IEC TR 60728-3-2

Edition 1.0 2016-10

TECHNICAL REPORT

colour inside

Cable networks for television signals, sound signals and interactive services – Part 3-2: Method of measurement of 5th order non-linearity for active electronic equipment using five carriers

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Cable networks for television signals, sound signals and interactive services – Part 3-2: Method of measurement of 5th order non-linearity for active electronic equipment using five carriers

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CONTENTS

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CABLE NETWORKS FOR TELEVISION SIGNALS, SOUND SIGNALS AND INTERACTIVE SERVICES –

Part 3-2: Method of measurement of 5th order non-linearity for active electronic equipment using five carriers

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IEC TR 60728-3-2, which is a technical report, has been prepared by technical area 5: Cable networks for television signals, sound signals and interactive services, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
100/2708/DTR	100/2761/RVC

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

The list of all parts of the IEC 60728 series, under the general title, *Cable networks for television signals, sound signals and interactive services*, can be found on the IEC website.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

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INTRODUCTION

Standards and deliverables of the IEC 60728 series deal with cable networks including equipment and associated methods of measurement for headend reception, processing and distribution of television and sound signals, and for processing, interfacing and transmitting all kinds of data signals for interactive services using all applicable transmission media. These signals are typically transmitted in networks by frequency-multiplexing techniques.

This includes, for instance:

- regional and local broadband cable networks,
- extended satellite and terrestrial television distribution systems,
- individual satellite and terrestrial television receiving systems,

and all kinds of equipment, systems and installations used in such cable networks, distribution and receiving systems.

The extent of this standardization work is from the antennas and/or special signal source inputs to the headend or other interface points to the network up to the terminal input of the equipment on the customer's premises.

The standardization work will consider coexistence with users of the RF spectrum in wired and wireless transmission systems.

The standardization of any user terminals (i.e. tuners, receivers, decoders, multimedia terminals etc.) as well as of any coaxial, balanced and optical cables and accessories thereof is excluded.

CABLE NETWORKS FOR TELEVISION SIGNALS, SOUND SIGNALS AND INTERACTIVE SERVICES –

Part 3-2: Method of measurement of 5th order non-linearity for active electronic equipment using five carriers

1 Scope

This part of IEC 60728 is applicable to the measurement of 5th order non-linearity for active electronic equipment which carries only digitally modulated television signals, sound signals and signals for interactive services. This method of measurement is specifically applicable to MATV installations but could be applied to broadband and channel selective amplifiers used in all kinds of cable networks.

NOTE 1 The methods of measurement of non-linearity (intermodulation products) applicable to active equipment, when loaded with analogue signals, considered that third order intermodulation products were the most important ones. The new era of television digital signals, transmitted according to DVB-S/S2, DVB-C/C2 and DVB-T/T2 modulation formats, has shown that the non-linear distortions (intermodulation products) in active equipment, when loaded with digital signals, are significant up to the 5th order.

NOTE 2 With this method of measurement it is possible to obtain information on non-linear distortions (intermodulation products) up to the 5th order in active wideband equipment, using only 5 carriers, placed in an appropriate and suitable way in the equipment bandwidth. Moreover, with this method of measurement it is possible to obtain information on non-linear distortions (up to the 5th order) in narrowband equipment (channel amplifiers and channel frequency converters) carrying DVB-C/C2 and/or DVB-T/T2 signals.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60728-3, *Cable networks for television signals, sound signals and interactive services – Part 3: Active wideband equipment for cable networks*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60728-3 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
extended satellite television distribution network or system
distribution network or system designed to provide sound and television signals received by a satellite receiving antenna to households in one or more buildings

Note 1 to entry: This kind of network or system could be combined with terrestrial antennas for the additional reception of TV and/or radio signals via terrestrial networks.

Note 2 to entry: This kind of network or system could also carry control signals for satellite switched systems or other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

[SOURCE: IEC 60728-1:2014, 3.1.35]

3.1.2
extended terrestrial television distribution network or system
distribution network or system designed to provide sound and television signals received by a terrestrial receiving antenna to households in one or more buildings

Note 1 to entry: This kind of network or system could be combined with a satellite antenna for the additional reception of TV and/or radio signals via satellite networks.

Note 2 to entry: This kind of network or system could also carry other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

[SOURCE: IEC 60728-1:2014, 3.1.36]

3.1.3
individual satellite television receiving system
system designed to provide sound and television signals received from one or more satellites to an individual household

Note 1 to entry: This kind of system could also carry control signals for satellite switched systems or other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

[SOURCE: IEC 60728-1:2014, 3.1.51]

3.1.4
individual terrestrial television receiving system
system designed to provide sound and television signals received via terrestrial broadcast networks to an individual household

Note 1 to entry: This kind of system could also carry other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

[SOURCE: IEC 60728-1:2014, 3.1.52]

3.1.5
local broadband cable network
network designed to provide sound and television signals as well as signals for interactive services to a local area (e.g. one town or one village)

[SOURCE: IEC 60728-1:2014, 3.1.56]

3.1.6
MATV network
extended terrestrial television distribution networks or systems designed to provide sound and television signals received by terrestrial receiving antennas to households in one or more buildings

Note 1 to entry: Originally defined as Master Antenna Television network.

Note 2 to entry: This kind of network or system could be combined with a satellite antenna for the additional reception of TV and/or radio signals via satellite networks.

Note 3 to entry: This kind of network or system could also carry other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

[SOURCE: IEC 60728-1:2014, 3.1.60]

3.1.7
regional broadband cable network
network designed to provide sound and television signals as well as signals for interactive services to a regional area covering several towns and/or villages

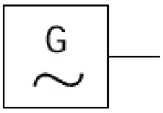
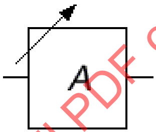
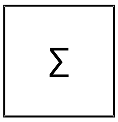
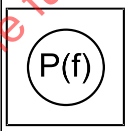
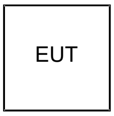
[SOURCE: IEC 60728-1:2014, 3.1.75]

3.1.8
maximum operating output level
output level of the EUT when measured with an input signal containing five carriers equally spaced, at distance D, that produces a given C/I_5 intermodulation ratio at frequencies $-2D$, $-D$ lower than the lowest carrier and at frequencies $+D$, $+2D$ higher than the highest carrier of the applied signal

SEE: Figure 2.

3.2 Symbols

The following graphical symbols are used in the figures of this document. These symbols are either listed in IEC 60617 or based on symbols defined in IEC 60617.

Symbols	Terms	Symbols	Terms
	sine-wave generator [IEC 60617-S01226 (2001-07)]		variable attenuator [IEC 60617-S01245 (2001-07)]
	combiner based on [IEC 60617-S00059 (2001-07)]		spectrum analyzer (electrical) based on [IEC 60617-S00910 (2001-07)]
	equipment under test based on [IEC 60617-S00059 (2001-07)]		

3.3 Abbreviated terms

DVB Digital Video Broadcasting
EUT Equipment Under Test
MATV Master Antenna TeleVision (system)
MoCA Multimedia over Coax Alliance
QAM Quadrature Amplitude Modulation
RF Radio Frequency
UHF Ultra-High Frequency
VHF Very-High Frequency
U_{M5C} maximum operating output level with five carriers applied
U_{MNC} maximum operating output level with N carriers applied
WiFi synonym of WLAN

4 Method of measurement of 5th order non-linearity for active electronic equipment using five carriers

4.1 General

Active equipment (e.g. amplifiers) has a non-linear behaviour mainly due to the third and fifth order components of the transfer (input-output) characteristic approximated by the formula:

$$V_u = k_1 V_{in} + k_2 V_{in}^2 + k_3 V_{in}^3 + k_4 V_{in}^4 + k_5 V_{in}^5 \quad (1)$$

The gain of the active equipment (amplifier) is directly related to the k_1 value.

The measurement method of non-linearity for active equipment using five carriers allows analysis of the importance and contribution of both the 3rd and 5th order intermodulation products within the active equipment bandwidth.

The method of measurement requires that five carriers, equally spaced at a distance D, be applied at the input of the active equipment:

$$V_{in} = V_i \cos(2\pi f_i t) + V_j \cos(2\pi f_j t) + V_k \cos(2\pi f_k t) + V_z \cos(2\pi f_z t) + V_w \cos(2\pi f_w t) \quad (2)$$

Measurements are made at the frequencies of 3rd and 5th order intermodulation products with significant levels, namely:

- 3rd order (e.g. at $f_i + f_j - f_k = f_i - D$ and at $-f_k + f_z + f_w = f_w + D$) (beats of 3 carriers) (3)
- 3rd order (e.g. at $f_i + f_j - f_z = f_i - 2D$ and at $-f_j + f_z + f_w = f_w + 2D$) (beats of 3 carriers) (4)
- 5th order (e.g. at $f_i + f_j - f_k + f_z - f_w = f_i - 2D$ and at $-f_i + f_j - f_k + f_z + f_w = f_w + 2D$) (beats of 5 carriers) (5)
- 5th order (e.g. at $2f_i - f_j + f_k - f_z = f_i - 2D$ or at $2f_j - f_k + f_z - f_w = f_i - D$ and at $2f_z - f_k + f_j - f_i = f_w + D$ or at $2f_w - f_z + f_k - f_j = f_w + 2D$) (beats of 4 carriers) (6)

It is important to note that 3rd order and 5th order intermodulation products both fall at the same frequencies which are:

- at distance D below the first carrier and at distance D above the fifth carrier,
- at distance $2D$ below the first carrier and at distance $2D$ above the fifth carrier.

The method of measurement also allows the determination of the 2nd order intermodulation products at frequencies that are (besides the 2nd harmonic frequency of each carrier) at the sum and difference frequency of the 5 applied carriers:

- 2nd order at D, $2D$, $3D$, $4D$ (frequency difference of two applied carriers (beats of 2 carriers)

  (e.g. $f_w - f_z = D$, $f_w - f_k = 2D$, $f_w - f_j = 3D$, $f_w - f_i = 4D$)
- 2nd order at the frequency sum of two applied carriers (beats of 2 carriers)

  (e.g.: $f_i + f_j = 2f_i + D$ and $f_i + f_j = 2f_j - D$, ..$f_j + f_k = 2f_j + D$ and $f_j + f_k =$

  $2f_k - D$,…… ..$f_i + f_k = 2f_i + 2D$ and $f_i + f_k = 2f_k - 2D$,………..

  $f_i + f_z = 2f_i + 3D$ and $f_i + f_z = 2f_z - 3D$, …………$f_i + f_w =$

  $2f_i + 4D$ and $f_i + f_w = 2f_w - 4D$, ...etc.

  i.e.: in many cases these products are at the second harmonic frequency of each carrier

  $\pm D$, $\pm 2D$, $\pm 3D$, $\pm 4D$).

4.2 Equipment required

The equipment required is:

a) five sine-wave signal generators able to produce the five carriers at a suitable level;

b) a combiner for the output signals of the five signal generators, with negligible distortion and suitable isolation for the applied signals;

c) precision attenuators (1 dB steps) to be placed before and after the equipment under test (EUT);

d) a spectrum analyser able to display the carriers and the intermodulation signals in the VHF/UHF band. Its distortion should be sufficiently lower (e.g. 20 dB) than that to be measured.

4.3 Connection of the equipment

Connect the measuring equipment as indicated in Figure 1. The 5 carriers are applied to the EUT input and the signal level of each carrier at its output is measured by means of a suitable spectrum analyser. The variable attenuator B can be the attenuator incorporated in the spectrum analyser.

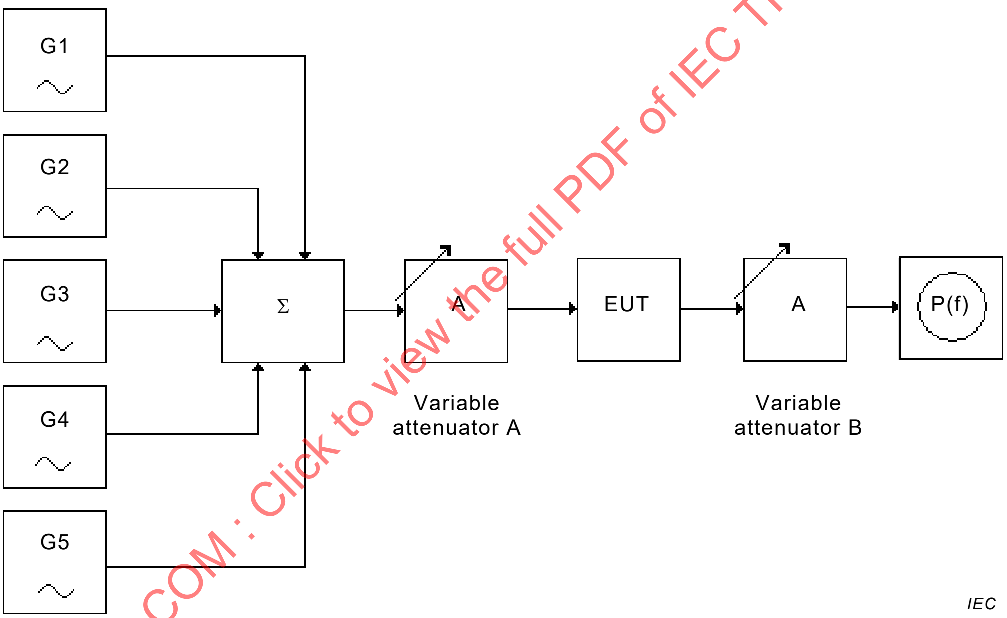


Figure 1 – Measurement configuration with 5 carriers

4.4 Measurement procedure for 3rd order and 5th order intermodulation products

a) Set the output frequencies of the five signal generators at a distance D = 8 MHz or D = 7 MHz (see Annex A) or D = 6 MHz (see Annex B), at the centre frequency of five adjacent channels within the VHF/UHF band where the measurement has to be performed (Figure 2).

NOTE 1 Figure 2 shows the 5 carriers (allocated in 5 adjacent channels) together with the 3rd order and 5th order intermodulation products that fall at $-D$ and $-2D$ with respect to the lower carrier and at $+D$ and $+2D$ with respect to the higher carrier.

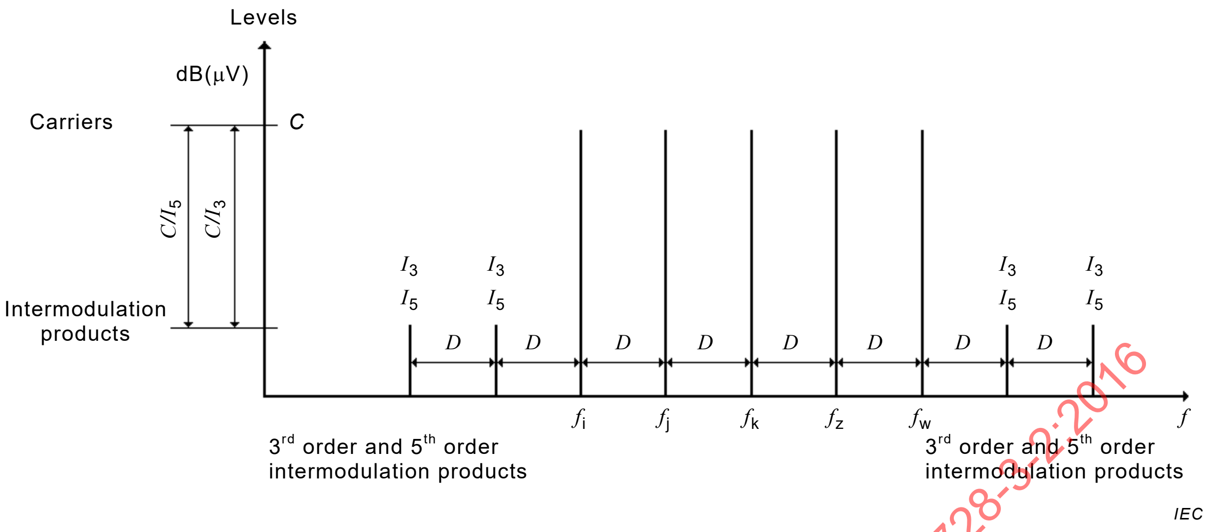


Figure 2 – The five carriers equally spaced at distance *D* and the intermodulation products

NOTE 2

3rd order at $f_i - D$ and at $f_w + D$	(beats of 3 carriers)
3rd order at $f_i - 2D$ and at $f_w + 2D$	(beats of 3 carriers)
5th order at $f_i - 2D$ and at $f_w + 2D$	(beats of 5 carriers)
5th order at $f_i - D$ and at $f_w + D$	(beats of 4 carriers)
5th order at $f_i - 2D$ and at $f_w + 2D$	(beats of 4 carriers)

b) Tune the spectrum analyser to display the channels of the VHF/UHF band where the five carriers are placed (Figure 2).

c) Measure the performance of the test configuration by connecting directly the output of the variable attenuator A to the input of the variable attenuator B, reducing the attenuation of the variable attenuator A to 0 dB and setting the variable attenuator B to a value that allows the best performance of the spectrum analyser in terms of C/I_3 and C/I_5. Note that the level of the signals applied to the spectrum analyser and the level of the 3rd order and 5th order intermodulation products, that should be sufficiently lower (e.g. 20 dB) than the expected value to be measured when the EUT is inserted.

   This permits verifying that the signal generators are suitably isolated from each other and do not produce significant intermodulation products. Otherwise the isolation should be appropriately increased.

   Care should be taken to ensure that the spectrum analyser does not itself introduce intermodulation products owing to the high level of the carriers applied to its input when the EUT (amplifier) is present. To verify this, the attenuator B at the input of the spectrum analyser should be increased by several dB and to show that the difference between the carrier levels and the intermodulation products remains constant. If this is not true an appropriate attenuation at the input of the spectrum analyser can be inserted and maintained during the measurement. This attenuation can be of the same value as the gain of the EUT.

d) Connect the EUT between the variable attenuator A and the variable attenuator B.

e) The equipment under test should be operated at nominal gain and with nominal slope.

f) Using the variable attenuator A, set the signal level (C) of each carrier at the output of the EUT to a value at least 10 dB lower than the expected maximum value; set the variable attenuator B so as to obtain the previously determined optimum signal level at the input of the spectrum analyser.

g) Read the level (in dB (μV)) of each intermodulation product (I_3 and/or I_5) at the frequencies $-D$ and $-2D$ below the lowest carrier f_i and at the frequencies $+D$ and $+2D$ above the highest carrier f_w.

h) Using the attenuator A, increase the output level of all carriers by 1 dB and set the variable attenuator B so as to obtain the previously determined optimum signal level at the input of the spectrum analyser.

i) Repeat procedure h) and calculate the C/I_3 (dB) and/or C/I_5 (dB) values. Plot them versus the output level C (in dB (μV)) of each carrier of the EUT.

j) Determine the slope of the plotted diagram, noting that 3rd order intermodulation products are in the range where the C/I_3 decreases 2 dB for 1 dB of increase of output level (2:1 slope) and 5th order intermodulation products are in the range where the C/I_5 decreases 4 dB for 1 dB of increase of output level (4:1 slope).

k) Note the output level point where the C/I_5 value of the 5th order intermodulation products (4:1 slope) is about 54 dB, which represents the maximum operating output level U_{M5C} (in dB (μV)) of the EUT.

   The value of 54 dB has been derived from a simulation of full channels load using 64 QAM modulated signals. If the amplifier will be loaded with 256 QAM modulated signals, this value should be raised to 60 dB to 62 dB or the U_{M5C} obtained value at 54 dB should be lowered by 2 dB.

This procedure should be repeated in different parts of the EUT bandwidth and the worst case (lowest value of the maximum operating output level) determined.

NOTE To test the behaviour of the EUT across the UHF band, the first setting of the carriers can be in the high part of the UHF band (e.g. centre frequency of channels 54, 55, 56, 57 and 58) and the intermodulation products measurement done on channels 52, 53 and channels 59, 60. A second setting of the carries can be in the low part of the UHF band (e.g centre frequency of channels 23, 24, 25, 26 and 27) and the intermodulation products measurement done on channels 21, 22 and channels 28, 29. A third setting of the carriers can be in the middle of the UHF band. Examples of carriers allocation is given in Clause A.1

4.5 Measurement procedure for 2nd order intermodulation products

a) Set the output frequencies of the five signal generators at a distance D = 8 MHz or D = 7 MHz (see Annex A) or D = 6 MHz (see Annex B) at the centre frequency of 5 adjacent channels within the VHF/UHF band where the measurement has to be performed (Figure 2).

b) Tune the spectrum analyser to display the channels of the VHF/UHF band where the five carriers are placed.

c) Connect the EUT between the variable attenuator A and the variable attenuator B.

d) The equipment under test should be operated at nominal gain, with nominal slope and at the maximum operating output level U_{M5C} determined before.

e) Read the value of each 2nd order product at the difference frequency of 2 carriers (D, 2D, 3D, 4D), at the 2nd harmonic of each carrier and at the sum frequency of 2 carriers (e.g. in many cases these products at the second harmonic frequency of each carrier ±D, ±2D, ±3D, ±4D).

   NOTE The measurement of the 2nd order products can be ignored when they are outside the minimum and maximum operating frequency range of the EUT.

f) Calculate the C/I_2 (dB) value of each measured 2nd order distortion product, at the maximum operating output level U_{M5C} of the EUT.

4.6 Presentation of the results

The value of the maximum operating output level U_{M5C} of the EUT, expressed in dB (μV), should be published. The worst-case channel condition should be determined.

If the test carriers are applied to an amplifier with frequency slope, the maximum operating output level (U_{M5C}) should be stated for the highest channel, taking into account the relative slope value between the worst case channel and the highest channel.

The worst-case value of C/I_2, expressed in dB, at the difference frequencies of the carriers (D, $2D$, $3D$, $4D$), at the maximum operating output level (U_{M5C}) of the EUT, should also be published.

The publication of measurements at the 2^{nd} order products is not required when these frequencies are outside the minimum and maximum operating frequency range of the EUT.

4.7 Estimated maximum usable output level with a higher number of channels

If the amplifier is used with N_c channels the maximum operating output level U_{M5C} measured with 5 carriers should be reduced using the formula:

$$U_{MNC} = U_{M5C} - 10 \lg ((N_c - 1)/4) \tag{7}$$

If N_c = 40 (e.g. full channel load in UHF, Band IV and Band V, according to Annex A), the above formula gives:

$$U_{MNC}(40) = U_{M5C} - 9{,}89 \text{ dB} \tag{8}$$

If N_c = 50 (e.g. full channel load in UHF, Band IV and Band V according to Annex B), the above formula gives:

$$U_{MNC}(50) = U_{M5C} - 10{,}88 \text{ dB} \tag{9}$$

NOTE This formula calculates an approximate value of the maximum operating output level (U_{MNC}) of EUT with a higher number of channels. The effective maximum operating output level with a full digital channel load requires the EUT to be measured with the measuring methods described in IEC 60728-3-1.

4.8 Setting of the 5 carriers frequencies for narrow-band equipment

An alternative setting of the 5 carrier frequencies is at a distance D = 1 MHz within the band of a 8 MHz channel or at a distance D = 0,8 MHz within the band of a 7 MHz channel (see Annex A) or at a distance D = 0,7 MHz within the band of a 6 MHz channel (see Annex B). The frequency f_k is assumed to be the centre frequency of the channel.

NOTE Examples of carrier allocations are given in Clause A.2.

This setting of the 5 carriers can be used for non-linear distortion measurement of channel amplifiers or channel frequency converters.

The measurement procedure can be easily derived from that of clause 4.4 and permits:

a) measurement of the 3^{rd} order and 5^{th} order intermodulation products within the EUT operating channel;

b) determination of the maximum operating output level U_{M5C}, expressed in dB (μV), for the EUT operating channel.

5 Equipment characteristics required to be published

The maximum operating output level U_{M5C} achieved by applying the method of measurement described in Clause 4 should be published.

The maximum operating output level U_{MNC} obtainable with a higher number of channels (e.g. N_c = 40, full channel load in UHF, Band IV and Band V), applying the calculation method described in 4.7, should also be published.

In addition, the nominal gain and nominal slope of the EUT, applied during the measurements, should be published.

6 Example of measurement results

Figure 3 shows an example of measurement results of 3rd order (2:1 slope) and 5th order (4:1 slope) intermodulation products obtained using the measuring method with 5 carriers.

The maximum operating output level U_{M5C} corresponds to the output level V_u at C/I_5= 54 dB.

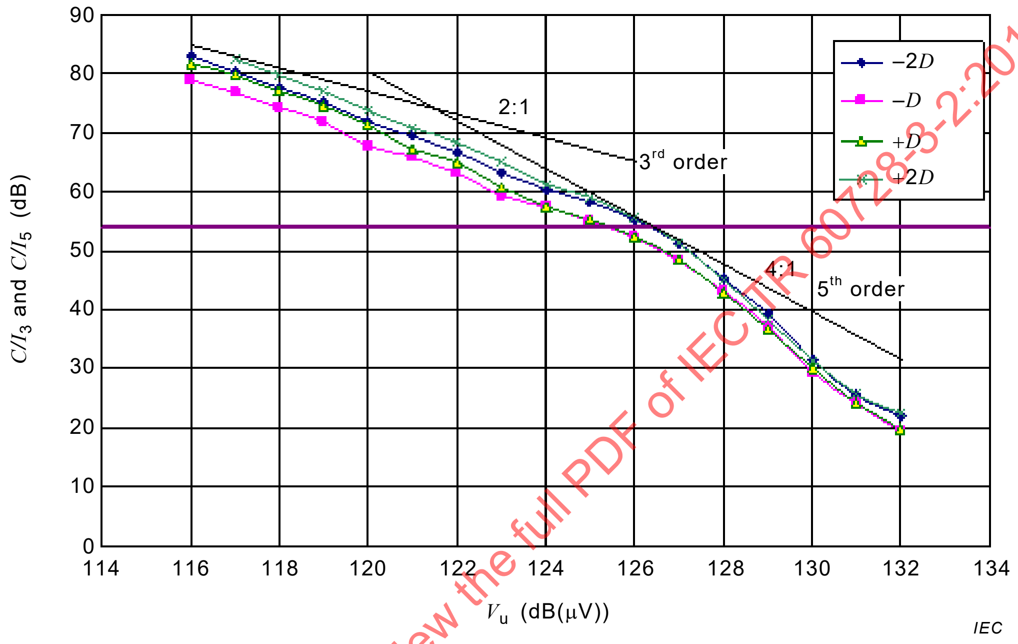


Figure 3 – Example of measurement results using the measuring method with 5 carriers

Annex A
(informative)

Examples of measurement frequencies for channel spacing of 7 MHz and 8 MHz

A.1 Wide-band equipment

A.1.1 General

Examples of carrier frequencies allocation to be used for measurement of wide-band equipment are indicated in the following tables. The 3rd order and 5th order intermodulation products frequencies are also indicated.

A.1.2 Operating frequency range: VHF

Table A.1 shows the allocation of the five carriers frequencies (D = 7 MHz) for measurement in the VHF Band III and the related intermodulation products frequencies.

Table A.1 – Allocation of measurement carrier frequencies (MHz) and intermodulation products in VHF – Band III

I_3, I_5	I_3, I_5	Carrier 1	Carrier 2	Carrier 3	Carrier 4	Carrier 5	I_3, I_5	I_3, I_5
$f_i - 2D$	$f_i - D$	f_i	f_j	f_k	f_z	f_w	$f_w + D$	$f_w + 2D$
Ch. E5	Ch. E6	Ch. E7	Ch. E8	Ch. E9	Ch. E10	Ch. E11	Ch. E12	–
177,5	184,5	191,5	198,5	205,5	212,5	219,5	226,5	233,5

A.1.3 Operating frequency range: UHF

Table A.2, Table A.3 and Table A.4 show the allocation of the five carriers frequencies (D = 8 MHz) for measurement in the UHF, Band IV and Band V, and the related intermodulation products frequencies.

Table A.2 – Allocation of measurement carrier frequencies (MHz) and intermodulation products in UHF – Band IV

I_3, I_5	I_3, I_5	Carrier 1	Carrier 2	Carrier 3	Carrier 4	Carrier 5	I_3, I_5	I_3, I_5
$f_i - 2D$	$f_i - D$	f_i	f_j	f_k	f_z	f_w	$f_w + D$	$f_w + 2D$
Ch. 21	Ch. 22	Ch 23	Ch. 24	Ch 25	Ch. 26	Ch 27	Ch 28	Ch 29
474	482	490	498	506	514	522	530	538

Table A.3 – Allocation of measurement carrier frequencies (MHz) and intermodulation products in UHF – Band V (Low part)

I_3, I_5	I_3, I_5	Carrier 1	Carrier 2	Carrier 3	Carrier 4	Carrier 5	I_3, I_5	I_3, I_5
$f_i - 2D$	$f_i - D$	f_i	f_j	f_k	f_z	f_w	$f_w + D$	$f_w + 2D$
Ch. 38	Ch. 39	Ch 40	Ch. 41	Ch 42	Ch. 43	Ch 44	Ch 45	Ch 46
610	618	626	634	642	650	658	666	674

Table A.4 – Allocation of measurement carrier frequencies (MHz) and intermodulation products in UHF – Band V (High part)

I_3, I_5	I_3, I_5	Carrier 1	Carrier 2	Carrier 3	Carrier 4	Carrier 5	I_3, I_5	I_3, I_5
$f_i - 2D$	$f_i - D$	f_i	f_j	f_k	f_z	f_w	$f_w + D$	$f_w + 2D$
Ch. 52	**Ch. 53**	**Ch 54**	**Ch. 55**	**Ch 56**	**Ch. 57**	**Ch 58**	**Ch 59**	**Ch 60**
722	730	738	746	754	762	770	778	786

A.2 Narrow-band equipment

A.2.1 General

Examples of carrier frequency allocation to be used for measurement of narrow-band equipment (e.g. channel amplifier or frequency converter) are shown in the following tables. The 3rd order (I_3) and 5th order (I_5) intermodulation products frequencies are also indicated.

A.2.2 Operating frequency range: VHF

Table A.5 shows the allocation of the five carriers frequencies (D = 0,8 MHz) for measurement in the VHF Band III and the related intermodulation product frequencies.

Table A.5 – Allocation of measurement carrier frequencies (MHz) and intermodulation products in VHF – Band III, narrow-band equipment

Channel	I_3, I_5	I_3, I_5	Carrier 1	Carrier 2	Carrier 3	Carrier 4	Carrier 5	I_3, I_5	I_3, I_5
N.	$f_i - 2D$	$f_i - D$	f_i	f_j	f_k	f_z	f_w	$f_w + D$	$f_w + 2D$
E5	174,3	175,1	175,9	176,7	177,5	178,3	179,1	179,9	180,7
E6	181,3	182,1	182,9	183,7	184,5	185,3	186,1	186,9	187,7
E7	188,3	189,1	189,9	190,7	191,5	192,3	193,1	193,9	194,7
E8	195,3	196,1	196,9	197,7	198,5	199,3	200,1	200,9	201,7
E9	202,3	203,1	203,9	204,7	205,5	206,3	207,1	207,9	208,7
E10	209,3	210,1	210,9	211,7	212,5	213,3	214,1	214,9	215,7
E11	216,3	217,1	217,9	218,7	219,5	220,3	221,1	221,9	222,7
E12	223,3	224,1	224,9	225,7	226,5	227,3	228,1	228,9	229,7

A.2.3 Operating frequency range: UHF

Table A.6 shows the allocation of the five carriers frequencies (D = 1 MHz) for measurement in the UHF Band IV and the related intermodulation product frequencies.

Table A.6 – Allocation of measurement carrier frequencies (MHz) and intermodulation products in UHF – Band IV, narrow-band equipment

Channel	I_3, I_5	I_3, I_5	Carrier 1	Carrier 2	Carrier 3	Carrier 4	Carrier 5	I_3, I_5	I_3, I_5
N.	$f_i - 2D$	$f_i - D$	f_i	f_j	f_k	f_z	f_w	$f_w + D$	$f_w + 2D$
21	470	471	472	473	474	475	476	477	478
22	478	479	480	481	482	483	484	485	486
23	486	487	488	489	490	491	492	493	494
24	494	495	496	497	498	499	500	501	502
25	502	503	504	505	506	507	508	509	510
26	510	511	512	513	514	515	516	517	518
27	518	519	520	521	522	523	524	525	526
28	526	527	528	529	530	531	532	533	534
29	534	535	536	537	538	539	540	541	542
30	542	543	544	545	546	547	548	549	550
31	550	551	552	553	554	555	556	557	558
32	558	559	560	561	562	563	564	565	566
33	566	567	568	569	570	571	572	573	574
34	574	575	576	577	578	579	580	581	582
35	582	583	584	585	586	587	588	589	590
36	590	591	592	593	594	595	596	597	598
37	598	599	600	601	602	603	604	605	606

Table A.7 shows the allocation of the five carriers frequencies (D = 1 MHz) for measurement in the UHF Band V and the related intermodulation product frequencies.

Table A.7 – Allocation of measurement carrier frequencies (MHz) and intermodulation products in UHF – Band V, narrow-band equipment

Channel	I_3, I_5	I_3, I_5	Carrier 1	Carrier 2	Carrier 3	Carrier 4	Carrier 5	I_3, I_5	I_3, I_5
N.	$f_i - 2D$	$f_i - D$	f_i	f_j	f_k	f_z	f_w	$f_w + D$	$f_w + 2D$
38	606	607	608	609	610	611	612	613	614
39	614	615	616	617	618	619	620	621	622
40	622	623	624	625	626	627	628	629	630
41	630	631	632	633	634	635	636	637	638
42	638	639	640	641	642	643	644	645	646
43	646	647	648	649	650	651	652	653	654
44	654	655	656	657	658	659	660	661	662
45	662	663	664	665	666	667	668	669	670
46	670	671	672	673	674	675	676	677	678
47	678	679	680	681	682	683	684	685	686
48	686	687	688	689	690	691	692	693	694
49	694	695	696	697	698	699	700	701	702
50	702	703	704	705	706	707	708	709	710
51	710	711	712	713	714	715	716	717	718
52	718	719	720	721	722	723	724	725	726
53	726	727	728	729	730	731	732	733	734
54	734	735	736	737	738	739	740	741	742
55	742	743	744	745	746	747	748	749	750
56	750	751	752	753	754	755	756	757	758
57	758	759	760	761	762	763	764	765	766
58	766	767	768	769	770	771	772	773	774
59	774	775	776	777	778	779	780	781	782
60	782	783	784	785	786	787	788	789	790

Annex B
(informative)

Examples of measurement frequencies for channel spacing of 6 MHz

B.1 Wide-band equipment

B.1.1 General

Examples of carrier frequencies allocation to be used for measurement of wide-band equipment are shown in the following tables. The 3rd order and 5th order intermodulation product frequencies are also indicated.

B.1.2 Operating frequency range: VHF

Table B.1 shows the allocation of the five carriers' frequencies (D = 6 MHz) for measurement in the VHF Band III and the related intermodulation product frequencies.

Table B.1 – Allocation of measurement carrier frequencies (MHz) and intermodulation products in VHF – Band III

I_3, I_5	I_3, I_5	Carrier 1	Carrier 2	Carrier 3	Carrier 4	Carrier 5	I_3, I_5	I_3, I_5
$f_i - 2D$	$f_i - D$	f_i	f_j	f_k	f_z	f_w	$f_w + D$	$f_w + 2D$
Ch. 4	Ch. 5	Ch. 6	Ch. 7	Ch. 8	Ch. 9	Ch. 10	Ch. 11	Ch. 12
173	179	185	191	197	203	209	215	221

B.1.3 Operating frequency range: UHF

Table B.2, Table B.3 and Table B.4 show the allocation of the five carriers frequencies (D = 6 MHz) for measurement in the UHF, Band IV and Band V, and the related intermodulation product frequencies.

Table B.2 – Allocation of measurement carrier frequencies (MHz) and intermodulation products in UHF – Band IV

I_3, I_5	I_3, I_5	Carrier 1	Carrier 2	Carrier 3	Carrier 4	Carrier 5	I_3, I_5	I_3, I_5
$f_i - 2D$	$f_i - D$	f_i	f_j	f_k	f_z	f_w	$f_w + D$	$f_w + 2D$
Ch. 13	Ch. 14	Ch 15	Ch. 16	Ch 17	Ch. 18	Ch 19	Ch 20	Ch 21
473	479	485	491	497	503	509	515	521

Table B.3 – Allocation of measurement carrier frequencies (MHz) and intermodulation products in UHF – Band V (Low part)

I_3, I_5	I_3, I_5	Carrier 1	Carrier 2	Carrier 3	Carrier 4	Carrier 5	I_3, I_5	I_3, I_5
$f_i - 2D$	$f_i - D$	f_i	f_j	f_k	f_z	f_w	$f_w + D$	$f_w + 2D$
Ch. 35	Ch. 36	Ch 37	Ch. 38	Ch 39	Ch. 40	Ch 41	Ch 42	Ch 43
605	611	617	623	629	635	641	647	653