IEC 60728-3

Edition 5.0 2017-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Réseaux de distribution par câbles pour signaux de télévision, signaux de radiodiffusion sonore et services interactifs – Partie 3: Matériel actif à large bande pour réseaux de distribution par câbles

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

Part 3: Active wideband equipment for cable networks

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International Standard IEC 60728-3 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.

This fifth edition cancels and replaces the fourth edition published in 2010. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) extension of upper frequency range limit for cable network equipment in the forward path from 1 000 MHz to 1 218 MHz (optional up to 1 794 MHz);
b) extension of upper frequency range limit for cable network equipment in the return path from 85 MHz to 204 MHz;
c) integration and update of IEC 60728-3-1 content;
d) integration and update of the Technical Specification CLC/TS 50083-3-3 content;
e) deletion of specifications and test methods for obsolete analogue parameters;

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f) additional normative references;

g) additional terms and definitions and abbreviations.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
100/2975/FDIS	100/2990/RVD

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

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

The list of all the 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 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.

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INTRODUCTION

Standards and other 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 customer premises equipment.

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.

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

Part 3: Active wideband equipment for cable networks

1 Scope

This part of IEC 60728 specifies the measuring methods, performance requirements and data publication requirements for active wideband equipment of cable networks for television signals, sound signals and interactive services.

This document

- applies to all amplifiers used in cable networks;
- covers the frequency range 5 MHz to 3 000 MHz;

NOTE The upper limit of 3 000 MHz is an example, but not a strict value.

- applies to one-way and two-way equipment;
- specifies the basic methods of measurement of the operational characteristics of the active equipment in order to assess the performance of this equipment;
- identifies the performance specifications to be published by the manufacturers;
- states the minimum performance requirements of certain parameters.

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 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Tests A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Tests B: Dry heat*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test dB: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-31, *Environmental testing – Part 2-31: Tests – Test Ec: Rough handling shocks, primarily for equipment-type specimens*

IEC 60068-2-40, *Basic environmental testing procedures – Part 2-40: Tests – Test Z/AM: Combined cold/low air pressure tests*

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IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60728-2, *Cable networks for television signals, sound signals and interactive services – Part 2: Electromagnetic compatibility for equipment*

IEC 60728-4, *Cable networks for television signals, sound signals and interactive services – Part 4: Passive wideband equipment for coaxial cable networks*

IEC 60728-5, *Cable networks for television signals, sound signals and interactive services – Part 5: Headend equipment*

IEC 60728-11, *Cable networks for television signals, sound signals and interactive services – Part 11: Safety*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61319-1, *Interconnections of satellite receiving equipment – Part 1: Europe*

IEC 61319-2, *Interconnections of satellite receiving equipment – Part 2: Japan*

IEC 62368-1, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the following terms, definitions, symbols and abbreviated terms 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 Terms and definitions

3.1.1
amplitude frequency response
gain or loss of an equipment or system plotted against frequency

3.1.2
attenuation
ratio of the input power to the output power of an equipment or system, usually expressed in decibels

3.1.3
carrier-to-noise ratio
difference in decibels between the vision or sound carrier level at a given point in an equipment or system and the noise level at that point (measured within a bandwidth appropriate to the television or radio system in use)

3.1.4
composite intermodulation noise
CIN
sum of noise and intermodulation products from digital modulated signals

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3.1.5
CINR
composite intermodulation noise ratio
ratio of the signal level and the CIN level

3.1.6
crosstalk attenuation
ratio of the wanted signal power to the unwanted signal power, which is caused by electromagnetic coupling between two leads, while equal signal powers are applied to the leads

Note 1 to entry: Crosstalk attenuation is usually expressed in decibels.

3.1.7
decibel ratio
ten times the logarithm of the ratio of two quantities of power P_1 and P_2, i.e.

$$10\lg\frac{P_1}{P_2} \text{ in dB}$$

3.1.8
equaliser
device designed to compensate over a certain frequency range for the amplitude/frequency distortion or phase/frequency distortion introduced by feeders or equipment

Note 1 to entry: This device is for the compensation of linear distortions only.

3.1.9
feeder
transmission path forming part of a cable network

Note 1 to entry: Such a path may consist of a metallic cable, optical fibre, waveguide or any combination of them. By extension, the term is also applied to paths containing one or more radio links.

3.1.10
gain
ratio of the output power to the input power, usually expressed in decibels

3.1.11
ideal thermal noise
noise generated in a resistive component due to the thermal agitation of electrons

Note 1 to entry: The thermal power generated is given by

$$P = 4 \cdot B \cdot k \cdot T$$

where

P is the noise power, in watts;

B is the bandwidth, in hertz;

k is the Boltzmann's constant = 1,38 × 10^{-23} J/K;

T is the absolute temperature, in kelvins.

It follows that

$$\frac{U^2}{R} = 4 \cdot B \cdot k \cdot T$$

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and

$$U = \sqrt{4 \cdot R \cdot B \cdot k \cdot T}$$

where

U is the noise voltage (e.m.f.);

R is the resistance, in ohms.

In practice, it is normal for the source to be terminated with a load equal to the internal resistance value, the noise voltage at the input is then $U/2$.

3.1.12
level
decibel ratio of any power P_1 to the standard reference power P_0, i.e.

$$10 \lg \frac{P_1}{P_0}$$

decibel ratio of any voltage U_1 to the standard reference voltage U_0, i.e.

$$20 \lg \frac{U_1}{U_0}$$

Note 1 to entry: The power level may be expressed in decibels relative to $P_0 = (U_0^2/R) = (1/75)$ pW, i.e. in dB(P_0), taking into account that the level of P_0 corresponds to 0 dB(P_0) or, as more usually, in dB(pW), taking into account that the level of P_0 corresponds to −18,75 dB(pW). The voltage level is expressed in decibels relative to 1 μV (across 75 Ω), i.e. in dB(μV).

3.1.13
modulation error ratio
MER
sum of the squares of the magnitudes of the ideal symbol vectors is divided by the sum of the squares of the magnitudes of the symbol error vectors of a sequence of symbols, the result being expressed as a power ratio in dB

$$MER = 10 \lg \left\{ \frac{\sum_{j=1}^{N} \left(I_j^2 + Q_j^2 \right)}{\sum_{j=1}^{N} \left(\delta I_j^2 + \delta Q_j^2 \right)} \right\} \text{ in dB}$$

3.1.14
multi-switch
equipment used in distribution systems for signals that are received from satellites and converted to a suitable IF

Note 1 to entry: The IF signals that are received from different polarisations, frequency bands and orbital positions are input signals to the multi-switch. Subscriber feeders are connected to the multi-switch output ports. Each output port is switched to one of the input ports, depending on control signals that are transmitted from the subscriber equipment to the multi-switch. Besides a splitter for each input port and a switch for each output port, a multi-switch can contain amplifiers to compensate for distribution or cable losses.

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3.1.15
multi-switch loop through port
one or more ports to loop through the input signals through a multi-switch

Note 1 to entry: This enables larger networks with multiple multi-switches, each one installed close to a group of subscribers. The multi-switches are connected in a loop through manner. The IF signals that are received by an outdoor unit from different polarisations, frequency bands and orbital positions are input signals to a first multi-switch. Cables connect the loop through ports of this multi-switch to the input ports of a second multi-switch and so on.

3.1.16
noise factor
noise figure
figure of merit describing the internally generated noise of an active device

Note 1 to entry: The noise factor, F, is the ratio of the carrier-to-noise ratio at the input, to the carrier-to-noise ratio at the output of an active device.

$$F = \frac{C_1/N_1}{C_2/N_2}$$

where

C_1 is the signal power at the input;

C_2 is the signal power at the output;

N_1 is the noise power at the input (ideal thermal noise);

N_2 is the noise power at the output.

In other words, the noise factor is the ratio of noise power at the output of an active device to the noise power at the same point if the device had been ideal and added no noise.

$$F = \frac{N_{2\text{actual}}}{N_{2\text{ideal}}}$$

The noise factor is dimensionless and is often expressed as noise figure, NF, in dB

$$NF = 10 \lg F \quad \text{in dB}$$

3.1.17
slope
difference in gain or attenuation at two specified frequencies between any two points in an equipment or system

Note 1 to entry: The slope sign is considered

a) negative when the attenuation increases with frequency (cables) or the gain (amplifiers) decreases with frequency,

b) positive when the gain (amplifiers) increases with frequency (compensating slope).

3.1.18
surge voltage
surge which is produced by a direct or indirect lightning stroke

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.

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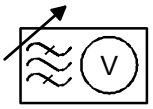
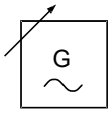
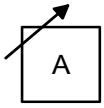
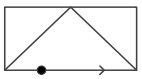
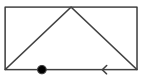
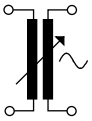
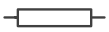
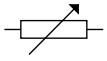
Symbols	Terms	Symbols	Terms
	Ammeter based on [IEC 60617-S00910 (2001-07)]		Voltmeter based on [IEC 60617-S00910 (2001-07)]
	Selective voltmeter		Power meter based on [IEC 60617-S00910 (2001-07)]
	Equipment under test based on [IEC 60617-S00059 (2001-07)]		Signal generator based on [IEC 60617-S00899, IEC 60617-S01403 (2001-07)]
	Noise generator [IEC 60617-S01230 (2001-07)]		Variable signal generator based on [IEC 60617-S00081, IEC 60617-S00899, IEC 60617-S01403 (2001-09)]
	Surge generator [IEC 60617-S01228 (2001-07)]		High-pass filter [IEC 60617-S01247 (2001-07)]
	Low-pass filter [IEC 60617-S01248 (2001-07)]		Band-stop filter [IEC 60617-S01250 (2001-07)]
	Band-pass filter [IEC 60617-S01249 (2001-07)]		Oscilloscope based on [IEC 60617-S00059, and IEC 60617-S00922 (2001-07)]
	Spectrum analyser (electrical) based on [IEC 60617-S00910 (2001-07)]		Attenuator based on [IEC 60617-S01244 (2001-07)]
	Variable attenuator [IEC 60617-S01245 (2001-07)]		Amplifier [IEC 60617-S01239 (2001-07)]
	RF modulator based on [IEC 60617-S01278 (2001-07)]		RF demodulator based on [IEC 60617-S01278 (2001-07)]
	Combiner based on [IEC 60617-S00059 (2001-07)]		Detector with LF-amplifier
	Functional equipotential bonding [IEC 60617-S01410 (2001-11)]		Adjustable AC voltage source
	Resistor [IEC 60617-S00555 (2001-07)]		Variable resistor [IEC 60617-S00557 (2001-07)]
	Capacitor [IEC 60617-S00567 (2001-07)]		RF choke [IEC 60617-S00583 (2001-07)]

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3.3 Abbreviated terms

AC	alternating current
AM	amplitude modulation
BER	bit error ratio
CATV	community antenna television (system)
CIN	composite intermodulation noise
CINR	composite intermodulation noise ratio
CSO	composite second order
CTB	composite triple beat
CW	continuous wave
DC	direct current
DUT	device under test
DVB-C	Digital Video Broadcasting – cable
EMC	electromagnetic compatibility
EUT	equipment under test
HP	high pass
IF	intermediate frequency
LF	low frequency
LP	low pass
MER	modulation error ratio
PRBS	pseudo-random bit sequence
QAM	quadrature amplitude modulation
RF	radio frequency
RMS	root mean square
TV	television

4 Methods of measurement

4.1 General

This clause defines basic methods of measurement. Ensure that all test equipment is calibrated and all connectors, leads, and terminations have an adequate quality in order to not affect the test results.

Unless stated otherwise, all measurements shall be carried out with 0 dB plug-in attenuators and equalisers. The position of variable controls used during the measurements shall be published.

A network can be used to distribute terrestrial signals in addition to the signals received from satellites. The terrestrial antennas are connected to an optional terrestrial input port of a multi-switch. On each output port, the terrestrial signals are available in addition to the satellite IF signals. Since the normal frequency ranges for terrestrial signals and satellite IF signals do not overlap, both can be carried on the same cable.

For large networks with loop through connected multi-switches, two possibilities exist to carry the terrestrial signals from one multi-switch to another multi-switch:

- to use a specialised cable for the terrestrial signal, in addition to the cables used for the satellite IF signals and then, on each output port the terrestrial signal is combined with the selected satellite IF signal;

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- to combine the terrestrial signal with each satellite IF signal before the first multi-switch in order to minimise the number of cables between multi-switches.

NOTE The signal coming from an outdoor unit for satellite reception can contain unwanted signal-components with frequencies below the foreseen satellite IF frequency range. These signal-components overlap with the frequency range of terrestrial signals. For example, an outdoor unit that converts the frequency band 11,7 GHz to 12,75 GHz to the satellite IF frequency range can convert signals in the 10,7 GHz to 11,7 GHz band to frequencies below the satellite IF frequency range. These frequencies have to be sufficiently filtered out to avoid interference with terrestrial signals on the same cable.

For measurements on multi-switches, it is necessary that control signals be fed to the output ports that are involved in the measurement. Therefore, a bias-tee has to be connected between the multi-switch output port and the measurement set. The DC port of the bias-tee is connected to a standard receiver that generates the required control signals. Care has to be taken that the influence of the bias-tee on the measurement result is insignificant. This can be achieved by including it into the calibration or using a network analyser with a built in bias-tee.

4.2 Linear distortion

4.2.1 Return loss

4.2.1.1 General

The method described is applicable to the measurement of the return loss of equipment operating in the frequency range 5 MHz to 3 000 MHz.

All input and output ports of the unit shall meet the specification under all conditions of automatic and manual gain controls and with any combination of plug-in equalisers and attenuators fitted.

4.2.1.2 Equipment required

A network analyser covering the frequency range of the equipment to be tested is required.

4.2.1.3 Measurement procedure

All coaxial input and output ports, other than those under test, shall be terminated in 75 Ω.

Ensure that there is no supply voltage on the port being measured as this could damage the network analyser. If it is necessary to use a voltage blocking device, use one with a good return loss (10 dB above the expected test result). Return loss shall be measured at all RF signal ports of the EUT. Take into account the impact of test equipment mismatch as detailed in Annex C and adjust the results accordingly.

4.2.2 Group delay variation

4.2.2.1 General

The group delay (GD) is a parameter affected by the physical length and propagation velocity in the passive and active circuits involved, where frequency-selective components, such as L-C filters, e.g. diplexers, and amplifiers, are present.

GD is defined as the negative derivative of phase with respect to frequency, and is expressed mathematically as

$$GD = -(d\varphi/d\omega)$$

The GD value is measured in time units and usually expressed in nanoseconds.

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The group delay variation (GDV), also called group delay distortion, is the absolute value of the difference between the maximum and minimum group delay within a specified frequency interval, i.e. between one frequency and another in a circuit, device, or system.

$$GDV = \left| -\left(d\varphi_1/d\omega_1\right) \right| - \left| -\left(d\varphi_2/d\omega_2\right) \right|$$

The frequency interval is defined by the given specifications for the equipment under test or can be derived from the specification of the transmission system. In cascaded systems, group delay variation of each (cascaded) device accumulates and simple summation is assumed.

NOTE 1 Example for GDV derivation of cascaded systems:

If the system allows a GDV of 120 ns, a maximum number of 6 devices, with a GDV of 20 ns for each device, can be cascaded.

NOTE 2 The term ‘group delay’ is wrongly used in some documents instead of group delay variation.

4.2.2.2 Equipment required

The following equipment is required: a vector network analyzer covering the frequency range of the equipment to be tested and with features to measure transmission group delay (GD) and frequency response at the specified frequencies.

4.2.2.3 Measurement procedure

The measurement procedure is as follows:

a) Calibrate and align the vector network analyzer in the same manner as for linear distortion measurements.

b) Set frequency markers in frequency steps according to the specified frequency interval.

NOTE Examples of typical frequency intervals (bandwidths) can be found in IEC 60728-101:2016, Annex C.

c) The frequency interval over which the GD measurement is made shall be recorded.

d) Set the smoothing function in the network analyzer according to the recommendations of the manual of the test equipment manufacturer to get the optimum reading of the values.

e) Plot the GD curve versus the specified frequency interval and record it.

f) Read the GD values for frequency 1 (ω_1) and frequency 2 (ω_2), calculate the difference (GDV) between the two values and record the result.

4.2.2.4 Presentation of the results

Present the group delay variation results (GDV) and the specified frequency interval.

4.3 Non-linear distortion

4.3.1 General

In a non-linear device, the expression for the output signal will, in general, have an infinity of terms, each generated from one or more of the (assumed sinusoidal) terms in the input, and particularly by the interaction of two or more terms.

It is recommended that, for mixed analogue/digital loads, both the analogue and digital methods of measurement should be considered.

4.3.2 Types of measurements

Measurements related to the following phenomena are described:

- intermodulation between two or three single frequency signals;

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- composite beats produced by a number of single frequency signals;
- intermodulation between digital modulated signals.

The specification shall include at least the following details:

a) the particular effect that is measured;

b) the required signal to distortion ratio.

The result of the measurement shall be given as the worst-case maximum signal level at the equipment output that allows the required signal to distortion ratio to be met. If the output level is sloped with frequency, this shall be defined.

The effect shall be defined as being of a particular order (e.g. "third-order intermodulation").

4.3.3 Intermodulation

4.3.3.1 General

The two equal carrier and the three equal carrier methods described are applicable to the measurement of the ratio of the carrier to a single intermodulation product at a specified point within the cable network. The methods can also be used to determine the intermodulation performance of individual items of equipment.

It should be especially noted that the simultaneous use of many channels spaced by the same frequency interval results in a large number of intermodulation products (particularly those of the third-order) falling near the vision carrier of a wanted television channel. In these cases, the resultant interference is of an extremely complex nature and an alternative measurement procedure shall be needed. This is covered in 4.3.4 and 4.3.5.

Examples of second-order and third-order intermodulation products are given in Annex A.

Second-order products are encountered only in wideband equipment and systems, covering more than one octave, and shall be measured using two signals (see Clause A.1).

Third-order products are encountered in wideband and narrowband equipment and systems and shall be measured using three signals (see Clause A.2).

If the unequal carrier method of measurement, as described in IEC 60728-5, is used, the output level giving the appropriate signal to distortion ratio shall be decreased by 6 dB to obtain the correct result for the equal carrier method described here.

4.3.3.2 Equipment required

The following equipment is required:

a) a selective voltmeter covering the frequency range of the equipment or system to be tested; this may be a spectrum analyser;

b) the appropriate number of signal generators covering the frequencies at which the tests are to be carried out;

c) a variable attenuator with a range greater than the signal to intermodulation ratio expected, if not incorporated in the voltmeter described in 4.3.3.2 a);

d) a combiner will be required for tests on equipment and systems with a single input (Figure 1).

Additional items may be necessary, for example to ensure that the measurements are not affected by spurious signals generated in the test equipment itself.

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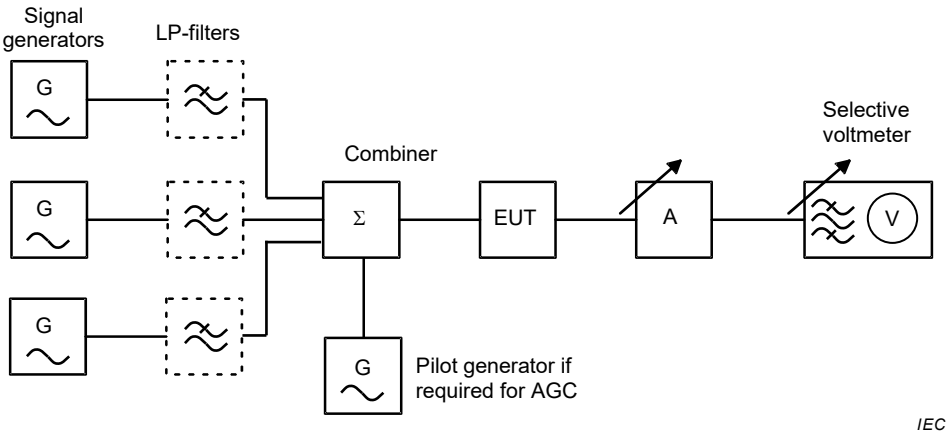
4.3.3.3 Connection of equipment

The equipment shall be connected as shown in Figure 1.



The filters at the signal generator outputs may be needed to suppress spurious signals. The selective voltmeter input filter may be required to prevent intermodulation in the meter. If a filter is used, then the possible mismatch should be avoided by not reducing the attenuator value below 10 dB.

To avoid intermodulation between the signal generators, it may be necessary for the combiner to be in the form of one or more directional couplers.

Figure 1 – Basic arrangement of test equipment for evaluation of the ratio of signal to intermodulation product

4.3.3.4 Measurement procedure

4.3.3.4.1 General

The measurement procedure comprises the following steps.

Unless otherwise required, the reference output levels used in the measurements shall be the nominal output levels for the equipment. It shall be quoted whether the signal output levels are constant over the frequency range or not. If the specified output levels are not constant over frequency range then the output levels off all the test signals shall be quoted in the results.

Measurements of both second order and third order products shall be carried out with the test signals widely and closely spaced over each band of interest at frequencies capable of producing significant products within the overall frequency range.

Where the equipment to be measured includes automatic gain control, tests shall be carried out at the nominal operating signal input levels.

4.3.3.4.2 Calibration and checks

A check shall be made to determine if the harmonics and other spurious signals at the outputs of the signal generators are likely to affect materially the results of the measurements.

The selective voltmeter shall be calibrated and checked for satisfactory operation.

A check shall be made for possible intermodulation between the signal generators at the output levels to be used for the tests.

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4.3.3.4.3 Measurement

Set the signal generators, in CW mode, to the frequencies as described in Annex A and adjust their outputs and that of the different points of the system as far as the point of measurement to obtain the specified system operating levels throughout.

Connect the variable attenuator and selective voltmeter and other items if required to the output of the equipment under test. Tune the meter to each test signal and note the attenuator value a_1 required to obtain a convenient meter reading R for the reference signal. The attenuator value a_1 should be slightly greater than the signal to intermodulation ratio expected at the point of measurement.

Tune the meter to the intermodulation product to be measured and reduce the setting of the variable attenuator to the value a_2 required to obtain the same meter reading R.

When measuring levels of intermodulation products, it can be necessary to insert a filter at the input to the meter. In such instances the insertion loss (in dB) of the filter at the frequency of the products shall be added to the attenuator value.

The signal to intermodulation product ratio in dB is given by

$$S/I = a_1 - a_2$$

where

a_1 is the attenuator value for the test signal used as a reference in dB;

a_2 is the attenuator value for the intermodulation product in dB.

4.3.4 Composite triple beat

4.3.4.1 General

The method of measurement of composite triple beat using CW signals is applicable to the measurement of the ratio of the carrier to composite triple beat at a specified point in a cable network. The method can also be used to determine the composite triple beat intermodulation performance of individual items of equipment.

When the input signals are at regularly spaced intervals (as is common in most allocations for TV channels), the various distortion products tend to cluster in groups, close to the TV channels. The number of different products in each cluster increases rapidly with the number of channels, and they combine in different ways, depending on the degree of coherence between generating signals, and the relative phases of the different distortion products.

The method described in this subclause measures the non-linear distortion of a device or system by the composite effect of all the beats clustered within ± 15 kHz of the vision carrier of a TV channel. During the measurement, the vision carrier of that channel shall be turned off, so that the composite triple beat measured is that generated by all the carriers except that of the measured channel.

The method is used to support a specification of the following general format:

"The composite triple beat ratio for groups of carriers in channel (A) at (B) dBµV is (C) dB."

where

(A) designates the channel in which the test is made. If omitted, the specification is understood to be a minimum specification for measurements at all the channels specified by the list of carriers;

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(B) is the reference level at which all the carriers should be set during the measurement, unless otherwise specified. If all the carriers are not at the same level, the specification should clearly indicate the level of each carrier relative to the reference level;

(C) is the composite triple beat ratio, usually given as a minimum specification.

Because of the large variety of frequency plans in use throughout the world and the need to compare readily performance specifications of different manufacturers' equipment, the measurement should be made with the carriers listed in Annex B (the carriers are all in an 8 MHz raster, except for the special case of 48,25 MHz).

The vision carrier frequencies are arranged in groups and only complete groups shall be used, except as stated below. If an amplifier is specified up to 450 MHz, group A shall be used. If specified up to 550 MHz, groups A and B shall be used. If specified up to 862 MHz, all groups A, B, C, D and E shall be used.

Group A can also be used in part, depending on the specified bandwidth of the equipment under test. The frequencies deleted shall be stated. If the carrier 48,25 MHz is not used in cases where the forward path starts with 85 MHz, then the results of measurements shall be published including the notice "without Band I". If the equipment can operate at all frequencies in group A, this result shall be quoted together with the result where only a part of group A is used.

For all pass bands, the performance shall be quoted for the maximum possible number of complete groups. The manufacturer may, in addition, provide a performance figure for a larger number of carriers. The frequencies deleted shall be stated.

4.3.4.2 Equipment required

The following equipment is required:

a) a spectrum analyser with 30 kHz intermediate frequency (IF) bandwidth and 10 Hz video bandwidth capability. When using a spectrum analyser with minimum video filtering capabilities greater than 10 Hz, the composite third-order distortion may be noisy and should be read at the middle of the trace;

b) a variable 75 Ω attenuator, adjustable in 1 dB steps;

c) a bandpass filter for each channel to be tested or a tunable bandpass filter. This filter shall attenuate the other channels present on the system to be tested to ensure that the products generated by non-linearity in the spectrum analyser itself do not contribute significantly to the composite beat products to be measured.

   The passband of this filter shall be flat, at least to within 1 dB over the frequency range of interest. If necessary, a fixed attenuator shall be connected at the input to the filter;

d) CW generators, operating at the frequencies of the vision carriers used in the system to be tested; the tuning accuracy and stability shall be better than ± 5 kHz. The number of generators needed is governed by the number of groups of frequencies used for the tests (see 4.3.4.1);

e) a combiner for the signals from the generators;

f) matching devices, attenuators and filters, etc., to obtain the correct signal levels, matching conditions and reduction of spurious signals at the input of the system.

4.3.4.3 Connection of equipment

The equipment shall be connected as shown in Figure 2.

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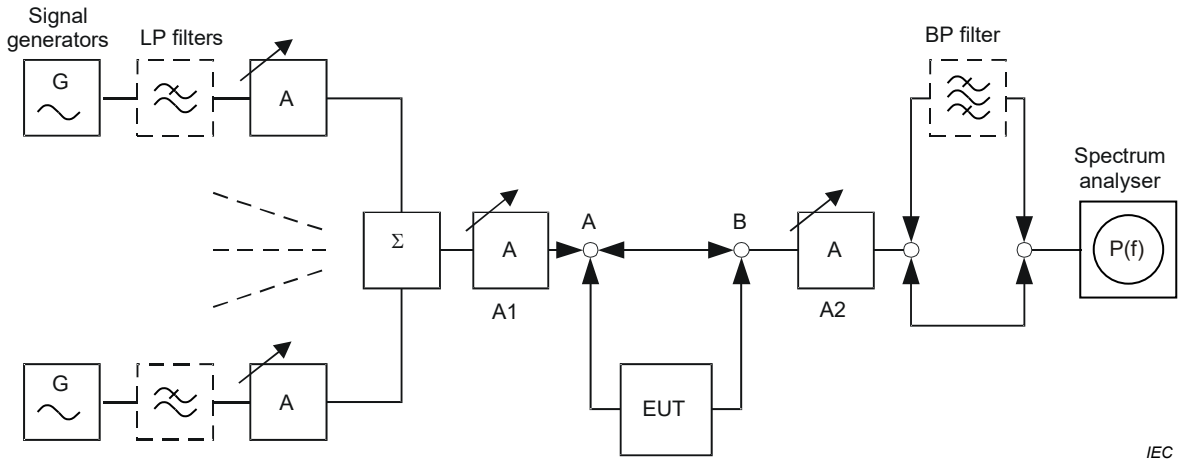

Figure 2 – Connection of test equipment for the measurement of non-linear distortion by composite beat

4.3.4.4 Measurement procedure

The measurement procedure comprises the following steps.

a) Connect point A directly to point B and disconnect the bandpass filter (see Figure 2). Adjust the level of each generator for an output level at point A equal to that which will be present when the system or equipment under test is connected.

b) Adjust the spectrum analyser as follows:

IF bandwidth	30 kHz
video bandwidth	10 Hz
scan width	50 kHz/div.
vertical scale	10 dB/div.
scan time	0,5 s/div.

c) Tune the spectrum analyser so that the vision carrier of the channel in which the measurement is to be made is centred on the display screen.

d) Adjust the sensitivity of the spectrum analyser together with its internal and external input attenuator in such a way that the response to the vision carrier corresponds to a full scale reference. At the same time, the noise level shall be at least 10 dB lower than the distortion level expected.

e) Insert the bandpass filter corresponding to the channel to be measured and adjust the input attenuator to correct for the attenuation of the filter.

f) Disconnect the generator for the channel to be measured and terminate the combiner with its nominal impedance.

g) Verify that the intermodulation products generated in the spectrum analyser over the entire channel are at least 20 dB below the distortion ratio required. If this is not the case, disconnect the bandpass filter and repeat steps d) to g) of this procedure with decreased sensitivity of the spectrum analyser.

h) Note the setting of the sensitivity control.

i) Connect the signal generator again and repeat steps c) to h) of this procedure for all channels.

j) Connect the device to be tested between points A and B and reset the signal generators to obtain the required output levels at point B.

k) Adjust the centre frequency of the spectrum analyser as in step c) and insert the appropriate bandpass filter.

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l) Adjust the input attenuator (internal or external) to return the response of the spectrum analyser to the vision carrier to full scale with the appropriate setting of its sensitivity control (see step h).

m) Disconnect the generator for the channel to be measured and terminate the combiner with its nominal impedance.

n) The composite triple beats are clustered within ± 15 kHz of the vision carrier, so the signal/composite triple beat ratio can be read directly off the screen of the spectrum analyser.

o) Adjust the attenuator A1 of Figure 2 to obtain the required signal/composite triple beat ratio and compensate for the change in output level by using attenuator A2.

p) Measure the signal level at the output of the equipment under test.

q) Repeat steps k) to p) of this procedure for every channel used in this test.

r) The worst-case maximum output level giving the required signal to composite triple beat ratio shall be noted for publication.

4.3.5 Composite second order beat

4.3.5.1 General

The test equipment required, the connection of equipment and the measurement procedure are as for the composite triple beat measurement but with the following differences.

4.3.5.2 Equipment required

The test equipment required is the same as described in 4.3.4.2.

4.3.5.3 Measurement procedure

The procedure is as for composite triple beat except that the second order beats are not clustered (± 15 kHz) about the exact carrier frequencies but may be clustered (± 10 kHz) at ± 0,75 MHz or ± 0,25 MHz from them. The carrier/composite second order distortion ratio can be read directly off the screen of the spectrum analyser.

For composite second order, it is also necessary to measure the beats close to the channel at 48,25 MHz or, where this is not possible with the equipment under test, at the lowest frequency available. Although it is not essential to have the carrier present at this frequency, it may be useful for reference purposes. In this case, the second order beats are clustered around 48,00 MHz ± 10 kHz and so again may be read directly off the screen of the spectrum analyser.

The worst-case maximum output level giving the required signal to composite second order distortion ratio shall be noted for publication.

4.3.6 Method of measurement of non-linearity for pure digital channel load

4.3.6.1 General

This method of measurement is based on the capability of an amplifier when handling a full load of DVB-C signals.

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

4.3.6.2.1 Bit error rate in the forward path

4.3.6.2.1.1 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).

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This test is able to define the performance (maximum output level) of the EUT when loaded with a high number ($N \leq 138$) of digitally modulated signals in the 256 QAM format covering a frequency range from 110 MHz to 1 214 MHz with a raster of 8 MHz, or a part of it, for example 110 MHz to 1 006 MHz or 262 MHz to 1 214 MHz.

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 Examples of these measurement channels are given in Annex A.

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

4.3.6.2.1.2 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 1 214 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 A);

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}.

4.3.6.2.1.3 Connection of equipment

Connect the measuring equipment as indicated in Figure 3. 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.

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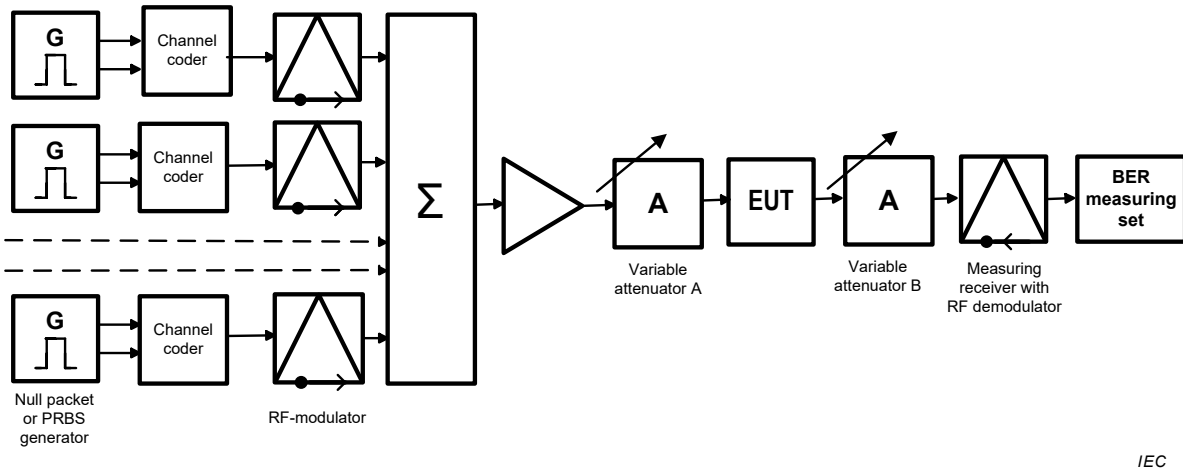

Figure 3 – BER measurement test configuration

4.3.6.2.1.4 Measurement procedure

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

a) Tune the measuring receiver to an operating channel.

b) Measure the performance of the test configuration by connecting the output of the variable attenuator A directly to the input of the variable attenuator B. Reduce 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_{Meas} 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 4.3.4 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 4.3.6.2.1.1 and the worst case (lowest value of the maximum operating output level) shall be determined.

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4.3.6.2.1.5 Presentation of the results

The worst case value of the maximum operating output level $U_{\text{max }(N)}$ of the EUT, with N channels applied and expressed in dB (μV), as defined in 4.3.6.2.1.1 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.

4.3.6.2.2 Bit error rate in the return path

4.3.6.2.2.1 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. a return path amplifier) when handling a full load of DVB-C signals.

To simplify matters, DVB-C signals are used to simulate DOCSIS signals (according to e.g. ETSI EN 302 878 series) usually used in cable networks for data transmission purposes.

The method of measurement is applicable in the return path frequency range (5 MHz to 65 MHz) as well as in the extended return path frequency ranges.

For EUT designed for the return path frequency range (5 MHz to 65 MHz), this test is able to define the performance (maximum input level) of the EUT when loaded with a number N = 6 of digitally modulated signals in the 256 QAM format covering a maximum frequency range from 11 MHz to 59 MHz for full channel load with a raster of 8 MHz.

For EUT designed for the extended return path frequency ranges, this test is able to define the performance (maximum input level) of the EUT when loaded with a number N of digitally modulated signals in the 256 QAM format. See Table 1 for detailed loading.

The maximum operating input level is defined for a limit value of the bit error ratio BER ≤ 1×10^{-9}. The measurements shall be performed using the measurement parameters as described hereinafter.

4.3.6.2.2.2 Measurement parameters for full channel load

The measurement parameters for full channel load are given in Table 1.

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Table 1 – Measurement parameters for full channel load

	Return path frequency range (5 MHz to 65 MHz)	Extended return path frequency range 1 (5 MHz to 85 MHz)	Extended return path frequency range 3 (5 MHz to 204 MHz)
Modulation format	256 QAM		
Symbol rate	6,9 MSymb/s		
Channel bandwidth	8 MHz		
Number of channels N	6	9	24
Channel raster with centre frequencies	15, 23, 31, 39, 47 and 55 MHz	15, 23, 31, 39, 47, 55, 63, 71, and 79 MHz	15, 23, 31, 39, 47, 55, 63, 71, 79, 87, 95, 103, 111, 119, 127, 135, 143, 151, 159, 167, 175, 183, 191, and 199 MHz
BER limit value	$\leq 1 \times 10^{-9}$		

The measurement channel shall be the lowest channel, a centre channel and the highest channel.

The worst-case value of $U_{\text{max }(N)}$ for the EUT out of the measured BER values at the different measurement channels shall be presented as $U_{\text{max }(N)}$.

4.3.6.2.2.3 Equipment required

The equipment required is as follows:

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;

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

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 in front of and behind the EUT;

f) a test receiver able to measure the BER of the received 256 QAM signals; the receiver's distortion performance should be sufficiently lower than that to be measured (e.g. a BER better than 1×10^{-10}).

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

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

4.3.6.2.2.4 Connection of equipment

Connect the measuring equipment as indicated in Figure 3. 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 itself.

4.3.6.2.2.5 Measurement procedure

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

a) Tune the measuring receiver to an operating channel.

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b) Measure the performance of the test configuration by connecting the output of the variable attenuator A directly to the input of the variable attenuator B. Reduce the attenuation of the variable attenuator A to 0 dB and set the variable attenuator B to a value that allows the best performance of the measuring receiver in terms of BER_{Source} (< 1×10^{-10} measured over an observation time > 10 min). Note the level of the signal applied to the measuring receiver and the BER_{Meas} value obtained.

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

d) The EUT shall be operated at nominal gain and with nominal slope. All settings (variable gain and/or slope) shall be set to zero.

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 expected maximum value. 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_{Meas} on the measuring set, which shall be ≤ 1×10^{-9} (measured over an observation time > 60 s).

g) Using the attenuator A, increase the input 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 procedures g) and h) until the BER measuring set shows a value > 1×10^{-9}. Now reduce the input 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.

i) Read the BER_{Meas} on the measuring set which once more shall be ≤ 1×10^{-9} (measured over an observation time of > 60 s).

j) Note the input level $U_{\text{max input }(N)}$ of the EUT which represents the maximum operating input level of the EUT at the measured channel.

4.3.6.2.2.6 Presentation of results

The worst-case value of the maximum operating input level $U_{\text{max input }(N)}$ of the EUT at full gain, with N channels applied and expressed in dB (µV/Hz), as defined in 4.3.6.2.2.5 j) shall be published.

For single house amplifiers the output level $U_{\text{max, output }(N)}$ can be used instead of $U_{\text{max,input }(N)}$. Such return path in-house amplifiers typically have the adjustable attenuator at the input of the return path amplifier to avoid overloading of the return path amplifier.

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

4.3.6.3 Measurement of the composite intermodulation noise ratio CINR

4.3.6.3.1 General

In addition to the measurement of the maximum operating level $U_{\text{max }(N)}$ of broadband equipment at the borderline of the bit error ratio (1×10^{-9}) according to 4.3.6.2, the carrier-to-interference noise ratio shall be determined.

4.3.6.3.2 Equipment required

Figure 4 shows the measurement test setup.

The equipment required is the following:

a) for the forward path, use the full channel loading described in 4.3.6.2.1.1; for the return path use the channel loading shown in Table 1;

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

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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 the EUT;

f) a spectrum analyser 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 4) should be inserted in front of the EUT to achieve, for the test equipment, the required CINR value > 60 dB.

Furthermore, the CINR value of the test equipment can be improved by inserting a bandpass filter at the input of the spectrum analyser (dashed box in Figure 4). In this case, the minimum attenuation of the variable attenuator B shall not go below a limit of 5 dB to ensure sufficient broadband impedance matching and appropriate return loss for correct measurement results.

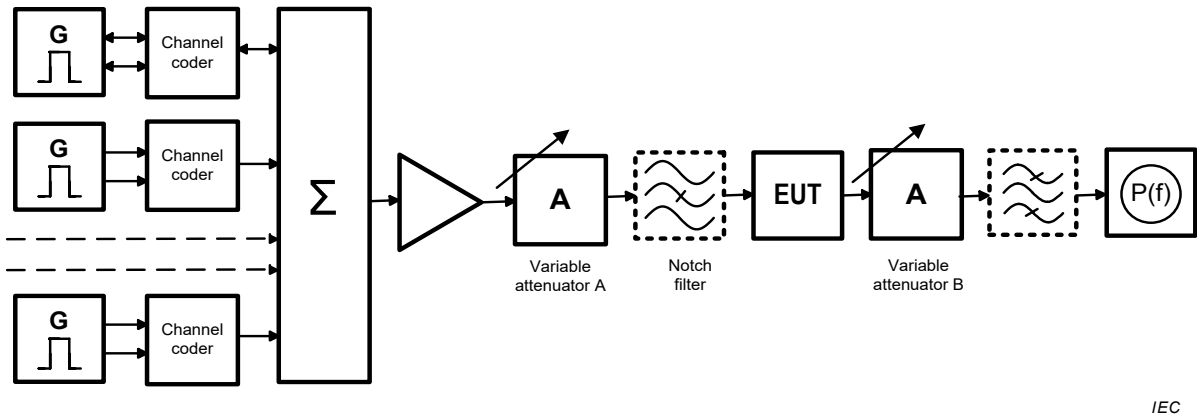

Figure 4 – CINR measurement test setup

4.3.6.3.3 Connection of the equipment

Connect the measuring equipment as indicated in Figure 4. The input signal is applied to the equipment under test (EUT) input and its output signal level is measured by means of a suitable spectrum analyser.

4.3.6.3.4 Measurement procedure

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

a) Tune the spectrum analyser to the channel to be measured in the used frequency band and measure the system level as reference. The system level is defined as the level of one of the occupied QAM channels. Switch off the channel modulator temporarily for the CINR measurement.

b) Measure the performance of the test setup 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 CINR. Note the value of CINR obtained by subtracting the measured noise signal level from the system level. This is the value $CINR_{SYS}$ (in dB) of the measuring system that shall be subtracted from the measured values, to obtain performance of the EUT.

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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 at a value at least 20 dB lower than the maximum value U_{max} according to Figure 4 for which it has been designed; set the variable attenuator B so as to obtain the previously determined optimum signal level at the input of the spectrum analyser.

f) Read the value $CINR_{MEAS}$ on the spectrum analyser.

g) Calculate the value $CINR_{EUT}$ (in dB) of the EUT by subtracting the system performance $CINR_{SYS}$ from the measured value $CINR_{MEAS}$, using the following formula:

$$CINR_{EUT} = -10\lg\left[10^{\frac{-CINR_{MEAS}}{10}} - 10^{\frac{-CINR_{SYS}}{10}}\right]$$

h) Using the attenuator A, increase the output level of all applied channels at the EUT in steps of 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; measure again the $CINR_{MEAS}$ on the measuring set and the channel output signal level of the EUT.

i) When the channel output level of the EUT approaches its upper limit, non-linear distortion appears and the CINR decreases sharply.

j) Plot a graph of the $CINR_{EUT}$ referred to the channel output signal level in dBµV for the forward path, and referred to the channel signal input level in dB(µV/Hz) for the return path. An example of the plot of $CINR_{EUT}$ versus channel output level of EUT is shown in Figure 5.

NOTE The EUT channel output signal level is obtained from the level measured with the spectrum analyser adding the attenuation due to the attenuator B and the band pass filter (if used).

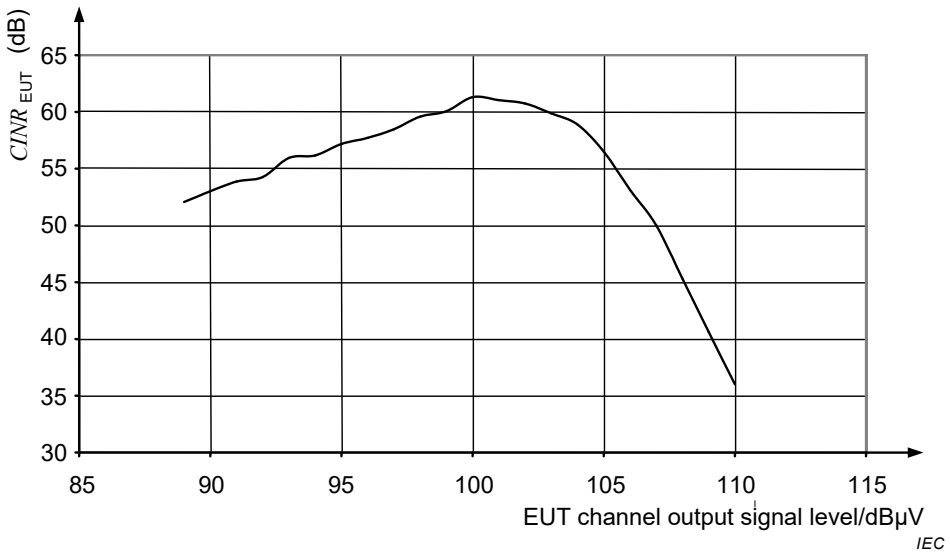

Figure 5 – Plot of CINR in dB curve (forward path) versus EUT channel output signal level in dBµV

This procedure shall be repeated for each of the three channels, as defined in 4.2.6.2.1.1.

4.3.6.3.5 Presentation of the results

The worst-case CINR curve out of the three measured CINR curves according to 4.2.6.2.1.1 shall be presented. The CINR curve for the forward path is a function of the output level in dBµV, and for the return path a function of the input level in dBµV/Hz.

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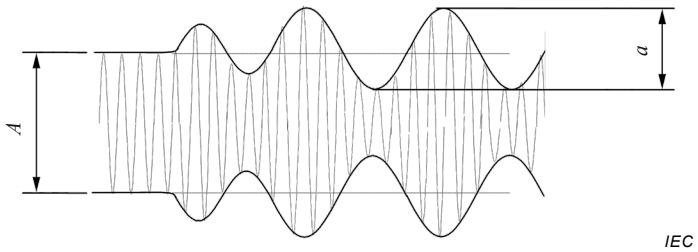
NOTE Examples of these measurement channels for the forward path are given in Annex D.

4.3.7 Hum modulation of carrier

4.3.7.1 Definition

The interference ratio for hum modulation is given by the ratio, expressed in dB, between the peak-to-peak value (A) of the unmodulated carrier and the peak-to-peak value, a, of one of the two envelopes caused by the hum modulated to this carrier (see Figure 6).



$$\text{Carrier/hum ratio} = 20 \lg \frac{A}{a} \text{ dB}$$

Figure 6 – Carrier/hum ratio

4.3.7.2 Description of the method of measurement

4.3.7.2.1 General

This method of measurement is valid for radio and TV signal equipment within a cable network that is supplied with alternating current, 50 Hz.

For measuring purposes, sinusoidal voltages from a source with sufficient low output impedance are used. Taking into account the maximum admissible voltage or the maximum admissible current, the worst value for the operating frequency range shall be published.

NOTE For cable networks, the peak value of the supply voltage or of the supply current can be higher than the value resulting from calculation using the corresponding waveform factor.

To measure the test object, an oscilloscope method is used.

4.3.7.2.2 Test equipment required

The following test equipment is required:

- adjustable voltage source;
- variable load resistor;
- power inserter;
- variable attenuator;
- oscilloscope;
- voltmeter (RMS);
- ampere meter;
- tunable RF signal generator with sufficient phase noise and hum modulation ratio, including AM capability (400 Hz);
- detector including (battery powered) LF-amplifier and 1 kHz LP-filter in the output, to suppress low frequency distortion (A HP-filter shall be used at the input).

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4.3.7.2.3 Connection of test equipment

The connection scheme for local-powered test objects is shown in Figure 7. The connection scheme for remote-powered test objects is shown in Figure 8.

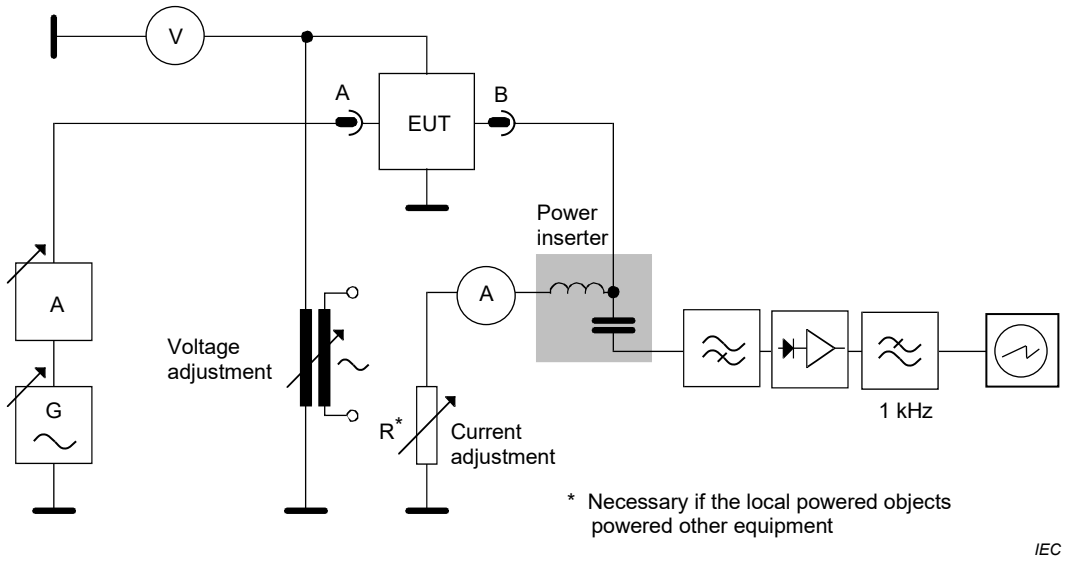

Figure 7 – Test set-up for local-powered objects

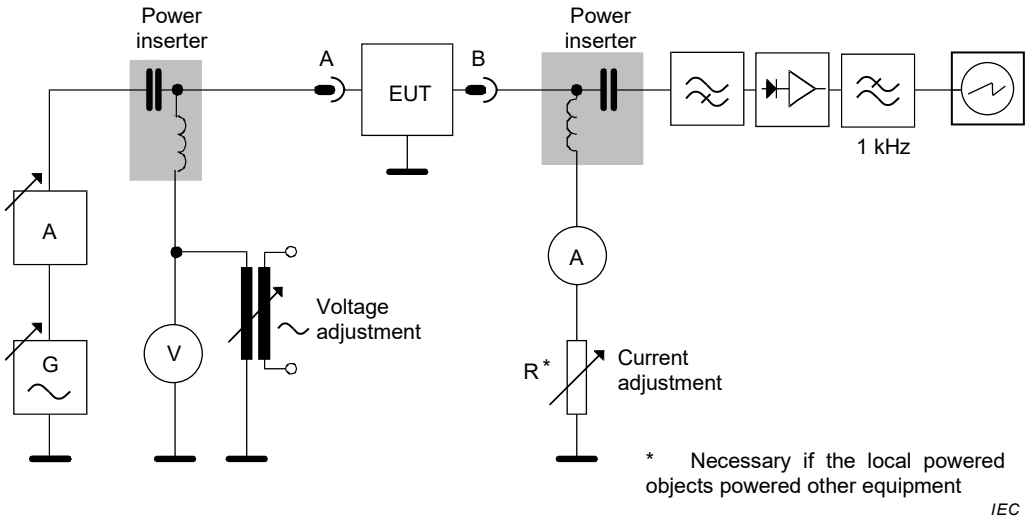

Figure 8 – Test set-up for remote-powered objects

4.3.7.3 Measuring procedure

4.3.7.3.1 Set-up of calibration

The reference signal is generated by means of the RF signal generator shown in Figure 7 and Figure 8. Select an RF carrier frequency that suits the TV channel under consideration and modulate it to a depth of 1 % at a frequency of 400 Hz. Adjust the RF signal generator to an appropriate level and read the peak-to-peak value of the demodulated AM signal (c in Figure 9) on the oscilloscope. This is the reference signal. With 1 % modulation this value is

$$-20 \lg (0{,}01) = 40 \text{ dB}$$

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The modulation of the signal generator has to be switched off. The remaining value m in Figure 9 is the value to be measured.

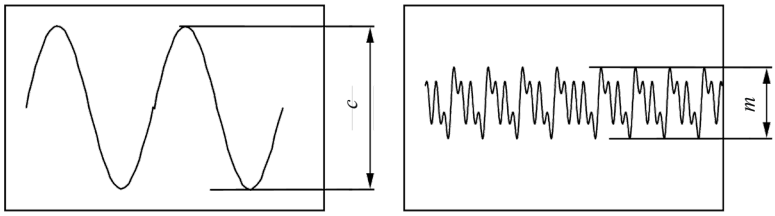

Figure 9 – Oscilloscope display

Check the suitability of the measuring set-up by connecting points A and B together and measuring the set-up's inherent hum. The calculation of the hum modulation ratio is given in 4.3.7.4. This value should be at least 10 dB better than the values to be measured for the equipment under test. For measurements with set-ups for local powered objects, use the set-up shown in Figure 7 to check. The subsequent measurements shall be carried out in suitable increments through the entire operating frequency range. The measured value is independent of the RF level, however, the RF level should be at least the magnitude of the test object's operating level.

4.3.7.3.2 Local-powered test objects

Adjust the test object to maximum or minimum operating voltage using the transformer. The supply current depends on the power requirement of the test object. Modulate the signal generator with the reference signal and adjust the level at point B by means of an attenuator so that neither the measuring object is overdriven nor the detector is within a non-admissible operating range. Note down the peak-to-peak amplitude c of the demodulated reference signal which is displayed on the oscilloscope. Then switch off the reference signal and measure the peak-to-peak value m of the remaining signal.

In addition, for test objects with remote supply terminals, adjust the maximum admissible current for the respective terminal by means of resistor R.

4.3.7.3.3 Remote-powered test objects

For remotely supplied test objects, generally proceed as described in 4.3.7.3.2. The only difference is that the supply energy is routed to the equipment via an RF terminal. In case there are several RF interfaces available for power insertion, each of these interfaces shall be included in the measurement procedure in a suitable manner.

4.3.7.4 Calculating the hum modulation ratio

4.3.7.4.1 Frequency range

The considered frequency range for the hum is from 50 Hz to 1 kHz.

4.3.7.4.2 Individual object

Hum modulation ratio $\text{Hum}_{[\text{EUT}]} = 40 + 20 \lg(c/m)$[dB] for 1 % reference modulation depth

For other chosen reference modulation depth, the value 40 dB has to be replaced by the result of the term: −20 lg(modulation depth).

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