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:

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Delete the appendices F to L inclusive.

Add the following new annexes:

Annex M – Rayleigh fading simulators.....

Annex N – Accuracy for diversity receiver sensitivity measurement .....

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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.

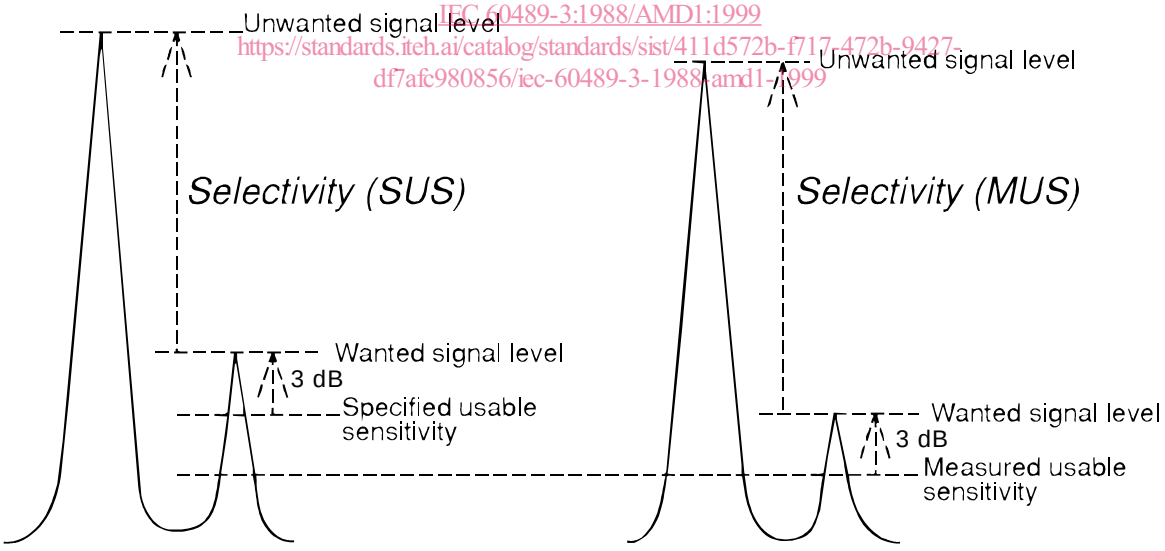

Figure 11 – Illustration of selectivity (SUS and MUS)

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.