

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

Part 3: Receivers employing A3E, F3E or G3E emissions

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Electronic Equipment Standards Policy Committee (EEL/-) to Technical Committee EEL/25, upon which the following bodies were represented:

- British Broadcasting Corporation
- British Radio and Electronic Equipment Manufacturers' Association
- British Telecommunications plc
- Department of Trade and Industry (Radiocommunications Division)
- Independent Broadcasting Authority
- Institution of Electrical Engineers
- Radio Electrical and Television Retailers' Association

The following bodies were also represented in the drafting of the standard, through sub-committees and panels:

- British Approvals Board for Telecommunications
- EEA (the Electronics and Business Equipment Association)
- ERA Technology Ltd
- GAMBICA (BEAMA Ltd)
- OFTEL (Office of Telecommunications)
- Radio Society of Great Britain
- Telecommunication Engineering and Manufacturing Association

This British Standard, having been prepared under the direction of the Electronic Equipment Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 27 July 1990

© BSI 10 May 2002

First published October 1981
Second edition July 1990

The following BSI references relate to the work on this standard:
Committee reference EEL/25
Draft for comment 84/21922 DC

ISBN 0 580 18215 0

Amendments issued since publication

Amd. No.	Date	Comments
13483	10 May 2002	See national foreword and correction to title of standard

Contents

	Page
Committees responsible	Inside front cover
National foreword	iv
Section 1. General	
1 Scope	1
2 Object	1
Section 2. Supplementary definitions and conditions of measurement	
3 Supplementary terms and definitions	3
4 Standard test conditions	4
5 Supplementary test conditions	4
6 Characteristics of the measuring equipment	8
Section 3. Methods of measurement for receivers equipped with suitable antenna terminals	
7 Sensitivity	9
8 Acceptable radio-frequency displacement	10
9 Noise-quieting input-signal level	10
10 Audio-frequency response	11
11 Total distortion factor	11
12 Relative audio-frequency intermodulation product level	12
13 Squelch characteristics	13
14 Signal-to-residual output-power ratio	15
15 Expander characteristics	16
16 Impulsive noise	17
17 Selectivity	19
18 Automatic gain-control (A.G.C.) characteristic	24
19 Radiated spurious components	26
20 Conducted spurious components	27
21 Evaluation of the receiving part of the equipment under duplex conditions	28
22 Receiver performance under conditions deviating from standard test conditions	28
Section 4. Methods of measurement for receivers with integral antennas	
23 Receiver output power	31
24 Radiation sensitivity	33
25 Remarks on measurements requiring the use of a coupling device (radio-frequency and/or acoustic)	38
26 Acceptable radio-frequency displacement	40
27 Noise-quieting input-signal level (under consideration)	40
28 Audio-frequency response (RFCD)	40
29 Total distortion factor	41
30 Relative audio-frequency intermodulation product level	42
31 Squelch characteristics	43
32 Signal-to-residual output-level ratio	46
33 Selectivity	46
34 Automatic gain-control (A.G.C.) characteristic	46
35 Dynamic automatic gain-control characteristic	47
36 Impulsive-noise tolerance (integral antenna)	48

	Page
Appendix A Examples of combining networks	49
Appendix B Supplementary recommended methods for testing measuring arrangements	51
Appendix C General information on impulsive noise and the random impulse generator	52
Appendix D Intermodulation responses	56
Appendix E Example of a mains power line impedance stabilization network	57
<i>Appendix F to Appendix H deleted</i>	
Annex M Rayleigh fading simulators	69
Annex N Accuracy for diversity receiver sensitivity measurement	76
Figure 1 — Input-signal source arrangement	4
Figure 2 — Example of an arrangement for testing receivers for duplex operation	6
Figure 3 — General arrangement for measuring receiver characteristics	9
Figure 4 — Arrangement for measuring the relative intermodulation product level	12
Figure 5 — Squelch opening and closing levels	13
Figure 6 — Noise-quieting input level as a function of input-signal frequency in the presence of impulsive noise	23
Figure 7 — Example of dynamic A.G.C. characteristic	26
Figure 8 — Deleted	26
Figure 9 — Measurement arrangements for antenna terminal and a.c power terminal conducted spurious components	27
Figure 10 — Arrangements for measuring the characteristics of receivers having integral antennas	39
Figure A.1 — Network for combining two signals	49
Figure A.2 — Network for combining three signals	49
Figure A.3 — Example of combining network using a hybrid ring	50
Figure A.4 — Example of a matching network	51
Figure E.1 — Mains power line impedance stabilization network (also known as an artificial mains network)	58
Figure E.2 — Vector diagram of interference voltages	58
Figure E.3 — Example of a mains power line impedance stabilization network	59
Figure F.1 — Deleted	59
Figure F.2 — Deleted	59
Figure G.1 — Deleted	59
Figure H.1 — Deleted	59
Figure H.2 — Deleted	59
Figure J.1 — RFCD (stripline)	62
Figure J.2 — Detail of stripline load	63
Figure J.3 — Detail of stripline input matching resistor	63
Figure J.4 — Antenna voltage versus frequency (example)	64

	Page
Figure K.1 — Measuring arrangement for radio pagers on a radiation test site (30 m)	65
Figure L.1 — Measuring arrangement for equipment emitting radio-frequency electromagnetic energy (30 m)	68
Table C.I	54
Table C.II	55
Table E.I	57

National foreword

This Part of BS 6160 has been prepared under the direction of the Electronic Equipment Standards Policy Committee. It is identical with IEC 489-3:1988, *Methods of measurement for radio equipment used in the mobile services — Part 3: Receivers employing A3E, F3E or G3E emissions*, including amendment 1:1999, published by the International Electrotechnical Commission (IEC). This Part of BS 6160 supersedes BS 6160-3:1981 which is withdrawn.

This Part of BS 6160 should be read, where applicable, in conjunction with BS 6160-1.

For the purposes of this British Standard any references to IEC page numbers in the text should be ignored.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **A1** **A1**.

Cross references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 79 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

Section 1. General

1 Scope

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) ~~F3E~~ angle modulation [frequency modulation (F3E)/phase modulation (G3E)], or
- b) double-sideband amplitude modulation with full carrier (A3E). ~~A1~~

This standard is intended to be used in conjunction with IEC Publication 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.

2 Object

The object of this standard is to standardize the definitions, the conditions and the methods of measurement used to ascertain the performance of receivers within the scope of this standard and to make possible a meaningful comparison of the results of measurements made by different observers and on different equipment.

Section 2. Supplementary definitions and conditions of measurement

3 Supplementary terms and definitions

For the purpose of this standard, the following supplementary terms and definitions apply.

3.1 Output level

3.1.1

rated output level

the level, as defined in the equipment specifications, corresponding to:

- the power at the audio output terminals when these are connected to a specified load; or
- the voltage appearing across the output transducer; or
- the sound pressure;

in the absence of a value specified by the manufacturer, the rated output level is 3 dB below the maximum output level

3.1.2

reference output level

- a) where there is a continuously variable gain control, the reference output level is that which is 6 dB below the rated output level;
- b) where there is step-by-step output control, the reference output level is that which is closest to the level defined in step a) above;
- c) where there is no gain control, the reference output level is the level obtained when the standard input signal is applied to the receiver.

3.2 Audio-frequency load

For equipment with an integral audio-frequency output transducer, the load is the output transducer.

The manufacturer shall specify the method of connection and state the impedance (and tolerance) of the output transducer at 1 000 Hz. It is desirable also to state the impedance at specified upper and lower audio-frequency band limits.

3.2.1

audio-frequency test load

an impedance network which replaces the load to which the receiver is connected under normal operating conditions. It simulates the impedance of the normal load and any cables with which it is normally used.

The network shall be specified by the manufacturer. It usually consists of a single pure resistance.

3.3

standard signal-to-noise ratio

ratio of:

the power of the signal-plus-noise-plus-distortion; to

the power of the noise-plus-distortion at the test load;

this ratio is abbreviated as:

$$\frac{S + N + D}{N + D}$$

where

S is the wanted audio-frequency signal due to standard test modulation;

N is the noise with standard test modulation;

D is the distortion with standard test modulation;

it is expressed in decibels and is often referred to as SINAD

the value of the standard signal-to-noise ratio is 12 dB

the standard signal-to-noise ratio allows comparison between different equipment when the standard test modulation is used

NOTE Other types and values of signal-to-noise ratio may be used by agreement between the purchaser and the manufacturer.

3.4

radiation sensitivity of a receiver with an integral antenna, in a given direction (field strength)
the field strength required to produce the standard signal-to-noise ratio under specified conditions of operation

NOTE 1 An integral antenna is an antenna which is considered to be an integral part of the equipment. In some cases the receiver operates with the antenna inside the housing and in others with the antenna mounted on the exterior of the housing.

NOTE 2 For certain applications another characteristic, for example the squelch opening level, may be specified.

NOTE 3 In this publication, the term “antenna” is synonymous with “aerial”.

3.5

de-emphasis

the process intended to restore the original form of a signal which has been transmitted with pre-emphasis

NOTE Pre-emphasis may be applied before modulation.

3.6

modulation depth

for double-sided amplitude modulation, the modulation depth, in percent, is given by the following:

$$\text{modulation depth} = \frac{(V_{\max} - V_{\min})}{(V_{\max} + V_{\min})} \times 100\%$$

where

$V_{\max}$ is the peak-to-peak voltage at the crest of modulation;

$V_{\min}$ is the peak-to-peak voltage at the valley of modulation.

4 Standard test conditions

Unless otherwise stated, measurements shall be performed under the general test conditions given in IEC Publication 489-1 and the supplementary test conditions described below.

5 Supplementary test conditions

5.1 Input-signal arrangements for testing receivers equipped with suitable antenna terminals

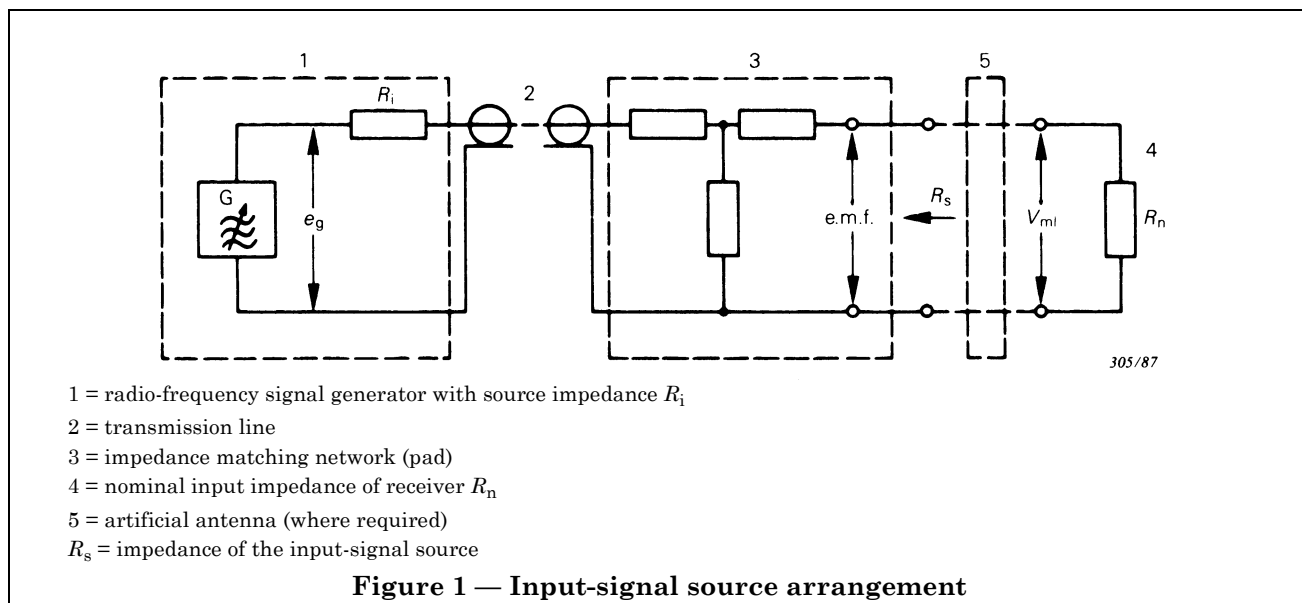


Figure 1 — Input-signal source arrangement

The nominal radio-frequency input impedance (R_n) is that value stated by the manufacturer for which the equipment performance will be optimum when connected to an antenna of the same impedance.

The input-signal level should preferably be expressed as: the electromotive force present at the output of the unterminated input-signal source (e.m.f. of Figure 1) when the input-signal source impedance (R_s) is equal to the nominal radio-frequency input impedance (R_n) of the receiver.

Alternatively, the input signal may be expressed as the matched-load voltage (V_{ml}) measured across an impedance having a value equal to R_n , when the source impedance (R_s) is equal to the nominal radio-frequency input impedance (R_n).

The matched-load voltage (V_{ml}) is equal to one-half the value of the e.m.f.

When the meter that indicates the value of e_g is not in close proximity to the receiver input terminals, the transmission line loss shall be taken into account in addition to the loss of the impedance matching network.

5.1.1 Input-signal source for receivers requiring a specified source resistance

This sub-clause applies to receivers which are connected to the antenna by means of a transmission line (synonymous with “feeder line”).

The input-signal source shall consist of a radio-frequency signal generator, a transmission line, and an impedance-matching network (pad) placed as close as possible to the receiver under test (see Figure 1, page 4).

5.1.2 Input-signal source receivers tested with the aid of an artificial antenna

This sub-clause is applicable to receivers intended to operate with an antenna having a complex impedance.

The input-signal source shall consist of a radio-frequency signal generator, a transmission line, an impedance matching network and an artificial antenna. The characteristics of the artificial antenna shall be specified by the manufacturer of the receiver.

5.2 Input-signal level

In this standard, the input-signal level of the wanted and unwanted signals is the r.m.s. voltage of the unmodulated carrier.

NOTE Radio-frequency signal generators that are in accordance with the requirements of IEC Publication 716 are calibrated in this manner.

The input levels of the wanted and unwanted signals shall be recorded in μV or $\text{dB}(\mu\text{V})$.

5.2.1 Receivers requiring a specified source resistance

The presentation of the results shall state whether the electromotive force (e.m.f.) of the source or the matched-load (V_{ml}) voltage has been recorded, for example, $2\ \mu\text{V}$ (e.m.f.) or $1\ \mu\text{V}$ (V_{ml}). The source resistance (R_s) shall be stated. See Figure 1.

5.2.2 Receivers tested with the aid of an artificial antenna

The input-signal level is the e.m.f. of the source connected to the input terminals of an artificial antenna.

5.3 Standard input signal

A radio-frequency signal at standard input-signal level, with standard modulation, at the standard input-signal frequency.

5.4 Standard input-signal level

Unless otherwise specified, the standard input-signal level for a receiver of the type considered in this standard is $60\ \text{dB}\ (\mu\text{V})$ (e.m.f.) or $54\ \text{dB}\ (\mu\text{V})$ (V_{ml}).

5.5 Standard input-signal frequency

For all tests, except where otherwise specified, the standard input-signal frequency is one of the specified nominal frequencies.

5.6 Standard modulation of an input signal

The modulation due to an input signal of 1 000 Hz at a level to produce:

- a modulation depth of 30 %;
- 60 % of maximum permissible frequency (or phase) deviation.

5.7 Networks for combining several signal sources

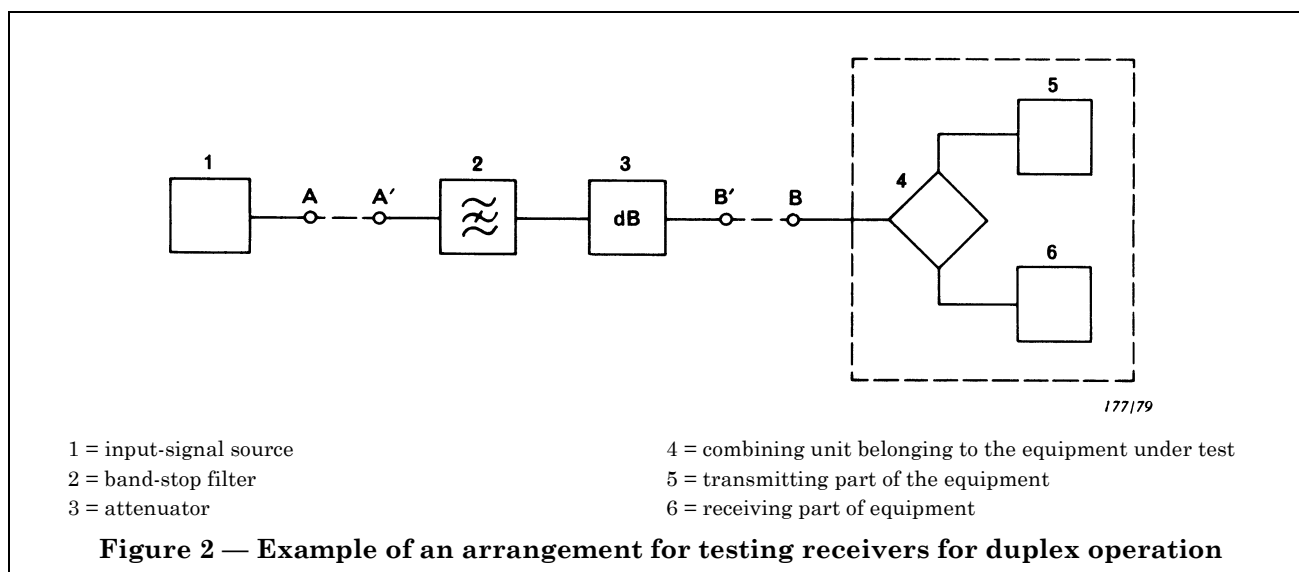
Examples of combining networks may be found in Appendix A.

5.8 Input-signal arrangements for testing the receiving part of equipment for duplex operation

When the performance of the receiver section of equipment for duplex operation is to be evaluated while the associated transmitter section is operating, precautions shall be taken in order to ensure that the operation of the signal generator or generators used for testing the receiver section is not affected by the radio-frequency signal of the transmitter section and that the latter is terminated by its proper load impedance.

5.8.1 Input-signal source

An example of a suitable arrangement for making measurements on receivers of equipment for duplex operation is shown in Figure 2.



Connect the input-signal source arrangement (see 5.1) to point A'. The centre frequency of the band-stop filter (2) is adjusted to the operating frequency of the transmitter under test.

The impedance at point B' shall be such that the transmitter section is operating under the specified matched conditions. To ensure that the V.S.W.R. will be less than 1.25, irrespective of any mismatch caused by the band-stop filter (2) and the combining unit (4), the attenuation of the attenuator (3) shall be at least 30 dB. It should be noted that the attenuator will dissipate nearly all of the power from the transmitter section and therefore must have suitable power-handling capability.

5.8.2 Input-signal level

The level of the radio-frequency input signal shall be determined at point B' of Figure 2.

5.9 Input-signal arrangements for testing receivers having an integral antenna

For receivers provided with an integral antenna and for equipment which has no facilities suitable for connection to the measuring equipment, the input-signal source shall include the antenna specified by the manufacturer. For absolute measurements, a radiation test site where the field strength of the test signals is known shall be used. For relative measurements, a coupling device (radio-frequency and/or acoustic) may be used.

5.10 Connections of the measuring equipment

Care must be taken that the input impedance of the measuring equipment does not affect the output loading conditions specified for the receiver.

5.10.1 Limitation of the audio-frequency band

[A₁] 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 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	—

[A₁]

5.11 Squelch condition

The squelch circuit shall be adjusted for the unsquelched condition unless otherwise specified.

NOTE The term “squelch” is synonymous with “mute”.

5.12 De-emphasis condition

De-emphasis, if used, shall be operative for all tests.

5.13 Instrument input impedance

Depending upon the requirement, the measuring instrument (14) or (15), in Figure 10, page 39 may be either a distortion-factor/audio-level meter (14) or a selective measuring device (15). The input impedance Z_2 of the band limiting filter (13), in Figure 10 should be much greater than Z_1 . If the band-limiting filter (13) is not used, the input impedance of the measuring instrument (14) or (15) should be much greater than Z_1 .

6 Characteristics of the measuring equipment

NOTE For supplementary recommended methods for testing measuring arrangements, refer to Appendix B.

6.1 True r.m.s. voltage meters

For the measurement of the signal-to-noise ratio, the characteristics of the indicating meter are important. In addition, for certain characteristics, measurement of the true r.m.s. voltage is required.

6.2 Distortion-factor meter or SINAD meter

The distortion-factor meter or SINAD meter shall have the following characteristics:

- The wide-band response shall not vary by more than 0.1 dB over the frequency range 50 Hz to 20 000 Hz.
 - The band elimination filter attenuation shall be at least 40 dB at 1 000 Hz, but not more than 0.5 dB between 50 Hz and 500 Hz, and between 2 000 Hz and 20 000 Hz.
- If the SINAD meter has a fixed filter, it shall have 40 dB attenuation over the frequency band of 980 Hz to 1 020 Hz.
- The noise signal level from a constant amplitude noise source between 300 Hz and 3 000 Hz shall not be attenuated by more than 1 dB by the filter.
 - The indicator shall be a true r.m.s. type for a crest factor of 3 or less.

NOTE As a result of the different characteristics of the band elimination filters, the measurement result obtained with the SINAD meter or distortion-factor meter specified above may differ from those obtained with the measuring equipment specified in earlier editions of this standard.

6.3 Selective measuring device

The selective measuring device may be either a frequency selective voltmeter, a spectrum analyser, or a calibrated field-strength meter. The bandwidth of the measuring device shall be appropriate for the measurement being made or shall be adjusted to the value stated in the method of measurement.

6.4 Radio-frequency coupling device (RFCD)

[A] 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. **[A]**

6.5 Acoustic coupling device

See Clause **F.2** of Appendix F.

Section 3. Methods of measurement for receivers equipped with suitable antenna terminals

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

- Connect the equipment as illustrated in Figure 3.
- Apply the standard input signal to the receiver input terminals.
- Adjust the receiver volume control to obtain the reference output level (see 3.1.2). Record this level.
- Adjust the input-signal level to produce the standard signal-to-noise ratio. Record this level.
- 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.
- The measured usable sensitivity is the level recorded in step d). It is expressed as follows:

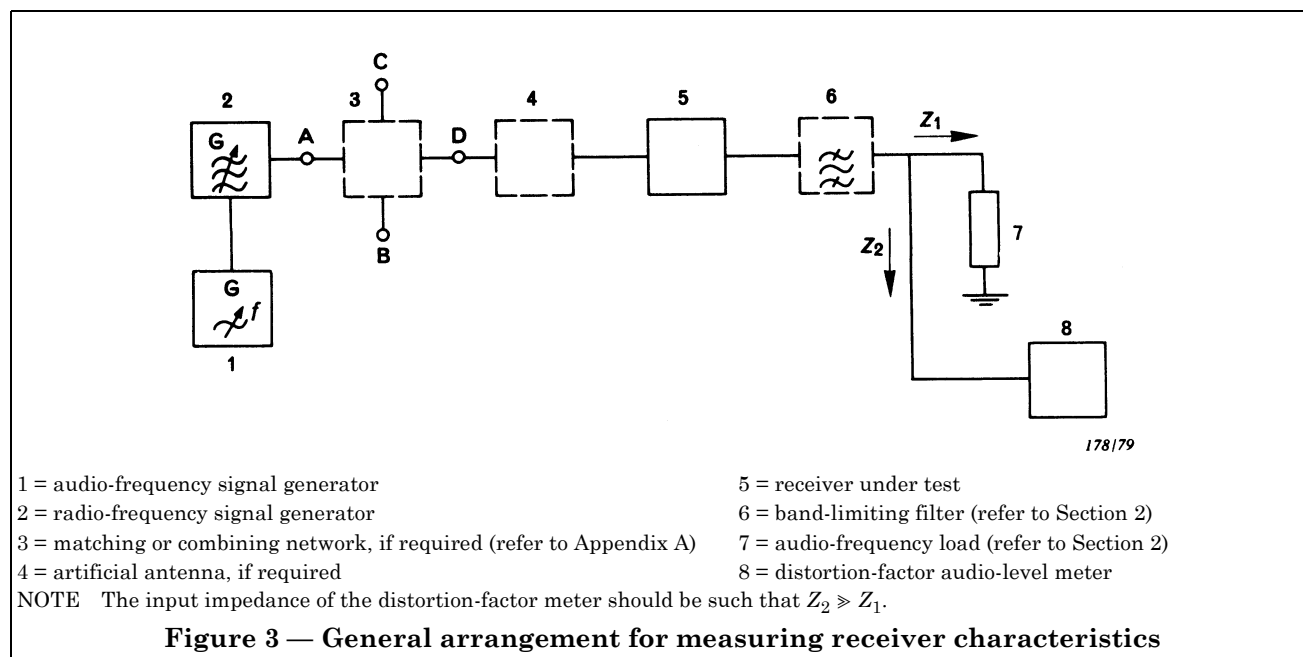
the measured usable sensitivity for a $\frac{S+N+D}{N+D}$ ratio of 12 dB is _____ μV or dB (μV).

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. 



8 Acceptable radio-frequency displacement

8.1 Definition

A) 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. **A)**

9 Noise-quieting input-signal level

This measurement is applicable to receivers intended for the reception of angle-modulated signals. The measurement also may be made on receivers intended for the reception of amplitude-modulated signals and which are equipped with automatic gain control (A.G.C.) during the measurement of impulsive-noise tolerance.

9.1 Definition

The level of an unmodulated input signal which produces a specified reduction of audio-frequency noise power.

9.2 Method of measurement

- a) Connect the equipment as illustrated in Figure 3.
- b) In the absence of an input signal, measure the receiver noise output power. A receiver equipped with an accessible volume control is to be adjusted to provide a level approximately 6 dB below the rated output power.

NOTE In receivers where the volume control precedes the audio-output stages, this reduction avoids overload.

- c) At the standard input-signal frequency, adjust the unmodulated input-signal level to produce a 20 dB reduction in the noise output power.
- d) The noise-quieting input-signal level is the level measured in step c). It is expressed either in μV or dB (μV).

NOTE By varying the input-signal frequency and noting the input signal required to maintain the noise level at the value obtained at the nominal reception frequency, the intermediate frequency bandwidth of the receiver may be obtained.

10 Audio-frequency response

10.1 Definition

The audio-frequency output-signal level variation as a function of the modulating frequency of a specified radio-frequency input-signal that has a constant amplitude deviation or a constant frequency deviation.

10.2 Method of measurement

- a) Connect the equipment as illustrated in Figure 3.
- b) Apply the standard input signal to the receiver input terminals.
- c) Operate the receiver at the reference output level.
- d) Maintain the following deviations as the modulating audio-frequency is varied over the specified range:
 - 20 % of maximum permissible frequency deviation for angle modulation;
 - 30 % of modulation depth for amplitude modulation.
- e) For each modulating frequency, record the audio-frequency output level.
- f) These tests may be repeated at other deviations, but care should be taken to avoid overloading in the receiver output stages.

10.3 Presentation of results

A₁ 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	1000	2000	3000	3400
Reference value dB	+10,5	+6,0	0	–6,0	–9,5	–10,6

If de-emphasise is not provided in the receiver, flat audio-frequency response is considered as reference one in the specified audio-frequency bandwidth. **A₁**

11 Total distortion factor

11.1 Definition

The ratio, expressed as a percentage, of the r.m.s. value of a distorted signal without its fundamental component, to the r.m.s. value of the complete signal. The distorted signal includes harmonically related components, supply ripple and non-harmonically related components.

11.2 Method of measurement

- a) Connect the equipment as illustrated in Figure 3.
- b) Apply the standard input signal to the receiver input terminals.
- c) Operate the receiver at the rated output level.
- d) Measure the total distortion factor at the audio-frequency load.

NOTE 1 This method of measurement is valid for other modulating frequencies and other values of deviation.

NOTE 2 The audio-frequency measuring bandwidth may be limited in accordance with Section 2.

12 Relative audio-frequency intermodulation product level

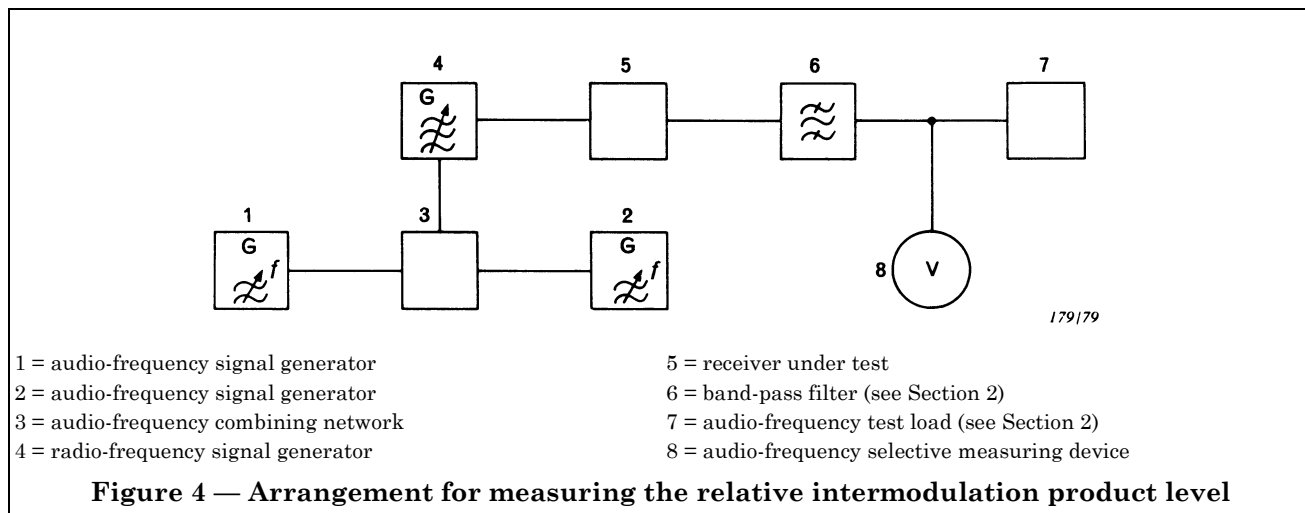
12.1 Definition

The ratio, expressed in decibels, of:

- the level of an unwanted non-harmonic output-signal component, caused by non-linear distortion in the receiver when receiving a carrier which is modulated simultaneously by two modulating signals, each producing a specified amplitude or frequency deviation, to
- the level of one of the wanted output signals.

12.2 Method of measurement

- Connect the equipment as shown in Figure 4.
- In the absence of an output from audio-frequency signal generator (2), adjust audio-frequency signal generator (1) and radio-frequency signal generator (4) to produce the standard input signal.
- Adjust the receiver volume control to produce the rated audio-frequency output level.



- Adjust the level of generator (1) to obtain 30 % of the maximum permissible frequency (or phase) deviation or a modulation depth of 30 %. Record this level.
- In the absence of output from generator (1), set the frequency of generator (2) to 1 600 Hz and adjust its level to obtain 30 % of the maximum permissible frequency (or phase) deviation or a modulation depth of 30 %.
- Restore the output level of generator (1) to the value recorded in step d).
- With the selective measuring device (8), measure the level of the 1 000 Hz component and the frequency and level of each intermodulation product at the output of the receiver.

NOTE 1 The audio-frequency bandwidth should be limited in accordance with Section 2.

NOTE 2 This method of measurement can be used for other modulating frequencies and other values of deviation.

12.3 Presentation of results

Calculate the ratio, in decibels, of the intermodulation product level to the wanted signal level at 1 000 Hz, both measured in step g).

Tabulate the results as follows:

Intermodulation product frequency (Hz)	Ratio (dB)

13 Squelch characteristics

This clause deals with all squelch circuits except those operated by tone signals.

NOTE The term “squelch” is synonymous with “mute”.

13.1 Squelch opening and closing levels

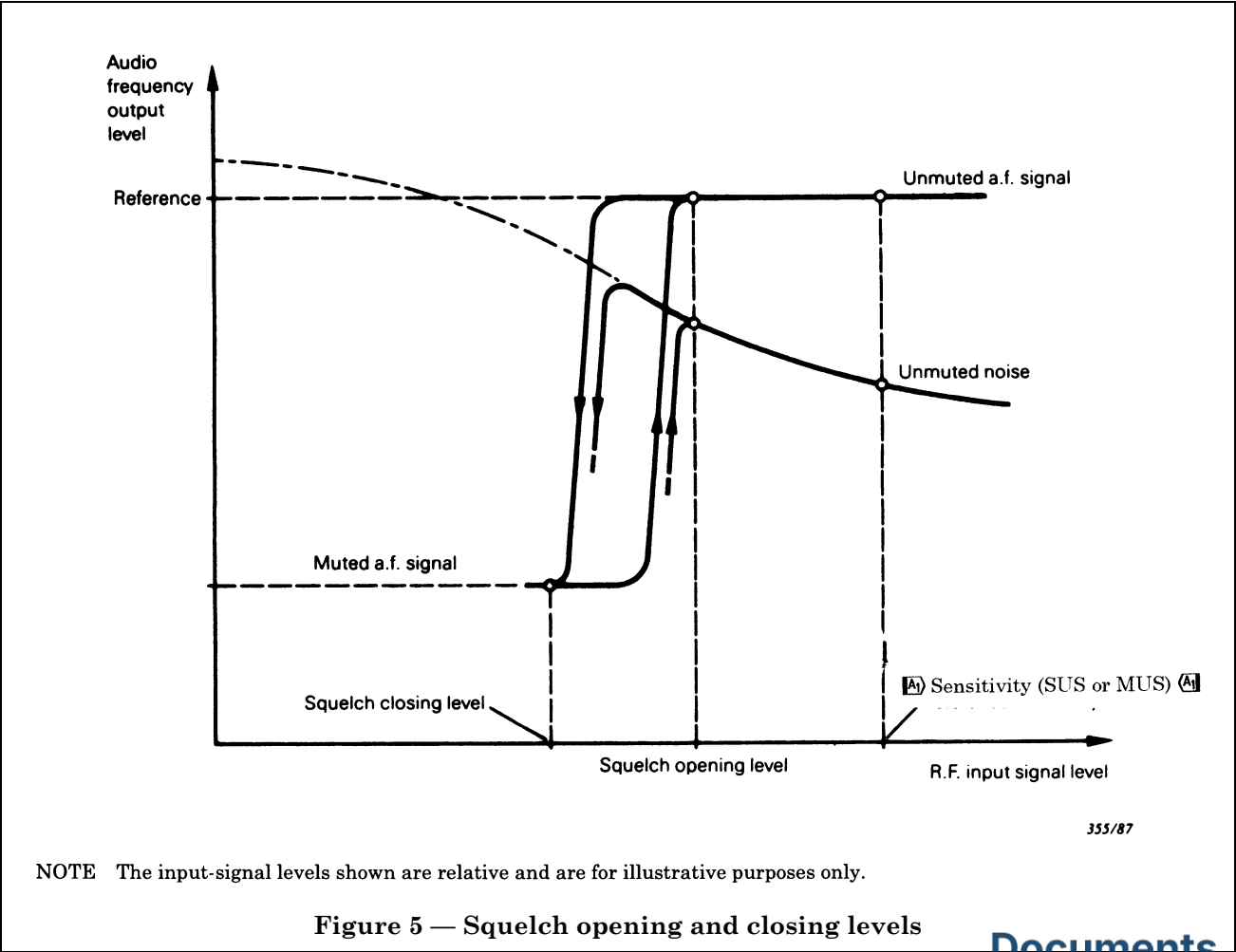
13.1.1 Definition

The modulated input-signal levels at which the squelch opens and closes.

NOTE If the receiver has an adjustable squelch control, these levels will vary with the setting of this control.

13.1.2 Method of measurement for receivers having adjustable squelch controls

- a) Connect the equipment as illustrated in Figure 3.
- b) Apply the standard input signal to the receiver input terminals.



- c) Operate the receiver at reference output level.
- d) Reduce the input-signal level to the minimum possible. Adjust the squelch control until the squelch opens. Should it not open, adjust the squelch control to the position that requires the smallest signal to unsquelch the receiver and proceed to step h).
- e) Adjust the squelch control until the squelch just closes.
- f) Increase the input-signal level until the squelch just opens.
- g) Again reduce the input-signal level to the minimum possible and observe whether the squelch closes again. If it does not close, readjust the squelch control until the squelch just closes.
- h) Increase the input-signal level until the squelch just opens and record the signal level as the minimum squelch opening level in μV or dB (μV).
- i) Reduce the input-signal level until the squelch just closes. Record this signal level as the minimum squelch closing level in μV or dB (μV).
- j) Adjust the squelch control to the position that requires the largest signal to unsquelch the receiver. Adjust the input-signal level until the squelch just opens. Record this level as the maximum squelch opening level in μV or dB (μV).
- k) Reduce the input-signal level until the squelch just closes. Record this signal level as the maximum squelch closing level in μV or dB (μV).

13.1.3 Method of measurement for receivers having pre-set squelch controls

Perform the measurements according to 13.1.2, steps a), b), c), d), h), and i), and record the signal levels obtained in steps h) and i) as the squelch opening and closing levels, respectively.

13.2 Squelch opening and closing delays

13.2.1 Definition

The intervals between the time of occurrence of a specified increase or decrease of the level of a modulated radio-frequency input signal and the time at which the voltage across the audio-frequency load is 50 % of its steady-state unsquelched value.

13.2.2 Method of measurement

- a) Connect the equipment as illustrated in Figure 3 with:
 - 1) an oscilloscope having a calibrated horizontal sweep connected in parallel with the audio-frequency load; and
 - 2) an electronically-controlled, single-step attenuator having a difference of at least 30 dB between its two states connected between the input-signal source and the receiver.The switching time of the attenuator shall be short compared with the expected squelch opening and closing times.
- b) Operate the receiver with no input signal. If equipped with an adjustable squelch control, adjust it to the position where the squelch just closes [see 13.1.2, step g)].
- c) Apply the standard input signal and operate the receiver at reference output level. Note this level on the oscilloscope.
- d) With the 30 dB single-step attenuator at the maximum attenuation value, adjust the input-signal level of the receiver to a value which is approximately 6 dB below the minimum squelch closing level.
- e) Derive the synchronizing pulse for the calibrated horizontal sweep of the oscilloscope from the attenuator activating signal.
- f) Change the state of the step attenuator from maximum to minimum attenuation. Measure and record the interval between the time of changing the attenuation and the time at which the voltage across the audio-frequency load increases to and remains above 50 % of the value noted in step c). This interval is the squelch opening delay.

- g) Change the state of the step attenuator from minimum to maximum attenuation. Measure and record the interval between the time of changing the attenuation and the time at which the voltage across the audio-frequency load decreases to 50 %. This interval is the squelch closing delay.

NOTE A variant of this method may be used whereby a dual-trace storage oscilloscope is made to show on one trace the radio-frequency signal which triggers the sweep, and on the other trace the audio-frequency signal.

13.3 Squelch blocking threshold

13.3.1 Definition

The value of frequency, phase or amplitude deviation of the input signal at a specified input-signal level and modulation frequency, which recloses the receiver squelch after it has been opened by the wanted signal.

13.3.2 Method of measurement

- Connect the equipment as illustrated in Figure 3.
- Operate the receiver with no input signal. If equipped with an adjustable squelch control, adjust it to the position where the squelch just closes [see 13.1.2, step g)].
- Apply the standard input signal and adjust it to a level 12 dB greater than the squelch opening level.
- Increase the deviation (amplitude, phase or frequency) of the input signal until the squelch just closes. Record this deviation as the squelch blocking threshold.
- This test should be repeated for other values of modulating frequency.
- Steps c), d) and e) should be repeated at the maximum squelch opening level [see 13.1.2, step j)].

13.4 Squelch detuning threshold

13.4.1 Definition

The values of positive and negative frequency offsets from the standard input-signal frequency (at specified modulation frequencies and modulation deviation) at which the squelch closes.

13.4.2 Method of measurement

- Connect the equipment as illustrated in Figure 3.
- Operate the receiver with no input signal. If equipped with an adjustable squelch control, adjust it to the position where the squelch just closes [see 13.1.2, step g)].
- Apply the standard input signal and adjust it to a level 12 dB greater than the squelch opening level.
- Vary the frequency of the radio-frequency signal generator above and below the standard input-signal frequency until the squelch just closes and record the frequency differences as the squelch detuning thresholds.
- This test should be repeated for other specified values of modulating frequencies while maintaining:
 - a modulation depth of 30 %;
 - 60 % of maximum permissible frequency deviation.
- Steps c), d) and e) should be repeated at the maximum squelch opening level [see 13.1.2, step j)].

14 Signal-to-residual output-power ratio

14.1 Definition

The ratio, in decibels, of:

- the reference output power; to
- the residual output power in the absence of modulation, both measured at standard input-signal level.

14.2 Method of measurement

- Connect the equipment as illustrated in Figure 3.
- Where possible, adjust the squelch control to the unsquelched position.
- Apply the standard input signal to the receiver.

- d) Operate the receiver at the reference output level.
- e) Remove the modulating signal and record the reduction, in decibels, of the power into the audio-frequency test load.

14.3 Presentation of results

Record the signal-to-residual output-power ratio obtained in step e), the value of the standard input signal and the reference audio-frequency output level.

NOTE When required by the equipment specification signal, the measurement may be carried out for various values of the input-signal level so that a graphical representation can be made of the ratio of signal-to-noise as a function of the input-signal level.

[A1]

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 μ s 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 μ s 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. **[A1]**

A1

16 A1 Impulsive noise

16.1 General

Impulsive noise degrades the performance of a receiver by reducing its sensitivity, for example, the input-signal level should be increased to maintain a specified signal-to-noise ratio. The response of the receiver to impulsive noise will vary with the spectrum amplitude of the noise (see Appendix C) and the noise pulse-repetition rate.

16.2 Impulsive-noise tolerance

16.2.1 Definition

A1 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:

- 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
- the wanted signal level [sensitivity (SUS) plus 3 dB] or the sensitivity (MUS) [the wanted signal level is the sensitivity (MUS) plus 3 dB]. A1

16.2.2 Method of measurement

NOTE 1 A1 The value of the sensitivity (SUS or MUS) determined in 7.1.2 or defined in 7.2.1 is required for this measurement A1.

NOTE 2 For information on the characteristics and calibration of a random impulse generator, see Appendix C.

- Calibrate the random impulse generator in accordance with Appendix C, Clause C.3 and record the minimum attenuation median spectrum amplitude S and the minimum attenuation value M . Increase the attenuation to a high value.
- Connect the equipment as illustrated in Figure 3 and connect the random impulse generator to terminal C of the appropriate matching or combining network (see Appendix A).
- A1 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. A1
- Increase the level of the wanted input signal by 3 dB.
- Adjust the random impulse generator to the following settings:
 - a frequency 100 kHz below the standard input frequency;
 - an average pulse repetition rate of 100 impulses per second;
 - a pulse duration of 0.2 μ s;
 - a standard deviation of amplitude of 6 dB;
 - a 10 Hz cut-off frequency of the low-pass filter;
 - a minimum spectrum amplitude.

NOTE The random impulse generator settings simulate the noise produced by city traffic that would impinge on the antenna of a nearby land mobile station. The above settings of the random impulse generator are not applicable to other environments.

- Adjust the attenuator of the random impulse generator until the standard signal-to-noise ratio at the receiver output terminals is obtained. Record the attenuation A in decibels.

16.2.3 Presentation of results

a) The impulsive noise tolerance is:

$$S - A + M - B - E \quad \text{dB} \left[\frac{\mu\text{V}/\text{MHz}}{\mu\text{V}} \right]$$

where

S is the minimum attenuation median spectrum amplitude recorded in 15.2.2, step a);

A is the attenuation value recorded in 15.2.2, step f);

M is the minimum attenuation value recorded in 15.2.2, step a);

B is the loss of the combining network (3) in decibels;

E is the $\overline{A_1}$ sensitivity (SUS or MUS) $\overline{A_1}$ in dB (μV).

b) Record the impulsive-noise tolerance, the standard input-signal frequency, the $\overline{A_1}$ sensitivity (SUS or MUS) $\overline{A_1}$ and the settings of the random impulse generator.

16.3 Noise-quieting input level as a function of input-signal frequency in the presence of impulsive noise

16.3.1 Definition

The input-signal level required to maintain a constant noise-quieting ratio in the presence of impulsive noise of specified characteristics.

16.3.2 Method of measurement

NOTE This measurement is directly applicable to receivers for angle modulation. It provides useful information about the performance of amplitude-modulated receivers which are equipped with automatic-gain control.

- a) Connect the equipment as illustrated in Figure 3 and connect an impulse generator to terminal B of the combining network.
- b) Apply the noise-quieting input signal in accordance with Sub-clause 9.2.
- c) Increase the input-signal level by 3 dB. Record this level in μV or dB (μV).
- d) At the specified pulse-repetition rate, adjust the impulse generator spectrum amplitude to a level that will again produce 20 dB noise quieting.
- e) With the spectrum amplitude established in step d) held constant, vary the input-signal frequency in increments above and below the standard input-signal frequency. Readjust the input-signal level at each frequency increment to obtain 20 dB noise quieting. Record this level in μV or dB (μV) and the frequency increment in kilohertz.
- f) Calculate the ratio, in decibels, of each level measured in steps c) and e) to the value established in step b).
- g) Repeat the measurement for higher spectrum amplitudes than used in step e).

NOTE This test may be repeated for other values of pulse repetition rates.

16.3.3 Presentation of results

Plot the ratio, in decibels, of the noise-quieting signal levels calculated in step f) on the linear ordinate of a graph and the frequency increments recorded in step e), in kilohertz, on the linear abscissa (see Figure 6 for an example). A separate graph is required for each value of pulse-repetition frequency. State the noise-quieting input-signal level in μV or dB (μV) and the standard input-signal frequency with the results.

A1

17 Selectivity

17.1 General

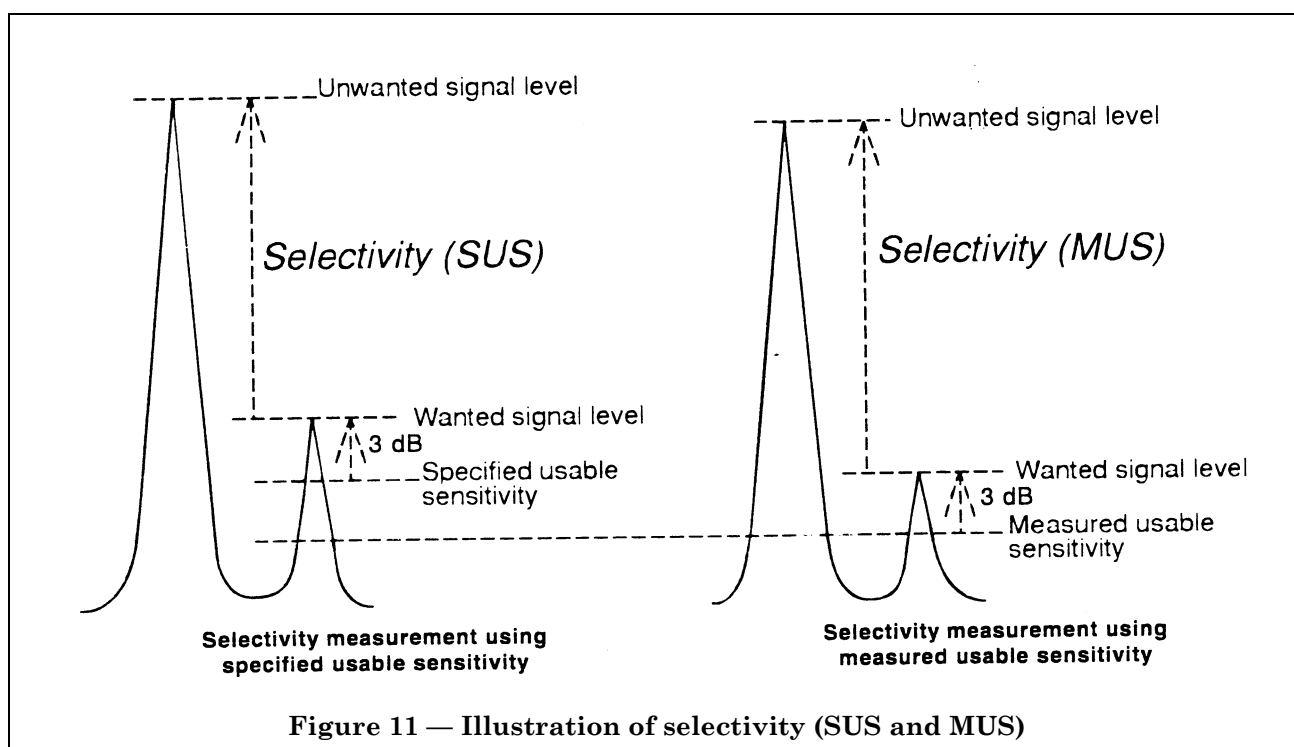
Selectivity is the ability of the receiver to discriminate between wanted and unwanted input signals.

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:

- 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)”;
- 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.



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:

- 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
- 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.

- 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).
- 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 the level in μV or $\text{dB}(\mu\text{V})$.
- Increase the level of this wanted input signal by 3 dB.
- 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.
- 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 $\text{dB}(\mu\text{V})$.
- Step e) may be repeated for other values of frequency displacement.

17.2.3 Presentation of results

- 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
- 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:

- the level of an unwanted signal, with specified modulation, that results in a specified signal level at the receiver output terminals; to
- the level of the wanted unmodulated input signal.