100/2555/FDIS

FINAL DRAFT INTERNATIONAL STANDARD
PROJET FINAL DE NORME INTERNATIONALE

	Project number / Numéro de projet	**IEC 60728-5 Ed 3.0**
	IEC/TC or SC CEI/CE ou SC **100/TA 5**	Secretariat / Secrétariat **Finland**
☒ Submitted for parallel voting in CENELEC Soumis au vote parallèle au CENELEC	Distributed on / Diffusé le **2015-08-28**	Voting terminates on / Vote clos le **2015-10-30**
Also of interest to the following committees Intéresse également les comités suivants	Supersedes document Remplace le document 100/2314/CDV, 100/2420/RVC	

Horizontal standard
Norme horizontale

☐ Other TC/SCs are requested to indicate their interest, if any, in this FDIS to the TC/SC secretary
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Titre

IEC 60728-5 Ed 3.0: Réseaux de distribution par câbles pour signaux de télévision, signaux de radiodiffusion sonore et services interactifs – Partie 5: matériels de tête de réseau

Title

IEC 60728-5 Ed 3.0: Cable networks for television signals, sound signals and interactive services – Part 5: Headend equipment

ATTENTION VOTE PARALLÈLE IEC – CENELEC	ATTENTION IEC – CENELEC PARALLEL VOTING
L'attention des Comités nationaux de la CEI, membres du CENELEC, est attirée sur le fait que ce projet de comité pour vote (CDV) de Norme internationale est soumis au vote parallèle. Un bulletin de vote séparé pour le vote CENELEC leur sera envoyé par le Secrétariat Central du CENELEC.	The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) for an International Standard is submitted for parallel voting. A separate form for CENELEC voting will be sent to them by the CENELEC Central Secretariat.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 5: Headend equipment

FOREWORD

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International Standard IEC 60728-5 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 third edition cancels and replaces the second edition published in 2007. This edition constitutes a technical revision.

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

- new text for the introduction, following the scope of IEC TC 100/TA 5;
- introduction of IPTV to the scope;
- headend specification for digital terrestrial TV signals according to the DVB-T2 standard;

- headend specification for digital TV signals in cable networks according to the DVB-S2 standard.

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

FDIS	Report on voting
100/XX/FDIS	100/XX/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 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.

For special national conditions existing in some countries, see Annex D.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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.

The National Committees are requested to note that for this publication the stability date is 2018.

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

INTRODUCTION

The IEC 60728 series deals 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 networks or systems,
- individual satellite and terrestrial television receiving networks or 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.

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

Part 5: Headend equipment

1 Scope

This part of IEC 60728 specifies the characteristics of equipment used in the headends of terrestrial broadcast and satellite receiving systems (without satellite outdoor units and without those broadband amplifiers in the headend as described in IEC 60728-3). The satellite outdoor units for fixed satellite systems (FSS) are described in ETSI ETS 300 158, and for broadcast satellite systems (BSS) in ETSI ETS 300 249. Test methods for both types (FSS and BSS) of satellite outdoor units are laid down in ETSI ETS 300 457.

This part of IEC 60728

a) covers the frequency range 5 MHz to 3 000 MHz;
b) identifies performance requirements for certain parameters;
c) lays down data publication requirements for certain parameters;
d) stipulates methods of measurements;
e) introduces minimum requirements defining quality grades (Q-grades).

This part of IEC 60728 specifies the overall characteristics for upstream/downstream signals between external sources/sinks (for example, antennas, cable modem termination systems, etc.) and the system interface to the cable network. In the case of modular headend systems, single equipment items such as modulators, converters, etc. are also described. Cable modem termination systems, encrypters, decrypters, etc. are not described in this part of IEC 60728. If such equipment is used in headends, the relevant parameters for RF, video, audio and data interfaces should be met.

According to the definitions in 3.1, the headends are divided into the following three quality grades:

- Grade 1: central headend;
- Grade 2: hub headend or hubsite;
- Grade 3: MATV headend/individual reception headend.

Figure 1 shows the block diagram of a headend consisting of typical processing units with the corresponding interfaces at the input and output.

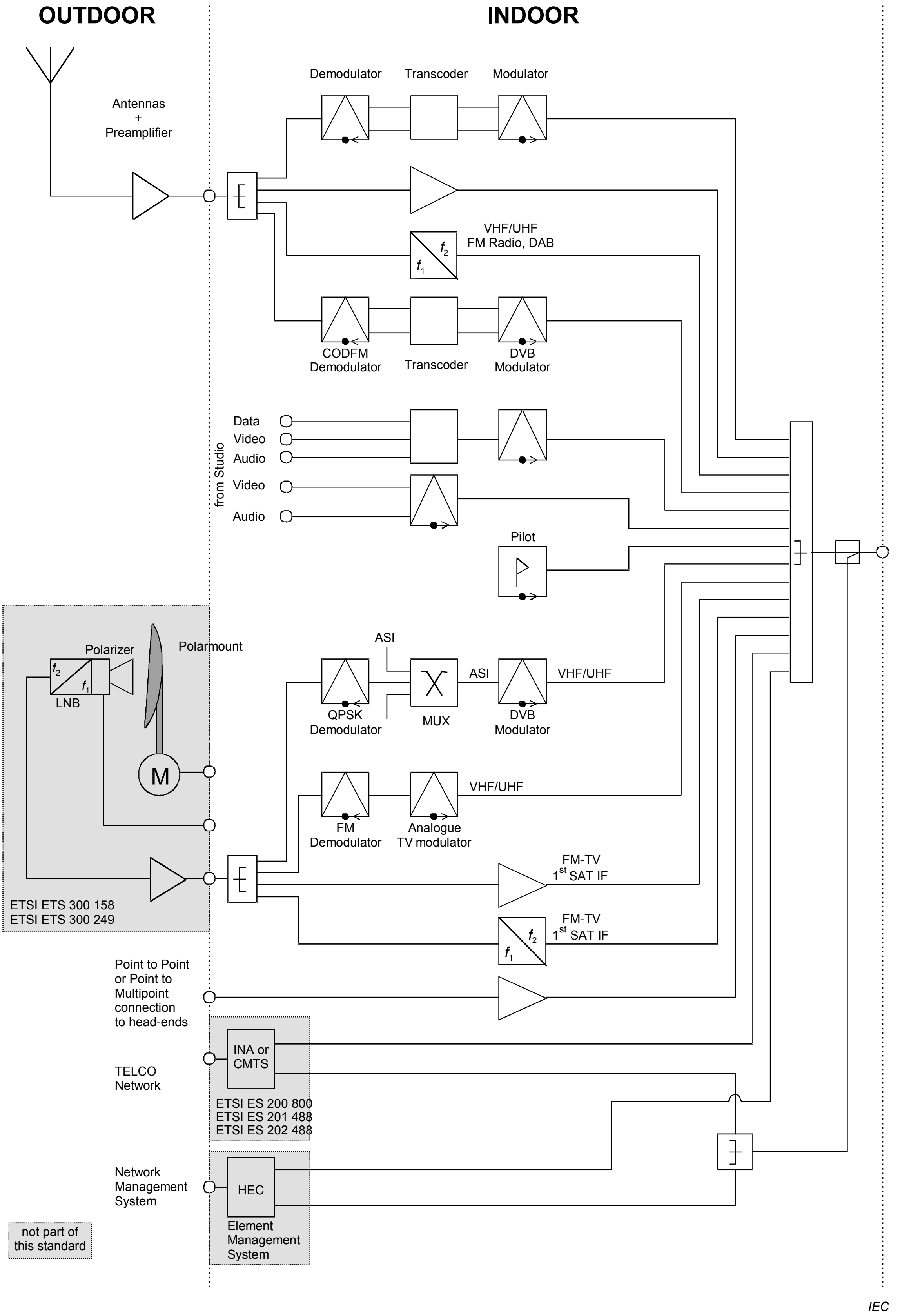


Figure 1 – Example of headend

For IP interfaces, specifications from the transmission standard ETSI TS 102 034 are taken into account where applicable. The content of the data streams can be digital video, audio or other digital data.

The necessary characteristics and parameters of equipment such as IP gateways or IP interfaces on equipment at the input of headends (Figure 2) as well as at the output of headends (Figure 3) are described in CLC/TR 50083-5-1.

Equipment at the input of headends can be either IP gateways which enable the connection to a Digital Video Broadcasting-Asynchronous Serial Interface (DVB-ASI) headend infrastructure according to EN 50083-9 or, in the case of modular headend systems, can also be single equipment with IP interfaces such as DVB modulators, transcoders, multiplexers and FM radio processors as shown in Figure 2. Edge devices are also covered by CLC/TR 50083-5-1.

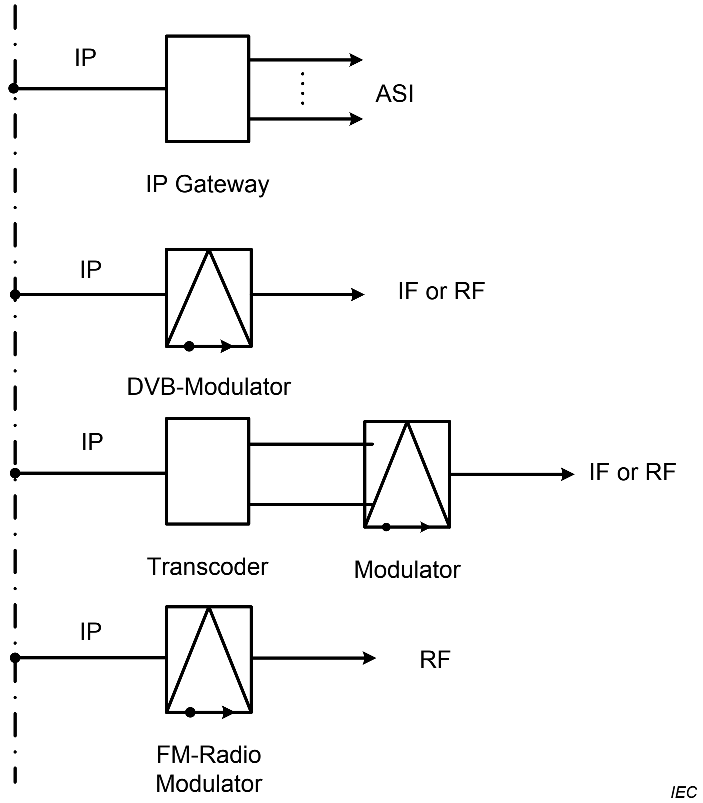


Figure 2 – Examples of IP gateways/interfaces at the input of headends

Equipment at the output of headends can be either IP gateways which enable the connection from DVB-ASI interfaces according to EN 50083-9 to IP based networks or, in the case of modular headend systems, can also be single equipment with IP interfaces such as encoders, multiplexers and switches as shown in Figure 3.

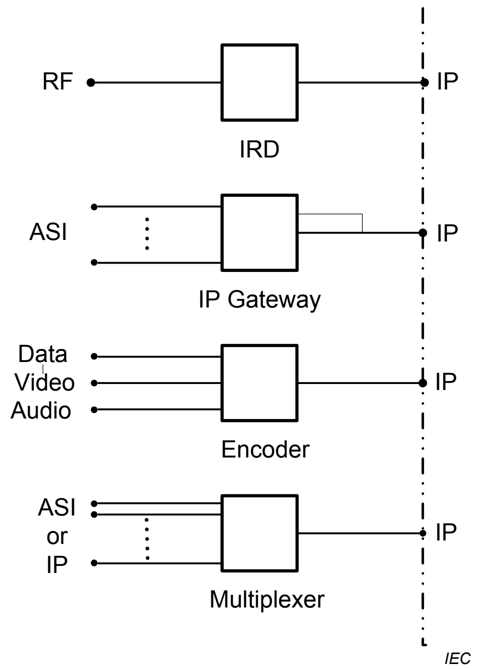


Figure 3 – Examples of IP gateways and interfaces at the output of central headends

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

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

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*

IEC 60244-5, *Methods of measurement for radio transmitters – Part 5: Performance characteristics of television transmitters*

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

IEC 60728-1, *Cable networks for television signals, sound signals and interactive services – Part 1: System performance of forward paths*

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

IEC 60728-3:2010, *Cable networks for television signals, sound signals and interactive services – Part 3: Active wideband equipment for cable networks*

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

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

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

ISO/IEC 13818-2, *Information technology – Generic coding of moving pictures and associated audio information – Part 2: Video*

ISO/IEC 13818-3, *Information technology – Generic coding of moving pictures and associated audio information – Part 3: Audio*

ISO/IEC 13818-4, *Information technology – Generic coding of moving pictures and associated audio information – Part 4: Conformance testing*

ITU-R Recommendation BS.468-4, *Measurement of audio-frequency noise voltage level in sound broadcasting*

ITU-R Report BT.624-4, *Characteristics of television systems*

ITU-T Recommendation J.61, *Transmission performance of television circuits designed for use in international connections*

ITU-T Recommendation J.101, *Measurement methods and test procedures for teletext signals*

ETSI EN 300 421, *Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for 11/12 GHz satellite services*

ETSI EN 300 429, *Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems*

ETSI EN 300 468, *Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems*

ETSI EN 300 473, *Digital Video Broadcasting (DVB); Satellite Master Antenna Television (SMATV) distribution systems*

ETSI EN 300 744, *Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television*

ETSI EN 302 307, *Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2)*

ETSI EN 302 755, *Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)*

ETSI ETS 300 163, *Television systems; NICAM 728: Specification for transmission of two-channel digital sound with terrestrial television systems B, G, H, I and L*

ETSI TR 101 211, *Digital Video Broadcasting (DVB); Guidelines on implementation and usage of Service Information (SI)*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

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

NOTE Terms and definitions defined in IEC 60050 (IEC 60050-312, IEC 60050-702, IEC 60050-713, IEC 60050-723) are used as far as possible.

3.1.1
amplitude-frequency response
gain or losses 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 a system

Note 1 to entry: Attenuation is usually expressed in decibels.

3.1.3
automatic gain control
AGC
automatic control of an equipment to maintain the level of the signal at its output constant, using the signal to be controlled as the control stimulus

Note 1 to entry: This note applies to the French language only.

3.1.4
back-off
nominal difference between the lower level and a higher reference level

3.1.5
carrier-to-intermodulation ratio
C/I
difference in decibels between the carrier level at a specified point in a system or in an equipment and the level of a specified intermodulation product or combination of products

Note 1 to entry: This note applies to the French language only.

3.1.6
carrier-to-noise ratio
C/N
difference in decibels between the vision or sound carrier level at a given point in the system and the noise level at that point (measured within a bandwidth appropriate to the television or radio system in use)

3.1.7
central headend
headend from which signals are delivered to a local headend via a long-distance terrestrial link

3.1.8
frequency converter
equipment for changing the carrier frequency of one or more signals

3.1.9
extended satellite television distribution network or system
distribution network or system designed to provide sound and television signals received by a satellite receiving antenna to households in one or more buildings

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

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

3.1.10
extended terrestrial television distribution network or system
distribution network or system designed to provide sound and television signals received by a terrestrial receiving antenna to households in one or more buildings

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

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

3.1.11
gain
ratio of the output power to the input power of any equipment or system

Note 1 to entry: Gain is usually expressed in decibels.

3.1.12
grade
classification of performance for equipment for use in cable networks

Note 1 to entry: The choice of the appropriate grade depends on, for example,

– size of network,
– structure of network,
– lengths of cable between equipment,
– kind of services,
– kind of signals.

Note 2 to entry: The essential requirement is that the system performance specification is fulfilled by the design of the network and choice of the grade of equipment used.

3.1.13
headend
equipment, which is connected between receiving antennas or other signal sources and the remainder of the cable network, for processing the signals to be distributed

Note 1 to entry: The headend may, for example, comprise antenna amplifiers, frequency converters, combiners, separators and generators.

3.1.14
headend for individual reception
headend supplying an individual household

Note 1 to entry: This type of installation may include one or more system outlets.

3.1.15
hub headend
hubsite
headend used to feed the entire operating network in the service area (local distribution) via multiple optical or RF trunks

Note 1 to entry: This note applies to the French language only.

Note 2 to entry: The hubsite has no local signal acquisition.

3.1.16
individual satellite television receiving system
system designed to provide sound and television signals received from satellite(s) to an individual household

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

3.1.17
individual terrestrial television receiving system
system designed to provide sound and television signals received via terrestrial broadcast networks to an individual household

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

3.1.18
intermodulation
process whereby the non-linearity of equipment in a system produces spurious output signals (called intermodulation products) at frequencies which are linear combinations of those of the input signals

3.1.19
level
<power> decibel ratio of any power P_1 to the standard reference power P_0:

$$10\ \lg \frac{P_1}{P_0} \tag{1}$$

3.1.20
level
<voltage> decibel ratio of any voltage U_1 to the standard reference voltage U_0:

$$20\ \lg \frac{U_1}{U_0} \tag{2}$$

3.1.21
local broadband cable network
network designed to provide sound and television signals as well as signals for interactive services to a local area

Note 1 to entry: This may be expressed in decibels (relative to 1 μV in 75 Ω) or more simply in dB(μV) if there is no risk of ambiguity.

Note 2 to entry: A local area can be, for example, one town or one village.

3.1.22
local headend
headend having stand-alone signal acquisition or fed from a central headend

Note 1 to entry: Distribution to hubsites is realized via optical or RF trunks and possibly some local area distributions.

3.1.23
MATV headend
headend used in blocks of flats and in built-up sites to feed TV channels and FM radio channels into the house network or the spur network

Note 1 to entry: This note applies to the French language only.

3.1.24
modulation error ratio
MER
sum of the squares of the magnitudes of the ideal symbol vectors divided by the sum of the squares of the magnitudes of the symbol error vectors of a sequence of symbols:

$$\mathrm{MER} = 10\ \lg \left\{ \frac{\sum_{j=1}^{N} \left(I_j^2 + Q_j^2 \right)}{\sum_{j=1}^{N} \left(\delta I_j^2 + \delta Q_j^2 \right)} \right\} \ [\mathrm{dB}] \qquad (3)$$

Note 1 to entry: The result is expressed as a power ratio in decibels. MER is used to quantify the performance of a digital radio transmitter or receiver in a communications system.

3.1.25
MPEG-2
generic coding method for moving pictures and associated audio information as defined in the ISO/IEC 13818 series

Note 1 to entry: System coding is defined in ISO/IEC 13818-1, video coding in ISO/IEC 13818-2, and audio coding in ISO/IEC 13818-3.

Note 2 to entry: This note applies to the French language only.

3.1.26
multiplex
stream of all the digital data carrying one or more services within a single physical channel

3.1.27
phase noise
phase instability of random nature

Note 1 to entry: The sources of random sideband noise in an oscillator are thermal noise, flicker noise and shot noise.

Note 2 to entry: Each time the signal is frequency processed, this signal is degraded by an addition of phase noise due to phase noise of the local oscillator. Frequency converters or modulators generate phase noise.

3.1.28
regional broadband cable network
network designed to provide sound and television signals as well as signals for interactive services to a regional area covering several towns and/or villages

3.1.29
satellite master antenna television system
SMATV
system which is designed to provide sound and television signals to the households of a building or group of buildings

Note 1 to entry: Two system configurations are defined in ETSI EN 300 473 as follows:

- SMATV system A, based on transparent transmodulation of QPSK satellite signals into QAM signals to be distributed to the user;
- SMATV system B, based on direct distribution of QPSK signals to the user, with two options:
  - SMATV-IF distribution in the satellite IF band (above 950 MHz);
  - SMATV-S distribution in the VHF/UHF band, for example in the extended S-band (230 MHz to 470 MHz).

Note 2 to entry: This note applies to the French language only.

Note 3 to entry: This note applies to the French language only.

Note 4 to entry: This note applies to the French language only.

Note 5 to entry: This note applies to the French language only.

Note 6 to entry: This note applies to the French language only.

Note 7 to entry: This note applies to the French language only.

3.1.30
$\boldsymbol{S_{\mathrm{D,RF}}/N}$
signal-to-noise ratio for a digitally modulated signal intended in the RF band

3.1.31
shoulder attenuation
ratio between signal and spectrum re-growth outside the channel

3.1.32
standard reference power and voltage
in cable networks, 1/75 pW

Note 1 to entry: This is the power dissipated in a 75 Ω resistor with an rms voltage drop of 1 μV across it.

Note 2 to entry: The standard reference voltage U_0 is 1 μV.

3.1.33
transport stream
TS
data structure defined in ISO/IEC 13818-1 which is the basis of the digital video broadcasting (DVB) related standards

Note 1 to entry: This note applies to the French language only.

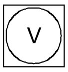
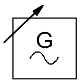
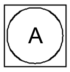
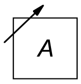
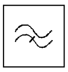
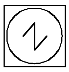
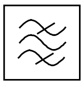
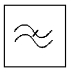
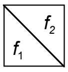
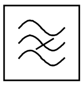
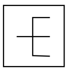
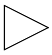
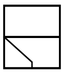
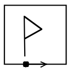
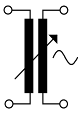
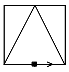
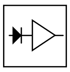
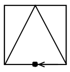
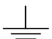
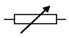
3.1.34
well-matched
matching condition when the return loss of the equipment complies with the requirements of Table 3 of IEC 60728-3:2010

Note 1 to entry: Through mismatching of measurement instruments and the measured equipment, measurement errors are possible. Comments on the estimation of such errors are given in Annex H.

3.2 Symbols

The following graphical symbols are used in the figures of this part of IEC 60728. These symbols are either listed in IEC 60617 or based on symbols defined in IEC 60617.

NOTE Numbers in brackets ([ ]) refer to symbols in IEC 60617.

Symbol	Term	Symbol	Term
	voltmeter [IEC 60617-S00059(2001:07)] [IEC 60617-S00913(2001:07)]		spectrum analyser [IEC 60617-S00059(2001:07)] [IEC 60617-S00910(2001:07)]
	variable generator [IEC 60617-S00081(2001:07)] [IEC 60617-S01225(2001:07)] [IEC 60617-S01403(2001:09)]		ampere meter [IEC 60617-S00059(2001:07)] [IEC 60617-S00910(2001:07)]
	equipment under test [IEC 60617-S00059(2001:07)]		variable attenuator [IEC 60617-S01245(2001:07)]
	high pass filter [IEC 60617-S01247(2001:07)]		oscilloscope [IEC 60617-S00059(2001:07)] [IEC 60617-S00922(2001:07)]
	band pass filter [IEC 60617-S01249(2001:07)]		low pass filter [IEC 60617-S01248(2001:07)]
	frequency converter [IEC 60617-S00213(2001:07)]		band stop filter [IEC 60617-S01250(2001:07)]
	splitter		amplifier [IEC 60617-S01239(2001:07)]
	tap		pilot generator
	adjustable AC voltage source		modulator [IEC 60617-S01278(2001:07)]
	detector with LF-amplifier [IEC 60617-S00641(2001:07)] [IEC 60617-S01239(2001:07)]		demodulator [IEC 60617-S01278(2001:07)]
	ground [IEC 60617-S00200(2001:07)]		variable resistor [IEC 60617-S00557(2001:07)]

3.3 Abbreviations

AC	alternating current
AF	audio frequency
AFC	automatic frequency control
AGC	automatic gain control
ALC	automatic level control
AM	amplitude modulation
BER	bit error ratio
BSS	broadcast satellite services
BW	bandwidth
C/*N*	carrier to noise (ratio)
CATV	community antenna television (system)
CH	channel
CPE	common phase error
CW	continuous wave
DAB	Digital Audio Broadcasting
DPH_{pp}	differential phase (peak-to-peak)

DVB	Digital Video Broadcasting
DVB-C	Digital Video Broadcasting, Cable
DVB-C2	Digital Video Broadcasting, Cable, second generation
DVB-S	Digital Video Broadcasting, Satellite
DVB-S2	Digital Video Broadcasting, Satellite, second generation
DVB-T	Digital Video Broadcasting, Terrestrial
DVB-T2	Digital Video Broadcasting, Terrestrial, second generation
EMC	electromagnetic compatibility
EUT	equipment under test
FM	frequency modulation
FSS	fixed satellite services
HP	high pass
ICI	inter-carrier interference
IF	intermediate frequency
IP class	international protection class
ITS	insertion test signal
LF	low frequency
LNB	low noise block converter
LP	low pass
LUM_{NL}	luminance non-linearity
MATV	master antenna television (system)
MER	modulation error ratio
MMDS	microwave multichannel distribution systems
MPEG	motion picture experts group
MVDS	multichannel video distribution system
NF	noise figure
NICAM	near-instantaneously companied audio multiplex
OFDM	orthogonal frequency division multiplexing
PAL	phase alternating line
PSK	phase shift keying
QAM	quadrature amplitude modulation
Q grade(s)	quality grade(s)
QPSK	quaternary phase shift keying
RF	radio frequency
rms	root mean square
RSBW	resolution bandwidth
S/*N*	signal to noise (ratio)
SAT IF	(1st) satellite intermediate frequency
SECAM	séquentiel couleur à mémoire (sequential colour with memory)
SMATV	satellite master antenna television (system)
TS	transport stream
T-STD	transport stream system target decoder
TV	television

TVRO television receive only (system)

VCO voltage-controlled oscillator

VHF very high frequency

VSB IF vestigial sideband intermediate frequency

4 Methods of measurement

4.1 Methods of measurement for digitally modulated signals

4.1.1 General

The methods of measurement for digitally modulated signals differ from those for analogue modulation for several reasons.

a) The carrier is not present in the modulated signal and therefore cannot be measured (i.e. DVB systems using PSK or QAM modulation) or there are thousands of carriers (i.e. DVB systems using OFDM modulation).

b) The modulated signal has a spectrum that is flat in the bandwidth and is similar to noise.

c) The parameters that affect the quality of the received signal are related to the bit and word errors introduced by the channel (noise, amplitude and phase response inequalities, echoes, etc.) before demodulation and error correction.

4.1.2 Basic assumptions and measurement interfaces

The methods of measurement for digitally modulated signals are based on the following assumptions.

a) The MPEG-2 TS is the specified input and output signal for all the baseline systems, i.e. for satellite, cable, SMATV, MMDS/MVDS and terrestrial distribution; as an alternative the MPEG-4 TS can be used as input and output signal for the baseline systems satellite, cable, and SMATV.

b) The digitally modulated signals received by satellite are modulated in the PSK format, i.e. according to ETSI EN 300 421 and ETSI EN 302 307 for the QPSK format, or according to ETSI EN 302 307 for the 8PSK and APSK formats, and can be distributed in the same format in cable systems (SMATV systems).

c) The digitally modulated signals received by satellite are distributed in CATV systems in the QAM format, i.e. according to ETSI EN 300 429.

d) The digitally modulated signals received from terrestrial broadcasting in the OFDM format are distributed in SMATV/CATV systems in the same OFDM format; sometimes it is more efficient in terms of frequency economy to convert the signal to DVB-C as described in ETSI EN 300 429.

e) An I/Q baseband signal source for PSK, QAM or OFDM formats is available, as described in IEC 60728-1. Appropriate interfaces are accessible and are consistent with the DVB-SI documents (see ETSI TR 101 211 and ETSI EN 300 468).

f) A reference receiver for PSK, QAM or OFDM formats is available (for details, see IEC 60728-1), where appropriate interfaces are indicated.

g) The decoder implementation will not affect the consistency of the results. The MPEG-2 T-STD model constraints, as defined in ISO/IEC 13818-1 (MPEG-2 system), shall be satisfied as specified in ISO/IEC 13818-4 (MPEG-2 compliance testing).

4.1.3 Signal level for digitally modulated signals

4.1.3.1 General

This measurement method applies to the measurement of the level of digitally modulated signals using QPSK (ETSI EN 300 421 and ETSI EN 302 307), 8PSK or APSK

(ETSI EN 302 307), QAM (ETSI EN 300 429 and ETSI EN 300 473), and OFDM (ETSI EN 300 744 and ETSI EN 302 755) formats.

Because the modulated signal is similar in characteristics to white noise, the measurement is based on the use of a suitable spectrum analyser, able to tune the frequency range of the channel and to display the whole bandwidth, to measure spectral power density. The result may be expressed as dB(mW/Hz). The signal level in dB(mW) or in dB(μV) can be calculated if the bandwidth is known.

4.1.3.2 Equipment required

The equipment required is a spectrum analyser having a known noise bandwidth and a calibrated display of the tuned signal. The calibration accuracy should preferably be ±0,5 dB and shall be stated with the results.

The equipment shall be able to tune over the nominal frequency range of the system.

4.1.3.3 Connection of the equipment

Connect the measuring equipment to the headend output, using a suitable cable and connectors, taking care to maintain correct impedance matching.

4.1.3.4 Measurement procedure

The measurement procedure is as follows.

a) When signal levels are to be measured where a high ambient field is present, the measuring equipment shall be checked for spurious readings. Connect a shielded termination to its input cable, place both the meter and the lead approximately in their measuring positions and check that there is a negligible reading at the frequency or frequencies and on the meter ranges to be used.

b) Tune the channel to be measured (selecting the centre frequency of the spectrum analyser) and select the span and level settings to show the whole channel whose bandwidth depends on the type of modulation used (see Annex F).

c) Set the *RSBW* of the spectrum analyser to 100 kHz and set the video bandwidth low enough to obtain a smooth display (100 Hz if available).

d) Measure the level *S* of the flat top of the displayed signal in dB(μV) or in dB(mW), using the display line cursor if this feature is available.

e) If the spectrum of the signal does not have a flat top, due to echoes, measure the signal level at the centre frequency of the channel.

f) Measure on the displayed channel the upper and lower frequencies at the channel edges where the level is 3 dB lower than the maximum level *S*; the difference between these two frequencies is assumed to be the equivalent signal bandwidth *BW*, expressed in Hz.

g) Calculate the level $S_{\mathrm{D,RF}}$ of the signal using the following formula:

$$S_{\mathrm{D,RF}} = S + 10\ \lg\left[\frac{BW}{RSBW}\right] + K_{\mathrm{sa}} \qquad (4)$$

where

$S_{\mathrm{D,RF}}$ is the signal level for a digitally modulated signal;

S is the displayed signal level (flat top);

BW is the signal bandwidth;

$RSBW$ is the resolution bandwidth of the spectrum analyser;

K_{sa} is the correction factor.

The correction factor K_{sa} depends on the measuring equipment used and shall be provided by the manufacturer of the measuring equipment or obtained by calibration. The value of the correction factor for a typical spectrum analyser is about 1,7 dB (see also Annex I).

The correction factor is not necessary if the measuring equipment can be set to display the level in dB(mW/Hz). In this case, the level $S_{D,RF}$ of the signal can be obtained from the measured maximum level S using the following formula:

$$S_{D,RF} = S + 10\,\lg(BW) \tag{5}$$

where

$S_{D,RF}$ is the signal level for a digitally modulated signal;

S is the displayed maximum signal level;

BW is the signal bandwidth (in Hz).

In this formula, the bandwidth BW shall be expressed in hertz.

This measurement method actually measures the $S + N$ level. The contribution of noise (N) is considered negligible if the level of noise displayed outside the channel band is at least 15 dB lower than the maximum level displayed within the channel band. This noise level includes that of the measuring equipment (spectrum analyser), which is assumed to be at least 10 dB lower than the noise level displayed outside the channel band in order not to affect the results. Otherwise, the contribution of noise (due to the system or the equipment under test and to the measuring equipment) needs to be taken into account in the measurement of signal level S (see Annex F).

4.1.3.5 Presentation of the results

The measured level is expressed in dB(μV) or dB(mW) with reference to the BW and referred to 75 Ω or in dB(mW/Hz). The accuracy of the measuring equipment shall be stated with the results.

4.2 Single-channel intermodulation specification for channel amplifier and frequency converter

Frequencies and levels of test carriers, as shown in Figure 4, simulate a colour television transmission where f_a, f_b and f_c correspond to vision carrier, colour subcarrier and sound carrier, respectively. The most significant intermodulation products are:

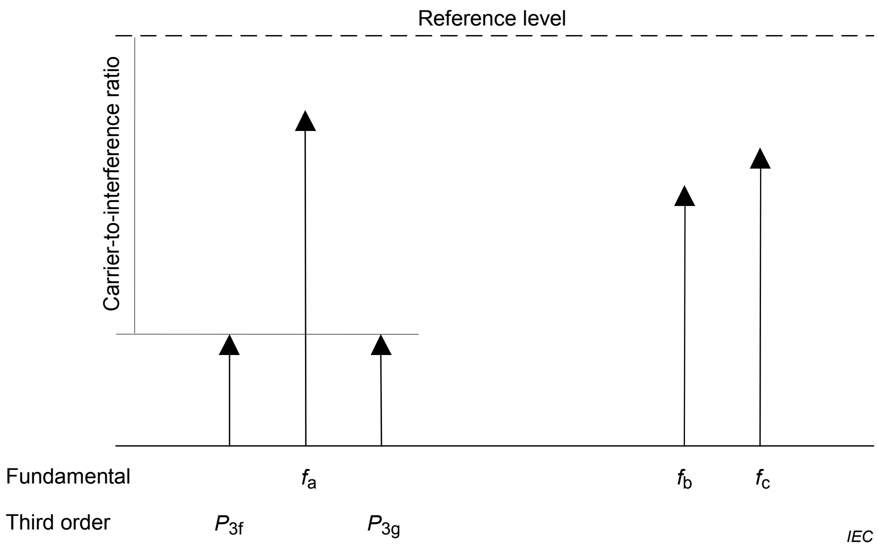
$$P_{3f} = f_a + f_b + f_c \tag{6}$$

$$P_{3g} = f_a + f_c - f_b \tag{7}$$

The carrier levels for different television systems are given in Table 1.

Table 1 – Test signal levels for the different television standards in decibels relative to reference level

Test signal		Relative signal level dB	
		System	
		B, G, H, I, D, D1, K	L
Vision carrier	f_a	−8	0
Colour subcarrier	f_b	−17	0
Sound carrier	f_c	−10	0



Levels of measuring signals are to be adjusted as in Table 1.

Figure 4 – Frequencies and levels of test carriers

4.3 Three-carrier intermodulation measurement

The specifications for the measurement of three-carrier intermodulation apply to sub-band, full-band and multi-band amplifiers or multi-channel frequency converters.

In television band amplifiers, the simultaneous transmission of multi-channel programming may cause mutual interference between vision carriers through cross-modulation. The carrier-to-cross-modulation distortion ratio is defined as the difference between the level of a given test carrier and the level of the-cross modulation products produced by interfering signals and falling near that test carrier.

This method of measurement is used to simulate transfer of modulation between two television signals. The test carrier having the frequency f_a is an unmodulated wanted signal, while the carriers having the frequencies f_b and f_c represent the sidebands of a 100 % AM interfering signal (see Table 2 and Figure 5).

Table 2 – Test signal levels in decibels relative to reference level

Test signal		Relative signal level dB
Test frequency	f_a	0
Interfering frequency	f_b	–6
Interfering frequency	f_c	–6

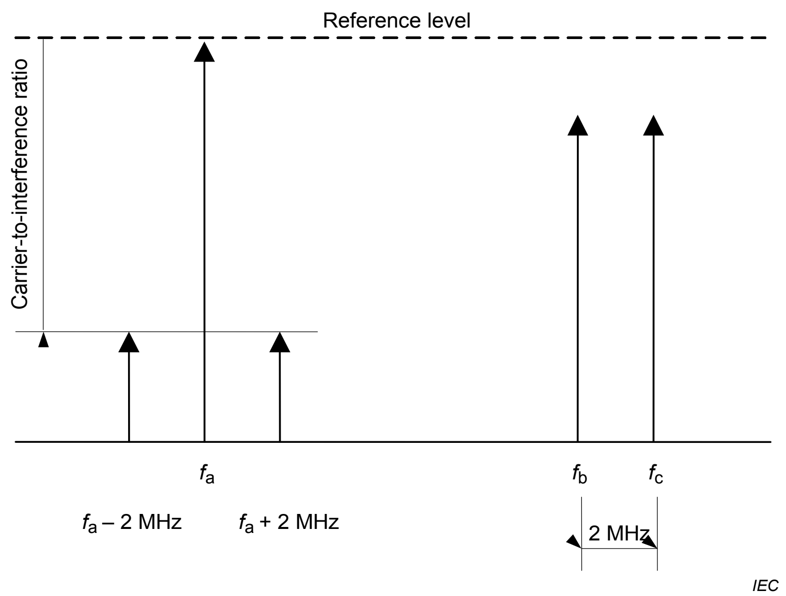


Figure 5 – Test carrier and interfering products in the pass band

The carriers having the frequencies f_a, f_b and f_c shall be varied over the entire frequency range.

If the equal carrier method of measurement as described in IEC 60728-3 is used, the output level giving the appropriate signal-to-distortion ratio shall be increased by 6 dB.

4.4 Two carrier intermodulation measurements for second- and third-order products

4.4.1 General

The two-carrier method is applicable to the measurement of the ratio of the carrier to a single intermodulation product at a specified point within a cable network. The method can also be used to determine the intermodulation performance of individual items of equipment.

Second-order products are encountered only in wideband equipment and systems covering more than one octave and can be measured using two signals.

Third-order products are encountered in both wideband and narrowband equipment and systems and, depending on the type, can also be measured using two signals.

4.4.2 Intermodulation products with test signals at frequencies f_a and f_b

Second-order products: $P_{2a} = f_b - f_a$

$P_{2b} = f_a + f_b$

NOTE Not applicable to narrowband equipment unless the frequency range covered by the equipment is such that $2f_{min} < f_{max.}$

Third-order products: $P_{3a} = 2f_a - f_b$ where $2\ f_a > f_b$

$P_{3a} = f_b - 2f_a$ where $2\ f_a < f_b$

$P_{3b} = 2f_b - f_a$

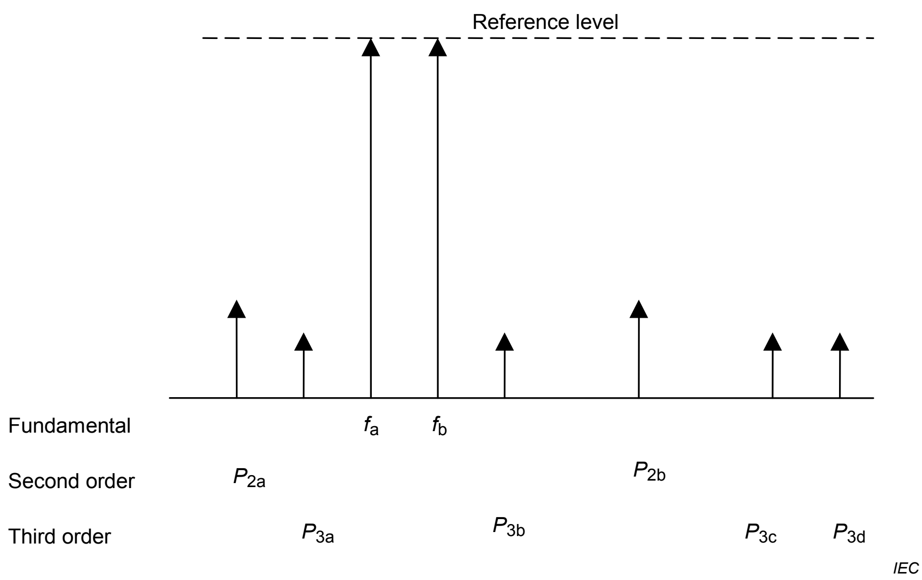
$P_{3c} = 2f_a + f_b$

$P_{3d} = 2f_b + f_a$

4.4.3 Signal levels

The two test carriers shall be set to the reference level.

An example showing products formed when $2f_a > f_b$ is shown in Figure 6.



NOTE The sequence of the intermodulation products will depend on the fundamental frequency chosen.

Figure 6 – Example showing products formed when $2f_a > f_b$

4.5 Carrier-to-spurious signal ratio at the output

4.5.1 Carrier-to-spurious signal ratio at the output of equipment for AM TV systems

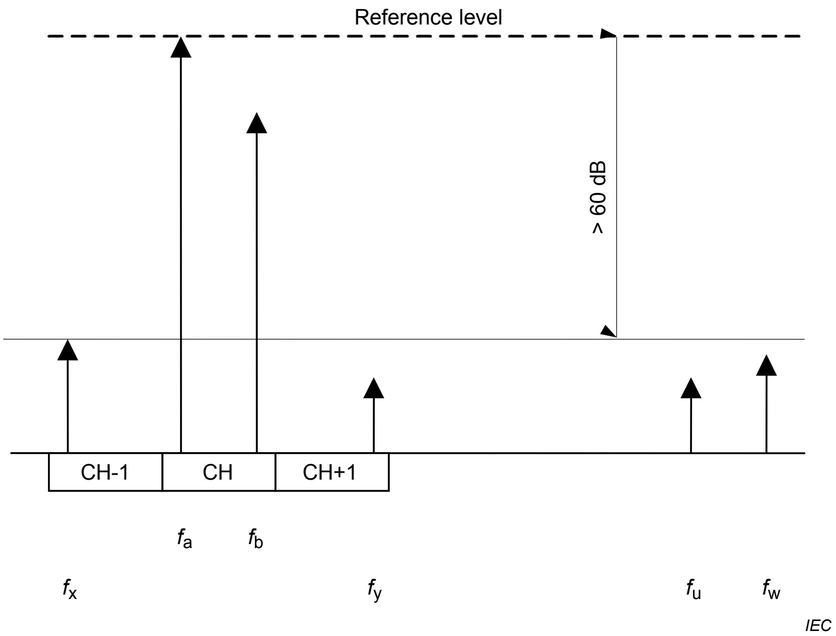
The carrier-to-spurious signal ratio at the output, out of channels, is applied between 40 MHz and 862 MHz.

The carrier levels are given in Table 3.

Table 3 – Test signal levels for sound and vision carriers in decibels relative to reference level

Test signal		Relative signal level dB	
		System	
		B, G, I, D, D1, K	L
Vision carrier	f_a	0	0
Sound carrier	f_b	−10	0

The carrier-to-spurious signal ratio in the output is shown in Figure 7.



$f_x = 2f_a – f_b$; $f_y = 2f_b – f_a$

f_u, f_w are examples for all other spurious outputs.

Figure 7 – Carrier-to-spurious signal ratio at the output

If for channel processing in CH-1 and CH+1 the difference between the intermodulation products f_x and f_y and the reference level is less than 60 dB, the equipment shall be marked with the followingnote: “not suitable for adjacent channel operation”.

4.5.2 Carrier-to-spurious signal ratio at the output of equipment for FM TV systems

Carrier-to-spurious signal ratio at the output of equipment for FM TV systems, out of channels and in channels between 950 MHz and 3 000 MHz, shall be in accordance with Figure 8.

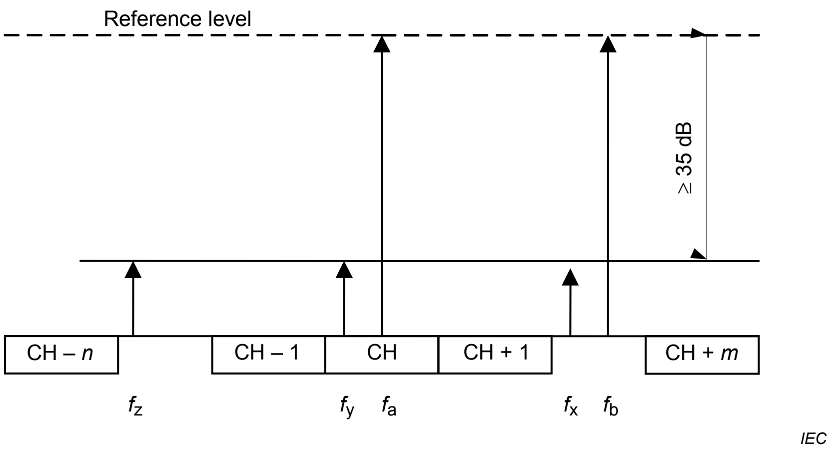


Figure 8 – Carrier-to spurious signal ratio at the output

Values f_x, f_y and f_z are intermodulation products between f_a and f_b or with other signals occurring in the system like oscillator frequency signals. f_b varies within the whole transmission range assigned to the equipment except for the useful channel studied.

4.5.3 Shoulder attenuation

The shoulder attenuation is measured as the difference between the top of channel N and maximum noise-like spurious signals of channel N measured in the adjacent channels N + 1 or channel N – 1 (see Figure 9).

The resolution bandwidth of the measurement should be 10 kHz.

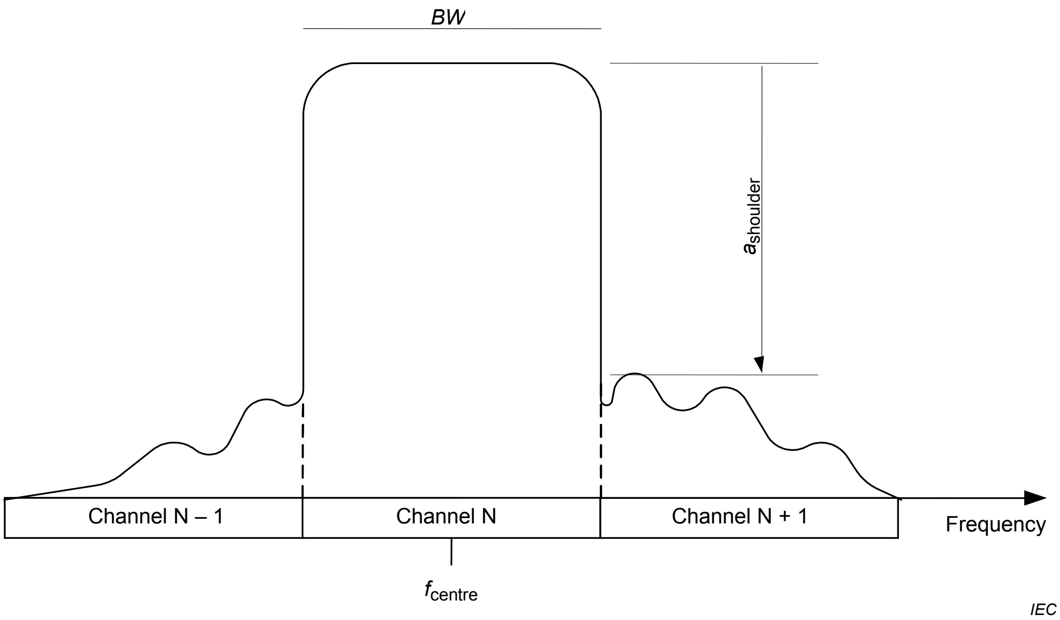


Figure 9 – Shoulder attenuation

4.6 Signal-to-noise measurement

4.6.1 Television carrier-to-noise ratio (analogue modulated signals)

4.6.1.1 General

The method described is applicable to the measurement of the carrier-to-random-noise ratio within an analogue television channel at a specified point within the headend or at the output of the equipment under test (EUT). The method of measurement actually determines carrier-(plus noise)-to-noise ratio; however, the difference between this and the carrier-to-noise ratio is very small if the value exceeds 20 dB.

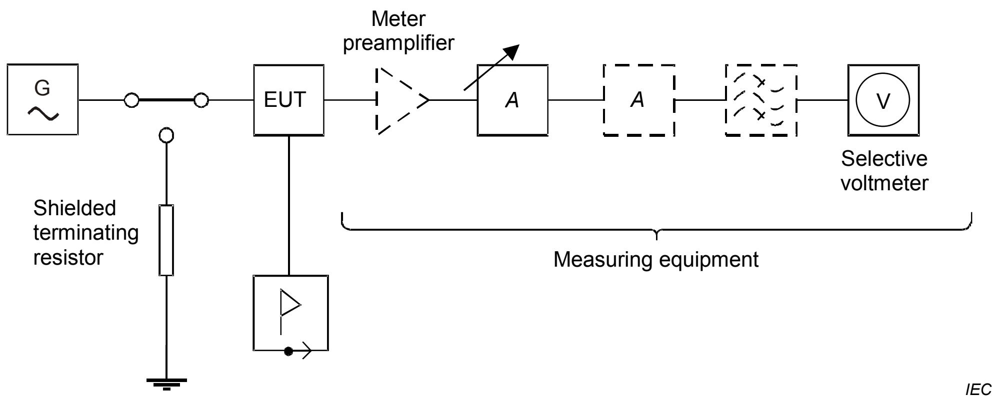
The method assumes that the random noise is evenly distributed within the channel.

The following equipment is required:

- selective voltmeter with a known noise bandwidth less than that of the channel to be measured;
- CW signal generator covering the frequencies at which the tests are to be carried out;
- variable attenuator with a range greater than the carrier-to-noise ratio expected;
- shielded terminating resistor.

NOTE Additional items may be necessary, for example, to ensure correct calibration and operation of the test equipment (see 4.6.1.3).

The equipment shall be connected as in Figure 10.



NOTE Dotted lines signify items which may be required.

Figure 10 – Arrangement of test equipment for carrier-to-noise ratio measurement

4.6.1.2 Measurement procedure

4.6.1.2.1 General

The test set-up shall be well-matched and the sensitivity of the measuring equipment (see Annex H) shall be known over the frequency range of the channel to be measured.

Where the system to be measured includes AGC, tests shall be carried out at minimum and maximum levels of signal input.

Where the system to be measured includes ALC, pilot signals of the correct type, frequency and level shall be maintained throughout the tests.

4.6.1.2.2 Voltmeter calibration and check

The selective voltmeter shall be calibrated and checked for satisfactory operation as follows:

- level correction, average/rms or peak/rms (see 4.6.1.3.3);
- noise bandwidth (see Annex F).

Other checks:

a) sensitivity (see 4.6.1.3);
b) noise (see 4.6.1.3.4.1);
c) intermodulation (see 4.6.1.3.4.2);
d) overload (see 4.6.1.3.4.3).

4.6.1.2.3 Measurement

Set the signal generator to the vision carrier frequency of the channel to be tested and adjust its output, and those 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; see 4.6.1.3) to the point of measurement. Tune the voltmeter to the reference signal and note the attenuator value a_1 required to obtain a convenient voltmeter reading U_R. The attenuator value a_1 should be slightly greater than the signal-to-noise ratio expected at the point of measurement.

Disconnect the generator and replace it by the shielded terminating resistor, or, if the reference signal is used for AGC, retune the voltmeter within the channel such that it is influenced only by random noise. Reduce the attenuator setting to the value a_2 required to again obtain the same voltmeter reading U_R.

The carrier-to-noise ratio in decibels is given by

$$C/N = a_1 - a_2 - C_m - C_b \qquad (8)$$

where

a_1 is the attenuator value for the reference signal;
a_2 is the attenuator value for the noise;
C_m is the voltmeter level correction factor (see 4.6.1.3.3.1);
C_b is the bandwidth correction factor (see 4.6.1.3.3.2).

4.6.1.3 Equipment required – additional items

4.6.1.3.1 Voltmeter preamplifier

If the sensitivity of the selective voltmeter is not adequate for the levels of noise expected at the point of measurement, a suitable preamplifier of the correct input impedance and considerably flat response over the channel to be measured will be necessary. This preamplifier should be included as part of the measuring equipment when making the checks described in 4.6.1.3.4.

4.6.1.3.2 Voltmeter input filter

If the selectivity of the selective voltmeter is not adequate to reduce the effects of "out-of-channel" signals on the measurement of the noise voltage to an insignificant level, a suitable filter having a considerably flat response over the channel to be measured will be required as shown in Figure 10.

In this case, it is important that the matching between the filter and the equipment in front of it shall be such that it results in a return loss of not less than 20 dB within the frequency range of the channel to be measured, and that the whole measuring equipment shall satisfy all the requirements of Annex H.

Where this is in doubt, an attenuator of sufficient value to satisfy this requirement should be included as shown in Figure 10.

4.6.1.3.3 Correction factors

4.6.1.3.3.1 Level correction factor C_m

If a selective voltmeter responding to the average value of the applied voltage but calibrated in rms values (assuming a sinusoidal input signal) is employed, it will indicate a level approximately 1 dB below the rms value of the applied noise voltage in its noise bandwidth. In this instance, C_m may be taken as 1 dB.

If a selective voltmeter of the peak reading type is used, a correction appropriate to the particular instrument shall be employed as C_m.

4.6.1.3.3.2 Bandwidth correction factor C_b

This correction factor takes into account the difference between the noise bandwidth of the selective voltmeter BW_m and that of the appropriate television system BW_{TV}.

$$C_b = 10 \lg \frac{BW_{TV}}{BW_m} \text{ [dB]} \qquad (9)$$

4.6.1.3.3.3 Noise bandwidth BW_{TV}

The noise bandwidth BW_{TV} for various television systems is given in Table 4.

Table 4 – Noise bandwidth

System	I	B, D1, G	D, K	L
BW_{TV} (MHz)	5,08	4,75	5,75	5,58

The values in Table 4 shall be used when determining C_b (see 4.6.1.3.3.2).

4.6.1.3.4 Preliminary checks on the measuring equipment for carrier-to-noise ratio

4.6.1.3.4.1 Noise

With the input to the measuring equipment terminated and the variable attenuator set to zero, tune the voltmeter over the frequency range of interest and check that the reading remains negligible relative to that expected when measuring the system noise.

4.6.1.3.4.2 Intermodulation

Connect signals, corresponding to those which will be present at the point of measurement, via a matched directional coupler to the measuring equipment. Tune the meter to any significant intermodulation product and note the lowest value of the signal/intermodulation ratio within the channel being considered. This ratio should exceed the minimum carrier-to-noise ratio expected at the point of measurement by an amount relevant to the accuracy desired. For example, 20 dB would result in an error of less than 1 dB.

If this requirement is not met, an appropriate channel pass-band filter to attenuate one of the signals should be included as indicated in Figure 10, and the checks of 4.6.1.3.4.1 and 4.6.1.3.4.2 should be repeated.

NOTE This check relating to intermodulation is necessary only if ALC pilot signals or other signals are present during the carrier-to-noise ratio tests.

4.6.1.3.4.3 Overload

Connect signals as in 4.6.1.3.4.2 and attenuate one of them to a level comparable with that of the noise voltage expected at the point of measurement. Tune the meter to the low-level signal. Tune the low-level signal and the meter in step over the frequency range of the channel to be measured and check that the meter reading does not change when the high-level signals are switched off and on.

If this requirement is not met, a filter to attenuate one or more of the signals should be included as indicated in Figure 10, and all the checks described in 4.6.1.3.4.2 should be repeated.

4.6.1.3.5 Calibration of the noise bandwidth BW_m of the selective voltmeter

A well-matched noise generator is required, having a known bandwidth BW_g (see Note) and an output voltage of known rms value U_g sufficient to give a convenient reading on the voltmeter.

The voltmeter is connected to the noise generator and tuned to a test frequency. The true rms voltage U_m is measured (see 4.6.1.3.3). This procedure is repeated at each test frequency.

The noise bandwidth of the voltmeter (BW_m) is given by

$$BW_m = BW_g \left(\frac{U_m}{U_g} \right)^2 \qquad (10)$$

where BW_m and BW_g are in the same units, for example megahertz, and U_m and U_g are in the same units, for example microvolts.

NOTE BW_g will usually be taken as 1 MHz and U_g is calculated for this bandwidth from information provided by the manufacturer of the noise generator.

4.6.2 RF signal-to-noise ratio ($S_{D,RF}/N$) for digitally modulated signals

4.6.2.1 General

This measurement method applies to the measurement of the RF signal-to-noise ratio $S_{D,RF}/N$ of digitally modulated signals using the QPSK, QAM, OFDM formats.

Because the modulated signal is similar in characteristics to white noise, the measurement is based on the use of a suitable spectrum analyser, able to tune the frequency range of the channel and to display the whole bandwidth, as well as to measure the spectral power densities of both the signal and the noise.

4.6.2.2 Equipment required

The equipment required is a spectrum analyser having a calibrated display of the tuned signal and which shall be able to tune over the frequency range of the system under test.

4.6.2.3 Connection of the equipment

Connect the measuring equipment to the headend output, or to the EUT, using a suitable cable and connectors, taking care to maintain correct impedance matching.

4.6.2.4 Measurement procedure

The measurement procedure is as follows.

a) Tune the channel that shall be measured (selecting the centre frequency of the spectrum analyser) and select the span and level settings to show the whole channel whose bandwidth depends on the type of modulation used. In Table F.1, examples of the equivalent signal *BW* of digitally modulated signals are given.
b) Set the *RSBW* of the spectrum analyser to 100 kHz and set the video bandwidth low enough to obtain a smooth display (100 Hz if available). If a different setting is used, this must be the same when measuring the signal level and the noise level.
c) Measure the level *S* of the flat top of the displayed signal in dB(μV) or in dB(mW), using the display line cursor if this feature is available.

   If the spectrum of the signal does not have a flat top, due to echoes, measure the signal level at the centre frequency of the channel.
d) Switch off the channel at the input of the equipment under test, terminating the input port with a matched impedance (or depointing the antenna, if the measurement is performed at the output of an outdoor unit for satellite reception) and measure the noise level *N* in the same units as the signal level [in dB(μV) or in dB(mW) or in dB(mW/Hz)].
e) Calculate the RF signal-to-noise ratio $S_{\mathrm{D,RF}}/N$ by the following formula:

$$S_{\mathrm{D,RF}}/N = S\ [\mathrm{dB}(\mu\mathrm{V})] - N\ [\mathrm{dB}(\mu\mathrm{V})] \quad \mathrm{dB} \tag{11}$$

or

$$S_{\mathrm{D,RF}}/N = S\ [\mathrm{dB(mW)}] - N\ [\mathrm{dB(mW)}] \quad \mathrm{dB} \tag{12}$$

or

$$S_{\mathrm{D,RF}}/N = S\ [\mathrm{dB(mW/Hz)}] - N\ [\mathrm{dB(mW/Hz)}] \quad \mathrm{dB} \tag{13}$$

where

$S_{\mathrm{D,RF}}/N$ is the RF signal-to-noise ratio, in dB;

S is the signal level in dB(μV), dB(mW) or dB(mW/Hz);

N is the noise level in dB(μV), dB(mW) or dB(mW/Hz).

NOTE This measurement method actually measures the $(S_{\mathrm{D,RF}} + N)/N$ ratio. The measuring equipment (spectrum analyser) is assumed to have a noise level at least 10 dB lower than the noise level displayed outside the channel band in order not to affect the results.

Otherwise, the contribution of the measuring equipment noise in the measurement of the noise level *N* should be taken into account (see Annex E).

4.6.2.5 Presentation of the results

The measured signal-to-noise ratio $S_{\mathrm{D,RF}}/N$ is expressed in dB.

4.7 Differential gain and phase for PAL/SECAM signals

4.7.1 General

The methods described are applicable to the measurement of differential gain and differential phase for complete systems and items of equipment thereof. The test signals employed are in both cases those recommended in ITU-T Recommendation J.61, and are shown in Figure 12 and Figure 13. The definitions are also those given in the same recommendation.

It is intended that these measurements be carried out with test signals inserted at the system headend. They may be either of the full field type or, where convenient, may be inserted in the field blanking period.

The use of frame inserted test signals available on the broadcast TV channels is not generally recommended as these are subject to variations beyond the control of the user. However, where such signals of known stability and of adequate quality are available, they may be used to carry out these measurements.

4.7.2 Differential gain (for PAL/SECAM only)

4.7.2.1 General

Differential gain is expressed by two values, x (%) and y (%), which represent the two peak amplitudes of the sub-carrier relative to the amplitude of the sub-carrier at blanking level. In the case of a monotonic characteristic, either x or y will be zero.

Differential gain, in percentage referred to blanking level, can be found from the following expressions.

$$x = \left| \frac{A_{max} - A_0}{A_0} \right| \times 100\ \% \qquad y = \left| \frac{A_{min} - A_0}{A_0} \right| \times 100\ \% \tag{14}$$

Peak-to-peak differential gain (DG_{pp}) can be found from the following expression.

$$DG_{pp} = \left| \frac{A_{max} - A_{min}}{A_0} \right| \times 100\ \% \tag{15}$$

where

A is the amplitude of the sub-carrier on one of the other treads of the staircase;

A_0 is the amplitude of the received sub-carrier at blanking level.

4.7.2.2 Equipment required

The test set-up shall be well-matched and shall consist of:

a) an oscilloscope which will not contribute significant distortion to the signal displayed;
b) a modulator (unless transmitted test signals in the field blanking interval are to be used) having the following characteristics:
    1) RF characteristics (excluding sound) corresponding to ITU-R Report BT.624-4, and appropriate to the television transmission system used;
    2) video signal input requirement of 1 V peak-to-peak composite;
    3) modulated output signal of a convenient amplitude;
c) a demodulator having characteristics appropriate to the television transmission system used;
d) two attenuators variable in steps of not more than 1 dB;
e) a band-pass filter with f_0 = 4,43 MHz and a bandwidth of 0,5 MHz;

f) a test signal generator providing signals having characteristics appropriate to the television transmission system under consideration, as specified in ITU-T Recommendation J.61 (signal D2) (see Figure 12).

NOTE Most commercially available test signal generators will provide this signal as part of a composite test line.

4.7.2.3 Connection of the equipment

The equipment shall be connected as in Figure 11.

4.7.2.4 Measurement procedure

With point A connected direct to point B (see Figure 11), adjust attenuator A_1 for an output level sufficient to drive the system to be tested and attenuator A_2 to obtain the correct input level to the demodulator.

Insert the appropriate band-pass filter after the demodulator (see Figure 11) and measure the differential gain by examining the modified staircase waveform (see Figure 13 and 4.7.2.1).

Ensure that the distortion of the test signal caused by the control loop (test equipment) is small compared with the maximum distortion allowed for the system or equipment to be tested.

Where the linearity of the modulator/demodulator is such that on systems B and G (10 % residual carrier) this requirement cannot be met, it will be necessary either to reduce the sub-carrier amplitude or to ignore the sixth (uppermost) tread.

Connect the system or equipment to be tested between points A and B and disconnect the band-pass filter. Adjust attenuator A_2 to return the input level to the demodulator to the one mentioned above.

Reinsert the band-pass filter and measure the maximum differential gain by examining the modified staircase waveform (see also Figure 13 and 4.7.2.1).

NOTE This figure includes the distortion due to the test equipment as well as the system or equipment under test.

4.7.3 Differential phase

4.7.3.1 General

Differential phase is expressed by two values, x and y, in degrees, which represent the two peak phases of the sub-carrier relative to the phase of the sub-carrier at blanking level. In the case of a monotonic characteristic, both x and y will be zero.

Differential phase, in degrees, with reference to blanking level, can be found from the expressions below:

$$x = \left| \varphi_{\text{max}} - \varphi_0 \right| \qquad (16)$$

$$y = \left| \varphi_{\text{min}} - \varphi_0 \right|$$

Peak-to-peak differential phase (DPH_{pp}) in degrees can be found from the expression

$$DPH_{\text{pp}} = \left| \varphi_{\text{max}} - \varphi_{\text{min}} \right| \qquad (17)$$

where

φ_0 is the phase of the received sub-carrier at blanking level;

φ is the phase of the sub-carrier on one of the other treads of the staircase.

4.7.3.2 Equipment required

The following equipment is required:

a) a modulator (unless transmitted test signals in the field blanking interval are to be used) having the following characteristics:
   1) RF characteristics (excluding sound) corresponding to ITU-R Report BT.624-4, and appropriate to the television transmission system used;
   2) video signal input requirement of 1 V peak-to-peak composite;
   3) a modulated output signal of a convenient amplitude;

b) a demodulator having characteristics appropriate to the television transmission system used;

c) two attenuators variable in steps of not more than 1 dB;

d) a test set capable of measuring the difference in phase of the subcarrier at each tread of the staircase, with reference to the blanking level;

e) a test waveform generator (unless transmitted test signals in the field blanking intervals are to be used) providing signals having characteristics appropriate to the television transmission system under consideration, as specified in ITU-T Recommendation J.61 (signal D2), although a lower chrominance amplitude of the chrominance component would be acceptable.

NOTE 1 Most commercially available test signal generators will provide this signal as part of a composite test line.

NOTE 2 Certain types of test sets require the presence of a colour burst during the back porch period of the test signal.

4.7.3.3 Connection of the equipment

The equipment shall be connected as in Figure 11.

4.7.3.4 Measurement procedure

With point A connected direct to point B (see Figure 11), adjust attenuator A_1 for an output level sufficient to drive the system to be tested and attenuator A_2 to obtain the correct input level to the demodulator. Connect the differential phase test set.

Ensure that the distortion of the test signal due to the control loop (test equipment) is small compared with the maximum distortion allowed for the system or equipment to be tested (see also Note 2 of 4.7.2.4).

Connect the system or equipment to be tested between points A and B. Adjust attenuator A_2 to return the input level to the demodulator to that mentioned above.

Determine the relative sub-carrier phases corresponding to the six treads of the staircase waveform. The differential phase of the system or equipment under test is the maximum phase change between the blanking level tread and that of any other tread of the staircase.

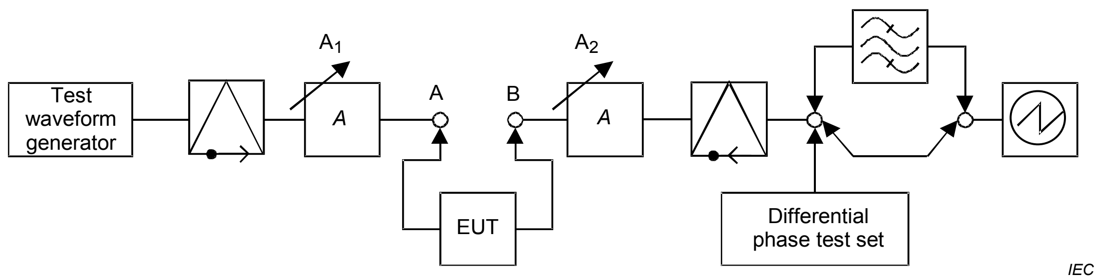


Figure 11 – Arrangement of test equipment for measurement of differential gain and phase

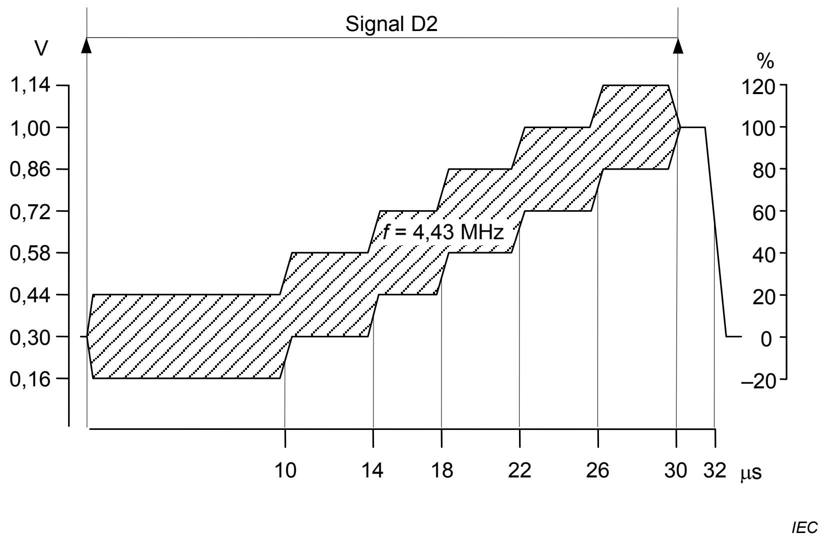


Figure 12 – Signal D2 waveform

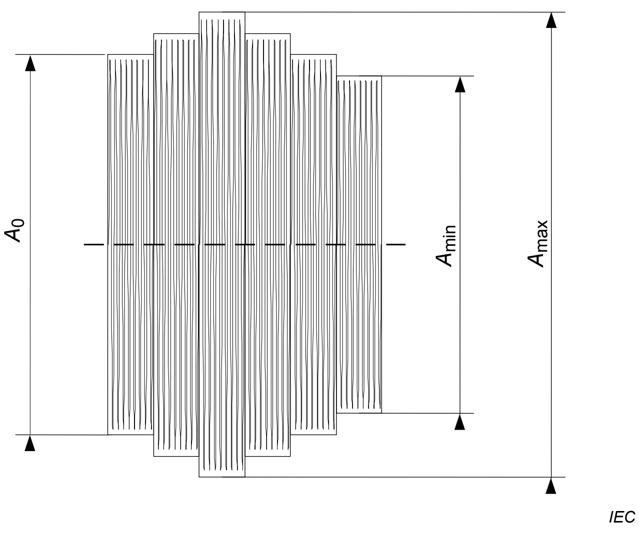


Figure 13 – Example of modified staircase

4.8 Group delay measurements

4.8.1 Group delay variation of analogue TV signals

4.8.1.1 General

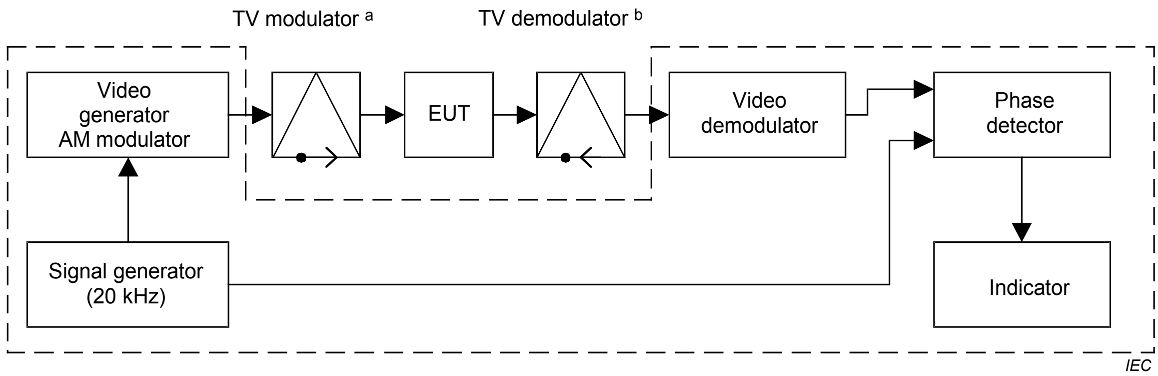
Group delay variation is defined as the deviation from a linear phase-frequency response. This deviation is measured as the difference between the maximum and the minimum slope of the phase-frequency response within the channel.

NOTE For analogue systems, the measurements are made in the video band 25 Hz to 5,0 MHz (for standards D, K within the video band 25 Hz to 6,0 MHz) related to the reference frequency of 200 kHz.

For NICAM 728 the reference frequency is the NICAM carrier.

4.8.1.2 Method of measurement

The method of measurement corresponds to IEC 60244-5 and is shown in Figure 14.



[a] For TV modulator measurements, remove TV modulator and connect video generator directly to the equipment to be tested.

[b] For TV demodulator measurements, remove TV demodulator and connect the equipment to be tested directly to the video demodulator.

Figure 14 – Measuring set-up for determining the group delay variation

The complete measuring set-up (apart from the TV modulator and TV demodulator) is available as a commercial measuring instrument (dotted line).

The output signal from the video generator/AM modulator is a carrier, which is amplitude-modulated with a 20 kHz signal. Synchronization pulses are added to the signal and it is sent through the TV modulator to the equipment under test. After demodulation, the signal is passed to a phase detector where the phase shift of the test tone in relation to the modulation signal is measured.

The phase shift is expressed as group delay by means of the formula

$$\tau_g = \frac{\Delta\varphi}{360^\circ \times f_m} \qquad (18)$$

where

$\Delta\varphi$ is the phase difference in degrees;

f_m is the frequency of the test signal in hertz;

τ_g is the group delay in seconds.

The TV modulator is set to the vision carrier of the TV channel. The measuring level shall be the nominal input level of the test item as prescribed by the manufacturer.

The TV demodulator is set to receive the selected TV channel. The frequency of the AM modulator is varied within the range 0,1 MHz to 4,43 MHz, and the measurement is repeated so that the group delay is expressed as a function of the frequency within the video band for the test item.

The group delay variation is determined by using the formula above, or is read directly on the commercial measuring instrument.

4.8.2 Procedure for the measurement of group delay variation on DVB channel converters

4.8.2.1 General

To measure the group delay time on DVB channel converters (for the conversion of QPSK, OFDM or QAM modulated signals), the split-frequency procedure (which has already proven itself as viable for measurements on conventional converters), presents itself as a solution.

4.8.2.2 Principle

An RF carrier signal is amplitude-modulated on the transmitter side by a sine signal with the split frequency f_S (see Figure 15). The object of the delay time measurement is the envelope which is created by amplitude modulation. The delay time of a specific point of the envelope (preferably the maximum of the envelope) running through the measured equipment will be registered. The phase of the split frequency on the reception side, regained by demodulation, is then compared with the reference phase of the split frequency on the transmitter side.

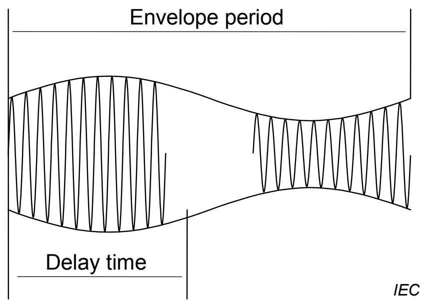


Figure 15 – RF signal (time domain) amplitude-modulated with a split-frequency signal

The spectral presentation of the measuring principle is shown in Figure 16.

The test signal, composed of the three spectral components of the carrier frequency f_c, the lower sideband $f_C - f_S$ and the upper sideband $f_C + f_S$ frequency, is swept through the examined transmission range.

The delay time between $f_C - f_S$ and $f_C + f_S$ is averaged. The aperture of the measuring set-up is $2f_S$.

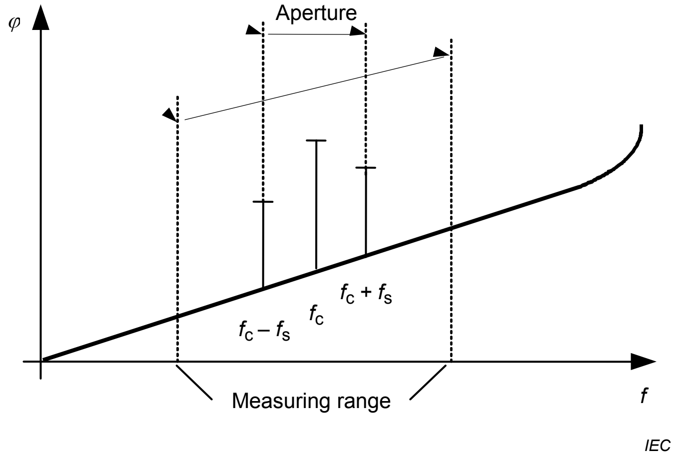


Figure 16 – Spectral presentation of the group delay measurement

The measurement of the group delay time corresponds to the measurement of the phase difference in the $2f_S$ range:

$$\tau_g = \left(\frac{\varphi_{f_c + f_s} - \varphi_{f_c - f_s}}{2f_s} \right) \tag{19}$$

Looked at from the mathematical point of view, this is the approximation for the differential quotient of the phase angle, relative to the time constituting the group delay time.

$$\tau_g = \frac{d\varphi}{df} \tag{20}$$

4.8.2.3 Description of the measuring set-up

Figure 17 shows a measuring set-up realized with scalar network analysers (suitable for measuring the frequency-dependent amplitude-frequency response) equipped with a group delay time option.

Existing AGC or AFC of the EUT should be switched off during the measurements in order to avoid invalid measurement results.

If the signals are noisy, auxiliary means such as video filters and specific averaging mode may be used.

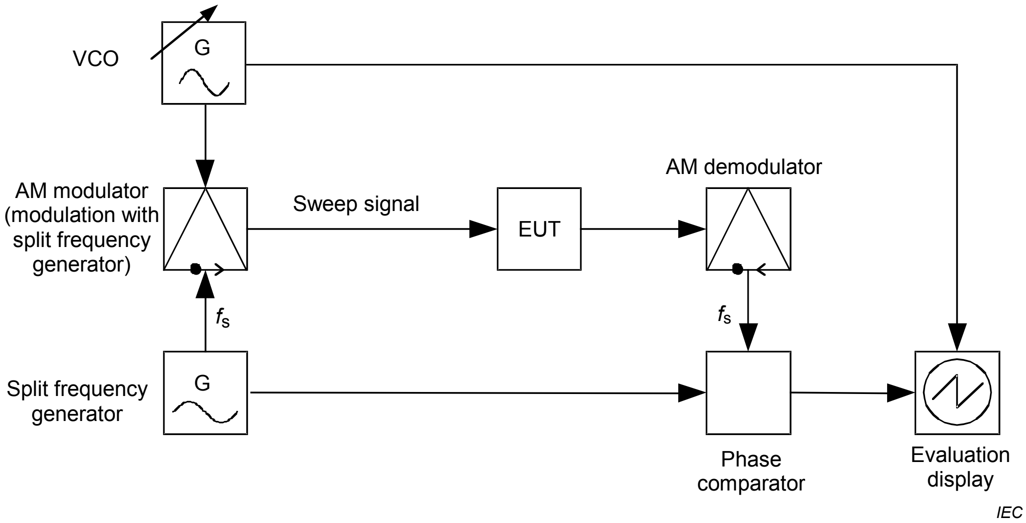
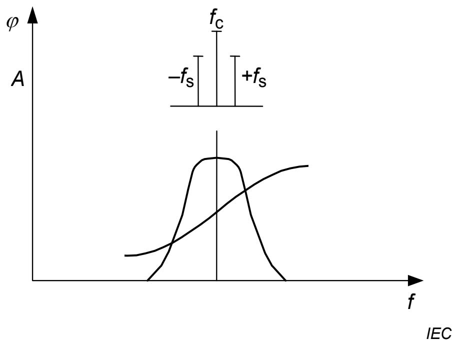


Figure 17 – Description of the measuring set-up

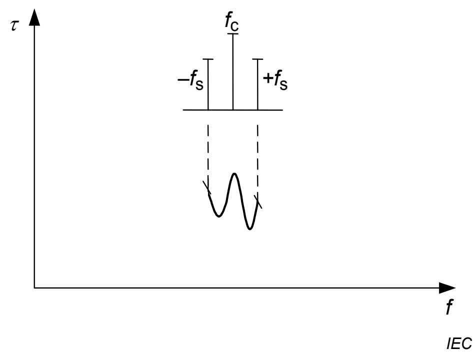
The amplitude modulation of the sweep signal from the VCO, generated by the LF signal coming from the split-frequency generator, is carried out in the AM modulator. The amplitude-modulated sweep signal is applied to the equipment under test. The output of the equipment under test is connected to the AM demodulator, where the LF signal of the split frequency is regained by demodulation of the envelope. The demodulated signal is then applied to the phase comparator where the phase difference in relation to the reference signal generated by the split-frequency generator is determined. The delay time difference – which is displayed – is then derived from the ascertained phase difference (see Formula (20)).

4.8.2.4 Choice of the aperture

The chosen split frequency must permit an adequately high measurement resolution to be attained for a sufficiently small aperture (required for narrowband filters (Figure 18a) or for surface acoustic wave filters (Figure 18b) the group delay ripple of which is to be determined).



a) Narrow band filter



b) Surface acoustic wave filter: Group delay ripple measured with too high split frequency

Figure 18 – Choices of measuring aperture (value of the split frequency) for various measurement tests

A split frequency of 20 kHz demands that, at the lower measuring limit of 1 ns, the measurements of a minimum phase angle of 0,01° shall be possible.

Split-frequency values between 10 kHz and 20 kHz proved in practice sufficiently correct for surveys of surface acoustic wave filters (group delay ripple).

It is also important that the envelope's oscillation period of $1/f_s$ shall always be bigger than the measured group delay time, in order to ensure that the registered maximum of the envelope can be uniquely defined after having passed through the measured equipment.

4.9 Phase noise of an RF carrier

4.9.1 General

This measurement method is able to provide an indication of the phase noise of a carrier due to the phase or frequency fluctuations of an oscillator used in an equipment of the cable network (i.e. in a frequency converter).

For PSK, APSK or QAM modulation formats, using such an oscillator with digitally modulated signals, phase noise may result in a sampling uncertainty in the receiver, because the carrier regeneration cannot follow the phase fluctuations. Phase noise outside the loop bandwidth of the carrier recovery circuit leads to a circular smearing of the constellation points in the I/Q plane. This reduces the operating margin (noise margin) of the system and may directly increase the BER.

In an OFDM system, the phase noise can cause CPE, which affects all carriers simultaneously and which can be corrected by using continual pilots, and ICI which is noise-like and that cannot be corrected.

The effects of CPE are similar to any single carrier system and the phase noise, outside the loop bandwidth of the carrier recovery circuit, leads to a circular smearing of the constellation points in the I/Q plane. This reduces the operating margin (noise margin) of the system and may directly increase the BER.

The effects of ICI are peculiar to OFDM and cannot be corrected for. This shall be taken into account as part of the total noise of the system.

The measurement is performed at the headend output, or the EUT output (frequency converter), while an unmodulated carrier is applied at the input of the equipment under test.

The headend can include modulation converters (from PSK, APSK to QAM format).

This measurement method should be performed under out-of-service conditions.

4.9.2 Equipment required

The following equipment is required:

a) an RF signal generator for the frequency bands of input signals at the EUT;

   The phase noise characteristic of the signal generator is assumed to be sufficiently lower (at least 10 dB) than that to be measured. If this is not known, a preliminary check should be performed.

b) a spectrum analyser able to tune the nominal frequency range of the equipment.

4.9.3 Connection of the equipment

The measuring set-up for the phase noise measurement is shown in Figure 19.

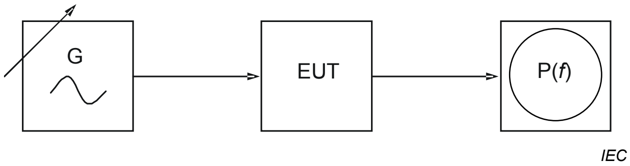


Figure 19 – Test set-up for phase noise measurement

The measuring equipment shall be connected taking care to maintain correct impedance matching and using suitable cables and connectors.

4.9.4 Measurement procedure

The measurement procedure is as follows.

a) Set the carrier frequency of the RF signal generator to that of the channel where the measurement shall be performed.

b) Adjust the carrier level of the RF signal generator to obtain the same level at the EUT output as in normal operating conditions.

c) Tune the spectrum analyser on the same channel; select the centre frequency of the spectrum analyser, the span and level settings to show the carrier and its sidebands due to the phase noise.

d) Set the *RSBW* of the spectrum analyser to 300 Hz and the video bandwidth to 30 Hz or 10 Hz.

e) Measure the unmodulated carrier level *C* in dB(mW).

f) Measure the level $PN_{(f_m)}$ in dB(mW), of each component in one noise sideband and note its frequency f_m.

g) Convert the measured value of *PN* to one hertz bandwidth, using the following formula:

$$PN_{0(f_m)} = PN_{(f_m)} - 10\ \lg(RSBW) + K_{sa}\ \text{dB} \qquad (21)$$

where *RSBW* is the resolution bandwidth of the spectrum analyser.

NOTE 1 The correction factor K_{sa} depends on the measuring equipment used and is provided by the manufacturer of the measuring equipment or obtained by calibration.

NOTE 2 The value of the correction factor for a typical spectrum analyser is about 1,7 dB (see Annex I).

NOTE 3 The correction factor is not necessary if the measuring equipment can be set to display the noise level in dB(mW/Hz) units. In this case the $PN_{0(f_m)}$ value is obtained directly.

h) Calculate the phase noise performance of the carrier, defined as the ratio of the measured power in one sideband component, on a per hertz bandwidth spectral density basis, to the total signal power:

$$\alpha_{(f_m)} = PN_{0(f_m)} - C\ [\text{dB(Hz}^{-1})] \qquad (22)$$

NOTE 4 For this measurement it is assumed that contributions from amplitude modulation to the noise spectrum are negligible compared to those from frequency modulation and that the *RSBW* is much smaller than f_m.

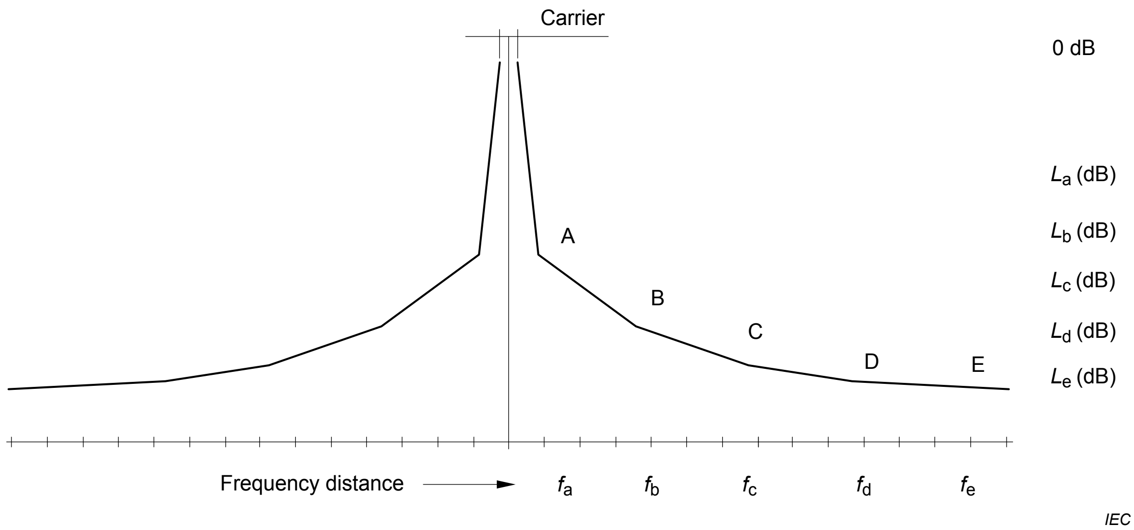
4.9.5 Presentation of the results

The measured phase noise PN_0, expressed in dB(Hz^{-1}), is plotted versus the frequency distance f_m away from the carrier as indicated in Table 5.

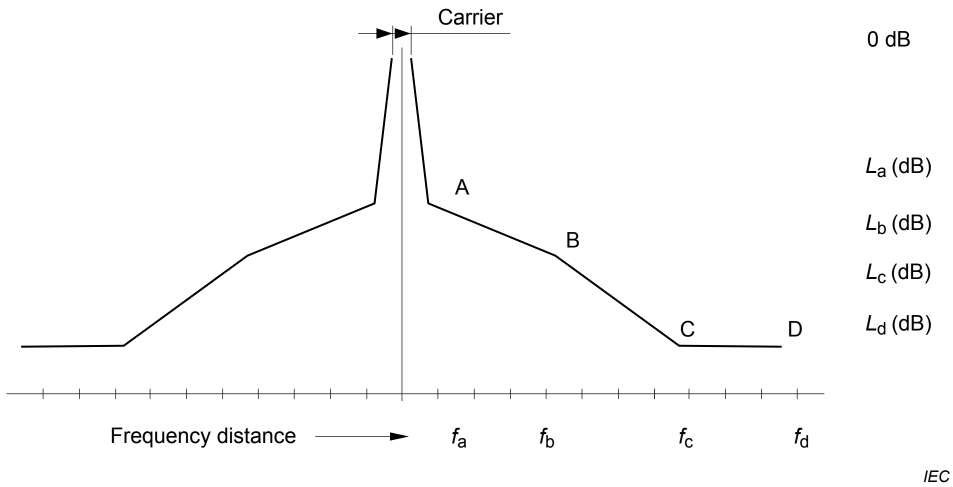
Table 5 – Frequency distances for phase noise measurement

Modulation format	f_a	f_b	f_c	f_d	f_e
PSK, APSK and QAM	100 Hz	1 kHz	10 kHz	100 kHz	1 000 kHz
OFDM	1 kHz	10 kHz	100 kHz	1 000 kHz	–

Examples of measurement results are given in Figure 20.



a) PSK, APSK and QAM formats



b) OFDM format

Figure 20 – Mask for phase noise measurements

4.10 Hum modulation of carrier

4.10.1 General

The interference ratio for hum modulation is the ratio stated in dB between the peak-to-peak value of the unmodulated carrier and the peak-to-peak value of one of the two envelopes caused by the hum modulated to this carrier.

NOTE This method is not applicable for modulators and demodulators.

The hum modulation ratio (carrier/hum ratio) is shown in Figure 21.

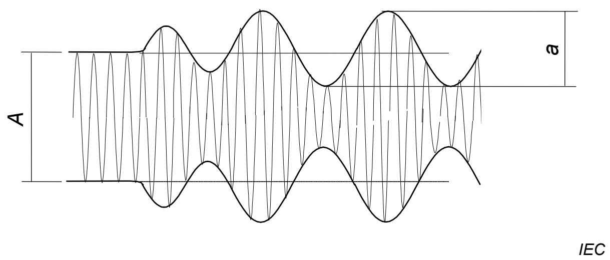


Figure 21 – Carrier/hum ratio

$$\textit{Carrier/hum ratio} = 20 \cdot \lg \frac{A}{a} \; [\mathrm{dB}] \qquad (23)$$

4.10.2 Description of the method of measurement

4.10.2.1 General

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

The measurement shall be made over the specified supply voltage and power range.

To measure the equipment under test, the oscilloscope method is used.

4.10.2.2 Test equipment

The following test equipment is required:

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

4.10.2.3 Connection of test equipment

The connection is shown in Figure 22 and Figure 23.

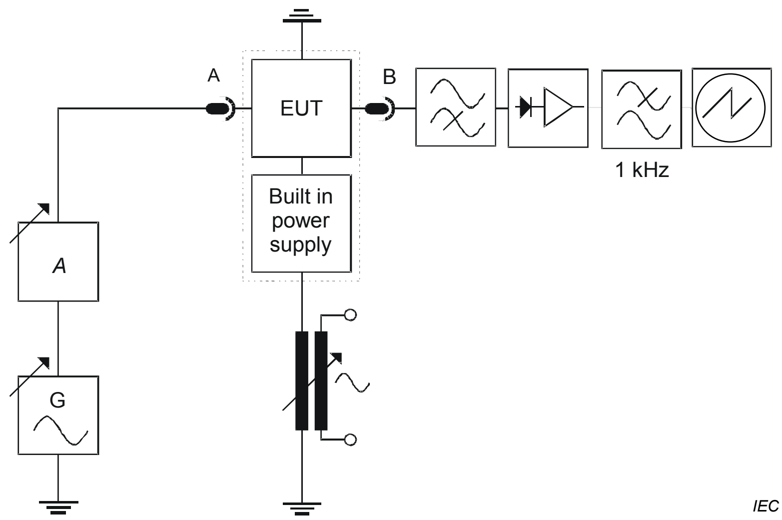


Figure 22 – Test set-up for equipment with built-in power supply

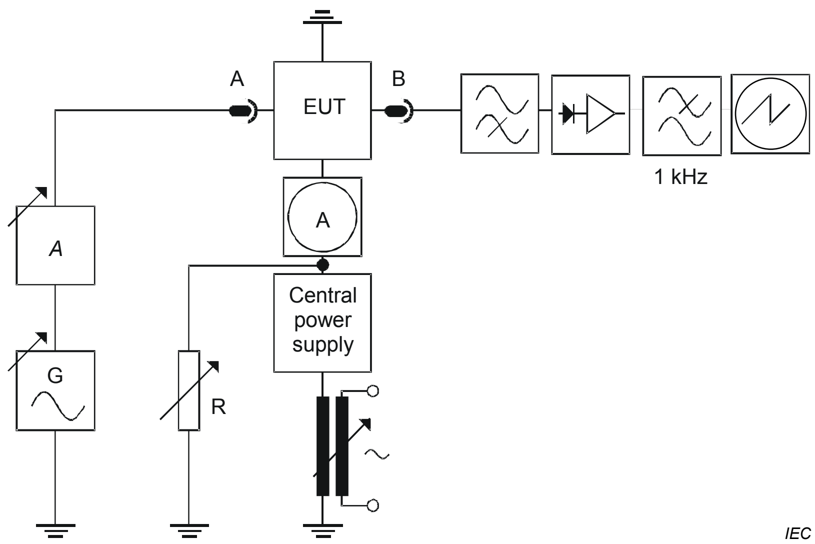


Figure 23 – Test set-up for equipment with external power supply

4.10.3 Measuring procedure

4.10.3.1 Set-up of calibration

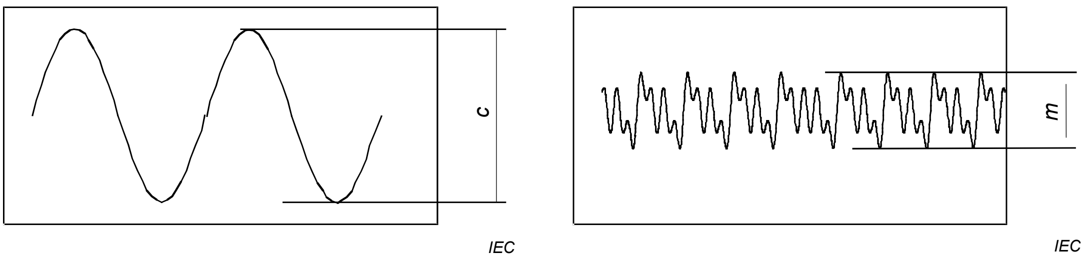
The reference signal is generated by means of the RF signal generator shown in Figure 22 and Figure 23. Select an RF carrier frequency that suits the TV channel under consideration and modulate it to a depth of 1 % at a frequency of 400 Hz. Adjust the RF signal generator to an appropriate level and read the peak-to-peak value of the demodulated AM signal ("*c*" in Figure 24a) on the oscilloscope. This is the reference signal. With 1 % modulation, this value is –20 lg (0,01) = 40 dB. The modulation of the signal generator has to be switched off. The remaining value "*m*" in Figure 24b is the value to be measured.

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 4.10.4. This value should be at least 10 dB better than the values to be measured on items of equipment. The subsequent measurements shall be carried out in suitable increments through the entire operating frequency range. The measured value is independent from the RF level; however, the RF level should be at least the magnitude of the operating level of the equipment under test.

4.10.3.2 Equipment with built-in power supply

Adjust the equipment under test to the whole range of the operating voltage using the transformer. The supply current depends on the power requirement of the equipment under test.

Modulate the signal generator with the reference signal and adjust the level at point B by means of an attenuator such that neither the measured equipment 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.



a) Calibration signal **b) Measured signal**

Figure 24 – Oscilloscope display

4.10.3.3 Equipment with external power supply

Adjust the equipment under test to the whole range of the operating voltage using the transformer. The supply current depends on the power requirement of the equipment under test. In addition, for the equipment with external power supply adjust the maximum admissible peak current of the power supply using the external resistor.

Modulate the signal generator with the reference signal and adjust the level at point B by means of an attenuator in such a way that neither the measured equipment 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 according to Figure 24. Then switch off the reference signal and measure the peak-to-peak value, *m*, of the remaining signal.

4.10.4 Calculating the hum modulation ratio

4.10.4.1 General

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

4.10.4.2 Individual equipment under test

$$\textit{Hum modulation ratio}\ [\mathrm{EUT}] = 40 + 20\ \lg\left(\frac{c}{m}\right)[\mathrm{dB}] \qquad (24)$$

for 1 % reference modulation depth.

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

4.10.4.3 Loop value correction

In case a set-up calibration correction is required, use the following formula:

$$\textit{Hum modulation ratio}_{[\mathrm{EUT}]} = -20\ \lg\left(10^{-\frac{\textit{measured value}}{20}} - 10^{-\frac{\textit{calibration correction}}{20}}\right)[\mathrm{dB}] \qquad (25)$$

4.11 2*T*-pulse response, *K*-factor

The main purpose of the measurement is the evaluation of the luminance transmission behaviour in the lower and middle video frequency range.

A test waveform generator should be used to provide a sine-squared pulse of half amplitude duration equal to 2*T*, where *T* is the periodic time appropriate to the TV system under consideration. For 625-line systems, *T* = 100 ns. The test signals are in accordance with ITU-T Recommendation J.61 (signal B1).

Synchronous demodulation should be used.

Figure 25 shows the *K*-factor mask, which shall be achieved for quality grade 2 equipment or systems.

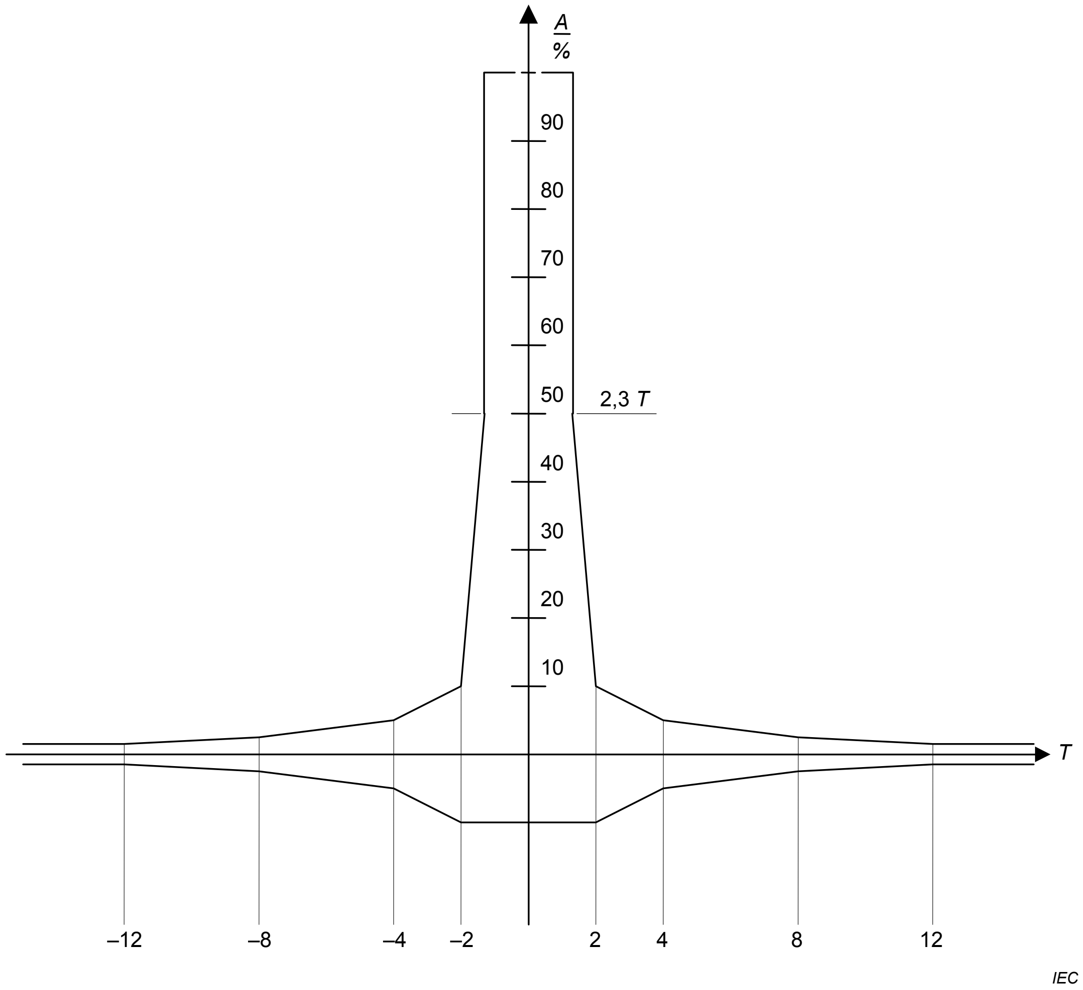


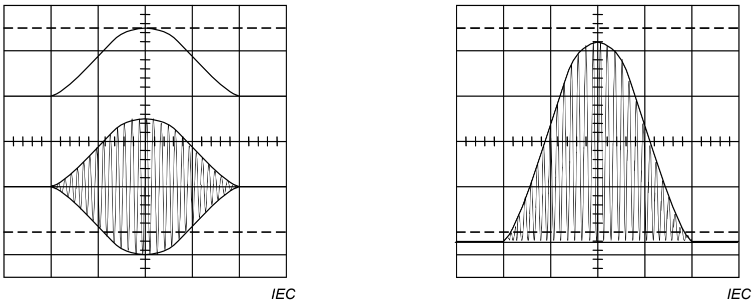
Figure 25 – *K*-factor mask for quality grade 2

4.12 Chrominance-luminance delay inequalities (20*T*-pulse method)

The 20*T*-pulse has a half-amplitude duration of 2 µs. It develops from a chrominance sub-carrier which is first modulated with a $\sin^2$ signal and then superimposed with the same signal as used for modulation (Figure 26). It has two spectrum ranges of the same bandwidth and the same amplitude in the luminance and chrominance ranges. Due to its pulse spectrum the 20*T*-pulse is particularly suitable for testing colour TV systems. Its baseline distortion is used to detect amplitude and delay time errors in the chrominance sub-carrier range. Amplitude-only errors cause a symmetric baseline distortion and a variation of the pulse amplitude. Delay-time-only errors cause an asymmetric baseline distortion and no variations of the pulse amplitude.

Only synchronous demodulation should be used.

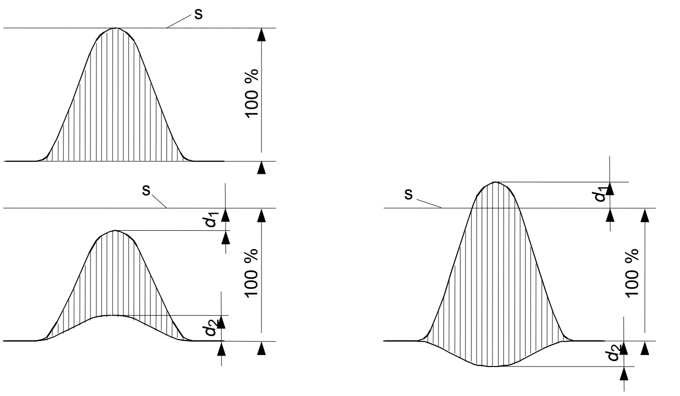
Figure 27 gives the pulse deformation caused by amplitude and delay time errors as well as how to determine the magnitude of the errors.



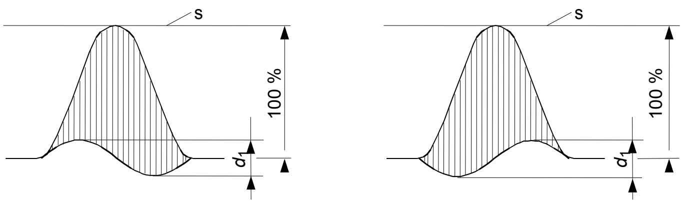
a) Luminance frequency portion and chrominance subcarrier pulse

b) 20*T*-pulse (ITU-T Rec. J.61 – Signal F)

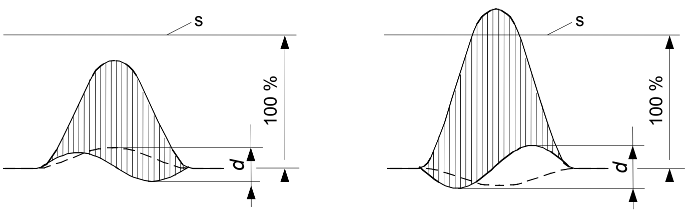
Figure 26 – Generation of 20*T*-pulse



Distortion of the modulated 20*T*-pulse for amplitude-only errors;
top: undistorted 20*T*-pulse (s pulse top of step function signal)
bottom: pulse shapes ($d_1 = d_2 = d_a$)



Distortion of the modulated 20*T*-pulse for delay-time-only errors; pulse shapes



Mixed amplitude and delay-time error;
dashed portion for amplitude-only errors;
d is not a linear addition of d_a and d_1

IEC

Figure 27 – Example of amplitude and delay error using 20*T*-pulse

4.13 Luminance non-linearity

Luminance non-linearity (LUM_{NL}) describes the changing gain for different output levels. It is defined by the linearity figure (minimum-to-maximum slope of the output characteristic).

To determine it, the staircase signal shall be used (Figure 28). The different step heights in the output signal – originally of equal height in the input signal – form the figure for the static linearity. In order to measure the output signal, it is differentiated. Each step transition generates a voltage peak, which is proportional to the relevant step height (Figure 28).

$$LUM_{NL} = \frac{A_{min}}{A_{max}} \tag{26}$$

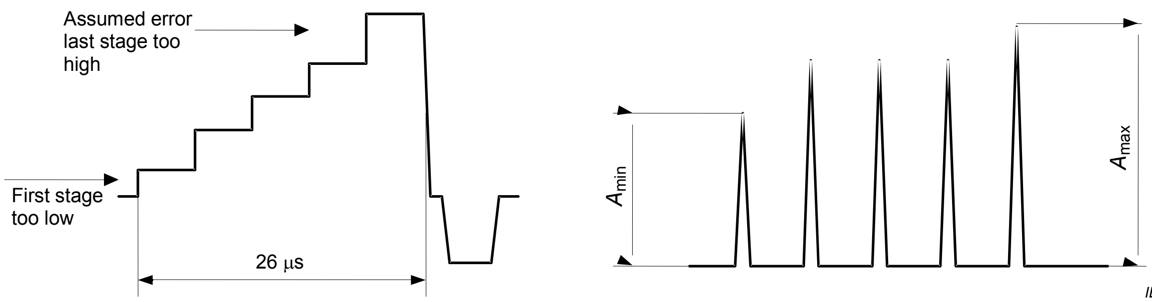


Figure 28 – Staircase signal for measurement of luminance non-linearity before and after differentiation

4.14 Intermodulation distortion (FM stereo radio)

4.14.1 General

In case wanted audio signals are inserted into a stereo transmission system, additional noise occurs besides the harmonics due to the addition and subtraction of the audio signal of the non-linearity and the pilot. The intermodulation products $f_p + f_1$, $f_p - f_1$, $2f_p + f_1$, $2f_1 - f_p$ take effect on the multiplex band or directly on the base band (Figure 29). The required transmission quality is obtained by a defined minimum spacing between noise signals and useful signals.

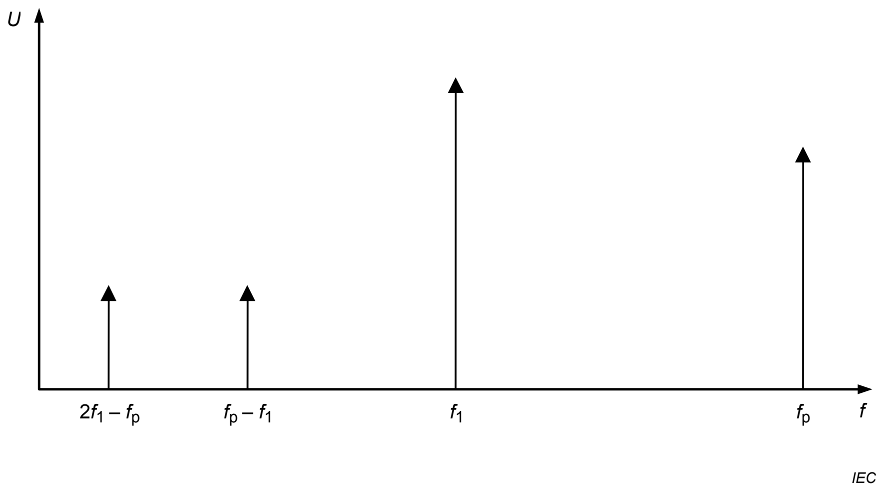


Figure 29 – Example of a possible frequency combination displayed on a spectrum analyser

4.14.2 Equipment required

The following items are required:

Item (see Figure 30)	Quantity	Designation
1	1	Audio signal generator 40 Hz to 15 kHz
8	1	Audio spectrum analyser
2, 7	1	Audio switch

Additionally required depending on equipment under test:

Item (see Figure 30)	Quantity	Designation
3	1	Stereo coder
4	1	FM modulator
5	1	FM demodulator
6	1	Stereo decoder

4.14.3 Connection of equipment

The equipment shall be connected as shown in Figure 30.

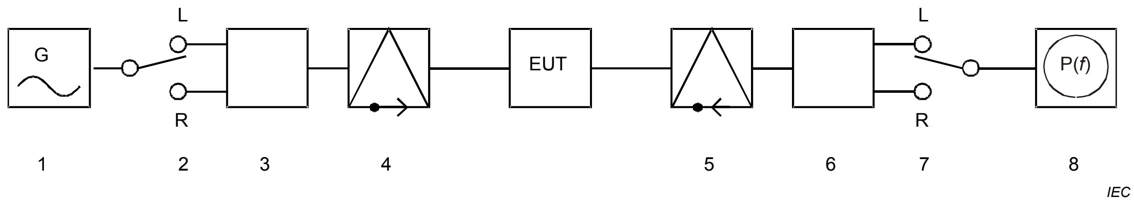


Figure 30 – Arrangement of test equipment for intermodulation distortion

4.14.4 Measurement

The two stereo channels shall be measured separately. The test value, which is compared to the minimum value, is the worst signal-to-noise ratio determined during all measurements.

Switch 2 shall be set to position L = left. The reference level is determined to be 400 Hz. Now, with the pilot audio signal switched off, the level of an audio signal generator is adjusted in such a way that a frequency deviation of 40 kHz results for stereo transmission equipment. Then, the pilot audio signal is switched on. The reference point of the spectrum analyser shall be adjusted to the 400 Hz signal level.

Any audio frequency between 40 Hz and 15 kHz shall not fall below the admissible minimum spacing.

Switch 2 shall be set to position R = right. The same adjustment procedure shall also be performed for this transmission channel.

4.15 Decoding margin (teletext)

4.15.1 General

The decoding margin of a text TV signal is defined in ITU-T Recommendation J.101.

The voltage difference is expressed in per cent in relation to 66 % of the ITS bar.

The text TV generator delivers a text TV signal which is inserted in given TV lines.

In the ITS inserter an 'ITS line 19' test signal is added (test signal 17 according to ITU-T Recommendation J.61). The resulting signal is fed to a VSB IF modulator. In the up-converter the IF signal is converted to the relevant TV channel. The output signal from the equipment under test is connected to a synchronous demodulator, and the demodulated signal is fed to a decoding margin meter. The measurement levels are adjusted as follows:

Output of ITS inserter:	Nominal video, 1 V_{pp}
Output of RF modulator:	Recommended input level of test item

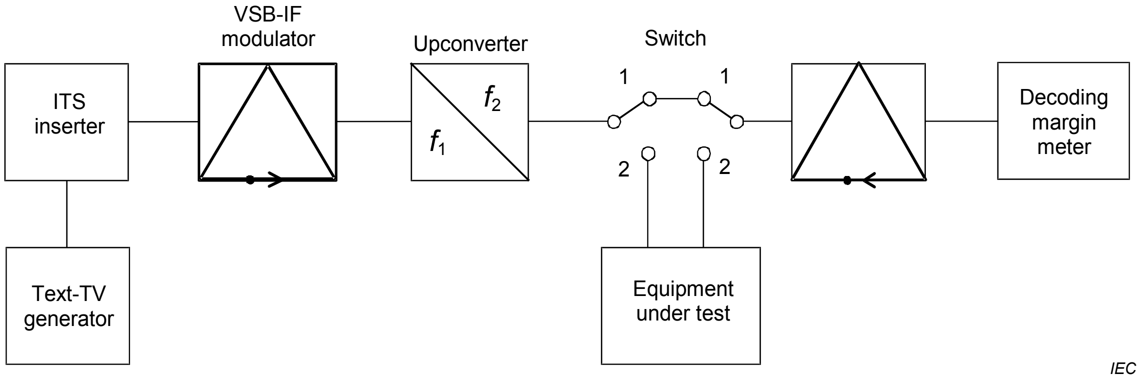


Figure 31 – Principal measuring set-up for determination of decoding margin

4.15.2 Method of measurement and measuring set-up (Figure 31)

First a reference measurement is performed without the test item (switches in position 1) and the decoding margin *DM1* is determined. For TV channel converters the reference measurement is performed at the input and output frequencies of the converter. The resulting reference decoding margin (*DM1*) is the average of the two measurements.

The test equipment is inserted in the measuring set-up and after adjustment of frequencies and levels the resulting decoding margin *DM2* is read.

The deterioration of the decoding margin will then be: (*DM1* – *DM2*)/*DM1*.

DM2 expresses the quality of the data channel.

4.15.3 Applicability of measuring set-up

The decoding margin measured at the reference measurement, *DM1*, shall be as high as possible.

5 Performance requirements and recommendations

5.1 Safety

The safety requirements of all equipment shall conform to IEC 60728-11, where applicable.

5.2 Electromagnetic compatibility

The relevant EMC requirements as laid down in IEC 60728-2 shall be met.

5.3 Environmental

Manufacturers shall publish relevant environmental information on their products in accordance with the requirements of the publications listed in Table 6. This will enable users to judge their suitability with regards to four main requirements: storage, transportation, installation and operation.

Table 6 – Publications for environmental requirements of headend equipment

Environmental requirements	Standards containing requirements
Storage	
(simulated effects of)	
Transportation	
Air freight (combined cold and low pressure)	IEC 60068-2-40
Road transport (bump test)	
Road transport (shock test)	IEC 60068-2-27
Installation or maintenance	
Topple or drop test	IEC 60068-2-31
Free fall test	
Operation	
IP Class protection provided by enclosures	IEC 60529
Cold	IEC 60068-2-1
Dry heat	IEC 60068-2-2
Damp heat	IEC 60068-2-30
Change of temperature (test Nb)	IEC 60068-2-14
Climatic category of component or equipment	For storage and operation as defined in Annex A of IEC 60068-1:2013.
Microphony	Under normal conditions (ventilation, opening of doors in racks, etc.), mechanical vibrations shall not influence the quality of the signals. Under heavy influence from the environment where disturbance could occur, normal operation should be re-established within a few seconds.

5.4 Marking

5.4.1 Marking of equipment

Each equipment shall be legibly and durably marked with manufacturer's name and type number.

5.4.2 Marking of ports

Symbols in accordance with IEC 60417 and IEC 60617 database should be used when marking ports.

6 Equipment characteristics required to be met

6.1 General

The specifications given in Clause 6 represent limits which shall be met over the specified frequency range of the respective equipment. The manufacturer may publish these specifications in his data sheets.

NOTE For special national conditions, see Annex D.

6.2 Power supply voltage

The power supply voltage shall be 230 V ± 10 %, 50 Hz or 110 V ± 10 %, 60 Hz.

6.3 RF signal requirements

6.3.1 Impedance (input)

The nominal input impedance shall be 75 Ω.

NOTE There is also headend equipment with 50 Ω available.

6.3.2 Impedance (output)

The nominal output impedance shall be 75 Ω.

NOTE There is also headend equipment with 50 Ω available.

6.3.3 Return loss (input, output) of equipment

The requirements for return loss of the equipment are specified in Table 7.

Table 7 – Return loss (input, output) of equipment

Frequency range	Grade 1	Grade 2	Grade 3
5 MHz to 10 MHz	Shall be published	Shall be published	Shall be published
10 MHz to 47 MHz	≥ 18 dB	≥ 14 dB	≥ 10 dB
47 MHz to 950 MHz	≥ (18 dB to 1,5 dB/octave) but ≥ 10 dB	≥ (14 dB to 1,5 dB/octave) but ≥ 10 dB	≥ 10 dB
950 MHz to 3 000 MHz	≥ 10 dB	≥ 6 dB (for input) ≥ 10 dB decreasing linearly to 6 dB (for output)	≥ 6 dB (for input) ≥ 10 dB decreasing linearly to 6 dB (for output)
NOTE See Annex A for definition of the specified test frequency range.			

6.3.4 Return loss (output) of headend

The requirements for return loss of the headend are specified in Table 8.

Table 8 – Return loss (output) of headend

Frequency range	Grade 1	Grade 2	Grade 3
5 MHz to 10 MHz	Shall be published	Shall be published	Shall be published
10 MHz to 47 MHz	≥ 18 dB	≥ 14 dB	≥ 10 dB
47 MHz to 950 MHz	≥ (18 dB to 1,5 dB/octave) but ≥ 10 dB	≥ (14 dB to 1,5 dB/octave) but ≥ 10 dB	≥ 10 dB
950 MHz to 3 000 MHz	10 dB decreasing linearly to 6 dB	10 dB decreasing linearly to 6 dB	10 dB decreasing linearly to 6 dB

6.3.5 Typical back-off for digital against analogue signals

The requirements for the typical back-off for digital against analogue signals are specified in Table 9.

Table 9 – Typical levels of digital signals with respect to analogue signals (back-off)

Modulation scheme	Grade 1	Grade 2	Grade 3
OFDM (DVB-T)			
Up to 16 QAM		–19 dB [a]	
64 QAM		–13 dB [a]	
OFDM (DVB-T2)			
Up to 16 QAM		–20 dB [a]	
64 QAM		–15 dB [a]	
256QAM		–10 dB [a]	
OFDM (DVB-C2)			
16 QAM		–20 dB [a]	
64 QAM		–15 dB [a]	
256 QAM		–10 dB [a]	
1024 QAM		–4 dB … –6 dB [a]	
4096 QAM		0 … 2 dB [a]	
QPSK (DVB-S/-S2)		−16 dB	
8PSK (DVB-S2)		−16 dB	
(DVB-C)			
16 QAM		−16 dB	
64 QAM		−10 dB	
256 QAM		−4 dB … −6 dB	
[a] tbc: for further considerations			

6.3.6 Immunity against other signals in the FM radio and TV range

For immunity against other signals in the FM radio and TV range, see IEC 60728-2.

6.3.7 Carrier-to-spurious-signals ratio at output in the frequency range of 40 MHz to 862 MHz

6.3.7.1 Carrier-to-spurious-signals ratio of an analogue TV channel

The carrier-to-spurious-signals ratio of an analogue TV channel at the output and in the frequency range of 40 MHz to 862 MHz shall be ≥ 60 dB.

The measurement method and notes for adjacent channel operation and exception are described in 4.5.

6.3.7.2 Carrier-to-spurious-signals ratio of digital modulated channel with respect to the peak level of an analogue TV carrier

The requirements for carrier-to-spurious-signals ratio of digital modulated channels with respect to the peak level of an analogue TV carrier are specified in Table 10.

Table 10 – Carrier-to-spurious-signals ratio of digital modulated channel with respect to the peak level of an analogue TV carrier

Modulation scheme	Sine wave spurious	Other spurious
16 QAM (DVB-C)	≥ 60 dB	≥ 57 dB
64 QAM (DVB-C)	≥ 60 dB	≥ 57 dB
256 QAM (DVB-C)	≥ 60 dB	≥ 57 dB
QPSK (DVB-S/-S2)	≥ 60 dB	≥ 57 dB
8 PSK (DVB-S2)	≥ 60 dB	≥ 57 dB
OFDM (DVB-T/-T2/-C2)	≥ 60 dB	≥ 57 dB
For other spurious signals, the resolution bandwidth should be 1 MHz.		

6.3.8 Image rejection for AM TV and FM radio

See IEC 60728-2.

6.3.9 Carrier to local oscillator signal ratio at the output for AM TV and FM radio

The carrier to local oscillator signal ratio at the output for AM TV and FM radio shall be ≥ 60 dB.

NOTE Measured at the minimum output level.

6.3.10 Frequency stability

6.3.10.1 General

The signal frequency stability is defined as the maximum deviation to the nominal signal frequency.

6.3.10.2 Frequency stability for FM radio related to the nominal FM radio frequency

The frequency stability for FM radio measured as deviation to the nominal FM radio frequency shall be ≤ 12 kHz.

6.3.10.3 Frequency stability for AM TV related to the nominal AM TV frequency

The requirements for frequency stability for AM TV related to the nominal AM TV frequency are specified in Table 11.

Table 11 – Frequency stability for AM TV related to the nominal AM TV frequency

	Grade 1	Grade 2	Grade 3
AM TV without data	±75 kHz		
AM TV with data	±30 kHz		

6.3.10.4 Long-term frequency stability for digital modulated signals

See Table 12.

Table 12 – Long-term frequency stability for digital modulated signals

Modulation scheme	Grade 1	Grade 2	Grade 3
OFDM (DVB-T/-T2/-C2)	±30 kHz		
QPSK (DVB-S/-S2)	±200 kHz		
8 PSK (DVB-S2)	±200 kHz		
16 QAM (DVB-C)	±100 kHz		
64 QAM (DVB-C)	±100 kHz		
256 QAM (DVB-C)	±100 kHz		
NOTE 1 The figure for QPSK is valid for signal conversion in the headend only; for the outdoor unit, see ETSI ETS 300 158 or ETSI ETS 300 249. NOTE 2 ±30 kHz for DOCSIS signals.			

For OFDM, QPSK and 8 PSK the values in Table 12 are related to frequency converters.

6.3.10.5 Shoulder attenuation for digital modulated signals

The shoulder attenuation for digital modulated signals is specified in Table 13.

Table 13 – Shoulder attenuation for digital modulated signals

Transmission standard	Modulation scheme	Grade 1	Grade 2	Grade 3
DVB-C	16 QAM	37 dB	34 dB	31 dB
	64 QAM	43 dB	40 dB	37 dB
	256 QAM	49 dB	46 dB	43dB
DVB-C2	1 024 QAM (OFDM)	49 dB [a]	46 dB [a]	43 dB [a]
	4 096 QAM(OFDM)	55 dB [a]	52 dB [a]	49 dB [a]
[a] tbc: for further considerations				

For the method of measurement, see 4.5.3.

6.3.11 Phase noise of digital modulated signals at the output of the headend

For any RF carrier of a digitally modulated signal (PSK or QAM) at the output of the headend, the phase noise shall be lower than the values L_a, L_b, L_c, L_d, L_e given in Table 14 at the frequency distances f_a, f_b, f_c, f_d, f_e from the carrier (see also Figure 20a).

Table 14 – Phase noise of a DVB signal (PSK and QAM)

Signal modulation	Frequency distance f_a, f_b, f_c, f_d, f_e →	Phase noise, L_i dB(Hz^{-1})				
		100 Hz	1 kHz	10 kHz	100 kHz	1 000 kHz
	Symbol rate (per second) ↓	L_a	L_b	L_c	L_d	L_e
QPSK (DVB-S)	> 5 × 10^6	–40	–55	–75	–80	–100
QPSK (DVB-S2)	> 5 × 10^6	–40	–55	–75	–80	–100
8 PSK (DVB-S2)		–40	–55	–75	–80	–100
16 QAM	> 3,5 × 10^6 1,7 × 10^6 to 3,5 × 10^6		–32 –41	–74 –80	–94 –100	–104 –104
64 QAM	> 3,5 × 10^6 1,7 × 10^6 to 3,5 × 10^6		–38 –47	–80 –86	–100 –106	–110 –110
256 QAM	> 3,5 × 10^6 1,7 × 10^6 to 3,5 × 10^6		–44 –53	–86 –92	–106 –112	–116 –116

For a digitally modulated signal in the OFDM format, the phase noise can cause CPE, which affects all the carriers simultaneously, and ICI.

For any RF carrier of a DVB signal modulated in the OFDM format, measured with the method of measurement given in 4.9, the value of phase noise shall be lower than the values L_a, L_b, L_c, L_d given in Table 15 at the frequency distances f_a, f_b, f_c, f_d from the carrier (see also Figure 20b).

Table 15 – Phase noise of a DVB signal (OFDM)

Signal modulation	Frequency distance f_a, f_b, f_c, f_d →	Phase noise, L_i dB(Hz^{-1})			
		1 kHz	10 kHz	100 kHz	1 000 kHz
		L_a	L_b	L_c	L_d
OFDM (DVB-T/-T2)		–75	–85	–110	–110
OFDM (DVB-C2)		–85 [a]	–88 [a]	–106 [a]	–125 [a]
[a] tbc: for further considerations					

6.3.12 In-channel group delay variation for digital modulated signals

The requirements for in-channel group delay for digital modulated signals are specified in Table 16.

Table 16 – In-channel group delay variation for digital modulated signals

Modulation scheme	Grade 1	Grade 2	Grade 3
OFDM (DVB-T/-T2/-C2)	NA	NA	100 ns
QPSK (DVB-S/-S2)	NA	NA	100 ns
8 PSK (DVB-S2)	NA	NA	100 ns
16 QAM (DVB-C)	20 ns	60 ns	100 ns
64 QAM (DVB-C)	20 ns	60 ns	100 ns
256 QAM (DVB-C)	20 ns	60 ns	100 ns

For method of measurement, see 4.8.2.

6.3.13 In-channel peak-to-peak amplitude response variation for digitally modulated signals

The value of in-channel peak-to-peak amplitude response variation in the pass-band up to 0,85 f_N shall be lower than the figures given in Table 17.

NOTE f_N is the Nyquist frequency.

Table 17 – In-channel peak-to-peak amplitude response variation of DVB signals

Modulation scheme	Grade 1	Grade 2	Grade 3
OFDM (DVB-T/-T2/-C2)	NA	NA	6 dB
QPSK (DVB-S/-S2)	NA	NA	6 dB
8 PSK (DVB-S2)	NA	NA	6 dB
16 QAM (DVB-C)	1 dB	2 dB	3 dB
64 QAM (DVB-C)	1 dB	2 dB	3 dB
256 QAM (DVB-C)	1 dB	2 dB	3 dB

6.3.14 Stability of sound intercarrier

The requirements for the stability of sound intercarrier are specified in Table 18.

Table 18 – Stability of sound intercarrier

	Grade 1	Grade 2	Grade 3	NOTE
Mono or unmodulated carrier	±5 kHz	±15 kHz		
Stereo or dual sound	The difference between sound sub-carriers shall be maintained (precision half-line offset)		±1 kHz	
NICAM 728, Standard I	6 552 kHz	$\pm 1 \times 10^{-6}$ above the vision carrier		For NICAM, see ETSI ETS 300 163
NICAM 728, Standard B/G	5 850 kHz			

6.3.15 Stability of residual carrier amplitude

The requirements for the stability of residual carrier amplitudes are specified in Table 19.

Table 19 – Stability of residual carrier amplitude

	Grade 1	Grade 2	Grade 3	NOTE
Standard B/G/D/D1/K	$10\ \%^{+2,5\ \%}_{-0\%}$	$10\ \%^{+10\ \%}_{-0\%}$		Measured with black-to-white amplitude and nominal video level
Standard I	20 % ± 2 %	20 % ± 5 %		

6.3.16 Frequency stability – SAT IF/IF converter

The requirements for the frequency stability of a SAT IF/IF converter are specified in Table 20.

Table 20 – Frequency stability – SAT IF/IF converter

Frequency range	Grade 1	Grade 2	Grade 3
0,95 GHz to 2,150 GHz	± 500 kHz		

NOTE For minimum frequency distance of converted satellite signals in the IF range, see Annex G.

6.3.17 Typical modulation error ratio (MER) for a QAM signal

The modulation error ratio MER is defined in 3.1.24. The measurement of MER is a fast and simple method that can provide an indication of the quality of the digital service at the cable headend output interface. This measurement will provide a first indication of the margin to failure of the digital service. It can be used as a signal quality check during headend installation, and as a maintenance tool for basic monitoring of signal quality through the cable TV network. The minimum requirements for the typical modulation error ratio are specified in Table 21.

Table 21 – Minimum requirements for MER for different QAM modulation schemes

Transmission standard	Modulation scheme	Grade 1	Grade 2	Grade 3
DVB-C	16 QAM	33 dB	31 dB	28 dB
	64 QAM	39 dB	37 dB	34 dB
	256 QAM	40 dB	38 dB	35 dB
DVB-C2	1 024 QAM	40 dB [a]	38 dB [a]	35 dB [a]
	4 096 QAM	46 dB [a]	43 dB [a]	39 dB [a]
[a] To be confirmed.				

The measurement shall be performed as described in IEC 60728-1. For the measurement, the use of an equaliser is assumed.

6.3.18 Minimum *C*/*N* values at the output of the headend

This parameter is specified for terrestrial OFDM converters and satellite QPSK IF/IF converters in Table 22.

Table 22 – *C*/*N* values for converters at the headend output

Modulation scheme	Grade 1	Grade 2	Grade 3
OFDM	NA	NA	Values specified in ETSI EN 300 744 +6 dB
QPSK (DVB-S)	NA	NA	12,3 dB
QPSK (DVB-S2)	NA	NA	11,4 dB
8 PSK (DVB-S2)	NA	NA	16 dB

The values in Table 22 are related to the code rates 7/8 (DVB-S) and 9/10 (DVB-S2).

6.4 Composite video signal requirements

6.4.1 Impedance

The nominal input impedance shall be 75 Ω.

Due to its higher mechanical stability, a 50 Ω BNC connector (IEC 61169-8) is recommended also for an impedance of 75 Ω in the video frequency range.

6.4.2 Return loss

For return loss specification, see Table 23.

Table 23 – Return loss

Grade 1	Grade 2	Grade 3
≥ 34 dB	≥ 26 dB	
NOTE Values in nominal transmission range.		

6.4.3 Signal voltage

For signal voltage specification, see Table 24.

Table 24 – Signal voltage

Grade 1	Grade 2	Grade 3
$(1 \pm 0{,}1)\ V_{pp}$		$(1 \pm 0{,}3)\ V_{pp}$

6.4.4 Polarity

The polarity is negative.

NOTE Synchronization level is the lowest or the most negative value.

6.4.5 Offset voltage

The offset voltage shall be ≤ 2,75 V at 75 Ω.

6.5 Audio signal requirements

6.5.1 Input impedance

The nominal input impedance shall be ≥ 600 Ω.

NOTE See 7.18.

6.5.2 Output impedance

The nominal output impedance shall be ≤ 30 Ω.

NOTE See 7.18.

6.5.3 Signal level

The signal levels are specified in Table 25.

Table 25 – Signal level

	Grade 1	Grade 2	Grade 3
AM TV modulator standard B/G/D/D1/K/I [a]	+6 dB(mW) for ±30 kHz deviation		
AM TV modulator standard L	6 dB(mW) = 50 % AM	–6 dB(mW) = 50 % AM	
FM radio modulator	+6 dB(mW) for ±40 kHz deviation		

[a] f_m = 400 Hz, pre- and de-emphasis 50 μs.

6.6 Requirements for decoding margin (teletext)

The decoding margin from the input to the output of the headend shall not deteriorate more than the requirements shown in Table 26.

Table 26 – Requirements for decoding margin (Teletext)

Grade 1	Grade 2	Grade 3
15 %	25 %	35 %

For the method of measurement, see 4.15.

6.7 IF signal requirements (AM-TV)

6.7.1 Impedance

The nominal impedance shall be 75 Ω, which is recommended for all grades. Connectors according to IEC 61169-2 are recommended.

6.7.2 Return loss

Return loss of IF signal is specified in Table 27.

Table 27 – Return loss – IF signal

Grade 1	Grade 2	Grade 3
≥ 18 dB	≥ 14 dB	

6.8 Antennas for terrestrial reception

6.8.1 Impedance

The nominal impedance shall be 75 Ω.

6.8.2 Return loss

Return loss of antennas for terrestrial reception is specified in Table 28.

Table 28 – Return loss – Antennas for terrestrial reception

Grade 1	Grade 2	Grade 3
≥ 18 dB	≥ 14 dB	

6.9 Antenna amplifier

For antenna amplifiers see the corresponding parameters of 6.3.

7 Equipment characteristics required to be published

7.1 General

All applicable parameters given in Clause 7 shall be published as worst-case figures on data sheets. For some parameters, in addition, recommended values are given in Clause 7.

7.2 Environmental conditions

The minimum amount of information to be published on environmental conditions shall be that covered by 5.3.

The operating temperature ranges are specified in Table 29.

Table 29 – Recommended temperature ranges

	Grade 1	Grade 2	Grade 3
Operating temperature range	0 °C to +55 °C	–40 °C to +55 °C Northern Europe –20 °C to +55 °C Central Europe –10 °C to +60 °C Southern Europe	
Operating temperature range within the specification limits	5 °C to +45 °C	5 °C to +55 °C	–10 °C to +55 °C
NOTE For special national conditions, see Annex D.			

The specifications mentioned in Table 29 shall be met at temperatures reached after 30 min of warm-up time.

7.3 Maximum permissible output level

The maximum permissible output level shall be specified on the data sheets as well as on the equipment.

The values are valid for the following minimum carrier-to-interference ratios given in Table 30 to Table 34.

Table 30 – Carrier-to-third-order intermodulation ratio for maximum output level of channel amplifiers/frequency converters

	Grade 1	Grade 2	Grade 3
Standard B/G/I/D/D1/K	≥ 66 dB	≥ 54 dB	≥ 54 dB
Standard L	≥ 48 dB	≥ 48 dB	≥ 42 dB

For the measurement method, see 4.2.

Table 31 – Carrier-to-third-order intermodulation ratio for maximum output level of sub-band, full band, multi-band amplifiers and multi-channel frequency converters for AM TV (not for channel amplifier)

	Grade 1	Grade 2	Grade 3
Standard B/G/I	≥ 80 dB	≥ 66 dB	≥ 66 dB
Standard L	≥ 64 dB	≥ 64 dB	≥ 64 dB
For FM radio	≥ 60 dB	≥ 60 dB	≥ 60 dB

For the measurement method, see 4.3.

Table 32 – Carrier-to-second-order intermodulation ratio for maximum output level of sub-band, full band, multi-band amplifiers and frequency converters for AM TV or FM radio (not for channel amplifier)

Grade 1	Grade 2	Grade 3
≥ 60 dB		

NOTE 1 Only for products being generated by signals in the range 87,5 MHz to 108 MHz and falling in the range 174 MHz to 230 MHz.

For the measurement method, see 4.4.

Table 33 – Carrier-to-intermodulation ratio for maximum output level of FM-TV channel amplifiers/frequency converters

Grade 1	Grade 2	Grade 3
≥ 60 dB		

For the measurement method, see 4.5.2.

Table 34 – Carrier-to-third-order intermodulation ratio for maximum output level of FM TV full band, sub-band amplifiers

Grade 1	Grade 2	Grade 3
≥ 35 dB		

For the measurement method, see 4.4.

NOTE 2 This value includes a margin for additional reception of TV signals at a later time.

NOTE 3 Not applicable to narrowband equipment unless the frequency range covered by the equipment is such that $2f_{min} < f_{max}$.

7.4 Operating range for output level

State the minimum and maximum permissible output levels in order to determine the operating range, if necessary.

7.5 TV standard

Specify the TV standard(s) for which the equipment is intended.

See Annex C for the recommended selectivity diagram for adjacent channel transmission.

7.6 Clamp

Where clamping is employed, specify on the data sheets the method used and the level of performance achieved.

7.7 Noise figure

7.7.1 Equipment without AGC

State the worst value at maximum gain in the specified frequency range. This range is described in Annex A.

7.7.2 Equipment with AGC

Publish the graph for noise in the specified operating range. Alternatively, *C*/*N* or *S*/*N* may be published. An example is shown in Figure 32.

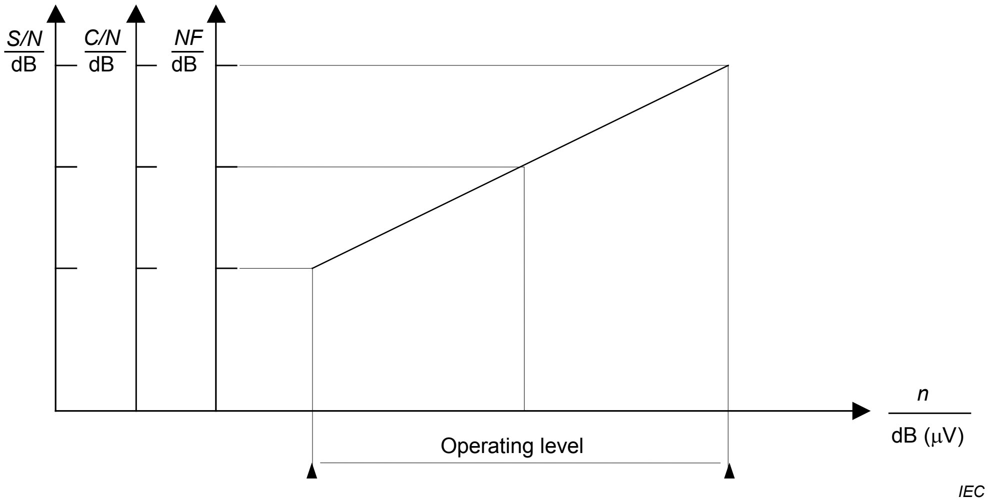


Figure 32 – Example of diagram of *NF, C*/*N* or *S*/*N* for equipment with AGC

7.8 Data control signals, description of interface

For data control signals, the following values shall be stated on the data sheets:

- impedance;
- voltage or level;
- polarity;
- bit rate;
- protocol;
- connector.

7.9 Output level stability for TV modulators, TV converters and pilot generators

State the output level stability for TV modulators, pilot generators and TV converters. The values given in Table 35 should be met.

Table 35 – Output level stability for TV modulators, pilot generators and TV converters

Grade 1	Grade 2	Grade 3
±0,5 dB	±1,0 dB	±2,5 dB

The input level range for conditions mentioned shall be provided.

7.10 Pilot signal

The pilot signal shall be supplied at a constant level. The accuracy of the pilot signal level should be ±0,25 dB.

NOTE The pilot signal can be a CW or modulated carrier.

7.11 Differential gain and phase

7.11.1 Differential gain

The values are specified in Table 36.

Table 36 – Recommendation for differential gain

	Grade 1	Grade 2	Grade 3
Standard B/G/I/D/D1/K and standard L	5 %	8 %	14 %

For the measurement method, see 4.7.2.

7.11.2 Differential phase

The values are specified in Table 37.

Table 37 – Recommendation for differential phase

	Grade 1	Grade 2	Grade 3
Standard B/G/I/D/D1/K	3°	6°	12°
Standard L	5°	8°	12°

For the measurement method, see 4.7.3.

7.12 Group delay variation for analogue TV signals

For details on method of measurement of video frequency, see 4.8.

For measurements concerning AM TV at RF frequencies, use a measuring range between 0,5 MHz and 4,43 MHz apart from the vision carrier. Use a measuring aperture of ≤ 40 kHz. The values are given in Table 38.

Table 38 – Recommendation for group delay variation

	Grade 1	Grade 2	Grade 3
AM TV standard B/G/I/D/D1/K	50 ns	80 ns	80 ns
AM TV standard L	See Annex C		
FM TV	Under consideration		

The values are valid for 0,1 MHz to 4,43 MHz. All values shall be within a tolerance range; a reference is not stated.

For recommendations for modulators Grade 1 and Grade 2, see Annex C.

For the measurement method, see 4.8.

7.13 Luminance non-linearity

The values are specified in Table 39.

Table 39 – Recommendation for luminance non-linearity

	Grade 1	Grade 2	Grade 3
Standard B/G/I	3 %	3 %	8 %
Standard L	5 %	5 %	10 %

NOTE Different videocrypt systems require better values (for example, ≤ 2 %).

For the measurement method, see 4.13.

7.14 2*T*-pulse

The displayed pulse should be within the mask defined in 4.11. The *K*-factor masks for quality grades 1, 2 and 3 are defined in Table 40.

Table 40 – *K*-factor masks for 2*T*-pulse responses

T	Grade 1	Grade 2	Grade 3
±0	+100 % –6 %	+100 % –12 %	+100 % –24 %
±2	±6 %	±12 %	±24 %
±4	±3 %	±6 %	±12 %
±8	±1,5 %	±3 %	±6 %
±12	±1 %	±1,5 %	±3 %

7.15 20*T*-pulse

For the measurement method, see 4.12; value under consideration.

7.16 Hum modulation

The value of the hum modulation shall be given in dB over the specified output range, excepted for modulators, demodulators and frequency converters for analogue signals.

For the measurement method, see 4.10.

NOTE The value only applies to channels carrying signals.

In some countries with TV-standard I, the NICAM carrier frequency and bit rate are locked to each other. In this case, the intercarrier frequency needs to be precisely maintained.

7.17 Television carrier-to-noise ratio

For the measurement method, see 4.6.1. The conditions of measurements including the defined bandwidth shall be stated.

7.18 Audio in TV

Specify on the data sheets if the audio input is balanced or unbalanced. A balanced input and a connector according to IEC 60130-9 should be used. Pin and signal applications are given in Annex B.

Audio signal-to-noise-ratio shall be measured with weighting according to ITU-R Recommendation BS.468-4 and quasi-peak detection.

7.19 Processing units for FM radio

7.19.1 Audio input

Specify on the data sheets if the audio input is balanced or unbalanced. A balanced input and a connector according to IEC 60130-9 should be used. Pin and signal applications are given in Annex B.

7.19.2 Stereo crosstalk

The crosstalk suppression of the stereo channels should be better than 30 dB in the frequency range 200 Hz to 10 kHz. State the values together with the test frequencies.

7.19.3 Total harmonic distortion

The total harmonic distortion ratio produced by an FM converter within the range 40 Hz to 15 kHz should be better than 46 dB when using a test signal generator modulated with a signal in the range 40 Hz to 7,5 kHz and set to provide an FM signal having 40 kHz deviation.

7.19.4 Intermodulation distortion

The resulting intermodulation products should not be less than 40 dB below the level of the wanted reference audio. For the measurement method, see 4.14.

7.19.5 Deviation, pre-emphasis

Values for deviation and pre-emphasis shall be published.

7.20 Antennas for terrestrial reception

7.20.1 Antenna gain

The minimum gain of the receiving antenna with respect to the half-wave dipole for a nominal impedance of 75 Ω and a linear polarization stating the relevant frequency range shall be supplied on the data sheets.

7.20.2 Sidelobe suppression

The recommended values for sidelobe suppression are specified in Table 41.

Table 41 – Recommendations for sidelobe suppression

Grade 1	Grade 2	Grade 3
> 18 dB	> 18 dB	> 10 dB

NOTE The values refer to the maximum of the main lobe.

7.20.3 Return loss of antennas

The return loss of the antenna when measured with respect to its specific impedance should be not less than given in Table 42.

Table 42 – Recommendation for return loss of antennas

	Grade 1	Grade 2	Grade 3
TV channel antenna	> 20 dB	> 16 dB	> 14 dB
TV multi-channel antenna	> 16 dB	> 14 dB	> 14 dB
FM antenna	> 14 dB	> 10 dB	> 10 dB

7.21 Control signals for outdoor units

Control signals for outdoor units shall meet the specifications of IEC 61319-1.

Annex A
(normative)

Definition of the specified test frequency range for return loss and noise figure

A.1 Test frequency range for TV channel processor

The test frequency range for TV channel processor is shown in Figure A.1.

When measuring noise, it should be taken into consideration that the bandwidth of the measuring system used is within the transmission bandwidth of the equipment under test as shown in Figure A.1. The lowest measuring point using standard B/G is, for example:

$$f_{\text{vision}} - 0{,}75\ \text{MHz} + 1/2\ \text{measuring bandwidth}$$

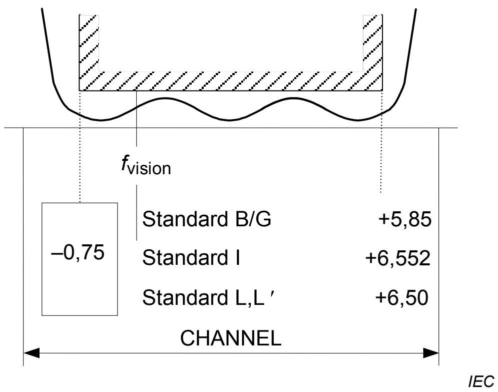


Figure A.1 – Test frequency range for TV channel processors

A.2 Test frequency range for sub-band, full-band and multi-band amplifiers

The test frequency range for sub-band, full-band and multi-band amplifiers is shown in Figure A.2.

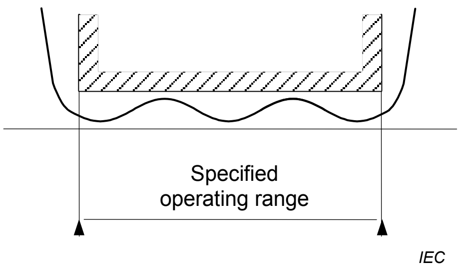


Figure A.2 – Test frequency range for sub-band, full-band and multi-band amplifiers

A.3 Test frequency range for an FM radio channel processor

The test frequency range for an FM radio channel processor is shown in Figure A.3.

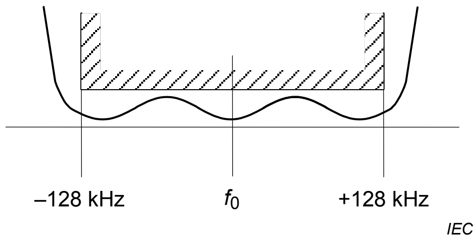


Figure A.3 – Test frequency range for an FM radio channel processor

Annex B
(informative)

Audio connector for European system according to IEC 60130-9

B.1 Contact allocation and mechanical dimensions

Figure B.1 and Table B.1 show the contact allocation and numbering as well as the mechanical dimensions of audio connectors according to IEC 60130-9.

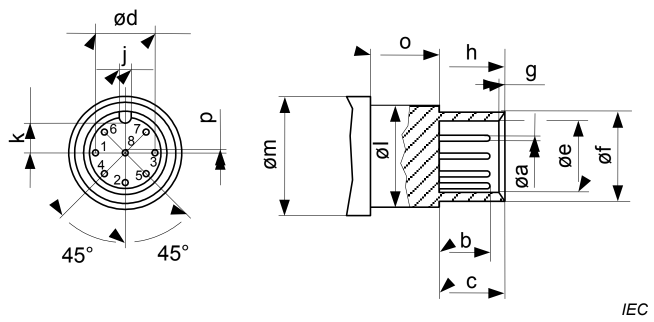


Figure B.1 – Contact allocation and mechanical dimensions

Table B.1 – Mechanical dimensions

Reference	mm	
	Max.	**Min.**
∅ a	1,5	1,46
b	8,5	7,5
c	9,3	8,8
∅ d	7,05	6,95
∅ e	12,4	12,1
∅ f	13,6	13,1
g	1	–
h	9	8,5
j	2,4	2,2
k	4,9	4,55
∅ l	16,5	–
∅ m	18	–
o	–	15
p	0,75	0,65

B.2 Signal-to-pin allocations and applications

The signal-to-pin allocation is shown in Table B.2. Table B.3 shows the audio applications.

Table B.2 – Signal-to-pin allocation

Pin	Signal
1	Audio L+/Mono 1+
2	Screen
3	Audio R+/Mono 2+
4	Audio L-/Mono 1-
5	Audio R-/Mono 2-
6	Line, Contact 1
7	Line, Contact 2
8	Common line

Table B.3 – Application

Application	Pin 6 – 8	Pin 7 – 8
Mono	Open	Closed
Stereo	Closed	Open
Dual sound	Open or Closed	Open or Closed

Annex C
(informative)

Selectivity diagram for adjacent channel transmission

C.1 General

If not otherwise stated, the values of the bandpass width apply only to Grade 1 equipment. For the necessary interference ratio of 60 dB in the adjacent channel, the sideband suppression (for example, 16 dB using standard B/G) is considered.

C.2 TV modulator for standard PAL B/G with mono or stereo sound

The requirements are shown in Figure C.1 and specified in Table C.1.

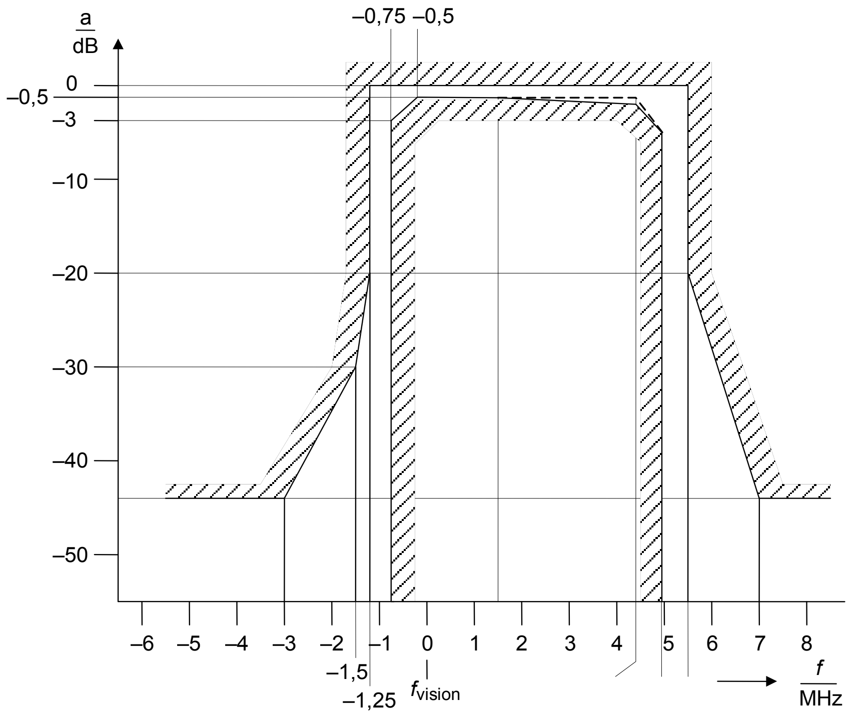


Figure C.1 – Selectivity diagram for PAL B/G with mono or stereo sound

Table C.1 – Selectivity table for PAL B/G with mono or stereo sound

Δ*f* MHz	Modulator		RF-IF-RF converter	
	a dB	***a*** dB	***a*** dB	***a*** dB
≤ 3,0	–	–44	–	–44
–1,5	–	–30	–	–30
–1,25	–	+0,5/–20	–	+0,5/–20
–0,75	–3,0	+0,5	–3	+0,5
–0,5	–0,5	+0,5	–0,5	+0,5
1,5	–0,5	+0,5	–0,5	+0,5
4,43	–0,5	+0,5	–0,5	–
4,9	–3	+0,5	–	–
5,5	–	+0,5/–20	–	+0,8/–20
6,0	–	–30	–	–30
≥ 7,0	–	–44	–	–44

C.3 TV modulator for standard PAL B/G with NICAM 728 in the lower adjacent channel

The requirements are shown in Figure C.2.

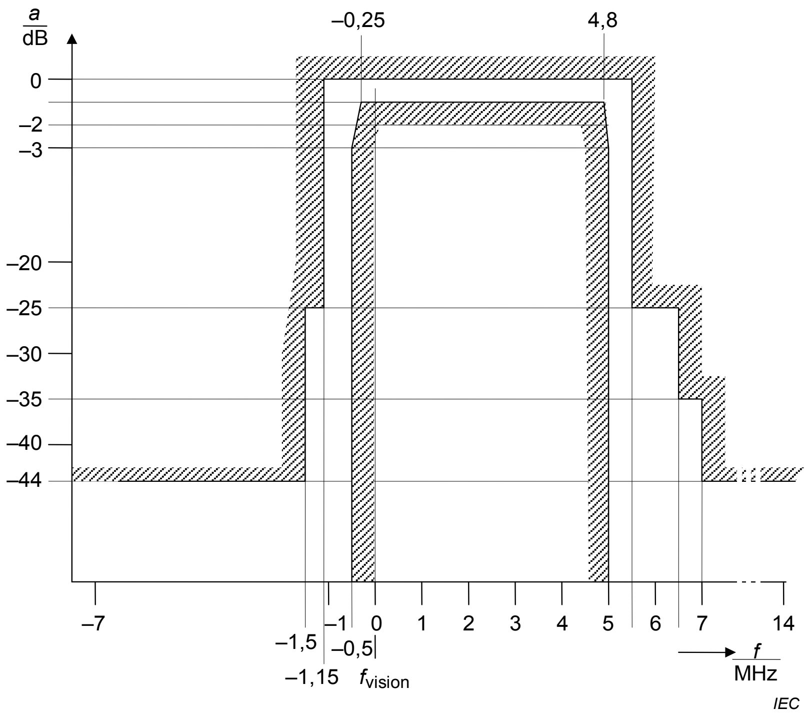


Figure C.2 – Selectivity diagram for PAL B/G with NICAM 728 in the lower adjacent channel

C.4 Standard PAL I

The requirements are shown in Figure C.3.

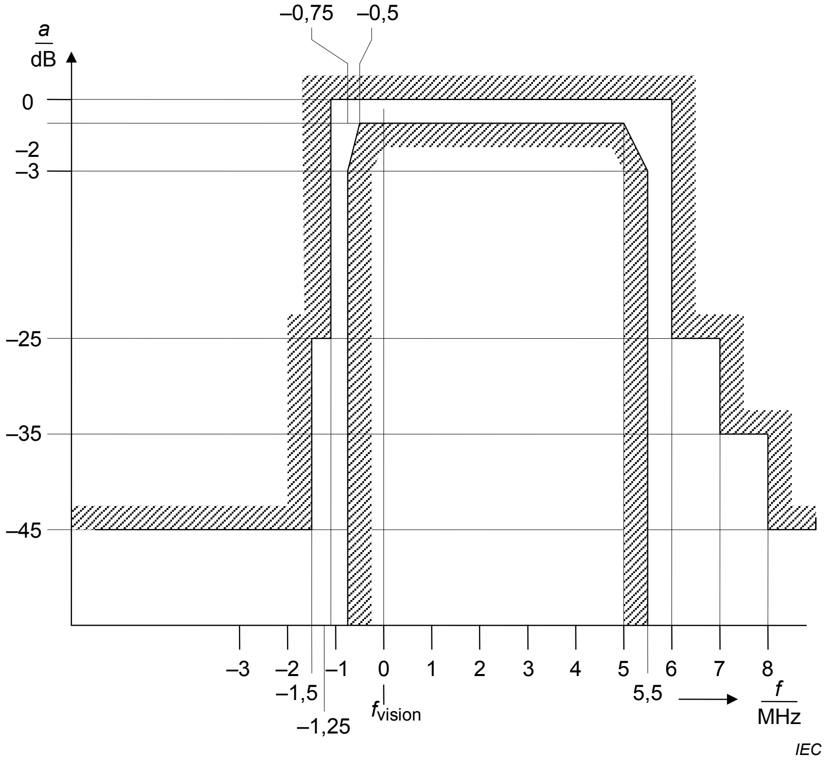


Figure C.3 – Selectivity diagram for PAL I

C.5 Group delay for the standards B/G, D/D1/K and I

The requirements are shown in Figure C.4.

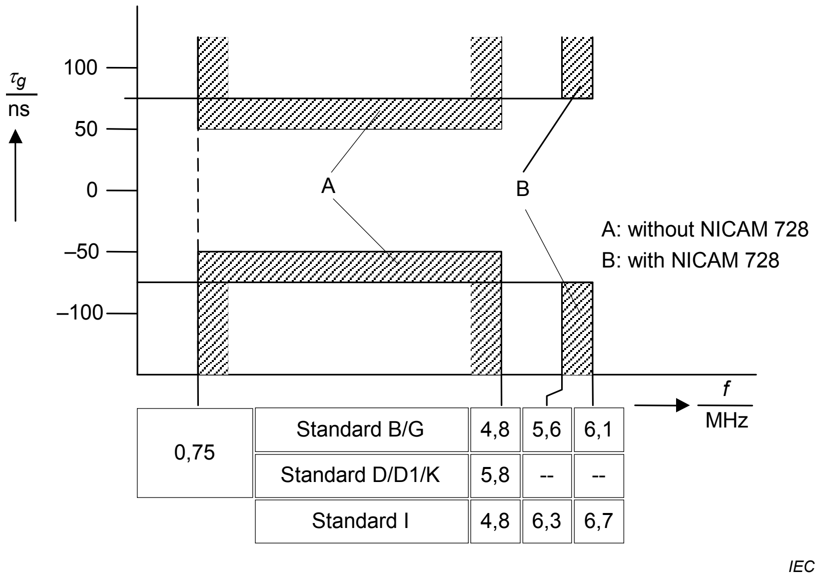


Figure C.4 – Group delay mask for the standards B/G, D/D1/K and I

C.6 Group delay pre-correction for TV modulator for standard B/G

The group delay pre-correction is specified in Table C.2, and shown in Figure C.5.

Table C.2 – Group delay pre-correction table for standard B/G

Frequency MHz	**Pre-correction** ns	**Tolerance** ns	
		Grade 1	Grade 2
0	0	±12	±24
0,25	5	±12	±24
1	53	±12	±24
2	90	±12	±24
3	75	±12	±24
3,75	0	±12	±24
4,43	–170	±20	±40
4,8	–400	±90	±180

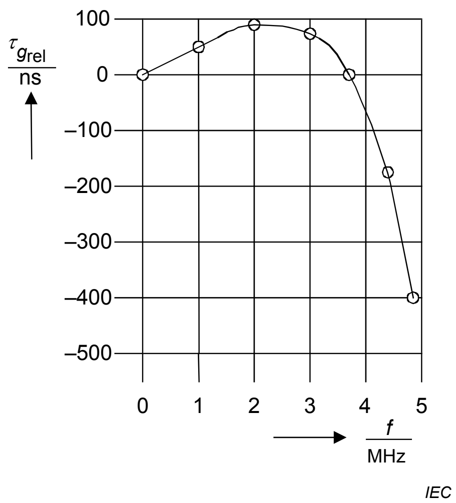


Figure C.5 – Group delay pre-correction diagram for standard B/G

C.7 TV modulator for standard SECAM L

The requirements are shown in Figure C.6.

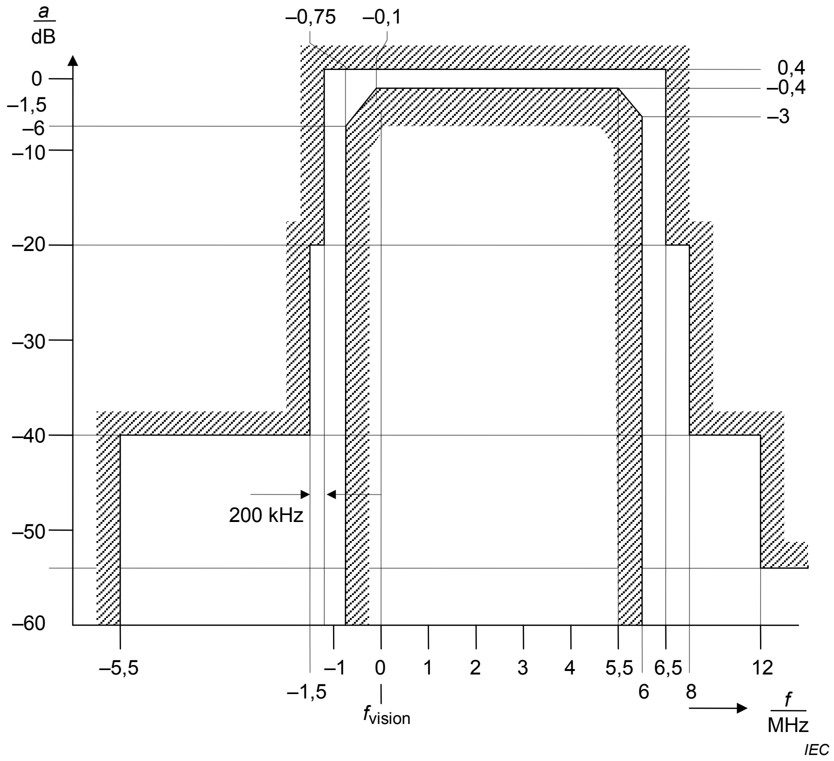


Figure C.6 – Selectivity diagram for SECAM L

C.8 Group delay for TV modulator for standard SECAM L

The requirements are shown in Figure C.7.

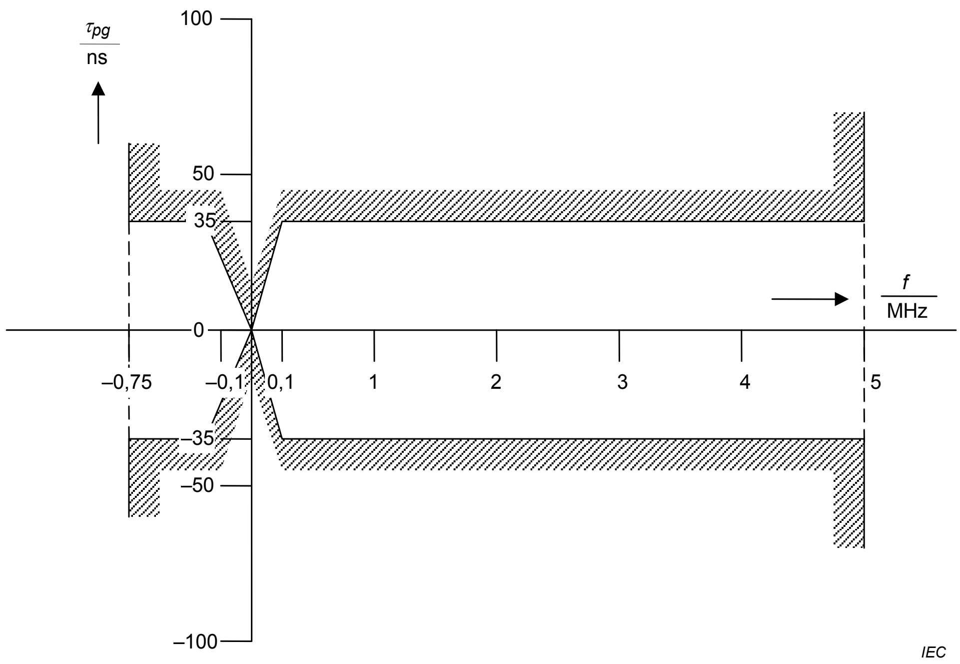
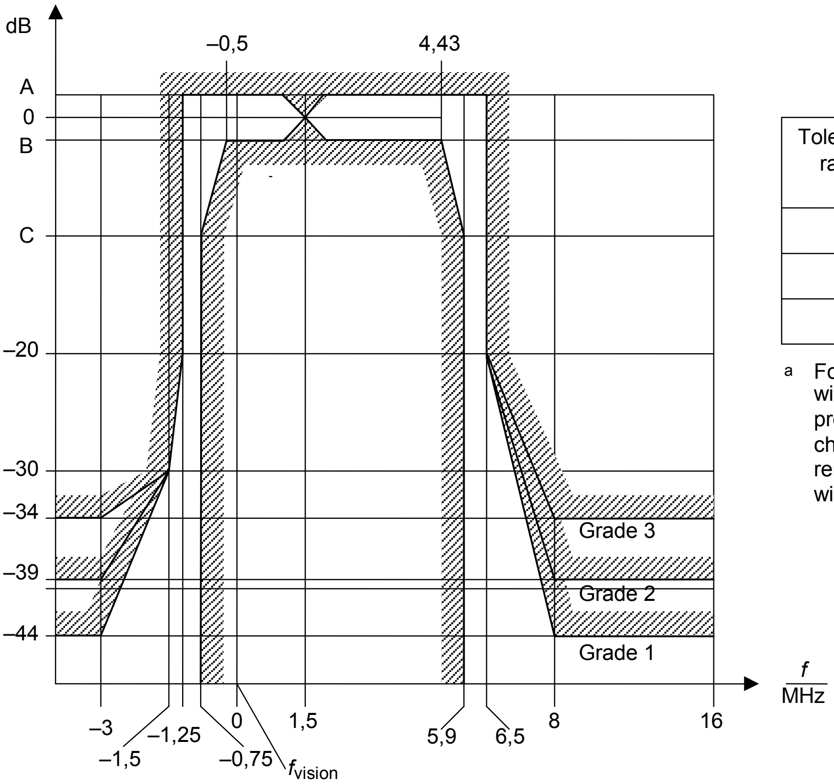


Figure C.7 – Group delay mask for SECAM L

C.9 TV modulator for standard PAL D/K with mono or stereo sound

The requirements are shown in Figure C.8.



Tolerance range	Grade headend		
	1	2	3 [a]
A	+0,5	+1	+2
B	–0,5	–2	–2
C	–5		

[a] For MATV equipment a modulation without VSB reduction is permitted provided that the distribution of channels is not considered. The remaining parameter shall be complied with.

IEC

NOTE The standard D1 contains a NICAM sound carrier at 5,85 MHz.

Figure C.8 – Selectivity diagram for PAL D/K

Annex D
(informative)

Differences in some countries

D.1 General

Special national conditions are national characteristics or practice that cannot be changed even over a long period, for example, climatic conditions, electrical earthing conditions.

For the countries for which the relevant special national conditions apply, these provisions are normative, for other countries they are informative.

D.2 Finland, Sweden

In Finland and Sweden all equipment installed in locations that are not temperature-controlled shall meet the requirements within the temperature range –40 °C to +55 °C.

Annex E
(normative)

Correction factors for noise

E.1 Signal level measurement

When measuring a signal level, the contribution of noise can be taken into account by reducing the measured signal level S_m by an amount CF that depends on the difference D between the measured signal S_m and noise N_m levels.

Firstly calculate the difference D:

$$D = S_m - N_m$$

then from Table E.1 or Figure E.1 derive the correction factor CF and apply it to obtain the signal level S using the following formula:

$$S = S_m - CF$$

E.2 Noise level measurement

When measuring a noise level, the contribution of the measuring equipment noise can be taken into account by reducing the measured noise level by an amount given by the correction factor CF indicated in Table E.1 and in Figure E.1, which depends on the difference D between the noise level N_m measured when the measuring equipment is connected to the system or equipment under test and that N_{eq} measured when the input of the measuring equipment is terminated on its characteristic impedance.

Firstly calculate the difference D:

$$D = N_m - N_{eq}$$

Then, from Table E.1 or Figure E.1, derive the correction factor CF and apply it to obtain the noise level N using the following formula:

$$N = N_m - CF$$

NOTE If the level difference D is lower than 2 dB, the reliability of the measurement becomes very low due to the big value of the correction factor CF.

Table E.1 – Noise correction factor

Level difference, *D* dB	**Correction factor, *CF*** dB
3,0	3,02
4,0	2,20
5,0	1,65
8,0	0,75
9,0	0,58
10,0	0,46

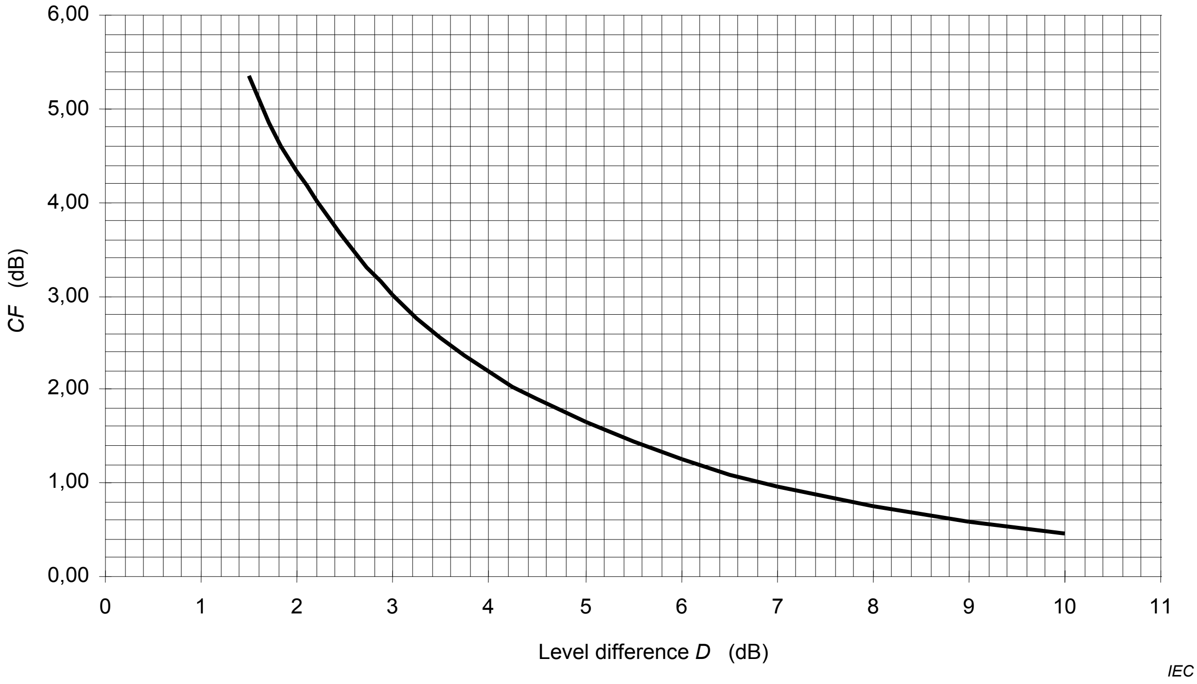


Figure E.1 – Noise correction factor *CF* (dB) versus measured level difference *D* (dB)

Annex F
(informative)

Digital signal level and bandwidth

F.1 RF/IF power ("carrier")

When describing the QAM signals employed by DVB-C or the PSK signals employed by DVB-S/-S2 (QPSK for DVB-S and -S2, 8 PSK for DVB-S2), it is common to refer to the modulated RF/IF signal as "carrier" *C*, mainly to distinguish it from "signal" *S* which is generally used to refer to the baseband demodulated signal.

Strictly, it is incorrect to describe this signal as "carrier" because QAM and QPSK (which is equivalent to 4-state QAM) are suppressed carrier modulation schemes. For OFDM (employed by DVB-T/-T2/-C2), with thousands of suppressed carriers and assorted pilot tones, the label "carrier" is even more inappropriate.

Therefore, the term "wanted information power" should be more appropriately used to consider the "RF/IF power" in the transmitted channel, but most of the engineers and technical people involved in CATV work will continue to use the term "carrier" for this parameter, particularly when talking about the "carrier"-to-noise ratio.

The "carrier", or the "RF/IF power", is the total power of the modulated RF/IF signal as would be measured by a thermal power sensor in the absence of any other signals (including noise).

If the measuring set is able to measure the power in a small part of the channel spectrum, the total power can be obtained taking into account the bandwidth of the channel or what is called "equivalent signal bandwidth" of the digital channel.

F.2 Occupied bandwidth of a digital signal

F.2.1 QAM/QPSK modulation

For DVB systems using the QAM/QPSK modulation, the passband spectrum is shaped by root raised cosine filtering with a roll-off factor α = 0,15 for DVB-C systems, α = 0,35 for DVB-S systems, or additionally α = 0,25 and α = 0,2 for DVB-S2 systems.

For an ideal QAM/QPSK system this means that all the RF/IF power will lie in the frequency band

$$f_C \pm (1 + \alpha)\, f_S/2 \qquad \text{(F.1)}$$

where

f_C is the carrier frequency;

f_S is the symbol rate of the modulation;

α is the filter roll-off factor.

This means that the occupied bandwidth is given by the formula

$$BW_{OCC(QAM/QPSK)} = (1 + \alpha)\, f_S \qquad \text{(F.2)}$$

where

$BW_{OCC(QAM/QPSK)}$ is the occupied bandwidth;

α is the filter roll-off factor;

f_S is the symbol rate of the modulation.

The RF/IF power (or "carrier") is the total power in this "rectangular" bandwidth, with no further filtering applied. This bandwidth is used for defining the channel width, the transponder bandwidth and so on. Formula (F.2) above can be used to obtain the useable symbol rate in a given channel bandwidth:

$$f_S = BW_{OCC}/(1 + \alpha) \tag{F.3}$$

where

f_S is the symbol rate of the modulation;

BW_{OCC} is the occupied bandwidth;

α is the filter roll-off factor.

F.2.2 OFDM modulation

For DVB systems using OFDM modulation the definition of used bandwidth is expressed differently because of the radically different modulation technique, although the principle is very similar. The OFDM "shoulders" are not considered to be wanted information power, and are not included in the RF/IF power calculation, even though the power does actually come out of the transmitter:

$$BW_{OCC(OFDM)} = n \times f_{SPACING} \tag{F.4}$$

where $BW_{OCC(OFDM)}$ is the occupied bandwidth and the values of n and $f_{SPACING}$ are given for 8 MHz channel spacing in Table F.1.

Table F.1 – Total number of carriers and channel spacing for the OFDM modes (8 MHz channel)

Mode	n	$f_{SPACING}$	Format
1k	853	8 929 Hz	DVB-T2
2k	1 705	4 464 Hz	DVB-T/T2
4k	3 409	2 232 Hz	DVB-T2, DVB-C2
8k	6 817	1 116 Hz	DVB-T/T2
16k	13 633	558 Hz	DVB-T2
32k	27 265	279 Hz	DVB-T2

In a multi-signal system (for example, a CATV network), measurement of the RF/IF power in a single channel requires a frequency selective technique. This could employ a thermal power meter preceded by a suitably calibrated channel filter, a spectrum analyser with band power measurement capability, or a measuring receiver. Depending on the measurement technique, a filter may be required to exclude the "shoulders" of a single OFDM signal.

F.3 Noise bandwidth

F.3.1 General

The transmission of digitally modulated signals employs Nyquist filtering split equally between the transmitter and receiver.

F.3.2 QAM/QPSK/8 PSK modulation

The noise bandwidth of the receiver equals the symbol rate f_S. This is considered to be appropriate for *C*/*N* measurements of digital TV systems since this reflects the amount of noise entering the receiver. This is also consistent with the same assumption for analogue TV signals. This leads to the following formula:

$$BW_{\mathrm{NOISE(QAM/QPSK)}} = f_S \quad \text{(F.5)}$$

F.3.3 OFDM modulation

Because the OFDM "shoulders" are not considered to be wanted information power, the noise bandwidth can be assumed to equal the occupied bandwidth:

$$BW_{\mathrm{NOISE(OFDM)}} = BW_{\mathrm{OCC(OFDM)}} \quad \text{(F.6)}$$

F.4 Equivalent signal bandwidth

F.4.1 General

The transmission of digitally modulated signals employs Nyquist filtering split equally between the transmitter and receiver; therefore the RF/IF channel bandwidth (transmitter bandwidth) has a –3 dB bandwidth that is equal to the receiver bandwidth.

F.4.2 QAM/QPSK/8 PSK modulation

The "equivalent signal bandwidth" *BW* (–3 dB bandwidth) is equal to the receiver noise bandwidth for QAM/QPSK modulation:

$$BW_{\mathrm{(QAM/QPSK)}} = f_S \quad \text{(F.7)}$$

F.4.3 OFDM modulation

Because the OFDM "shoulders" are not considered to be wanted information power, the "equivalent signal bandwidth" *BW* (–3 dB bandwidth) can be assumed equal to the occupied bandwidth for OFDM modulation:

$$BW_{\mathrm{(OFDM)}} = BW_{\mathrm{OCC(OFDM)}} \quad \text{(F.8)}$$

F.5 Examples

In Table F.2, examples are given for the "occupied bandwidth" or "channel bandwidth", the "noise bandwidth" and the "equivalent signal bandwidth" for the QAM, QPSK and OFDM modulation techniques.

Table F.2 – Examples of bandwidths for digital modulation techniques

Digital modulation	**Roll-off factor, α**	**Occupied or channel bandwidth** MHz	**Noise bandwidth, BW_{NOISE}** MHz	**Equivalent signal bandwidth, BW** MHz
QPSK	0,35	37,125	27,5	27,5
QAM	0,15	8	6,95	6,95
		7	6,09	6,09
OFDM	–	8	7,61	7,61
		7	6,66	6,66

Annex G
(informative)

Minimum frequency distance of converted satellite signals in the IF range

When single transponders of satellite signals from different LNBs are converted to a common output IF range, for the minimum channel spacing the oscillator tolerances of two LNBs and the channel converter should be added to the transponder bandwidths.

NOTE As stated in ETSI ETS 300 158 and ETSI ETS 300 249, the maximum frequency tolerance of an LNB is 3 MHz.

If all signals are from one single LNB, only the tolerances of the channel converter should be added to the transponder bandwidth. The requirements are shown in Figure G.1.

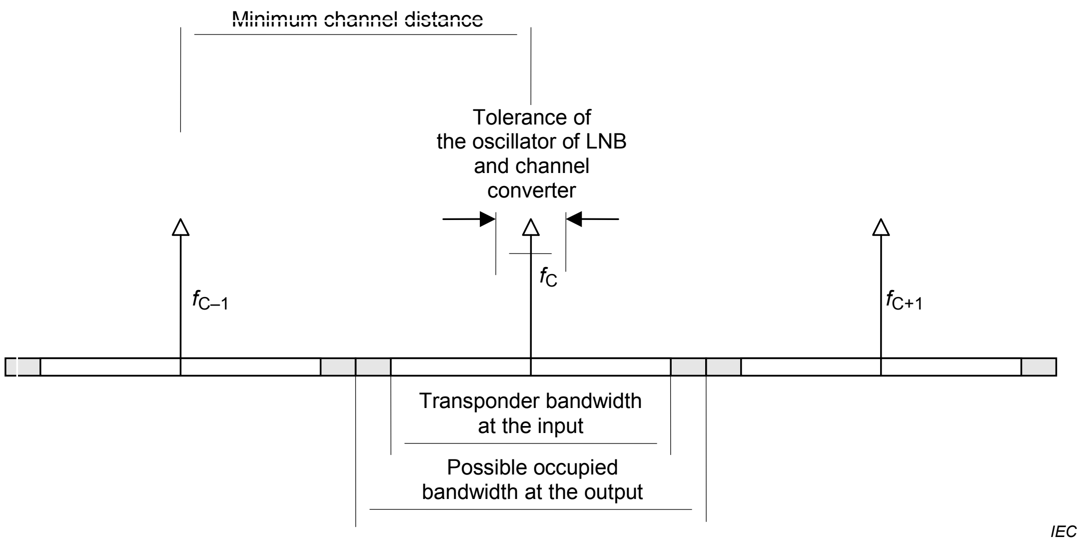


Figure G.1 – Frequency tolerance of converted signals in the IF range

The bandwidth of a converted signal is the distance between the two measured frequencies, where the signal is 15 dB below the top of the transmitted signal.

Annex H
(informative)

Measurement errors which occur due to mismatched equipment

The matching condition is met when the error introduced by the mismatch of the equipment facing the EUT and that of the EUT is acceptable. Examples of maximum errors of measurement results are given in Figure H.1 and Figure H.2.

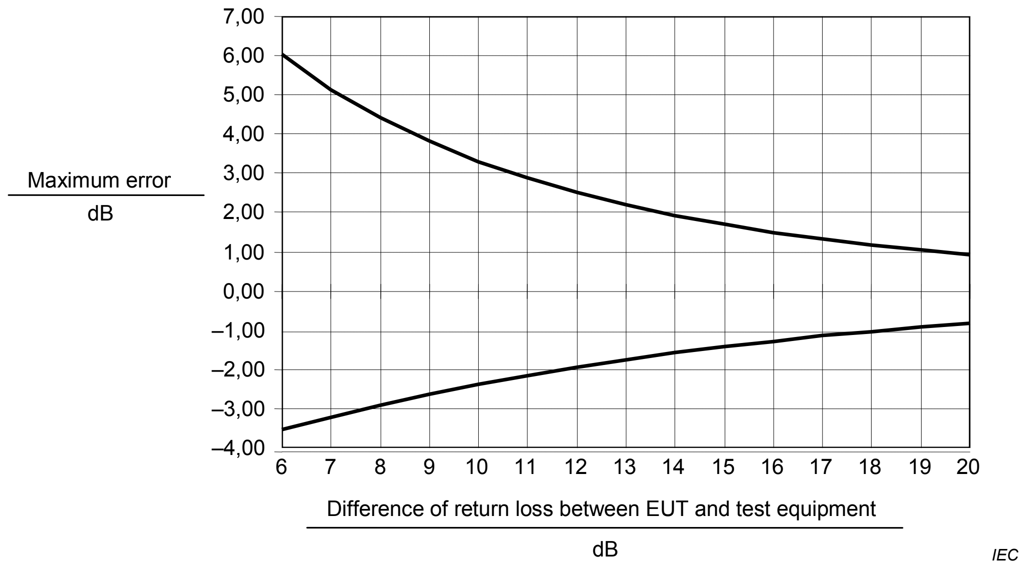


Figure H.1 – Error concerning return loss measurement

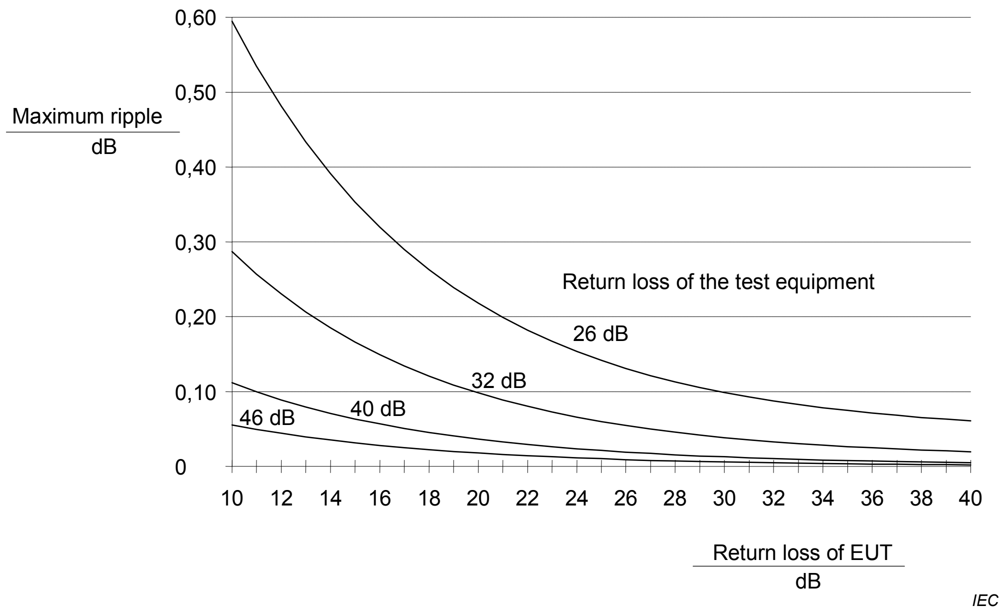


Figure H.2 – Maximum ripple

The return loss of the test equipment should be at least 10 dB better than the expected EUT value.

Annex I
(normative)

Correction factor for spectrum analyser

The correction factor (K_{sa}) for a typical spectrum analyser is about 1,7 dB and is due to two contributions:

- +2,5 dB – term for the effect of the detector/log amplifier (it accounts for the correction of 1,05 dB due to the narrowband envelope detection and of 1,45 dB due to the logarithmic amplifier);
- –0,8 dB – term that takes into account that the equivalent noise bandwidth of the IF filter of the spectrum analyser is greater than its nominal resolution bandwidth (*RSBW*) by a factor of 1,2.

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