INTERNATIONAL STANDARD

IEC 60489-3

1988

AMENDMENT 1
1999-04

Amendment 1

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

**Part 3:
Receivers employing A3E, F3E or G3E emissions**

Amendement 1

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

*Partie 3:
Récepteurs conçus pour 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
102/42/FDIS	102/50/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 published at a later date.

____

Amend the title of this standard on the cover page, the title page and on pages, 7 and 11 as follows:

METHODS OF MEASUREMENT FOR RADIO EQUIPMENT USED IN THE MOBILE SERVICES –

Part 3: Receivers employing A3E, F3E or G3E emissions

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CONTENTS

Replace the title of clause 7 by the following:

Insert after clause 14, the title of the following new clause 15:

Re-number the existing clauses 15 to 21 as clauses 16 to 22, respectively.

Delete the title of the current clause 22.

Replace the title of the current clause 23 by the title of new clause 23:

Re-number clause 24 as clause 25.

Delete the title of clause 25.

Add the title of the following new clause 36:

Page 3

Delete the appendices F to L inclusive.

Add the following new annexes:

Page 7

PREFACE

Add, on page 9, after 489-1 (1983), the following:

Amendment 1 (1986)
Amendment 2 [1)]

Insert, before 489-6 (1987) the following:

IEC 60489-2 (1991): Part 2: Transmitters employing A3E, F3E and G3E emissions
Amendment 1[1)]

Add the following footnote, referring to both amendment 2 of IEC 60489-1 and amendment 1 of IEC 60489-2:

Add, under 489-6 (1987) the following:

ITU-T Recommendation O.41(19/94): Psophometer for use on telephone-type circuits.

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SECTION ONE – GENERAL

1 Scope

Replace the text of this clause by the following:

This standard refers specifically to mobile radio receivers having audio-frequency bandwidths generally not exceeding 10 kHz for the reception of voice and other types of signals, using:

a) angle modulation (frequency modulation (F3E)/phase modulation (G3E)), or
b) double-sideband amplitude modulation with full carrier (A3E).

This standard is intended to be used in conjunction with IEC 60489-1. The supplementary terms and definitions and the conditions of measurement set forth in this standard are intended for type tests and may also be used for acceptance tests.

————————

1) To be published.

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5.10.1 Limitation of the audio-frequency band

Replace the text of this subclause by the following:

Because some properties, for example noise and audio-frequency harmonic distortion, depend upon the audio-frequency bandwidth, 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 should be specified.

In the case of speech transmission, the filter shall be in accordance with the psophometric filter described in ITU-T Recommendation O.41 (see table 1).

Table 1 – Characteristics of the psophometric filter

Frequency Hz	**Relative weighting** dB	**Limit** dB
16,66	–85,0	–
50	–63,0	2
100	–41,0	2
200	–21,0	2
300	–10,6	1
400	–6,3	1
500	–3,6	1
600	–2,0	1
700	–0,9	1
800	0	0 (reference)
900	+0,6	1
1 000	+1,0	1
1 200	0	1
1 400	–0,9	1
1 600	–1,7	1
1 800	–2,4	1
2 000	–3,0	1
2 500	–4,2	1
3 000	–5,6	1
3 500	–8,5	2
4 000	–15,0	3
4 500	–25,0	3
5 000	–36,0	3
6 000	–43,0	–

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6.4 Radio-frequency coupling device (RFCD)

Replace the text of this subclause by the following:

The measurements described in this standard are applicable to receivers having either antenna terminals or an integral antenna.

Measurements of the radio-frequency parameter of receivers having an integral antenna are performed in a test site or in an RFCD. See IEC 60489-1, annex A, for details of these.

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SECTION THREE – METHOD OF MEASUREMENT FOR RECEIVERS EQUIPPED WITH SUITABLE ANTENNA TERMINALS

Replace the title and text of clause 7 by the following:

7 Sensitivity

7.1 Measured usable sensitivity (MUS)

7.1.1 Definition

Level of the input signal at a specified frequency with specified modulation which will result in the standard signal-to-noise ratio (see 3.3) at the output of the receiver.

7.1.2 Method of measurement

a) Connect the equipment as illustrated in figure 3.

b) Apply the standard input signal to the receiver input terminals.

c) Adjust the receiver volume control to obtain the reference output level (see 3.1.2). Record this level.

d) Adjust the input-signal level to produce the standard signal-to-noise ratio. Record this level.

e) If the audio output level obtained in d) is more than 3 dB below the level recorded in step c), this fact should be recorded. The input-signal level at which the audio output level has fallen by 3 dB should be recorded.

f) The measured usable sensitivity is the level recorded in step d). It is expressed as follows: the measured usable sensitivity for a $\frac{S+N+D}{N+D}$ ratio of 12 dB is_____μV or dB (μV).

7.2 Specified usable sensitivity (SUS)

7.2.1 Definition

Level of the input signal specified by the regulatory authority, manufacturer or customer at the specified input-signal frequency (see 5.5) with standard modulation (see 5.6) which results in a signal-to-noise ratio, equal to or greater than the standard signal-to-noise ratio.

NOTE – To make meaningful measurements, the specified input-signal level should be chosen taking into account the dispersion of the sensitivities of various equipment in defined environmental conditions.

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8 Acceptable radio-frequency displacement

Replace the text of this clause by the following:

8.1 Definition

Change of input-signal frequency that is required to restore the standard signal-to-noise ratio after an increase of the input-signal level by 6 dB from the sensitivity (SUS or MUS). The acceptable radio-frequency displacement is then the smaller of the two possible radio-frequency displacements.

NOTE – Radio-frequency displacement is an absolute value and an increase in the displacement is to move the radio-frequency away from the nominal frequency.

8.2 Method of measurement

a) Connect the equipment as illustrated in figure 3.

b) Apply the standard input signal to the receiver input terminals.

c) Adjust the receiver gain control to obtain the reference output level (see 3.1.2). Record this level.

d) Adjust the input-signal level to produce the standard signal-to-noise ratio or the sensitivity (SUS). Record this level.

e) Increase the input signal level in step d) by 6 dB and then increase the input signal frequency until the standard signal-to-noise ratio is again obtained. Record this frequency.

f) Repeat step e) for input signal frequencies below the standard input-signal frequency.

8.3 Presentation of results

a) Calculate and record the differences between the standard input-signal frequency of the receiver and each of the frequencies recorded in steps e) and f), respectively.

b) The acceptable radio-frequency displacement (SUS or MUS) is the smaller of the two values in step a).

c) Record the standard input-signal frequency.

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10.3 Presentation of results

Replace the existing subclause by the following:

Plot the values recorded in step e), in decibels relative to the level at 1 kHz, on the linear ordinate of a graph, and the modulating frequency on the logarithmic abscissa.

Calculate the audio-frequency response deviations from reference audio-frequency response, in decibels, taking the deviation at 1 000 Hz equal to 0 dB. The deviation from the reference audio-frequency response, having de-emphasis of –6 dB/octave, shall be calculated according to the data listed in the table below, unless otherwise specified in the equipment specification.

Modulation frequency Hz	300	500	1 000	2 000	3 000	3 400
Reference value dB	+10,5	+6,0	0	–6,0	–9,5	–10,6

If de-emphasis is not provided in the receiver, flat audio-frequency response is considered as reference one in the specified audio-frequency bandwidth.

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Figure 5

Replace, in figure 5, "Reference Sensitivity" *with* "Sensitivity (SUS or MUS)".

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Insert the following new clause before the current clause 15:

15 Expander characteristics

This measurement is applicable to receivers intended for the reception of angle-modulated signals.

15.1 Expander overall amplitude characteristics

15.1.1 Definition

Relationship between the deviation of the received carrier, at one frequency, and the audio level or the receiver output.

15.1.2 Method of measurement

a) Connect a radio-frequency signal source to the input of the receiver.

b) Modulate the radio-frequency signal source with an audio-frequency tone of 1 kHz to obtain 25 % of the maximum permissible frequency (or phase) deviation.

c) Measure the audio level at the receiver output. This is the reference level.

d) Change the frequency deviation which is specified by users and manufacturers, and measure the audio level at the receiver output.

e) Calculate the relative level at the receiver output, using the reference value obtained in step c), for each frequency deviation measured in step d).

15.2 Expander attack and recovery time

15.2.1 Definitions

Expander attack time is the time between the instant when a step increase of carrier frequency deviation is applied and the instant when the audio level at the receiver output rises to a value equal to 0,75 times the new steady-state value.

Expander recovery time is the time between the instant when a step decrease of the carrier frequency deviation is applied and the instant when the audio level at the receiver output falls to a value equal to 1,5 times the new steady-state value.

15.2.2 Method of measurement

a) Connect a radio-frequency signal source to the input of the receiver.

b) Modulate the radio-frequency signal source with an audio tone frequency of 2 kHz to obtain 25 % of the maximum permissible frequency (or phase) deviation.

c) Measure the audio level at the receiver output.

d) Change the deviation of the radio-frequency signal source to 50 % of the maximum permissible frequency (or phase) deviation.

e) Measure the level at receiver output. Note the result.

f) Switch the deviation from 50 % to 25 % within 100 µs and measure the time for the audio level of the speaker input to fall to 1,5 times the value recorded in step c). Record this time as the recovery time.

g) Switch the deviation from 25 % to 50 % within 100 µs and measure the time taken for the audio level at the receiver output to rise 0,75 times of the value recorded in step e). Record this time as the attack time.

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15 Impulsive noise

Renumber this clause as clause 16.

15.2.1 Definition

Replace the text of this subclause by the following. The subclause number becomes 16.2.1.

Ability of a receiver to prevent impulsive noise from degrading the desired response at the output of the receiver.

It is expressed as the ratio of

a) the median level of spectrum amplitude of the impulsive noise that causes a wanted signal, which is 3 dB in excess of the sensitivity (SUS or MUS), to restore the standard signal-to-noise ratio at the receiver output terminals

to

b) the wanted signal level (sensitivity (SUS) plus 3 dB) or the sensitivity (MUS) (the wanted signal level is the sensitivity (MUS) plus 3 dB).

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15.2.2 Method of measurement

Replace, in this subclause, the number of which becomes 16.2.2 according to the new numbering, Note 1 by the following:

NOTE 1 – The value of the sensitivity (SUS or MUS) determined in 7.1.2 or defined in 7.2.1 is required for this measurement.

Replace c) of 15.2.2 by the following:

c) In the absence of the impulsive noise, apply the standard input signal to terminal A and B of the combining network (see 5.3). Reduce its level to obtain the sensitivity (SUS or MUS) at the input of the receiver.

15.2.3 Presentation of result

In the new 16.2.3, replace twice "reference sensitivity" *with* "sensitivity (SUS or MUS)".

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16 Selectivity

Replace the text of this clause by the following. The new clause number becomes 17.

17.1 General

Selectivity is the ability of the receiver to discriminate between wanted and unwanted input signals.

The methods of measurement described in this clause deal only with interference that degrades the receiver output signal due to the simultaneous presence of a wanted and an unwanted input-signal. It is to be noted, however, that unwanted signals may also be objectionable when the wanted signal is not present.

The methods of measurement are described in a manner which allows the limit for the selectivity of the receiver to be expressed either as

a) the ratio of the level of the unwanted input signal to the level of the wanted signal, which is set to the SUS (see 7.2) plus 3 dB; this is expressed as "selectivity (SUS)";

or

b) the ratio of the level of the unwanted input signal level to the value of the sensitivity (MUS) (see 7.1), the wanted signal being set 3 dB above the value of the MUS; this is expressed as "selectivity (MUS)".

Figure 11 illustrates the two methods.

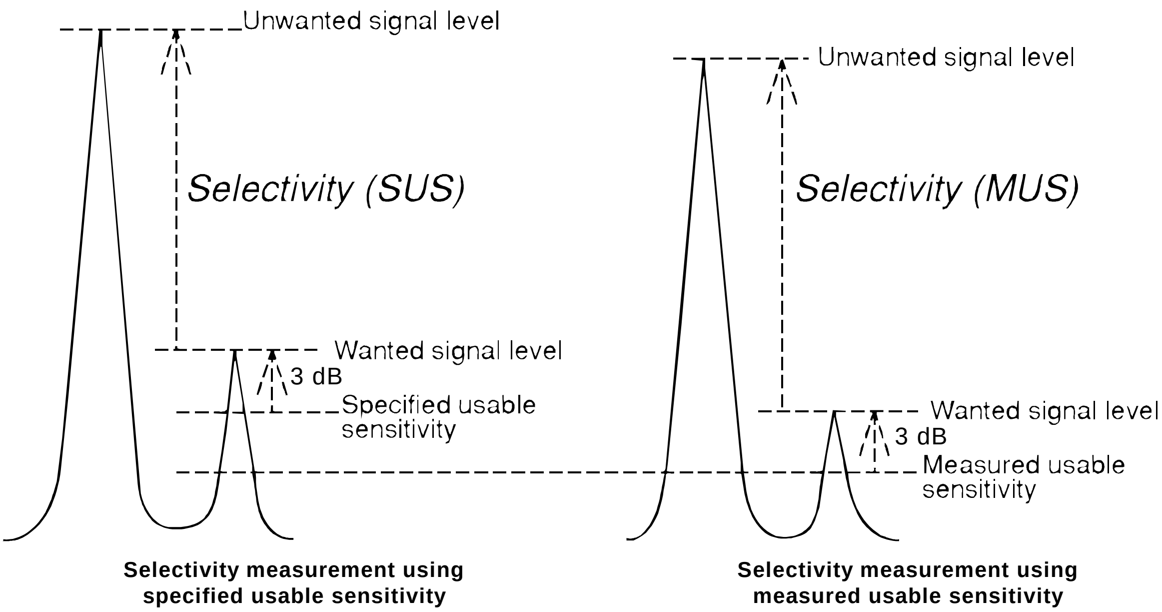

Figure 11 – Illustration of selectivity (SUS and MUS)

These two methods of measurement are intended to cover different practical applications.

The SUS method is intended to cover the case of mobile radio systems used in environments having a high level of interference (e.g. in areas where the cell size is mainly determined by interference) and where the frequency planning is based on parameters virtually common to all radio systems implemented in that area.

The MUS method is intended to cover the case of mobile radio systems used in environments having a low level of interference (e.g. rural areas), where the actual measured usable sensitivity (MUS) and radio-frequency coverage are the key factors, together with the overall power budget of the links.

These two methods generally provide different results. In the special case where the sensitivity (MUS) of a particular equipment is equal to the sensitivity (SUS), the level of the wanted and unwanted signals used in both measurements will be the same, but the results calculated according to the two methods will differ by 3 dB.

17.2 Adjacent signal selectivity (including co-channel rejection and blocking)

17.2.1 Definition

Ability of the receiver to minimize the degrading effect of an unwanted adjacent signal on the desired response at the output of the receiver. It is the ratio, expressed in decibels, of

a) the level of an unwanted input signal that causes a wanted input signal, which is 3 dB in excess of the sensitivity (SUS or MUS), to produce the standard signal-to-noise ratio

to

b) the wanted signal level (sensitivity (SUS) plus 3 dB), or the sensitivity (MUS) (the wanted signal level is sensitivity (MUS) plus 3 dB).

Co-channel rejection is a particular case of adjacent signal selectivity where the difference between the unwanted signal frequency and the standard input-signal frequency is a specified amount less than 300 Hz.

Blocking is a particular case of adjacent signal selectivity where the difference between the unwanted signal frequency and the standard input frequency is a specified amount greater than 1 % of the standard input-signal frequency.

17.2.2 Method of measurement

NOTE – Knowledge of the sensitivity (SUS or MUS) is required in this measurement.

a) Connect the equipment as illustrated in figure 3 and connect a second audio-frequency signal generator (unwanted signal source) to terminal B of the appropriate matching or combining network (see appendix A).
b) In the absence of the unwanted signal, apply the standard input signal to terminal A of the combining network. Reduce its level to the level of the sensitivity (SUS or MUS). Record this level in µV or dB(µV).
c) Increase the level of this wanted input signal by 3 dB.
d) Apply an unwanted input-signal, modulated with 400 Hz at a modulation depth of 60 % or at 60 % of the permissible frequency deviation, to terminal B of the combining network.
e) Adjust the unwanted signal frequency by a specified amount above and below the wanted signal frequency and adjust the unwanted signal level each time so as to re-establish the standard signal-to-noise ratio. Record these levels in µV or dB(µV).
f) Step e) may be repeated for other values of frequency displacement.

17.2.3 Presentation of results

a) Calculate the ratios, in decibels, of the unwanted signal levels recorded in 17.2.2 step e) to the level of the wanted signal. (The wanted signal level is 3 dB above the sensitivity (SUS)). The smaller value is the adjacent signal selectivity (SUS) and is expressed in decibels,

or

b) Calculate the ratios, in decibels, of the unwanted signal levels recorded in 17.2.2 step e) to the sensitivity (MUS). (The wanted signal level is 3 dB above the sensitivity (MUS)). The smaller value is the adjacent-signal selectivity (MUS) and is expressed in decibels.

NOTE – The result may be displayed in a table.

17.3 Adjacent channel selectivity

Where the mobile radio service uses discrete channel spacings, the value of the adjacent signal selectivity, measured with a signal spacing equal to the discrete channel spacing, may be quoted as the value of the adjacent channel selectivity, for a given frequency spacing of the channels.

17.4 Cross-modulation

This test is normally performed only on amplitude-modulation receivers.

17.4.1 Definition

Amplitude modulation of the wanted signal, within the receiver, by the modulation of an unwanted signal.

It is expressed as the ratio of:

a) the level of an unwanted signal, with specified modulation, that results in a specified signal level at the receiver output terminals,

to

b) the level of the wanted unmodulated input signal.

17.4.2 Method of measurement

a) Connect the equipment as illustrated in figure 3 and connect a second radio-frequency signal generator (unwanted signal source) to terminal B of the appropriate matching or combining network (see appendix A).

b) In the absence of the unwanted signal, apply the standard input signal (see 5.3 and 5.4) to terminal A of the combining network. Record this level in μV or dB(μV).

c) Adjust the receiver volume control, if available, to produce the reference output level.

d) Remove the modulation from the wanted input signal.

e) Apply an unwanted signal with the standard modulation to terminal B of the combining network and adjust the unwanted input signal to a frequency approximately 100 kHz above or below the standard input-signal frequency. (For receivers in which the adjacent signal selectivity at 100 kHz would affect the results, use a greater frequency separation.)

f) Increase the unwanted input signal level until the signal at the receiver output terminals is 20 dB below the reference output level. Record the unwanted input signal level in μV or dB(μV).

NOTE – To test that the observed effect is cross-modulation, remove the wanted signal and verify that the unwanted audio-frequency signal disappears from the receiver output terminals.

g) Calculate the ratio, in decibels, of the level recorded in step f) to the level in step b). The smaller ratio is cross-modulation attenuation. If the effect of cross-modulation is required to be stated as an absolute level, use the level recorded in step f).

17.5 Spurious response immunity

17.5.1 Definition

Ability of the receiver to prevent a single unwanted spurious signal from degrading the desired response at the output of the receiver. It is the ratio, expressed in decibels, of

a) the level of an unwanted input signal that causes a wanted input signal, which is 3 dB in excess of the sensitivity (SUS or MUS), to produce the standard signal-to-noise ratio

to

b) the wanted signal level (sensitivity (SUS) plus 3 dB), or the sensitivity (MUS) (the wanted signal level is sensitivity (MUS) plus 3 dB).

17.5.2 Method of measurement

a) Connect the equipment as illustrated in figure 3, and connect a second signal generator (unwanted signal source) to terminal B of the appropriate matching or combining network (see appendix A).

b) In the absence of the unwanted signal, apply the standard input signal to terminal A of the combining network. Reduce its level to the level of the sensitivity (SUS or MUS). Record this level in µV or dB(µV).

c) Increase the level of this wanted input signal by 3 dB.

d) Apply a high-level, unwanted input signal, for example, 90 dB (µV), modulated with 400 Hz at a modulation depth of 60 %, or at 60 % of the permissible frequency deviation, as appropriate for the class of emission, to terminal B of the combining network.

e) Vary the unwanted input-signal frequency over a specified range to search for a degradation of the signal-to-noise ratio. When a response is found, carefully adjust the frequency of the unwanted signal to maximize the degradation.

f) At the frequency of each spurious response, change the level of the unwanted input signal until the standard signal-to-noise ratio is obtained at the receiver output terminals. Record the frequency of the unwanted input-signal and record its level at the input of the receiver in µV or dB(µV).

17.5.3 Presentation of results

a) Calculate the ratios, in decibels, of the unwanted signal levels recorded in 17.5.2 step f) to the level of the wanted signal. (The wanted signal level is 3 dB above the sensitivity (SUS)). The smaller value is the spurious response immunity (SUS) and is expressed in decibels,

or

b) calculate the ratios, in decibels, of the unwanted signal levels recorded in 17.5.2 step f) to the sensitivity (MUS). (The wanted signal level is 3 dB above the sensitivity (MUS)). The smaller value is the spurious response immunity (MUS) and is expressed in decibels.

Tabulate these ratios or the absolute values obtained in step f) together with the frequencies recorded in step f). Record the nominal operating frequency.

17.6 Intermodulation immunity

17.6.1 Definition

Ability of the receiver to prevent two unwanted adjacent signals which have specific frequency relationship to the wanted signal frequency (see appendix D), from degrading the desired response of the receiver output. It is the ratio, expressed in decibels, of

a) the common level of two unwanted input signals that cause a wanted input signal, which is 3 dB in excess of the sensitivity (SUS or MUS), to produce the standard signal-to-noise ratio

to

b) the wanted signal level (sensitivity (SUS) plus 3 dB), or the sensitivity (MUS) (the wanted signal level is sensitivity (MUS) plus 3 dB).

17.6.2 Method of measurement

a) Connect the equipment as illustrated in figure 3, and connect two additional signal generators (unwanted signal sources) to terminals B and C of an appropriate matching or combining network (see appendix A).

b) In the absence of the unwanted signal, apply the standard input signal to terminal A of the combining network. Reduce its level to the level of the sensitivity (SUS or MUS). Record this level in µV or dB(µV).

c) Increase the level of this wanted input signal by 3 dB.

d) Apply an unwanted unmodulated input signal from the generator connected to terminal B of the combining network and adjust it to a specified frequency f_n (see appendix D).

e) Apply an unwanted unmodulated input signal from the generator connected to terminal C of the combining network and adjust its frequency to a specified frequency f_r (see appendix D).

f) Incrementally increase the levels of the two unwanted signals until the signal-to-noise ratio is degraded.

g) Carefully adjust the frequency of one of the unwanted signals to maximize the degradation.

h) Adjust the levels of the unwanted signals to be equal at the receiver input and to produce the standard signal-to-noise ratio at the receiver output. Record this level in µV or dB(µV).

17.6.3 Presentation of results

a) Calculate the ratios, in decibels, of the unwanted signal levels recorded in 17.6.2 step h) to the level of the wanted signal. (The wanted signal level is 3 dB above the sensitivity (SUS).) The smaller value is the intermodulation immunity (SUS) and is expressed in decibels,

or

b) calculate the ratios, in decibels, of the unwanted signal levels recorded in 17.6.2 step h) to the sensitivity (MUS). (The wanted signal level is 3 dB above the sensitivity (MUS).) The smaller value is the intermodulation immunity (MUS) and is expressed in decibels.

Record these ratios or the absolute values recorded in step h). Record the nominal operating frequency.

NOTE – Measuring errors may result from intermodulation between generators, generator noise or receiver desensitization. See appendix B for precautions regarding the signal generators.

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17 Automatic gain control (AGC) characteristic

Replace the text of this clause and re-number the title and text as clause 18:

NOTE – This test is only applicable to the A3E mode.

18.1 Definition

Change in output level as a function of the level of the input signal.

18.2 Method of measurement

a) Connect the equipment as illustrated in figure 3.

b) Apply the standard input signal and increase its level to 100 dB(µV).

c) Adjust the receiver for the reference output level.

d) Progressively reduce the input signal level and record the output power for each level of the input signal. Continue until sensitivity (SUS or MUS) is reached.

e) The measurement may be continued at lower input signal levels to determine the performance at levels below the sensitivity (SUS or MUS).

f) The upper limit of automatic gain control characteristic is defined as input signal level value at which the total distortion factor becomes equal to the specified value and signal level change at the receiver output does not exceed the specified value. The lower limit of automatic gain control characteristic is defined as the receiver output level value at the input signal level equal to the sensitivity (SUS).

18.3 Presentation of results

Plot the relative output level in decibels on the linear ordinate of a graph and the input-signal level in dB(µV) on the linear abscissa. Record the reference output level.

The performance of automatic gain control is expressed in the following form:

– specified signal level change at the receiver input by ___ dB versus signal level change at the receiver output of ___ dB.

Alternatively, a table of values may be presented.

18.4 Dynamic automatic gain control characteristic

18.4.1 General

The dynamic automatic gain control characteristic is the transient effect upon the level of the output signal caused by a sudden change of input signal level. It is defined in terms of its attack and recovery times.

18.4.2 Definition – AGC attack time

Elapsed time from the instant at which the input signal level is suddenly increased by a specified amount until the instant at which the level of the output signal reaches and remains within 2 dB of the subsequent steady-state value.

18.4.3 Method of measurement

a) Connect the equipment as illustrated in figure 3 and connect an oscilloscope in parallel with the audio-frequency test load. Connect an electronically controlled attenuator capable of providing a specified change in input-signal level, for example 20 dB, between the radio-frequency signal source and the receiver input terminals.

b) Set the attenuator to its maximum attenuation.

c) Apply the standard input signal and reduce its level to sensitivity (SUS or MUS).

d) A receiver equipped with an accessible volume control should be adjusted to provide a level of at least 20 dB below the rated audio-frequency output level.

e) Synchronize the calibrated horizontal sweep of the oscilloscope with the attenuator actuating signal.

f) Actuate the attenuator.

g) Measure the time between the instant of actuating the attenuator and the instant after which the output signal reaches and remains within 2 dB of the subsequent steady-state level (points A and B in figure 7). This is the AGC attack time.

NOTE – A variation of this method is to use a dual-trace storage oscilloscope to show on one trace the radio-frequency signal, and on the other trace the audio-frequency signal.

18.4.4 Definition – AGC recovery time

Elapsed time from the instant when the input signal level is suddenly decreased by a specified amount until the instant at which the output signal reaches and remains within 2 dB of the subsequent steady-state value.

18.4.5 Method of measurement

a) Carry out steps a) to f) in 18.4.3, but arrange to decrease the input signal level, for example by 20 dB, at the moment of change.

   The radio-frequency input signal level initially applied should be approximately 20 dB greater than sensitivity (SUS or MUS).

b) Measure the time between the instant of actuating the attenuator and the instant after which the output signal reaches and remains within 2 dB of the subsequent steady-state level (points C and D in figure 7). This is the AGC recovery time.

NOTE – A variant of this method is to use a dual-trace storage oscilloscope to show on one trace the radio-frequency signal, and on the other trace, the audio-frequency signal.

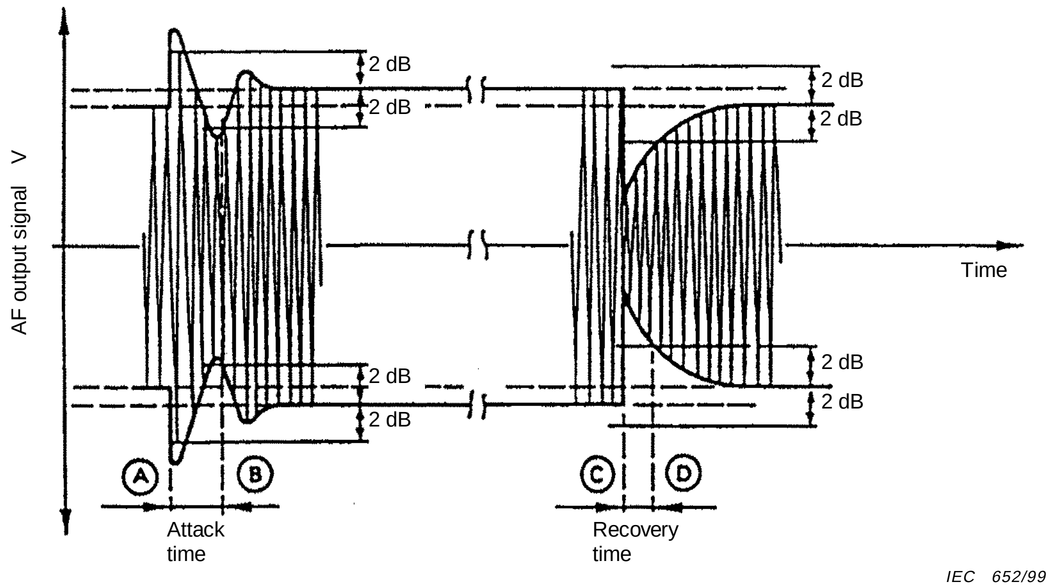

Figure 7 – Example of dynamic AGC characteristic

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18 Radiated spurious components

Replace the text of this clause by the following. The new clause number becomes 19:

The radiated spurious components are any radiation originating from within a receiver.

The radiated spurious components of a receiver may contain

– average radiated spurious components;
– maximum effective radiated spurious components;
– RFM (random field measurement) radiated spurious components;
– RFCD radiated spurious components.

The method of measurement for each of the above is the same as that for the radiated radio-frequency power of transmitters described in 9.2 to 9.5 of IEC 60489-2 respectively, replacing the words transmitter with receiver and radiated power with radiated spurious components.

Attention is necessary for the following difference between the radiated spurious components and the radiated radio-frequency power of transmitters in proceeding with the measurement mentioned in the subclause procedures.

1) The power levels of the radiated spurious components of receivers are far below the radiated radio-frequency power of transmitters and these test sites or RFCD which have higher coupling loss may not be able to measure low-level ones. A lower coupling loss test site, RFCD or measurement condition should be chosen.
2) If the receiver has an antenna terminal, it shall be terminated in a test load having an impedance equal to the nominal radio-frequency input impedance.
3) A transmitter transmits a frequency or frequencies which are known. However, frequencies of the radiated spurious components may not be known, and searching for and identifying them may be necessary. If necessary, closely couple a selective measuring device to the receiver under test.
4) The polarization of the radiated spurious components may not be the same as the antenna polarization. Confirmation of the radiation polarization may be necessary with measuring antenna polarization change.

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Delete figure 8.

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19 Conducted spurious components

Change clause number to 20.

Page 67

20 Evaluation of the receiving part of the equipment under duplex conditions

Change clause number to 21.

21 Receiver performance under conditions deviating from standard test conditions

Change clause number to 22 and add, on page 71, the following new subclauses:

22.11 Sensitivity of two-branch diversity receiver under multipath propagation conditions

22.11.1 Definition

RMS level of a Rayleigh faded input signal at a specified frequency with specified modulation which will produce the averaged signal-to-noise ratio of 12 dB at the output of the receiver.

NOTE – The median value of the envelope is 1,6 dB less than the r.m.s. value.

22.11.2 Method of measurement

a) Connect the equipment as illustrated in figure 12 (see annex M for details of a dual channel Rayleigh fading simulator).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies.

c) Modulate the radio-frequency signal generator (2) with a 1 000 Hz tone at standard deviation using an audio-frequency signal generator (1).

d) Apply the output of the radio-frequency signal generator (2) to the dual channel Rayleigh fading simulator (3) at the level specified by the manufacturer of the fading simulator.

e) Adjust the correlation factor of the simulator (3) to zero.

f) Adjust the velocity of the simulator (3) to a specified velocity. This may be specified as "maximum Doppler frequency" (f_m) or "velocity" (v). Record this value.

   $f_m = v$/wavelength

g) Record the r.m.s. value of the output signals of the simulator in dB (µV).

h) Adjust the step attenuators (4,4') for equal levels into each receiver branch at a level that is expected to yield the sensitivity of a two-branch diversity receiver under multipath propagation conditions.

i) 1) Measure the true r.m.s. voltage level of *S+N+D* (signal + noise + distortion) Vi at the output of the receiver during the time of measurement T. T shall be greater than 200/f_m (s). In order to measure the average value of a time varying *S+N+D*, an averaging technique is applied. The averaging process requires *n* data samples which are the instantaneous values sampled by a frequency greater than 100 × f_m, or the integrated values during a sub-multiple (less than one-fiftieth) of the measuring time T.

   NOTE – The length of the measuring time T has been chosen in order to achieve a dispersion of 1 dB. See annex N.

   2) Calculate SND_{AVE} by the following equation adding the squares of the r.m.s. voltages and dividing the sum by the number of samples:

$$SND_{AVE} = \frac{\sum_{i}^{n} Vi^2}{n}$$

j) 1) Using a distortion level meter with signal filtering characteristics as given in 6.2, measure the true r.m.s. voltage level of *N+D* (noise + distortion) *Vi′* output of the receiver. Use the same number *n* of samples and test period as in i)1).

2) Add the squares of the r.m.s. voltage and divide the sum by the number of samples.

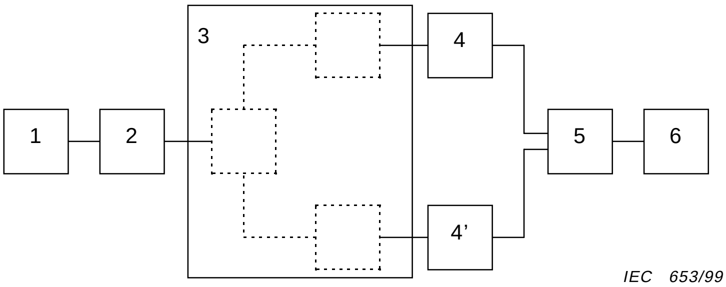
$$ND_{AVE} = \frac{\sum_{i}^{n} Vi'^2}{n}$$

k) Calculate $SINAD_{AVE}$ as follows from the number obtained in i)2) and j)2).

$$SINAD_{AVE} = 20\log\frac{SND_{AVE}}{ND_{AVE}}$$

l) 1) If $SINAD_{AVE}$ < 11 dB, reduce both step attenuators by an equal amount, selected to result in a measurement closer to 12 dB.

2) If $SINAD_{AVE}$ > 13 dB, increase both step attenuators by an equal amount, selected to result in a measurement closer to 12 dB.



Key

1	Audio-frequency generator	4	4': step attenuator (1 dB step)
2	Radio-frequency generator	5	Diversity receiver under test
3	Dual channel Rayleigh fading simulator	6	*SINAD* meter

Figure 12 – Arrangement for measuring diversity receivers

m) Repeat i) 1) until $SINAD_{AVE}$ = 12 ± 1 dB.

n) Using the procedures recommended by the manufacturer of the Rayleigh fading simulator, and the attenuation settings of the step attenuators, determine the r.m.s. voltage of the radio-frequency input to the receivers. Record this level as the sensitivity.

o) Repeat steps f) to n) for other fading rates as necessary for the type of equipment being tested (see annex M).

22.11.3 Presentation of results

The sensitivity is expressed as follows:

the sensitivity for a *SINAD* of 12 dB is _µV or dB (µV) at _ fading rate.

NOTE 1 – *SINAD* is defined as $\frac{S+N+D}{N+D}$

Add the following new clause:

23 Receiver output power

23.1 Definition

Receiver output power at pure resistance load equal to the nominal value of actual load impedance at 1 000 Hz.

23.2 Method of measurement

a) Connect the equipment as illustrated in figure 3.

b) Apply a standard input signal to the receiver input terminals.

c) Adjust the receiver volume control (if applicable) to obtain maximum output without exceeding the permissible total distortion factor specified by the manufacturer.

d) Measure the receiver output voltage (V) in terms of r.m.s. value at the load.

e) Calculate the output power of the receiver according to the formula given below:

$$P = \frac{V^2}{R}$$

where R is the resistance equal to the nominal value of the actual load impedance at 1 000 Hz.

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SECTION FOUR – METHODS OF MEASUREMENT FOR RECEIVERS WITH INTEGRAL ANTENNAS

22 Reference (radiation) sensitivity

Replace the existing clause 22 by the following, and the new clause number becomes 24:

24 Radiation sensitivity

24.1 General

The radiation sensitivity of a receiver may contain

– reference radiation sensitivity (MUS);
– normal radiation sensitivity (SUS or MUS);
– RFM radiation sensitivity (SUS or MUS);
– RFCD radiation sensitivity (SUS or MUS);
– average radiation sensitivity (SUS or MUS);
– diversity radiation sensitivity (SUS or MUS).

Receivers having an integral antenna or having no facility for connecting the external measuring equipment require special measuring arrangements. The arrangements for the former ones are test sites or RFCDs and for the later ones are the baseband signal connection arrangements. They are described in IEC 60489-1, annex A.

Deviations from standard atmospheric conditions may occur for measurements made out of doors. The actual conditions, however, should not cause the measurement results to deviate appreciably from those which have been obtained under standard test conditions.

24.2 Reference radiation sensitivity (MUS)

24.2.1 Definition

Minimum field strength of a signal at a specified frequency with specified modulation which will produce the standard signal-to-noise ratio at the output of the receiver. It will be found in a direction of horizontal plane.

NOTE – The reference sensitivity can be measured in OATS (open area test sites), LRTS (low reflection test sites) or 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.

24.2.2 Method of measurement for equipment fitted with squelch circuits (MUS)

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

b) Calibrate the test site and place the receiver under test as illustrated in a subclause for the chosen test site in the above-mentioned annex.

c) Measure the squelch opening level according to the combination of the same method of measurement for receivers equipped with suitable antenna terminals (see 13.1) and the basic measuring procedure for radiation measurement described in the above-mentioned subclause. Record this level in microvolts.

NOTE – In the case of an adjustable squelch, it is recommended to open it using an input signal level which provides a signal-to-noise ratio between 10 dB and 20 dB, as estimated by a listening test.

d) Rotate the equipment under test 45° clockwise in a horizontal plane and measure this direction squelch opening level by the same procedure used in step c).

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

f) Make a table of results and, if desired, plot them as points on a polar diagram.

g) If the results indicate that at a particular azimuth angle the level is significantly less than at other angles, determine the minimum level required to open the squelch, by proceeding as follows.

   In the vicinity of the assumed azimuth for the minimum level, select smaller azimuthal rotation angles, for example 15°, and for each azimuthal position, measure the level. Record the lowest level.

h) Transfer the equipment to an RFCD at a determined position and in a determined direction. Apply the standard input signal to the RFCD, and adjust the level to just open the squelch. Record this level in microvolts.

i) Adjust the output level of the radio-frequency signal generator to obtain the standard signal-to-noise ratio at the output of the sound-level meter. Record the output level of the radio-frequency generator in microvolts.

j) Calculate and record the ratio of the levels recorded in steps h) and i).

k) Multiply the level determined in step g) by the ratio recorded in step j) to obtain the minimum field strength needed to produce the standard signal-to-noise ratio.

   The field strength is the reference radiation sensitivity (MUS).

24.2.3 Method of measurement for equipment not fitted with squelch circuits (MUS)

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

b) Calibrate the test site and place the receiver under test as illustrated in a subclause for the chosen test site in the above-mentioned annex.

c) Measure the sensitivity (MUS) according to the combination of the same method of measurement for receivers equipped with suitable antenna terminals (see 7.1) and the basic measuring procedure for radiation measurement described in the above chosen subclause. Record this level in microvolts.

d) Rotate the equipment under test 45° clockwise in a horizontal plane and measure this direction sensitivity (MUS) by the same procedure used in step c).

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

f) Make a table of results and, if desired, plot them as points on a polar diagram.

g) If the results indicate that at a particular azimuth angle the level is significantly less than at other angles, determine the minimum level required to open the squelch, by proceeding as follows.

   In the vicinity of the assumed azimuth for the minimum level, select smaller azimuthal rotation angles, for example 15°, and for each azimuthal position, measure the level. Record the lowest level.

   The field strength is the reference radiation sensitivity (MUS).

24.3 Normal radiation sensitivity (SUS or MUS)

24.3.1 Definition

Field strength of a signal for the normal direction of a receiver, at a specified frequency with specified modulation which will produce the standard signal-to-noise ratio at the output of the receiver. The normal direction is specified by the manufacturer.

NOTE 1 – The normal direction of the equipment under test is usually the operation accessing side and is specified by the manufacturer. The normal direction may be the specific direction used for RFCD calibration measurements.

NOTE 2 – The normal radiation sensitivity can be measured in OATS (open area test sites), LRTS (low reflection test sites) or 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.

24.3.2 Method of measurement for normal radiation sensitivity (MUS)

NOTE 1 – Equipment fitted with squelch circuits measures the squelch opening level, and equipment not fitted with squelch circuits measures the sensitivity (MUS) in step c).

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

b) Calibrate the test site and place the receiver under test as illustrated in a subclause for the chosen test site in the above-mentioned annex.

c) Measure the squelch opening level or the sensitivity (MUS) for the normal direction of the equipment, according to the combination of the same method of measurement for receivers equipped with suitable antenna terminals (see 13.1 or 7.1 respectively), and the basic measuring procedure for radiation measurement described in the appropriate subclause. Record this level in microvolts.

For equipment not fitted with squelch circuits, the field strength is the reference radiation sensitivity (MUS). For equipment fitted with squelch circuits, continue with the following steps.

NOTE 2 – In the case of an adjustable squelch, it is recommended to open it using an input signal level which provides a signal-to-noise ratio between 10 dB and 20 dB, as estimated by a listening test.

d) Transfer the equipment to an RFCD at a determined position and in a determined direction. Apply the standard input signal to the RFCD, and adjust the level to just open the squelch. Record this level in microvolts.

e) Adjust the output level of the radio-frequency signal generator to obtain the standard signal-to-noise ratio at the output of the baseband signal connection arrangement. Record the output level of the radio-frequency generator in microvolts.

f) Calculate and record the ratio of the levels recorded in steps d) and e).

g) Multiply the level determined in step d) by the ratio recorded in step f) to obtain the minimum field strength needed to produce the standard signal-to-noise ratio.

The field strength is the radiation sensitivity (MUS) for equipment fitted with squelch circuits.

24.3.3 Compliance test method – Normal radiation sensitivity (SUS)

a) For equipment not fitted with squelch circuits, go to step d). For equipment fitted with squelch circuits, carry out the following procedure.

   Place the equipment in an RFCD at a determined position and in a determined direction. Apply the standard input signal to the RFCD, and adjust the level to just open the squelch. Record this level in microvolts.

b) Adjust the output level of the radio-frequency signal generator to obtain the standard signal-to-noise ratio at the output of the baseband signal connection arrangement. Record the output level of the radio-frequency generator in microvolts.

c) Calculate and record the ratio of the levels recorded in steps a) and b).

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

e) Calibrate the test site and place the receiver under test as illustrated or described in a subclause for the chosen test site in the above-mentioned annex.

f) Adjust the field strength to the value of the radiation sensitivity (SUS) or the value multiplied by the ratio recorded in step c).

g) If the receiver output signal-to-noise ratio is more than the standard signal-to-noise ratio or the squelch opens, record that the receiver does comply with the normal radiation sensitivity (SUS) specification, otherwise record that it does not comply.

24.4 RFM radiation sensitivity (SUS or MUS)

24.4.1 Definition

Median field strength value of received signal, at a specified frequency with specified modulation, in an RFM test site, over which the receiver output signal-to-noise ratio exceeds the standard signal-to-noise ratio for more than half the positions in 360 or more positions in a measuring period.

NOTE – RFM radiation sensitivity (SUS and MUS) can be measured in an RFM site.

24.4.2 Method of measurement for RFM radiation sensitivity (MUS)

NOTE – A receiver output signal-to-noise ratio, a squelch opening level or a receiving signal strength indicator may be used for this measurement with one of the baseband signal connection arrangements. However, these receiver circuit responses and measurement times should be faster than the random path travelling time divided by M (measuring position number in the random path; see A.2.5.3.2 of IEC 60489-1).

The receiver output signal-to-noise ratio with the direct electrical connection measuring arrangement or the receiving signal strength indicator with the loop-back arrangement from a receiver to a transmitter input in duplex operation equipment are used in the following method. The duplex operation equipment may only be able to transmit a signal which corresponds to the receiving signal, whether this exceeds the predetermined level or not.

a) Calibrate the RFM site and place the receiver under test as illustrated in A.2.5 of IEC 60489-1.

b) Measure the RFM radiation sensitivity (MUS) according to the basic measuring procedure described in the subclause mentioned. Record this level in microvolts.

If the receiving signal strength indicator is used, and an input signal level which produces the receiver output, the standard signal-to-noise ratio is identified in the indicator level and can be used as the standard signal-to-noise ratio level. If the same indicator is used, and the same level mentioned above is not identified in the indicator level, conversion from the indicator level of measured receiving signal strength to the standard signal-to-noise ratio level is necessary. The conversion ratio can be derived from steps a) to c) in 24.3.3, but replacing the squelch opening level by the receiving signal strength indicator level.

24.4.3 Compliance test method – RFM radiation sensitivity (SUS)

NOTE – A receiver output signal-to-noise ratio, a squelch opening level or a receiving signal strength indicator may be used for this measurement with one of the baseband signal connection arrangements. However, these receiver circuit responses and measurement times should be faster than the random path travelling time divided by M (measuring position number in the random path; see A.2.5.3.2 of IEC 60489-1).

The receiver output signal-to-noise ratio with the direct electrical connection measuring arrangement or the receiving signal strength indicator with the loop-back arrangement from a receiver to a transmitter input in duplex operation equipment are used in the following method. The duplex operation equipment may only be possible to transmit a signal which corresponds to the receiving signal, whether this exceeds the predetermined level or not.

a) Calibrate the RFM site and place the receiver under test as illustrated in A.2.5 of IEC 60489-1.

b) Adjust the radio-frequency signal generator level to obtain the median value of the specification.

c) Move the transmitting antenna from the beginning to the end of the random path in 360 or more positions approximately equally spaced and measure the receiver output signal-to-noise ratio in each position. Record the number of times N that the signal-to-noise ratio exceeds the standard signal-to-noise ratio (12 dB *SINAD*).

   If the receiving signal strength indicator is used, and an input signal level which produces the receiver output, the standard signal-to-noise ratio is identified in the indicator level and can be used as the standard signal-to-noise ratio level. If the receiving signal strength indicator is used, and the same level mentioned above is not identified in the indicator level, conversion from the indicator level of measured receiving signal strength to the standard signal-to-noise ratio level is necessary. The conversion ratio can be derived from step a) to c) in 24.3.3 but replacing the squelch opening level by the receiving signal strength indicator level.

d) If N is greater than half the total position numbers, record that the receiver complies with the RFM radiation sensitivity (SUS) specification, otherwise record that it does not comply.

24.5 RFCD radiation sensitivity (SUS or MUS)

24.5.1 Definition

Radiation sensitivity (SUS or MUS) measured in a calibrated RFCD at the determined position and direction.

24.5.2 Method of measurement for RFCD radiation sensitivity (MUS)

a) Choose the RFCD suitable for the frequency, environmental conditions and receiver dimensions, from those described in annex A of IEC 60489-1.

b) Calibrate the RFCD and place the receiver under test as described in the appropriate RFCD subclause in the above-mentioned annex. The receiver output should be connected to the distortion factor meter through the band-limiting filter (see 5.10.1), using one of the baseband connection arrangement described in the above annex.

c) Measure the RFCD input signal level which produces the standard signal-to-noise ratio at the receiver output with the same method for receivers equipped with suitable antenna terminals (see 7.2). Read the calibrated value for the RFCD input-signal level.

24.5.3 Compliance test – RFCD radiation sensitivity (SUS)

a) Choose the RFCD suitable for the frequency, environmental conditions and receiver dimensions from those described in annex A of IEC 60489-1.

b) Calibrate the RFCD and place the receiver under test as described in the appropriate RFCD subclause in the above-mentioned annex. The receiver output should be connected to the distortion factor meter through the band-limiting filter (see 5.10.1) using one of the base-band connection arrangements described in the above-mentioned annex.

c) Apply the standard input signal to the RFCD input terminal.

d) Adjust the input-signal level to the radiation sensitivity specification value on the calibrated value.

e) If the receiver output signal-to-noise ratio is more than the standard signal-to-noise ratio, record that the receiver does comply with the RFCD radiation sensitivity (SUS) specification, otherwise record that it does not comply.

24.6 Average radiation sensitivity (SUS or MUS)

24.6.1 Definition

Average of eight measurements of field strength at a specified frequency with specified modulation which produces the standard signal-to-noise ratio at the output of the receiver under test when the receiver rotates in 45° increments starting in the normal direction.

NOTE 1 – The normal direction of the equipment under test is usually the operation access side and is specified by the manufacturer.

NOTE 2 – The average radiation sensitivity (SUS or MUS) can be measured in OATS (open area test sites), LRTS (low reflection test sites) or 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.

24.6.2 Method of measurement for average radiation sensitivity (MUS)

For equipment fitted with squelch circuits, perform steps a) to f) and j) to l) of 24.2.2.

For equipment not fitted with squelch circuits, perform steps a) to f) of 24.2.3.

24.6.3 Presentation of results

a) Calculate the average of the eight levels recorded in steps e) and f) of 24.2.2 or steps e) and f) of 24.2.3. Record this value. For equipment fitted with squelch circuits, multiply this value by the ratio determined in step l) of 24.2.2.

b) State which of the baseband signal connection arrangements was used.

24.6.4 Compliance test – Average radiation sensitivity (SUS)

Perform steps a) to f) of 24.3.3.

g) If the receiver output signal-to-noise ratio is more than the standard signal-to-noise ratio or the squelch opens, record that the receiver does comply with this direction radiation sensitivity specification, otherwise record that it does not comply.

h) Rotate the equipment under test 45° clockwise in a horizontal plane and repeat step g) until eight azimuth positions have been tested.

i) If for five or more of the positions, a compliance with the specification has been noted, record that the equipment does comply with the average radiation sensitivity (SUS) specification; otherwise record that it does not comply.

24.7 Diversity radiation sensitivity (SUS or MUS)

24.7.1 Definition

Median field strength value of received signal, at a specified frequency with specified modulation, in an RFM test site, for which the receiver output signal-to-noise ratio exceeds the standard signal-to-noise ratio for more than half the positions in 360 or more positions in a measuring period.

NOTE 1 – The diversity radiation sensitivity (SUS and MUS) can be measured in a RFM site.

NOTE 2 – The diversity gain can be the difference of measured values in 24.7.2 with and without diversity function.

24.7.2 Method of measurement for diversity radiation sensitivity (MUS)

The same procedure as for 24.4.2 is followed.

24.7.3 Compliance test method – Diversity radiation sensitivity (SUS)

The same procedure as for 24.4.3 is followed.

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23 Average radiation sensitivity

Delete all this clause 23.

NOTE – The revised average radiation sensitivity is described in the new 24.6.

24 Remarks on measurements requiring the use of a coupling device (radio-frequency and/or acoustic)

Replace the text of this clause by the following, re-numbering the title and text as clause 25:

25.1 General

The measurements described in clauses 24 to 36 are applicable to receivers having an integral antenna. This includes receivers having

a) audio-frequency terminals (see figure 10a); or

b) an integral output transducer to which connections can be made (see figure 10b); or

c) an integral output transducer where direct connection is impossible (see figure 10c), except in the case of clauses 28, 29 and 30. Where it is possible, direct electrical connection to the output transducer shall be used, providing that this does not affect the results of the measurement.

It is intended that these measurements should provide the same results for the value of the radio-frequency parameters as would be obtained if there were accessible radio-frequency input and/or audio-frequency output terminals on the receiver. In order to obtain reproducible results, the measuring arrangement should include the baseband signal connection arrangement, appropriate to the type of receiver being measured (see clause A.5 of IEC 60489-1). However, for step c) above, it is not intended that measurements be made of audio-frequency response, harmonic distortion or audio intermodulation distortion.

The error in the measurement of absolute quantities may reach 5 dB. The accuracy of ratio measurement is similar to that obtained when electrical connections are used.

25.2 Remarks on radio-frequency coupling device measurements

These measurements require a means to couple the radio-frequency test signal to the receiver. In this standard, this means will be referred to as a "radio-frequency coupling device (RFCD)" which will be used in the measuring arrangement. The RFCD may be a radio-frequency test fixture or specific configurations of striplines or waveguides. See clause A.3 of IEC 60489-1.

25.3 Acoustic coupling requirements (see clause A.3 of IEC 60489-1)

Where measurements are made using acoustical coupling, the results of the radio-frequency measurements should be the same as those obtained using a direct electrical connection to the audio output transducer. The following characteristics for an acoustic coupling device are required to ensure reproducible results:

– a means for precise, repeatable and stable positioning of the receiver being measured;
– a means for precise positioning of the acoustic coupling device in relation to the audio output transducer of the receiver being measured.

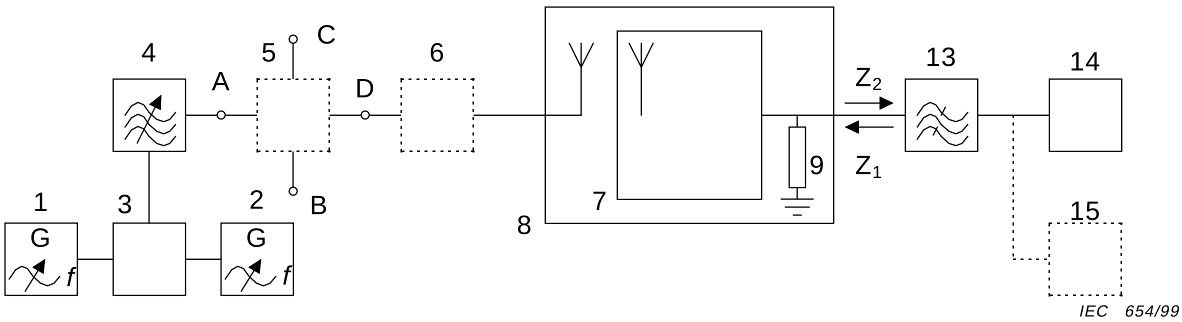

Figure 10a – Arrangement for receiver having audio-frequency output terminals but no integral output transducer

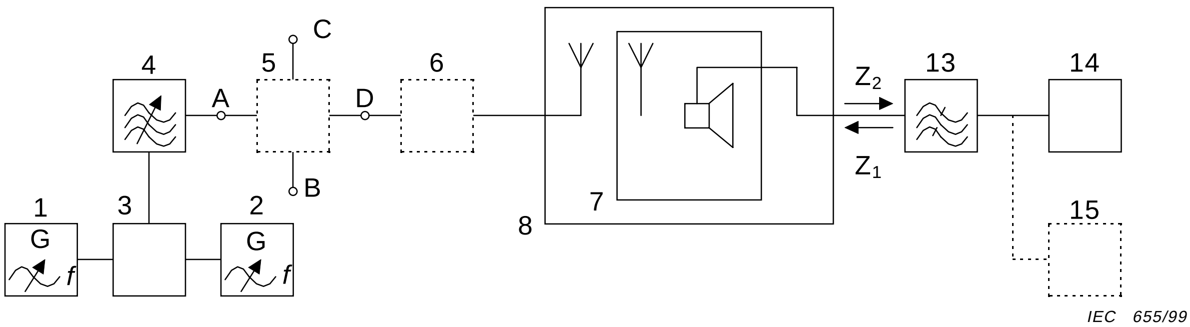

Figure 10b – Arrangement for receiver having an integral output transducer to which connections can be made

NOTE – In figures 10a and 10b, the input impedance Z_2 of the band-limiting filter (13) or of the distortion-factor meter (14), if a filter is not used, should be such that $Z_2 >> Z_1$.

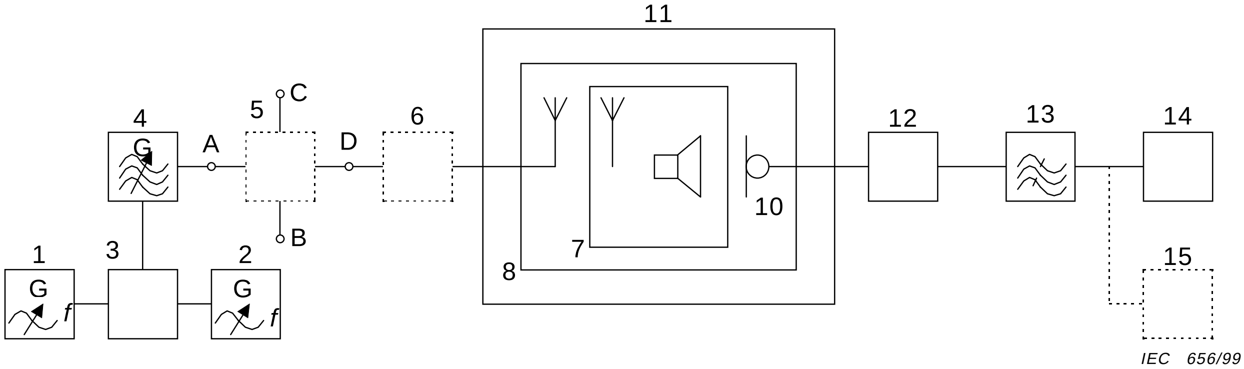

Figure 10c – Arrangement for receiver having an integral output transducer where direct connection is not possible

Key

1 Audio-frequency signal generator

2 Audio-frequency signal generator

3 Audio-frequency combining network

4 Radio-frequency signal generator

5 Matching or combining network, if necessary (see annex A)

6 Artificial antenna, if required

7 Receiver under test

8 Coupling device

9 Audio-frequency load (see clauses 3 to 6)

10 Microphone (part of sound level meter)

11 Acoustic isolation enclosure

12 Sound level meter

13 Band-limiting filter (see clauses 3 to 6)

14 Distortion factor/audio level meter

15 Selective measuring device

Figure 10 – Arrangement for measuring the characteristics of receivers having integral antennas

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25 Reference sensitivity (RFCD)

Delete clause 25.

NOTE – The revised RFCD radiation sensitivity (SUS or MUS) is described in 24.5.

Page 83

26 Acceptable radio-frequency displacement

Replace the text of this clause by the following:

Acceptable radio-frequency displacement of a receiver with integral antennas is recommended to be measured in an RFCD. The input of the RFCD is measured with the same method for a receiver equipped with suitable antenna terminal (see clause 8). The input of the RFCD can be calibrated by the calibration method described in IEC 60489-1, annex A.

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28.3 Presentation of results

Replace the text of this subclause by the following:

Plot the values recorded in step e), in decibels relative to the level at 1 kHz, on the linear ordinate of a graph, and the modulating frequency on the logarithmic abscissa.

Calculate the audio-frequency response deviations from reference one, in decibels, taking the deviation at 1 000 Hz equal to 0 dB. The deviation from the reference audio-frequency response, having de-emphasis of –6 dB/octave, shall be calculated according to the data listed in the table below unless otherwise specified in the equipment specification.

Table 2 – Reference audio-frequency response

Modulation frequency, Hz	300	500	1 000	2 000	3 000	3 400
Reference value, dB	+10,5	+6,0	0	–6,0	–9,5	–10,6

If de-emphasis is not provided for in the receiver, flat audio-frequency response is considered as reference one in the specified audio-frequency bandwidth.

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33 Selectivity

Replace the text of this clause by the following:

The selectivity of a receiver with integral antennas is recommended to be measured in an RFCD. The input of the RFCD is measured with the same method for receivers equipped with suitable antenna terminal (see clause 17). The input of the RFCD can be calibrated by the calibration method described in IEC 60489-1, annex A.

The selectivity may be measured in a test site if the test site is clear about the interfering problem described in the above-mentioned annex.

The selectivity can be evaluated by measuring

- adjacent signal selectivity;
- adjacent channel selectivity;
- cross-modulation;
- spurious response immunity;
- intermodulation immunity.

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34 Automatic gain-control AGC characteristic

Add, just after the title, the following note:

NOTE – This test is only applicable to the A3E mode. Replace, on page 101, the text of step f) in 34.2, by the following:

f) The upper limit of the automatic gain control characteristic is defined as the input signal-level value at which the total distortion factor becomes equal to the specified value and where the signal level change at the receiver output does not exceed the specified value. The lower limit of automatic gain control characteristic is defined as the receiver output level value at the input signal level equal to the nominal receiver sensitivity.

34.3 Presentation of results

Replace this subclause by the following:

Plot the relative audio-output level, in decibels, on the linear ordinate of the graph and the input-signal level, in decibels, relative to the value which produces the standard signal-to-noise ratio as recorded in step b) on the linear abscissa. Record the audio-output level as recorded in step d).

The performance of automatic gain control is expressed in the following form:

- specified signal level change at the receiver input by ___ dB versus signal level change at the receiver output of ___ dB.

Alternatively, a table of values may be presented.

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Add, after 35.5, the following new clause:

36 Impulsive-noise tolerance (integral antenna)

The degradation measurement of a receiver with integral antennas is recommended to be measured in an RFCD. The input of the RFCD is measured with the same method as for a receiver equipped with suitable antenna terminal (see clause 16). The input of the RFCD can be calibrated by the calibration method described in IEC 60489-1, annex A.

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Annex B

Supplementary recommended method for testing measuring arrangements

B.2 Method of testing signal generator noise

Add a new paragraph to the end of clause B.2 as follows:

In order to keep the receiver selectivity measurement error due to the signal generator noise below 0,4 dB, the spectrum density of the signal generator noise at a given frequency deviation shall not exceed the value calculated by the following formula:

$$G_{\mathrm{n}}(\mathrm{dBc/Hz}) = S(\mathrm{dB}) + 10 \log B_{\mathrm{k}} + 10 \ \mathrm{dB}$$

where

S is the measured selectivity value, expressed in decibels;

B_{k} is the receiver bandwidth, in hertz.

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Delete annexes F to H inclusive.

Page 176

Add the following new annexes:

Annex M

Rayleigh fading simulators

M.1 General characteristics of a Rayleigh fading simulator

A Rayleigh fading simulator is a test apparatus which will modulate a radio-frequency signal in a manner which simulates the fast variation of signals encountered in the mobile services. The following three characteristics of a fading simulator must be known:

a) the phase distribution of the fading-modulated signal;

b) the level distribution of the envelope of the modulated signal;

c) the mean rate at which the envelope of the modulated signal crosses a given level (in one direction). Two fading simulators correlated to each other are required for the evaluation of a dual branch diversity receiver and the following characteristic needs to be known:

d) the correlation factor of a dual channel fading simulator.

Measurements using Rayleigh fading simulators are meaningful only if the results which are obtained depend only slightly on the simulator used. To ensure this, it is necessary that the Rayleigh simulator has the following characteristics.

a) The phase of the modulated radio-frequency signal shall have a density distribution within ± 20 % of ½ π with reference to the phase of the radio-frequency input signal over the range of –π to +π radians.

b) The cumulative distribution of the envelope of the modulated radio-frequency signal shall be within ±2 dB of a cumulative Rayleigh distribution over a range of +8 dB to –32 dB referred to the r.m.s. value of the modulated radio-frequency signal. According to the Rayleigh law, $P(\Gamma)$ is the probability that the envelope of the modulated radio-frequency is equal to, or less than, the value of x as calculated below:

$$P(\Gamma) = 1 - e^{-\Gamma^2}$$

where

$$\Gamma = \frac{x}{x(\text{r.m.s.})} = \frac{\text{instantaneous envelope voltage}}{\text{r.m.s.voltage of the envelope}}$$

c) The mean level crossing rate (in one direction), shall be within ±2 % of:

$$\overline{N_\theta} = \sqrt{2\pi} \times f_m \times \theta \times e^{-\theta^2}$$

for θ varying from +5 dB to –25 dB with $f_m = v/\lambda$

where

v is the vehicle velocity, in metres per second

λ is the wavelength of signal, in metres

$$\theta = \frac{y}{y(\text{r.m.s.})} = \frac{\text{voltage level for envelope crossing-rate determination}}{\text{r.m.s. voltage of the envelope}}$$

The r.m.s. will have large short-term variations. Therefore, to reduce the uncertainty, its value should be determined over a sufficiently long period.

NOTE – The median value of the envelope is 1,6 dB less than the r.m.s. value.

For an example of a Rayleigh fading simulator, see figure M.1.

Two fading simulators correlated to each other are required for the evaluation of a dual branch diversity receiver and the following characteristic needs to be known.

d) The correlation factor of a dual channel fading simulator is expressed as:

$$\rho = \frac{\text{cross-correlated power spectrum}}{\text{auto-correlated power spectrum}} \quad (6)$$

and shall be within ±10 % with reference to the specified value in the equipment.

M.2 Performance verification of a Rayleigh fading simulator

M.2.1 Principle of verification

This verification applies to each of the parameters previously defined under Items a), b), c) and d) of clause M.1. It consists of

1) comparing the values obtained at the simulator output with the theoretical values corresponding to phase distribution, envelope distribution, mean level crossing rate and correlation factor;
2) ensuring that the corresponding deviations do not exceed the permitted tolerance.

M.2.2 Equipment used

A fast logarithmic radio-frequency selective measuring device, a phase meter, and means for analysing a distribution are required to carry out the performance verification. An example of equipment for doing this is illustrated in figure M.2.

The requirements for the equipment are

– the baseband output of the logarithmic radio-frequency measuring device shall have a flat response from 0 Hz to 3 000 Hz and an output range of 40 dB. The output of the radio-frequency selective measuring device shall be compatible with the input range of the A/D converter;

– the A/D converter shall have 8-bit encoding and have a conversion time no greater than 80 ms;

– the memory should be capable of storing at least 23 000 8-bit words (bytes) at the rate generated by the A/D converter. Although this memory size will not hold all of the information generated in one measurement, statistical significance will not be lost if the samples are taken in several segments, provided that the sum of the samples in the segments is equal to the required number of samples;

– the baseband output of the phase meter shall have a flat response from 0 Hz to 3 000 Hz and be able to make accurate phase measurement over an amplitude range of at least 40 dB;

– the processor should be capable of storing the output of the A/D converter in the memory and then taking the information from the memory and processing it.

NOTE 1 – If the output of the A/D converter is processed in real time to provide an address to a memory position that can be made to correspond to a level or phase, then the memory position content can be increased by 1 each time that it is addressed. This method requires only 256 16-bit words of memory for the amplitude or phase measurement and reduces the time needed to process the data.

NOTE 2 – For the crossing-rate measurement, the same process can be used. In this case, however, seven analogue comparators, each connecting to a 16-bit word of memory, would be required.

M.2.3 Method of measurement

M.2.3.1 Method of measurement for phase distribution

NOTE – To achieve statistical significance, this measurement requires that 64 000 phase samples be used to verify the phase performance of the Rayleigh fading simulator.

a) Connect the equipment as illustrated in figure M.2.

b) Adjust the frequency of the clock of the A/D converter to 40 times f_m, in hertz.

c) Adjust the frequency of the radio-frequency signal generator to the frequency band of interest and note the frequency.

NOTE – The Rayleigh fading simulator should be verified at a radio-frequency which is within 20 % of the frequency of the receiver being measured.

d) Adjust the velocity control of the Rayleigh fading simulator (or bandwidth of the noise lowpass filters) according to equation (4) for a specified velocity of the application of interest and note the velocity.

   The specified velocities are:

   10 km/h, 20 km/h, 50 km/h and 100 km/h for mobile application;

   1 km/h, 2 km/h, 5 km/h and 10 km/h for portable application.

   If the velocity control is adjustable in discrete steps, it shall be set to within 20 % of the specified velocity.

e) Adjust the radio-frequency input level to the Rayleigh fading simulator to the value specified by the manufacturer.

f) Clear the memory, and reset the sample counter (or clock).

g) Run the measurement for 64 000 samples, and store the values of the samples in the memory.

h) Process the information in the memory to determine the number of samples that occurred in each 10-degree phase increment, and record the results.

i) Repeat steps d) to h) for the other specified velocities.

M.2.3.2 Presentation of results

a) Record the radio-frequency noted in step c) and the velocity in step d) of M.2.3.1.

b) Make a table of the phase angles and the number of samples in each of the 36 10-degree increments for each velocity recorded in step d) or M.2.3.1.

c) If the number of samples in each class lies between 1 422 and 2 134, record that the simulator complies with this IEC standard for the phase distribution at the specified velocity and radio-frequency.

M.2.3.3 Method of measurement for crossing-rate and envelope distribution

NOTE – To achieve statistical significance, the crossing-rate measurement requires that 128 000 samples of the envelope be used to verify the crossing-rate performance of the Rayleigh fading simulator. The same samples may be used to measure the envelope distribution of the Rayleigh fading simulator.

a) Connect the equipment as illustrated in figure M.2.

b) Adjust the conversion rate of the A/D converter to 128 times f_{m}, in hertz.

c) Adjust the frequency of the radio-frequency signal generator to the frequency band of interest, and note the frequency.

NOTE – The Rayleigh fading simulator should be verified at a radio-frequency which is within 20 % of the frequency of the receiver being measured.

d) Adjust the velocity control of the Rayleigh fading simulator (or bandwidth of the noise lowpass filters) according to equation (4) for a specified velocity of the application of interest and note the velocity.

   The specified velocities are:

   – 10 km/h, 20 km/h, 50 km/h and 100 km/h for mobile application;

   – 1 km/h, 2 km/h, 5 km/h and 10 km/h for portable application.

   If the velocity control is adjustable in discrete steps it shall be set to within ±20 % of the specified velocity.

e) Adjust the radio-frequency input level to the Rayleigh fading simulator to the value specified by the manufacturer.

f) Clear the memory, and reset the sample counter (or clock).

g) Run the measurement for 128 000 samples, and store the value of the samples in the memory.

h) Process the information in the memory to determine the cumulative distribution of the samples. It is recommended that each class have a width of 1 dB.

i) Process the information in the memory to determine the number of level crossings (one direction) of the envelope for each level (–25, –20, –15, –10, –5, 0 and +5 dB) referred to the r.m.s. value of the signal envelope.

j) Repeat steps d) to i) for the other specified velocities.

M.2.3.4 Presentation of results for envelope distribution

a) Record the frequency noted in step c) and the velocity noted in step d) of M.2.3.3.

b) Plot the cumulative distribution determined in step h) of M.2.3.3 on Rayleigh graph paper, or make a table of Γ in decibels and the cumulative number of samples.

c) Record the verification that the simulator complies with this IEC standard for the cumulative envelope distribution at the specified velocity and radio-frequency if the value lies within 2 dB of the corresponding value defined by equation (1) or if the cumulative number of samples is within the range shown in table M.1.

M.2.3.5 Presentation of results for level crossing rate

a) Make a table of the envelope levels, and the number of crossings for each level and for each velocity observed in step d) of M.2.3.3.

b) Record the verification that the simulator complies with IEC standards for level crossing rate if the number of crossings for each level is within the range shown in table M.2 for each specified velocity and radio-frequency.

Table M.1 – Limits for the cumulative number of samples at each value of decibels

Level dB	Lower limit	Expected value	Upper limit
–32	51	81	128
–31	64	102	161
–30	81	128	203
–29	102	161	255
–28	128	203	321
–27	161	255	404
–26	203	321	509
–25	255	404	640
–24	321	509	805
–23	404	640	1 013
–22	509	805	1 274
–21	640	1 013	1 601
–20	805	1 274	2 013
–19	1 013	1 601	2 529
–18	1 274	2 013	3 175
–17	1 601	2 529	3 984
–16	2 013	3 175	4 996
–15	2 529	3 984	6 257
–14	3 175	4 996	7 827
–13	3 984	6 257	9 774
–12	4 996	7 827	12 181
–11	6 257	9 774	15 141
–10	7 827	12 181	18 761
–9	9 774	15 141	23 153
–8	12 181	18 761	28 432
–7	15 141	23 153	34 702
–6	18 761	28 432	42 036
–5	23 153	34 702	50 456
–4	28 432	42 036	59 893
–3	34 702	50 456	70 159
–2	42 036	59 893	80 911
–1	50 456	70 159	91 653
0	59 893	80 911	101 764
1	70 159	91 653	110 595
2	80 911	101 764	117 617
3	91 653	110 595	122 582
4	101 764	117 617	125 611
5	110 595	122 582	127 148
6	117 617	125 611	127 767
7	122 582	127 148	127 955
8	125 611	127 767	127 994

Table M.2 – Limits for the number of level crossings in the measurements

Level dB	Expected rate f_m	Lower limit	Expected value	Upper limit
–25	0,14	112	141	169
–20	0,25	199	248	298
–15	0,43	345	432	518
–10	0,72	574	717	861
–5	1,02	822	1 027	1 233
0	0,92	738	922	1 107
+5	0,19	151	189	226

M.2.3.6 Method of measurement for correlation factor

a) Connect the equipment as illustrated in figure M.3.

b) Adjust the frequency of the radio-frequency signal generator to the frequency band of interest and note the frequency.

c) Adjust the velocity control of the Rayleigh fading simulator to any one of the specified velocities.

d) Adjust the correlation factor to a specified value and note the value. The specified values are:

   0; 0; 1; 0; 2; 0, 4 and 0,6.

NOTE – A certain specific method of measurement requires the use of only one correlation factor.

e) Adjust the radio-frequency input level to the Rayleigh fading simulator to the value specified by the manufacturer.

f) Calculate the auto-correlation power spectrum by applying CH 1 output of the fading simulator to a correlation power meter (e.g. FFT analyser) and record its value.

g) Calculate the cross-correlation power spectrum by applying CH 1 and CH 2 output of the fading simulator to the correlation power meter (e.g. FFT analyzer) and record its value.

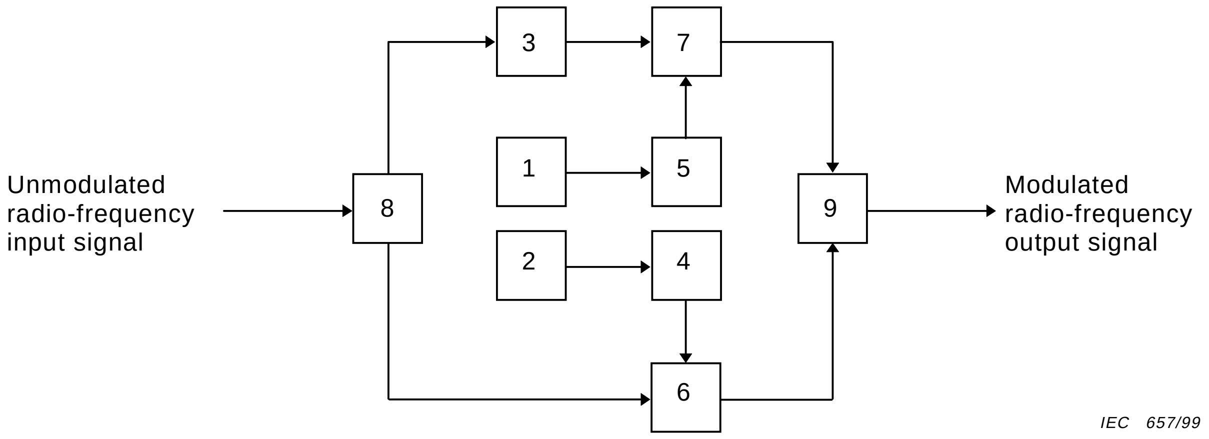
h) Repeat steps d) to g) for the other specified correlation factor.

M.2.3.7 Presentation of results for the correlation factor

a) Record the frequency noted in step b) and the specified correlation factors in step f) of M.2.3.6.

b) Calculate the correlation factor as a ratio of the value recorded in step f) to the value recorded in step g) for each specified correlation factor.

c) If the calculated correlation factors for all the specified correlation factors in step b) are within ±10 %, record that the simulator complies with this IEC standard for the correlation factor.



Key

1,2 Gaussian noise generators

3 90° phase shifter

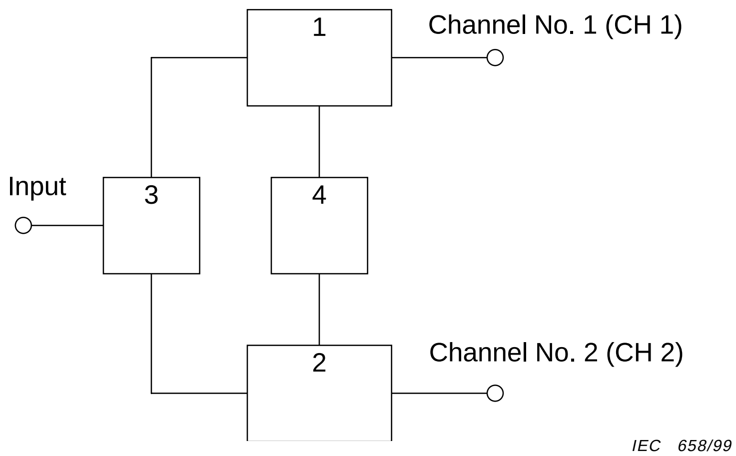
4,5 Low-pass filter

6,7 Balanced mixers

8 Power divider

9 Hybrid

Figure M.1a – Example of a Rayleigh fading simulator



Key

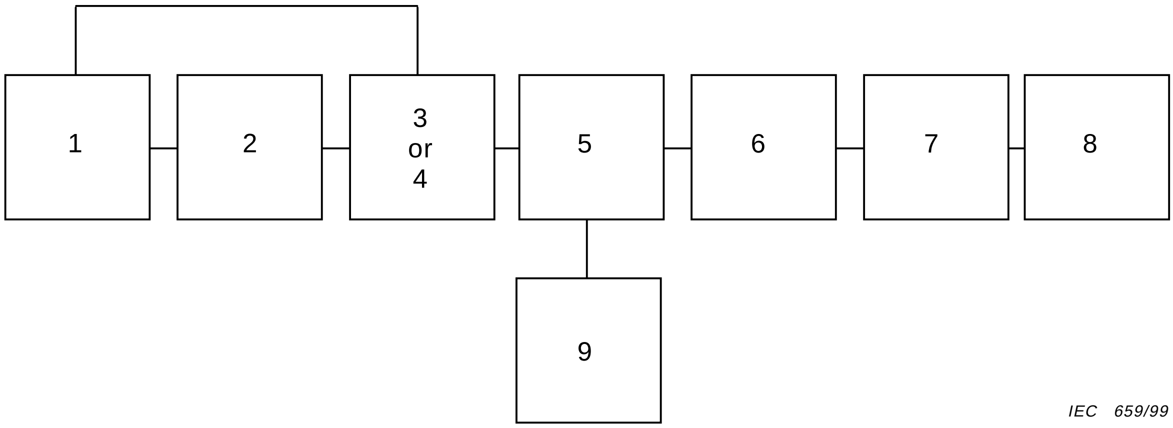
1,2 Rayleigh fading simulator channels 1 and 2

3 Power divider

4 Gaussian noise power signal combiner

Figure M.1b – Example of a dual channel Rayleigh fading simulator

Figure M.1 – Examples of Rayleigh fading simulators

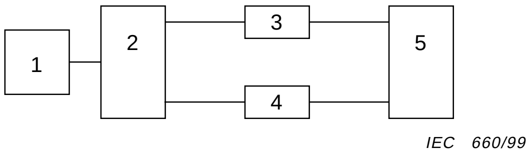


Key

1 Radio-frequency signal generator
2 Rayleigh fading simulator
3 Phase meter
4 Logarithmic, radio-frequency, selective measuring device
5 A/D converter
6 Memory (if necessary)
7 Processor
8 Output device
9 Variable clock

NOTE – If the simulator (2) does not have a zero velocity setting, it should be bypassed and the output of the generator (1) should be adjusted to allow for its attenuation.

Figure M.2 – Example of measuring arrangement for evaluating a Rayleigh fading simulator



Key

1 Radio-frequency signal generator
2 Dual-channel Rayleigh fading simulator
3,4 Logarithmic, radio-frequency, selective measuring device
5 Correlation power meter (e.g. FFT analyzer)

Figure M.3 – Example of measuring arrangement for evaluating a Rayleigh fading simulator correlation factor

Annex N

Accuracy for diversity receiver sensitivity measurement

N.1 Measurement accuracy

Since the *SINAD* of a receiver under a Rayleigh faded input signal varies with time, the sampling and averaging technique is required for measuring the *SINAD* values.

While there are many useful methods available for performing these measurements, two methods will produce the required accuracy as shown below.

Figure N.1 shows examples of measured, averaged *SINAD* values, and its experimental parameters are shown in table N.1. These are calculated from the instantaneous values (method A).

The test set-up used was as given in figure 12. It can be seen that the measured *SINAD* value approaches its final *SINAD* value as the measuring time increases and the deviation of the final *SINAD* value becomes less than 1 dB when the measuring time is greater than $200/f_m$ (s).

If the data samples are integrated for a period of time equal to the submultiple of the measuring time T (method B), the same measuring time ($200/f_m$) will produce the required accuracy. Figure N.2 shows the measured standard deviation σ (sigma) of *SINAD* values by method B, of which the experimental parameters are shown in table N.2, together with the standard deviation • by method A (mark @). Relatively satisfactory results have been obtained.

Table N.1 – Parameters for method A

Experimental conditions	Frequency 877,700 MHz Modulation 1 kHz, deviation 1,5 kHz Fading frequency 1 Hz, 4 Hz, 10 Hz, 20 Hz, 40 Hz (2-branch correlation factor = 0) Measuring time T: 5 s, 10 s, 20 s Measurement repetition N: 1 to 100 Frequency sampling frequency 10 kHz
Diversity receiver under test	Post-detection selection diversity Frequency stability $<1,5 \times 10^{-6}$

Table N.2 – Parameters for method B

Experimental conditions	Fading frequency 2 Hz, 10 Hz, 40 Hz, 80 Hz Sample interval 0,31 s (integration time) Sample size 50, 10, 200 Measurement repetition 24
NOTE – Other parameters are the same as for table N.1.	

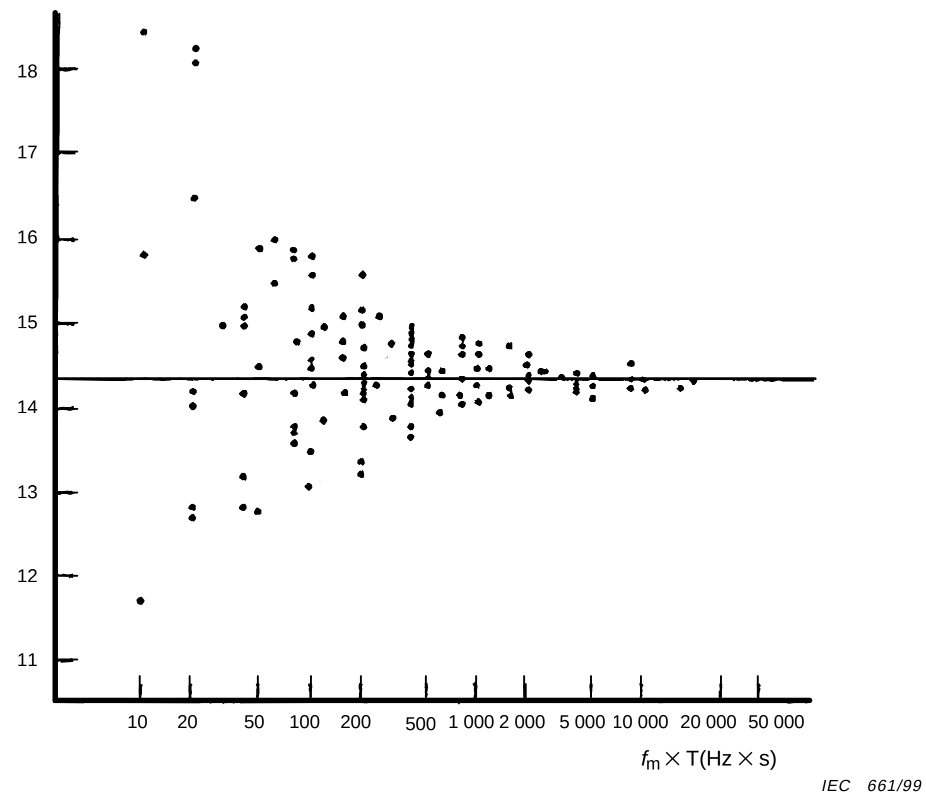


Figure N.1 – Examples of measured, arranged *SINAD* values

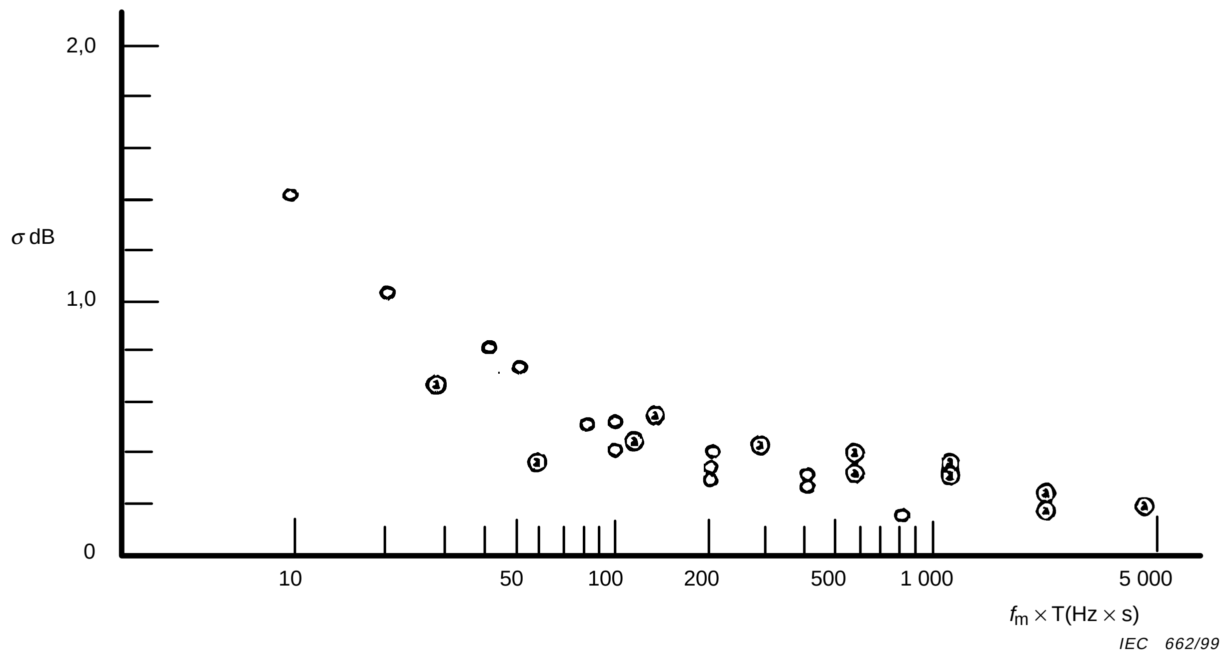


Figure N.2 – Measured standard deviation σ (signal) of *SINAD* value

N.2 Sampling frequency for method A

The required sampling frequency, f_p, is defined as the frequency which can make at least two samples in the average time period during which the input level is lower than 25 dB from its r.m.s. level.

The value $100 \times f_m$ is determined as follows.

a) The probability that the envelope of the input signal is equal to or less than the value of the r.m.s. input level is calculated from equation (M.1) in annex M as

$$P(-25 \text{ dB}) = 0{,}003\ 16$$

b) The mean level crossing rate (– dB) is calculated from equation (M.3) in annex M as

$$N(-25 \text{ dB}) = \sqrt{2\pi} \times f_m \times \Gamma \times \exp\left(-\Gamma^2\right)$$

$$= 0{,}14 \times f_m$$

c) The average time length τ is given as

$$\tau = 0{,}003\ 16 \ / \ (0{,}14 \times f_m)$$

$$= 0{,}022\ 6 \ / \ f_m$$

d) Then the sampling frequency f_p is calculated as:

$$f_p = 2/\tau = 88{,}5 \times f_m$$

This is the reason for the value of f_p to be taken as $100 \times f_m$.

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