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Edition 1.0 2012-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Cable networks for television signals, sound signals and interactive services – Part 3-1: Active wideband equipment for cable networks – Methods of measurement of non-linearity for full digital channel load with DVB-C signals

Réseaux de distribution par câbles pour signaux de télévision, signaux de radiodiffusion sonore et services interactifs – Partie 3-1: Matériel actif à large bande pour réseaux de distribution par câbles – Méthodes de mesure de la non-linéarité pour une charge tout numérique de signaux DVB-C

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Methods of measurement of non-linearity for
full digital channel load with DVB-C signals**

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International Standard IEC 60728-3-1 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 standard is based on the following documents:

FDIS	Report on voting
100/1969/FDIS	100/2006/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 2.

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.

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

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- withdrawn,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

INTRODUCTION

Standards of the IEC 60728 series deal with cable networks including equipment and associated methods of measurement for headend reception, processing and distribution of television signals, sound signals and their associated data signals and for processing, interfacing and transmitting all kinds of signals for interactive services using all applicable transmission media.

This includes

- CATV[1]-networks,
- MATV-networks and SMATV-networks,
- individual receiving networks,

and all kinds of equipment, systems and installations installed in such networks.

For active equipment with balanced RF signal ports this standard applies only to those ports which carry RF broadband signals for services as described in the scope of this standard.

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.

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.

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1 This word encompasses the HFC networks used nowadays to provide telecommunications services, voice, data, audio and video both broadcast and narrowcast.

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

Part 3-1: Active wideband equipment for cable networks – Methods of measurement of non-linearity for full digital channel load with DVB-C signals

1 Scope

This part of IEC 60728 is applicable to the methods of non-linearity measurement for cable networks which carry only digitally modulated television signals, sound signals and signals for interactive services. These methods take into account the specific signal form and behaviour of digitally modulated signals which differ from the analogue broadcast signals represented mainly by the existence of discrete carrier signals.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

ISO/IEC 13818-1:2007, *Information technology – Generic coding of moving pictures and associated audio information: Systems*

3 Terms, definitions, symbols and abbreviations

For the purposes of this document, the following terms, definitions, symbols and abbreviations apply.

3.1 Terms and definitions

Subclause 3.1 of IEC 60728-3 is applicable except as follows.

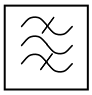
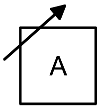
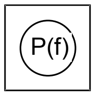
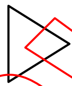
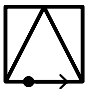
Addition:

3.1.25
maximum operating output level
average channel power level of a digitally modulated signal in the 256 QAM format with a symbol rate of 6,9 MSymb/s with 15 % cosine roll-off, measured with full digital channel load

Note 1 to entry: This maximum operating output level has no direct correlation to that derived from CTB/CSO measurements of analogue or mixed analogue-digital channel loads.

3.2 Symbols

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

Symbols	Terms	Symbols	Terms
	Equipment Under Test based on [IEC 60617-S00059 (2001-07)]		Band-pass filter [IEC 60617-S01249 (2001-07)]
	Variable attenuator [IEC 60617-S01245 (2001-07)]		Spectrum analyzer (electrical) based on [IEC 60617-S00910 (2001-07)]
	Combiner based on [IEC 60617-S00059 (2001-07)]		Amplifier [IEC 60617-S01239 (2001-07]
	Modulator based on [IEC 60617-S01278 (2001-07)]		Demodulator based on [IEC 60617-S01278 (2001-07]

3.3 Abbreviations

BER	bit error ratio
CATV	community antenna television (system)
CINR	carrier to intermodulation noise ratio
CSO	composite second order
CTB	composite triple beat
DVB	digital video broadcasting
EUT	equipment under test
HFC	hybrid fibre coax
MATV	master antenna television (system)
MEAS	measured
PRBS	pseudo-random bit sequence
QAM	quadrature amplitude modulation
RF	radio frequency
SMATV	satellite master antenna television (system)
SYS	system
UHF	ultra-high frequency
VHF	very-high frequency
$U_{max\ (N)}$	maximum operating output level with channel load of 112 carriers in the 256 QAM format

4 Methods of measurement of non-linearity for full digital channel load

4.1 Maximum operating output level using the measurement of bit error ratio (BER)

4.1.1 General

The method of measurement describes the measurement of the bit error ratio (BER) (before Reed Solomon decoder of the measurement receiver) of the output signal of the equipment under test (EUT) (e.g. an amplifier) when handling a full load of digitally modulated TV signals.

This test is able to define the performance (maximum output level) of the EUT when loaded with a number (N = 112) of digitally modulated signals in the 256 QAM format covering a frequency range from 110 MHz to 1 006 MHz with a raster of 8 MHz.

NOTE 1 Due to different channel spacing plans in use, the lower frequency limit may not be exactly 110 MHz, but may differ by some megahertz, e.g. 109 MHz. In the same way, the upper frequency limit may not be exactly 1 006 MHz, but may differ by some megahertz. The notation 110 MHz to 1 006 MHz in this standard is intended to include such small deviations.

The number N can be reduced according to the used frequency range of the EUT, e.g. to N = 94 for 862 MHz upper frequency limit. In all cases the EUT shall be fully loaded.

The measurement shall be performed for the following three channels:

a) the lowest RF channel according to the specified operating frequency range of the EUT;
b) the highest RF channel according to the specified operating frequency range of the EUT;
c) an RF channel at the arithmetic mean between the lowest and the highest RF channels according to a) and b).

NOTE 2 Examples of these measurement channels are given in informative Annex B.

The worst case value of $U_{max\,(N)}$ of the EUT out of the three measured values according to a) to c) shall be presented together with the worst case channel.

4.1.2 Equipment required

The equipment required is the following:

a) a number N of 256 QAM modulators (with channel coders) having a suitable linearity (*BER* better than 1×10^{-10}) and an occupied bandwidth of 8 MHz. The channels generated by the modulators shall be placed in the frequency range from 110 MHz to 1 006 MHz or in a subset of this frequency range with a raster of 8 MHz;
b) a number N of null packet or of pseudo-random bit sequence (PRBS) generators (see Annex B);
c) a combiner for the output signals of the 256 QAM modulators with negligible distortion;
d) a wide band amplifier with suitable linearity and gain over the full bandwidth of the EUT;
e) precision attenuators (1 dB steps) to be placed before and after EUT;
f) a test receiver able to measure the BER of the received 256 QAM signals; its distortion should be sufficiently lower than that to be measured (e.g. a BER better than 1×10^{-10}).

All applied QAM channels (channel load and measurement channels) shall have the same output level within a deviation of maximum ±0,5 dB.

The total BER introduced by source and measurement equipment shall not exceed 1×10^{-10}.

4.1.3 Connection of equipment

Connect the measuring equipment as indicated in Figure 1. The input signal is applied to the equipment under test (EUT) input and its output signal level is measured by means of a suitable measuring receiver, connected to a BER measuring set if not included in the measuring receiver.

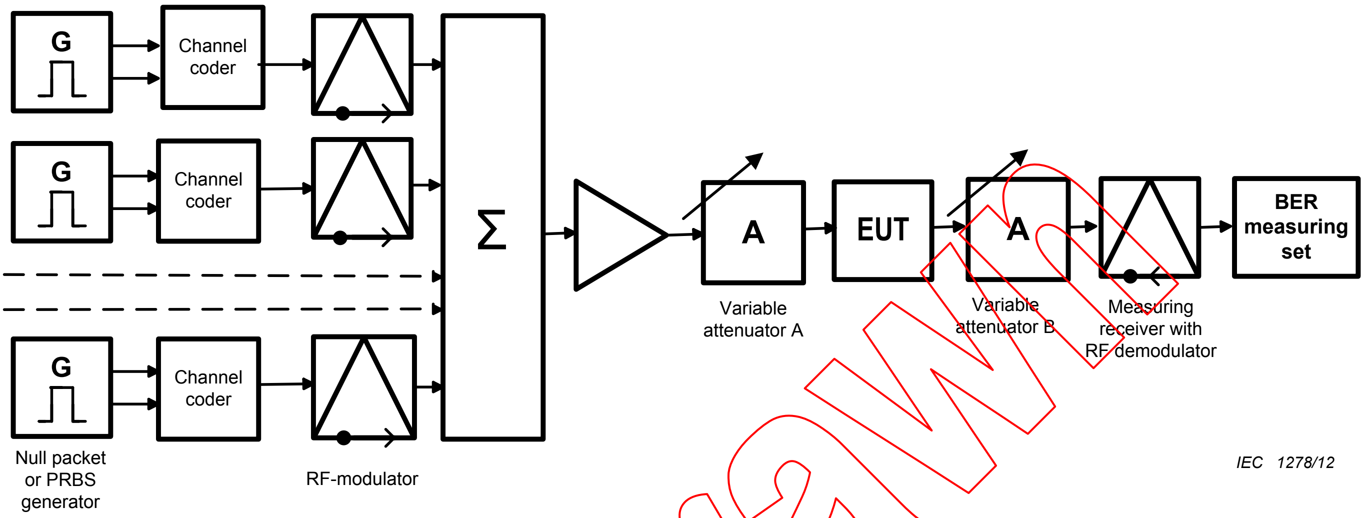


Figure 1 – BER measurement test configuration

4.1.4 Measurement procedure

The measurement shall be performed according to the steps described hereafter.

a) Tune the measuring receiver to an operating channel.

b) 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 measuring receiver in terms of *BER* ($<1 \times 10^{-10}$ measured over an observation time >10 min). Note the level of the signal applied to the measuring receiver and the *BER* value obtained.

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

d) The equipment under test shall be operated at nominal gain and with nominal slope.

e) Using the variable attenuator A, set the channel output signal level of the EUT to a value at least 10 dB lower than the maximum value (according to the methods of measurement described in IEC 60728-3, using the CENELEC 42 channel test frequency plan); set the variable attenuator B so as to obtain the previously determined optimum signal level at the input of the measuring receiver.

f) Read the *BER* on the measuring set which shall be $<1 \times 10^{-9}$ (measured over an observation time >60 s).

g) Using the attenuator A, increase the output level of all applied channels by 1 dB and set the variable attenuator B so as to obtain the previously determined optimum signal level at the input of the measuring receiver.

h) Repeat procedure g) until the BER measuring set shows a value $>1 \times 10^{-9}$.

i) Then reduce the output level of all applied channels by 1 dB and set the variable attenuator B so as to obtain the previously determined optimum signal level at the input of the measuring receiver.

j) Read the *BER* on the measuring set which once more shall be $<1 \times 10^{-9}$ (measured over an observation time of >60 s). If not, repeat step i).

k) Note the output level of the EUT which represents the maximum operating output level of the EUT.

This procedure shall be repeated for each channel as defined in 4.1.1 and the worst case (lowest value of the maximum operating output level) shall be determined.

4.1.5 Presentation of the results

The worst case value of the maximum operating output level $U_{\max\ (N)}$ of the EUT, with N channels applied and expressed in dB(μV), as defined in 4.1.1, shall be published. The worst-case-channel condition shall be determined.

If the three test channels are applied to an amplifier with frequency slope, the same method of measurement shall be applied as for amplifiers without frequency slope. But in this case the maximum operating output level of the EUT shall always be stated for the highest measurement channel, taking into account the relative slope value (slope value difference) between the worst case channel and the highest measurement channel.

The frequency response (slope) of the EUT used for the measurements shall be published.

4.2 Measurement of the carrier-to-interference noise ratio *CINR*

4.2.1 General

In addition to the measurement of the maximum operating output level $U_{\max\ (N)}$ of broadband equipment at the borderline of the bit error ratio (1×10^{-9}) according to 4.1 the carrier-to-interference noise ratio shall be determined.

4.2.2 Equipment required

Figure 2 shows the measurement test setup.

The equipment required is the following:

a) a number N of 256 QAM modulators (with channel coders) having a suitable linearity (*shoulder attenuation*) and an occupied bandwidth of 8 MHz; the channels generated by the modulators shall be placed in the frequency range from 110 MHz to 1 006 MHz or in a subset of this frequency range with a raster of 8 MHz;

b) a number N of null packet or of pseudo-random bit sequence (PRBS) generators (see Annex B);

c) a combiner for the output signals of the 256 QAM modulators with negligible distortion;

d) a wide band amplifier with suitable linearity and gain over the full bandwidth of the EUT;

e) precision attenuators (1 dB steps) with sufficient attenuation range to be placed before and after EUT;

f) a spectrum analyzer able to measure the *CINR* in a non-occupied measurement channel.

All applied QAM channels (channel load and measurement channels) shall have the same output level within a deviation of maximum ±0,5 dB.

The complete measurement setup as described above should have a *CINR* >60 dB.

If the shoulder attenuation of the modulators is not sufficient or in the case of residual general spurious signals transmitted by the modulators a notch filter (dashed box in Figure 2) should be inserted in front of the EUT to achieve for the test equipment the required *CINR* value >60 dB.