

Cable networks for television signals, sound signals and interactive services —

Part 3: Active wideband equipment for coaxial cable networks

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ICS 33.060.40

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The UK participation in its preparation was entrusted by Technical Committee EPL/100, Audio, video and multimedia systems and equipment, to Subcommittee EPL/100/4, Cable distribution systems, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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Partie 3: Matériels actifs à large bande utilisés dans le réseaux de distribution coaxiale

Kabelnetze für Fernsehsignale, Tonsignale und interaktive Dienste
Teil 3: Aktive Breitbandgeräte für koaxiale Kabelnetze

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Foreword

This second edition of the European Standard was prepared by CENELEC Technical Committee TC 209, Cable networks for television signals, sound signals and interactive services, on the basis of EN 50083-3:1994 and the first amendment to EN 50083-3.

The text of the first amendment was approved by CENELEC on 1998-01-01 with the request to prepare a second edition of EN 50083-3, by incorporating this amendment into the European Standard EN 50083-3:1994.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1999-03-01
- latest date by which national standards conflicting with the EN have to be withdrawn (dow) 1999-12-01

Annexes designated “normative” are part of the body of the standard.

Annexes designated “informative” are given only for information.

In this standard, annexes A, B, C and D are normative, annex E is informative.

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1 Scope

1.1 General

Standards of EN 50083 series deal with cable networks for television signals, sound signals and interactive services including equipment, systems and installations

- for head-end reception, processing and distribution of television and 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.

All kinds of networks like

- CATV-networks;
- MATV-networks and SMATV-networks;
- Individual receiving networks.

and all kinds of equipment, systems and installations installed in such networks, are within this scope.

The extent of this standardization work is from the antennas, special signal source inputs to the head-end or other interface points to the network up to the system outlet or the terminal input, where no system outlet exists.

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

1.2 Specific scope of this part 3

This standard

- applies to all broad-band amplifiers used in cable networks;
- covers the frequency range 5 MHz to 3 000 MHz;
- applies to one-way and two-way equipment;
- lays down 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 that shall be published by the manufacturers;
- states the minimum performance requirements of certain parameters.

Amplifiers are divided into the following two quality levels:

Grade 1: Amplifiers typically intended to be cascaded.

Grade 2: Amplifiers for use typically within an apartment block, or within a single residence, to feed a few outlets.

Practical experience has shown these types meet most of the technical requirements necessary for supplying a minimum signal quality to the subscribers. This classification shall not be considered as a requirement but as the information for users and manufacturers on the minimum quality criteria of the material required to install networks of different sizes. The system operator has to select appropriate material to meet the minimum signal quality at the subscriber's outlet, and to optimize cost/performance, taking into account the size of the network and local circumstances.

All requirements and published data are understood as guaranteed values within the specified frequency range and in well matched conditions.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revision of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

EN 50083, *Cable networks for television signals, sound signals and interactive services*.

EN 50083-1 1993 + A1 1997, *Safety requirements*.

EN 50083-2 1995 + A1 1997, *Electromagnetic compatibility for equipment*.

EN 50083-5 1998, *Head-end equipment*.

EN 60068/HD 323 series, *Environmental testing/Basic environmental testing procedures*.

EN 60529 1991, *Degrees of protection provided by enclosures (IP Code)*.

NOTE Basic Safety Publication (IEC 529:1989).

HD 243 S12 1995, *Graphical symbols for use on equipment — Index, survey and compilation of single sheets*.

(IEC 417:1973 + IEC 417A:1974 to IEC 417M:1994)

HD 571 S1 1990, *General principles for the creation of graphical symbols for use on equipment*.
(IEC 416:1988)

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purpose of this standard, the following definitions apply.

3.1.1

equalizer

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

NOTE This device is for the compensation of linear distortions only.

3.1.2

feeder

a transmission path forming part of a cable network. 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

3.1.3

decibel ratio

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

$$10 \lg \frac{P_1}{P_2} \text{ (dB)}$$

3.1.4

standard reference power and voltage

in cable networks the standard reference power, P_0 , is 1/75 pW

NOTE This is the power dissipated in a 75 ohm resistor with a voltage drop of $1\mu\text{V}_{\text{RMS}}$ across it.

The standard reference voltage, U_0 , is $1\mu\text{V}$.

3.1.5

level

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

$$10 \lg \frac{P_1}{P_2} \text{ (dB)}$$

The level of any voltage U_1 is the decibel ratio of that voltage to the standard reference voltage U_0 , i.e.

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

This may be expressed in decibel (relative to $1\mu\text{V}$ in 75 ohm) or more simply in dB (μV) if there is no risk of ambiguity.

3.1.6

attenuation

the ratio of the input power to the output power of an equipment or system, usually expressed in decibel

3.1.7

gain

the decibel ratio of the output power to the input power

3.1.8

amplitude frequency response

the gain or loss of an equipment or system plotted against frequency

3.1.9

slope

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

3.1.10

cross modulation

the undesired modulation of the carrier of a desired signal by the modulation of another signal as a result of equipment or system non-linearities

3.1.11

carrier to noise ratio

the difference in decibel 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)

3.1.12

noise factor/noise figure

the noise factor/noise figure are used as figures of merit describing the internally generated noise of an active device

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, assuming the incoming carrier is noise free.

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

where

C_1 = signal power at the input

C_2 = signal power at the output

N_1 = noise power at the input (ideal thermal noise)

N_2 = 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

$$NF = 10 \lg F \text{ (dB)}$$

3.1.13

ideal thermal noise

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

The thermal power generated is given by:

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

where

- P = noise power in watts
 B = bandwidth in hertz
 k = Boltzmann's constant = $1,38 \times 10^{-23}$ J/K
 T = absolute temperature in kelvins

It follows that:

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

and

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

where

- U = noise voltage
 R = 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 at the input is then $U/2$.

3.1.14

chrominance/luminance delay inequality

the delay inequality in nanoseconds, between the luminance and chrominance (4,43 MHz) within a single PAL/SECAM television channel. The worst case channels shall be identified by frequency

3.1.15

well-matched

the matching condition when the return loss of the equipment complies with the requirements of Table 1

NOTE Through mismatching of measurement instruments and the measurement object measurement errors are possible. Comments to the estimation of such errors are given in annex E.

3.2 Symbols

Symbols	Terms	Symbols	Terms
	voltmeter		oscilloscope
	variable generator		detector with LF-amplifier
	device under test		adjustable AC voltage source
	ampere meter		low pass filter
	variable attenuator		high pass filter
	ground		RF choke
	capacitor		variable resistor

3.3 Abbreviations

AC	alternating current
AF	audio frequency
AM	amplitude modulation
AGC	automatic gain control
CATV	community antenna television (system)
CSO	composite second order
CTB	composite triple beat
CW	continuous wave
DUT	device under test
EMC	electromagnetic compatibility
HP	high pass
IF	intermediate frequency
IP	international protection
LF	low frequency
LP	low pass
MATV	master antenna television (system)
MTBF	meantime between failure
PAL	phase alternating line
RF	radio frequency
RMS	root mean square
RS	rotary switch
SECAM	séquentiel couleur a mémoire
SG	signal generator
SMATV	satellite master antenna television (system)
TV	television
VSWR	voltage standing wave ratio
XMOD	cross modulation

NOTE Only the abbreviations used in the English version of this part of EN 50083 are mentioned in this subclause. The German and the French versions of this part may use other abbreviations. Refer to 3.3 of each language version for details.

4 Methods of measurement

This clause defines basic methods of measurement. Any equivalent method that ensures the same accuracy may be used for assessing performance.

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

The test set-up shall be well matched over the specified frequency band.

4.1 Linear distortion

4.1.1 Return loss

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 equalizers and attenuators fitted.

4.1.1.1 Equipment required

- a) A signal generator or sweep generator, adjustable over the frequency range of the equipment to be tested.

Care must be taken to ensure that the signal generator or sweep generator output does not have a high harmonic content as this can cause serious inaccuracy.

- b) A voltage standing wave ratio bridge with built-in or separate RF detector.

The accuracy of measurement is dependent on the quality of the bridge; in particular on the directivity and on the return loss of the test port of the bridge. For example Figure 2 shows the maximum accuracy achieved by a bridge with 46 dB directivity and 26 dB return loss.

- c) An oscilloscope.
d) Calibrated mismatches.

4.1.1.2 Connection of equipment

The equipment shall be connected as in Figure 1.

4.1.1.3 Measurement procedure

NOTE 1 All coaxial input and output ports, other than those under test, shall be terminated in 75 Ω.

NOTE 2 Ensure that there is no supply voltage on the port being measured as this could damage the bridge. If it is necessary to use a voltage blocking device, use one with a good return loss (10 dB above requirement).

NOTE 3 Only good quality calibrated connectors, adaptors and cables shall be used.

The measurement procedure comprises the following steps:

- a) connect the equipment as shown in Figure 1;
b) set the signal generator output level such that the device under test is not overloaded;
c) use calibrated mismatches to calibrate the display on the oscilloscope;
d) connect the device under test as shown in Figure 1 and check the return loss over the specified frequency range.

4.1.2 Flatness

Methods of measurement are well known and a full description of the procedure is not necessary.

Measurement is commonly made with a 75 Ω scalar or vector network analyzer. Care must be taken that all equipment used (connectors, adaptors, cable etc.) are well matched.

4.1.3 Chrominance/luminance delay inequality for PAL/SECAM only

The well known 20T pulse method of measurement is used as described in EN 50083-5.

4.2 Non-linear distortion

4.2.1 General

4.2.1.1 Fundamentals

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.

The transfer function of the device can be expressed as:

$$V_{\text{out}} = a_0 + a_1 V_{\text{in}} + a_2 V_{\text{in}}^2 + a_3 V_{\text{in}}^3 + \dots a_n V_{\text{in}}^n + \dots \text{etc.}$$

If the input signal V_{in} has m sinusoidal terms, then this can be expressed as:

$$V_{\text{in}} = V_1 \sin(\omega_1 t + \phi_1) + V_2 \sin(\omega_2 t + \phi_2) + \dots V_m \sin(\omega_m t + \phi_m)$$

The output signal is then a series of terms each of which can be expressed in the general form:

$$C V_i a_n \sin(\omega_i t + \phi_i)$$

where

ω_i is the sum or difference of integral positive multiples of one or more of the input frequencies, for example:

$$4\omega_2, 2\omega_1 - \omega_3, 4\omega_1 + \omega_2, 2\omega_1 + \omega_2 + \omega_3.$$

This may be written in a general form as:

$$\omega_i = p_1 \omega_1 \pm p_2 \omega_2 \pm p_3 \omega_3 \pm \dots p_m \omega_m$$

where

ω_i = angular velocity $2\pi f_i$;

$p_1, p_2, \dots, p_m$ are positive integers (including 0);

ϕ_i is the relative phase of the output signals;

a_n is a coefficient of the transfer function;

V_i is a term dependent on the product of powers of the amplitudes of the input signals (V_1, V_2 , etc.) where the sum of the powers equals n ;

C is a numerical multiplier.

It should be noted that terms at the same frequency may arise from several different terms in the transfer function, i.e. for several different values of n .

Each component of the output signal represented by such an expression with $n > 1$ is a non-linear distortion product, where ω_i is an integral multiple of a single term in the input signal, e.g. $4\omega_2$, the product is regarded as a harmonic distortion product. If it is formed from two or more terms, e.g. $2\omega_1 - \omega_3$, it is known as an intermodulation distortion product.

Since the values of a_1, a_2, a_3 , etc., usually decrease relatively rapidly with increasing values of n , it is found that the predominant non-linear output signals arise from the terms in the transfer function in such a way that the sum $p_1 + p_2 + \dots p_m = n$, and n is defined as the order of the non-linear distortion product, e.g. $3\omega_1 - 2\omega_3$ is a fifth order product arising from the term $a_5 V_{\text{in}}^5$.

The m input signals represented in the expression are not necessarily distinct signals. Any periodic signal may be represented by a series of sinusoidal terms as in the expression for V_{in} . For the predominant non-linear output signals it is found that:

$$V_i = V_1^{P_1} \pm V_2^{P_2} \pm V_3^{P_3} \pm \dots V_m^{P_m}$$

so that if the amplitudes of all the input signals are multiplied by a common factor K , the amplitude of the n^{th} order distortion products will be multiplied by K^n (since $p_1 + p_2 + p_3 + \dots p_n = n$). When the levels of all input signals are raised by 1 dB, the level of any signal n^{th} order distortion product will increase by n dB, and the resultant signal/distortion ratio will decrease by $(n-1)$ dB. This relationship will be referred to as the "standard level variation" of a distortion product.

If a distortion product is due to components of different order, and/or different order products occur within the bandwidth of the device used to measure the level of distortion products, then the measured level will not follow a standard level variation.

In principle, an infinite number of terms is necessary for a complete description of a non-linear characteristic. However, considering the standard level variation of terms of different order, the relative contribution of higher order terms increases with the level of input signals. Conversely, if signal levels are low enough, only a few of the lowest order terms will produce significant contributions at the output.

If all input signals are limited to a frequency band of less than one octave, the frequencies of all second order terms will fall outside the band limits. Signal frequencies can also be allocated in two or more non-contiguous bands in a manner that will place all second order products outside the bands.

Third order distortion products, in particular some of the products that occur at frequencies represented by $\omega_1 \pm \omega_2 \pm \omega_3$ cannot be kept out of the band that contains the input signals. The accumulation of third order distortion products may therefore be a limiting factor in the performance of a wideband multi-channel distribution system.

4.2.1.2 Measurement

Measurements related to the following phenomena are described:

- intermodulation between two or three single frequency signals;
- composite beats produced by a number of single frequency signals;
- composite cross modulation between a number of single frequency signals.

A proper 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").

4.2.2 Intermodulation

4.2.2.1 Introduction

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.

NOTE 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 will be needed. This is covered in 4.2.3 and 4.2.4.

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 A.1).

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

NOTE 2 If the unequal carrier method of measurement, as described in EN 50083-5, is used, the output level giving the appropriate signal to distortion ratio must be decreased by 6 dB to obtain the correct result for the equal carrier method described here.

4.2.2.2 Equipment required

- a) a selective voltmeter covering the frequency range of the equipment or system to be tested. This may be a spectrum analyzer;
- 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 4.2.2.2a);
- d) a combiner will be required for tests on equipment and systems with a single input (Figure 3).

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

4.2.2.3 Connection of equipment

The equipment shall be connected as shown in Figure 3.