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Methods of measurement for radio transmitters
Part 1: General conditions of measurement,
frequency, output power and power consumption
First supplement: Appendices

Méthodes de mesure applicables aux
émetteurs radioélectriques
Première partie: Conditions
générales de mesure, fréquence,
puissance de sortie et puissance
consommée
Premier complément: Annexes

Meßverfahren für
Funksender
Teil 1: Allgemeine Bedingungen für
Messungen, Frequenzen,
Ausgangsleistung und
Leistungsverbrauch
Erste Ergänzung:

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

(affiliée à l'Organisation Internationale de Normalisation — ISO)

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(affiliated to the International Organization for Standardization — ISO)

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Première partie: Conditions générales de mesure, fréquence, puissance de sortie
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Part 1: General conditions of measurement, frequency, output power and power consumption



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

METHODS OF MEASUREMENT FOR RADIO TRANSMITTERS

Part 1: General conditions of measurement, frequency, output power and power consumption

FOREWORD

- 1) The formal decisions or agreements of the I E C 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 this international unification, the I E C expresses the wish that all National Committees having as yet no national rules, when preparing such rules, should use the I E C recommendations as the fundamental basis for these rules in so far as national conditions will permit.
- 4) The desirability is recognized of extending international agreement on these matters through an endeavour to harmonize national standardization rules with these recommendations in so far as national conditions will permit. The National Committees pledge their influence towards that end.

PREFACE

This Recommendation has been prepared by Sub-Committee 12C, Radio Transmitting Equipment of IEC Technical Committee No. 12, Radio-communication.

This Recommendation forms Part 1 of a Recommendation which is intended, after its completion, to lay down recommended methods of measurements for radio transmitters for various classes of emission.

Part 1 deals with methods of measurement of a number of characteristics applicable to transmitters for all classes of emission. In addition, standard conditions of measurement are specified which apply to these measurements, as well as to those described in the other specialized parts. The other parts of the complete Recommendation should therefore always be used in conjunction with Part 1.

Information of a general character, C.C.I.R. Recommendations and Reports and Articles of the Radio Regulations drawn up by the International Telecommunication Union (I.T.U.) have been added in whole or in part in the appendices to this Recommendation, whenever it was considered useful to have these references at hand. These appendices are contained in the first Supplement to Part 1 (IEC Publication 244-1A).

It should be realized that the recommended methods of measurement may in due course be subject to improvement or extension; this Recommendation will then be amended or completed.

At a meeting held in Interlaken in 1961, it was decided to study recommended methods of measurement for radio transmitting equipment. Several drafts were discussed at meetings held in Kootwijk in 1961, and in Ulm and Stockholm in 1962. As a result of the meeting held in Venice in 1963, a final draft for each section was prepared and submitted to the National Committees for approval under the Six Months' Rule in July, August and November 1964, respectively.

Amendments received on Section Two were discussed at the meeting held in Tokyo in 1965 and were submitted to the National Committees for approval under the Two Months' Procedure in July 1966.

The following countries voted explicitly in favour of publication of Section One :

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METHODS OF MEASUREMENT FOR RADIO TRANSMITTERS

Part 1: General conditions of measurement, frequency, output power and power consumption

1. Object

The object of this Recommendation is to standardize the conditions and methods of measurement to be used to ascertain the performance of a radio transmitter and to make possible the comparison of the results of measurements made by different observers.

This Recommendation contains details of selected methods of making measurements, recommended for assessing the essential properties of a radio transmitter. The methods of measurement described are restricted to those properties that may be liable to ambiguous interpretation due to the application of different methods and conditions of measurement. They are neither mandatory nor limiting; a choice of measurements can be made in each particular case. If necessary, additional measurements may be performed, but these shall preferably be carried out in accordance with the standards as laid down by the standardizing body of the country concerned.

Limiting values of the various quantities for acceptable performance are not specified as these should be given in the relevant equipment specification, preferably in the form as laid down in a forthcoming IEC Recommendation.

The methods of measurement detailed in this Recommendation are intended for type tests and may also be used for acceptance tests and factory tests (see Clause 3).

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2. Scope

The standard conditions of measurement and (unless otherwise specified in the other parts) the methods of measuring the characteristics given in this part of the Recommendation, apply to radio transmitters for various classes of emission.

SECTION ONE — GENERAL

3. Terms and definitions

The methods of measurements described in this part and in the other parts of this Recommendation 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, or used by other Technical Committees of the IEC and international bodies. Where deviations exist, these deviations appeared necessary for a better understanding of this Recommendation.

In the sub-clauses below, some very general terms are given; those between quotation marks have been taken from the C.C.I.R. (See reference [1] of Appendix A.)

3.1 *(Radio) transmitter*

“Apparatus producing radio-frequency energy for the purpose of radiocommunication.”

For the purpose of this Recommendation, such auxiliary equipment as is necessary to maintain the transmitter in normal operation, together with any device to match the impedance of the aerial (or the aerial transmission line) to the transmitter, including harmonic or other filters, shall be considered as a part of the transmitter.

3.2 *(Radio) transmitting system*

“Apparatus comprising a radio transmitter connected to its aerial or aerials; also several transmitters connected to a common aerial.”

Unless specifically indicated, this Recommendation refers only to single radio transmitters.

3.3 *Relevant equipment specification*

Any document especially drawn up or provided, which describes the properties and the performance of an equipment (Note 1) under specified conditions of normal use, together with specified fault conditions (Note 2) which may arise under this normal use.

Notes 1. — For the purpose of this Recommendation, the word “equipment” denotes a radio transmitter as defined above.

2. — For the general principles and the test methods to be followed to assess that the equipment will remain safe under conditions of normal use and under specified fault conditions, reference is made to I E C Publication 215, Safety Requirements for Radio Transmitting Equipment.

3.4 *Type*

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A type comprises products having similar design features manufactured by the same techniques and falling within the manufacturer’s usual range of ratings (Notes 2 and 3) for these products.

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

2. — “Ratings” cover the combinations of:

- a) electrical ratings;
- b) sizes;
- c) behaviour under environmental stresses.

3. — The limits of the range of ratings shall be agreed between customer and manufacturer.

3.5 *Type test*

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

3.6 *Type approval*

The decision by the proper authority (the customer himself or his nominee) that a particular manufacturer can be considered capable of producing, in reasonable quantities, the type meeting the specification.

3.7 *Acceptance tests*

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

The agreement shall cover:

- a) the sample size;
- b) the selection of tests;
- c) the extent to which the test specimens shall conform to the requirements for the selected tests of the specification.

Note. — In cases of divergent test results, the IEC standard test methods shall be used for acceptance tests.

3.8 *Factory tests*

Tests carried out by the manufacturer to verify that his products meet the specification.

4. **Conditions of measurement**

Care shall be taken to avoid all conditions which may lead to damage of the transmitter, especially its tubes or valves or semiconductor devices.

If no other average data have been specified by the transmitter manufacturer, the actual characteristics of each tube or valve or semiconductor device used in the transmitter during the test shall lay within its normal average data range quoted by the tube, valve or semiconductor device manufacturer.

Unless otherwise specified, the measurements shall be carried out under standard conditions with respect to primary power supply, temperature, air pressure, humidity and terminal load, and under specified conditions of modulation, as laid down below in the Sub-clauses 4.1 and 4.2, respectively. After the radio transmitter has been finally set up for these conditions, the settings shall be kept constant during all measurements, with the exception of those settings that must be varied before or during a specified period of the measurements.

4.1 *Standard conditions of operation*

4.1.1 *Conditions for primary power supply*

The measurements are carried out at the nominal voltage and the nominal frequency of the power supply given in the relevant equipment specification.

During a series of measurements carried out as part of one test on one equipment, the voltage and the frequency of the power supply shall not deviate from the nominal values more than indicated in the relevant equipment specification.

Note. — If a voltage regulator is incorporated in the radio transmitter being measured, and if the transmitter performance is essentially dependent upon the proper function of this regulator, the results may be quite different whether the voltage fluctuates at a fast or at a slow rate. A voltage regulator of electromechanical type will not be able to compensate for fast voltage fluctuations and the latter may considerably affect the performance of the transmitter, unless they are taken care of in the rectifier and stabilizing circuits.

When the nominal voltage and frequency cannot be obtained during the measurements, the following shall apply:

- a) If the quantities to be measured depend on voltage and/or frequency and the law of dependence is known, the values are measured at a voltage and a frequency which shall be within the limits laid down in the relevant equipment specification. If necessary, the measured quantities are corrected to the nominal voltage and/or frequency by calculation.

Note. — Attention is drawn to the fact that, in the equipment specification, different limits of the voltage and the frequency may be given for different specified characteristics of the transmitter.

- b) If the quantities to be measured depend on voltage and/or frequency and the law of dependence is unknown, the values are measured at a voltage and a frequency which shall lay within $\pm 2\%$ of the nominal voltage and within $\pm 1\%$ of the nominal frequency, unless closer tolerances are specified in the equipment specification.

Investigation into the deviations from the rated data of the transmitter within the limits of the operating voltage and frequency given in the equipment specification is subject to agreement.

Standard conditions imply the presence of the supplementary conditions for the primary power supply specified in Clause 5.

4.1.2 *Environmental conditions*

As to the atmospheric conditions, the measurements are carried out under the “standard environmental testing conditions” or “standard environmental referee conditions” specified in the Sub-clauses 6.1 and 6.3.

Investigation of the properties of the transmitter at other environmental conditions is subject to agreement.

4.1.3 *Terminal load*

The transmitter shall be terminated by a test load. The characteristics of this test load with respect to power handling capacity and impedance in the relevant frequency range shall be in accordance with the quantities and tolerances given in the relevant equipment specification.

The apparatus connecting the test load to the output terminal device of the transmitter are part of the test load.

Notes 1. — If a fluid-cooled test load is used, the coolant at its normal rate of flow shall be present when the impedance is measured.

2. — The impedance of the test load may change depending on the power dissipated. Incandescent lamps are therefore not recommended as a test load for carrying out measurements according to this Recommendation, particularly when amplitude modulation is present.

Investigation into the deviation from the rated data of the transmitter within the limits of the load impedance given in the relevant equipment specification is subject to agreement.

4.2 *Conditions of modulation*

The measurements are carried out under conditions of modulation relevant to the class of emission specified in the relevant equipment specification, including, where applicable, the condition of no modulation.

Note. — The classification of emissions is given in Appendix B. Modulating signals and the condition of no modulation for the various classes of emissions are described in Table I of Appendix C.

If particular measurements require the condition of modulation to be standardized, this condition is given in the clauses relevant to such measurements.

5. **Supplementary conditions for primary power supply**

In addition to conforming to the relevant sections of the equipment specification, the primary power supply used for testing a radio transmitter shall be sufficiently stable that no appreciable

variations in the performance of the transmitter under test will be introduced by changes in the parameters of the power supply.

Note. — A power supply system simultaneously supplying another load of the same nature and of the same magnitude or a magnitude superior to the one presented by the transmitter and which may have influence on the transmitter performance is a special case which is outside the scope of this Recommendation. This case may be covered by special arrangements, using compensating and/or protecting devices.

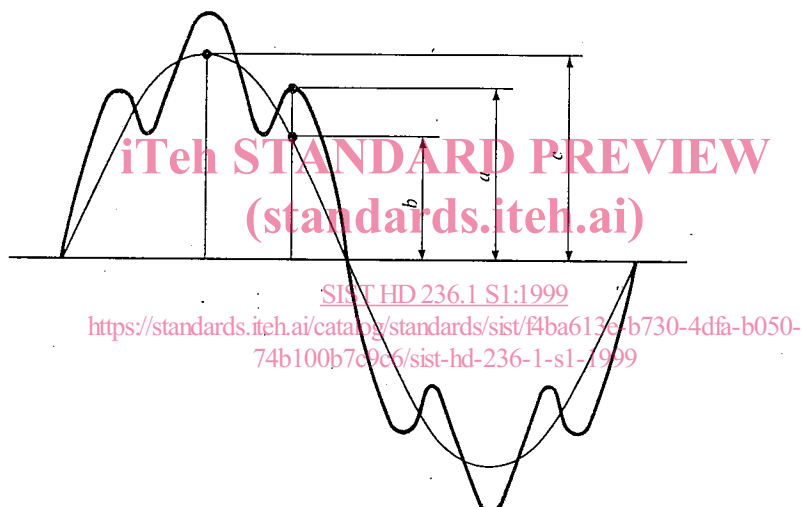
In general, the afore-mentioned condition will be met if the power supply conforms to the following stipulations.

5.1 *A. C. system conditions*

5.1.1 *Wave-form 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 transmitter, shall be connected to the a.c. terminals of the transmitter.

The wave-form 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 ($a - b \leq 0.05 c$; see Figure 1).



a = the instantaneous value of the voltage

b = the instantaneous value of the fundamental wave

c = the amplitude of the fundamental wave

FIG. 1. — Voltage wave-form of the primary a.c. power supply.

In addition to meeting the requirements of Sub-clause 4.1.1, the impedance of the a.c. system will be considered sufficiently low if the wave-form stipulations of the preceding paragraph are met with the equipment switched off, or functioning under any normal condition.

Notes 1. — These requirements are in accordance with IEC Publications:

84, Recommendations for Mercury-arc Convertors;

119, Recommendations for Polycrystalline Semiconductor Rectifier Stacks and Equipments.

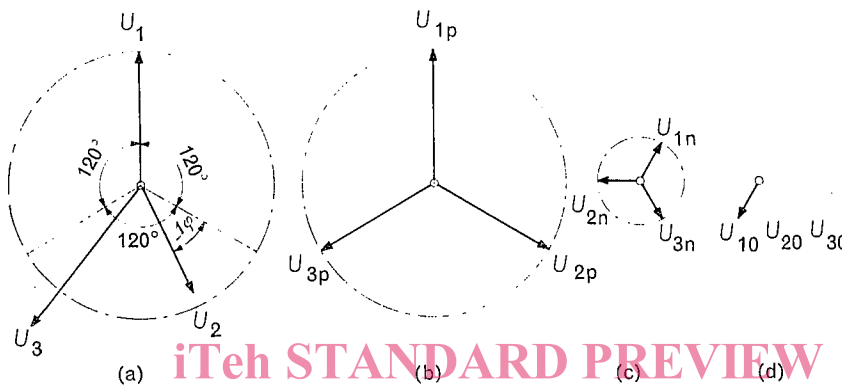
2. — For a transmitter where the ratio of the load on the a.c. system to its short-circuit capacity is such that the system impedance has influence, the applicable parts of the Clauses 443, 444, 445 and 446 of IEC Publication 84 should be followed.

5.1.2 Symmetry of poly-phase systems

Poly-phase supply sources shall be symmetrical in respect of the voltages.

Note 1. — It shall be clearly stated in the relevant equipment specification if the equipment is specifically designed for use with a non symmetrical poly-phase system, together with its tolerances.

The voltages are to be considered as 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 2.



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- a) Non-symmetrical system
- b) Positive sequence system
- c) Negative sequence system
- d) Zero sequence system

Note. — Any non-symmetrical three-phase system may be considered as a superposition of three symmetrical systems; a positive-sequence system, a negative-sequence system and a zero-sequence (in phase) system.

There is a specific relation between the components of these symmetrical systems and the amplitude and phase angle unbalance of the original non-symmetrical system.

Considering, e.g. the case where the negative-sequence component and the zero-sequence component both are $\alpha\%$ of the positive-sequence component, the largest component of the non-symmetrical system exceeds the smallest by less than $3\alpha\%$, the phase angle unbalance $\Delta\varphi$ being less than 1.72α degrees.

These approximate values are valid when α is less than 5%.

FIG. 2. — Unbalance of a three-phase system.

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

Note 2. — This requirement is in accordance with IEC Publications 84 and 119 (see Note 1, Sub-clause 5.1.1) and 76, Power Transformers.

5.2 *D.C. system conditions*

Though the characteristics of d.c. power supply systems may also have an appreciable influence on the performance of radio transmitters connected to this type of power supply, their use is not considered to be general.

In the majority of cases, the use of a d.c. power supply system is restricted to certain well defined areas such as portable transmitters, transmitters for use in vehicles, shipborne emergency transmitters, radio-relay systems, etc. Within these areas, the transmitter is usually designed to meet the prescribed requirements when connected to a specific d.c. power supply system that may or may not constitute a part of the transmitter itself.

The following general conditions relevant to d.c. power supply systems, however, may be applied in the various cases.

5.2.1 *Wave-form and source impedance of a supply system using d.c. generators*

Unless otherwise specified, a substantially smooth direct voltage source of sufficiently low impedance to have negligible influence on the operation of the radio transmitter, shall be connected to the d.c. terminals of the transmitter.

The direct voltage is considered to be substantially smooth if the maximum peak-to-peak value of the ripple does not exceed 2% of the rated operating voltage.

In addition to meeting the requirements of Sub-clause 4.1.1, the impedance of the d.c. system will only be considered sufficiently low if the voltage stipulations of the preceding paragraph are met with the equipment switched off, or functioning under any normal condition.

5.2.2 *Source impedance of a supply system using accumulators*

Unless otherwise specified, an accumulator type supply source of an impedance sufficiently low to have no influence on the operation of the radio transmitter shall be connected to the d.c. terminals of the transmitter.

In addition to meeting the requirements of Sub-clause 4.1.1, the impedance of the supply source is considered to be sufficiently low if, when operating at the rated supply voltage, the change in the voltage corresponding to a change from the conditions of no modulation to that of full modulation measured at the d.c. input terminals of the transmitter, is equal or less than 2% of the rated value of the supply voltage.

Note. — For lead-acid types accumulators, reference is made to IEC Publication 95, Lead-acid Starter Batteries.

6. **Environmental conditions**

Unless otherwise specified, the standard atmospheric conditions given in the Sub-clauses 6.1, 6.2 and 6.3 apply. The contents of these are in accordance with IEC Publication 68-1, Basic Environmental Testing Procedures for Electronic Components and Electronic Equipment, Part 1: General (third edition).

Other environmental conditions are referred to in Sub-clause 6.4.