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Quatrième partie: Caractéristiques amplitude/fréquence et distorsion de non-linéarité dans les émetteurs de radiotéléphonie et de radiodiffusion sonore
Premier complément: Section trois

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Teil 4: Amplituden/Frequenz-Charakteristiken und nichtlineare Verzerrung in Funksendern für Funkfernsprechen und Tonrundfunk
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Quatrième partie: Caractéristiques amplitude/fréquence et distorsion de non-linéarité dans les émetteurs de radiotéléphonie et de radiodiffusion sonore

Methods of measurement for radio transmitters

Part 4: Amplitude/frequency characteristics and non-linearity distortion in transmitters for radiotelephony and sound broadcasting

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

METHODS OF MEASUREMENT FOR RADIO TRANSMITTERS

Part 4: Amplitude/frequency characteristics and non-linearity distortion in transmitters for radiotelephony and sound broadcasting

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 recommendations and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

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

Several drafts were discussed at meetings held in Lidingö in June 1966, in Baden in May 1967 and in Baden-Baden in May 1968. As a result of this latter meeting, final drafts of the various sections and appendices, documents 12C(Central Office)75, 76 and 79, were submitted to the National Committees for approval under the Six Months' Rule in January 1971 and May 1971.

The following countries voted explicitly in favour of publication of Section One and the appendices of this recommendation:

Australia	Iran	Sweden
Belgium	Israel	Switzerland
Canada	Italy	Turkey
Denmark	Japan	United Kingdom
France	Netherlands	United States of America
Germany	Portugal	
Hungary	Romania	

The following countries voted explicitly in favour of publication of Section Two of this recommendation:

Australia	Iran	Switzerland
Belgium	Israel	Turkey
Czechoslovakia	Italy	Union of Soviet Socialist Republics
Denmark	Japan	United Kingdom
France	Netherlands	United States of America
Germany	Portugal	
Hungary	Sweden	

METHODS OF MEASUREMENT FOR RADIO TRANSMITTERS

Part 4: Amplitude/frequency characteristics and non-linearity distortion in transmitters for radiotelephony and sound broadcasting

Introduction

This recommendation forms Part 4 of a recommendation which, when completed, will describe recommended methods of measurement for assessing the performance of radio transmitters for various classes of emission.

Information of a general character and references to recommendations of other international organizations have been added in the appendices of this recommendation.

In due course, Part 4 will be supplemented with Section Three: Non-linearity distortion, including harmonic distortion and intermodulation.

Where references are made in Part 4, to other parts of the complete recommendation (IEC Publication 244), these references concern the following IEC publications:

Publication 244-1: (First edition, 1968)	Part 1: General conditions of measurement, frequency, output power and power consumption.
Publication 244-1A: (First edition, 1968)	First supplement to Publication 244-1 (1968) — Appendices.
Publication 244-2: (First edition, 1969)	Part 2: Bandwidth, out-of-band power and power of non-essential oscillations.
Publication 244-2A: (First edition, 1969)	First supplement to Publication 244-2 (1969) — Appendices.
Publication 244-2B: (First edition, 1969)	Second supplement to Publication 244-2 (1969) — Modulating signals for the measurement of bandwidth and out-of-band power of transmitters for telephony and sound broadcasting.
Publication 244-3: (First edition, 1972)	Part 3: Wanted and unwanted modulation.
Publication 244-3A: (First edition, 1971)	First supplement to Publication 244-3 (1972) — Appendices.
Publication 244-3B: (First edition, 1972)	Second supplement to Publication 244-3 (1972) — Unwanted modulation, including hum and noise modulation.
Publication 244-5: (First edition, 1971)	Part 5: Measurements particular to transmitters and transposers for monochrome and colour television.
Publication 244-5A: (First edition, 1971)	First supplement to Publication 244-5 (1971) — Appendices.
Publication 244-5B:	Second supplement to Publication 244-5 (1971) — Amplitude/frequency characteristic, group-delay and distortion, including differential gain and differential phase (in preparation).

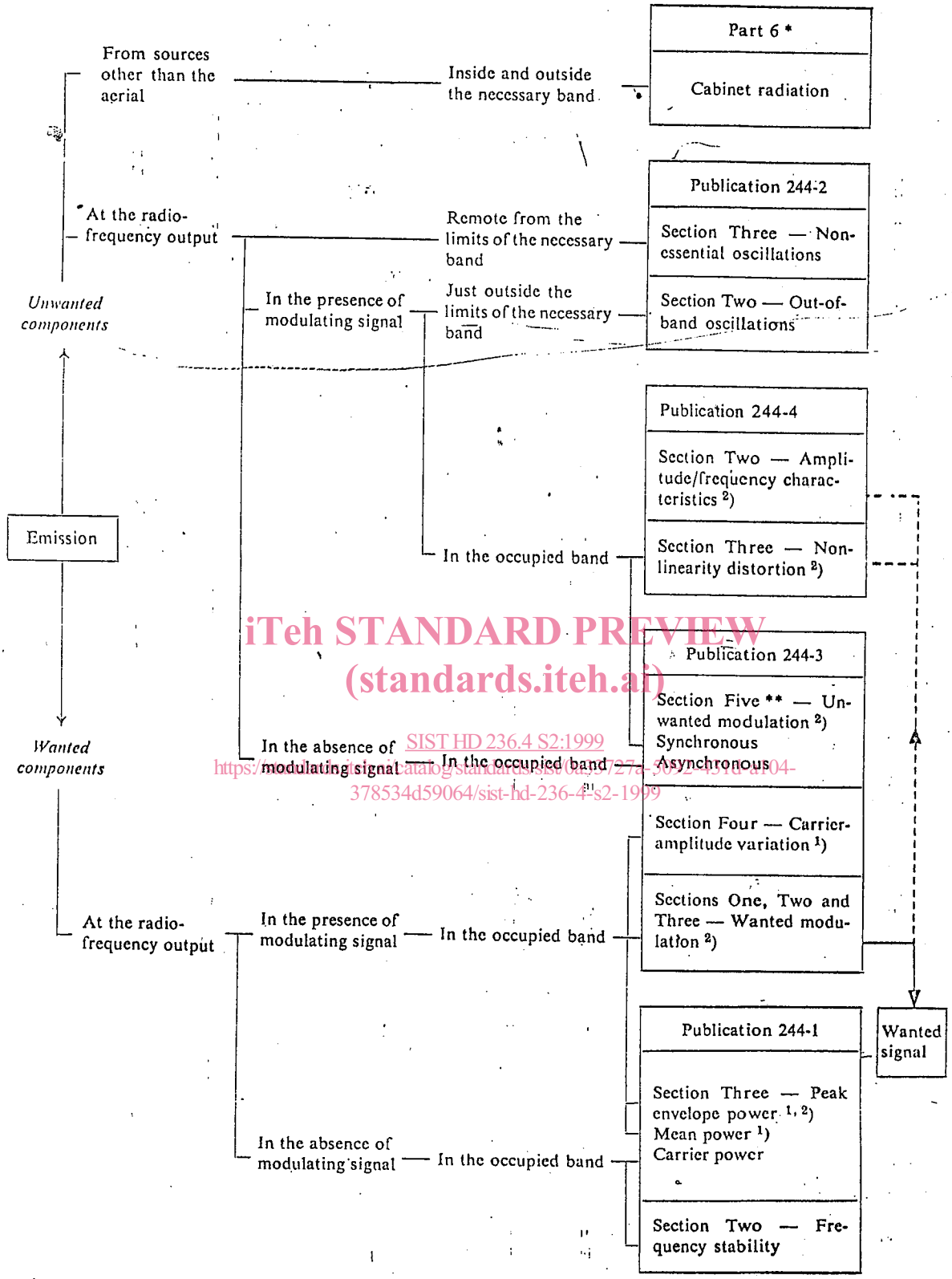
In due course, the recommendation will be supplemented with the following part:

Part 6: Cabinet radiation and terminal interference voltages.

The relation between this part and the other parts of the recommendation is shown in the table on page 9.

A separate IEC publication, which is under consideration, will deal with transmitters used in radio-relay systems.

TABLE SHOWING THE RELATION BETWEEN THE VARIOUS PARTS OF IEC PUBLICATION 244



1) Amplitude-modulation transmitters only.
2) For transmitters for monochrome and colour television, see IEC Publication 244-5.
* Under consideration.
** See IEC Publication 244-3B.

1. Object

This recommendation is intended to standardize the measurement of the performance of radio transmitters and, thus, to make meaningful the comparison of measurements made by different observers.

It is confined to giving details of selected methods for those parameters for which unreliable or ambiguous results may be obtained if varying methods or conditions are used. The methods are neither mandatory nor limiting; a choice can be made in each particular case. If necessary, additional measurements may be performed, but these shall preferably comply with the requirements of other IEC publications, or recommendations of other international bodies.

Limiting values for acceptable performance are not specified as these should be given in the equipment specification. They should preferably be specified in the form given in the appropriate IEC recommendation when this is published.

The methods of measurement detailed in this recommendation are intended for type tests, but they may also be used for acceptance tests and factory tests; see Clause 3 of IEC Publication 244-1.

2. Scope

This part, which shall be used in conjunction with IEC Publication 244-1 and, if applicable, with other parts, describes the conditions and methods to be used to measure the quality of the signal at the output of the transmitter.

The methods are applicable to:

— amplitude-modulated transmitters with full carrier, either for radiotelephony or sound broadcasting;

— amplitude-modulated transmitters with reduced or suppressed carrier, either for single-channel or multi-channel radiotelephony with not more than four channels;

— frequency-modulated transmitters for monophonic sound broadcasting.*

In certain cases, they may also be used for amplitude-modulated transmitters with reduced or suppressed carrier for multi-channel voice-frequency telegraphy.

SECTION ONE — GENERAL CONDITIONS OF OPERATION AND MODULATION INPUT SIGNAL ARRANGEMENTS

3. Introduction

Various forms of distortion may be identified (see reference [4] of Appendix A). In this part of the recommendation, the number of measured characteristics have been limited to those which are directly related to the quality of the signal at the output of the transmitter.

Section Two deals with the measurement of the amplitude/modulation-frequency and amplitude/radio-frequency characteristics, and crosstalk as far as intelligible (or linear) crosstalk is concerned.

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* Special measurements for stereophonic sound broadcasting are under consideration.

Section Three (under consideration) will describe methods for measuring those characteristics which are due to the non-linear transmission properties of the transmitter, viz. the harmonic distortion, intermodulation distortion and unintelligible (or non-linearity) crosstalk.

The operating and measuring conditions specified in this section apply to the measurements described in Sections Two and Three.

4. General conditions of operation

The transmitter shall be operated under the following conditions:

a) Unless otherwise agreed, any separate device to match the aerial to the aerial transmission line is excluded.

b) The equipment under test shall include auxiliary devices such as pre-amplifiers, band-pass filters for limiting the band of emitted frequencies, multiplexing equipment for multi-channel emissions and networks for providing pre-emphasis, if such devices are covered in the equipment specification.

c) Unless otherwise specified, devices to achieve privacy in radiotelephony emissions and equipment having non-linear characteristics (e.g. compressors, limiting amplifiers, amplifiers containing clipping devices, devices for automatic load [or level] control, etc.) shall be disabled. Assessing the performance of these devices may be the subject of separate measurements.

d) The transmitter shall be connected to a test load, the impedance of which shall meet the following requirements:

1) For transmitters designed to be connected to a transmission line with a specified characteristic impedance, the nominal value of the impedance shall be equal to the specified characteristic impedance. The actual impedance shall be within the tolerances for normal loading conditions stated in the equipment specification and shall be substantially constant over the frequency band occupied.

2) In the special case of low-power transmitters, the output of which is directly connected to the aerial, and in those cases where, in contrast to the normal conditions given in Item *a)*, the measurements are to be made with the separate aerial matching device included, the provisions of IEC Publication 244-2, Sub-clause 6.1.2, Item *a)*, apply.

e) The voltage and the frequency power supply shall be within the tolerances stated in the equipment specification.

f) The transmitter shall be adjusted to deliver rated output power.

5. Modulation input signal arrangements

5.1 *Input signal source*

The input signal source comprises the audio-frequency generator (or two such generators when the intermodulation distortion is to be measured) and any auxiliary networks used to provide the correct internal impedance or to combine the signals of the two generators.

5.2 *Internal impedance of signal source*

The internal impedance of the input signal source shall be equal to the value required in the equipment specification (see note).

If this impedance is not specified, and in the absence of any statement to the contrary, the internal impedance of the signal source shall be equal to the nominal transmitter input impedance (defined in Sub-clause 7.1 *b)*.

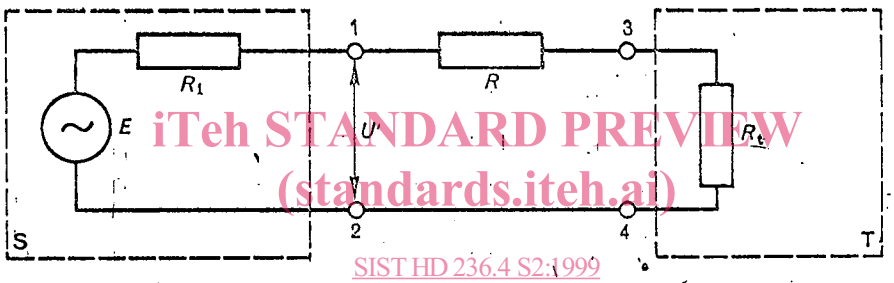
Note. — In accordance with current practice, the internal impedance is assumed to be a pure resistance.

For the considerations underlying the requirements of Sub-clause 5.2, refer to Appendix C, Clause 1.

5.3 *Networks for providing a given source impedance*

When the required source impedance differs from the internal impedance of the signal generator, a network providing the correct source impedance shall be inserted between the output of the generator and the input to the transmitter. Examples of such networks are given in Appendix C, Clause 3.

In most cases, however, a perfect match between the generator and its load is not required. In this case, the simple arrangement of Figure 1 below, may be used; see also the last paragraph of Sub-clause 5.4.



S = signal generator
T = transmitter
E = e.m.f. of signal generator
R_1 = internal impedance of signal generator
R = resistance equal to the required source impedance R_r
R_t = transmitter input impedance
U' = output voltage of signal generator under load

Note. — The internal impedance of the signal source at terminals 3 and 4 is equal to R_r only when R_1 is negligeably small compared with R_r. However, irrespective of the value of R_1, the arrangement simulates a signal source with an apparent source e.m.f. equal to the voltage U' across terminals 1 and 2 and an apparent source impedance equal to R_r.

FIG. 1. — Example of audio-frequency input signal arrangement (for unbalanced input terminals)

5.4 *Modulation input level*

The modulation input level shall be expressed in terms of apparent source e.m.f. The apparent source e.m.f. is the open circuit voltage of the signal source; see Appendix C, Clause 1.

Alternatively, the modulation input level may be expressed in terms of available input power (see note). The available power P' can be calculated from the formula:

$$P' = \frac{E'^2}{4\,R'_1} \qquad (5.4)$$

where:

E' = the apparent source e.m.f.

R'_1 = the internal resistance of the signal source.

Note. — The available power corresponds to the maximum power that a signal source with a given source resistance can supply to its load. The available power is equal to the actual input power only when the transmitter input resistance is equal to the internal resistance of the signal source.

With the arrangement of Figure 1, page 15, the apparent source e.m.f. can be determined by measuring the output voltage U' of the signal generator under load.

For ease of measurement and to ensure a correct impedance match, commercially available audio-frequency generators designed according to this principle, frequently include an oscillator with a low internal impedance R_1 and a resistance R adjustable in steps, in conjunction with a voltmeter across terminals 1 and 2, calibrated in apparent source e.m.f. or available input power, or both.

5.5 *Combining networks*

For the purpose of the application of two modulating signals simultaneously, suitable combining networks shall be used to avoid intermodulation in either signal generator as a result of interaction. Examples of such networks are given in Appendix D.

When the source impedance of the combining network differs from that required for the transmitter, a network providing the correct source impedance shall be inserted between the output of the combining network and the input to the transmitter, in accordance with the provisions of Sub-clause 5.3.

6. Modulation frequencies

6.1 *Preferred measuring frequencies*

Appendix B lists the preferred measuring frequencies. These frequencies are in accordance with the Recommendation of the International Organization for Standardization (ISO) on preferred frequencies for acoustical measurements mentioned in reference [1] of Appendix A.

6.2 *Reference modulation frequency*

The reference modulation frequency shall be 1 kHz.

Notes 1. — This value is in accordance with the ISO Recommendation mentioned in Sub-clause 6.1.

2. — 800 Hz and 400 Hz may be used for the time being.

SECTION TWO — AMPLITUDE/FREQUENCY CHARACTERISTICS AND INTELLIGIBLE CROSSTALK

7. Input impedance

7.1 *Definitions*

a) Transmitter input impedance

The complex ratio of the voltage to the current of a sinusoidal signal applied to the transmitter input terminals.

b) Nominal transmitter input impedance

The transmitter input impedance specified by the manufacturer, preferably at the reference frequency 1 kHz.

Note. — The nominal input impedance is assumed to be a pure resistance.

7.2 *Method of measurement*

The input impedance is determined as a function of frequency over the audio-frequency band concerned. Any suitable standard measuring technique may be employed.

8. Amplitude/modulation frequency characteristic

8.1 *Application*

Clause 8 primarily applies to:

a) transmitters for sound broadcasting (A3, F3); but may also be applied to:

b) single-channel and multi-channel telephony transmitters (A3, A3A, A3B, A3H, A3J) and

c) multi-channel voice frequency telegraphy transmitters (A7A, A7B).

8.2 *Definitions*

a) Amplitude/modulation frequency characteristic (see Note 1)

The relationship between either

1) the utilization factor (see Note 2) and the frequency of a sinusoidal modulating signal of constant level, or

2) the modulation signal level and the frequency of a sinusoidal modulating signal for a constant utilization factor (see Note 2).

Notes 1. — The term "audio-frequency response" may be used for transmitters for telephony and sound broadcasting.

2. — The term "utilization factor" applies to all classes of emission. For amplitude-modulated double-side-band transmitters (A3), this term may be replaced by the term "modulation factor"; see also Section One of I E C Publication 244-3.

b) Pre-emphasis

The process of enhancing the relative amplitude of the sinusoidal components at higher frequencies of the modulating signal in accordance with a predetermined characteristic. Pre-emphasis is mainly used in frequency-modulated transmitters to improve the signal-to-noise ratio at the receiving site.

c) De-emphasis

The process of restoring the relative amplitude of the sinusoidal components of the demodulated signal to the value they had before pre-emphasis was applied.

8.3 *Conditions of operation*

Clause 4 applies.

8.4 *Test conditions*

Connect the audio-frequency generator and the voltmeter for measuring the input signal level to the transmitter in accordance with Clause 5. For multi-channel transmitters, the inputs to the channels not being connected to the generator shall be terminated with their nominal input impedance.

Demodulate the signal at the output of the transmitter by a linear demodulator without de-emphasis, connected to an audio-frequency voltmeter. Determine the utilization factor as explained in Section Two of IEC Publication 244-3.

8.5 *Measurement procedure for amplitude-modulated transmitters* (without pre-emphasis)

Although either of the methods described in Items *b)* or *c)* below may be used, the method given in Item *b)* is preferable.

a) Initial adjustment common to both methods

Unless otherwise specified, adjust the level of the modulating signal at the reference frequency to obtain a utilization factor of 50%. Note the transmitter input voltage and the corresponding demodulator output voltage.

b) Constant transmitter input level

Vary the modulation frequency over the specified audio-frequency band while maintaining the transmitter input voltage at the value obtained in Item *a)*. Record the demodulator output voltage.

c) Constant demodulator output level

Vary the modulation frequency over the specified audio-frequency band while maintaining the demodulator output voltage at the value obtained in Item *a)*. Record the transmitter input voltage.

For multi-channel transmitters, the measurement shall be made for each channel separately.

If necessary, repeat the measurements for other values of the utilization factor.

Note. — Measurement errors may arise due to noise and hum for very low values of the utilization factor, or due to excessive distortion for high values of the utilization factor.

With the method described in Item *c)* errors at frequencies near to the limits of the specified audio-frequency band may also occur for moderate values of the utilization factor, due to:

— overloading of the modulator and pre-modulator stages at these frequencies,

— the operation of the limiting amplifier or compressor if these devices cannot be disabled; see Sub-clause 4 *c)*.