

Radio equipment used in mobile services —

Part 5: Methods of measurement for receivers employing single-sideband techniques (R3E, H3E or J3E)

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

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- British Approvals Board for Telecommunications
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- GAMBICA (BEAMA Ltd.)
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- Radio Society of Great Britain
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National foreword

This Part of BS 6160 has been prepared under the direction of the Electronic Equipment Standards Committee. It is identical with IEC Publication 489-5:1987 “*Methods of measurement for radio equipment used in the mobile services — Part 5: Receivers employing single-sideband techniques (R3E, H3E or J3E)*” published by the International Electrotechnical Commission (IEC).

This Part of BS 6160 is a revision of BS 6160-5:1981, which is withdrawn.

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

Terminology and conventions. The text of the International Standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

Cross-references

International Standard	Corresponding British Standard
	BS 4054 <i>Methods of measuring and expressing the performance of radio receivers for sound broadcasting</i>
IEC 315-1:1970	Part 1:1980 <i>General conditions</i> (Identical)
IEC 315-2:1971	Part 2:1980 <i>Measurements related to the audio-frequency part of the receiver</i> (Technically equivalent)
IEC 489-1:1983	BS 6160 <i>Radio equipment used in mobile services</i> Part 1:1989 <i>General requirements</i> (Identical)

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 62, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This standard refers specifically to mobile radio receivers having audio-frequency band-widths generally not exceeding 10 kHz for the reception of voice and other types of signals, using single-sideband amplitude modulation.

This standard is intended to be used in conjunction with IEC Publication 489-1. The supplementary terms and definitions and the conditions of measurement set forth in this standard are intended for type tests and may be used also 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 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 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 a 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.

NOTE The manufacturer should 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

NOTE 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

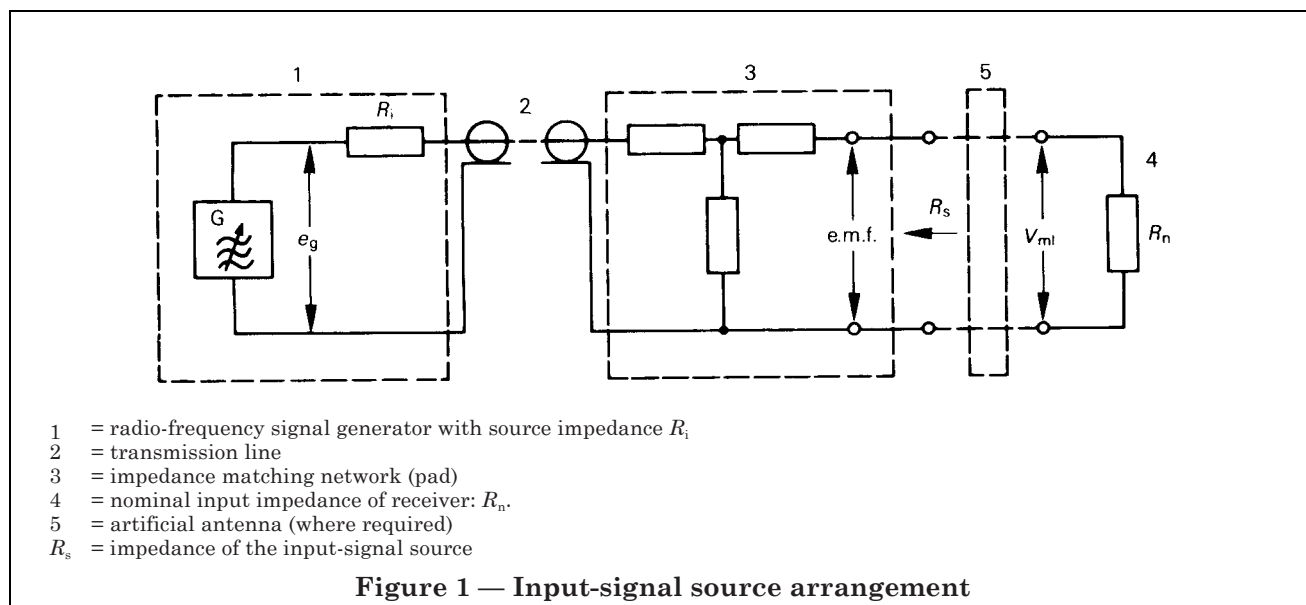
NOTE Pre-emphasis may be applied before modulation.

4 Standard test conditions

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

5 Supplementary test conditions

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



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 (e.m.f.) 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 (V_{ml}) voltage 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 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 (which is 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 3).

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

The input-signal level of the wanted signal shall be expressed as the r.m.s. value of a sinusoidal voltage, the peak value of which is equal to the amplitude of one radio-frequency cycle at the crest of the envelope of the modulation wave.

NOTE The input signal consisting of a carrier and a sideband component as specified in Sub-clause 5.3 should be expressed in terms of the sum of the r.m.s. voltages.

The input-signal level of any unmodulated unwanted signal shall be expressed in terms of its r.m.s. voltage.

The input levels of the wanted and unwanted signals shall be recorded in μV or dB (μV).

5.2.1 Receivers requiring a specific source resistance

The presentation of results should state whether the electromotive force of the source of 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}) should also 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 or a linear combination of two radio-frequency signals from a signal source that simulates the single-sideband emission from a transmitter when it is modulated with an audio-frequency signal of 1 000 Hz.

The frequencies and the levels of the input signal are dependent upon the class of emission they represent. Two frequencies, one of which represents the carrier and the other which represents the sideband, are chosen such that when demodulated they will produce an audio output at a frequency of 1 000 Hz.

The standard input-signal levels are:

Class of emission	Signal representing the	
	Carrier	Sideband
R3E	+ 42dB (μV)	+ 60 dB (μV)
H3E	+ 54 dB (μV)	+ 54 dB (μV)
J3E	Omit or + 20dB (μV), as specified	+ 60 dB (μV)

5.4 Networks for combining several signal sources

Examples of combining networks may be found in Appendix A.

5.5 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 should 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.

5.5.1 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 (1) (levels adjusted according to Sub-clause 5.3) 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) should 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 capacity.

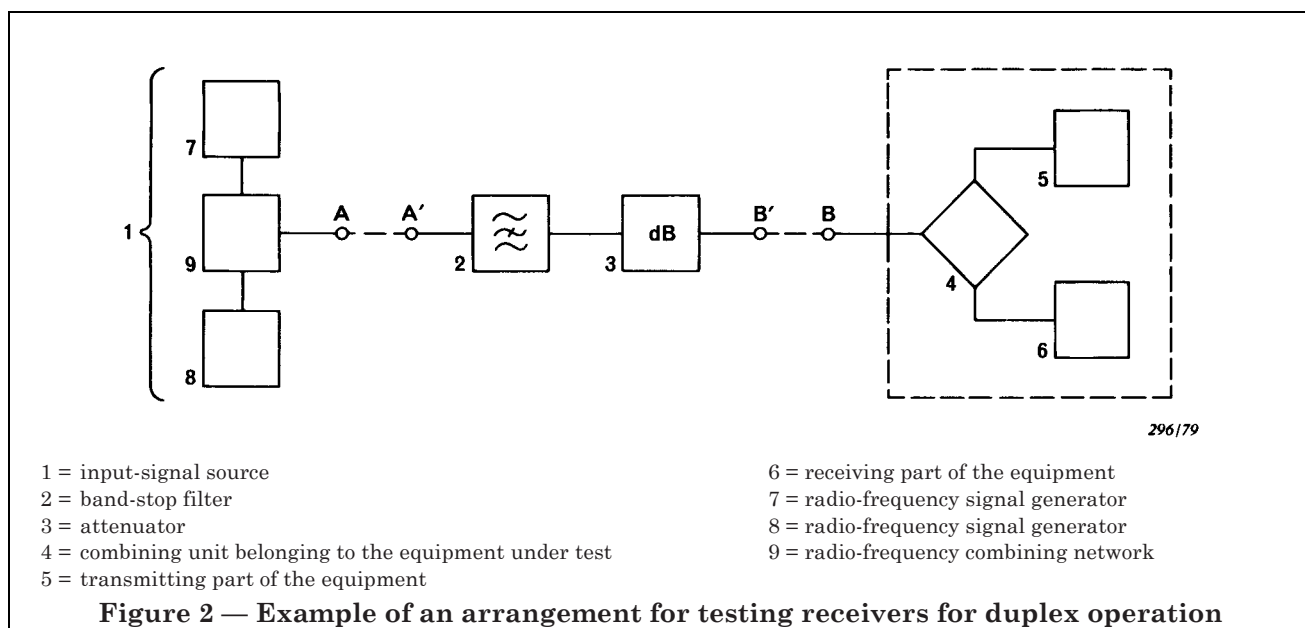


Figure 2 — Example of an arrangement for testing receivers for duplex operation

5.5.2 Input-signal level

The level of the r.f. input signal shall be determined at point B' of Figure 2, page 5.

5.6 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 connecting the measuring equipment, the input-signal source will include the antenna specified by the manufacturer. For absolute measurements, a radiation test site where the field strength of the test signals is known should be used. For relative measurements, a radio-frequency coupling device (RFCD) may be used.

5.7 Connection of the measuring equipment

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

5.7.1 Limitation of the audio-frequency band

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. The filter may be incorporated within the measuring equipment. When measuring residual hum and noise, only the low-pass portion of the filter need be specified.

5.8 Squelch condition

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

NOTE The term "squelch" is synonymous with "mute".

5.9 De-emphasis condition

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

5.10 Instrument input impedance

Depending upon requirement, the measuring instrument (13) or (14), in Figure 7, page 31, 85, may be either a distortion factor/audio level meter (13) or a selective measuring device (14). The input impedance Z_2 of the band-limiting filter (12), in Figure 7, should be much greater than Z_1 . If the band-limiting filter (12) is not used, the input impedance of the measuring device (13) or (14) should be much greater than Z_1 .

6 Characteristics of the measuring equipment

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

6.1 True r.m.s. voltage meter

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 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.
- NOTE If the SINAD meter has a fixed filter, it should have 40 dB attenuation over a 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 analyzer, 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)

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

Measurements of the radio-frequency parameters of receivers having an integral antenna are performed in an RFCD. When making these measurements, precautions shall be taken to ensure that:

- the receiver is adequately shielded from electromagnetic disturbance;
- the attenuation of the coupling between the radiation source and the receiver being measured is sufficiently low, stable, and constant throughout the measuring frequency range.

NOTE The coupling loss depends on the particular measuring arrangement, the frequency being used, and the receiver being measured. Normally, it is not precisely measured, as it will only be useful for a particular measuring arrangement and frequency.

The coupling loss shall be sufficiently low so that the output power requirements of the signal generators used in this standard will not exceed the power output capability of commercially available signal generators.

To ensure measurement repeatability, an RFCD which includes the following should be used in the measurement arrangement:

- a radiating element;
- a radio-frequency input terminal connected to the radiating element through a transmission line;
- a means to ensure that the input impedance of the RFCD be the same as the impedance of the transmission line from the radio-frequency signal generator;
- a means for positioning the receiver being measured in a precise, repeatable and stable manner;
- a means to ensure that the presence of the person making the measurement shall not affect the results.

It shall also have the following characteristics:

- a coupling loss between the radio-frequency input terminal and the receiver being measured of less than 30 dB;
- a coupling loss variation over the frequency range used in the measurement which does not exceed 2 dB;
- no non-linear elements which can affect the accuracy of the measurement results.

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 Reference sensitivity

7.1 Definition

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

7.2 Method of measurement

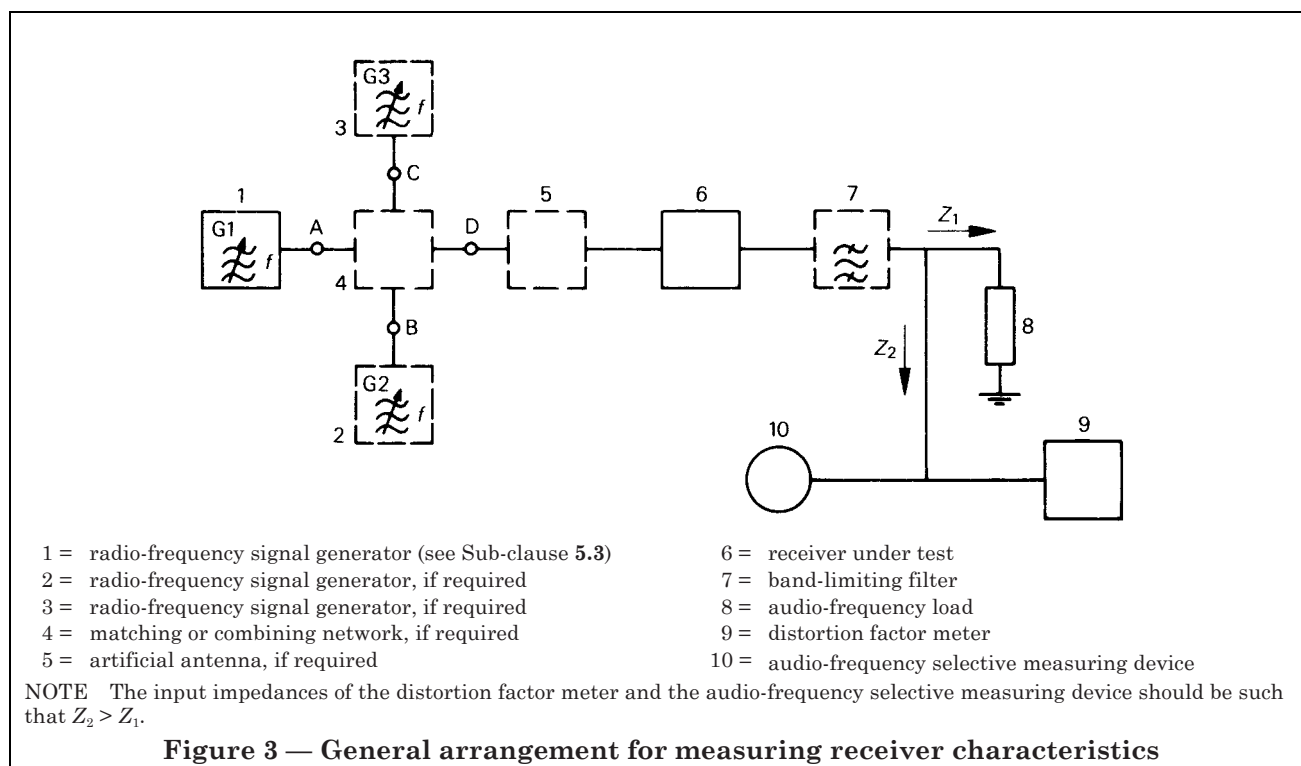
- Connect the equipment as illustrated in Figure 3, page 7.
- Apply a standard input signal (see Sub-clause 5.3) to the receiver-input terminals.
- Adjust the receiver volume control to obtain the reference output level (see Sub-clause 3.1.2). Record this level.
- Adjust the input-signal level to produce the standard signal-to-noise ratio. Record this level.
- If the output level obtained in step 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 output level has fallen by 3 dB should be recorded.
- The reference sensitivity is the level recorded in step d). It is expressed as:

The reference sensitivity for a $\frac{S+N+D}{N+D}$ ratio of 12 dB is ____ μV or dB (μV).

8 Audio-frequency response

8.1 Definition

The audio-frequency output signal level variation as a function of the sideband frequency corresponding to the audio-frequency being measured, for a constant input signal level.



8.2 Method of measurement

- a) Connect the equipment as illustrated in Figure 3 and connect an additional signal generator G3 to the matching or combining network (R3E, J3E).
- b) Apply a standard input signal to the receiver input terminals (see Sub-clause 5.3).
- c) Reduce the necessary sideband signal by 10 dB.
- d) For reception modes R3E and J3E, apply a signal from the additional generator G3 at a level of 60 dB (μ V) to produce an additional 1 600 Hz signal at the receiver output to stabilize the gain of the receiver.
- e) Adjust the receiver volume control to produce the reference output level.
- f) While maintaining a constant input signal level, vary the frequency of the necessary sideband signal c) over the specified range. At each test frequency, measure the level and frequency of the output signal by means of the selective measuring device. When measuring in the vicinity of 1 600 Hz, the frequency of the additional signal generator must be displaced so that the resultant pilot signal is just outside the passband of the selective measuring device. Record each audio-frequency and the corresponding output level.
- g) These tests may be repeated at other necessary sideband signal levels, but care should be taken to avoid overloading in the receiver audio-output stages.

8.3 Presentation of results

Plot the levels recorded in Step f), in decibels relative to the level at 1 000 Hz, on the linear ordinate of a graph, and the audio-frequency on the logarithmic abscissa.

9 Total distortion factor

9.1 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.

9.2 Method of measurement

- a) Connect the equipment as illustrated in Figure 3, page 7.
- b) Apply a standard input signal to the receiver input terminals (see Sub-clause 5.3).
- c) Operate the receiver at rated output level (see Sub-clause 3.1.1).
- d) Measure the total distortion factor at the audio-frequency load.

NOTE 1 This method of measurement is valid for other audio-frequencies and other levels of sideband signal.

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

10 Relative audio-frequency intermodulation product level

10.1 Definition

The ratio, expressed in decibels, of:

- a) the level of an unwanted non-harmonic output-signal component caused by non-linear distortion in the receiver when receiving an input signal representing simultaneous modulation of an appropriate mode transmitter by two signals, each producing a specified level of wanted sideband,
- to
- b) the level of one of the wanted output signals.

10.2 Method of measurement

- a) Connect the equipment as shown in Figure 3 and connect an additional radio-frequency signal generator G3 to terminal C of the matching and combining network.
- b) In the absence of a signal from generator G3, adjust generators G1 and G2 to produce a standard input signal at the receiver.
- c) Adjust the receiver volume control to produce the rated audio-frequency output level.

d) Adjust generator G3 to produce a sideband corresponding to 1 600 Hz modulation at one of the following levels at the receiver input terminals:

R3E 60dB (μ V)

H3E 54dB (μ V)

J3E 60dB (μ V)

e) With the selective measuring device, 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 can be used with sideband components producing audio-frequencies other than 1 000 Hz and 1 600 Hz.

10.3 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 e).

Tabulate the results as follows:

Intermodulation product frequency (Hz)	Ratio (dB)

State the class of emission.

11 Squelch characteristics

This clause deals with squelch circuits operated by the presence of modulation sidebands and/or carrier.

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

11.1 Squelch opening and closing levels

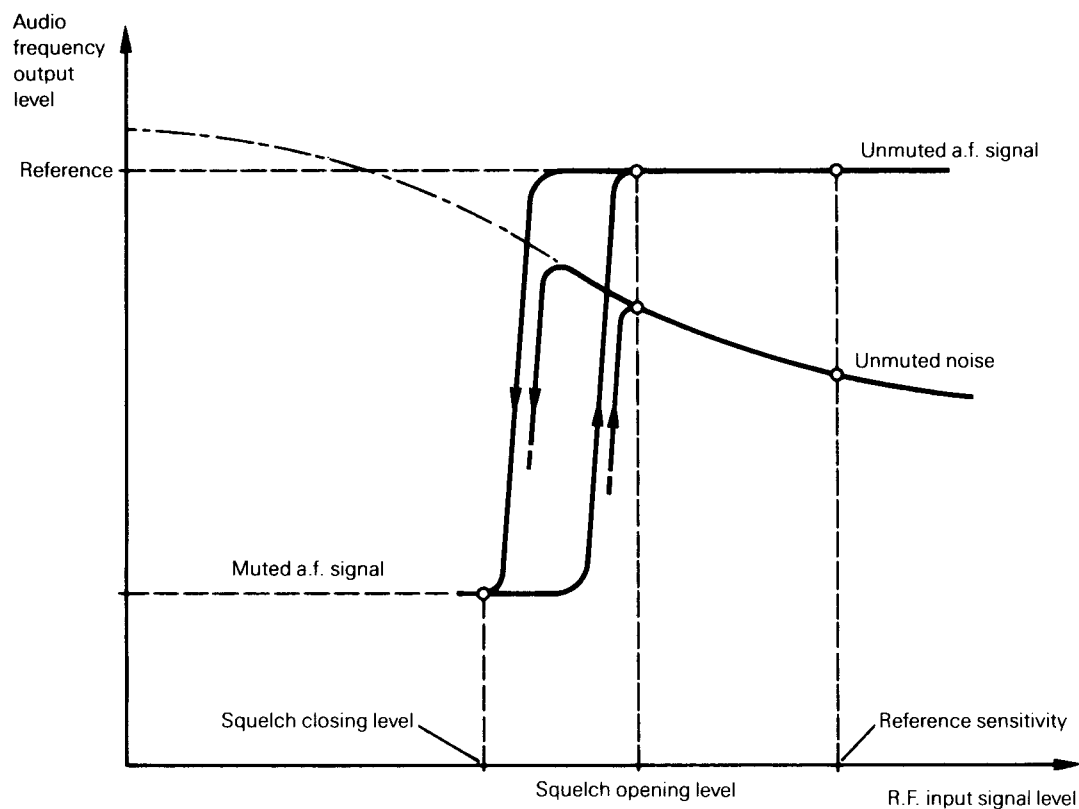
11.1.1 Definition

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.

11.1.2 Method of measurement for receivers having adjustable squelch controls

- Connect the equipment as illustrated in Figure 3, page 7.
- A test signal at a level of 1 mV (unless otherwise specified), and having modulation characteristics suitable for the particular squelch circuit as specified by the manufacturer, shall be used.
- Operate the receiver at the reference output level.
- 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).
- Adjust the squelch until the squelch just closes.
- Increase the input-signal level until the squelch just opens.
- 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.
- Increase the input-signal level until the squelch just opens and record the signal level as the minimum squelch opening level in μ V or dB (μ V).
- Reduce the input-signal level until the squelch just closes. Record this signal as the minimum squelch closing level in μ V or dB (μ V).
- 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 μ V or dB (μ V).
- Reduce the input-signal level until the squelch just closes. Record this signal level as the maximum squelch closing level in μ V or dB (μ V).



NOTE The input-signal levels shown are relative and are for illustrative purposes only.

Figure 4 — Squelch opening and closing levels

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

Perform the measurement according to Steps a), b), c), d), h) and i) of Sub-clause 11.1.2 and record the signal levels obtained in Steps h) and i) as the squelch opening and closing levels, respectively.

11.2 Squelch opening and closing delays

11.2.1 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.

11.2.2 Method of measurement

- a) Connect the equipment as illustrated in Figure 3, page 7, 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.

NOTE The switching time of the attenuator should 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 Sub-clause 11.1.2, Step g)].
- c) Apply the standard input signal and operate the receiver at the 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.

11.3 Squelch blocking threshold

Under consideration.

12 Signal-to-residual output-power ratio

This test is only applicable to the H3E mode.

12.1 Definition

The ratio, in decibels, of:

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

12.2 Method of measurement

- a) Connect the equipment as illustrated in Figure 3, page 7.
- b) Where possible, adjust the squelch control to the unsquelched position.
- c) Apply a standard input signal to the receiver.
- d) Operate the receiver at the reference output level.
- e) Remove the sideband signal and record the reduction, in decibels, of the level into the audio frequency test load.

13 Impulsive noise

13.1 General

Impulsive noise degrades the performance of a receiver by reducing its sensitivity, for example, the input-signal level must 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.

13.2 Impulsive-noise tolerance

13.2.1 Definition

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

It is expressed as a 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 reference sensitivity, to restore the standard signal-to-noise ratio at the receiver output terminals
- to
- b) the reference sensitivity.

13.2.2 Method of measurement

NOTE 1 The value of the reference sensitivity determined in Sub-clause 7.2 is required for this measurement.

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

- a) 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.
- b) Connect the equipment as illustrated in Figure 3, page 7, and connect the random impulse generator to terminal C of the appropriate matching or combining network (see Appendix A).
- c) In the absence of the impulsive noise, apply the standard input signal to terminals A and B of the combining network (see Sub-clause 5.3). Reduce its level to obtain reference sensitivity at the input of the receiver.
- d) Increase the level of the wanted input signal by 3 dB.
- e) 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.

- f) 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.

13.2.3 Presentation of results

- a) The impulse noise tolerance is:

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

where:

S is the minimum attenuation median spectrum amplitude recorded in Step a) of Sub-clause 13.2.2

A is the attenuation value recorded in Step f) of Sub-clause 13.2.2

M is the minimum attenuation value recorded in Step a) of Sub-clause 13.2.2

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

E is the reference sensitivity in dB (μ V)

- b) Record the impulsive-noise tolerance, the standard input signal frequency, the reference sensitivity and the settings of the random impulse generator.

14 Selectivity

14.1 General

Selectivity is the ability of the receiver to discriminate between wanted and unwanted input signals. It can be evaluated by measuring the adjacent-signal selectivity, the spurious response, crossmodulation and blocking or desensitization.

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

NOTE It is important that the signal generators used in the following measurements be free of spurious emissions. If spurious emissions do exist, notch filters should be used to eliminate them.

14.2 Adjacent-signal selectivity (including blocking)

14.2.1 Definition

The ratio of

a) the level of an unwanted input signal that reduces the signal-to-noise ratio, produced by a signal 3 dB in excess of the reference sensitivity, to the standard signal-to-noise ratio

to

b) the reference sensitivity.

Blocking 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 greater than 1 % of the standard input-signal frequency.

14.2.2 Method of measurement

NOTE This measurement requires knowledge of the reference sensitivity (see Clause 7).

a) Connect the equipment as illustrated in Figure 3, page 7, and connect an additional signal generator (unwanted signal source) to terminal C of the appropriate matching or combining network (see Appendix A).

b) In the absence of the unwanted signal, apply the standard input signal (see Sub-clause 5.3) to the receiver. Reduce its level to obtain the reference sensitivity at the input of the receiver. Record this level in μV or dB (μV).

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

d) Apply an unwanted, unmodulated input signal to terminal C of the matching or combining network.

e) Adjust the unwanted signal frequency by a specified amount above and below the wanted carrier frequency outside the passband of the receiver. At each frequency adjust the unwanted level so as to re-establish the standard signal-to-noise ratio. Record the level of the unwanted signals in μV or dB (μV).

f) Calculate the ratios, in decibels, of the unwanted signal levels measured in Step e) to the reference sensitivity.

The smaller value is the adjacent-signal selectivity.

g) Steps e) and f) may be repeated for other values of frequency displacement.

NOTE The results may be displayed in a table.

14.2.3 Adjacent channel selectivity

Where mobile radio services use discrete channel spacings, the value of 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.

14.3 Crossmodulation

14.3.1 Definition

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

14.3.2 Method of measurement

a) Connect the equipment as illustrated in Figure 3 and connect an additional signal generator (unwanted signal source) to terminal C of the appropriate matching or combining network (see Appendix A).

b) In the absence of the unwanted signal, apply a standard input signal (see Sub-clause 5.3).

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

d) Apply an unwanted signal 30 % amplitude modulated with 400 Hz to the combining network and adjust the unwanted input signal to a frequency approximately 30 kHz above or below the standard input-signal frequency.

NOTE For receivers in which the adjacent-signal selectivity at 30 kHz would affect the results, greater frequency separation should be used.

e) Increase the unwanted input-signal until the SINAD at the receiver output is reduced to 20 dB due to crossmodulation.

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

- f) The input level of the unwanted signal, in decibels relative to 1 μV , at which the condition in Step e) is obtained, is a measure of the crossmodulation immunity.

14.4 Spurious-response immunity

14.4.1 Definition

The ability of the receiver to prevent single unwanted signals from causing an unwanted response at the output of the receiver.

It is expressed as the ratio, in decibels, of:

- a) the level of a single unwanted signal that reduces the signal-to-noise ratio, produced by a wanted signal 3 dB in excess of the reference sensitivity, to the standard signal-to-noise ratio
- to
- b) the reference sensitivity.

14.4.2 Method of measurement

NOTE This measurement requires knowledge of the reference sensitivity (see Clause 7).

- a) Connect the equipment as illustrated in Figure 3, page 7, and connect an additional signal generator (unwanted signal source) to terminal C of the appropriate matching or combining network (see Appendix A).
- b) In the absence of the unwanted signal, apply the standard input signal (see Sub-clause 5.3) to the receiver. Reduce its level to obtain the reference sensitivity at the input of the receiver. Record this wanted signal level in μV or dB (μV).
- c) Increase the level of the wanted input signal by 3 dB.
- d) Apply a high-level, unwanted, unmodulated input signal [for example, 90dB (μV)] to terminal C of the combining network.
- e) Vary the unwanted input-signal frequency over a specified frequency range to search for 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).
- g) Calculate the ratios, in decibels, of the unwanted signal levels recorded in Step f) to the reference sensitivity. This ratio is the spurious-response immunity for the frequency concerned.

14.4.3 Presentation of results

Tabulate the ratios obtained in Step g) together with the frequencies recorded in Step f). Record the nominal operating frequency.

14.5 Intermodulation immunity

14.5.1 Definition

The ability of the receiver to prevent two unwanted signals, with a specific frequency relationship to the wanted-signal frequency, from causing an unwanted response at the output of the receiver due to intermodulation.

It is expressed as the ratio, in decibels, of

- a) the level of two equal-level unwanted signals that reduce the signal-to-noise ratio, produced by a wanted signal 3 dB in excess of the reference sensitivity, to the standard signal-to-noise ratio
- to
- b) the reference sensitivity.

NOTE Refer to Appendix D for frequency relationships likely to result in an unwanted response due to intermodulation.

14.5.2 Method of measurement

NOTE This measurement requires knowledge of the reference sensitivity (see Clause 7).

- a) Connect the equipment as illustrated in Figure 3, page 7, and connect two additional signal generators (unwanted signal sources) to an appropriate matching or combining network (see Appendix A for examples of combining networks).

- b) In the absence of unwanted signals, apply the standard input signal (see Sub-clause 5.3) to the receiver and reduce its level to obtain the reference sensitivity at the input of the receiver. Record this level in μV or $\text{dB}(\mu\text{V})$.
- c) Increase the level of the wanted input signal by 3 dB.
- d) Apply an unwanted, unmodulated input signal adjusted to a specified frequency f_n .
- e) Apply an unwanted, unmodulated input signal adjusted to a specified frequency f_r .
- f) Incrementally increase the levels of the two unwanted signals until the wanted 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 $\text{dB}(\mu\text{V})$.
- i) Calculate the ratio, in decibels, of the level recorded in Step h) to the reference sensitivity. This ratio is the intermodulation immunity for the frequencies concerned.

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

15 Automatic gain control (A.G.C.) characteristics

15.1 Definition

The change in output level as a function of the level of the input signal.

15.2 Method of measurement

- a) Connect the equipment as illustrated in Figure 3 and connect an additional signal generator G3 to the matching or combining network.

NOTE The additional generator is used in mode J3E to control the gain. The gain variation is determined by measuring the level of the necessary sideband.

- b) Apply a standard input signal to the receiver input terminals and increase the level by 40 dB.
- c) Reduce the level of the necessary sideband by 10 dB.
- d) For reception mode J3E, apply a signal from the additional generator at a level of 100 dB (μV) to produce an additional 1 600 Hz signal at the receiver output terminals at a level 10 dB greater than 1 000 Hz audio-frequency signal.
- e) Adjust the receiver volume control to provide the reference output level.
- f) Reduce the composite-signal level in steps and record the 1 000 Hz audio-frequency output-level for each value of the composite-signal level. Continue until the reference sensitivity is reached.
- g) The measurement may be continued at lower input-signal levels to determine the performance at levels below the reference sensitivity.
- h) The measurement may also be extended to levels above 100 dB (μV) to identify the upper limit of the A.G.C. characteristic.

15.3 Presentation of results

Plot the level of the output (1 000 Hz) relative to the reference 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.

Alternatively, a table of values may be presented.

15.4 Dynamic automatic gain-control characteristic

15.4.1 General

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

15.4.2 Definition — A.G.C. attack time

The 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.