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Methods of measurement of equipment used in terrestrial radio-relay systems - Part 1: Measurement common to sub-systems and simulated radio-relay systems

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METHODS OF MEASUREMENT FOR EQUIPMENT USED IN TERRESTRIAL RADIO-RELAY SYSTEMS PART 1: MEASUREMENTS COMMON TO SUB-SYSTEMS AND SIMULATED RADIO-RELAY SYSTEMS

Méthodes de mesure applicables au matériel utilisé dans les faisceaux hertziens terrestres
Première partie: Mesures communes aux sous-ensembles et aux liaisons simulées

Meßverfahren für Geräte in terrestrischen Richtfunksystemen
Teil 1: Gemeinsame Messungen an Untersystemen und simulierten Richtfunksystemen

BODY OF THE HD

The Harmonization Document consists of:

- IEC 487-1 (1984) ed 2; IEC/SC 12E, not appended

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The English and French versions of this Harmonization Document are provided by the text of the IEC publication and the German version is the official translation of the IEC text.

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to announce the existence of this Harmonization Document at national level
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to publish their new harmonized national standard
by or before 1987-09-15

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Méthodes de mesure applicables au matériel utilisé dans les faisceaux hertziens terrestres

Première partie:
Mesures communes aux sous-ensembles et aux liaisons simulées

Methods of measurement for equipment used in terrestrial radio-relay systems

Part 1:
Measurements common to sub-systems and simulated radio-relay systems

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

METHODS OF MEASUREMENT FOR EQUIPMENT USED IN TERRESTRIAL RADIO-RELAY SYSTEMS

Part 1: Measurements common to sub-systems and simulated radio-relay systems

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by Sub-Committee 12E: Microwave Systems, of IEC Technical Committee No. 12: Radiocommunications.

This second edition replaces the first edition of IEC Publication 487-1, IEC Publication 487-1A and IEC Publication 487-1-4.

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

Six Months' Rule	Report on Voting
12E(CO)89	12E(CO)105
12E(CO)92	12E(CO)106
12E(CO)93	12E(CO)100

Further information can be found in the relevant Reports on Voting indicated in the table above.

The following IEC publications are quoted in this standard:

Publications Nos.	68:	Basic Environmental Testing Procedures.
	68-1 (1982):	Part 1: General and Guidance.
	68-2-1 (1974):	Part 2: Tests — Tests A: Cold.
	68-2-2 (1974):	Tests B: Dry Heat.
	68-2-3 (1969):	Test Ca: Damp Heat, Steady State.
	76:	Power Transformers.
	84 (1957):	Recommendations for Mercury-arc Convertors.
	119 (1960):	Recommendations for Polycrystalline Semiconductor Rectifier Stacks and Equipment.
	215 (1978):	Safety Requirements for Radio Transmitting Equipment.
	487-2-4 (1984):	Part 2: Measurements for Sub-systems. Section Four — Frequency Modulators.
	487-2-5 (1984):	Part 2: Measurements for Sub-systems. Section Five — Frequency Demodulators.
	487-3 (1975):	Part 3: Simulated Systems.
	487-3-3 (1981):	Part 3: Simulated Systems. Section Three — Measurements for Monochrome and Colour Television Transmission.
C.I.S.P.R. Publication 16 (1977):		C.I.S.P.R. Specification for Radio Interference Measuring Apparatus and Measurement Methods.

METHODS OF MEASUREMENT FOR EQUIPMENT USED IN TERRESTRIAL RADIO-RELAY SYSTEMS

Part 1: Measurements common to sub-systems and simulated radio-relay systems

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SECTION ONE — GENERAL

1. Scope

The standard conditions of measurement and the methods of measuring the characteristics given in this standard are common to sub-systems of terrestrial line-of-sight radio-relay systems and to simulated radio-relay systems using frequency modulation. The tests described are limited to analogue transmission systems.

These test methods are general and are applicable to systems of large and small capacity, but it may be unnecessary to specify and to measure some of these characteristics for systems having a capacity of 60 telephone channels or less. The tests to be made should be agreed upon between the parties concerned.

Methods of measurement for parameters which are related to a specific baseband signal, such as frequency division multiplex telephony, television or sound-programme transmission, are given in the appropriate sections of IEC Publication 487-3: Methods of Measurement for Equipment Used in Terrestrial Radio-relay Systems, Part 3: Simulated Systems.

2. Object

The object of this standard is to standardize the conditions and methods of measurement to be used to ascertain the performance of terrestrial radio-relay systems and of the equipment used in such systems, and to facilitate the comparison of the results of measurements made by different observers. It contains details of selected methods of making measurements to enable the assessment of the essential properties of a terrestrial radio-relay system and of the equipment used in such systems. These methods are neither mandatory nor limiting; a choice of measurements can be made in each particular case. If necessary, additional measurements may be made but these should preferably be carried out in accordance with the standards laid down by other IEC Technical Committees or Sub-Committees or by other international bodies.

Limiting values of the various quantities for acceptable performance are not specified since these should be given in the detailed equipment specification.

The methods of measurement described in this standard are intended for "type" and "acceptance" tests and they may also be used for factory tests.

3. Terms and definitions

The methods of measurement described in this standard and in the other parts of this standard are preceded by the definition of the quantity to be measured, either in the relevant clause or in a separate clause in order to show the coherence between the various definitions.

As far as practicable, the definitions are in conformity with those given in the IEC International Electrotechnical Vocabulary (IEV), or used by other Technical Committees of the IEC and other international bodies. Where deviations exist, they appeared necessary for a better understanding of this standard.

3.1 *Detailed equipment specification*

Any document especially drawn up or provided, which describes the properties and the performance of an equipment under specified conditions of normal use, together with specified fault conditions which may arise.

Note. — For the general principles and the test methods to be followed to assess that the equipment conforms to the appropriate safety regulations under conditions of normal use and under specified fault conditions, reference should be made to IEC Publication 215: Safety Requirements for Radio Transmitting Equipment.

3.2 *Terrestrial radio-relay system*

For the purpose of this standard, the elements comprising a terrestrial radio-relay system are those shown in Figure 1, page 94.

3.3 *Type*

A type comprises products having similar design features and employing similar manufacturing techniques, and which fall within the manufacturer's usual range of characteristics.

Notes 1. — Mounting accessories can be ignored, provided that they have no significant effect on the test results.

2. — "Characteristics" cover the combinations of:
a) electrical ratings;
b) sizes;
c) behaviour under environmental stress.

3. — The list of characteristics and their limits should be agreed upon between purchaser and manufacturer.

3.4 *Type test*

The complete series of tests to be carried out on a number of specimens representative of the type, and which contribute to determining that a particular manufacturer can be considered capable of producing equipment meeting the specification.

3.5 *Type approval*

The decision by the proper authority, e.g. Government agency, the purchaser himself or his nominee, that a particular manufacturer can be considered capable of producing, in reasonable quantities, the type of equipment capable of meeting the specification.

3.6 *Acceptance tests*

Tests carried out to determine the acceptability of a consignment on the basis of an agreement between purchaser and manufacturer.

The agreement shall cover:

a) the size of the sample;

b) the selection of tests;

c) tolerances and exceptions.

Note. — When alternative test methods yield differing results, the preferred methods recommended by the IEC should be used.

3.7 *Factory tests*

Tests carried out by the manufacturer to ascertain whether his products meet the specification.

4. Conditions of measurement

Care shall be taken to avoid all conditions which may lead to the equipment being damaged.

Unless otherwise specified, the measurements shall be carried out under standard conditions with respect to power supply, temperature, air pressure, humidity and terminal load, as given below. After the equipment has been finally set up for these conditions, the settings shall be kept constant during all measurements, with the exception of those settings which must be varied before or during a specified measurement period.

5. Standard test conditions

5.1 *Standard conditions for the power supply*

Measurements under standard power supply conditions are carried out at the nominal voltage and the nominal frequency stated in the detailed equipment specification. The voltage shall be measured at the power supply terminals of the equipment under test.

During tests carried out on a sub-system or on a simulated system, the voltage and the frequency of the power supply shall not deviate from the nominal values by more than $\pm 2\%$, unless otherwise specified.

Unless otherwise specified, standard power supply conditions include the supplementary conditions given in Clause 6.

5.2 *Standard atmospheric conditions*

Measurements under standard atmospheric conditions are normally carried out in accordance with Sub-clause 5.2.1 below. If necessary, the results of the measurements should be corrected by calculation to the standard reference temperature of 20 °C and to the standard reference air pressure of 1.013×10^5 Pa (1 013 mbar) as explained in Sub-clause 5.2.2.

If this correction is not possible the measurements should be made at one of the standard referee conditions specified in Sub-clause 5.2.3 preferably at that corresponding to an ambient temperature of 20 ± 1 °C.

Note. — The standard atmospheric conditions stated in Sub-clauses 5.2.1, 5.2.2 and 5.2.3 are in conformity with those given in IEC Publication 68-1: Basic Environmental Testing Procedures, Part 1: General and Guidance.

5.2.1 *Standard testing conditions*

Measurements and mechanical tests, the results of which are either independent of temperature and air pressure, or can be corrected by calculation to the standard reference temperature and air pressure stated in Sub-clause 5.2.2, normally may be carried out under any existing combination of temperature, humidity and air pressure, provided they are within the following limits:

— temperature: +15 °C to +35 °C;
— relative humidity: 45% to 75%;
— air pressure: 8.6×10^4 Pa to 1.06×10^5 Pa (860 mbar to 1 060 mbar).

If the quantities to be measured depend on temperature, humidity and air pressure and the law of dependence is unknown, Sub-clause 5.2.3 applies.

5.2.2 *Standard reference conditions*

If the quantities to be measured depend on temperature and/or air pressure and the law of dependence is known, the values should be measured under the conditions given in Sub-clause 5.2.1 and, if necessary, corrected by calculation to the following reference values:

— temperature: +20 °C;
— air pressure: 1.013×10^5 Pa (1 013 mbar).

Note. — No requirements for relative humidity are given because correction by calculation is not generally possible.

5.2.3 *Standard referee conditions*

If the quantities to be measured depend on temperature, humidity and air pressure and the law of dependence is unknown, the measurement should be made, by mutual agreement, under one of the following sets of conditions:

Temperature	*Relative humidity*	*Air pressure*
+20 ± 1 °C	63% — 67%	8.6×10^4 Pa — 1.06×10^5 Pa (860 mbar — 1 060 mbar)
+23 ± 1 °C	48% — 52%	8.6×10^4 Pa — 1.06×10^5 Pa (860 mbar — 1 060 mbar)
+25 ± 1 °C	48% — 52%	8.6×10^4 Pa — 1.06×10^5 Pa (860 mbar — 1 060 mbar)
+27 ± 1 °C	63% — 67%	8.6×10^4 Pa — 1.06×10^5 Pa (860 mbar — 1 060 mbar)

Measurements at temperatures differing from the above table may be made by agreement between purchaser and manufacturer, in which case suitable limits for the characteristic values shall be agreed upon.

The test results shall give the actual value of temperature, relative humidity and air pressure during the measurements.

Note. — For large equipment or in test rooms where temperature, relative humidity and/or air pressure limits as indicated above are difficult to maintain, wider tolerances may be allowed, subject to mutual agreement. The actual values shall be given in the test results.

6. Supplementary conditions for the power supply

In addition to meeting the relevant sections of the equipment specification, the power supply used for testing the equipment shall be sufficiently stable so that no significant variations in the performance of the equipment under test will be introduced by changes in the characteristics of the power supply.

In general, the above conditions will be met if the power supply is in accordance with Sub-clauses 6.1 and 6.2.

6.1 *A.C. source conditions*

6.1.1 *Waveform and source impedance*

Unless otherwise specified, a substantially sinusoidal alternating voltage source of sufficiently low impedance to have negligible influence on the operation of the equipment shall be connected to the a.c. terminals of the equipment.

The waveform of a voltage is considered to be substantially sinusoidal if the largest deviation from the instantaneous value of the fundamental wave for any part of the curve does not exceed 5% of the amplitude of the fundamental wave ($a - b \leqslant 0.05\ c$; see Figure 2, page 95).

Notes 1. — These conditions are in accordance with IEC Publications 84: Recommendations for Mercury-arc Convertors, and 119: Recommendations for Polycrystalline Semiconductor Rectifier Stacks and Equipment.

2. — Where the ratio of the load to the short-circuit capacity of the a.c. supply is such that the source impedance is significant, the recommendations given in the appropriate parts of Clauses 443, 444, 445 and 446 of IEC Publication 84 should be observed.

6.1.2 *Symmetry of polyphase systems*

Polyphase supply sources shall be symmetrical with respect to voltages.

The polyphase system voltages are considered to be symmetrical if, with respect to the fundamental frequency, neither the negative sequence component nor the zero sequence component exceeds 1% of the positive sequence component when the equipment is in operation (see Figure 3, page 95).

If a polyphase system is not perfectly symmetrical but is within these limits, the arithmetic mean value of all phase-to-phase voltages shall be taken as the source voltage.

Note. — These conditions are in accordance with IEC Publications 84, 119 (see Sub-clause 6.1.1, Note 1) and 76: Power Transformers.

6.2 *D.C. source conditions*

Equipment intended for use in radio-relay systems may be powered from a d.c. source for test purposes. This d.c. source may be:

a) a battery, which may or may not be used on a floating charge;

b) a rectifier supply fed from a.c. mains (see Sub-clause 6.1).

The source used to obtain the d.c. test voltage should not be used to power other equipment during the test.

6.2.1 *Source impedance and polarity*

Unless otherwise specified, the d.c. source should have an internal impedance low enough to have negligible influence on the equipment under test.

One specified pole of the d.c. source should be earthed.

6.2.2 *Noise superimposed on the d.c. test voltage*

6.2.2.1 *General considerations*

Noise which arises in the d.c. source and is superimposed on the d.c. test voltage may affect the performance of the equipment under test. When equipment to be tested is connected to a d.c. source, the noise appearing on the d.c. test voltage may be introduced by the d.c. source itself or by the equipment under test. Only noise related to the d.c. source is of interest in defining the d.c. source conditions.

Noise present on the d.c. source may be of a relatively continuous nature or it may be transient, occurring sporadically. Both types of noise may be present simultaneously. Non-recurring transients (e.g., a transient caused by the opening of a fuse or a circuit-breaker) should be disregarded if no damage is caused to the equipment under test.

If other items of equipment are connected to the d.c. source simultaneously with the equipment under test, they could introduce noise on the d.c. test voltage. It is therefore desirable to avoid using the d.c. source to supply more than one item of equipment at a time.

When required, the level of the noise which arises in the d.c. source and is superimposed on the d.c. test voltage may be verified by substituting an equivalent passive load for the equipment under test and measuring the noise level across this load.

The following measurements apply only when a disagreement arises. In such a case, the maximum noise values shall be agreed upon between the parties concerned.

6.2.2.2 *Selective measurements of superimposed noise*

Measurements should be made as a function of frequency. A selective level meter or the C.I.S.P.R. measuring set may be used, as convenient.

One pole of the d.c. source should be earthed and the input of the selective level meter or C.I.S.P.R. measuring set should be connected to the other pole by means of a capacitor having series impedance which is less than one-tenth of the input impedance of the measuring instrument at the lowest frequency to be measured. The voltage rating of this capacitor should be that of the d.c. source plus an appropriate margin of safety.

The measuring instrument should be connected to the d.c. source using leads which are as short as possible, preferably using coaxial cable. Care needs to be taken to avoid short-circuiting the d.c. source.

The frequency range to be measured should include the entire baseband frequency of the equipment under test.

The bandwidth of the selective level meter or C.I.S.P.R. measuring set should be appropriate to the separation between the spectral lines of the noise to be measured. For frequencies up to about 10 kHz, a bandwidth of about 10 Hz is suitable, since spectral lines

separated by 50 Hz or 60 Hz may be present. For frequencies between 10 kHz and 150 kHz, a bandwidth of 200 Hz would be appropriate. For frequencies higher than 150 kHz, bandwidths between 500 Hz and 6 kHz may be used.

Note. — For details of the C.I.S.P.R. measurement methods, see C.I.S.P.R. Publication 16: C.I.S.P.R. Specification for Radio Interference Measuring Apparatus and Measurement Methods.

6.2.2.3 *Wideband measurements of superimposed noise*

Measurements should be made using a wideband oscilloscope having a bandwidth equal to at least twice the baseband bandwidth. The peak-to-peak value of the superimposed noise voltage should be expressed as a percentage of the nominal value of the d.c. voltage (e.g. 2%).

7. Measurements under conditions deviating from standard test conditions

If required, the performance characteristics of the equipment may be determined during or after a period within which the equipment is subjected to conditions differing from the standard test conditions specified in Clause 5.

In such cases, the acceptable degradation in performance and the conditions under which the tests should be made (preferably in accordance with those of the following sub-clauses which are relevant) shall be given in the detailed equipment specification.

7.1 *Initial measurements under standard test conditions*

The performance characteristics shall first be evaluated under standard test conditions (see Clause 5).

As these characteristics may depend on temperature and humidity and the law of dependence is generally unknown, the measurements should be made at one of the standard referee conditions specified in Sub-clause 5.2.3, preferably at that corresponding to an ambient temperature of $+20 \pm 1$ °C.

7.2 *Variation of power supply voltage within the specified range*

7.2.1 *Definition*

The power supply voltage range is the range of voltages over which the equipment should operate with a specified performance.

7.2.2 *Test conditions*

The equipment shall be operated under standard atmospheric conditions (see Sub-clause 5.2) and standard power supply conditions (see Sub-clause 5.1), except for the voltage which shall be subsequently adjusted to the maximum and to the minimum values stated in the detailed equipment specification.

Care shall be taken to ensure that the measurement is made after thermal equilibrium has been reached.

7.3 *Variation of ambient temperature within the specified temperature range*

7.3.1 *Definition*

The term "temperature range" refers to the range of ambient temperatures over which the equipment should operate with a specified performance.

7.3.2 *Test conditions*

The equipment shall be operated under standard power supply conditions and the temperature shall be raised and lowered to the maximum and minimum values specified in the detailed equipment specification, in accordance with the provisions of IEC Publication 68-2-2: Basic Environmental Testing Procedures, Part 2: Tests — Tests B: Dry Heat, and if necessary IEC Publication 68-2-1: Tests A: Cold.

7.4 *Humidity*

When tests under specified conditions of humidity are required, they should be carried out under the conditions specified in IEC Publication 68-2-3: Test Ca: Damp Heat, Steady State.

7.5 *Other environmental conditions*

When, by mutual agreement, the performance of the equipment is to be determined under conditions other than those stated in the preceding sub-clauses, e.g. vibration, shock, dust and/or sand, etc., the measurements may be made during and/or after exposing the equipment to the agreed conditions selected from the appropriate parts of IEC Publication 68: Basic Environmental Testing Procedures.

SECTION TWO — MEASUREMENTS IN THE RADIO-FREQUENCY RANGE

8. General

It is not possible to describe fully the precautions necessary to obtain quantitative results of acceptable accuracy for all possible cases which may be covered by the types of measurements described below, but attention is drawn to the following cases of general interest.

The possible presence of spurious signals, including harmonics, at the ports where the test signals are applied should not be overlooked. These spurious signals could disturb the operation of the test equipment itself or the simulated system or sub-system under test. Consideration should be given to the removal of undesired signals at the test ports because, although their amplitudes may be insufficient to affect the test arrangement, they may modify the r.f. characteristics to be measured—for example by the generation of heat.