INTERNATIONAL STANDARD

IEC 60489-6

Third edition
1999-07

Radio equipment used in mobile services – Methods of measurement –

Part 6: Data equipment

Matériel de radiocommunication utilisé dans les services mobiles – Méthodes de mesure –

Partie 6: Matériel numérique

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For general terminology, readers are referred to IEC 60050: *International Electrotechnical Vocabulary* (IEV).

For graphical symbols, and letter symbols and signs approved by the IEC for general use, readers are referred to publications IEC 60027: *Letter symbols to be used in electrical technology*, IEC 60417: *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets* and IEC 60617: *Graphical symbols for diagrams.*

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

RADIO EQUIPMENT USED IN MOBILE SERVICES – METHODS OF MEASUREMENT –

Part 6: Data equipment

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organization.
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International Standard IEC 60489-6 has been prepared by IEC technical committee 102: Equipment used in radio communications for mobile services and for satellite communication systems.

This third edition of IEC 60489-6 cancels and replaces the second edition, published in 1987, amendment 1 (1989) and amendment 2 (1991). This third edition constitutes a technical revision.

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

FDIS	Report on voting
102/44/FDIS	102/54/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

IEC 60489-6 forms one of a series of publications under the general title*: Radio equipment used in mobile services – Methods of measurement.* Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next revision.

Annexes A, B, C, E, F and G form an integral part of this standard.

Annexes D, H and I are for information only.

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

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RADIO EQUIPMENT USED IN MOBILE SERVICES – METHODS OF MEASUREMENT –

Part 6: Data equipment

1 General

1.1 Scope and object

This part of IEC 60489 refers specifically to mobile radio transmitters and receivers for the transmission of data (telegraphy) signals having the emission characteristics given in 1.1.

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

The object of this standard is to standardize the definitions, the conditions and the methods of measurement used to ascertain the radio-frequency performance of data and selective call equipment, thus making possible meaningful comparisons of the results of measurements made by different observers and on different equipment.

This standard will cover the following types of data signals:

– bit streams;
– character strings;
– messages;
– selective calling.

Selective calling differs from messages in their intended functions; it may be considered as data signals, analogous to messages transmitting only the information required to activate an alarm on one receiver or a group of receivers.

The methods of measurements for the radio-frequency parameters are appropriate for the four types of data signals.

To differentiate between the radio-frequency parameters (e.g. adjacent channel power, frequency error) measured in this standard from those in associated standards, the name of each parameter is followed by either “(bit stream)” or “(character string)” or “(message)” or “(selective calling)”. After each radio-frequency parameter the general term “(data)” is used. When each equipment is measured, the proper data type “(bit stream)” “(character string)” “(message)” or “(selective calling)” will be substituted for “(data)”.

1.2 Emission characteristics

This standard is applicable to the following emission characteristics expressed according to the ITU Radio Regulations Emission Designation.

Emission characteristics are expressed by four symbols:

a) – b) – c) – d)

where

a) is the type of modulation of the main carrier;

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b) is the nature of signals modulating the main carrier;

c) is the type of information to be transmitted;

d) is the detail of signal(s) (optional).

a) Type of modulation of the main carrier (first symbol):

(A) double-sideband;

(H) single-sideband, full carrier;

(R) single-sideband, reduced or variable level carrier;

(J) single-sideband, suppressed carrier;

(F) frequency modulation;

(G) phase modulation.

b) Nature of signal(s) modulating the main carrier (second symbol):

(1) a single channel containing quantized or digital information without the use of a modulating sub-carrier;

(2) a single channel containing quantized or digital information with the use of a modulating sub-carrier;

(3) two or more channels containing quantized or digital information.

c) Type of information to be transmitted (third symbol):

(A) telegraphy – for aural reception;

(B) telegraphy – for automatic reception;

(C) facsimile;

(D) data transmission, telemetry or telecommand.

d) Details of signal(s) (fourth symbol, optional):

(A) two-condition code with elements of differing numbers and/or durations;

(B) two-condition code with elements of the same number and duration without error-correction;

(C) two-condition code with elements of the same number and duration with error-correction;

(D) four-condition code in which each condition represents a signal element (of one or more bits);

(E) multi-condition code in which each condition represents a signal element (of one or more bits);

(F) multi-condition code in which each condition or combination of conditions represents a character.

NOTE – See ITU Radio Regulations (edition 1982), Article 4 and Appendix 6 (AP6, part A) for details and definition of the emission characteristics.

1.3 System characteristics

1.3.1 Transmitter

The transmitters that are measured using the methods in this standard may be capable of simultaneously transmitting two or more data signals or voice and a data signal. The operational characteristics of the system in which the transmitter will be used will establish if the transmitter will be required to simultaneously transmit several types of signals.

Many of the systems that require the transmitter to transmit both analogue voice and data arrange it so that either voice or data are transmitted, but not simultaneously. In this instance this standard would be used to measure the transmitter radio-frequency parameters with the transmitter in the data mode only. IEC 60489-2 should be used to measure the radio-frequency parameters with the transmitter in the analogue voice mode.

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When the system requires that the transmitter transmit simultaneously more than one signal, the radio-frequency parameters will be measured with the transmitter transmitting only the maximum number of simultaneous signals required by the system. For example, a transmitter may be capable of transmitting three types of signals, but the system may require under some circumstances that two signals be transmitted simultaneously and, at all other times, only one signal will be transmitted. In this case, the measurements should be made while the transmitter is transmitting the two simultaneous signals.

When the system requires that input signals, other than the data signal to be used in the measurement, be applied simultaneously with the data signal to the transmitter under test, they should be applied to the proper port and at the signal levels specified by the manufacturer. The measurements in this standard will then be made using simultaneously the data signal and the other required signals (see figure 1).

1.3.2 Receiver

In this standard, the subclauses entitled “Method of measurement” are designed to measure the value of a radio-frequency parameter. In some cases, it is only necessary to determine if the receiver-decoder is compliant with the radio-frequency parameter specification. This can usually be done more simply and with less effort than measuring the radio-frequency parameter. For the more frequently measured radio-frequency parameters, a compliance test method is included in the appropriate clauses. The specified value for the radio-frequency parameter will be the appropriate value specified by a regulation, contract or equipment specification.

The degradation measurements for receivers (4.3 to 5.1) requires the knowledge of the sensitivity. This sensitivity is used to derive a value for the wanted signal level. In one case, the sensitivity to use is the measured usable sensitivity – MUS – (determined according to 4.2 for every equipment under test). Alternatively, it is possible to use the specified usable sensitivity – SUS – applicable for a set of equipment.

According to the type of measurement performed, it is necessary to add, immediately after the name of each measured parameter, either “(referred to MUS)” or “(referred to SUS)”.

1.4 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60489. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60489 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(721), *International Electrotechnical Vocabulary – Chapter 721: Telegraphy, facsimile and data communication*

IEC 60489-1, *Methods of measurement for radio equipment used in the mobile services – Part 1: General definitions and standard conditions of measurement*

IEC 60489-2, *Methods of measurement for radio equipment used in the mobile services – Part 2: Transmitters employing A3E, F3E or G3E emissions*

2 Terms and definitions

For the purpose of this part of IEC 60489, the definitions given in IEC 60489-1, as well as the following supplementary definitions, apply.

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2.1
average frequency
number of positive (or negative) going zero crossings of the signal divided by the total time duration of the measurement

2.2
binary digit bit
member of a set of two elements commonly used to represent information [IEV 721-02-08]

2.3
bit rate
number of bits transmitted per unit of time, expressed in bit/s, kbit/s or Mbit/s

2.4
bit stream
continuous series of bits

2.5
character
member of a set of elements agreed upon to be used for organization, representation or control of information

NOTE – Characters may be letters, digits, punctuation marks or other symbols and, by extension, function controls such as space shift, carriage return or line feed contained in a message.

[IEV 721-03-09]

2.6
character string
character or sequence of characters

2.7
comparator (data)

2.7.1
comparator (bit stream or character string)
device capable of

– storing a reference sequence of bits or characters,
– counting the number of bits or characters that are transmitted,
– comparing the bits or characters received with the reference sequence of bits or characters,
– counting the number of correctly received bits or characters

2.7.2
comparator (message or selective calling)
device or person capable of

– storing a reference message or call,
– counting the number of times a message or a call is transmitted,
– comparing the message or the call received with the reference message or call,
– counting the number of correctly received message or calls

2.8
data
information represented in a manner suitable for automatic processing

[IEV 721-01-02]

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2.9
data source
device that generates the standard baseband test signals in the form of an electrical signal. For character and messages, this is normally specified by the equipment manufacturer

2.10
decoder
device, which may be in the receiver, that translates the demodulated signal into the intended output signal.

For selective calling, the output signal is only an alarm, indicating that any or all receivers and their associated decoders have received their intended coded signals

NOTE – The alarm may be a lamp, a "bleep" generated within the decoder, a vibrator, or only the opening of a mute or squelch circuit. The latter is usually indicated by an increase in the residual noise level at the output of the receiver.

2.11
encoder
device which translates a group of input signals into a unique group of output signals suitable for transmission (see figure 1)

NOTE – Examples of functions that may be involved are

– addition of synchronization bits,
– addition of error correction bits,
– parallel/serial conversion,
– amplitude and phase shaping.

2.12
erroneous bit, character or message
any decoded bit, character or message that is not the same as the transmitted bit, character or message

2.13
error
failure to decode correctly the intended transmitted bit, character, message or selective calling

NOTE – Another type of error is the reception of data in the absence of any intended transmission (false reception). The mean time between two successive false receptions is generally so high that a measurement would be impractical; this parameter is estimated by calculation.

2.14
error ratio
number of erroneous bits, character messages or selective callings received, divided by the total number of bits, characters, messages or selective callings transmitted, respectively.

For selective calling (1 – error ratio) is also called "calling probability"

2.15
message
group of characters and function control sequences which is transferred as an entity from a transmitter to a receiver, where the arrangement of the characters is determined at the transmitter

[IEV 721-09-01]

2.16
message format
description of the elements and their arrangement in a message

NOTE – The arrangements may include among other items, synchronization bits, address bits, text, flag bits and additional bits for error correction and/or detection:

a) synchronization bits: additional bits which are provided only for the purpose of synchronization;

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b) address: information that identifies the address or identifies the sending unit;

c) function: information that identifies which of a plurality of responses is to be executed;

d) text: information (e.g. character string);

e) error control bits: bits which are provided solely for the purpose of error correction and/or detection.

2.17
modulation

NOTE – The detailed description of the modulation should be given in specifications of equipment under test.

2.17.1
analogue modulation

2.17.1.1
amplitude modulation:
– peak envelope amplitude: the amplitude of one radio-frequency oscillation at the crest of the envelope of the modulated wave;

– modulation depth: for double-sideband amplitude modulation, the modulation depth, in per cent, 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

2.17.1.2
frequency or phase modulation
– maximum permissible deviation: the value to which the peak frequency or phase deviation is limited by an agreed convention for a particular class of service;

– deviation: the variation of the carrier wave in frequency or phase, expressed in per cent of the maximum permissible deviation

2.17.2
digital modulation

2.17.2.1
keying method
for example,

– frequency-shift keying (FSK)

– phase-shift keying (PSK)

– minimum-shift keying (MSK)

2.17.2.2
roll-off factor and its transmitter percentage
– roll-off factor is expressed by the product of the pulse-shaping function baseband filter cut-off frequency and the modulation symbol time

– transmitter percentage is the ratio percentage of the roll-off factor, which is performed by transmitters, the residual percentage being performed by receivers

2.18
port
place of access to a device or network where energy, representing data, may be supplied or withdrawn, or where the device or network variable may be observed or measured

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2.19
radio pager
small radio receiver-decoder which produces an alarm following reception of a selective call; intended to be worn on a person and usually has an integral antenna

2.20
reference error ratio
the following reference error ratios apply for an equipment measured with the standard test signal code (data):

– reference error ratio (bit stream or character string) 0,01 or 1 %;

– reference error ratio (message or selective calling) 0,2 or 20 %.

For selective calling (1 – reference error ratio) = 0,8 or 80 % is also called “standard calling probability”

2.21
selective-calling system
system whereby the transmission of a signal code from a station enables another predetermined station or group of stations to be called exclusively; it may be used as “selective calling” or “selective call”

2.22
standard baseband test signals
for the purpose of the measurements described in this standard the following definitions apply:

a) reference sequence of bits

binary sequence pattern of 511 bits which are generated in a pseudo-random order

NOTE – For details concerning the generation of the pseudo-random binary sequence (PRBS) pattern, see CCITT Fascicle VIII.1, Recommendation O.153.

b) reference sequence of characters

character sequence pattern comprising all elements of a specified character set arranged in a specified pseudo-random order

c) reference message or selective call

message or selective call whose content is defined in the equipment specification

NOTE – This unique message is repeated three or four times in the “up and down” method.

2.23
standard coded test signal (data): SCTS (data)
radio-frequency signal applied to a data receiver-decoder that simulates the output of a transmitter which is modulated by one of the following standard baseband test signals:

– the reference sequence of bits; or

– the reference sequence of characters, or

– the reference message or the selective call

– at the bit rate defined in the data equipment specification

All parameter tolerances (e.g. rise time, tone frequencies, phase-shift angles) should be small enough to ensure that the results are not significantly influenced. In addition to any other parameters, the equipment specification should define the appropriate values for

– the modulation depth of double-sideband modulation, or

– the frequency/phase deviation of angle modulation, or

– the amplitude relationship to the carrier of single-sideband, full, reduced or variable carrier modulation,

– the frequency relationship to the carrier of single-sideband, full, reduced or variable carrier modulation

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2.24
standard train of standard coded test signal (bit stream or character string)

NOTE 1 – The length of the standard trains has been chosen in order to achieve a dispersion of ±1 dB for the measurement of reference sensitivity and of ±2 dB for all other measurements.

For all measurements and compliance tests, except sensitivity reduction under multipath propagation conditions (bit stream or character string), the standard trains are

– for bit stream : 2 556 bits of SCTS;

– for character string : 2 556 characters of SCTS

NOTE 2 – For the measurements in this standard, the required reliability is obtained if the transmission is stopped after 26 bit or character errors are detected.

2.25
standard unwanted signal (data)
the standard unwanted signal for measuring spurious response immunity and intermodulation immunity is not modulated.

The standard unwanted signal for measuring adjacent radio-frequency signal selectivity or co-channel interference rejection is continuously modulated with a binary sequence pattern of 32 767 bits which is generated in a pseudo-random order. The modulation is identical with the modulation characteristics of the system transmitter

2.26
telegraphy
form of telecommunication in which the transmitted information is intended to be recorded on arrival as a graphic document; the transmitted information may sometimes be presented in an alternative form or may be stored for subsequent use

NOTE 1 – A graphic document records information in a permanent form and is capable of being filed and consulted; for example, it may take the form of written or printed matter or of a fixed image.

NOTE 2 – This is the definition given in the International Telecommunication Convention (Nairobi, 1982).

NOTE 3 – Telegraphy does not include television or videography.

[IEV 721-01-06, modified]

3 Test conditions

3.1 Standard test conditions

3.1.1 Unless otherwise stated, measurements shall be performed under the general test conditions as stated in IEC 60489-1 and the supplementary test conditions given in 3.2.

3.1.2 In this standard, the methods of measurement have been developed under the assumption that automatic test equipment is available.

3.1.3 If the data source and encoder are external to the transmitter but are dedicated to its application, the manufacturer shall supply to the organization making the measurements either detailed information so that the items can be fabricated, or the device itself.

3.2 Supplementary test conditions

3.2.1 Receivers

3.2.1.1 Receiver-decoder having an integral antenna

In this standard, the methods of measurement and compliance tests have been written for receivers having antenna terminals. For receivers with integral antennas, the following test conditions apply:

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– for average radiation sensitivity (data) (see 11.1.6), measurements and compliance tests are made on a test site;

– measurements and compliance tests in 4.1 through 4.9 (data) for receiver-decoders having an integral antenna are made with the receiver in a suitable radio-frequency coupling device (RFCD).

The RFCD may be

– a test fixture device for coupling a given equipment with an integral antenna to an input socket. It is generally designed and provided by the manufacturer. It allows relative measurements to be performed at the same frequency or around the same frequency. Therefore the measurements and compliance tests in 4.5 (spurious response immunity) and in 6.1 (radiated spurious components) are excluded;

– a stripline arrangement as described in IEC 60489-1, annex A, clause A.3. This is a measuring instrument for coupling any equipment with integrated antenna to an input socket. It allows relative measurement of signals to be performed situated at different frequencies.

The same procedures are used as for receivers having antenna terminals, except that the input-signal level recorded is that introduced at the input terminals of the RFCD instead of at the antenna terminals of the receiver.

NOTE 1 – For message or selective calling, the measurements and compliance tests (4.1 through 4.9) have been designed for non-automatic use: the number of trials in these measurements and compliance tests have been reduced to the minimum required to obtain the necessary accuracy and variation. Various automatic measurement procedures may be used, but it is not proposed that they be standardized at this time. On the other hand, for bit stream and character string, the measurements and compliance tests (4.1 through 4.9) have been designed to use automatic error counting equipment.

NOTE 2 – The measurements in 4.1 through 4.9 (message or selective calling) can be used for continuous signal (e.g. continuous tone controlled squelch systems) provided that a time for the operation of the decoder is specified (e.g. 300 ms).

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

Depending on the type of modulation and the measuring equipment available, one of the three measuring arrangements described below shall be employed.

a) Arrangement A

The arrangement comprises the following pieces of equipment:

– a test data source and an encoder as required, or a test encoder combining these two functions;

– a radio-frequency signal generator or an alternate signal source (see 3.3.9) capable of being modulated in accordance with the type of modulation used by the receiver;

– an impedance matching network (or pad; see (3) of figure 2) placed as close as possible to the receiver under test.

NOTE – Examples of impedance matching networks and combining networks are given in annex A.

b) Arrangement B

For some types of single-sideband modulation, with corresponding characteristics as given in 1.2 b) (1), it may be possible to simulate the modulated signal by using two radio-frequency generators. In this case, an arrangement similar to arrangement A may be used, but with the signal generator or alternate signal source replaced by two radio-frequency signal generators, the outputs of which are connected to a combining network terminated in an adjustable attenuator.

c) Arrangement C

The arrangement is similar to arrangement A, except that it also requires a means to convert the output frequency of the alternate signal source to the nominal frequency specified for the receiver. This is accomplished by using a radio-frequency signal generator

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and a frequency converter which is terminated in an adjustable attenuator. Some measurements require an unwanted signal to be added. This signal is supplied by a radio-frequency signal generator connected to one of the inputs of a combining network which is inserted at a convenient place in the transmission line (2) shown in figure 2.

The presentation of results shall state which of the arrangements A, B or C has been used.

For arrangements A and C, the performance of the alternate signal source should be such that the receiver parameters may be measured up to values which are at least 10 dB greater than the receivers specified values.

3.2.1.2.1 Source impedance of the measuring arrangement for receivers requiring a specified source resistance

This subclause applies to receivers which are connected to the antenna by means of a transmission line (which is synonymous with “feeder line”) having a specified characteristic impedance, for example equal to R_n, R_n being the specified nominal radio-frequency input impedance of the receiver.

The source impedance R_s of the measuring arrangement shown in figure 2 shall be equal to the specified source resistance, or, in the absence of such specification, to the specified nominal radio-frequency input impedance R_n of the receiver.

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

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

This subclause 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.

3.2.1.2.3 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. It should be expressed in µV or dB(µV).

3.2.1.3 Input-signal measuring convention

3.2.1.3.1 Receiver requiring a specified source resistance

The input-signal level should preferably be determined by measuring the electromotive force present at the output terminals of the unterminated input-signal source (e.m.f. of figure 2).

Alternatively, the input-signal level may be determined by measuring the matched-load (ml) voltage across a resistance having a value equal to R_s.

The matched-load (ml) voltage is one-half the value of the e.m.f.

When the input-signal level is determined with a voltmeter incorporated in the equipment supplying the input signal (voltage e_g in figure 2), the loss of the impedance matching network and, if applicable, also the losses of the transmission line and any combining network and adjustable attenuators inserted in the transmission line shall be taken into account.

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The presentation of results shall state which voltage has been recorded, for example, 2 µV (e.m.f.) or 1 µV (ml). The source resistance R_S, shall be stated with the results.

3.2.1.3.2 Input-signal level

In this standard, the input-signal levels of the wanted and unwanted signals shall be expressed in terms of r.m.s. values as follows:

– for angle (type G or F: phase or frequency) modulation, including frequency-shift and phase-shift modulation or keying: the r.m.s. voltage of the signal, either modulated or unmodulated;
– for on-off modulation, or keying of a sinusoidal carrier which may or may not be modulated with an additional signal: the r.m.s. voltage of the continuous carrier, without modulation;
– for double-sideband amplitude (type A) modulation with full carrier: the r.m.s. voltage of the unmodulated carrier;
– for single-sideband amplitude (type H or R) modulation with full, reduced or variable carrier: 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 modulated wave.

The input-signal levels may be expressed in µV or dB(µV) and shall be determined in accordance with 3.2.1.2.

3.2.1.4 Connections of the measuring equipment

The data measuring equipment shall be connected to the port that provides signals for the intended application.

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

3.2.1.5 Standard input signal

3.2.1.5.1 Standard input signal (type A, G or F modulation)

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

3.2.1.5.2 Standard input signal (type H or R modulation)

A radio-frequency signal or 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 the sideband, are chosen so 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 carrier dB(µV)	Signal representing sideband dB(µV)
R3E	+42	+60
H3E	+54	+54

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3.2.1.6 Standard input-signal level

Unless otherwise specified, the standard input-signal level for a receiver of the type considered in this standard is 60 dB(µV) (e.m.f.) or 54 dB(µV) (ml).

3.2.1.7 Standard input-signal frequency

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

3.2.1.8 Standard modulation of an input signal

a) for digital modulation

The standard modulation is the nominal modulation specified in the systems to be used. The modulation type (e.g. GMSK or π/4 shifted QPSK), the pulse-shaping function, its transmitter percentage and the symbol rate will be the dominant parameters of the digital modulation.

b) for analogue modulation

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.

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

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

3.2.1.9.1 Input-signal source

An example of a suitable arrangement for making measurements on receivers of equipment for duplex operation is shown in figure 3.

Connect the input-signal source (1) (levels adjusted in accordance with 3.2.1.3) 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 transmitting part is operating under the specified matched conditions. To ensure that the VSWR 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 transmitting part and therefore shall have suitable power-handling capability.

3.2.1.9.2 Input-signal level

The level of the radio-frequency input signal shall be determined at point B' of figure 3.

3.2.1.9.3 Input-signal location

The radio-frequency input signal shall be determined at point B' of figure 3.

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3.2.2 Transmitter

3.2.2.1 General

This standard allows for the measurement of many types of data signals. While some of the data signals are continuous or extend for many seconds, there are others that have a duration of only a few milliseconds. In this standard, the radio-frequency parameter is measured and the results averaged only over the duration of the data signal. However, in the case of short duration signal, this signal may be repeated for the purpose of the measurement.

For transmitters used in systems that require the transmitter to transmit more than one signal simultaneously, the measurement is made while the transmitter is transmitting the maximum number of signals required by the system. If one of the data signals has a short duration, the measurement is made during that short duration.

This standard recognizes that the methods of measurements that are suitable for making the measurements for long-duration data signals may not be suitable when the data signals are of short duration. Therefore, this standard contains different methods of measurement for different equipment and provides a guide for determining when each method of measurement should be used.

3.2.2.2 Selection guideline for methods of measurement

A guideline for selecting the correct method of measurement to be used for the transmitter under test is provided. The operation mode of a transmitter is characterized by modulation state (unmodulated or modulated), transmission mode (continuous or intermittent) and modulating signal (random date or non-random data). Such characteristics propose several types of signal:

a) Type 1: Continuous emission, capable of unmodulated carrier transmission

   Transmitters which can emit an unmodulated carrier which may be considered to be continuous for the purpose of the measurement.

b) Type 2: Continuous emission, allowed state

   Transmitters (e.g. FSK modulation) which can emit a radio-frequency signal that represent one of the allowed states (e.g. mark or space for a two-state system) and may be considered to be continuous for the purpose of the measurement.

c) Type 3: Continuous emission, modulated carrier

   Transmitter which cannot be operated unless the carrier is modulated, and whose signal may be considered to be continuous for the purpose of the measurement.

   This type is further classified by the type of modulating signal for the purpose of the frequency error measurement:

   Type 3 a: modulated with random data (symmetrical spectrum);

   Type 3 b: modulated with non-random data (asymmetrical spectrum).

   NOTE – Standard baseband test signal (bit stream) (see 2.22) is a kind of random data for the purpose of this measurement. Another source signal is not necessarily random for the purpose of this measurement.

d) Type 4: Short emission, modulated carrier

   Transmitters which may only emit a data modulated radio-frequency signal for a short time (however, such transmitters may emit for a longer period of time either unmodulated or modulated with another signal) but repeatedly, either periodically or manually triggered.

   This type is further classified by the type of modulating signal for the purpose of the frequency measurement:

   Type 4 a: modulated with random data (symmetrical spectrum);

   Type 4 b: modulated with non-random data (asymmetrical spectrum).

   NOTE – It is possible to define a type 5: short emission, unmodulated carrier but this type is not necessary in this standard.

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3.2.2.3 Output signal measuring arrangements for transmitters having accessible antenna terminals

3.2.2.3.1 Test load

A non-radiating load, with an impedance and power rating specified by the transmitter manufacturer, to replace the antenna including any associated transmission line when the transmitter is being tested.

3.2.2.3.2 Connections to the measuring equipment

Care should be taken to ensure that measuring equipment and any coupling devices do not adversely affect the transmitter loading conditions.

3.3 Characteristics of the measuring equipment

Where necessary (for measuring equipment which may not be commercially available), and to ensure that different operators at different locations will obtain similar results when measuring the same receiver, certain characteristics of the measuring equipment and test sites have been specified. Procedures for verifying that the measuring equipment meets these specifications are also given.

3.3.1 Signal generator intermodulation characteristics

A method for identifying intermodulation between signal generators, the outputs of which are combined, is given in annex B.

3.3.2 Signal generator noise characteristics

A method for identifying signal generator noise is given in annex B.

3.3.3 Selective measuring device

The selective measuring device may be 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.

3.3.4 Radio-frequency coupling device (RFCD) characteristics and measurements

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. The RFCD may be

– a test fixture, device for coupling a given equipment with an integral antenna to an input socket. It is generally designed and provided by the manufacturer. It allows relative measurements to be performed at the same frequency or around the same frequency. Therefore, the measurements and compliance tests of measured usable sensitivity, of spurious response immunity and radiated spurious components are excluded;

– a stripline arrangement as described in IEC 60489-1, annex A, clause A.3. This is a measuring instrument for coupling any equipment with integrated antenna to an input socket. It allows relative measurement of signals to be performed situated at different frequencies.

When making these measurements, precautions shall be taken to ensure that

– the receiver is adequately shielded from electromagnetic disturbance;

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– 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.

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 is only useful for a particular measuring arrangement and frequency.

The coupling loss shall be sufficiently low so that the output power requirements at 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 is 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 does 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 measurement results.

3.3.5 Combining networks

Examples of combining networks are given in annex A.

3.3.6 Rayleigh fading simulator characteristics

Annex C contains the following items:

– an example of a Rayleigh fading simulator;
– specifications for the required parameters;
– a method of measurement for the required parameters.

3.3.7 Characteristics of radiation test sites

IEC 60489-1, annex A, clause A.2 provides a guide for selection, characteristics, basic measuring procedure, construction, evaluation measurement and calibration method for OATS (Open area test site), LRTS (Low reflection test site), AC (Anechoic chamber) and RFM (Random field measurement) test sites.

3.3.8 Simulated man

A simulated man is required when the average radiation sensitivity (selective calling) of a radio pager is measured. A description of a simulated man and its use is given in IEC 60489-1, annex A, clause A.4.

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3.3.9 Alternate signal source

For certain measurements, it may not be possible to modulate a radio-frequency signal generator to produce the necessary input signals, for example for single-sideband. In these circumstances, a transmitter may have to be used as an alternate signal source for the wanted or unwanted signal.

Some measurements require that the frequency be moved. A local oscillator, balanced mixer and filters may be used to make the frequency translation.

The characteristics of the alternate signal source should be such that the receiver parameters may be measured up to values which are at least 10 dB greater than the receivers' specified values.

Care shall be taken to shield the receiver from the transmitter.

3.3.10 Signal generators

Signal generators are normally characterized for sine-wave modulation, and application of non-sinusoidal waveforms, which are often encountered in the transmission of data, may lead to monitoring or modulation problems. Such problems can affect the overall accuracy of any measurements that are made.

3.3.10.1 Monitoring problems

If the signal generator is provided with a voltmeter system to monitor the applied external modulation signal, the readings may be in error when non-sinusoidal waveforms are applied. It is recommended that an oscilloscope be used to monitor the peak voltage of the applied data signal and that the level be adjusted to be equal to the amplitude of a pure sine-wave which would produce the required modulation condition. If the signal generator monitor shows the same indication on both input-signal conditions, then the user can be confident that inaccuracies due to monitoring will not be a problem.

3.3.10.2 Modulating problems

The signal generator modulating system has a finite bandwidth which is determined by high-pass and low-pass filters. The high-pass filter can introduce phase and amplitude errors at low frequencies, and the user should assess the suitability of the instrument from the data provided by the manufacturer. In some circumstances, a signal source with a response extending down to a sufficiently low frequency (e.g. 1 Hz) will be satisfactory.

The effect of the low-pass filter on the signal source will be most noticeable when modulating signals with fast rise and fall times are applied. Depending on the characteristics of the filters, the modulation applied to the carrier signal will exhibit overshoot or degradation of the rise and fall times. In practice, these problems can be eliminated by filtering the modulating signal before it is applied to the signal generator, so that the source correctly simulates a narrow-band transmitter.

3.3.11 Power meter

A device that responds to mean power.

3.3.12 Frequency measuring device

3.3.12.1 The accuracy of the frequency measuring device shall be at least 10 times more precise than the frequency tolerance given in the transmitter specification.

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3.3.12.2 When measuring frequency, phase-modulated or unmodulated continuous signals, conventional frequency counters which measure the number of positive- (or negative-) going zero crossings of the signal, divided by the duration of the measurement, may be used.

Systematic measuring error may exist depending on randomness of the modulating signal, but this may become negligible for the purpose of this standard if the 511-bit length pseudo-random binary sequence is used as a modulating signal.

3.3.12.3 When measuring a pulsed signal, a frequency counter with synchronous trigger mode may be used. Measuring accuracy and required measuring time depends on the pulse duration. When the pulse duration is longer than several milliseconds, this method may give a permissible measuring accuracy for the purpose of this standard in a practical measuring time. Measuring accuracy may be improved by averaging operation among multiple pulses.

NOTE – If pulse durations and gate width (GW) are 5 ms, pulse period Tp is 20 ms and resolution (R) is set at 10 Hz:

– measuring accuracy = ±0,5/GW
  = ±100 Hz r.m.s.
– measuring time = Tp × 1/(R x GW)^2
  = 8 s

3.3.12.4 When measuring other type of signals, a digital storage spectrum analyser may be used to measure the centre frequency of the frequency band occupied by an emission.

3.3.13 Power measuring receiver

Details for the power measuring receiver are given in annex B, clause B.3.

3.3.14 Waveform recorder

When a short or complex voltage waveform has to be averaged over the duration of the data modulation, the waveform should be captured so that the averaging calculations can be made. A digital sampling waveform recorder is one instrument that has this capability.

A waveform recorder is a voltage sampling device that has the following features:

– an envelope detector which has a bandwidth of at least three times the highest modulating frequency;
– an analogue-to-digital converter that produces words of at least 8 bits for each sample;
– a memory to store the digitized samples: the memory size shall be at least equal to the sampling rate times the modulation duration;
– a means to start and stop the sampling at the beginning and end of the data signal. This is the sampling gate. The duration of the data signal is usually given in the equipment specification;
– a means to delay the sampling gate. In some transmitters, it may be impossible to obtain a signal from the data source or encoder that coincides with the start of the data signal. The equipment specifications will usually indicate that the data signal will start at a given time after some other event, for example activation of the transmitter or an input function, which can be used to activate the delaying circuit;
– a means to read and transfer the stored samples to a computing device for calculations;
– a sampling rate that is at least three times the highest modulating frequency. This instrument may be a separate unit or it may be part of another instrument, for example a digital oscilloscope.

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4 Measurements of receiver-decoder radio-frequency parameters

4.1 Sensitivity (data)

4.1.1 Measured usable sensitivity (MUS) (data)

4.1.1.1 Definition

The radio-frequency level of the standard coded test signal (SCTS) (data), at a specified frequency, which will result in the reference error ratio (data).

4.1.1.2 Method of measurement for bit stream or character string

a) Connect the equipment as illustrated in figure 4 with the switches in position b. Test equipment items (1) and (2) and a comparator are required (see 2.7).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1) modulate the radio-frequency signal generator (2) with the standard train of coded test signal (bit stream or character string) to generate the SCTS (bit stream or character string) (see 2.22, 2.23 and 2.24).

d) Adjust the level of the input signal to the receiver-decoder to the value of the measured usable sensitivity (bit stream or character string) stated in the equipment specification.

e) Transmit the standard train of SCTS (see 2.24).

f) Calculate and note the error ratio.

g) If the error ratio equals the reference error ratio (bit stream or character string), terminate the measurement. Record the radio-frequency signal level as the measured usable sensitivity (bit stream or character string) and proceed to step b) of 4.1.1.3.

   If the error ratio is less than the reference error ratio (bit stream or character string), decrease the input-signal level to the receiver-decoder by 0,5 dB.

   If the error ratio is greater than the reference error ratio (bit stream or character string), increase the input-signal level to the receiver-decoder by 0,5 dB.

h) Repeat steps e) through g) until two consecutive values of error ratio have been obtained, which bracket the reference error ratio (bit stream or character string). Record the input-signal level, V, in dB(µV) that corresponds to the error ratio which is just greater than the reference error ratio (bit stream or character string).

4.1.1.3 Presentation of results for bit stream or character string

a) Calculate the measured usable sensitivity (bit stream or character string), S, as:

$$S = V + 0{,}25 \quad (\text{dB}(\mu\text{V}))$$

   where V is the value of the input-signal level to the receiver-decoder recorded in step h) of 4.1.1.2.

b) Record the input signal arrangement used, characteristics of the SCTS (bit stream or character string) and the measured usable sensitivity (bit stream or character string).

4.1.1.4 Method of measurement for message or selective calling

a) Connect the equipment as illustrated in figure 4 with the switches in position b. Test equipment items (1), (2) and (3) are required (see 2.7).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Apply to the attenuator (3) a signal having the standard input-signal frequency and at a level of approximately 60 dB(µV). Record this level as A.

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d) Using the encoder (1) modulate the radio-frequency signal generator (2) with the reference sequence of messages or selective callings to generate the SCTS (message or selective calling) (see 2.22 and 2.23).

e) Adjust the step attenuator (3) to a value which will produce a high error ratio (e.g. 50 % or greater).

f) 1) Transmit the SCTS a maximum of three times, terminating the transmission sequence, if the receiver-decoder does not recognizes any of its SCTS. Adjust the step attenuator(3) according to step f)2) or f)3) whichever is appropriate.

2) If the receiver-decoder fails to recognize either the first, second or third SCTS, decrease the attenuation of (3) by 2 dB and repeat step f)1).

3 If the receiver-decoder recognizes the three SCTS, record the attenuation value in decibels, increase the attenuation of (3) by 1 dB, record the new attenuation value in decibels, and proceed to step g)1).

g) 1) Transmit the SCTS a maximum of three times, terminating the transmission sequence, if the receiver-decoder does not recognizes any of its SCTS. Adjust the step attenuator (3) according to step g)2) or g)3), whichever is appropriate.

2) If the receiver-decoder fails to recognize either the first, second or third SCTS, decrease the attenuation of (3) by 1 dB, record the new attenuation value in decibels, and repeat step g)1). See step h).

3) If the receiver-decoder recognizes the three SCTS, increase the attenuation of (3) by 1 dB, record the new attenuation value in decibels, and repeat step g) 1). See step h).

h) Continue steps g)1), g)2) and g)3) until attenuator values have been recorded 10 times.

NOTE – A careful study of the example in figure E.8 of annex E, is recommended to avoid the possibility of misunderstanding steps g) and h).

4.1.1.5 Presentation of results for message or selective calling

a) Calculate the average of the attenuation values recorded in decibels in steps f)3), g)2) and g)3) of 4.1.1.4.

b) The measured usable sensitivity (message or selective calling) is:

$$A - B \quad (\text{dB}(\mu\text{V}))$$

where

A is the value recorded in step c) of 4.1.1.4;

B is the average of the attenuation values calculated in step a) in decibels.

c) Record the input signal arrangement used, characteristics of the SCTS (message or selective calling) and measured usable sensitivity (message or selective calling).

4.1.2 Specified usable sensitivity (SUS) (data)

4.1.2.1 Definition

The radio-frequency level of the standard coded test signal (SCTS) (data) specified by the regulatory authority, manufacturer or customer at the specified frequency, which results in an error ratio equal to or smaller than the reference error ratio (data).

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

4.1.2.2 Compliance test method – sensitivity (SUS) (data)

a) Connect the equipment as illustrated in figure 4 with the switches in position b, using test equipment items (1) and (2) and a comparator (see 2.7).

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b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency signal generator (2) with the standard train of coded test signal (data) or with the specified message or selective call to generate the standard coded test signal (SCTS) (data) (see 2.16, 2.22, 2.23 and 2.24).

d) Adjust the level of the input signal to the receiver-decoder to the value of sensitivity (SUS) (data).

e) Transmit the standard train of SCTS for bit stream or character string (see 2.24), or 18 specified messages or selective calls.

f) If there are 25 or less errors for bit stream or character string, or three or less errors for message or selective calls, record that the receiver-decoder complies with the sensitivity (SUS) (data) specification, otherwise record that it does not comply.

g) Record the input signal arrangement used, characteristics of the SCTS (data) and the sensitivity (SUS) (data).

4.2 Adjacent radio-frequency signal selectivity (data)

4.2.1 General

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

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

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

a) the ratio of the level of the unwanted input signal to the level of the wanted signal, which is set to the SUS (see 4.1.2) plus 3 dB; this is expressed as “selectivity (SUS)”;

or

b) the ratio of the level of the unwanted input-signal level to the value of the sensitivity (MUS) (see 4.1.1), the wanted signal being set 3 dB above the value of the MUS; this is expressed as “selectivity (MUS)”.

Figure 5 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 field 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.

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4.2.2 Definition

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

a) the level of an unwanted input signal that causes a wanted input signal, which is 3 dB in excess of the sensitivity (SUS or MUS) (data), to produce an error ratio equal to the reference error ratio (data), to

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

4.2.3 Method of measurement for bit stream or character string

NOTE – The value of the sensitivity (MUS or SUS) (bit stream or character string) determined in 4.1.1.3 or defined in 4.1.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b. Test equipment items (1), (2), (4), (5) and (6) and a comparator are required (see 2.7). Item (5) is replaced with an unwanted signal encoder.

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1) modulate the radio-frequency signal generator (2) with the standard train of standard coded test signal (bit stream or character string) to generate the standard coded test signal (SCTS) (bit stream or character string) (see 2.22, 2.23 and 2.24).

d) In the absence of the unwanted signal, adjust the wanted signal level at the input of the matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (bit stream or character string) determined in 4.2 plus the loss of the matching and combining network (4).

e) Using the encoder (1), modulate radio-frequency generator (6) with the standard unwanted signal (data) to generate the unwanted signal at the upper ("lower" for step j) specified frequency of the adjacent unwanted signal (see 2.25).

   Adjust the level to the input of the matching and combining network (4) to equal the sensitivity (SUS or MUS) (bit stream or character string) multiplied by the ratio of the adjacent radio-frequency signal selectivity (bit stream or character string), stated in the equipment specification plus the loss of the matching and combining network (4).

f) Transmit the standard train of SCTS (see 2.24).

g) Calculate and note the error ratio.

h) If the error ratio equals the reference error ratio (bit stream or character string), terminate the measurement. Record the unwanted radio-frequency signal level, *G*, in dB(μV), and proceed to step b) of 4.2.4.

   If the error ratio is less than the reference error ratio (bit stream or character string), increase the unwanted signal level by 0,5 dB.

   If the error ratio is greater than the reference error ratio (bit stream or character string), decrease the unwanted signal level by 0,5 dB.

i) Repeat steps e) through h) until two consecutive values of error ratio have been obtained which bracket the reference error ratio (bit stream or character string). Record the unwanted radio-frequency signal level, *U*, in dB(μV) that corresponds to the error ratio which is just greater than the reference error ratio (bit stream or character string).

j) Repeat steps e) through i) for the lower specified frequency of the adjacent unwanted signal.

NOTE – This method of measurement is suitable for making measurements at other than the specified unwanted signal frequency.

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4.2.4 Presentation of results for bit stream or character string

a) Calculate the level of the unwanted radio-frequency, G, as follows:

$$G = U - 0{,}25 \quad (\text{dB}(\mu\text{V}))$$

b) Calculate the upper and the lower adjacent radio-frequency signal selectivities, *S*, either as:

$$S = G - R \text{ (for selectivity MUS)} \quad (\text{dB}); \text{ or}$$

$$S = G - R - 3 \text{ (for selectivity SUS)} \quad (\text{dB})$$

where

G is the value recorded in step h) of 9.3 or in step a) of 9.4;

R is the sensitivity (SUS or MUS) (bit stream or character string) plus the loss of the matching and combining network (4).

c) Record the adjacent radio-frequency signal selectivity (referred to SUS or MUS) (bit stream or character string) as the smaller of the values of *S* calculated above.

d) Record the input signal arrangement used, the characteristics of the SCTS (bit stream or character string), the characteristics of the unwanted signal, the frequencies of the specified unwanted adjacent signals and the sensitivity (SUS or MUS) (bit stream or character string).

4.2.5 Method of measurement for message or selective calling

NOTE – The value of the sensitivity (MUS or SUS) (message or selective calling) determined in 4.1.1.5 or defined in 4.1.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b. Test equipment items (1), (2), (4), (5), (6) and (9) and a comparator are required (see 2.7). Item (5) is replaced with an unwanted signal encoder.

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency signal generator (2) with the reference sequence of messages or selective callings to generate the standard coded test signal (SCTS) (message or selective calling) (see 2.22 and 2.23).

d) In the absence of the unwanted signal, adjust the signal level at the input of the matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (message or selective calling) determined in 4.2 plus the loss of the matching and combining network (4).

e) Using the encoder (1), modulate the radio-frequency generator (6) with the standard unwanted signal (data) to generate the unwanted signal at the upper ("lower" for step j) specified frequency of the adjacent unwanted signal (see 2.25). Apply a high-level signal (e.g. 100 dB(μV)) to the attenuator (9). Record this value, A, in dB(μV).

f) Adjust the step attenuator (9) to a value which will produce a high error ratio (e.g. 50 % or greater).

g) 1) Transmit the SCTS a maximum of three times, terminating the transmission sequence if the receiver-decoder does not recognize any of the SCTS. Adjust the step attenuator (9) according to step g)2) or g)3), whichever is appropriate.

2) If the receiver-decoder fails to recognize either the first, second or third SCTS, increase the attenuation of (9) by 2 dB and repeat step g)1).

3) If the receiver-decoder recognizes the three SCTSs, record the attenuation value in decibels, decrease the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and proceed to step h)1).

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h) 1) Transmit the SCTS a maximum of the three times, terminating the transmission sequence if the receiver-decoder does not recognize any of the SCTS. Adjust the step attenuator (9) according to step h)2) or h)3), whichever is appropriate.

2) If the receiver-decoder fails to recognize either the first, second or third SCTS, increase the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and repeat step h)1). See step i).

3) If the receiver-decoder recognizes the three SCTS, decrease the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and repeat step h)1). See step i).

i) Continue steps h)1), h)2) and h)3) until attenuator values have been recorded 20 times.

NOTE – A careful study of the example in figure E.10 of annex E, is recommended to avoid the possibility of misunderstanding step h) and i).

j) Repeat steps e) through i) for the lower specified frequency of the adjacent unwanted signal.

4.2.6 Presentation of results for message or selective calling

a) Calculate the average of the attenuation values recorded in decibels in steps g)3), h)2) and h)3) of 8.5 for the upper frequency of the adjacent unwanted signal.

b) Calculate the average of the attenuation values recorded in decibels in steps g)3), h)2) and h)3) of 8.5 for the lower frequency of the adjacent unwanted signal.

c) Calculate the upper and lower adjacent radio-frequency signal selectivity, S, either as:

$$S = A - B - R \text{ (for selectivity MUS) (dB), or}$$

$$S = A - B - R - 3 \text{ (for selectivity SUS) (dB)}$$

where

A is the value recorded in dB(μV) in step e)of 8.5;

B is the average of the attenuation values calculated in step a) and in step h) in decibels;

R is the sensitivity (SUS or MUS) (message or selective calling) plus the loss of the matching and combining network (4).

d) Record the adjacent radio-frequency signal selectivity (referred to SUS or MUS) (message or selective calling) as the smaller of the values of S calculated above.

e) Record the input signal arrangement used, the characteristics of the SCTS (message or selective calling), the characteristics of the unwanted signal and the frequencies of the specified unwanted adjacent signals and sensitivity (SUS or MUS) (message or selective calling).

4.2.7 Compliance test method – Adjacent radio-frequency signal selectivity (data)

NOTE – The value of the sensitivity (MUS or SUS) (data) determined in 4.1.1.3 or 4.1.1.5 or defined in 4.1.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b. Test equipment items (1), (2), (4), (5), (6) and a comparator are required (see 2.7). Item (5) is replaced with an unwanted signal encoder.

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency signal generator (2) with the standard train of standard coded test signal (data) or with the specified message to generate the standard coded test signal (SCTS) (data) (see 2.16, 2.22, 2.23 and 2.24).

d) Adjust the wanted signal level at the input of the matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (data) determined in 4.1, plus the loss of the matching and combining network (4).

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e) Using the encoder (1), modulate the radio-frequency generator (6) with the standard unwanted signal (data) to generate the unwanted signal at the upper specified adjacent frequency (see 2.25).

f) Adjust the unwanted signal level at the input of the matching and combining network (4) to equal the sensitivity (SUS) plus 3 dB or the sensitivity (MUS), determined in 4.1, increased by the specified value of the adjacent radio-frequency signal selectivity (data) plus the loss of the matching and combining network (4).

g) Transmit the standard train of SCTS for bit stream or character string (see 2.24), or 33 specified messages or selective calls.

h) If there are 25 or less errors for bit stream or character string, or six or less errors for message or selective call, record that for the upper specified frequency the receiver-decoder does comply with the adjacent radio-frequency signal selectivity (data) specification.

i) Repeat steps e) through h) for the lower specified adjacent frequency.

j) If it was recorded in step h) that the receiver-decoder does comply for both specified frequencies, then record that it does comply with the adjacent radio-frequency signal selectivity (data) specification, otherwise record that it does not comply.

k) Record the input signal arrangement used, characteristics of the SCTS (data), the sensitivity (SUS or MUS) (data) and the specified adjacent radio-frequency signal selectivity (data).

4.3 Co-channel interference rejection (data)

Co-channel interference rejection (data) is a special case of adjacent radio-frequency signal selectivity (data). It is measured using the method of measurement given in 4.2 with the frequency of the standard unwanted signal (data) the same as the wanted signal.

4.4 Adjacent-channel selectivity (data)

When mobile radio services use discrete channel spacings, the value of adjacent radio-frequency signal selectivity (data) measured for a signal spacing equal to the discrete channel spacing may be quoted as the value of the adjacent-channel selectivity (data). Adjacent-channel selectivity (data) is measured using the method of measurement given in 4.2, with the frequency of the standard unwanted signal displaced one channel space.

4.5 Spurious response immunity (data)

4.5.1 Definition

The ability of the receiver-decoder to prevent a single unwanted spurious signal from degrading the desired response. It is the ratio, expressed in decibels, of

a) the level of an unwanted input signal that causes a wanted input signal, which is 3 dB in excess of the sensitivity (SUS or MUS) (data), to produce an error ratio equal to the reference error ratio (data), to

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

4.5.2 Method of measurement for bit stream or character string

NOTE 1 – The value of the sensitivity (MUS or SUS) (bit stream or character string) determined in 4.1.1.3 or defined in 4.1.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b. Test equipment items (1), (2), (4) and (6) and a comparator are required (see 2.7).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

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c) Using the encoder (1), modulate radio-frequency signal generator (2) with the standard train of standard coded test signal (bit stream or character string) to generate the standard coded test signal (SCTS) (bit stream or character string) (see 2.22, 2.23 and 2.24).

d) In the absence of the unwanted signal, adjust the signal level at the input of the matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (bit stream or character string) determined in 4.2 plus the loss of the matching and combining network (4).

e) Adjust the radio-frequency generator (6) to a frequency that may degrade the response of the receiver-decoder. Note the unwanted signal frequency (see 2.25).

Adjust the level to the input of the matching and combining network (4) to equal the sensitivity (SUS or MUS) (bit stream or character string), multiplied by the ratio of the spurious response immunity (bit stream or character string), stated in the equipment specification, plus the loss of the matching and combining network (4).

NOTE 2 – The method of measurement of spurious response immunity requires that the operator search for the frequencies of the unwanted signals which may degrade the output of the receiver (e.g. signal-to-noise ratio or error ratio). When the receiver has an audio output, this is normally done by applying only the unwanted signal to the receiver at a high level. Then the frequency of the unwanted signal is slowly moved across the frequency band of interest and the frequencies that produce a change in the signal-to-noise ratio are noted. These frequencies are then used in the spurious response immunity method of measurement.

If the receiver-decoder does not have an audio output, other methods for making the search should be used. One method of making the search is to use a sensitive detector (e.g. a communication receiver tuned to the intermediate frequency of the receiver-decoder) and a pick-up (antenna) which may also be tuned to the intermediate frequency. By placing the pick-up near the later stages of the intermediate frequency amplifier, the activity of this amplifier can be monitored. When the above procedure is used, changes in the signal in the intermediate frequency amplifier can be detected and the frequency of the unwanted signal noted.

f) Transmit the standard train of SCTS (see 2.24).

g) Calculate and note the error ratio.

h) If the error ratio equals the reference error ratio (bit stream or character string), terminate the measurement. Record the unwanted radio-frequency signal level, *G*, in dB(μV), and proceed to step b) of 4.5.3.

If the error ratio is less than the reference error ratio (bit stream or character string), increase the unwanted signal level by 0,5 dB.

If the error ratio is greater than the reference error ratio (bit stream or character string), decrease the unwanted signal level by 0,5 dB.

i) Repeat steps f) through h) until two consecutive values of error ratio have been obtained which bracket the reference error ratio (bit stream or character string). Record the unwanted radio-frequency signal level, *U* in dB(μV), that corresponds to the error ratio which is just greater than the reference error ratio (bit stream or character string).

j) Repeat steps d) through i) for other unwanted signal frequencies that may degrade the response of the receiver-decoder.

4.5.3 Presentation of results for bit stream or character string

a) Calculate the radio-frequency level G, as follows:

$$G = U - 0{,}25 \quad \text{dB}(\mu\text{V})$$

where

U is the value recorded in step i) of 4.5.2.

b) Calculate the spurious response immunity, *S*, for each of the unwanted signals, either as:

$$S = G - R \quad \text{(for immunity MUS)} \quad \text{(dB), or}$$

$$S = G - R - 3 \quad \text{(for immunity SUS)} \quad \text{(dB)}$$

where

G is the value recorded in step h) of 4.5.2 or in step a) of 4.5.3.

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R is the sensitivity (SUS or MUS) (bit stream or character string) plus the loss of the matching and combining network (4).

c) Record the spurious response immunity (referred to SUS or MUS) (bit stream or character string) as the smaller of the values of *S* calculated above.

d) Record the input signal arrangement used, the characteristics of the SCTS (bit stream or character string), the characteristics of the unwanted signal, the frequencies of the specified unwanted adjacent signals and the sensitivity (SUS or MUS) (bit stream or character string).

4.5.4 Method of measurement for message or selective calling

NOTE 1 – The value of the sensitivity (MUS or SUS) (message or selective calling) determined in 4.1.1.5 or defined in 4.1.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b. Test equipment items (1), (2), (4), (6) and (9) and a comparator are required (see 2.7).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate radio-frequency signal generator (2) with the reference sequence of messages or selective calls to generate the standard coded test signal (SCTS) (message or selective calling) (see 2.22 and 2.23).

d) In the absence of the unwanted signal, adjust the signal level at the input of the matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (message or selective calling) determined in 4.2, plus the loss of the matching and combining network (4).

e) Adjust the radio-frequency generator (6) to a frequency that may degrade the response of the receiver-decoder and apply a high level signal (e.g. 100 dB(µV)) to the attenuator (9) (see 2.25). Record this value in dB(µV) as A. Record this frequency.

NOTE 2 – The method of measurement of spurious response immunity requires that the operator search for the frequencies of the unwanted signals which may degrade the output of the receiver (e.g. signal-to-noise ratio or error ratio). When the receiver has an audio output, this is normally done by applying only the unwanted signal to the receiver at a high level. Then the frequency of the unwanted signal is slowly moved across the frequency band of interest and the frequencies that produce a change in the signal-to-noise ratio are noted. These frequencies are then used in the spurious response immunity method of measurement.

If the receiver-decoder does not have an audio output, other methods for making the search should be used. One method of making the search is to use a sensitive detector (for example, a communication receiver tuned to the intermediate frequency of the receiver-decoder) and a pick-up (antenna) which may also be tuned to the intermediate frequency. By placing the pick-up near the later stages of the intermediate frequency amplifier the activity of this amplifier can be monitored. When the above procedure is used, changes in the signal in the intermediate frequency amplifier can be detected and the frequency of the unwanted signal noted.

f) Adjust the step attenuator (9) to a value which will produce a high error ratio (e.g. 50 % or greater).

g) 1) Transmit the SCTS a maximum of three times, terminating the transmission sequence if the receiver-decoder does not recognize any of its STS. Adjust the step attenuator (9) according to step g)2) or g)3), whichever is appropriate.

2) If the receiver-decoder fails to recognize either the first, second or third SCTS, increase the attenuation of (9) by 2 dB and repeat step g)1).

3) If the receiver-decoder recognizes the three SCTS, record the attenuation value in decibels, decrease the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and proceed to step h)1).

h) 1) Transmit the SCTS a maximum of three times, terminating the transmission sequence if the receiver-decoder does not recognize any of its SCTS. Adjust the step attenuator (9) according to step h)2) or h)3), whichever is appropriate.

2) If the receiver-decoder fails to recognize either the first, second or third SCTS, increase the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and repeat step h)1). See step i).

3) If the receiver-decoder recognizes the three SCTS decrease the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and repeat step h)1). See step i).

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i) Continue steps h)1), h)2) and h)3) until attenuator values have been recorded 20 times.

NOTE 3 – A careful study of the example in figure E.10 of annex E is recommended to avoid the possibility of misunderstanding steps g) and h).

j) Repeat steps e) through i) using other unwanted signal frequencies that may degrade the response of the receiver-decoder.

4.5.5 Presentation of results for message or selective calling

a) Calculate the average of the attenuation values recorded in decibels in steps g)3), h)2) and h)3) of 4.5.4 for each of the unwanted signals.

b) Calculate the spurious response immunity (message or selective calling), *S*, for each of the unwanted signals, either as:

$$S = A - B - R \quad \text{(for immunity MUS)} \quad \text{(dB), or}$$

$$S = A - B - R - 3 \quad \text{(for immunity SUS)} \quad \text{(dB)}$$

where

A is the value recorded in step e) of 4.5.4;

B is the average of the attenuation values calculated in step a) in decibels;

R is the sensitivity (SUS or MUS) (message or selective calling) plus the loss of the matching and combining network (4).

c) Record the spurious response immunity (referred to SUS or MUS) (message or selective calling) as the smaller of the values of S calculated above.

d) Record the input signal arrangement used, the characteristics of the SCTS (message or selective calling), the characteristics of the unwanted signal, the frequencies of the unwanted signals and the sensitivity (SUS or MUS) (message or selective calling).

4.5.6 Compliance test method – Spurious response immunity (data)

NOTE 1 – The value of the sensitivity (MUS or SUS) (data) determined in 4.1.1.3 or 4.1.1.5 or defined in 4.1.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b, using test equipment items (1), (2), (4) and (6) and a comparator (see 2.7).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate radio-frequency signal generator (2) with the standard train of standard coded test signal (data) or with the specified message to generate the standard coded test signal (SCTS) (data) (see 2.16, 2.22, 2.23 and 2.24).

d) Adjust the wanted signal level at the input of the matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (data) determined in 4.2, plus the loss of the matching and combining network (4).

e) Adjust the radio-frequency generator (6) to a frequency that may degrade the response of the receiver-decoder. Note the unwanted signal frequency (see 2.25).

NOTE 2 – The method of measurement of spurious response immunity requires that the operator search for the frequencies of the unwanted signals which may degrade the output of the receiver (e.g. signal-to-noise ratio or error ratio). When the receiver has an audio output, this is normally done by applying only the unwanted signal to the receiver at a high level. Then the frequency of the unwanted signal is slowly moved across the frequency band of interest and the frequencies that produce a change in the signal-to-noise ratio are noted. These frequencies are then used in the spurious response immunity method of measurement.

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If the receiver-decoder does not have an audio output, other methods for making the search shall be used. One method of making the search is to use a sensitive detector (e.g. a communication receiver tuned to the i.f. frequency of the receiver) and a pick-up (antenna) which may also be tuned to the i.f. frequency. By placing the pick-up near the later stages of the i.f. amplifier, the activity of the i.f. amplifier can be monitored. When the above procedure is used, changes in the signal in the i.f. amplifier can be detected and the frequency of the unwanted signal noted.

f) Adjust the unwanted signal level at the input of the matching and combining network (4) to equal the sensitivity (SUS) + 3 dB or the sensitivity (MUS) (data), determined in 4.2, increased by the specified value of the spurious response immunity (data) plus the loss of the matching and combining network (4).

g) Transmit the standard train of SCTS for bit stream or character string (see 2.24), or 33 specified messages or selective calls.

h) If there are 25 or less errors for bit stream or character string, or six or less errors for message or selective call, record that the receiver-decoder does comply for this unwanted frequency with the spurious response immunity (data) specification.

i) Repeat steps e) through h) for other unwanted signal frequencies that may degrade the response of the receiver-decoder.

j) If it was recorded in step h) for all of the unwanted frequencies selected in step e) that the receiver-decoder did comply, then record that the receiver-decoder does comply with the spurious response immunity (data) specification, otherwise record that it does not comply.

k) Record the input signal arrangement used, characteristics of the SCTS (data), sensitivity (SUS or MUS) (data) and specified spurious response immunity (data).

4.6 Intermodulation immunity (data)

4.6.1 Definition

The ability of the receiver-decoder to prevent two unwanted adjacent signals which have specific frequency relationships to the wanted signal frequency (see annex D), from degrading the desired response of the receiver-decoder. It is the ratio, expressed in decibels, of

a) the common level of two unwanted input signals that cause a wanted input signal, which is 3 dB in excess of the sensitivity (SUS or MUS) (data), to produce an error ratio equal to the reference error ratio (data), to

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

4.6.2 Method of measurement for bit stream or character string

NOTE – The value of the sensitivity (MUS or SUS) (bit stream or character string) determined in 4.1.1.3 or defined in 4.1.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b. Test equipment items (1), (2), (4), (6), (7), (8) and (9) and a comparator are required (see 2.7). Step attenuator (9) will need 0,5 dB steps.

   Matching and combining networks (4) and (7) have two inputs and may not have identical losses for each of the inputs. If there is a difference in the losses, it should be accounted for in the calculation of the intermodulation immunity (bit stream or character string).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency signal generator (2) with the standard train of coded test signal (bit stream or character string) to generate the standard coded test signal (SCTS) (bit stream or character string) (see 2.22, 2.23 and 2.24).

d) In the absence of the unwanted signal, adjust the signal level at the input of the matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (bit stream or character string) determined in 4.2 plus the loss of the matching and combining network (4).

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e) Choose a pair of frequencies, f_n and f_r, that may produce an intermodulation response (see annex D). Record these frequencies.

f) Adjust the attenuator (9) to 8 dB.

g) Adjust the frequency of the radio-frequency generator (6) to f_n and the radio-frequency generator (8) to f_r.

Adjust the levels of the unwanted signals f_n and f_r to the input of matching and combining network (7) to equal the sensitivity (SUS or MUS) (bit stream or character string) multiplied by the ratio of the intermodulation immunity (bit stream or character string), stated in the equipment specification plus the losses of matching and combining networks (7) and (4) plus 8 dB. Record this value as *G* in dB(µV).

h) Transmit the standard train of SCTS (see 2.24).

i) Calculate and note the error ratio.

j) If the error ratio equals the reference error ratio (bit stream or character string), terminate the measurement. Record the attenuation value of the attenuator (9), *C*, and proceed to step b) of 4.6.3.

If the error ratio is less than the reference error ratio (bit stream or character string) decrease the attenuation of (9) by 0,5 dB.

If the error ratio is greater than the reference error ratio (bit stream or character string), increase the attenuation of (9) by 0,5 dB.

k) Repeat steps h) through j) until two consecutive values of error ratio have been obtained which bracket the reference error ratio (bit stream or character string). Record the attenuation value of attenuator (9), *A*, that corresponds to the error ratio which is just greater than the reference error ratio (bit stream or character string).

l) Repeat steps d) through k) using other pairs of unwanted signal frequencies that may produce an intermodulation response.

4.6.3 Presentation of results for bit stream or character string

a) Calculate the attenuation, *C*, for each of the unwanted pairs of frequencies as:

$$C = A + 0{,}25 \quad \text{(dB)}$$

where

A is the attenuation value of the attenuator (9) recorded in step k) or l) of 4.6.2.

b) The intermodulation immunity, *S*, for each of the unwanted pairs of frequencies is either as:

$$S = G - L - C - R \quad \text{(for immunity MUS)} \quad \text{(dB), or}$$

$$S = G - L - C - R - 3 \text{ (for immunity SUS)} \quad \text{(dB)}$$

where

C is the value recorded in step j) of 4.6.2 or calculated in step a);

G is the unwanted input-signal level of matching and combining network (7) in dB(µV) recorded in step g) of 4.6.2;

L is the loss of matching and combining network (7) in decibels;

R is the sensitivity (SUS or MUS) (bit stream or character string) plus the loss of the matching and combining network (4).

c) Record the intermodulation immunity (referred to SUS or MUS) (bit stream or character string) as the smaller of the values of *S* calculated in step b).

d) Record the input signal arrangement used, the characteristics of the SCTS (bit stream or character string), the characteristics of the unwanted signals, the frequencies of the unwanted signals and the sensitivity (SUS or MUS) (bit stream or character string).

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4.6.4 Method of measurement for message or selective calling

NOTE 1 – The value of the sensitivity (MUS or SUS) (message or selective calling) determined in 4.1.1.5 or defined in 4.1.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b. Test equipment items (1), (2), (4), (6), (7), (8) and (9) and a comparator are required (see 2.7).

   Matching and combining networks (4) and (7) have two inputs and may not have identical losses for each of the inputs. If there is a difference in the losses it must be accounted for in the calculation of the intermodulation immunity (message or selective calling).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency signal generator (2) with the reference sequence of messages to generate the standard coded test signal (SCTS) (message or selective calling) (see 2.22 and 2.23).

d) In the absence of the unwanted signal, adjust the signal level at the input of the matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (message or selective calling) determined in 4.1, plus the loss of the matching and combining network (4).

e) Choose a pair of frequencies, f_n and f_r, that may produce an intermodulation response (see annex D). Record these frequencies.

f) Adjust the frequency of radio-frequency generator (6) to f_n and radio-frequency generator (8) to f_r. Adjust the output of each of the generators to apply the same high signal level (e.g. 100 dB(µV)) to the matching and combining network (7). Record this level, A, in dB(µV).

g) Adjust the step attenuator (9) to a value which will produce a high error ratio (e.g. 50 % or greater).

h) 1) Transmit the SCTS a maximum of three times, terminating the transmission sequence. Adjust the step attenuator (9) according to step h)2) or h)3), whichever is appropriate.

   2) If the receiver-decoder fails to recognize either the first, second or third SCTS, increase the attenuation of (9) by 2 dB and repeat step h)1).

   3) If the receiver-decoder recognizes the three SCTS, record the attenuation value in decibels, reduce the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and proceed to step i)1).

i) 1) Transmit the SCTS a maximum of three times, terminating the transmission sequence. Adjust the step attenuator (9) according to step i)2) or i)3), whichever is appropriate.

   2) If the receiver-decoder fails to recognize either the first, second or third SCTS, increase the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and repeat step i)1). See step j).

   3) If the receiver-decoder recognizes the three SCTS, reduce the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and repeat step i)1). See step j).

j) Continue steps i)1), i)2), and i)3) until attenuator values have been recorded 20 times.

   NOTE 2 – A careful study of the example in figure E.10 of annex E is recommended to avoid the possibility of misunderstanding steps h) and i).

k) Repeat steps e) through j) using other pairs of unwanted signal frequencies that may degrade the response of the receiver-decoder.

4.6.5 Presentation of results for message or selective calling

a) Calculate the average of the attenuation values recorded in decibels in steps h)3), i)2) and i)3) of 4.7.4 for each of the pairs of unwanted signals.

b) Calculate the intermodulation immunity, S, for each of the unwanted signals, either as:

$$S = A - B - D - R \quad \text{(for immunity MUS)} \quad \text{(dB), or}$$

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$$S = A - B - D - R - 3 \quad \text{(for immunity SUS)} \quad \text{(dB)}$$

where

A is the value recorded in step f) of 4.6.4;

B is the average of the attenuation values calculated in step a) in decibels;

D is the loss of the combining network (7) in decibels;

R is the sensitivity (SUS or MUS) (message or selective calling) plus the loss of the matching and combining network (4)

c) Record the intermodulation immunity (referred to SUS or MUS) (message or selective calling) as the smaller of the values of *S* calculated above.

d) Record the input signal arrangement used, the characteristics of the SCTS (message or selective calling), the characteristics of the unwanted signal, the frequencies of the unwanted signals and the sensitivity (SUS or MUS) (message or selective calling).

4.6.6 Compliance test method – Intermodulation immunity (data)

NOTE 1 – The value of the sensitivity (MUS or SUS) (data) determined in 4.1.1.3 or 4.1.1.5 or defined in 4.1.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b, using test equipment items (1), (2), (4), (6), (7) and (8), and a comparator (see 2.7).

NOTE 2 – Matching and combining networks (4) and (7) have two inputs and may not have identical losses for each of the inputs. If there is a difference in the losses it should be accounted for in determining the levels of the unwanted signals.

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency generator (2) with the standard train of standard coded test signal (data) or with the specified message to generate the standard coded test signal (SCTS) (data) (see 2.16, 2.22, 2.23 and 2.24).

d) Adjust the wanted signal level at the input of the matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (data) determined in 4.1, plus the loss of the matching and combining network (4).

e) Choose a pair of frequencies, f_n and f_r, that may produce an intermodulation response (see annex D). Record these frequencies.

f) Adjust the frequency of the radio-frequency generator (6) to f_n and the radio-frequency generator (8) to f_r.

g) Adjust the unwanted signal levels of f_n and f_r at the input of matching and combining network (7) to equal the sensitivity (SUS) plus 3 dB or the sensitivity (MUS) determined in 4.2, increased by the specified value of the intermodulation immunity (data), plus the losses of matching and combining networks (7) and (4).

h) Transmit the standard train of SCTS for bit stream or character string (see 2.24), or 33 specified messages or selective calls.

i) If there are 25 or less errors for bit stream or character string, or six or less errors for message or selective call, record that the receiver-decoder for this pair of unwanted frequencies does comply with the intermodulation immunity (data) specification.

j) Repeat steps e) through i) for other unwanted frequency pairs that may degrade the response of the receiver-decoder.

k) If it was recorded in step j) for all of the unwanted frequency pairs selected in step e) that the receiver-decoder did comply, then record that the receiver-decoder does comply with the intermodulation immunity (data) specification, otherwise record that it does not comply.

l) Record the input signal arrangement used, characteristics of the SCTS (data), the sensitivity (SUS or MUS) (data) and the specified intermodulation immunity (data).

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4.7 Sensitivity under multipath propagation conditions (data)

Variations of amplitude and phase of a radio-frequency signal are created by multipath reflections in the propagation medium whenever the transmitting or receiving antennas are in motion. These signal variations are a function of both the antenna velocity and the radio-frequency of the desired signal.

The resulting variations of signal amplitude and phase show a Rayleigh distribution in limited areas where the direct signal is missing. They can be simulated by an appropriate method of modulating both the envelope and phase.

4.7.1 Measured usable sensitivity under multipath propagation conditions (MUSM) (data)

4.7.1.1 Definition

The r.m.s. value of a Rayleigh faded input-signal level that produces the reference error ratio (data). The input signal is the standard coded test signal (SCTS) (data), at a specified frequency.

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

4.7.1.2 Method of measurement for bit stream or character string

a) Connect the equipment as illustrated in figure 6 (see annex C for details of the Rayleigh fading simulator). A comparator is also needed (see 2.7).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency signal generator (2) with the standard train of standard coded test signal (bit stream or character string) to generate the standard coded test signal (SCTS) (bit stream or character string) (see 2.22, 2.23 and 2.24).

d) Adjust the Rayleigh fading simulator (3) for a velocity of 100 km/h if the receiver-decoder under test is mobile, or 10 km/h if the receiver-decoder under test is portable.

e) Record the r.m.s. value of the output signal, *J*, of the Rayleigh fading simulator in dB(µV).

f) Adjust the attenuator (4) to produce a radio-frequency input-signal level to the input of the receiver-decoder, equal to the sensitivity under multipath propagation conditions (SUSM) (bit stream or character string) as stated in the equipment specification to the nearest decibel.

g) Transmit the standard train of SCTS (see 2.24).

h) Calculate and note the error ratio.

i) If the error ratio equals the reference error ratio (bit stream or character string), terminate the measurement. Record the attenuation, *M*, of step attenuator (4) and proceed to step b) of 4.7.1.3.

   If the error ratio is less than reference error ratio (bit stream or character string), increase the attenuation by 1 dB.

   If the error ratio is greater than the reference error ratio (bit stream or character string), decrease the attenuation by 1 dB.

j) Repeat steps g) through i) until two consecutive values of error ratio have been obtained which bracket the reference error ratio (bit stream or character string). Record the value of attenuation, *A*, that corresponds to the error ratio which is just greater than the reference error ratio (bit stream or character string).

k) Repeat steps d) through j) for velocities of 50 km/h, 20 km/h and 10 km/h if the receiver-decoder under test is mobile, or 5 km/h, 2 km/h and 1 km/h if the receiver-decoder under test is portable.

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4.7.1.3 Presentation of results for bit stream or character string

a) Calculate the attenuator values, *M*, for the three velocities as

$$M = A - 0{,}5 \quad \text{(dB)}$$

where

A is the attenuation recorded in step j) of 4.7.1.2.

b) Calculate the sensitivity under multipath propagation conditions (bit stream or character string), *S*, in decibels, for each velocity using

$$S = J - M \quad \text{(dB)}$$

where

J is the r.m.s. level of the output of the Rayleigh fading simulator in dB(µV), recorded in step e) of 4.7.1.2

M is the value recorded in step i) of 4.7.1.2 or calculated in step a) in decibels.

c) Record the input signal arrangement used, the characteristics of the SCTS (bit stream or character string), the velocities and the sensitivity under multipath propagation conditions (MUSM) (bit stream or character string).

4.7.1.4 Method of measurement for message or selective calling

a) Connect the equipment as illustrated in figure 6 (see annex C for details of the Rayleigh fading simulator). A comparator is also needed (see 2.7)

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency signal generator (2) with the reference sequence of messages to generate the standard coded test signal (SCTS) (message or selective calling) (see 2.22 and 2.23).

d) Adjust the Rayleigh fading simulator (3) for a velocity of 100 km/h if the receiver-decoder under test is mobile, or 10 km/h if the receiver-decoder under test is portable.

e) Record the r.m.s. value of the output signal, *J*, of the Rayleigh fading simulator in dB(µV).

f) Adjust the attenuator (4) to a value which will produce a high error ratio (e.g. 50 % or greater).

g) 1) Transmit the SCTS a maximum of three times, terminating the transmission sequence, if the receiver-decoder does not recognize any of its SCTS. Adjust the step attenuator (4) according to step g)2) or g)3), whichever is appropriate.

2) If the receiver-decoder fails to recognize either the first, second or third SCTS, reduce the attenuation of (4) by 2 dB and repeat step g)1).

3) If the receiver-decoder recognizes the three SCTS, record the attenuation value in decibels, increase the attenuation of (4) by 1 dB, record the new attenuation value in decibels, and proceed to step h)1).

h) 1) Transmit the SCTS a maximum of three times, terminating the transmission sequence, if the receiver-decoder does not recognize any of its SCTS. Adjust the step attenuator (4) according to step h)2) or h)3), whichever is appropriate.

2) If the receiver-decoder fails to recognize either the first, second or third SCTS, reduce the attenuation of (4) by 1 dB, record the new attenuation value in decibels, and repeat step h)1). See step i).

3) If the receiver-decoder recognizes the three SCTS, increase the attenuation of (4) by 1 dB, record the new attenuation value in decibels, and repeat step h)1). See step i).

i) Continue steps h)1), h)2) and h)3) until attenuator values have been recorded 20 times.

NOTE – A careful study of the example in figure E.10 of annex E is recommended to avoid the possibility of misunderstanding steps g) and h).

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j) Repeat steps d) through i) for velocities of 50 km/h, 20 km/h and 10 km/h if the receiver-decoder under test is mobile, or 5 km/h, 2 km/h and 1 km/h if the receiver-decoder under test is portable.

4.7.1.5 Presentation of results for message or selective calling

a) Calculate the average of the attenuation values recorded in decibels in steps g)3), h)2) and h)3) of 4.7.1.4 for each velocity.

b) The sensitivity under multipath propagation conditions (message or selective calling), *S*, is given by

$$S = J - B \quad \text{(dB)}$$

where

J is the value recorded in step e) of 4.7.1.4;

B is the average of the attenuation values calculated in step a) in decibels.

c) Record the input signal arrangement used, the characteristics of the SCTS (message or selective calling), the velocities and the sensitivity under multipath propagation conditions (MUSM) (message or selective calling).

4.7.2 Specified usable sensitivity under multipath propagation conditions (SUSM) (data)

4.7.2.1 Definition

The r.m.s. value of a Rayleigh faded input-signal level of the standard coded test signal (SCTS) (data) specified by the Regulatory Authority, manufacturer or customer at the specified frequency, which results in an error ratio equal to or smaller than the reference error ratio (data).

NOTE 1 – To make meaningful measurements, the specified input-signal level should be chosen taking into account the dispersion of the sensitivities of various equipments in defined environmental conditions.

NOTE 2 – The median value of the envelope is 1,6 dB less than the r.m.s. value.

4.7.2.2 Compliance test method – Sensitivity under multipath propagation conditions (SUSM) (data)

a) Connect the equipment as illustrated in figure 6 and include a comparator (see annex C for details of the Rayleigh fading simulator and 2.7 for the comparator).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency signal generator (2) with the standard train of coded test signal (data) or with the specified message or selective call to generate the standard coded test signal (data) (SCTS) (see 2.16, 2.22, 2.23 and 2.24)

d) Adjust the Rayleigh fading simulator (3) for a velocity of 100 km/h if the receiver-decoder under test is a mobile, or 10 km/h if the receiver-decoder under test is a portable.

e) Record the r.m.s. value of the output signal, *J*, of the Rayleigh fading simulator in dB(µV).

f) Adjust the attenuator (4) to produce a radio-frequency input level at the input of the receiver-decoder, equal to the sensitivity under multipath propagation conditions (SUSM) (data).

g) Transmit the standard train of SCTS for bit stream or character string (see 2.24), or 78 specified messages or selective calls.

h) If there are 25 or less errors for bit stream or character string, or 15 or less errors for message or selective call, record that the receiver decoder does comply for this velocity with the specified sensitivity reduction under multipath propagation conditions (data) specification.

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i) Repeat steps d) through h) for velocities of 50 km/h, 20 km/h and 10 km/h if the receiver-decoder under test is a mobile, or 5 km/h, 2 km/h and 1 km/h if the receiver-decoder under test is a portable.

j) If it was recorded in step h) for all the velocities selected in step d) that the receiver-decoder did comply, then record that the receiver-decoder does comply with the specified usable sensitivity under multipath propagation conditions (SUSM) (data) specification, otherwise record that it does not comply.

k) Record the characteristics of the SCTS (data) and the specified sensitivity under multipath propagation conditions (SUSM) (data).

4.8 Acceptable radio-frequency displacement (data)

4.8.1 Definition

The ability of a receiver-decoder to minimize the degradation of the desired response of the receiver-decoder when the input signal frequency is displaced from the specified nominal frequency.

It is the smaller of the two possible radio-frequency displacements that causes an input signal, which is 6 dB in excess of the sensitivity (SUS or MUS) (data) to produce an error ratio equal to the reference error ratio (data).

NOTE 1 – Radio-frequency displacement is an absolute value and an increase in the displacement moves the radio-frequency away from the nominal frequency.

NOTE 2 – Measured values with bit stream, character string or message may differ from each other in accordance with the construction of the character or the message.

4.8.2 Method of measurement for bit stream or character string

NOTE – The value of the sensitivity (MUS or SUS) (bit stream or character string) determined in 7.1.3 or defined in 7.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b. Test equipment items (1) and (2) and a comparator are required (see 2.7).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency signal generator (2) with the standard train of coded test signal (bit stream or character string) to generate the standard coded test signal (SCTS) (bit stream or character string) (see 2.22, 2.23, and 2.24).

d) Adjust the level of the input signal to the receiver-decoder to a value 6 dB in excess of the sensitivity (SUS or MUS) (bit stream or character string), determined in 4.1.

e) Adjust the input signal frequency displacement to the value of the acceptable radio-frequency displacement (bit stream or character string) stated in the equipment specification.

f) Transmit the standard train of SCTS (see 2.24).

g) Calculate and note the error ratio.

h) If the error ratio equals the reference error ratio (bit stream or character string), terminate the measurement. Record the radio-frequency displacement, *F*, as the acceptable radio-frequency displacement (SUS or MUS) (bit stream or character string), and proceed to step b) of 4.8.3.

   If the error ratio is less than the reference error ratio (bit stream or character string), increase the frequency displacement by 100 Hz.

   If the error ratio is greater than the reference error ratio (bit stream or character string), decrease the frequency displacement by 100 Hz.

i) Repeat steps f) through h) until two consecutive values of error ratio have been obtained which bracket the reference error ratio (bit stream or character string). Record the frequency displacement, *D*, that corresponds to the error ratio which is just greater than the reference error ratio (bit stream or character string).

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j) Repeat steps e) through i) for the frequency displacement on the other side of the specified nominal frequency.

4.8.3 Presentation of results for bit stream or character string

a) Calculate the upper and lower radio-frequency displacement, *F*, as

$$F = D - 50 \quad \text{(Hz)}$$

where

D is the magnitude of the frequency displacement recorded in step i) or j) of 4.9.2.

b) The acceptable radio-frequency displacement (SUS or MUS) is the smallest value of *F*.

c) Record the input signal arrangement used, characteristics of the SCTS (bit stream or character string) and the acceptable radio-frequency displacement (referred to SUS or MUS) (bit stream or character string).

NOTE – This method of measurement is suitable for making measurements at levels other than the 6 dB increase per step d) of 4.8.2

4.8.4 Method of measurement for message or selective calling

NOTE – The value of the sensitivity (MUS or SUS) (message or selective calling) determined in 7.1.5 or defined in 7.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b. Test equipment items (1) and (2) and a comparator are required (see 2.7).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency signal generator (2) with the reference sequence of message or selective calls to generate the standard coded test signal (SCTS) (message or selective calling) (see 2.22 and 2.23).

d) Adjust the level of the input signal to the receiver-decoder to a value 6 dB in excess of the sensitivity (SUS or MUS) (message or selective calling) determined in 4.1.

e) Increase the input-signal frequency displacement to a value which will produce a high error ratio (e.g. 50 % or greater).

f) 1) Transmit the SCTS a maximum of four times, terminating the transmission sequence, if the receiver-decoder does not recognize any of its SCTS, adjust the input signal frequency displacement according to step f)2) or f)3), whichever is appropriate.

   2) If the receiver decoder fails to recognize either the first, second, third, or fourth SCTS, decrease the input signal frequency displacement by 100 Hz, and repeat step f)1).

   3) If the receiver decoder recognizes four SCTS, record the frequency.

g) Repeat steps e) to f) for the frequency displacement on the other side of the specified nominal frequency.

4.8.5 Presentation of results for message or selective calling

a) Record the acceptable radio-frequency displacement (referred to SUS or MUS) (message or selective calling) as the smaller of the values in step f)3) of 4.8.4.

b) Record the input signal arrangement used, characteristics of the SCTS (message or selective calling) and the sensitivity (SUS or MUS) (message or selective calling).

NOTE – This method of measurement is suitable for making measurements at levels other than the 6 dB increase per step d) of 4.8.4.

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4.8.6 Compliance test method – Acceptable radio-frequency displacement (data)

NOTE – The value of the sensitivity (MUS or SUS) (data) determined in 7.1.3 or 7.1.5 or defined in 7.2.1 is required for this measurement.

a) Connect the equipment as illustrated in figure 4 with the switches in position b, using test equipment items (1) and (2) and a comparator (see 2.7).

b) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

c) Using the encoder (1), modulate the radio-frequency signal generator (2) with the standard train of coded test signal (data) or with the specified message or selective call to generate the standard coded test signal (data) (SCTS) (see 2.16, 2.22, 2.23 and 2.24).

d) Adjust the level of the input signal to the receiver-decoder to a value 6 dB in excess of the sensitivity (SUS or MUS) (data) determined in 4.1.

e) Adjust the input signal frequency displacement to the upper (“lower” for step h)) specified value of the acceptable radio-frequency displacement (data).

f) Transmit the standard train of SCTS for bit stream or character string (see 2.24), or 18 specified messages or selective calls.

g) If there are 25 or less errors for bit stream or character string, or three or less errors for message or selective call, record that for this displacement the receiver-decoder does comply with the upper specified acceptable radio-frequency displacement (data) specification, otherwise record that it does not comply.

h) Repeat steps e) through g) for the frequency displacement on the lower side of the specified nominal frequency.

i) If it was recorded in step g) that the receiver-decoder does comply for both frequency displacements, then record that it does comply with the acceptable radio-frequency displacement (data) specification, otherwise record that it does not comply.

j) Record the input signal arrangement used, characteristics of the SCTS (data) the sensitivity (SUS or MUS) (data) and the specified value of the acceptable radio-frequency displacement (data).

4.9 Impulsive-noise tolerance (data)

4.9.1 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 the ratio of

a) the median level of spectrum amplitude of the impulsive-noise that causes a wanted signal, which is 3 dB in excess of the sensitivity (SUS or MUS) (data), to produce an error ratio equal to the reference error ratio (data), to

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

4.9.2 Method of measurement for bit stream or character string

NOTE 1 – The value of the sensitivity (MUS or SUS) (bit stream or character string) determined in 7.1.3 or defined in 7.2.1 is required for this measurement.

NOTE 2 – For information on the characteristics and calibration of a random impulse generator, see annex G.

a) Calibrate the random impulse generator in accordance with clause G.3 of annex G and record the spectrum amplitude *S* in dB(μV)/MHz.

b) Connect the equipment as illustrated in figure 4, and connect the random impulse generator to the input of step attenuator (9). Increase the attenuation of attenuator (9) to a high value.

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c) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

d) Modulate the radio-frequency signal generator (2) with the standard coded test signal (SCTS).

e) In the absence of the impulsive noise, adjust the signal at the input of matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (bit stream or character string) determined in 4.1, plus the loss of the matching and combining network.

f) 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 µS;

– a standard deviation of amplitude of 6 dB;

– a 10 Hz cut-off frequency of the low-pass filter for random amplitude distribution;

– a minimum spectrum amplitude (the same state as step a)).

NOTE 3 – The random impulse generator settings simulate the radio-frequency noise produced by city traffic that would impinge on the antenna of a nearby mobile land station. The above settings of the random impulse generator are not applicable to other environments.

g) Adjust the step attenuator (9) to produce the sensitivity (SUS or MUS) (bit stream or character string) multiplied by the ratio of the impulse-noise tolerance (bit stream or character string) stated in the equipment specification, plus the loss of the matching and combining network (4).

h) Transmit the standard train of SCTS (see 2.24).

i) Calculate and note the error ratio.

j) 1) If the error ratio equals the reference error ratio (bit stream or character string), terminate the measurement. Record the attenuation *D* of the step attenuator (9) and proceed to step b) of 4.9.3.

2) If the error ratio is less than the reference error ratio (bit stream or character string), decrease the attenuation of the step attenuator (9) by 1 dB.

3) If the error ratio is greater than the reference error ratio (bit stream or character string) increase the attenuation of the step attenuator (9) by 1 dB.

k) Repeat steps h) to j) until two consecutive values of error ratio have been obtained which bracket the reference error ratio (bit stream or character string). Record the attenuation U in decibels of the step attenuator that corresponds to the error ratio which is just greater than the reference error ratio (bit stream or character string).

NOTE – The above procedure does not use the random impulse generator internal attenuator which would need to be set to the minimum constant value. If the attenuation variable range of the attenuator (9) is not sufficient, the internal attenuator may be used, in addition, and the attenuation value change could be added to or subtracted from the attenuation value of the attenuator (9).

4.9.3 Presentation of results for bit stream or character string

a) Calculate the attenuation level *D* as follows:

$$D = U - 0{,}5 \quad \text{(dB)}$$

where:

U is the attenuation recorded in step k) of 4.9.2.

b) Calculate the impulsive-noise tolerance, *I*, either as:

$$I = S - D - R \quad \text{(for tolerance MUS)} \quad \text{(dB(µV)/MHz), or}$$

$$I = S - D - R - 3 \quad \text{(for tolerance SUS)} \quad \text{(dB(µV)/MHz)}$$

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where

S is the spectrum amplitude recorded in step a) of 4.9.2;

D is the attenuation value calculated in step a) or the value recorded in step j) of 4.9.2;

R is the sensitivity (SUS or MUS) (bit stream or character string) in dB(µV) plus the loss of the matching and combining network (4).

c) Record the impulsive-noise tolerance (referred to SUS or MUS) (bit stream or character string), the standard input frequency, the sensitivity (SUS or MUS) (bit stream or character string) and the settings of the random impulse generator.

4.9.4 Method of measurement for message or selective calling

NOTE 1 – The value of the sensitivity (MUS or SUS) (message or selective calling) determined in 7.1.5 or defined in 7.2.1 is required for this measurement.

NOTE 2 – For information on the characteristics and calibration of a random impulse generator, see annex G.

a) Calibrate the random impulse generator in accordance with clause G.3 of annex G and record the spectrum amplitude *S* in dB(µV)/MHz.

b) Connect the equipment as illustrated in figure 4, and connect the random impulse generator to the input of step attenuator (9). Increase the attenuation of attenuator (9) to a high value.

c) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

d) Modulate the radio-frequency signal generator (2) with the standard coded test signal (SCTS).

e) In the absence of the impulsive noise, adjust the signal at the input of matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (message or selective calling) determined in 4.1 plus the loss of the matching and combining network.

f) 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 µS;

– a standard deviation of amplitude of 6 dB;

– a 10 Hz cut-off frequency of the low-pass filter for random amplitude distribution;

– a minimum attenuation (the same state as step a)).

NOTE 3 – The random impulse generator settings simulate the radio-frequency noise produced by city traffic that would impinge on the antenna of a nearby mobile land station. The above settings of the random impulse generator are not applicable to other environments.

g) Decrease the step attenuator (9) to a value which will produce a high error ratio (e.g. 50 % or greater).

h) 1) Transmit the SCTS a maximum of three times, terminating the transmission sequence. Adjust the step attenuator (9) according to step h)2) or h)3), whichever is appropriate.

2) If the receiver-decoder fails to recognize either the first, second or third SCTS, increase the attenuation of (9) by 2 dB and repeat step h)1).

3) If the receiver-decoder recognizes the three SCTS, record the attenuation value in decibels, decrease the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and proceed to step i)1).

i) 1) Transmit the SCTS a maximum of three times, terminating the transmission sequence. Adjust the step attenuator (9) according to step i)2) or i)3), whichever is appropriate.

2) If the receiver-decoder fails to recognize either the first, second or third SCTS, increase the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and repeat step i)1). See step j).

3) If the receiver-decoder recognizes the three SCTS, reduce the attenuation of (9) by 1 dB, record the new attenuation value in decibels, and repeat step i)1). See step j).

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j) Continue steps i)1), i)2), and i)3) until attenuator values have been recorded 20 times.

NOTE 4 – A careful study of the example in figure E.10 of annex E, is recommended to avoid the possibility of misunderstanding steps h) and i).

NOTE 5 – The above procedure does not use the random impulse generator internal attenuator which would need to be set to the minimum constant value. If the attenuation variable range of the attenuator (9) is not sufficient, the internal attenuator may be used, in addition, and the attenuation value change could be added to the attenuation value of the attenuator (9).

4.9.5 Presentation of results for message or selective calling

a) Calculate *D*, the average of the attenuation values recorded in steps h)3), i)2) and i)3) of 4.9.4.

b) Calculate the impulsive-noise tolerance, *I*, either as:

$$I = S - D - R \quad \text{(for tolerance MUS) (dB(µV)/MHz), or}$$

$$I = S - D - R - 3 \quad \text{(for tolerance SUS) (dB(µV)/MHz)}$$

where:

S is the spectrum amplitude recorded in step a) of 4.9.4;

D is the attenuation value calculated in step a) or the value recorded in step j) of 4.9.4;

R is the sensitivity (SUS or MUS) (bit stream or character string) in dB(µV) plus the loss of the matching and combining network (4).

c) Record the impulsive-noise tolerance (referred to SUS or MUS) (message or selective calling), the standard input frequency, the sensitivity (SUS or MUS) (message or selective calling) and the settings of the random impulse generator.

4.9.6 Compliance test method – Impulsive-noise tolerance (data)

NOTE 1 – The value of the sensitivity (MUS or SUS) (data) determined in 7.1.3 or 7.1.5 or defined in 7.2.1 is required for this measurement.

a) Calibrate the random impulse generator in accordance with clause G.3 of annex G and record the spectrum amplitude *S* in dB(µV)/MHz.

b) Connect the equipment as illustrated in figure 4, and connect the random impulse generator to the input of step attenuator (9). Increase the attenuation of attenuator (9) to a high value.

c) Adjust the frequency of the radio-frequency signal generator (2) to one of the specified nominal frequencies or to the nominal frequency if this frequency is unique.

d) Modulate the radio-frequency signal generator (2) with the standard train of standard coded test signal (SCTS) (data) or with the specified message or selective call to generate the standard coded test signal (SCTS) (data) (see 2.16, 2.22, 2.23 and 2.24).

e) In the absence of the impulsive noise, adjust the signal at the input of the matching and combining network (4) to be 3 dB in excess of the sensitivity (SUS or MUS) (data) determined in 4.2, plus the loss of the matching and combining network (4).

f) 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 µS;

– a standard deviation of amplitude of 6 dB;

– a 10 Hz cut-off frequency of the low-pass filter for random amplitude distribution;

– a minimum attenuation (the same state as step a)).

NOTE 2 – The random impulse generator settings simulate the radio-frequency noise produced by city traffic that would impinge on the antenna of a nearby mobile land station. The above settings of the random impulse generator are not applicable to other environments.

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