE	Radio and Telecommunications Terminal Equipment (Directive)
RF	Radio Frequency
RP	Radio Parameter
SDO	Standards Development Organization
SINAD	(Signal + Noise + Distortion)/(Noise + Distortion) ratio
SND/ND	Signal, Noise and Distortion / Noise and Distortion
UKAS	United Kingdom Accreditation Service

4 Measurement uncertainties

4.1 Accuracy and measurement uncertainty

4.1.1 Introduction

The terms "accuracy" and "uncertainty" are frequently misused and interchanged when applied to measurement equipment and to a measured value (measurand). The following clauses define the meaning of each of the phrases and how they are used in measurement equipment literature. The difference in their meanings can be significant and in many measurement applications it is vital to understand the difference.

The use of the term "accuracy" plays a significant role in measurement equipment sales literature often to compete against similar equipment from other manufacturers and this should be regarded with caution. It has been known for competing manufacturers to quote performance values that exceed the finest metrology laboratory values for calibration and this of course is impossible. Realistic values are derived from traceable standards where the term "accuracy" is never used; only the term "uncertainty" is used. The true value of a measurand is never known, as it is impossible to define or make perfect measurements.

When a measurand with its measurement uncertainty bounds is compared with a specification (standard) limit interpretation of the result is not always clear. Clause 4.2 gives guidance on how to make this assessment, which is dependant upon the testing regime that is being followed.

4.1.2 Accuracy of measurement

The term "accuracy of measurement" is defined by international agreement as:

- the closeness of the agreement between the result of a measurement and a true value of the measurand.

The full definition also states that accuracy is a qualitative concept and it can be attributed to be "high accuracy" or "low accuracy". In linguistic terms "accuracy" has a positive feeling and is easily accepted by engineers.

In practice, therefore, the definition is often redefined into a quantitative expression given as follows:

- the difference between a measurand and the true value expressed as "accurate to ±X".

This interpretation of the meaning immediately falls down for the reason given in clause 4.1.1, i.e. the true value is never known.

The use of the term "accurate to ±X" can also lead to confusion within the manufacturers" organization, particularly in financial terms. Given that the reference standard states that the maximum allowable measurement uncertainty is, let us say, ±6 dB, and an investment request is made for a measurement receiver. Manufacturers specifications for differently priced measurement receivers states accuracy for three instruments as ±2 dB, ±3 dB and ±4 dB at a price of 20 k Euros, 15 k Euros and 10 k Euros it is easy to see the equipment that the financial controller is prepared to pay for. However, the manufacturers' specification only relates to the actual value measured at the cable entry point to his receiver and does not take into account all the other additional components which make up the total measurement uncertainty of the overall test set-up.

4.1.3 Measurement uncertainty

The term "measurement uncertainty" is defined by international agreement as:

- a parameter, associated with the result of a measurement that characterizes the dispersion of values that could reasonably be attributed to the measurand.

This definition makes no attempt to define the true value, nor does it rely upon it. It is a statistical approach and is used to give a level of confidence that the measured value lays between a range of values. In linguistic terms "uncertainty" has a negative feeling and is not easily accepted by engineers.

The calculation of uncertainty is, to say the least, complex, and the test engineer has to have extensive knowledge of the test system that is making the measurement, and, at the same time, have some reasonable knowledge of how the equipment under test should perform.

ETSI has produced substantial reports on the subject in TR 102 273-1-1 [1] to TR 102 273-7 [8] and it is not intended to reproduce the information here.

The present document will use the previous work as reference to determine maximum allowable measurement uncertainty to be used when measuring RF electromagnetic fields above 1 GHz.

Having surveyed a number of existing ETSI specifications where measurement uncertainty and accuracy are confused the following clauses attempt to clarify this situation.

4.2 Application of measurement uncertainty to specification limits

4.2.1 Introduction

ETSI developed an interpretation for the application of measurement uncertainty when assessing compliance to specification limits from the outset of producing standards for radio products in 1991 (see TR 102 215 [19], annex A). This interpretation only related to the measured value (the measurand). If the measurand was equal to or below the limit the equipment was deemed to meet the requirement of the relevant standard. However, the test laboratory did not make the decision. The testing was subject to third party mandatory testing (which still exists in many countries around the world) and the National Regulatory Authorities (NRA) made the decision as to compliance to the standard. The test laboratory was required to declare their measurement uncertainty as part of the Accreditation process to carry out the testing on behalf of the NRA.

This assessment was declared as "shared risk" between the manufacturer and the NRA. The manufacturer accepted the risk that the product may exceed the limit specified in the standard, and the NRA accepted the risk that the product equalled or was below the limit specified in the relevant conformance standard.

This situation was acceptable to all parties, particularly to the test laboratories who had to declare their measurement uncertainty but did not have to judge whether a product conformed to the limits set in the standard; the NRA carried out this function.

4.2.2 Development of the "shared risk" concept

As a consequence of deregulation under the R&TTE Directive [9] mandatory type testing is no longer required. The method for compliance is normally by self-certification provided the standard used is a harmonized standard published under the requirements of the Directive. This implies that the manufacturer now declares his compliance to the harmonized standard, and not the NRA as before. Therefore the contract between external laboratories (when they are used) and manufacturers is now different. The manufacturer has to state with confidence that his product meets the specification, whilst the test laboratory only states his measurement with a measurement uncertainty in a report.

A number of expert bodies have therefore developed refinements on the original shared risk concept to assist manufacturers and test laboratories in reaching a compliance/non compliance assessment against limits given in product standards. The new "shared risk" concept has developed somewhat differently in differing organizations. In the UK the LAB24 [10] document from the United Kingdom Accreditation Service (UKAS), detailing "The Expression of Uncertainty in EMC Testing" provides a modified test approach when assessing against a specification limit. CISPR 16-4 [11] gives insight into what to do if the test laboratory measurement uncertainty exceeds the maximum allowable uncertainty given in the relevant product standard.

ETSI, in the meantime, is reviewing the shared risk issues within the present document. To have shared risk implies that the risks are shared by a minimum of two parties. In the old regime of mandatory type testing the two parties were the NRAs and the manufacturer. Today there are no NRAs involved in the compliance assessment under the R&TTE Directive [9]. It is assumed that the manufacturers who self certify compliance would therefore wish to share the risk of compliance/non-compliance with the test laboratory when measurements are close to the limit and within the limits of measurement uncertainty declared by the test laboratory.

Where a manufacturer carries out testing for compliance within their own test facility there is no second party to share the risk of compliance/non-compliance with - they themselves have to share the risk between their own test facility and the quality organization making the declaration of compliance.

In the absence of harmonized standards, or the use of other means allowed under the R&TTE Directive [9] to prove compliance, there are now two parties involved, the manufacturer and a Notified Body. Under this regime the notified bodies decide if a product meets or does not meet the essential requirements of the Directive. It is therefore possible to use the shared risk approach in this assessment.

When a product has a complaint made against it that it is causing interference to radio services, the shared risk approach can still be used providing of course that the National Authorities accept the concept.

In those countries where third party testing is still the normal assessment of products then the old methods of "shared risk" are still valid.

4.2.3 Shared risk, the new approach

Taking all the current documentation on the issue into account, it is reasonable to redefine the shared risk approach to cover the new situations of deregulation as follows:

1) all standards where measurements are made for compliance testing should include maximum allowable measurement uncertainty values for each test;

2) guidance should be given on assessing the measurements against defined limits in the standard when the measurand is close to the limit;

3) in the case where laboratory measurement uncertainty is greater than the maximum allowable uncertainty stated in the standard, guidance should be given on assessing compliance to standard limits.

This approach combines the current documented solutions in CISPR, ETSI and UKAS.

4.2.3.1 Maximum allowable measurement uncertainty

In most ETSI radio equipment standards a table of maximum allowable measurement uncertainty is included as a normative requirement. The table generally contains a list of the required measurement methods and their associated uncertainty.

The purpose of the table is to ensure that measurement uncertainty is controlled and that a wide variation of measured results between test laboratories is minimized. This approach also assists the process of laboratory accreditation for testing to the standard.

In discussion with test laboratories, they indicated that it would be extremely useful to associate directly the specification limit given in the standard with the required maximum allowable measurement uncertainty for the measured value.

As frequency ranges increase it may be difficult to conclude a maximum allowable value for the measurement uncertainty due to lack of knowledge of the new methods of test and determining the uncertainty components. Therefore some flexibility should be allowed to deviate from the initially determined maximum allowable values and this is dealt with in clause 5.3.3 of TR 102 215 [19].

4.2.3.2 Guidance on compliance assessment when measurement uncertainty is equal to or less than maximum allowable uncertainty

The interpretation of the results when comparing measurement values with specification limits should be as follows:

a) When the measured value does not exceed the limit value the equipment under test meets the requirements of the standard.

b) When the measured value exceeds the limit value the equipment under test does not meet the requirements of the standard.

c) The measurement uncertainty calculated by the test technician carrying out the measurement should be recorded in the test report.

d) The measurement uncertainty calculated by the test technician may be a maximum value for a range of values of measurement, or may be the measurement uncertainty for the specific measurement untaken. The method used should be recorded in the test report.

4.2.3.3 Guidance on compliance assessment when measurement uncertainty is greater than maximum allowable uncertainty

The interpretation of the results when comparing measurement values with specification limits should be as follows:

a) When the measured value plus the difference between the maximum allowable measurement uncertainty and the measurement uncertainty calculated by the test technician does not exceed the limit value the equipment under test meets the requirements of the standard.

b) When the measured value plus the difference between the maximum allowable measurement uncertainty and the measurement uncertainty calculated by the test technician exceeds the limit value the equipment under test does not meet the requirements of the standard.

c) The measurement uncertainty calculated by the test technician carrying out the measurement should be recorded in the test report.

d) The measurement uncertainty calculated by the test technician may be a maximum value for a range of values of measurement, or may be the measurement uncertainty for the specific measurement untaken. The method used should be recorded in the test report.

4.2.4 Assessment for market surveillance and enforcement

4.2.4.1 Market surveillance

For the purposes of market surveillance the interpretation of results should follow that given in clauses 5.3.2 and 5.3.3 of TR 102 215 [19] using the test methods given in the relevant standard. The testing laboratory should be competent in accordance with ISO/IEC 17025 [13] and be formally accredited to carry out the relevant tests given in the appropriate standard.

4.2.4.2 Enforcement

Enforcement of the limits given in the relevant standard, when market surveillance indicates that a product exceeds the relevant limit, is the responsibility of the individual National Regulatory Authority as provided for in EU Directives.

4.2.5 Interpretation of EMF test results in CENELEC standards

The following approach has been accepted by CENELEC voting procedures and published in EN 50392 [14], clause 6.

"The equipment is deemed to fulfil the requirements of this standard if the measured values are less than or equal to the limit and the assessment uncertainty is less than the measurement uncertainty of the applied assessment method(s)".

This statement implies that for the case of EMF testing the guidance given in TR 102 215 [19], clause 5.3.2, is valid. The guidance given in TR 102 215 [19], clause 5.3.3, does not apply.

4.3 The role of calibration in measurement uncertainty

4.3.1 Introduction to calibration

To determine the "quality" of any part of a test system it is necessary to place a tolerance on the extreme measurement uncertainty applicable to the test equipment measurement capability. This is achieved via traceable reference standards that are of a higher quality than that of the test equipment being examined.

Traceability is achieved by using primary reference standards held by National Metrology Laboratories to calibrate secondary reference standards that are then used to calibrate general-purpose test equipment. Primary reference standards are manufactured to the highest quality, are never used to make measurements, and comparisons are made on a regular basis between the metrology laboratories to further refine the measurement uncertainty when comparing secondary standards to the primary reference standards.

Test equipment used for EMC and radio testing is considered as general-purpose test equipment that has been calibrated to secondary reference standards. From this calibration, systematic errors can be determined (providing correction factors to be applied to a measurand) and the contribution to overall measurement uncertainty (from the measurement uncertainty declarations made by the calibration laboratory).

The following clauses address the calibration requirements for the various components of the overall test systems used to measure radiated RF fields.

Calibration of test equipment is normally carried out at a specific temperature e.g. 20°C, and therefore care should be taken to maintain the actual temperature when used to make formal measurements. Equipment used for calibration purposes is normally maintained in a controlled environment.

4.3.2 Test site calibration

RF field strength measurements both for EMC and radio parameters are normally performed on an Open Area Test Site (OATS) that have a clear and level terrain. Such sites are clear of buildings, electric cables, fences, trees and underground pipes and are only supplied with the necessary cabling to support the operation of the equipment under test, and the connections for making the necessary measurements. Specific instructions for the construction of an OATS can be found in CISPR 16-1 [12] for sites operating over the frequency range 30 MHz to 1 GHz. It should be noted that for both EMC and radio parameter testing a ground plane is required.

For testing above 1 GHz the OATS can be used subject to suitable calibration performance, and alternative test sites may be used. Current documentation only provides information to 18 GHz and does not cover the necessary performance of such a site above 1 GHz.

Research by a number of alternative site manufacturers has shown that testing can be carried out to 40 GHz with improved performance over the OATS. These alternative sites rely on semi-anechoic rooms, i.e. shielded rooms that have anechoic materials on the walls and ceiling whilst maintaining the ground plane.

The basis for the ±4 dB acceptance criteria for site attenuation is given in CISPR 16-1 [12], annex L.

4.3.2.1 Calibration of OATS

The calibration of an OATS is given in CISPR 16-1 [12], clause 5.6.6 as well as annex G. These procedures and acceptance criteria are currently only valid up to 1 GHz, but have been shown to also work up to 18 GHz with suitable modifications. For the purposes of the ETSI requirements it is recommended to use the same test site validation procedures with the same ±4 dB acceptance criteria until such time as an enhanced formal procedure is available from CISPR.

4.3.2.2 Calibration of semi-anechoic rooms

The calibration of semi-anechoic rooms (an alternative test site) is given in CISPR 16-1 [12], clause 5.6.7 up to 1 GHz. This method has been used by the room manufacturers up to 40 GHz and the results have shown that above 3 GHz to 18 GHz the deviation of the site attenuation against the calculated theoretical value is less than ±2 dB.

The method given in the reference above determines a volume of measurement area and the research shows that a quiet zone of 2,5 metres can be determined within the site attenuation limit of ±4 dB.

Actual calibrations of semi-anechoic rooms show that the deviation from calculated theoretical values of site attenuation from 20 GHz to 40 GHz is ±2,5 dB.

4.3.2.3 Calibration of fully lined anechoic rooms

The calibration of fully lined anechoic rooms has not been formally defined in standards. It is well known that there is a difference of a few dBs when comparing this form of test site with test sites having a ground plane. The difference varies between 3 dB and 6 dB. In the absence of formal international measurement methods for the calibration of fully lined anechoic rooms. TS 102 321 [15] provides the methods for validating an anechoic chamber up to 40 GHz to support the needs of radio testing.

4.3.3 Antenna calibration

Antenna calibration is used to determine the antenna factors applied as correction factors to measurements. A calibration test site can be constructed similar to the OATS. A procedure for the calibration of antennas is given in CISPR 16-1 [12], clause 5.13.

For antennae used above 1 GHz it is usual to have these calibrated by an independent calibration laboratory. Traceable calibration of antenna factors or antenna gain is available up to 40 GHz, for horizontal and vertical polarization, and at various measurement heights.

For antennae that have been calibrated for positive gain, i.e. directional antennae, it is important to also have the 3 dB beam width information to ensure that the antennae are correctly bore sight aligned when making measurements.

4.3.4 Test equipment calibration

The traceability route for calibration purposes is described in the introduction of TR 102 215 [19], clause 7.1. Calibration laboratories follow very strict rules for each measurement parameter they declare in their published capability documents. This allows clients seeking calibration services to evaluate the laboratories' capability and select the level of measurement uncertainty that they may require which is fit for the purpose of the test equipment calibration. *Smaller* measurement uncertainty value given by the calibration laboratory generally implies greater cost.

The calibration laboratory selected will provide a calibration certificate which gives the measurand of the parameter tested with a statement of measurement uncertainty. From this certificate it is possible to determine any systematic errors to be used as a correction factor for measurand made with the test instrument. The declared measurement uncertainty on the certificate can be used as a contribution to the overall measurement uncertainty calculations declared by the test engineer in his test report.

Calibration of this nature is normally carried out at regular intervals e.g. yearly, six monthly, and quarterly.

Some test equipment also has inbuilt calibration procedures defined by the manufacturer. This is normally carried out at power on and thereafter on a daily basis and is used to maintain the short-term quality of the calibration carried out by calibration laboratories.

In the same way as test laboratories have to maintain and declare their measurement uncertainties so calibration laboratories are required to do the same.

In researching the capabilities of independent calibration laboratories, providing calibration to industry, the upper limit of frequency capability is currently set at 40 GHz. Above this frequency calibration may be provided by test equipment manufacturers.

For the purposes of the present document the upper limit of frequency has been set at 40 GHz.

4.3.5 Automated test system calibration

Automated test systems, inclusive of computer controllers, can be very complex particularly when used to carry out protocol testing that relies on the use of a radio channel via integral antennae. The providers of such test systems have the responsibility to define the necessary calibration requirements. The present document does not evaluate such systems for calibration nor for their measurement uncertainty contributions. This subject area is for further study.

4.4 Controlling measurement uncertainty

4.4.1 Introduction

This clause presents the recommended processes and procedures to minimize measurement uncertainty. The following subjects are covered:

- test Laboratory Accreditation;
- competence of the Test Laboratory;
- skill level of test engineers and supervision of testing;
- design and validation of appropriate test sites;
- quality of test methods given in standards;
- validation of test methods;
- test instrumentation; and
- documentation.

4.4.2 Test laboratory accreditation

A test laboratory has two main criteria to meet if it is to provide confidence to a client that a product is fit to be placed upon the market in accordance with current legislation. The test laboratory should declare which standards it is accredited to test against and provide evidence of competence to carry out the tests within a standard. Accreditation authorities ensure that test laboratories of type first party, second party, and third party can provide testing to an allowable quality using ISO/IEC 17025 [13] as a reference.

NOTE: ISO/IEC 17025 [13] includes the requirements of ISO 9000 [21] series quality standards.

4.4.3 Competence of the test laboratory

The competence of a test laboratory is judged directly in accordance with ISO/IEC 17025 [13]. As stated above the standard includes ISO 9000 [21] series requirements, but goes further in that it is not just a quality system. Each laboratory is judged on its technical capability to carry out testing and its quality procedures to ensure the validity of the results declared by the test laboratory to its clients.

The following clauses discuss the additional requirements demanded by ISO/IEC 17025 [13] to ensure the technical and quality competence of a testing laboratory.

The descriptions below are not specific to radio and EMC test laboratories but to any test laboratory (including calibration laboratories). Any specific requirements for radio and EMC laboratories should be declared by the laboratory seeking accreditation, or should be declared in the requirements of any applicable standard.

4.4.4 Skill level of test engineers and supervision of testing

The management of an accredited test facility have the responsibility to ensure that the competence of the personnel that operates test equipment, carry out testing, evaluate results and sign test reports. This implies that sufficient supervision is provided for engineers under training, and that test engineers have the necessary education, training and experience in the appropriate measurements being undertaken defined in the standards in use by the test laboratory.

The major source of confusion when assessing results obtained from different test laboratories is that considerable variation of measurement results on the same test sample can be easily identified. The causes for this anomaly can normally be traced to either insufficiently defined test methods that have then been interpreted by the test engineer or complacency by the test engineer due to the long period of testing.

Experiments have been carried out using a travelling test sample and then tested in two ways. The first is the circulation of the test sample to a number of test laboratories for testing to a defined test method and the second is the use of specific test equipment, test engineers who travel with the test sample and who carry out the testing on each test site.

Results of such experiments have been extensively analysed and show that in the first experiment considerable differences in measurement values can be seen, in a range of up to 15 dB. In the second experiment the measurement values are very close to each other, in a range of up to 1 dB. Considerable confusion exists in industry over these anomalies. Many believe the cause is measurement uncertainty, but in fact the anomalies are due to errors and interpretations made by the test engineer.

4.4.5 Design and validation of appropriate test sites

The current ETSI radio testing standards usually define an Open Area Test Site (OATS) as being the accepted test facility and this type of site is also defined for EMC measurements. The ETSI radio standards generally provide the option of using alternative test sites including semi and fully anechoic chambers.

EMC testing standards are generally limited to a maximum test frequency of between 1 GHz and 3 GHz at defined test distances (3 metres or 10 metres). An OATS is perfectly acceptable to meet EMC objectives and thus ensuring interference capability when co-located with any other equipment in the same environment.

However the same cannot be said when considering the testing of radiated radio RF parameters. These parameters are tested to restrict the interference capability to other radio services. It has become common practice in recent years to specify the use of fully lined anechoic chambers within ETSI radio standards when test measurements are required above 1 GHz, thus providing a quiet RF environment for the testing.

When reviewing the ETSI test methods, and relating them to the appropriate regulatory requirements, radiated RF parameters are required to be made in the far field of the frequency under investigation. However the definition of "far field" is dependent upon the size of the equipment, the size of the receiving antenna and the frequency of the RF emission.

It is therefore recommended that standards should clearly state the type of test facilities that is to be used in relation to the frequency of measurement and the type of equipment under test. This also implies that the capability of test equipment to measure microwave frequencies in the far field has to be clearly understood by the standards developers.

Having clearly identified the type of test site within the appropriate standards the validation of the site is important to ensure that the measurement uncertainty of any measurements that are made on the site are under control (see TR 102 215 [19], clause 7).

4.4.6 Quality of test methods given in standards

The quality of test methods given in standards is important to ensure the control of the tests to be carried out and ultimately will determine the measurement uncertainty of a measured result. Test laboratories are required to declare their testing capability and are accredited on their ability to fulfil the requirements stated in standards. The test laboratory is required to use test methods published in international, regional or national standards.

However where the methods are unclear in these reference standards internal test procedures are required to ensure consistency in the test methods used by the test engineers. In this case it is possible that each test laboratory may develop internal procedures that follow the spirit of the standards, but may interpret them in a slightly different way. This can lead then to anomalies in results between laboratories and lack of confidence by the client in the capability of the test methods in use.

It is important that test methods are validated and this is discussed in clause 4.4.7.

4.4.7 Validation of test methods

It is the responsibility of the test laboratory to validate all test methods used within the test facility, and hence determine the measurement uncertainties associated with the test methods. This validation is normally carried out using a number of different approaches:

1) comparison of repeated results;

2) comparison of results carried out using different test methods;

3) inter-comparisons with other test laboratories using standard test samples;

4) assessment of factors that can influence the result of the measurement; and

5) the assessment of the measurement uncertainty of the results using a scientific understanding of the test method and practical experience.

Item 1) is generally referred to as "measurement repeatability" and is used to judge the stability of a test set-up.

Item 2) is generally referred to as "measurement reproducibility" and is used to assess the quality of test methods by changing the Test procedure, the test engineer, the measurement equipment, test site, and time separation between tests.

Item 3) has been used successfully in the EMC environment but has been rarely used, if ever, within the radio parameter testing environment.

Items 4) and 5) are normal activities in determining the measurement uncertainty of a measurement, or series of measurements, as part of the general accreditation procedure of the test laboratory.

4.4.8 Test instrumentation

As the frequency range of radio testing develops into the higher microwave regions test methods become more complex and test equipment considerably more expensive to purchase as the number of equipment manufacturers is reduced. Test equipment capability can also exceed the ability to have traceability of calibration techniques. At the same time novel technologies are under development for which at the time of preparing standards test equipment is not yet available on the open market.

Standards makers should take great care that in specifying test methods for specific parameters that they do not define specific manufacturers" test equipment within the standards under their control. Advancing technologies often leaves the problem of testing to the test laboratories to solve and does nothing to assist the manufacturer's responsibility to regulators of the market. As a consequence, standards makers often stay with test methods they already know of from previous technologies and these test methods are often not applicable to the new technologies.

Test instrumentation in radio testing has been clearly defined by agreement between the manufacturers, the testing organizations, and the accreditation authorities by common practice. This arrangement has been suitable for test methods up to about 18 GHz, but as specific requirements advances towards 300 GHz this situation changes dramatically.

The stability of test instrumentation has largely been driven by the development of test cables and connectors that provides the flexibility in carrying out the specific test procedures. In the 1980s this imposed a limitation of flexible testing to a frequency of 18 GHz above which it was necessary to change to waveguide techniques. Today cables and connectors are available to approximately 50 GHz, but traceable calibration at such frequencies is still limited to 40 GHz.

4.4.9 Documentation

Test laboratories are required to maintain a considerable amount of documentation not limited to just the required test procedures.

To minimize measurement uncertainty historical and current calibration data for all test equipment used for making the measurements is required to be maintained.

The control of technical reports and approval certificates is required to assist in any future evaluation that may be required by regulatory authorities. As deregulation has developed from a strict regulatory regime some demanded records are no longer being maintained due to the distinct lack of guidance on such issues within regulatory standards.

Testing standards are required to be maintained from a historical point of view and the latest edition of the testing standards have to be easily available to all test personnel. This task is particularly onerous on the test laboratory as they are not always aware of new editions reaching the market from the standards organizations particularly when open public standards approval procedures are not used.

5 RF radiated test methods above 1 GHz

This clause details the recommended RF radiated test methods above 1 GHz for EMC, EMF and RP testing for the different radio technologies identified in the scope of the present document. Under the essential requirements for the EU R&TTE Directive radiated EMC testing is only applicable to ancillaries attached to radio equipment. Specific requirements for radio equipment EMC testing can be found in EN 301 489 [16].

5.1 ElectroMagnetic Compatibility (EMC)

There are no EMC emission requirements currently defined above 1 GHz. However, IEC/CISPR is considering test methods and limits for radiated emission tests up to 18 GHz.

5.1.1 Emissions

Under consideration by CISPR by revision of CISPR 22 [17] and EN 55022 [18].

NOTE: At the time of writing the present document recommended test methods and test limits have been formally proposed unto 6 GHz.

5.1.1.1 Transmitter

There are currently no requirements for EMC testing of radio transmitters. EMC parameters are covered by radiated spurious emissions and case radiation testing as defined in clause 5.2.1.

5.1.1.2 Receiver

There are currently no requirements for EMC testing of radio receivers. EMC parameters are covered by radiated spurious emissions and case radiation testing as defined in clause 5.2.2.

5.1.1.3 Integrated equipment

The EMC requirements for integrated equipment are specified in the relevant radio EMC product standards. IEC/CISPR is considering the inclusion of EMC testing of radio equipment operating in ICT equipment under standby and idle operation. The operation of the radio equipment itself for the communications link will not be included under this possible revision.

5.1.2 Immunity

EMC radiated immunity testing is currently limited to a maximum frequency of 2 GHz for radio communications equipment and associated ancillaries. However the test method may be used up to 40 GHz within a calibrated anechoic chamber and with suitable test field generation and controlling equipment.

WARNING: RF power levels encountered during these tests may lead to test personnel being exposed to RF levels above International limits for occupational exposure to ElectroMagnetic Fields (EMF). Sufficient test facility controls should be implemented to ensure that personnel are not exposed to EMF above the relevant limits for the transmitter frequency.

5.1.2.1 Electric field

This test is applicable to radio equipment and associated ancillary equipment. An anechoic chamber is recommended as the test site up to the maximum calibrated frequency for the chamber, e.g. 10 GHz, 18 GHz and 40 GHz

5.1.2.1.1 Definition

This test assesses the ability of the EUT to operate as intended in the presence of a radio frequency electromagnetic field disturbance.

5.1.2.1.2 Test method

The reference test standard is EN 61000-4-3 [20].

The following requirements and evaluation of test results applies:

- The test level is 3 V/m (measured unmodulated). The test signal is amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 000 Hz. If the wanted signal is modulated at 1 000 Hz, then an audio signal of 400 Hz is to be used.
- the test is performed over the frequency range 80 MHz to 1 000 MHz and 1 400 MHz to 2 000 MHz with the exception of the exclusion band for transmitters, receivers and duplex transceivers (see EN 301 489-1 [16], clause 4), as appropriate.
- for receivers and transmitters the stepped frequency increment is 1 % frequency increment of the momentary used frequency, unless specified otherwise in the part of EN 301 489 series [16] dealing with the relevant type of radio equipment.
- further product related spot frequency tests may be specified in the relevant part of EN 301 489 [16] dealing with the particular type of radio equipment.
- responses on receivers occurring at discrete frequencies, which are narrow band responses, are disregarded from the test (see EN 301 489-1 [16], clause 4).
- The frequencies selected and used during the test are to be recorded in the test report.

5.1.2.1.3 Measurement uncertainty

Typical measurement uncertainty of E field probes used to measure the field strength at the equipment under test is ±30 %. It is recommended that the value of the positive uncertainty is added to the standard field value so that the equipment is subjected to a minimum field of 3 V/m.

EXAMPLE: Required field strength = 3 V/m
Measurement uncertainty = 30%
Applied field strength = 3,9 V/m.

5.1.2.2 Magnetic field

There are no requirements for EMC magnetic field testing of radio equipment.

5.2 Radio parameters

The following radio parameters are required to be measured up to a maximum frequency of 300 GHz unless otherwise stated in the relevant product test standard. However national traceable reference measurement standards are only available on a commercial basis up to 40 GHz.

Manufacturers of test equipment above 40 GHz are able to calibrate their own equipment in house to their own standards. In this case the declared measurement uncertainty of the manufacturers" calibration may be used for the calculated measurement uncertainty of the test method.

The methods of measurement described in this subclause are based on an anechoic chamber or an indoor test site.

For each radiated measurement, the nature and the dimensions of the test arrangement used are to be recorded in the test report.

5.2.1 Transmitter

When conducting transmitter tests on equipment designed for intermittent operation, the specified maximum transmit time should not be exceeded.

The test method is applicable to transmitters with integral antennas, visible or invisible, that does not allow a conducted power measurement to be made.

The test method is only applicable to constant envelope transmission of type FM/PM and AM. Other forms of modulation/transmission schemes are under consideration.

It is recommended that the test measurements are made in an anechoic chamber up to 40 GHz. Above this frequency a suitable laboratory environment (open site) may be sufficient for low power devices due to the directivity of the source antenna and the measuring antenna and low RF power levels encountered. The use of these test sites means that height search of the test antenna is not required.

WARNING: RF power levels encountered during these tests may lead to test personnel being exposed to RF levels above International limits for occupational exposure to ElectroMagnetic Fields (EMF). Sufficient test facility controls should be implemented to ensure that personnel are not exposed to EMF above the relevant limits for the transmitter frequency.

5.2.1.1 Effective Radiated Power (ERP) and Equivalent Isotropically Radiated Power (EIRP)

5.2.1.1.1 Definition

For the purpose of this measurement, the maximum carrier radiated power is defined as the ERP or EIRP in the direction of maximum field strength under specific conditions of measurement and preferably in the absence of modulation.

NOTE: The use of ERP or EIRP is dependant upon the frequency of operation of the radio transmitter. Normally ERP is measured below 1 GHz and EIRP above 1 GHz. This reflects antenna calibration where below 1 GHz a reference dipole is used, and above 1 GHz the antennas are normally directional and defined in terms of isotropic values by the use of antenna gain.

The standard position in this test method is either:

a) the visible antenna is placed over the centre of the rotating table at a height of 1,5 metres; or

b) the volumetric centre of a transmitter with an internal antenna is placed over the centre of the rotating table at a height of 1,5 metres.

The range length is the greater of three (3) metres or 2(d1+d2) ^2/λ where d1 is the maximum dimension of the equipment under test in metres, d2 is the aperture of the test antenna in metres, and λ is the wavelength in metres of the maximum frequency of test.

5.2.1.1.2 Test procedure

a) A test site which fulfils the requirements of the specified frequency range of this measurement is to be used. The test antenna is oriented initially for vertical polarization unless otherwise stated. (In some product standards a single polarization for the test antenna may be specified for the measurements. In this case there is no need to proceed as in step e)).

The transmitter under test is placed on the support in its standard position and switched on without modulation.

b) A spectrum analyser or selective voltmeter is tuned to the transmitter carrier frequency. The maximum signal level detected on the spectrum analyser or selective voltmeter is recorded.

c) The transmitter is rotated through 360° about a vertical axis until the highest signal level is received. The maximum signal level detected on the spectrum analyser or selective voltmeter is recorded.

d) A substitution antenna is installed to replace the transmitter antenna in the same position and in vertical polarization. The frequency of the signal generator is adjusted to the transmitter carrier frequency. The input signal to the substitution antenna is adjusted in level until an equal or a known related level to that detected from the transmitter is obtained in the test receiver.

The carrier radiated power is equal to the power supplied by the signal generator, increased by the known relationship from d), if necessary, and after corrections due to the gain of the substitution antenna and the cable loss between the signal generator and the substitution antenna.

e) Steps b) to d) above are repeated with the test antenna and the substitution antenna oriented in horizontal polarization.

5.2.1.1.3 Measurement uncertainty

The maximum allowable measurement uncertainty for this test method is ±6 dB to 40 GHz. The measurement uncertainty for the frequency range from 40 GHz to 300 GHz is under consideration.

5.2.1.2 Spurious emissions

5.2.1.2.1 Definition

Spurious emissions are emissions at frequencies, other than those of the carrier and sidebands associated with normal modulation, radiated by the antenna and by the cabinet of the transmitter.

For the purpose of this measurement, the spurious emissions are defined as the ERP or EIRP in the direction of maximum field strength under specific conditions of measurement and normally in the absence of modulation.

The standard position in this test method is either:

a) the visible antenna is placed over the centre of the rotating table at a height of 1,5 metres; or

b) the volumetric centre of a transmitter with an internal antenna is placed over the centre of the rotating table at a height of 1,5 metres.

The range length is the greater of three (3) metres or 2(d1+d2) ^2/λ where d1 is the maximum dimension of the equipment under test in metres, d2 is the aperture of the test antenna in metres, and λ is the wavelength in metres of the maximum frequency of test.

Spurious emissions are specified as the radiated power of any discrete signal.

5.2.1.2.2 Test procedure

This Test procedure applies to transmitters having an integral antenna and covers the cabinet radiation test at the same time.

a) A test site which fulfils the requirements of the specified frequency range of this measurement is used.

   The test antenna is oriented initially for vertical polarization and connected to a spectrum analyser or a selective voltmeter, through a suitable filter to avoid overloading of the spectrum analyser or selective voltmeter. The bandwidth of the spectrum analyser or selective voltmeter is between 10 kHz and 100 kHz (as defined in the relevant product standard) set to a suitable value to correctly perform the measurement.

   For the measurement of spurious emissions below the second harmonic of the carrier frequency the filter to be used is a high 'Q' (notch) filter centred on the transmitter carrier frequency and attenuating this signal by at least 30 dB.

   For the measurement of spurious emissions at and above the second harmonic of the carrier frequency the filter used is a high pass filter with a stop band rejection exceeding 40 dB. The cut-off frequency of the high pass filter is approximately 1,5 times the transmitter carrier frequency.

   The transmitter under test is placed on the support in its standard position and is switched on without modulation. Transmitting equipment that has to have a modulating signal for its transmitting operation should be modulated with an applicable modulating signal and this should be recorded in the test report.

b) The radiation of any spurious emission is detected by the test antenna and spectrum analyser or selective voltmeter over the specified frequency range, except for the channel on which the transmitter is intended to operate and its adjacent channels. The frequency of each spurious emission detected is recorded. If the test site is disturbed by interference coming from outside, this qualitative search may be performed in a screened room, with a reduced distance between the transmitter and the test antenna.

c) At each frequency at which an emission has been detected, the spectrum analyser or selective voltmeter is tuned to the frequency and the test antenna raised or lowered through the specified height range until the maximum signal level is detected on the spectrum analyser or selective voltmeter.

d) The transmitter is rotated through 360° about a vertical axis, until the maximum signal is received.

e) This level is recorded.

f) The substitution antenna now replaces the transmitter antenna in the same position and in vertical polarization. It is connected to the signal generator for the frequency range of test.

g) At each frequency at which an emission has been detected, the signal generator, and spectrum analyser or selective voltmeter is tuned to the same frequency. The level of the signal generator giving the same indicated signal level on the spectrum analyser or selective voltmeter as in item e) above is recorded. This value, after corrections due to the gain of the substitution antenna and the cable loss between the signal generator and the substitution antenna, is the radiated spurious emission at this frequency.

h) Steps c) to g) above are then repeated with the test antenna oriented in horizontal polarization.

j) Steps c) to h) above are repeated with the transmitter in stand-by condition if this option is available.

5.2.1.2.3 Measurement uncertainty

The maximum allowable measurement uncertainty for this test method is ±6 dB to 40 GHz. The measurement uncertainty for the frequency range from 40 GHz to 300 GHz is under consideration.

5.2.1.3 Cabinet radiation

5.2.1.3.1 Definition

Cabinet radiation is radiation at frequencies, excluding the band containing the carrier and sidebands associated with normal modulation, coming from the cabinet of the transmitter.

For the purpose of this measurement, the cabinet radiation emissions are defined as the ERP or EIRP in the direction of maximum field strength under specific conditions of measurement and normally in the absence of modulation.

The standard position for integral antenna equipment in this test method is either:

a) the visible antenna is placed over the centre of the rotating table at a height of 1,5 metres; or

b) the volumetric centre of a transmitter with an internal antenna is placed over the centre of the rotating table at a height of 1,5 metres.

The standard position for equipment with an antenna socket in this test method is:

c) the volumetric centre of a transmitter with an antenna socket is placed over the centre of the rotating table at a height of 1,5 metres. The antenna socket is terminated with a shielded load.

The range length is the greater of three (3) metres or 2((d1+d2)^2)/λ where d1 is the maximum dimension of the equipment under test in metres, d2 is the aperture of the test antenna in metres, and λ is the wavelength in metres of the maximum frequency of test.

Cabinet radiation is specified as the radiated power of any discrete signal.

5.2.1.3.2 Test procedure

a) A test site which fulfils the requirements of the specified frequency range of this measurement is to be used. The test antenna is oriented initially for vertical polarization and connected to a spectrum analyser or selective voltmeter. The bandwidth of the spectrum analyser or selective voltmeter is between 10 and 100 KHz, set to a suitable value to correctly perform the measurement.

   The transmitter under test is placed on the support in its standard position, connected to a test load and switched on without modulation.

b) The same Test procedure as steps b) and j) of clause 5.2.1.1.2.2 is used to determine the values of emissions of cabinet radiation.

5.2.1.3.3 Measurement uncertainty

The maximum allowable measurement uncertainty for this test method is ±6 dB to 40 GHz. The measurement uncertainty for the frequency range from 40 GHz to 300 GHz is under consideration.

5.2.1.4 Transmitter mask, occupied bandwidth, necessary bandwidth

At the time of writing the present document a number of test methods have been reviewed. The complexity of modern modulation techniques has resulted in automated methods being implemented in complex test systems. Equally the limit values are specified in different units.

Further work is required to clearly identify the multitude of definitions in various standards, ITU-R, CEPT, ANSI, and IEC. A measurement method that can be implemented without automated test equipment should be a high priority for future work.

5.2.1.4.1 Definition

Reserved.

5.2.1.4.2 Test procedure

Reserved.

5.2.1.4.3 Measurement uncertainty

Reserved.

5.2.2 Receiver

5.2.2.1 Radiated spurious components

5.2.2.1.1 Definition

Radiated spurious components are emissions radiated by the antenna and the cabinet of the receiver.

For the purpose of this measurement, the radiated spurious components are defined as the ERP or EIRP in the direction of maximum field strength under specific conditions of measurement.

The standard position for integral antenna equipment in this test method is either:

a) the visible antenna is placed over the centre of the rotating table at a height of 1,5 metres; or

b) the volumetric centre of a receiver with an internal antenna is placed over the centre of the rotating table at a height of 1,5 metres.

They are specified as the radiated power of any discrete signal.

5.2.2.1.2 Test procedure

This Test procedure applies to receivers having an integral antenna.

a) A test site which fulfils the requirements of the specified frequency range of this measurement is to be used. The test antenna is oriented for vertical polarization and connected to a spectrum analyser or a selective voltmeter. The bandwidth of the spectrum analyser or selective voltmeter is between 10 kHz and 100 kHz, set to a suitable value to correctly perform the measurement.

   The receiver under test is placed on the support in its standard position.

b) The radiation of any spurious component is detected by the test antenna and spectrum analyser or selective voltmeter over the specified frequency range. The frequency of each spurious component is recorded. If the test site is disturbed by radiation coming from outside, this qualitative search may be performed in a screened room with reduced distance between the receiver and the test antenna.

c) At each frequency at which a component has been detected, the spectrum analyser or selective voltmeter is tuned to the frequency until the maximum signal level is detected on the spectrum analyser or selective voltmeter.

d) The receiver is rotated through 360º about a vertical axis, until the maximum signal is received.

e) This level should be recorded.

f) The substitution antenna now replaces the receiver antenna in the same position and in vertical polarization. It is connected to the signal generator for the frequency range of test.

g) At each frequency that a spurious component has been detected, the signal generator and spectrum analyser or selective voltmeter is tuned to the same frequency. The level of the signal generator giving the same signal level on the spectrum analyser or selective voltmeter as in item e) above is recorded. This value, after correction due to the gain of the substitution antenna and the cable loss between the signal generator and the substitution antenna, is the radiated spurious component at this frequency.

h) Measurements b) to g) above are then repeated with the test antenna oriented in horizontal polarization.

5.2.2.1.3 Measurement uncertainty

The maximum allowable measurement uncertainty for this test method is ±6 dB to 40 GHz. The measurement uncertainty for the frequency range from 40 GHz to 300 GHz is under consideration.

5.2.2.2 Cabinet radiation

5.2.2.2.1 Definition

Cabinet radiation is radiation at frequencies coming from the cabinet of the receiver.

For the purpose of this measurement, the cabinet radiation emissions are defined as the ERP or EIRP in the direction of maximum field strength under specific conditions of measurement.

The standard position for equipment with an antenna socket in this test method is the volumetric centre of a receiver with an antenna socket is placed over the centre of the rotating table at a height of 1,5 metres. The antenna socket is terminated with a shielded load.

The range length is the greater of three (3) metres or 2((d1+d2)^2)/λ where d1 is the maximum dimension of the equipment under test in metres, d2 is the aperture of the test antenna in metres, and λ is the wavelength in metres of the maximum frequency of test.

Cabinet radiation is specified as the radiated power of any discrete signal.

5.2.2.2.2 Test procedure

a) A test site which fulfils the requirements of the specified frequency range of this measurement is used. The test antenna is oriented initially for vertical polarization and connected to a spectrum analyser or selective voltmeter. The bandwidth of the spectrum analyser or selective voltmeter is between 10 kHz and 100 KHz, set to a suitable value to correctly perform the measurement.

   The receiver under test is placed on the support in its standard position, connected to a test load and switched on.

b) The same Test procedure as steps b) to h) of clause 5.2.1.2.2 is used to determine the value of emissions of cabinet radiation.

5.2.2.2.3 Measurement uncertainty

The maximum allowable measurement uncertainty for this test method is ±6 dB to 40 GHz. The measurement uncertainty for the frequency range from 40 GHz to 300 GHz is under consideration.

5.3 Protocol testing

Many of the modern radio systems are based upon digital techniques that require a sophisticated communications protocol for its communication link. These protocols rely upon a bi-directional controlling protocol and the basic radio communication transmission of the intended information.

The sophistication of the protocol and the integration of the software often means that it is difficult to test the radio system unless a communications link is set-up in a test environment using communication test sets.

These test sets are able to control the radio transmissions in a defined way to test the responses from the radio equipment under test when specific commands are sent across the communications link. The configuration of the equipment under test and the test equipment allow fully automated testing that has been standardized using protocol testing standards specific to each radio test requirement.

The present document does not define the test methods or measurement uncertainties for such testing. The implementation within the radio test set is often manufacturer specific and it is not possible for a general assessment to be made.

It is therefore recommended that:

1) the general rules for the calculation of measurement uncertainties are used and declared by the testing organization; and

2) the test method should be clearly stated by the radio test set manufacturer so that the testing organization are able to calculate the measurement uncertainties.

The present document may be extended for protocol test methods after further study.

5.4 Aeronautical parameters

A review has been carried out of existing ETSI Aeronautical radio standards published or under development. For radio communications equipment used in aircraft the majority are used in the frequencies below 1 GHz. Current test methods used in support of the standards have not yet been validated for inclusion within the present document. However, the majority of existing Aeronautical test parameters can be considered as equivalent to radio parameters covered in the present document.

5.5 Satellite system parameters

A review has been carried out of existing ETSI Satellite equipment standards. No test methods have been included in the present document as the test methods and associated measurement uncertainties are clearly defined within the product standards.

5.6 Fixed links parameters

A review has been carried out of existing ETSI Fixed Links standards. No test methods have been included in the present document as the test methods and associated measurement uncertainties are clearly defined within the product standards.

5.7 Maritime

A review has been carried out of existing ETSI Maritime standards. Most Maritime radio equipment operates at frequencies below 1 GHz. No test methods have been included in the present document as the test methods and associated measurement uncertainties are clearly defined within the product standards.

5.8 Transport

A review has been carried out of existing ETSI Transport standards published or under development. As this sector is still in its infancy and utilizes emerging technologies, test methods are also still under development. Test methods have not been included in the present document.

5.9 ElectroMagnetic Fields (EMF)

Measurement methods of EMF are still under development within relevant standards from CENELEC. The nominal measurement uncertainty requirement being proposed is ±30 %. As these measurements are required to be carried out using radiated test methods up to a frequency of 300 GHz, the defined measurement uncertainties are difficult to achieve using traditional radiated test methods.

New test methods are under evaluation to comply with the measurement uncertainty requirements and further recommendations will be provided in a future edition of the present document.

EG 202 373 [23] provides guidance on the measurement of RF fields on radio sites.

6 RF conducted test methods above 1 GHz

6.1 EMC

6.1.1 Introduction

Conducted EMC test methods are developed by IEC/CISPR. For radio systems specific product EMC standards have been produced by ETSI (see EN 301 489 [16]). They indicate the relevant conducted EMC parameters that are needed for each system and the necessary test configurations based upon the application. Variations of the EMC requirements are categorized as portable, mobile and fixed radio equipment.

It is therefore recommended that the specific radio product standards are used for conformance to EMC requirements.

6.1.2 Measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2 General radio RF parameters

6.2.1 Transmitter

6.2.1.1 Frequency error

6.2.1.1.1 Definition

The frequency error of the transmitter is the difference between the unmodulated carrier frequency and the nominal frequency selected for the test.

6.2.1.1.2 Test procedure

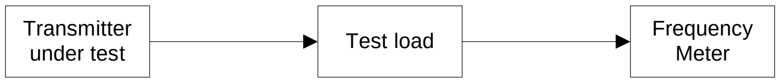

Figure 1: Measurement arrangement

a) Figure 1 shows the transmitter under test connected via the test load to a frequency meter. Measurement of the carrier frequency should then be made in the absence of modulation and the results recorded.

b) The measurement should then be repeated under extreme test conditions (see clause A.1).

6.2.1.1.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.2 Carrier power

6.2.1.2.1 Definition

The carrier power is the average power delivered to the test load during one radio frequency cycle in the absence of modulation.

6.2.1.2.2 Test procedure

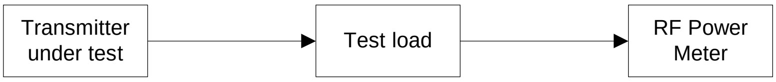

Figure 2: Measurement arrangement

a) The transmitter under test should be connected to the test load as shown in figure 2; the test load is then connected to the RF power meter prior to measurement taking place.

b) The carrier or mean power delivered to this test load should then be measured and compared with the rated RF output power of the transmitter. The results should then be recorded.

c) The measurement should then be repeated under extreme test conditions (see clause A.1).

6.2.1.2.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.3 Frequency deviation

6.2.1.3.1 Definition

The frequency deviation is the maximum difference between the instantaneous frequencies of the frequency or phase modulated radio frequency signal and the carrier frequency in the absence of modulation.

6.2.1.3.2 Maximum frequency deviation

6.2.1.3.2.1 Test procedure

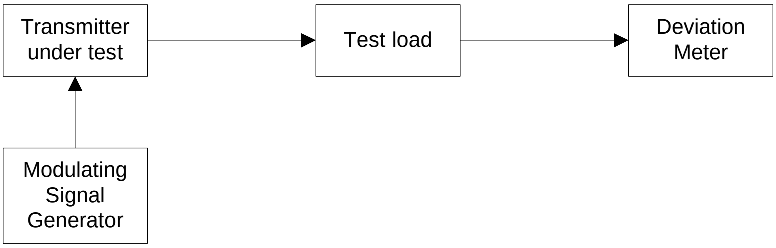

Figure 3: Measurement arrangement

The transmitter under test should be connected to the test load as shown in figure 3; the test load should also be connected to a deviation meter for measurement of the frequency deviation. For the purposes of this test procedure the transmitter under test should be exercised by a modulating signal generator.

The deviation meter should be capable of measuring the maximum permissible frequency deviation, including that due to any harmonics and intermodulation products that may be produced in the transmitter. The deviation meter bandwidth should be sufficient to accommodate the highest modulating frequency and to achieve the required dynamic range.

6.2.1.3.2.1.1 Analogue signals within the audio bandwidth

a) This test should be performed by varying the modulation frequency between 300 Hz and the upper specified audio frequency limit. The level of the test signal should be 20 dB above the level corresponding to a deviation at 1000 Hz of 12 % of the channel separation.

b) The maximum (positive or negative) frequency deviation should then be recorded.

6.2.1.3.2.1.2 Analogue signals above the audio bandwidth

a) This test should be performed by varying the modulation frequency between the upper specified audio frequency limit and a frequency equal to the channel separation for which the equipment is intended. The level of this signal should correspond to a deviation at 1 000 Hz of 12 % of the channel separation.

b) The maximum (positive or negative) frequency deviation should then be recorded.

6.2.1.3.2.1.3 Digital signals

The following test procedure should be used for indirect modulation where the digital signal may either phase or frequency modulate an audio frequency sub-carrier, which in turn modulates the radio frequency carrier.

a) The transmitter under test should be exercised by a modulating signal generator using test modulation D-M0 (see clause A.2) at the normal deviation level.

b) The maximum (positive or negative) frequency deviation should then be recorded.

c) The transmitter under test should then be modulated with the test modulation D-M1 (see clause A.2) at the normal deviation level.

d) The maximum (positive or negative) frequency deviation should then be recorded.

NOTE: Other types of digital modulation will require an alternative method.

6.2.1.3.2.2 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.3.3 Modulation frequencies above 3 kHz

6.2.1.3.3.1 Test procedure

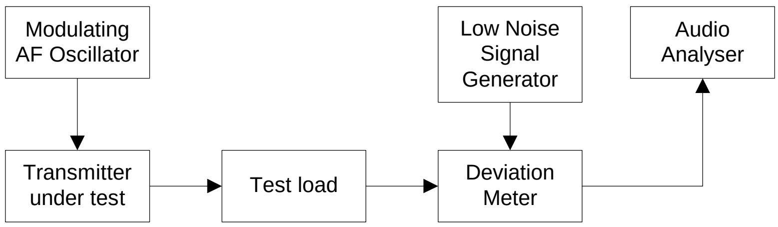

Figure 4: Measurement arrangement for modulation frequencies above 3 kHz

The AF signal from the audio frequency oscillator is applied to the modulation input of the transmitter under test. The RF signal from the transmitter under test is applied to a deviation meter through a test load. The demodulated signal is then applied to the audio analyser. A low noise signal generator is used as local oscillator for the deviation meter for demodulating signals with modulation frequencies above 3 kHz, to improve the noise behaviour. The result is corrected for AF gain and AF filter shaping.

6.2.1.3.3.2 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.4 Adjacent channel power

6.2.1.4.1 Definition

The adjacent channel power is that part of the total power output of a transmitter under defined conditions of modulation, which falls within a specified passband centred on the nominal frequency of either of the adjacent channels. This power is the sum of the mean power produced by the modulation, hum and noise of the transmitter.

It is specified either as the ratio expressed in decibels of the carrier power to the adjacent channel power or as an absolute value.

6.2.1.4.2 Power meter method

6.2.1.4.2.1 Test procedure

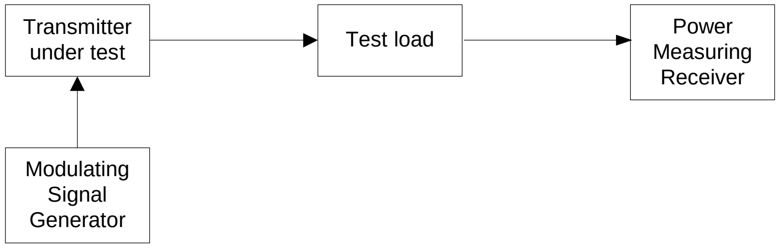

Figure 5: Measurement arrangement

a) As shown in figure 5, the transmitter under test should be connected via the test load to a power measuring receiver calibrated to measure rms power level. The level at the receiver input should be within its allowed limit. The transmitter should be operated at the maximum operational carrier power level.

b) With the transmitter unmodulated, the tuning of the power measuring receiver should be adjusted so that a maximum response is obtained. This is the 0 dB response point. The power measuring receiver attenuator setting and the reading of the meter should be recorded.

c) The tuning of the power measuring receiver should be adjusted away from the carrier so that its -6 dB response nearest to the transmitter carrier frequency is located at a displacement from the nominal frequency of the carrier as given in table 1.

NOTE: The power measuring receiver is assumed to be either a spectrum analyser or selective frequency voltmeter.

Table 1: Frequency displacement

Channel separation (kHz)	Displacement (kHz)
12,5	8,25
20	13
25	17

The same result may be obtained by tuning the power measuring receiver to the nominal frequency of the adjacent channel, if it has been suitably calibrated.

d) The transmitter should be modulated as follows:

1) Equipment for analogue speech should be modulated with a 1 250 Hz tone at a level that is 20 dB higher than that required to produce normal deviation.

2) Equipment for data bits should be modulated with the test modulation D-M2 (see clause A.2) at the agreed deviation.

3) Equipment for messages should be modulated with the test modulation D-M3 (see clause A.2) repeated continuously at the agreed deviation.

e) The power measuring receiver variable attenuator should be adjusted to obtain the same meter reading as in step b) or a known relation to it. This value should be recorded.

f) The ratio of adjacent channel power to carrier power is the difference between the attenuator settings in step b) and e), corrected for any differences in the reading of the meter. Alternatively the absolute value of the adjacent channel power may be calculated from the above ratio and the transmitter carrier power.

g) Steps c) to f) should be repeated with the power measuring receiver tuned to the other side of the carrier.

6.2.1.4.2.2 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.4.3 Spectrum analyser method

6.2.1.4.3.1 Test procedure

The transmitter under test is connected to spectrum analyser via a matching and attenuating network and the carrier is recorded as reference. The adjacent channel power is calculated from spectrum analyser reading (9 samples) by means of Simpson's Rule.

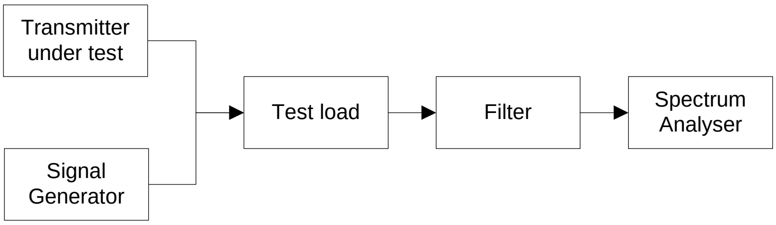

Figure 6: Measurement arrangement

6.2.1.4.3.2 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.5 Spurious emissions

6.2.1.5.1 Definition

Conducted spurious emissions are discrete signals whose power is conveyed by conduction to the test load at frequencies other than those of the carrier and sidebands resulting from the normal process of modulation.

They are specified as the power level of any discrete signal delivered into a test load.

6.2.1.5.2 Test procedure

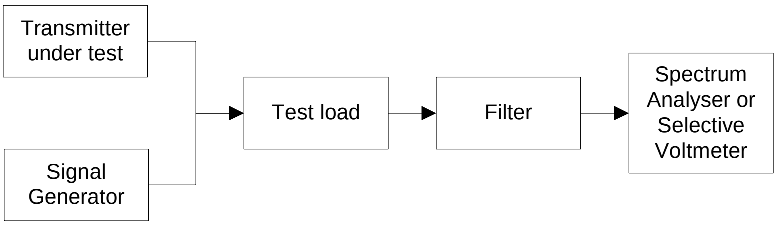

Figure 7: Measurement arrangement

a) The transmitter should be connected to a spectrum analyser or a selective voltmeter through a test load and an appropriate bandpass filter during measurements below 2,9 GHz to avoid overloading of the spectrum analyser or selective voltmeter. The bandwidth of the spectrum analyser or selective voltmeter should be between 10 kHz and 100 kHz. The equipment used should have sufficient dynamic range and sensitivity to achieve the required measurement accuracy at the specified limit.

   For the measurement of spurious emissions below the second harmonic of the carrier frequency the filter used should be a high "Q" (notch) filter centred on the transmitter carrier frequency and attenuating this signal by at least 30 dB.

   For the measurement of spurious emissions at and above the second harmonic of the carrier frequency the filter used should be a high pass filter with a stop band rejection exceeding 40 dB. The cut-off frequency of the high pass filter should be approximately 1,5 times the transmitter carrier frequency.

Precautions may be required to ensure that the test load does not generate, or that the high pass filter does not attenuate, the harmonics of the carrier.

b) The transmitter should be unmodulated and operating at the maximum limit of its specified power range.

c) The frequency of the spectrum analyser or selective voltmeter should be adjusted over the specified frequency range. The frequency and level of every spurious emission found should be noted. The emissions within the channel occupied by the transmitter carrier and its adjacent channels should not be recorded.

d) If the spectrum analyser or selective voltmeter has not been calibrated in terms of power level at the transmitter output, the level of any detected components should be determined by replacing the transmitter by the signal generator and adjusting it to reproduce the frequency and level of every spurious emission recorded in step c).

e) The absolute power level of each of the emissions noted should be measured and recorded.

f) The measurement should be repeated with the transmitter in stand-by condition if this option is available.

The individual spurious components are found and read from the analyser and corrected for attenuation and mismatch loss in the matching network (test load), or they are substituted by means of a signal generator signal.

6.2.1.5.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.6 Inter-modulation attenuation

6.2.1.6.1 Definition

For the purpose of this test the intermodulation attenuation is a measure of the capability of a transmitter to inhibit the generation of signals in its non-linear elements caused by the presence of the carrier and an interfering signal entering the transmitter via its antenna.

It is specified as the ratio, in decibels, of the power level of the third order intermodulation product to the carrier power level.

6.2.1.6.2 Test procedure

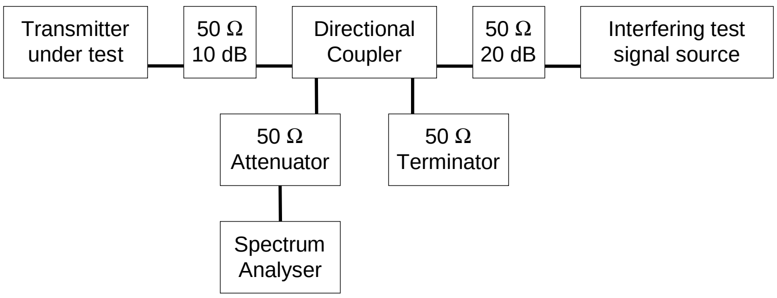

Figure 8: Measurement arrangement

a) Preliminary to the measurement the carrier power of the transmitter under test should be measured according to clause 6.2.1.2, under normal conditions only, and the value recorded.

The transmitter should be connected to a 50 Ω 10 dB test load and via a directional coupler to a spectrum analyser. An attenuator may be required to avoid overloading the spectrum analyser.

The length of the cable between the transmitter under test and the 10 dB test load should be kept to a minimum.

The directional coupler should have an insertion loss of less than 1 dB, a sufficient bandwidth, and a directivity of more than 20 dB.

The test signal source may be a signal generator and a power amplifier or another transmitter, the output power of which is adjustable.

The transmitter under test and the test signal source should be physically separated in such a way that the measurement is not influenced by direct radiation.

b) Replace the transmitter under test in the measurement arrangement above by a RF power meter.

c) The test signal source should be unmodulated and the frequency should be within 50 kHz to 100 kHz above the frequency of the transmitter under test.

The frequency should be chosen in such a way that the intermodulation components to be measured do not coincide with other spurious emissions.

d) The test signal power level should be adjusted to -30 dB, relative to the carrier power level recorded above, measured on the RF power meter.

e) The transmitter under test should be reconnected to the 10 dB test load, as shown above.

f) The transmitter should be unmodulated and the spectrum analyser adjusted to give a maximum indication with a frequency scan width of 500 kHz.

g) The intermodulation components should be measured by direct observation on the spectrum analyser and the ratio of the largest third order intermodulation component to the carrier recorded which is situated at the same frequency offset (within 50 kHz to 100 kHz) selected in step c, below the transmitter frequency.

h) This measurement should be repeated with the test signal at a frequency within 50 kHz to 100 kHz below the transmitter frequency. In this case the largest third order intermodulation component to be observed in step g is situated at the same frequency offset selected in step c, above the transmitter frequency.

6.2.1.6.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.7 Attack/release time

6.2.1.7.1 Attack time

6.2.1.7.1.1 Definition

The transmitter attack time is the time interval between the instant at which the final irrevocable logic decision to power up the transmitter is taken and the moment after which:

a) the unmodulated transmitter power always remains within a level -1 dB and +1,5 dB of the steady state carrier power, or

b) the frequency of the carrier always remains within ±1 kHz from its steady state frequency.

NOTE: This may be used for checking the channel efficiency of systems and for defining the timings in protocols.

6.2.1.7.1.2 Test procedure

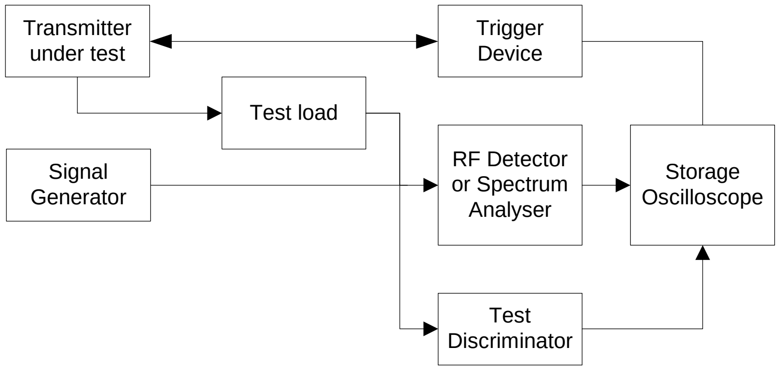

Figure 9: Measurement arrangement

a) The transmitter is connected to a RF detector and to a test discriminator via a matched test load. The attenuation of the test load should be chosen in such a way that the input of the test discriminator is protected against overload and the limiter amplifier of the test discriminator operates correctly in the limiting range as soon as the transmitter carrier power (before attenuation) exceeds 1 mW. A dual trace storage oscilloscope (or a transient recorder) records the amplitude transient from the detector on a logarithmic scale and the frequency transient from the discriminator. A trigger device may be required to ensure that the start of the sweep of the oscilloscope timebase occurs at the instant at which the final irrevocable logic decision to power up the transmitter is taken.

b) The traces of the oscilloscope should be calibrated in power and frequency (Y axes) and in time (X axis), using the signal generator.

c) The transmitter attack time should be measured by direct reading on the oscilloscope.

6.2.1.7.1.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.7.2 Release time

6.2.1.7.2.1 Definition

The transmitter release time is the time interval between the instant at which the final irrevocable logic decision to power down the transmitter is taken and the moment when the unmodulated transmitter power has decayed to a level 50 dB below the rated RF output power.

NOTE: This may be used for checking the channel efficiency of systems and for defining the timings in protocols.

6.2.1.7.2.2 Test procedure

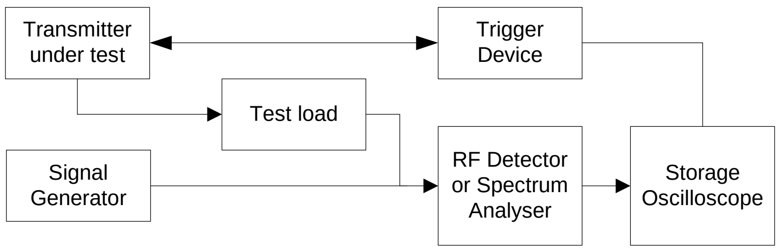

Figure 10: Measurement arrangement

a) The transmitter is connected to a RF detector via a matched test load. A storage oscilloscope (or a transient recorder) records the amplitude transients from the detector on a logarithmic scale (dynamic range ≥ 50 dB).

   A trigger device may be required to start the sweep of the oscilloscope the instant at which the final irrevocable decision to power down the transmitter is taken.

   If the transmitter possesses an automatic powering down facility (e.g. in the case of fixed length messages transmission), it will replace the trigger device for starting the sweep of the oscilloscope.

b) The traces of the oscilloscope should be calibrated in power (Y axis) and in time (X axis) by replacing the transmitter and test load by the signal generator.

c) The transmitter release time should be measured by direct reading on the oscilloscope.

6.2.1.7.2.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.7.3 Frequency behaviour

6.2.1.7.3.1 Definition

Frequency behaviour (attack) is the time elapsed between switching on the transmitter and the moment when the carrier frequency is within defined limits.

Frequency behaviour (release) is the time elapsed between switching off the transmitter and the moment when the carrier frequency falls outside defined limits.

6.2.1.7.3.2 Test procedure

Transmitter output frequency variation as a function of time during the attack or release period, this is measured by means of a test discriminator providing vertical deflection to a storage oscilloscope (see figure 11).

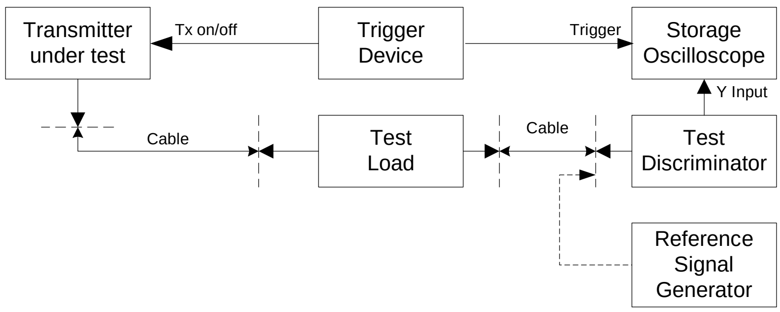

Figure 11: Measurement arrangement

With the oscilloscope time base set to "repetitive" at an appropriate sweep rate, the oscilloscope display graticule is calibrated by means of the signal generator, to provide vertical reference points corresponding to the specification frequency limits or mask e.g. ± one channel. The oscilloscope is then set to "single sweep" in preparation for the measurement.

When the trigger device is operated, it initiates the oscilloscope sweep and simultaneously switches on the transmitter. Any variation in transmitter output frequency will appear at the discriminator output as a varying Direct Current (DC) voltage which will be recorded on the oscilloscope display as a plot of frequency against time.

6.2.1.7.3.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.7.4 Power level behaviour

6.2.1.7.4.1 Definition

Power behaviour (attack) is the time elapsed between switching on the transmitter and the moment when the transmitter output power level is within defined limits i.e. a percentage of full power.

Power behaviour (release) is the time elapsed between switching off the transmitter and the moment when the transmitter output power level falls outside defined limits i.e. a percentage of full power.

6.2.1.7.4.2 Test procedure

Transmitter output power variation as a function of time during this period is measured on a spectrum analyser set to zero span mode (see figure 12)

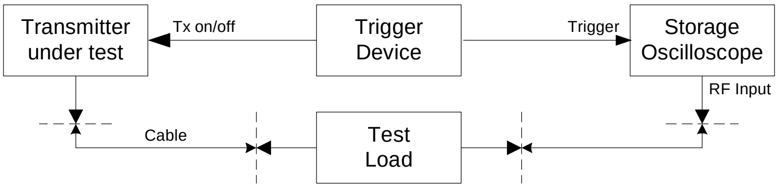

Figure 12: Measurement arrangement

With the spectrum analyser time base set to "repetitive" at an appropriate sweep rate, the transmitter is switched on and the analyser sensitivity adjusted until the measured signal coincides with the reference level. The analyser is then set to "single shot", and the transmitter switched off in preparation for the measurement.

When the trigger device is operated, this simultaneously initiates the spectrum analyser sweep and switches on the transmitter. Any variation in transmitter output power level will be recorded on the spectrum analyser display as a plot of output power level against time.

6.2.1.7.4.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.1.8 Transient behaviour

6.2.1.8.1 Definition

The transient adjacent channel power of a transmitter is expressed as the ratio in decibels of the peak power in the adjacent channels, during the rise or decay time, to the unmodulated carrier power.

6.2.1.8.2 Test procedure

This method of measurement uses a power measuring receiver in the adjacent channels. It is recommended that in order to guarantee that the transients will not appear outside either of the channels adjacent to the carrier the test should be preceded by two preliminary verifications. The measurement should then be made in the first adjacent channels next to the carrier only.

6.2.1.8.2.1 Preliminary verification N°1

This verification is to be made when both the transmitter is turned on and off. It uses in both cases the measuring arrangement described for the transmitter "attack time". While the carrier power is greater than 1 mW the instantaneous frequency of the carrier should remain within the tolerance of $\pm\delta f1$, where $\delta f1$ is the channel separation.

6.2.1.8.2.2 Preliminary verification N°2

This verification uses the measuring arrangement described for the transmitter "attack time" and transmitter "release time". The rise and decay time measured as the time elapsed between the -30 dB and the -6 dB relative to the steady state carrier power must be greater than 0,2 ms. In addition the shape of the slopes during the rise and decay time should not exhibit abrupt changes in level or parasitic oscillation.

6.2.1.8.2.3 Test procedure

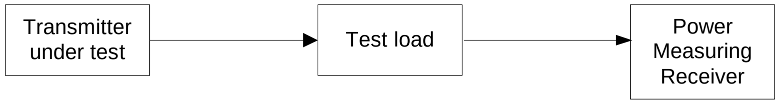

Figure 13: Measurement arrangement

a) The transmitter under test should be connected via the test load to a power measuring receiver calibrated to measure peak power level. The level at the receiver input should be within its allowed limit. The transmitter should be operated unmodulated at the maximum carrier power level under normal test conditions.

b) The tuning of the power measuring receiver should be adjusted so that a maximum response is obtained. This is the 0 dB response point. The receiver attenuator setting and the reading of the meter should be recorded and the transmitter switched off.

c) The tuning of the power measuring receiver should be adjusted away from the carrier so that its -6 dB response nearest to the transmitter carrier frequency is located at a displacement from the nominal frequency of the carrier as given in table 2.

Table 2: Frequency displacement

Channel separation (kHz)	Displacement (kHz)
12,5	8,25
20	13
25	17

The same result may be obtained by tuning the power measuring receiver to the nominal frequency of the adjacent channel, if it has been suitably calibrated.

d) The transmitter should be switched on and off once. The receiver variable attenuator should be adjusted to obtain, with the peak transient power, the same level as in step b) or a known relation to it. This value should also be recorded.

e) The ratio of adjacent channel peak power to carrier power is the difference between the attenuator settings in steps b) and d), corrected for any differences in the reading of the meter.

f) Steps c) to e) should be repeated with the power measuring receiver tuned to the other side of the carrier.

6.2.1.8.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2 Receiver

6.2.2.1 Maximum usable sensitivity

6.2.2.1.1 Analogue speech

6.2.2.1.1.1 Definition

The measured usable sensitivity for analogue speech of the receiver is the minimum level of signal, expressed as an EMF, at the nominal frequency of the receiver and with specified test modulation which produces through a psophometric weighting network a SINAD ratio of 20 dB.

6.2.2.1.1.2 Test procedure

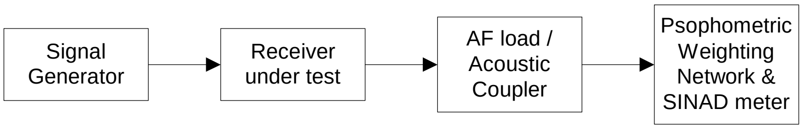

Figure 14: Measurement arrangement

a) A signal generator is connected to the receiver input. The signal generator is set at the nominal frequency of the receiver and modulated with test modulation A-M1 (see clause A.2).

b) The amplitude of the signal generator is adjusted until a SINAD ratio of 20 dB is obtained.

c) The test signal input level under these conditions is the value of the measured usable sensitivity for analogue speech. This level is recorded.

d) The measurement is repeated under extreme test conditions (see clause A.1).

6.2.2.1.1.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.1.2 Bit stream

6.2.2.1.2.1 Definition

The measured usable sensitivity for bit stream of the receiver is the minimum level of signal expressed as an EMF, at the nominal frequency of the receiver modulated with specified test signal which produces, after demodulation, a data signal with a bit error ratio of 10^{-2} or as specified in the equipment product specification.

6.2.2.1.2.2 Test procedure

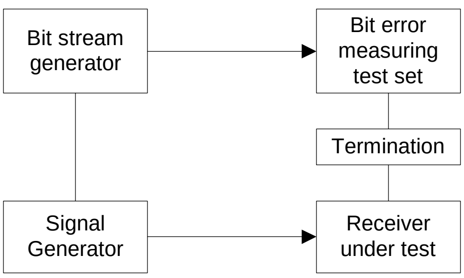

Figure 15: Measurement arrangement

a) A signal generator is connected to the receiver input. The signal generator is set at the nominal frequency of the receiver and modulated by the test modulation D-M2 (see clause A.2).

b) The amplitude of the signal generator should be adjusted until the bit error ratio of 10^{-2} is obtained or as specified in the equipment product specification.

c) The measured usable sensitivity for bit stream is recorded as the EMF of the input signal to the receiver.

d) The measurement is repeated under extreme test conditions (see clause A.1).

6.2.2.1.3 Messages

6.2.2.1.3.1 Definition

The measured usable sensitivity for messages of the receiver is the minimum level of signal, expressed as an EMF, at the nominal frequency of the receiver modulated by a test signal which produces, after demodulation, a message acceptance ratio of 80 %.

6.2.2.1.3.2 Test procedure

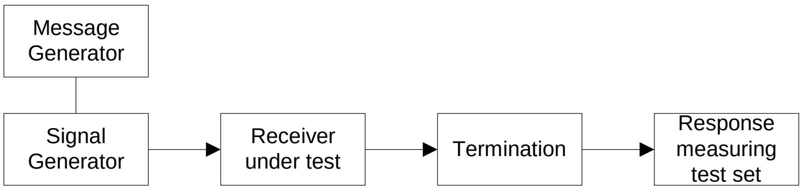

Figure 16: Measurement arrangement

a) A signal generator is connected to the receiver input. The signal generator is set at the nominal frequency of the receiver and modulated by the test modulation D-M3 (see clause A.2).

b) The amplitude level of the signal generator is adjusted so that a successful message response ratio of less than 10 % is obtained.

c) The test signal is applied repeatedly whilst observing in each case whether or not a successful response is obtained. The input level is increased by 2 dB for each occasion that a successful response is not obtained. The procedure continued until three consecutive successful responses are observed. The level of the input signal is recorded.

d) The input signal level is reduced by 1 dB and the new value recorded. The test signal is then continuously repeated. In each case, if a response is not obtained, the input level is increased by 1 dB and the new value recorded. If a successful response is obtained, the input level is not changed until three consecutive successful responses have been observed. In this case, the input level is reduced by 1 dB and the new value recorded. No input signal levels are recorded unless preceded by a change in level. The measurement is stopped after a total of 10 values have been recorded.

e) The measured usable sensitivity for messages is the average of the values recorded in steps c) and d).This value is recorded.

f) The measurement is repeated under extreme test conditions (see clause A.1).

6.2.2.1.3.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.2 Amplitude characteristic

6.2.2.2.1 Definition

The amplitude characteristic of the receiver is the relationship between the radio frequency input level of a specified modulated signal and the audio frequency level at the receiver output.

6.2.2.2.2 Test procedure

The receiver under test is connected to a signal generator via a cable. The output from the receiver is connected to an AF voltmeter and load. The signal generator is adjusted to produce an appropriate level (usually near the threshold of limiting) and a reading on the AF voltmeter obtained. The signal generator is then adjusted to produce a considerably higher level and a second reading on the AF voltmeter obtained. The amplitude characteristic is recorded as the ratio (in dBs) between the two readings.

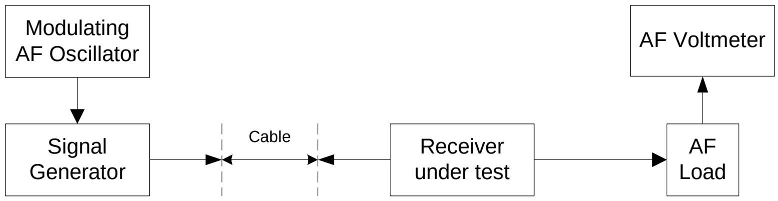

Figure 17: Measurement arrangement

Uncertainty contributions affecting RF input level must be included for the first measurement (combined and converted to AF level uncertainty by an appropriate dependency function), because at low RF levels below limiting, a small change in receiver RF input level may result in a relatively large change in AF output. In the second measurement (well above limiting) the resulting change at in AF output will usually be relatively small and the uncertainty of the RF input signal therefore considered negligible.

6.2.2.2.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.3 Two signal measurements

6.2.2.3.1 Definition - In band

The in-band (co-channel) rejection is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due the presence of an unwanted modulated signal, both signals being at the nominal frequency of the receiver.

6.2.2.3.2 Definition - Out-of-band

The out-of-band (adjacent channel) selectivity is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted signal which differs in frequency from the wanted signal by an amount equal to the adjacent channel separation for which the equipment is intended.

6.2.2.3.3 Analogue speech

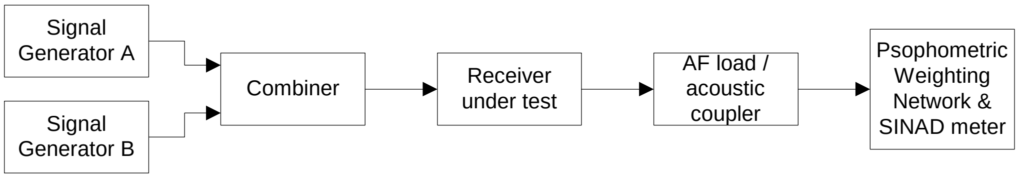

Figure 18: Measurement arrangement

6.2.2.3.3.1 In band

6.2.2.3.3.1.1 Test procedure

a) connect the two input signals to the receiver via a combining network, as shown in figure 18.

b) the wanted test signal, at the nominal frequency of the receiver, with normal test modulation (see clause A.2), at an e.m.f. of 6 dBμV, value of the limit for the maximum usable sensitivity, is then applied to the receiver input via one input of the combining network.

c) the unwanted test signal, at the nominal frequency of the receiver, modulated with a frequency of 400 Hz at a deviation of 60 % of the maximum permissible frequency deviation (see clause 6.2.1.3) is then applied to the receiver input via the second input of the combining network.

d) the amplitude of the unwanted test signal should then be adjusted until the SND/ND ratio, psophometrically weighted, at the output of the receiver is reduced to 14 dB.

e) the measure of the co-channel rejection is the ratio in dB of the level of the unwanted test signal to the level of the wanted test signal at the receiver input for which the specified reduction in SND/ND ratio occurs. This ratio should be recorded.

f) repeat the measurement for displacements of the unwanted test signal of ±1 500 Hz and ±3 000 Hz.

g) the lowest value of the five measurement results recorded should then be recorded as the in-band (co-channel) rejection.

6.2.2.3.3.1.2 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.3.3.2 Out-of-band

6.2.2.3.3.2.1 Test procedure

a) connect the two input signals to the receiver via a combining network, as shown in figure 18.

b) the wanted test signal, at the nominal frequency of the receiver, with normal test modulation (see clause A.2), at an e.m.f. of 6 dBμV, value of the limit for the maximum usable sensitivity is then applied to the receiver input via one input of the combining network.

c) the unwanted test signal, at the frequency of one channel separation above the nominal frequency of the receiver, modulated with a frequency of 400 Hz at a deviation of 60 % of the maximum permissible frequency deviation (see clause 6.2.1.3) is then applied to the receiver input via the second input of the combining network.

d) the amplitude of the unwanted test signal should then be adjusted until the SND/ND ratio, psophometrically weighted, at the output of the receiver is reduced to 14 dB.

e) the measure of the adjacent channel selectivity is the ratio in dB of the level of the unwanted test signal to the level of the wanted test signal at the receiver input for which the specified reduction in SND/ND ratio occurs. This ratio should be recorded.

f) repeat the measurement with an unwanted signal at the frequency of the channel below that of the wanted signal.

g) record the two noted ratios as the upper and lower out-of-band (adjacent channel) selectivity.

h) repeat the measurements under extreme test conditions (see clause A.1), with the amplitude of the wanted test signal adjusted to an e.m.f. of 12 dBμV.

6.2.2.3.3.2.2 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.3.4 Bit stream

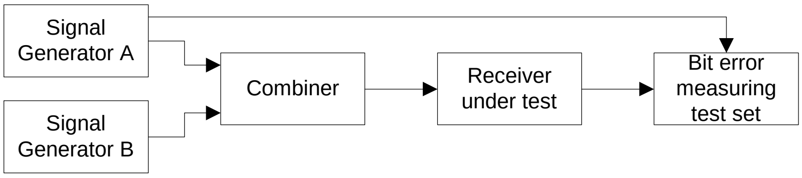

Figure 19: Measurement arrangement

6.2.2.3.4.1 In band

6.2.2.3.4.1.1 Test procedure

a) two signal generators, A and B, are connected to the receiver via a combining network as shown in figure 19:

- the wanted signal, from signal generator A, is modulated by the normal test signal D-M2 or D-M3, as appropriate (see clause A.2);
- the unwanted signal, provided by signal generator B, is modulated with signal A-M3 (see clause A.2);
- both input signals are provided at the nominal frequency of the receiver under test;

b) initially, signal generator B (unwanted signal) is switched off (maintaining the output impedance):

- with signal generator B off, adjust the level of the wanted signal from generator A to a level that is 3 dB above the level of the limit of the maximum usable sensitivity, at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions);

c) once the level from signal generator A has been adjusted, switch on signal generator B and adjust the level of the unwanted signal until a bit error ratio of 10^{-1} or worse is obtained;

d) transmit the normal test signal D-M2 (see clause A.2) and observe the bit error ratio;

e) reduce the level of the unwanted signal in steps of 1 dB until a bit error ratio of 10^{-2} or better is obtained. Then record the level of the unwanted signal;

f) record for each frequency of the unwanted signal, the in-band (co-channel) rejection ratio. Where this expressed as the ratio, in dB, of the level of the unwanted signal to the level of the wanted signal, at the receiver input.

g) repeat the measurement for displacements of the unwanted test signal of ±12 % of the channel separation;

h) the in-band (co-channel) rejection ratio of the equipment under test is expressed as the lowest of the three values expressed in dB, recorded in step f):

- the value of the in-band (co-channel) rejection ratio, expressed in dB, is generally negative (therefore, for example, -12 dB is lower than -8 dB).

6.2.2.3.4.1.2 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.3.4.2 Out-of-band

6.2.2.3.4.2.1 Test procedure

a) two signal generators, A and B, are connected to the receiver via a combining network as shown in figure 19:

- the wanted signal, from signal generator A, is modulated by the normal test signal D-M2 or D-M5, as appropriate (see clause A.2);

- the unwanted signal, provided by signal generator B, is modulated with signal A-M3 (see clause A.2);
- both input signals are provided at the nominal frequency of the receiver under test;

b) initially, signal generator B (unwanted signal) is switched off (maintaining the output impedance);

- with signal generator B off, adjust the level of the wanted signal from generator A to a level that is 3 dB above the level of the limit of the maximum usable sensitivity, at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions);

c) once the level from signal generator A has been adjusted, switch on signal generator B and adjust the level of the unwanted signal until a bit error ratio of 10^{-1} or worse is obtained;

d) transmit the normal test signal D-M2 (see clause A.2) and observe the bit error ratio;

e) reduce the level of the unwanted signal in steps of 1 dB until a bit error ratio of 10^{-2} or better is obtained. Then record the level of the unwanted signal;

f) record for each adjacent channel, the selectivity is expressed as the ratio, in dB, of the level of the unwanted signal to the level of the wanted signal, at the receiver input;

g) repeat the measurement with the unwanted signal at the frequency of the channel below that of the wanted signal;

h) the out-of-band (adjacent channel) selectivity of the equipment under test is expressed as the lower of the two values measured in the upper and lower channels nearest to the receiving channel (see step f) above);

j) repeat the measurements under extreme test conditions (see clause A.1), using the level of the wanted signal increased by 6 dB.

6.2.2.3.4.2.2 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.3.5 Messages

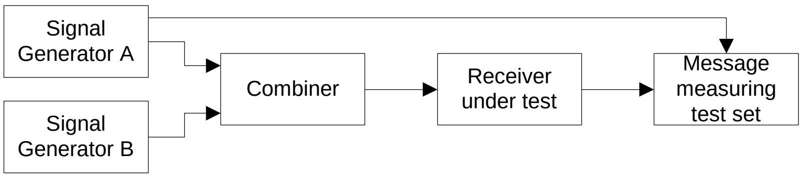

Figure 20: Measurement arrangement

6.2.2.3.5.1 In band

6.2.2.3.5.1.1 Test procedure

a) two signal generators, A and B, are connected to the receiver via a combining network as shown in figure 20:

- the wanted signal, from signal generator A, is modulated by the normal test signal (see clause A.2);
- the unwanted signal, provided by signal generator B, is modulated with signal A-M3 (see clause A.2);
- both input signals are provided at the nominal frequency of the receiver under test;

b) initially, signal generator B (unwanted signal) is switched off (maintaining the output impedance):

- with signal generator B off, adjust the level of the wanted signal from generator A to a level that is 3 dB above the level of the limit of the maximum usable sensitivity, at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions);

c) once the level from signal generator A has been adjusted, switch on signal generator B and adjust the level of the unwanted signal until a successful message ratio of less than 10 % is obtained;

d) transmit the normal test signal (see clause A.2) repeatedly whilst observing in each case whether or not a message is successfully received:

- for each occasion that a message is not successfully received reduce the level of the unwanted signal by 2 dB;

- repeat the procedure until three consecutive messages are successfully received. Then record the level of the input signal;

e) increase the level of the unwanted signal by 1 dB and record the new value:

- transmit the normal test signal (see clause A.2) 20 times. In each case, if a message is not successfully received reduce the level of the unwanted signal by 1 dB and record the new value;

- if a message is received successfully, then the level of the unwanted signal should remain unchanged until three consecutive messages have been received successfully. Only when there has been three consecutive messages received successfully should the unwanted signal be increased by 1 dB and the new value noted;

- no level of the unwanted signal level should be noted unless preceded by a change in level;

- record the average of the values noted in steps d) and e) (which provides the level corresponding to the successful message ratio of 80 %);

f) record for each frequency of the unwanted signal, the in-band (co-channel) rejection ratio expressed as the ratio, in dB, of the average level noted in step e) to the level of the wanted signal, at the receiver input.

g) repeat the measurement for displacements of the unwanted test signal of ±12 % of the channel separation;

h) the in-band (co-channel) rejection ratio of the equipment under test is expressed as the lowest of the three values expressed in dB, recorded in step f):

- the value of the in-band (co-channel) rejection ratio, expressed in dB, is generally negative (therefore, for example, -12 dB is lower than -8 dB).

6.2.2.3.5.1.2 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.3.5.2 Out-of-band

6.2.2.3.5.2.1 Test procedure

a) two signal generators, A and B, are connected to the receiver via a combining network as shown in figure 20:

- the wanted signal, from signal generator A, is provided at the nominal frequency of the receiver under test and modulated by the normal test signal (see clause A.2);

- the unwanted signal, provided by signal generator B, is provided be at the frequency of the channel immediately above that of the wanted signal and modulated with signal A-M3 (see clause A.2);

b) initially, signal generator B (unwanted signal) is switched off (maintaining the output impedance):

- with signal generator B off, adjust the level of the wanted signal from generator A to a level that is 3 dB above the level of the limit of the maximum usable sensitivity, at the receiver input terminals (i.e. 6 dB above 1 μV emf under normal test conditions);

c) once the level from signal generator A has been adjusted, switch on signal generator B and adjust the level of the unwanted signal until a successful message ratio of less than 10 % is obtained;

d) transmit the normal test signal (see clause A.2) repeatedly whilst observing in each case whether or not a message is successfully received:

   - for each occasion that a message is not successfully received reduce the level of the unwanted signal by 2 dB;

   - repeat the procedure until three consecutive messages are successfully received. Then record the level of the input signal;

e) increase the level of the unwanted signal by 1 dB and record the new value:

   - transmit the normal test signal (see clause A.2) 20 times. In each case, if a message is not successfully received reduce the level of the unwanted signal by 1 dB and record the new value;

   - if a message is received successfully, then the level of the unwanted signal should remain unchanged until three consecutive messages have been received successfully. Only when there has been three consecutive messages received successfully should the unwanted signal be increased by 1 dB and the new value noted;

   - no level of the unwanted signal level should be noted unless preceded by a change in level;

   - record the average of the values noted in steps d) and e) (which provides the level corresponding to the successful message ratio of 80 %);

f) record for each adjacent channel, the out-of-band selectivity expressed as the ratio, in dB, of the average level noted in step e) to the level of the wanted signal, at the receiver input.

g) repeat the measurement with the unwanted signal at the frequency of the channel below that of the wanted signal;

h) the adjacent channel selectivity of the equipment under test is expressed as the lower of the two values measured in the upper and lower adjacent channel nearest to the receiving channel (see step f) above);

i) repeat the measurement under extreme test conditions (see clause A.1), using the level of the wanted signal increased by 6 dB.

6.2.2.3.5.2.2 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.4 Intermodulation immunity

6.2.2.4.1 Analogue speech

6.2.2.4.1.1 Definition

The intermodulation immunity for analogue speech is a measure of the capability of a receiver to receive a wanted modulated signal at the nominal frequency without exceeding a given degradation due to the presence of two or more unwanted signals with a specific frequency relationship to the wanted signal frequency.

For the purpose of this measurement it is specified as the ratio in decibels of the common level of two equal unwanted signals to a specified level of the wanted signal at the receiver input, which produces through a psophometric weighting network a SINAD ratio of 14 dB.

6.2.2.4.1.2 Test procedure

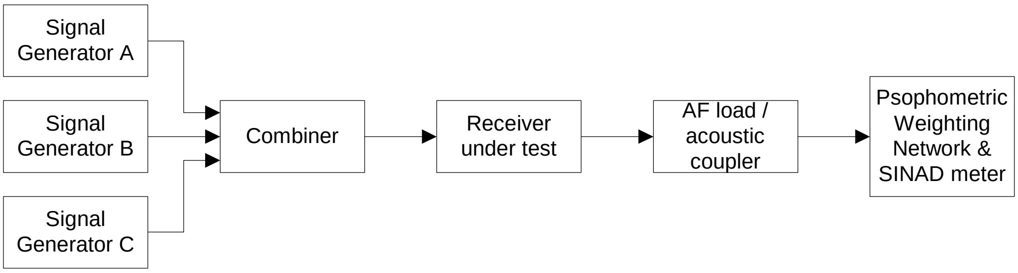

Figure 21: Measurement arrangement

a) Three signal generators, A, B and C are connected to the receiver via a combining network. The wanted signal, represented by signal generator A, is set at the nominal frequency of the receiver and modulated with test modulation A-M1 (see clause A.2). The unwanted signal, represented by signal generator B, is unmodulated and adjusted to the frequency 50 kHz above the nominal frequency of the receiver. The second unwanted signal, represented by signal generator C, is modulated with test modulation A-M3 (see clause A.2) and adjusted to a frequency 100 kHz above the nominal frequency of the receiver.

b) Initially the unwanted signals are switched off and the amplitude of signal generator A is adjusted to the wanted signal level when measured at the receiver input.

c) The two unwanted signals are then be switched on. The amplitude of the two unwanted signals is maintained equal and adjusted until the SINAD ratio, through a psophometric weighting network is reduced to 14 dB. The frequency of signal generator B is adjusted to produce the maximum degradation of the SINAD ratio. The level of the two unwanted test signals is readjusted to restore the SINAD ratio of 14 dB. This level is recorded.

d) The intermodulation immunity for analogue speech is recorded as the ratio in dB of the level of the unwanted signals recorded in step (c) to the level of the wanted signal.

e) The measurements are repeated with the unwanted signal generator B at the frequency 50 kHz below that of the wanted signal and the frequency of the unwanted signal generator C at the frequency 100 kHz below that of the wanted signal.

6.2.2.4.1.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.4.2 Intermodulation immunity for bit stream

6.2.2.4.2.1 Definition

The intermodulation immunity for bit stream is a measure of the capability of a receiver to receive a wanted modulated signal at the nominal frequency without exceeding a given degradation due to the presence of two or more unwanted signals with a specific frequency relationship to the wanted signal frequency.

For the purpose of this measurement it is specified as the ratio in decibels of the common level of two equal unwanted signals to a specified level of the wanted signal at the receiver input for which the bit error ratio is 10^{-2} or as specified in the equipment product specification.

6.2.2.4.2.2 Test procedure

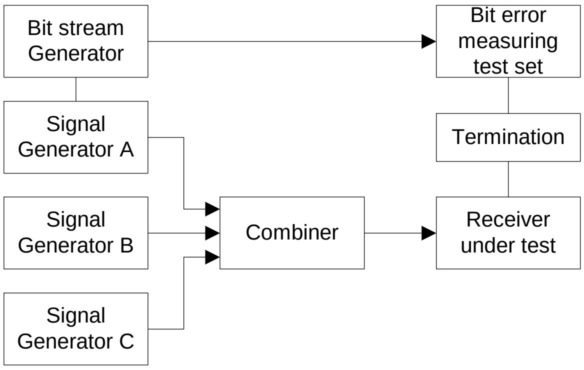

Figure 22: Measurement arrangement

a) Three signal generators, A, B and C are connected to the receiver via a combining network. The wanted signal, represented by signal generator A, is set at the nominal frequency of the receiver and modulated with test modulation D-M2 (see clause A.2). The unwanted signal, represented by signal generator B, is unmodulated and adjusted to the frequency 50 kHz above the nominal frequency of the receiver. The second unwanted signal, represented by signal generator C, modulated with test modulation A-M3 (see clause A.2) and adjusted to a frequency 100 kHz above the nominal frequency of the receiver.

b) Initially signal generators B and C are switched off and the amplitude of signal generator A adjusted to the wanted signal level when measured at the receiver input.

c) Signal generators B and C are then switched on. The output levels of the two signal generators are maintained equal and adjusted to a value such that a bit error ratio of about 10^{-1} is obtained.

d) The wanted signal is then transmitted whilst observing the bit error ratio. The level of the unwanted signals is reduced in steps of 1 dB until a bit error ratio of 10^{-2} or better is obtained (or as specified in the equipment product specification). This level is recorded.

e) The intermodulation immunity for bit stream is recorded as the ratio in dB of the level of the unwanted signals recorded in step (d) to the level of the wanted signal.

f) The measurement is repeated with the unwanted signal generator B at the frequency 50 kHz below that of the wanted signal and the frequency of the unwanted signal generator C at the frequency 100 kHz below that of the wanted signal.

6.2.2.4.2.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.4.3 Messages

6.2.2.4.3.1 Definition

The intermodulation immunity for messages is a measure of the capability of a receiver to receive a wanted signal at the nominal frequency modulated by a test signal without exceeding a given degradation due to the presence of two or more unwanted signals with a specific frequency relationship to the wanted signal frequency.

For the purpose of this measurement it is specified as the ratio in decibels of the common level of two equal unwanted signals to a specified level of the wanted signal at the receiver input, for which the message acceptance ratio is 80 %.

6.2.2.4.3.2 Test procedure

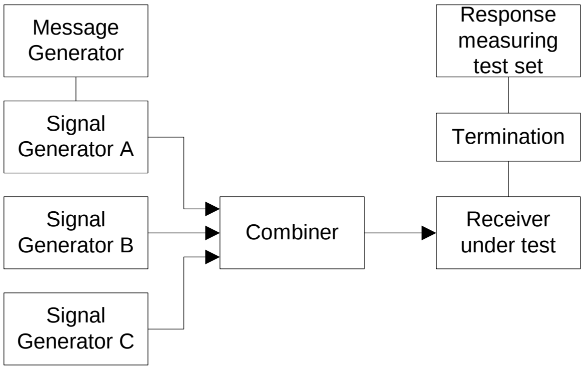

Figure 23: Measurement arrangement

a) Three signal generators, A, B and C are connected to the receiver via a combining network. The wanted signal, represented by signal generator A, is set at the nominal frequency of the receiver and modulated with test modulation D-M3 (see clause A.2). The unwanted signal, represented by the signal generator B, is unmodulated and adjusted to the frequency 50 kHz above the nominal frequency of the receiver. The second unwanted signal, represented by the signal generator C, is modulated with test modulation A-M3 (see clause A.2) and adjusted to a frequency 100 kHz above the nominal frequency.

b) Initially signal generators B and C are switched off and the amplitude of signal generator A adjusted to the wanted signal level when measured at the receiver input.

c) The wanted signal is then transmitted repeatedly and signal generators B and C switched on. The output levels of the two signal generators are maintained at equal amplitude and adjusted to a value such that a successful message ratio of less then 10 % is obtained.

d) The levels of the unwanted signals are reduced by 2 dB for each occasion that a successful response is not observed. The procedure is continued until three consecutive successful responses are observed. The level of the input signal is recorded.

e) The unwanted input signals are then increased by 1 dB and the new value recorded. The wanted signal is then continuously repeated. In each case if a response is not obtained the level of the unwanted signals is reduced by 1 dB and the new value recorded. If a successful response is obtained, the level of the unwanted signals is not changed until three consecutive successful responses have been obtained. In this case the unwanted signals are increased by 1 dB and the new value recorded. No levels of the unwanted signals are recorded unless preceded by a change in level. The measurement is stopped after a total of 10 values have been recorded.

f) The intermodulation immunity for messages is recorded as the ratio in dB of the average of the levels of the unwanted signals recorded in steps d) and e) to the level of the wanted input signal.

g) The measurements are repeated with the unwanted signal generator B at the frequency 50 kHz below that of the wanted signal and the frequency of the unwanted signal generator C at the frequency 100 kHz below that of the wanted signal.

6.2.2.4.3.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.5 Spurious emissions

6.2.2.5.1 Definition

Conducted spurious components are discrete radio frequency signals conveyed from the antenna socket by conduction to the test load.

They are specified as the power level of any discrete signal delivered into a test load within the specified frequency range.

6.2.2.5.2 Test procedure

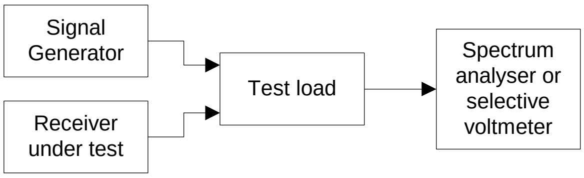

Figure 24: Measurement arrangement

A test load may be used to protect the spectrum analyser or selective voltmeter against damage when testing a receiver combined in one unit with a transmitter.

The spectrum analyser or selective voltmeter used has to have sufficient dynamic range and sensitivity to achieve the required measurement accuracy at the specified limit.

a) The receiver input terminals are connected to a spectrum analyser or selective voltmeter having an input impedance of 50 Ω and the receiver is switched on.

b) The frequency of the spectrum analyser or selective voltmeter is adjusted over the specified frequency range. The frequency and the absolute power level of each of the spurious components found are recorded.

c) If the detecting device is not calibrated in terms of power input, the level of any detected components may be determined by replacing the receiver by the signal generator and adjusting it to reproduce the frequency and level of every spurious component recorded in step b). The absolute power level of each spurious component is recorded.

6.2.2.5.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.6 Blocking immunity or desensitization

6.2.2.6.1 Analogue speech

6.2.2.6.1.1 Definition

Blocking immunity or desensitization for analogue speech is a measure of the capability of the receiver to receive the wanted modulated signal at the nominal frequency without exceeding a given degradation due to the presence of an unwanted unmodulated high input signal.

It is specified as the ratio in decibels of the level of the unwanted signal to a specified level of the wanted signal at the receiver input, which produces through a psophometric weighting network either a SINAD ratio of 14 dB (blocking immunity) or a power reduction of 3 dB in the receiver audio output power (desensitization).

6.2.2.6.1.2 Test procedure

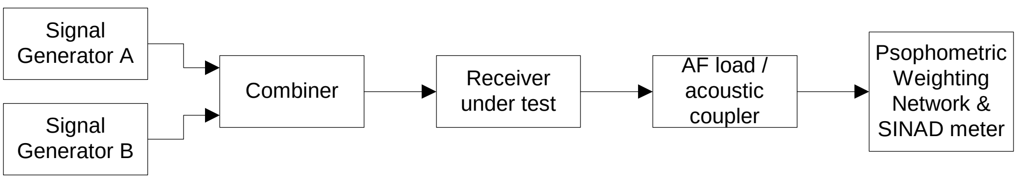

Figure 25: Measurement arrangement

a) Two signal generators A and B are connected to the receiver input via a combining network. The wanted signal, represented by signal generator A, is set at the nominal frequency of the receiver and modulated with test modulation A-M1 (see clause A.2).

b) Initially the unwanted signal, represented by signal generator B, is switched off and the amplitude of signal generator A adjusted to the wanted signal level when measured at the receiver input.

c) The unwanted signal is unmodulated. Its frequency is set at least 1 MHz away from the carrier frequency and its amplitude level increased until a reduction in the receiver output power or a reduction of the SINAD ratio at the receiver output is observed.

d) Maintaining the amplitude level constant the frequency of the unwanted signal is varied between +1 MHz and +10 MHz, also between -1 MHz and -10 MHz relative to the nominal frequency of the receiver. However for practical reasons the measurements are carried out at certain frequencies of the unwanted signal at approximately ±1 MHz, ±2 MHz, ±5 MHz and ±10 MHz relative to the nominal frequency of the receiver. The frequency at which the greatest degradation occurs is recorded taking care to be sure that it is not a receiver spurious response.

e) The amplitude level of the unwanted signal is then adjusted to give:

   a) a reduction of 3 dB in the receiver audio output power; or

   b) a reduction to 14 dB of the SINAD ratio at the receiver output;

   whichever occurs first. This level is recorded.

f) The blocking ratio for analogue speech is recorded as the ratio in dB between the level of the unwanted signal to the level of the wanted signal, at the receiver input.

6.2.2.6.1.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.6.2 Bit stream

6.2.2.6.2.1 Definition

Blocking immunity for bit stream is a measure of the capability of the receiver to receive the wanted modulated signal at the nominal frequency without exceeding a given degradation due to the presence of an unwanted unmodulated high input signal.

It is specified as the ratio in decibels of the level of the unwanted signal to a specified level of the wanted signal at the receiver input for which the bit error ratio is 10^{-2} or as specified in the equipment product specification.

6.2.2.6.2.2 Test procedure

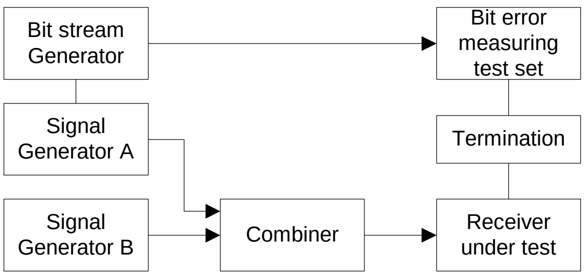

Figure 26: Measurement arrangement

a) Two signal generators A and B are connected to the receiver input via a combining network. The wanted signal, represented by signal generator A, is set at the nominal frequency of the receiver and modulated with test modulation D-M2 (see clause A.2).

b) Initially the unwanted signal, represented by the signal generator B, is switched off and the amplitude level of signal generator A adjusted to the wanted signal level when measured at the receiver input.

c) The unwanted signal is unmodulated and its frequency varied between +1 MHz and +10 MHz, also between -1 MHz and -10 MHz relative to the nominal frequency of the receiver. However for practical reasons the measurements are carried out at certain frequencies of the unwanted signal at approximately ±1 MHz, ±2 MHz, ±5 MHz and ±10 MHz. The selection of the measurement frequency is determined by the absence of any detected spurious response. The level of the unwanted signal is adjusted until a bit error ratio of less then 10^{-1} is obtained.

d) The wanted signal is then transmitted to the receiver whilst observing the bit error ratio. The amplitude level of the unwanted signal is reduced in steps of 1 dB until a bit error ratio of 10^{-2} or better is obtained (or as specified in the equipment product specification). The amplitude level of the unwanted signal is recorded at each test frequency.

e) The blocking level for bit stream is recorded as the lower value of the ratios in dB of the level of the unwanted signal to the level of the wanted signal, at the receiver input.

6.2.2.6.2.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.6.3 Messages

6.2.2.6.3.1 Definition

Blocking immunity for messages is a measure of the capability of the receiver to receive the wanted modulated signal at the nominal frequency without exceeding a given degradation due to the presence of an unwanted unmodulated high input signal.

It is specified as the ratio in decibels of the level of the unwanted signal to a specified level of the wanted signal at the receiver input for which the message acceptance ratio is 80 %.

6.2.2.6.3.2 Test procedure

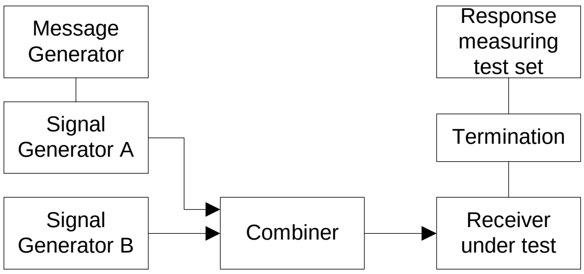

Figure 27: Measurement arrangement

a) Two signal generators A and B are connected to the receiver input via a combining network. The wanted signal, represented by signal generator A, is set at the nominal frequency of the receiver and modulated by test modulation D-M3 (see clause A.2).

b) Initially the unwanted signal, represented by the signal generator B, is switched off and the amplitude level of signal generator A adjusted to the wanted signal level when measured at the receiver input.

c) The wanted signal is transmitted repeatedly and the signal generator B is switched on. The unwanted signal is unmodulated and its frequency selected in the range +1 MHz ± 10 % relative to the nominal frequency of the receiver. The frequency selected is one at which no spurious response has been detected. The level of the unwanted signal is be adjusted until a successful message ratio of less than 10 % is obtained.

d) The level of the unwanted signal is reduced by 2 dB for each occasion that a successful response is not observed. The procedure is continued until three consecutive successful responses are observed. The level of the input signal is then recorded.

e) The unwanted input signal is then increased by 1 dB and the new value recorded. The wanted signal is then continuously repeated. In each case, if a response is not obtained, the level of the unwanted signal is reduced by 1 dB and the new value recorded. If a successful response is obtained, the level of the unwanted signal is not changed until three consecutive successful responses have been obtained. In this case the unwanted signal is increased by 1 dB and the new value recorded. No level of the unwanted signal is recorded unless preceded by a change in level. The measurement is stopped after a total of 10 values have been recorded.

f) Repeat the measurements for frequency of the unwanted signal selected in the range -1 MHz ± 10 % relative to the nominal frequency of the receiver.

g) The blocking level for messages is recorded as the lower value of the ratios in dB, of the two measurements above, of the average of the levels of the unwanted signal recorded in steps d) and e) to the level of the wanted signal.

6.2.2.6.3.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.7 Spurious response immunity

6.2.2.7.1 Analogue speech

6.2.2.7.1.1 Definition

The spurious response immunity for analogue speech is a measure of the capability of the receiver to discriminate between the wanted modulated signal at the nominal frequency and an unwanted signal at any other frequency at which a response is obtained.

It is specified as the ratio in decibels of the level of the unwanted signal to the level of the wanted signal at the receiver input, which produces through a psophometric weighting network a SINAD ratio of 14 dB.

6.2.2.7.1.2 Test procedure

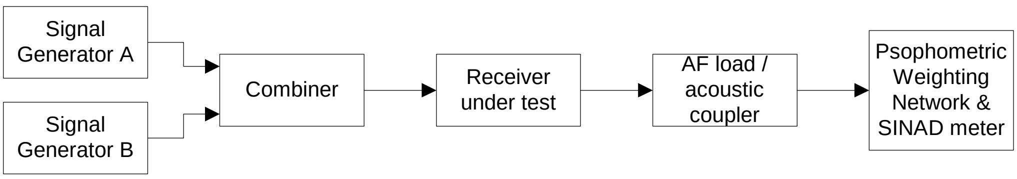

Figure 28: Measurement arrangement

a) Two signal generators A and B are connected to the receiver input via a combining network. The wanted signal, represented by signal generator A, is set at the nominal frequency of the receiver and is modulated with test modulation A-M1 (see clause A.2). The unwanted signal, represented by signal generator B, is modulated with test modulation A-M3 (see clause A.2).

b) Initially the unwanted signal is switched off and the amplitude of signal generator A adjusted to the wanted signal level when measured at the receiver input. The unwanted signal is then be switched on and its level adjusted to level which is 80 db in excess of the wanted signal level, when measured at the receiver input. The frequency of the unwanted signal is then varied over the specified limited frequency range plus other frequencies within the full specified frequency range at which it is calculated that a spurious response could occur. The frequencies of all responses are to be noted.

c) At any frequency at which a response is obtained, the unwanted signal level is adjusted until the SINAD ratio through a psophometric weighting network is reduced to 14 dB.

d) The spurious response immunity ratio for analogue speech is recorded for the frequency concerned as the ratio in dB between the unwanted signal and the wanted signal at the receiver input.

6.2.2.7.1.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.7.2 Bit stream

6.2.2.7.2.1 Definition

The spurious response immunity for bit stream is a measure of the capability of the receiver to discriminate between the wanted modulated signal at the nominal frequency and an unwanted signal at any other frequency at which a response is obtained.

It is specified as the ratio in decibels of the level of the unwanted signal to a specified level of the wanted signal at the receiver input for which the bit error ratio is 10^{-2}.

6.2.2.7.2.2 Test procedure

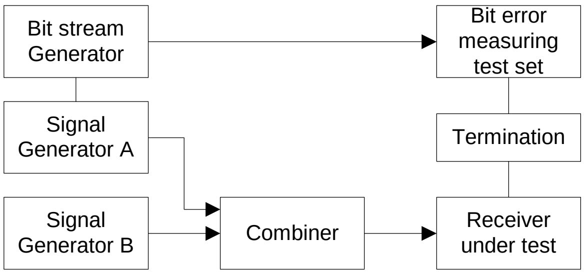

Figure 29: Measurement arrangement

a) Two signal generators A and B are connected to the receiver input via a combining network. The wanted signal, represented by signal generator A, is set at the nominal frequency of the receiver and is modulated with test modulation D-M2 (see clause A.2). The unwanted signal, represented by signal generator B, is modulated with test modulation A-M3 (see clause A.2) and adjusted to a frequency within the specified frequency range at which it is calculated that a spurious response could occur.

b) Initially signal generator B is switched off. The amplitude of signal generator A is adjusted to the wanted signal level when measured at the receiver input.

c) The unwanted signal is then switched on, and the input level adjusted until a bit error ratio of about 10^{-1} is obtained.

d) The wanted signal is then transmitted whilst observing the bit error ratio. The level of the unwanted signal is reduced in steps of 1 dB until a bit error ratio of 10^{-2} or better is obtained. The level of the unwanted signal is then recorded.

e) The measurement is repeated at each frequency within the specified frequency range at which it is calculated that a spurious response could occur.

f) The spurious response immunity for bit stream should be recorded for the frequency concerned as the ratio in dB of the level of the unwanted signal to the level of the wanted signal at the receiver input.

6.2.2.7.2.3 Maximum allowable measurement uncertainty

Use the maximum allowable measurement uncertainty as stated in the product standard.

6.2.2.7.3 Messages

6.2.2.7.3.1 Definition

The spurious response immunity for messages is a measure of the capability of the receiver to discriminate between the wanted signal modulated by a test signal at the nominal frequency and an unwanted signal at any other frequency at which a response is obtained.

It is specified as the ratio in decibels of the level of the unwanted signal to a specified level of the wanted signal at the receiver input for which the message acceptance ratio is 80 %.

6.2.2.7.3.2 Test procedure

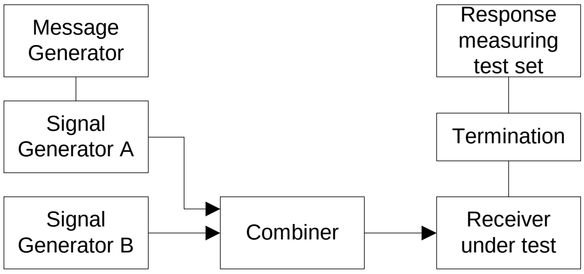

Figure 30: Measurement arrangement

a) Two signal generators, A and B are connected to the receiver via a combining network. The wanted signal, represented by signal generator A, is set at the nominal frequency of the receiver and modulated with test modulation D-M3 (see clause A.2). The unwanted signal, represented by signal generator B, is modulated with test modulation A-M3 (see clause A.2) and adjusted to a frequency within the specified frequency range at which it is calculated that a spurious response could occur.

b) Initially signal generator B is switched off. The amplitude of signal generator A is adjusted to the wanted signal level when measured at the receiver input.

c) The wanted signal is then transmitted repeatedly and the signal generator B is switched on. The input level of the unwanted signal is adjusted until a successful message ratio of less than 10 % is obtained.

d) The level of the unwanted signal is reduced by 2 dB for each occasion that a successful response is not observed. The procedure is continued until three consecutive successful responses are observed. The level of the input signal is then recorded.

e) The unwanted input signal is then increased by 1 dB and the new value recorded. The wanted signal is then continuously repeated. In each case if a response is not obtained the level of the unwanted signal is reduced by 1 dB and the new value recorded. If a successful response is obtained, the level of the unwanted signal is not changed until three consecutive successful responses have been obtained. In this case the unwanted signal is increased by 1 dB and the new value recorded. No levels of the unwanted signal should be recorded unless preceded by a change in level. The measurement is stopped after a total of 10 values have been recorded.

f) The measurement is repeated at each frequency within the specified frequency range at which it is calculated that a spurious response could occur.

g) The spurious response immunity for messages is recorded for the frequency concerned as the ratio in dB of the average of the levels of the unwanted signal recorded in steps d) and e) to the level of the wanted signal at the receiver input.

6.2.2.7.3.3 Maximum allowable measurement uncertainty

Use the maximum allowable as stated in the product standard.

6.3 Aeronautical RF parameters

See clause 5.4.

6.4 Satellite system RF parameters

See clause 5.5.

6.5 Fixed radio links RF parameters

See clause 5.6.

6.6 Maritime equipment RF parameters

See clause 5.7.

6.7 Transport equipment RF parameters

See clause 5.8.

Annex A (informative): Test stimuli and environment definitions

A.1 Extreme test conditions

The extreme test conditions are defined in terms of temperature and supply voltage. Tests should be made with the extremes of temperature and voltage applied simultaneously. The upper and lower temperature limits are specified in the relevant ETSI standard. The test report should state the actual temperatures measured.

When extreme temperatures are applied to the equipment, provisions have to be made so that thermal balance has been reached and that condensation does not occur. Further details will be specified in the relevant base reference standard.

The extreme test voltage for equipment to be connected to an AC supply should be the nominal mains voltage ±10 %.

The extreme test voltages for equipment intended for use with lead acid batteries fitted on vehicles and charged from a regulator should be 0,9 and 1,3 times the nominal voltage of the battery.

The lower extreme test voltages for equipment with power sources using other types of batteries are as follows:

[1] For the Leclanché or lithium type of cell, 0,85 times the nominal voltage of the battery.

[2] For the mercury or nickel-cadmium type of cell, 0,9 times the nominal voltage of the battery.

[3] For other types of batteries, the end point voltage declared by the equipment manufacturer.

The upper extreme test voltage is the nominal voltage of the battery.

For equipment using other power sources, or capable of being operated from a variety of power sources, the extreme test voltages should be those agreed between the equipment manufacturer and the type testing authority and subsequently recorded with the results.

A.2 Test modulation

The test modulating signal is a baseband signal which modulates a carrier and is dependent upon the type of equipment under test and also the measurement to be performed.

Normal test modulation:

A modulation frequency of 1 kHz with a resulting frequency deviation of 60 % of the maximum permissible frequency deviation (see clause 6.2.1.3). The test signal should be substantially free from amplitude modulation.

Signals for analogue speech:

***A-M1*:** A 1 000 Hz tone at a level which produces a deviation of 12 % of the channel separation.

***A-M2*:** A 1 250 Hz tone at a level which produces a deviation of 12 % of the channel separation.

***A-M3*:** A 400 Hz tone at a level which produces a deviation of 12 % of the channel separation. This signal is used as an unwanted signal for analogue and digital measurements.

Signals for data (bit stream):

The level of deviation used in digital measurements is system and method dependent (sub-carrier or direct modulation) and should be agreed between the testing authority and the supplier. At no time should the level exceed 20 % of the channel separation.

***D-M0*:** A signal representing an infinite series of '0' bits.

***D-M1*:** A signal representing an infinite series of '1' bits.

D-M2**:** A signal representing a pseudorandom bit sequence of at least 511 bits in accordance with ITU-T Recommendation O.153 [22]. This sequence should be continuously repeated. This signal is used as a wanted signal. In the case of digital duplex measurements it is also used to modulate the transmitter but the sequence should start at a different time from the signal modulating the receiver.

Signals for data (messages):

D-M3**:** A test signal should be agreed between the testing authority and the manufacturer in the cases where it is not possible to measure a bit stream or if selective messages are used and are generated or decoded within an equipment. The agreed test signal may be formatted and may contain error detection and correction.

For test purposes if special equipment is required to generate or indicate correct acceptance of the messages then it should be supplied by the manufacturer.

Details of the test signal should be supplied in the test report.

A.3 Test load

The test load is a 50 Ω substantially non-reactive, non-radiating power attenuator which is capable of safely dissipating the power from the transmitter.

A.4 Trigger device

A trigger device is a circuit or mechanism to trigger the oscilloscope timebase at the required instant. It may control the transmit function or inversely receive an appropriate command from the transmitter.

Annex B (informative): Bibliography

- ETSI TR 100 028-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 1".
- ETSI TR 100 028-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 2".
- Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations (as amended).
- ETSI ETS 300 086 (1991): "Radio Equipment and Systems (RES); Land mobile group; Technical characteristics and test conditions for radio equipment with an internal or external RF connector intended primarily for analogue speech".
- ETSI EN 300 086-1 (V1.2.1): "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Land Mobile Service; Radio equipment with an internal or external RF connector intended primarily for analogue speech; Part 1: Technical characteristics and methods of measurement".
- ETSI EN 301 681 (V1.3.2): "Satellite Earth Stations and Systems (SES); Harmonized EN for Mobile Earth Stations (MESs) of Geostationary mobile satellite systems, including handheld earth stations, for Satellite Personal Communications Networks (S-PCN) in the 1,5/1,6 GHz bands under the Mobile Satellite Service (MSS) covering essential requirements under article 3.2 of the R&TTE Directive".

History

Document history		
V1.1.1	February 2006	Membership Approval Procedure MV 20060414: 2006-02-14 to 2006-04-14