INTERNATIONAL STANDARD

IEC 60489-2

1991

AMENDMENT 1
1999-07

Amendment 1

Methods of measurement for radio equipment used in the mobile services –

**Part 2:
Transmitters employing A3E, F3E or G3E emissions**

Amendement 1

Méthodes de mesure applicables au matériel de radiocommunication utilisé dans les services mobiles –

*Partie 2:
Emetteurs utilisant les émissions A3E, F3E ou G3E*

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FOREWORD

This amendment has been prepared by IEC technical committee 102: Equipment used in radio communications for mobile services and for satellite communication systems.

The text of this amendment is based on the following documents:

FDIS	Report on voting
102/43/FDIS	102/52/RVD

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

A bilingual version of this amendment may be issued at a later date.

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CONTENTS

Insert, after clause 12, the following new clause 13:

Renumber the existing clause 13 and amend its title as follows:

Renumber clause 14 as clause 15.

Insert the following new clause 16.

Renumber the existing clauses 15, 16, 17 and 18, as 17, 18, 19 and 20, respectively.

APPENDICES

Delete appendices B and D.

Rename appendix C as appendix B.

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PREFACE

Add, in the list of quoted publications, after 60244-6 (1976) the following:

60244-7 (1979): *Part 7: Cabinet radiation at frequencies above 1 GHz*

Add, under 60489-1 (1983) the following:

Amendment 1 (1996)
Amendment 2 [1)]

With regard to amendment 2, add the following footnote:

Add, under 60489-3 (1988) the following:

ITU-T Recommendation O.41 (1994): Psophometer for use on telephone-type circuits

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SECTION 1: GENERAL, SUPPLEMENTARY DEFINITIONS AND CONDITIONS OF MEASUREMENT

5.4 Limitation of the measuring audio-frequency band

Replace, on page 11, this subclause by the following:

Because some properties, for example noise and audio-frequency harmonic distortion, depend upon the audio-frequency bandwidth of the test equipment, reproducible results can be obtained only when the band of audio-frequencies occupied by the demodulated signal is restricted to specified limits.

This restriction may be accomplished by means of a band-limiting filter preceding any audio-frequency measuring device and adapted to the type of signals to be transmitted. The filter may be incorporated within the measuring equipment. When measuring residual hum and noise, only the low-pass portion of the filter need be specified (see appendix A).

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SECTION 2: METHODS OF MEASUREMENT

8.3.2 Method of measurement at the antenna terminals

Add, on page 15, the following sentence to 8.3.2 a):

If the band rejection filter exhibits unwanted attenuation (certain types of band rejection filters, such as those constructed with transmission lines or cavities, can have unwanted attenuation at odd multiples of the centre frequency of the rejection bandwidth), for the measurement of spurious components at and above the second harmonic of the carrier frequency, the band rejection filter shall be replaced by a high-pass filter whose cut-off frequency is approximately 1,5 times the carrier frequency.

[1)] To be published.

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Replace, in figure 2, the text of legend 8 by the following:

band-rejection filter or high-pass filter (if needed)

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8.4.3 Method of measurement

Add, at the end of 8.4.3 e), the following note:

NOTE – The permissible input level which does not degrade the receiver performance can be calculated from

$$P_{rt} = P_t - A \leq P_r + S - 10 \text{ dBm}$$

where

P_{rt} is the permissible receiver input level, in decibels (dBm);

P_t is the carrier power of transmitter under test, in decibels per metre (dBm);

A is the attenuation recorded in step e), in decibels (dB);

P_r is the reference sensitivity of the test receiver, in decibels per metre (dBm);

S is the selectivity of the receiver, in decibels (dB).

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Add, before 8.5.7 a), the following note 1:

NOTE 1 – This method of measurement can be applied to the transmitter that has a modulating signal which is superimposed on the speech signal and cannot be turned off (e.g. continuous tone controlled squelch systems).

Add, to 8.5.7 b), the following note 2:

NOTE 2 – In the case of transmitters that have a modulating signal which is superimposed on the speech signal and cannot be turned off (e.g. continuous tone controlled squelch systems), operate the transmitter in modulated condition at the power level specified by the manufacturer (which may correspond to the carrier power measured as described in 8.2).

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9 Radiated radio-frequency power

Replace the text of this clause by the following:

These measurements are usually made only on transmitters having integral antennas.

9.1 General

The radiated radio-frequency power output of a transmitter may contain

– average radiated carrier power (see 9.2);
– maximum effective radiated carrier power (see 9.3);
– RFM (random field measurement) radiated carrier power (see 9.4);
– RFCD radiated carrier power (see 9.5);
– modulation components determining transmission quality (see clauses 12, 13, 14 and 16);

– other modulation components (e.g. components contributing to the adjacent channel power) (see 9.8);
– spurious narrow-bandwidth components (see 9.6);
– noise, both inside the band (see clause 18) and outside the band, where it is called spurious transmitter noise (see 9.7);
– inter-transmitter intermodulation products (see clause 11), and
– cabinet radiation (see 9.9).

The measured levels may be due to the radiation from the antenna, audio lines, control lines, power mains or from the cabinet. These measurements generally require the use of a test site or an RFCD. Guides for the use of such test sites and RFCDs are given in IEC 60489-1, annex A.

9.2 Average radiated carrier power for transmitters with integral antennas

9.2.1 Definition

Average of the radiated carrier powers in eight directions distributed at 45° angles in the horizontal plane.

NOTE – The average radiated carrier power can be measured in OATS (open area test sites) or in LRTS (low reflection test sites) or in AC (anechoic chambers). Measured values in OATS may differ from the values measured in the other two test sites because of the ground reflected wave effect.

9.2.2 Method of measurement

a) Choose the test site and the measuring distance suitable for the frequency, the environmental conditions, the required measurement error and transmitter dimensions, from those described in annex A of IEC 60489-1.

b) Place the equipment under test as illustrated in a subclause for the chosen test site in the above-mentioned annex.

c) Measure the normal direction radiated power by the basic measuring procedure described in the subclause.

NOTE – The normal direction of the equipment under test is usually the operation side and is specified by the manufacturer. The normal direction may be the specific direction used for RFCD calibration measurements.

d) Rotate the equipment under test 45° clockwise and measure this direction radiated power by the same procedure as in step c).

e) Repeat step d) until values have been obtained for eight azimuth positions.

9.2.3 Presentation of results

Calculate the average of eight values measured in step d). Record measurement conditions of the test site.

9.3 Maximum effective radiated carrier power

9.3.1 Maximum effective radiated carrier power in the horizontal plane

9.3.1.1 Definition

Maximum effective radiated carrier power in the horizontal plane.

NOTE – The maximum radiated carrier power can be measured in OATS, LRTS or AC. Measured values in OATS may differ from the values measured in the other two test sites because of the ground reflected wave effect.

9.3.1.2 Method of measurement for the maximum effective radiated carrier power in the horizontal plane

a) Choose the test site and the measuring distance suitable for the frequency, the environmental conditions, the required measurement error and transmitter dimensions, from those described in annex A of IEC 60489-1.

b) Place the transmitter under test as illustrated in a subclause for the chosen test site in the above-mentioned annex. Calibrate the test site.

c) Measure the normal direction radiated power by the basic measuring procedure for radiation measurement described in the above-mentioned subclause.

NOTE – The normal direction of the equipment under test is usually the operation side and is specified by the manufacturer. The normal direction may be the specific direction used for RFCD calibration measurements.

d) Rotate the transmitter under test in the horizontal plane and find the direction which has the maximum indication on the power measuring device. Note the maximum indication.

9.3.1.3 Presentation of results

Calculate the maximum effective radiated carrier power in the horizontal plane and record the direction in step d).

9.3.2 Maximum effective radiated carrier power on a spherical surface

9.3.2.1 Definition

Maximum value of effective radiated carrier power observed on a closed surface surrounding an antenna.

NOTE – The maximum radiated carrier power can be measured in LRTS or in AC.

9.3.2.2 Method of measurement for the maximum effective radiated carrier power on a spherical surface

Follow the procedure described in items a) to c) of 9.3.1.2.

d) Rotate the transmitter under test in the horizontal plane and find the direction which has the maximum indication on the selective measuring device.

e) Rotate the transmitter under test 90° in the vertical plane keeping the direction found in step d) to the measuring antenna.

f) Orient the measuring antenna so that it is horizontally polarized. Rotate the transmitter under test in the horizontal plane and note the maximum indication. This will be the direction which has the maximum radiated carrier power on a spherical surface.

g) If another direction offers more radiated carrier power, confirm it for that direction by repeating step d) to step f).

9.3.2.3 Presentation of results

Calculate the maximum effective radiated carrier power in step f) and record the direction in step d) as the horizontal plane direction and the direction in step f) as the vertical plane direction.

9.4 RFM (random field measurement) radiated carrier power

9.4.1 Definition

Median of radiated carrier power measurements taken along a random path in a random field.

NOTE – The RFM radiated carrier power can be measured in the RFM site.

9.4.2 Method of measurement

a) Confirm the construction parameter of the RFM site and position the transmitter under test as illustrated in annex A of IEC 60489-1.

b) Measure the RFM radiated carrier power by the basic measuring procedure described in the above-mentioned annex.

9.4.3 Presentation of results

Record the RFM radiated carrier power, the path length and the DDD value measured in step b).

NOTE – The DDD value expresses the measuring error or repeatability in the test site evaluation measurement described in the above-mentioned annex.

9.5 RFCD (radio-frequency coupling device) radiated carrier power

9.5.1 Definition

Signal level at the output of an RFCD, in which the transmitter under test operates, calibrated by the specific direction radiated carrier power in a test site.

9.5.2 Method of measurement

a) Choose the RFCD for the frequency and size of the transmitter under test from those described in annex A of IEC 60489-1.

b) Calibrate or confirm the calibration value for the output signal level of the RFCD. The calibration should be performed with the calibration method for the chosen RFCD described in the subclause of the above-mentioned annex.

c) Place the transmitter under test in the specified position and in the specified direction and activate the transmitter.

d) Measure the output level of the RFCD.

9.5.3 Presentation of results

Calculate the RFCD radiated carrier power from the relation of the values in step b) and step d). Record the position, the direction of the transmitter under test in the RFCD, and the calibration value.

9.6 Radiated spurious narrow-bandwidth components

The methods of measurement for the radiated spurious narrow-bandwidth components are principally the same as those of the radiated carrier power described in 9.2 to 9.5. The only difference for radiated spurious measurement is the presence of a very high-level carrier. Therefore, the measurement conditions are the same as the combination of the above radiated carrier power measurement and the measurement of the terminal spurious narrow-bandwidth radio-frequency components in 8.3.

The different kinds of radiated spurious narrow-bandwidth components are as follows:

– average radiated spurious narrow-bandwidth components;
– maximum radiated spurious narrow-bandwidth components;
– RFM radiated spurious narrow-bandwidth components;
– RFCD radiated spurious narrow-bandwidth components.

9.7 Radiated spurious transmitter noise

9.7.1 Definition

Continuous spectrum of noise components radiated by transmitters with integral antennas.

NOTE – For more general information, see 8.4.1.

9.7.2 Method of measurement

This method uses the RFCD or near-field coupling of the transmitter and the test antenna in the Faraday cage (if necessary) and the output of the RFCD, or the test antenna is measured with the same method as for one of the terminal radio-frequency powers, for example 8.4. The method uses the ratio measurement, and the coupling of the RFCD or the coupling of the transmitter and the test antenna is calculated from the radiated carrier power measured as described in 9.2.

9.8 Radiated adjacent channel power

9.8.1 Definition

That part of the total power, under defined conditions of modulation, which falls within a specified bandwidth centred on the centre frequency of either of the adjacent channels radiated from transmitters with integral antennas.

9.8.2 Method of measurement

This method uses the RFCD or near-field coupling of the transmitter and the test antenna in the Faraday cage (if necessary), and the output of the RFCD or the test antenna is measured with the same method for one of the terminal radio-frequency powers, for example 8.5. The method uses the ratio measurement, and the coupling of the RFCD or the coupling of the transmitter and the test antenna is calculated from the radiated carrier power measured as described in 9.2 to 9.4.

9.9 Cabinet radiation

9.9.1 Definition

The cabinet radiation of transmitters with integral antennas is contained in the radiated spurious narrow-bandwidth components measured as described in 9.6.

9.9.2 Method of measurement

Methods of measurement for the cabinet radiation of transmitters equipped with suitable antenna terminals are given in IEC 60244-6 and IEC 60244-7.

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11 Inter-transmitter intermodulation

Replace the text of this clause by the following:

11.1 Definition

Process by which intermodulation products are generated in the output circuits of a transmitter due to the presence of an unwanted signal from another transmitter.

11.1.1 Inter-transmitter intermodulation (ITIM)

For the purpose of this standard, inter-transmitter intermodulation (ITIM) is expressed in terms of the ratio, in decibels, of the transmitter carrier power to the power of the third-order intermodulation product caused by the presence of an interfering signal which is 30 dB below the level of the transmitter output and which is incident upon the output of the disturbed transmitter.

11.1.2 Transmitter intermodulation conversion loss (TIMCL)

For the purpose of this standard, transmitter intermodulation conversion loss (TIMCL) is expressed in terms of the ratio, in decibels, of the power of the interfering signal (which is 30 dB below the transmitter carrier power) which is incident upon the output of the disturbed transmitter to the power of the third-order intermodulation product.

NOTE – Inter-transmitter intermodulation (ITIM) and transmitter intermodulation conversion loss (TIMCL) are related arithmetically by the expression

$$ITIM = TIMCL + 30 \text{ dB}$$

11.2 Method of measurement (antenna terminals)

11.2.1 Method of measurement using a line stretcher and a circulator

a) Connect the equipment as shown in figure 8a.

NOTE 1 – The impedance of all components in the measuring arrangement (with the possible exception of the output impedance of the transmitter under test) should be the same as the characteristic impedance of the measuring arrangement transmission line. The directional couplers should be used to measure the incident and the reflected powers, and to make certain that there is not a gross mismatch between the test load and the measuring arrangement.

b) Operate the transmitter without modulation at rated power output and adjust the selective voltmeter (3) for maximum indication at the operating frequency of the transmitter. Record the carrier level with the switch (4) in position A.

c) Adjust the frequency of the radio-frequency test signal source (9) to a frequency 100 kHz above the operating frequency of the transmitter.

d) Change switch (4) to position B. Adjust the selective voltmeter for maximum reading at the frequency of the radio-frequency test signal source (9) and adjust the test signal level to produce a value 30 dB below the level recorded in step b).

e) With switch (4) in position A and the transmitter operating at rated power, adjust the selective voltmeter for maximum reading at the frequency of the third-order intermodulation product which is 100 kHz below the transmitter operating frequency.

f) Adjust the line stretcher (5) until the maximum level of the intermodulation product is obtained.

g) Repeat step d) and record the level of the signal from the radio-frequency test signal source.

h) Repeat step e) and record the level of the intermodulation product.

i) Change switch (4) to position B and note the reading of the selective voltmeter. A level less than 10 dB lower than that measured in step h) indicates a source of intermodulation other than the transmitter under test, for example the radio-frequency test signal source (9) or the circulator (7). This shall be eliminated and step h) shall then be repeated.

j) The ratio, in decibels, of the level of the transmitter signal measured in step b) to the level of the intermodulation product measured in step h) is the inter-transmitter intermodulation (ITIM).

k) The ratio, in decibels, of the level of the unwanted signal level measured in step g) to the level of the intermodulation product measured in step h) is the transmitter intermodulation conversion loss (TIMCL).

NOTE 2 – The method of measurement can be used for other frequency spacings and levels of the radio-frequency test signal source (9).

NOTE 3 – The selective voltmeter (3) should have a selectivity sufficiently high so as not to be influenced by the carrier level when measuring the intermodulation product.

11.2.2 Method of measurement using a resistive or a capacitive coupler

a) Connect the equipment as shown in figure 8b.

NOTE 1 – In order to reduce mismatch errors, it is important that the 10 dB power attenuator (2) is coupled to the transmitter with the shortest possible connection.

b) Operate the transmitter without modulation at rated power output and adjust the spectrum analyser (8) to give a maximum indication with a frequency span of 500 kHz.

c) Adjust the frequency of the unmodulated radio-frequency test signal source (6) to a frequency 100 kHz above the operating frequency of the transmitter.

d) Adjust the level of the value monitored on the spectrum analyser to 10 dB below the level of the transmitter (as displayed on the spectrum analyser).

NOTE 2 – This procedure will ensure that the ratio of the levels at the transmitter terminals is 30 dB.

e) Measure the intermodulation component by direct observation on the spectrum analyser (8) and record the ratio, in decibels, of the level of the largest intermodulation component to the level of the interfering signal.

f) Calculate the inter-transmitter intermodulation (ITIM) using the following relationship:

$$\text{ITIM} = X - 2\,A_2 \quad \text{dB}$$

where

X is the ratio recorded in step e);

A_2 is the attenuation of the power attenuator (2) (nominally 10 dB).

g) Calculate the transmitter intermodulation conversion loss (TIMCL) using the following relationship:

$$\text{TIMCL} = X - 2\,A_2 - 30 \quad \text{dB}$$

where

X is the ratio recorded in step e);

A_2 is the attenuation of the power attenuator (2) (nominally 10 dB).

NOTE 3 – This method of measurement may be used for other frequency spacings and levels of radio-frequency test signal source (9).

NOTE 4 – The spectrum analyser should have a selectivity sufficiently high so as not to be influenced by the transmitter carrier level when measuring the intermodulation product.

11.3 Method of measurement (integral antenna)

11.3.1 Method of measurement using a circulator and a line stretcher

a) Connect the equipment as shown in figure 8c.

NOTE 1 – The impedance of all components in the measuring arrangement (with the possible exception of the output impedance of the transmitter) should be the same as the characteristic impedance of the measuring arrangement transmission line. The directional couplers should be used to measure the incident and reflected powers, and to make certain that there is not a gross mismatch between the test load and the measuring arrangement. The value of the maximum effective radiated power, P_{max} (see 9.3), is required for this measurement method.

b) Operate the transmitter without modulation at rated power output. Connect P1 (of figure 8c) to Q2 and adjust the attenuator (12) so that the spectrum analyser (3) is operating in its linear region. Record the value of the attenuation of the attenuator (12) in decibels and the level measured on the spectrum analyser in decibels per metre.

c) Calculate and record the amount of the coupling loss (A_c) of the RFCD using the relationship:

$$A_c = P_{max} - A - B \quad \text{dB}$$

where

P_{max} is the maximum effective radiated power (see 9.3);

A is the attenuation of the attenuator (12) recorded in step b);

B is the level measured by the spectrum analyser (3) in step b).

d) With switch (4) in position A, connect P1 to P2 and Q1 to Q2. Adjust the attenuator (12) so that the spectrum analyser is operating in its linear range. Record the level measured on the spectrum analyser (3) in decibels per metre.

e) Adjust the frequency of the radio-frequency test signal source (9) to a frequency 100 kHz above the operating frequency of the transmitter.

f) Change the switch (4) to position B. Adjust the level of the radio-frequency test signal source to produce a level displayed on the spectrum analyser (3) which is below the level recorded in step d) by an amount:

$$30 - 2\,A_c \quad \text{dB}$$

where A_c is the coupling loss calculated in step c).

Record the level indicated.

NOTE 2 – This procedure will ensure that the ratio of the levels at the transmitter antenna is 30 dB.

g) With switch (4) in position A, observe the level of the third-order intermodulation product on the spectrum analyser (3) at the frequency which is 100 kHz below the transmitter operating frequency.

h) Adjust the line stretcher (5) until the maximum level of the intermodulation product is obtained. Record the level in decibels per metre.

i) Change switch (4) to position B and note the reading of the intermodulation product. A level less than 10 dB lower than that measured in step h) indicates a source of intermodulation other than the transmitter under test, for example the radio-frequency test signal source (9) or the circulator (7). This shall be eliminated and the test restarted.

j) Calculate the inter-transmitter intermodulation using the following relationship:

$$\text{ITIM} = D - E - 2\,A_c \quad \text{dB}$$

where

D is the spectrum analyzer level recorded in step d);

E is the spectrum analyzer level recorded in step h);

A_c is the RFCD coupling loss calculated in step c).

k) Calculate the transmitter intermodulation conversion loss (TIMCL) using the following relationship:

$$\text{TIMCL} = F - E - 2\,A_c \quad \text{dB}$$

where

F is the spectrum analyser level recorded in step f);

E is the spectrum analyser level recorded in step h);

A_c is the RFCD coupling loss calculated in step c).

NOTE 3 – This method of measurement may be used for other frequency spacings and levels of radio-frequency test signal source (9).

NOTE 4 – The spectrum analyser should have a selectivity sufficiently high so as not to be influenced by the transmitter carrier level when measuring the intermodulation product.

11.3.2 Method of measurement using a resistive or a capacitive coupler

a) Connect the equipment as shown in figure 8d.

NOTE 1 – In order to reduce mismatch error, it is important that the attenuator (2) is coupled to the RFCD with the shortest possible connections.

NOTE 2 – The value of the maximum effective radiated power, P_{max} (see 9.3), is required for this test.

b) Operate the transmitter without modulation at the rated power output. Connect A1 (figure 8d) to B2 and measure the output of the transmitter on the spectrum analyser (8). Record the spectrum analyser level value in decibels per metre.