

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Réseaux de distribution par câbles pour signaux de télévision, signaux de
radiodiffusion sonore et services interactifs –
Partie 5: Équipements de tête de réseau**



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

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Partie 5: Équipements de tête de réseau**

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CONTENTS

FOREWORD.....	9
INTRODUCTION.....	11
1 Scope.....	12
2 Normative references.....	15
3 Terms, definitions, symbols and abbreviations.....	17
3.1 Terms and definitions.....	17
3.2 Symbols.....	21
3.3 Abbreviations.....	22
4 Methods of measurement.....	24
4.1 Methods of measurement for digitally modulated signals.....	24
4.1.1 General.....	24
4.1.2 Basic assumptions and measurement interfaces.....	24
4.1.3 Signal level for digitally modulated signals.....	24
4.2 Single-channel intermodulation specification for channel amplifier and frequency converter.....	26
4.3 Three-carrier intermodulation measurement.....	27
4.4 Two carrier intermodulation measurements for second- and third-order products.....	28
4.4.1 General.....	28
4.4.2 Intermodulation products with test signals at frequencies f_a and f_b	29
4.4.3 Signal levels.....	29
4.5 Carrier-to-spurious signal ratio at the output.....	29
4.5.1 Carrier-to-spurious signal ratio at the output of equipment for AM TV systems.....	29
4.5.2 Carrier-to-spurious signal ratio at the output of equipment for FM TV systems.....	30
4.5.3 Shoulder attenuation.....	31
4.6 Signal-to-noise measurement.....	32
4.6.1 Television carrier-to-noise ratio (analogue modulated signals).....	32
4.6.2 RF signal-to-noise ratio ($S_{D,RF}/N$) for digitally modulated signals.....	35
4.7 Differential gain and phase for PAL/SECAM signals.....	36
4.7.1 General.....	36
4.7.2 Differential gain (for PAL/SECAM only).....	37
4.7.3 Differential phase.....	38
4.8 Group delay measurements.....	41
4.8.1 Group delay variation of analogue TV signals.....	41
4.8.2 Procedure for the measurement of group delay variation on DVB channel converters.....	42
4.9 Phase noise of an RF carrier.....	45
4.9.1 General.....	45
4.9.2 Equipment required.....	45
4.9.3 Connection of the equipment.....	46
4.9.4 Measurement procedure.....	46
4.9.5 Presentation of the results.....	46
4.10 Hum modulation of carrier.....	48
4.10.1 General.....	48
4.10.2 Description of the method of measurement.....	48

4.10.3	Measuring procedure	49
4.10.4	Calculating the hum modulation ratio	50
4.11	2T-pulse response, K-factor	51
4.12	Chrominance-luminance delay inequalities (20T-pulse method)	52
4.13	Luminance non-linearity	54
4.14	Intermodulation distortion (FM stereo radio)	54
4.14.1	General	54
4.14.2	Equipment required	55
4.14.3	Connection of equipment	55
4.14.4	Measurement	55
4.15	Decoding margin (teletext)	55
4.15.1	General	55
4.15.2	Method of measurement and measuring set-up (Figure 31)	56
4.15.3	Applicability of measuring set-up	56
5	Performance requirements and recommendations	56
5.1	Safety	56
5.2	Electromagnetic compatibility	56
5.3	Environmental	56
5.4	Marking	57
5.4.1	Marking of equipment	57
5.4.2	Marking of ports	57
6	Equipment characteristics required to be met	57
6.1	General	57
6.2	Power supply voltage	58
6.3	RF signal requirements	58
6.3.1	Impedance (input)	58
6.3.2	Impedance (output)	58
6.3.3	Return loss (input, output) of equipment	58
6.3.4	Return loss (output) of headend	58
6.3.5	Typical back-off for digital against analogue signals	58
6.3.6	Immunity against other signals in the FM radio and TV range	59
6.3.7	Carrier-to-spurious-signals ratio at output in the frequency range of 40 MHz to 862 MHz	59
6.3.8	Image rejection for AM TV and FM radio	60
6.3.9	Carrier to local oscillator signal ratio at the output for AM TV and FM radio	60
6.3.10	Frequency stability	60
6.3.11	Phase noise of digital modulated signals at the output of the headend	61
6.3.12	In-channel group delay variation for digital modulated signals	62
6.3.13	In-channel peak-to-peak amplitude response variation for digitally modulated signals	63
6.3.14	Stability of sound intercarrier	63
6.3.15	Stability of residual carrier amplitude	63
6.3.16	Frequency stability – SAT IF/IF converter	63
6.3.17	Typical modulation error ratio (MER) for a QAM signal	64
6.3.18	Minimum C/N values at the output of the headend	64
6.4	Composite video signal requirements	64
6.4.1	Impedance	64
6.4.2	Return loss	65

6.4.3	Signal voltage	65
6.4.4	Polarity	65
6.4.5	Offset voltage	65
6.5	Audio signal requirements	65
6.5.1	Input impedance	65
6.5.2	Output impedance	65
6.5.3	Signal level	65
6.6	Requirements for decoding margin (teletext)	66
6.7	IF signal requirements (AM-TV)	66
6.7.1	Impedance	66
6.7.2	Return loss	66
6.8	Antennas for terrestrial reception	66
6.8.1	Impedance	66
6.8.2	Return loss	66
6.9	Antenna amplifier	66
7	Equipment characteristics required to be published	67
7.1	General	67
7.2	Environmental conditions	67
7.3	Maximum permissible output level	67
7.4	Operating range for output level	68
7.5	TV standard	68
7.6	Clamp	68
7.7	Noise figure	68
7.7.1	Equipment without AGC	68
7.7.2	Equipment with AGC	69
7.8	Data control signals, description of interface	69
7.9	Output level stability for TV modulators, TV converters and pilot generators	69
7.10	Pilot signal	69
7.11	Differential gain and phase	70
7.11.1	Differential gain	70
7.11.2	Differential phase	70
7.12	Group delay variation for analogue TV signals	70
7.13	Luminance non-linearity	70
7.14	2T-pulse	71
7.15	20T-pulse	71
7.16	Hum modulation	71
7.17	Television carrier-to-noise ratio	71
7.18	Audio in TV	71
7.19	Processing units for FM radio	72
7.19.1	Audio input	72
7.19.2	Stereo crosstalk	72
7.19.3	Total harmonic distortion	72
7.19.4	Intermodulation distortion	72
7.19.5	Deviation, pre-emphasis	72
7.20	Antennas for terrestrial reception	72
7.20.1	Antenna gain	72
7.20.2	Sidelobe suppression	72
7.20.3	Return loss of antennas	72
7.21	Control signals for outdoor units	72

Annex A (normative) Definition of the specified test frequency range for return loss and noise figure	74
A.1 Test frequency range for TV channel processor	74
A.2 Test frequency range for sub-band, full-band and multi-band amplifiers	74
A.3 Test frequency range for an FM radio channel processor	74
Annex B (informative) Audio connector for European system according to IEC 60130-9	76
B.1 Contact allocation and mechanical dimensions	76
B.2 Signal-to-pin allocations and applications	76
Annex C (informative) Selectivity diagram for adjacent channel transmission	77
C.1 General	77
C.2 TV modulator for standard PAL B/G with mono or stereo sound	77
C.3 TV modulator for standard PAL B/G with NICAM 728 in the lower adjacent channel	78
C.4 Standard PAL I	78
C.5 Group delay for the standards B/G, D/D1/K and I	79
C.6 Group delay pre-correction for TV modulator for standard B/G	79
C.7 TV modulator for standard SECAM L	80
C.8 Group delay for TV modulator for standard SECAM L	80
C.9 TV modulator for standard PAL D/K with mono or stereo sound	81
Annex D (informative) Differences in some countries	82
D.1 General	82
D.2 Finland, Sweden	82
Annex E (normative) Correction factors for noise	83
E.1 Signal level measurement	83
E.2 Noise level measurement	83
Annex F (informative) Digital signal level and bandwidth	85
F.1 RF/IF power ("carrier")	85
F.2 Occupied bandwidth of a digital signal	85
F.2.1 QAM/QPSK modulation	85
F.2.2 OFDM modulation	86
F.3 Noise bandwidth	86
F.3.1 General	86
F.3.2 QAM/QPSK/8 PSK modulation	87
F.3.3 OFDM modulation	87
F.4 Equivalent signal bandwidth	87
F.4.1 General	87
F.4.2 QAM/QPSK/8 PSK modulation	87
F.4.3 OFDM modulation	87
F.5 Examples	87
Annex G (informative) Minimum frequency distance of converted satellite signals in the IF range	89
Annex H (informative) Measurement errors which occur due to mismatched equipment	90
Annex I (normative) Correction factor for spectrum analyser	91
Bibliography	92
Figure 1 – Example of headend	13
Figure 2 – Examples of IP gateways/interfaces at the input of headends	14
Figure 3 – Examples of IP gateways and interfaces at the output of central headends	15

Figure 4 – Frequencies and levels of test carriers	27
Figure 5 – Test carrier and interfering products in the pass band	28
Figure 6 – Example showing products formed when $2f_a > f_b$	29
Figure 7 – Carrier-to-spurious signal ratio at the output	30
Figure 8 – Carrier-to spurious signal ratio at the output.....	31
Figure 9 – Shoulder attenuation	31
Figure 10 – Arrangement of test equipment for carrier-to-noise ratio measurement.....	32
Figure 11 – Arrangement of test equipment for measurement of differential gain and phase	40
Figure 12 – Signal D2 waveform.....	40
Figure 13 – Example of modified staircase	40
Figure 14 – Measuring set-up for determining the group delay variation	41
Figure 15 – RF signal (time domain) amplitude-modulated with a split-frequency signal.....	42
Figure 16 – Spectral presentation of the group delay measurement.....	43
Figure 17 – Description of the measuring set-up.....	44
Figure 18 – Choices of measuring aperture (value of the split frequency) for various measurement tests	44
Figure 19 – Test set-up for phase noise measurement.....	46
Figure 20 – Mask for phase noise measurements	47
Figure 21 – Carrier/hum ratio	48
Figure 22 – Test set-up for equipment with built-in power supply.....	49
Figure 23 – Test set-up for equipment with external power supply.....	49
Figure 24 – Oscilloscope display	50
Figure 25 – K-factor mask for quality grade 2	52
Figure 26 – Generation of 20T-pulse	53
Figure 27 – Example of amplitude and delay error using 20T-pulse.....	53
Figure 28 – Staircase signal for measurement of luminance non-linearity before and after differentiation.....	54
Figure 29 – Example of a possible frequency combination displayed on a spectrum analyser	54
Figure 30 – Arrangement of test equipment for intermodulation distortion.....	55
Figure 31 – Principal measuring set-up for determination of decoding margin.....	56
Figure 32 – Example of diagram of NF , C/N or S/N for equipment with AGC.....	69
Figure A.1 – Test frequency range for TV channel processors.....	74
Figure A.2 – Test frequency range for sub-band, full-band and multi-band amplifiers.....	74
Figure A.3 – Test frequency range for an FM radio channel processor	75
Figure B.1 – Contact allocation and mechanical dimensions	76
Figure C.1 – Selectivity diagram for PAL B/G with mono or stereo sound	77
Figure C.2 – Selectivity diagram for PAL B/G with NICAM 728 in the lower adjacent channel	78
Figure C.3 – Selectivity diagram for PAL I	79
Figure C.4 – Group delay mask for the standards B/G, D/D1/K and I.....	79
Figure C.5 – Group delay pre-correction diagram for standard B/G	80
Figure C.6 – Selectivity diagram for SECAM L.....	80
Figure C.7 – Group delay mask for SECAM L	81

Figure C.8 – Selectivity diagram for PAL D/K.....	81
Figure E.1 – Noise correction factor CF (dB) versus measured level difference D (dB)	84
Figure G.1 – Frequency tolerance of converted signals in the IF range.....	89
Figure H.1 – Error concerning return loss measurement	90
Figure H.2 – Maximum ripple	90
Table 1 – Test signal levels for the different television standards in decibels relative to reference level.....	27
Table 2 – Test signal levels in decibels relative to reference level.....	28
Table 3 – Test signal levels for sound and vision carriers in decibels relative to reference level.....	30
Table 4 – Noise bandwidth.....	34
Table 5 – Frequency distances for phase noise measurement.....	47
Table 6 – Publications for environmental requirements of headend equipment	57
Table 7 – Return loss (input, output) of equipment.....	58
Table 8 – Return loss (output) of headend	58
Table 9 – Typical levels of digital signals with respect to analogue signals (back-off)	59
Table 10 – Carrier-to-spurious-signals ratio of digital modulated channel with respect to the peak level of an analogue TV carrier.....	60
Table 11 – Frequency stability for AM TV related to the nominal AM TV frequency	60
Table 12 – Long-term frequency stability for digital modulated signals	61
Table 13 – Shoulder attenuation for digital modulated signals	61
Table 14 – Phase noise of a DVB signal (PSK and QAM).....	62
Table 15 – Phase noise of a DVB signal (OFDM).....	62
Table 16 – In-channel group delay variation for digital modulated signals.....	62
Table 17 – In-channel peak-to-peak amplitude response variation of DVB signals	63
Table 18 – Stability of sound intercarrier	63
Table 19 – Stability of residual carrier amplitude.....	63
Table 20 – Frequency stability – SAT IF/IF converter.....	64
Table 21 – Minimum requirements for MER for different QAM modulation schemes	64
Table 22 – C/N values for converters at the headend output	64
Table 23 – Return loss	65
Table 24 – Signal voltage.....	65
Table 25 – Signal level.....	66
Table 26 – Requirements for decoding margin (Teletext)	66
Table 27 – Return loss – IF signal.....	66
Table 28 – Return loss – Antennas for terrestrial reception	66
Table 29 – Recommended temperature ranges.....	67
Table 30 – Carrier-to-third-order intermodulation ratio for maximum output level of channel amplifiers/frequency converters.....	67
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).....	67
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).....	68

Table 33 – Carrier-to-intermodulation ratio for maximum output level of FM-TV channel amplifiers/frequency converters	68
Table 34 – Carrier-to-third-order intermodulation ratio for maximum output level of FM TV full band, sub-band amplifiers	68
Table 35 – Output level stability for TV modulators, pilot generators and TV converters.....	69
Table 36 – Recommendation for differential gain	70
Table 37 – Recommendation for differential phase	70
Table 38 – Recommendation for group delay variation	70
Table 39 – Recommendation for luminance non-linearity	71
Table 40 – K-factor masks for 2T-pulse responses	71
Table 41 – Recommendations for sidelobe suppression	72
Table 42 – Recommendation for return loss of antennas	72
Table B.1 – Mechanical dimensions	76
Table B.2 – Signal-to-pin allocation	76
Table B.3 – Application	76
Table C.1 – Selectivity table for PAL B/G with mono or stereo sound	78
Table C.2 – Group delay pre-correction table for standard B/G	80
Table E.1 – Noise correction factor	83
Table F.1 – Total number of carriers and channel spacing for the OFDM modes (8 MHz channel)	86
Table F.2 – Examples of bandwidths for digital modulation techniques	88

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**CABLE NETWORKS FOR TELEVISION SIGNALS,
SOUND SIGNALS AND INTERACTIVE SERVICES –****Part 5: Headend equipment**

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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
100/2555/FDIS	100/2602/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.

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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.

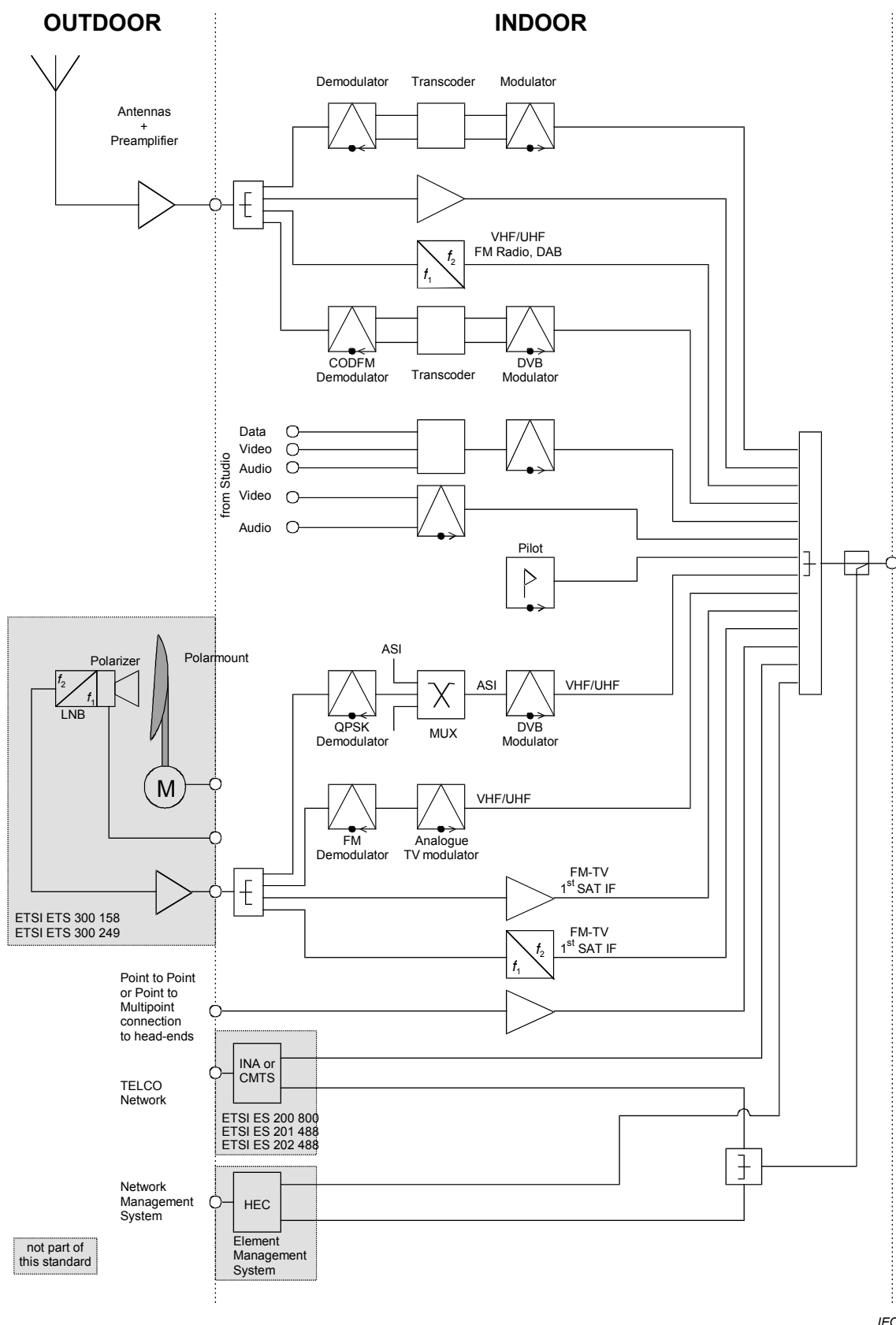
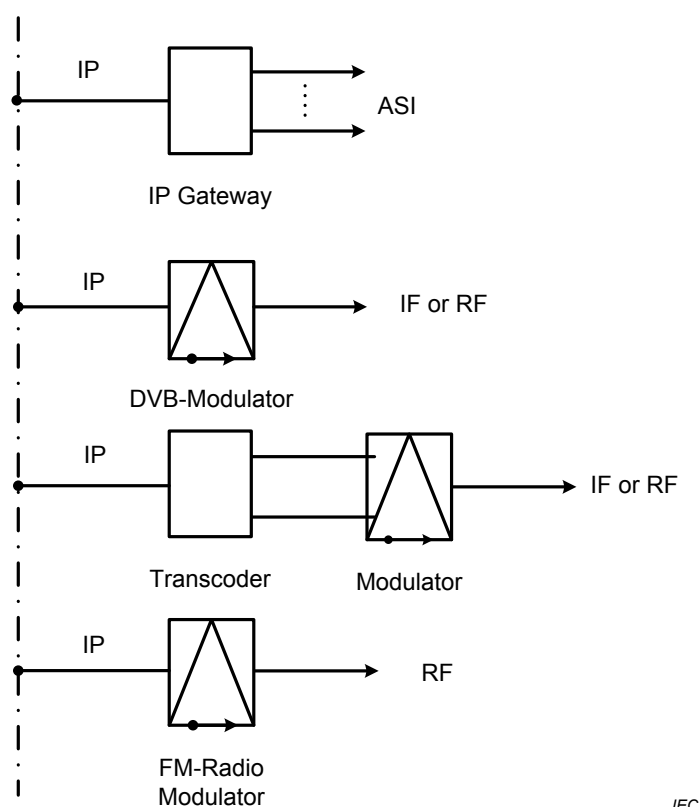


Figure 1 – Example of headend

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.



IEC

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.

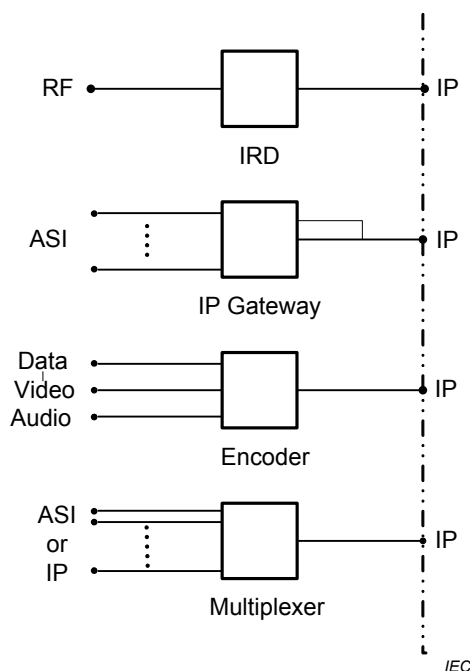


Figure 3 – Examples of IP gateways and interfaces at the output of central headends

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 :

$$10 \lg \frac{P_1}{P_0} \quad (1)$$

3.1.20**level**

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

$$20 \lg \frac{U_1}{U_0} \quad (2)$$

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:

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

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 **$S_{D,RF}/N$**

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 μ V across it.

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

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
<i>BW</i>	bandwidth
<i>C/N</i>	carrier to noise (ratio)
CATV	community antenna television (system)
CH	channel
CPE	common phase error
CW	continuous wave
DAB	Digital Audio Broadcasting
<i>DPH_{pp}</i>	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 $S_{D,RF}$ of the signal using the following formula:

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

where

$S_{D,RF}$ 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:

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

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:

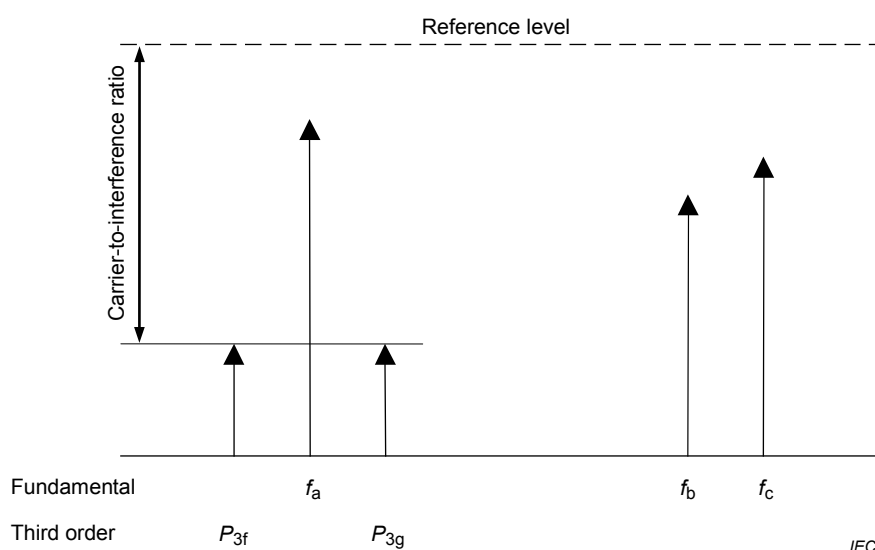
$$P_{3f} = f_a + f_b + f_c \quad (6)$$

$$P_{3g} = f_a + f_c - f_b \quad (7)$$

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

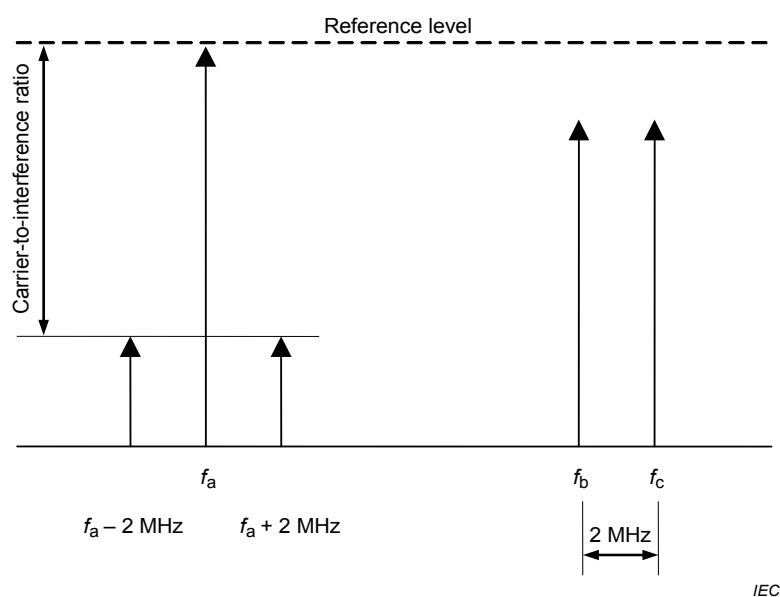


Figure 5 – Test carrier and interfering products in the pass band

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 $2f_a > f_b$

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

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

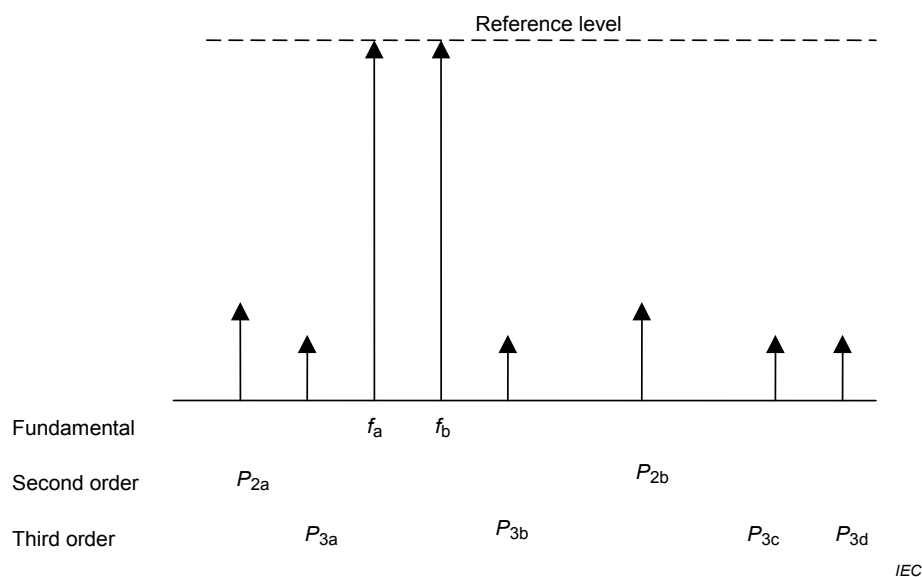
$$P_{3c} = 2f_a + f_b$$

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

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

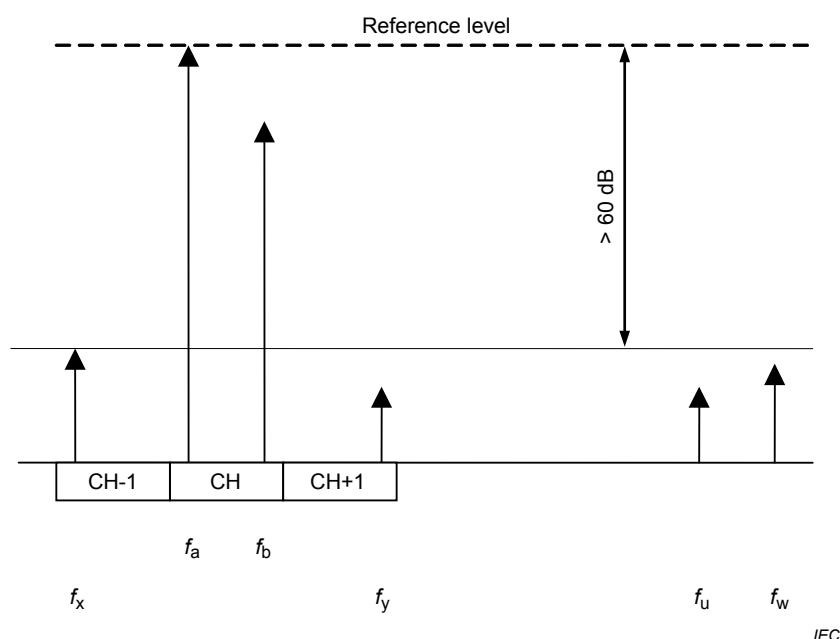
The carrier-to-spurious signal ratio at the output, out of channels, is applied between 40 MHz and 862 MHz.

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.



$$f_x = 2f_a - f_b; \quad f_y = 2f_b - f_a$$

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 following note: “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.

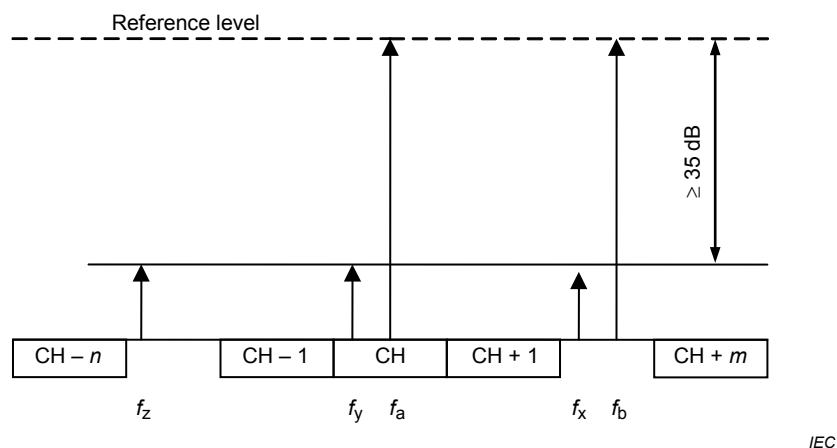


Figure 8 – Carrier-to spurious signal ratio at the output

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.

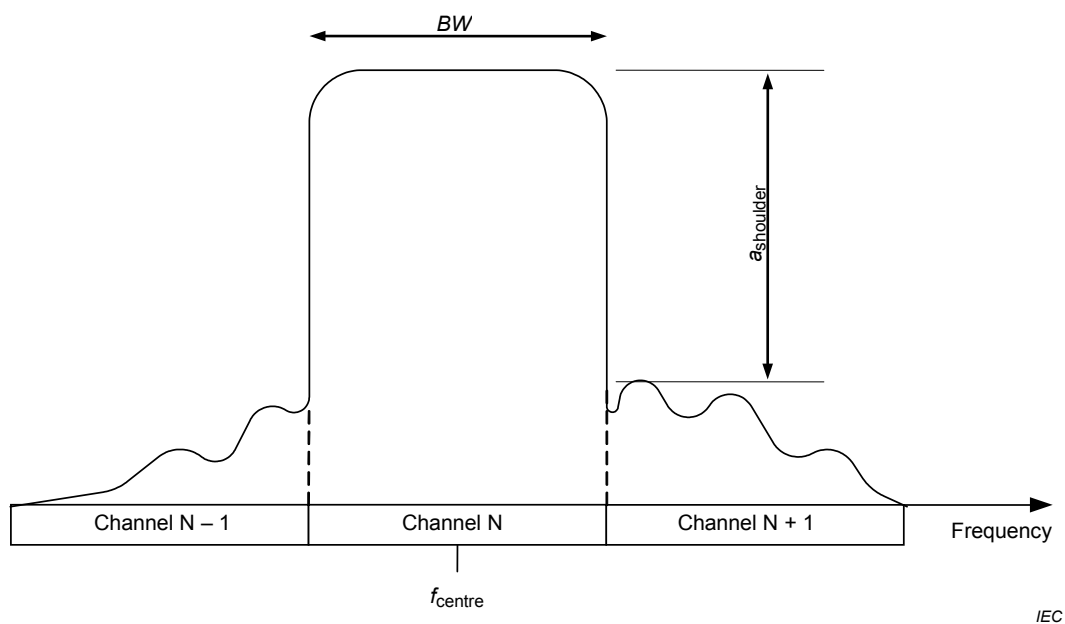


Figure 9 – Shoulder attenuation

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.

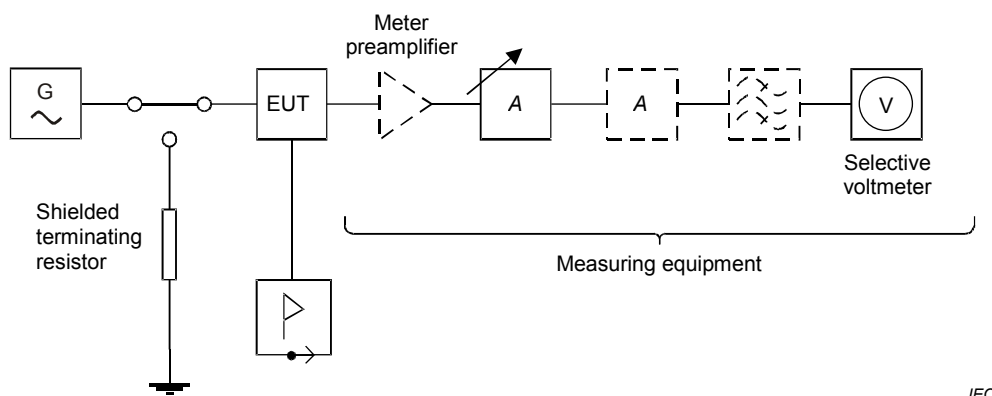
The method assumes that the random noise is evenly distributed within the channel.

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.



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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

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

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} .

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

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

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

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 $S_{D,RF}/N$ by the following formula:

$$S_{D,RF}/N = S \text{ [dB(μV)]} - N \text{ [dB(μV)]} \quad \text{dB} \quad (11)$$

or

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

or

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

where

$S_{D,RF}/N$ 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 $(S_{D,RF} + N)/N$ 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 $S_{D,RF}/N$ 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

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.

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

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

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

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:

$$x = |\varphi_{\max} - \varphi_0| \quad (16)$$

$$y = |\varphi_{\min} - \varphi_0|$$

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

$$DPH_{pp} = |\varphi_{\max} - \varphi_{\min}| \quad (17)$$

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.

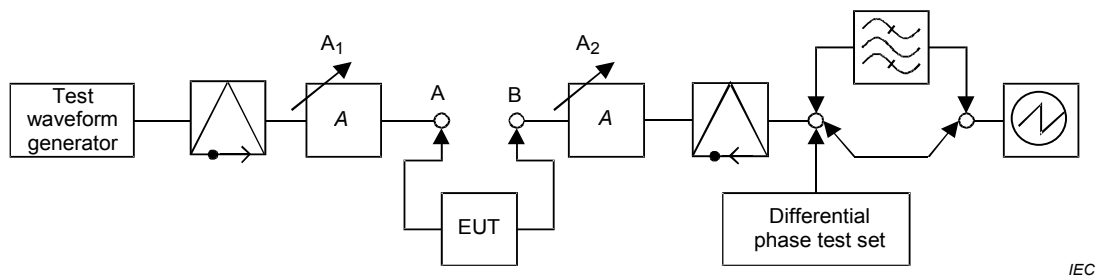


Figure 11 – Arrangement of test equipment for measurement of differential gain and phase

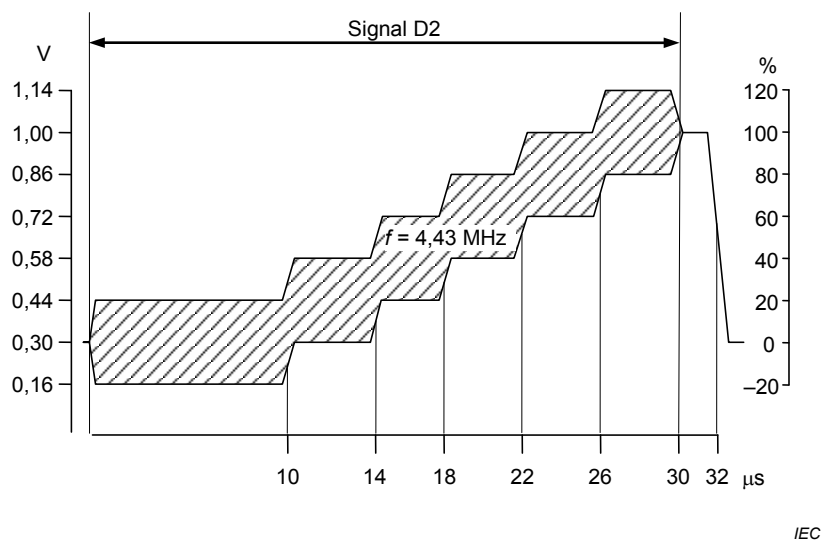


Figure 12 – Signal D2 waveform

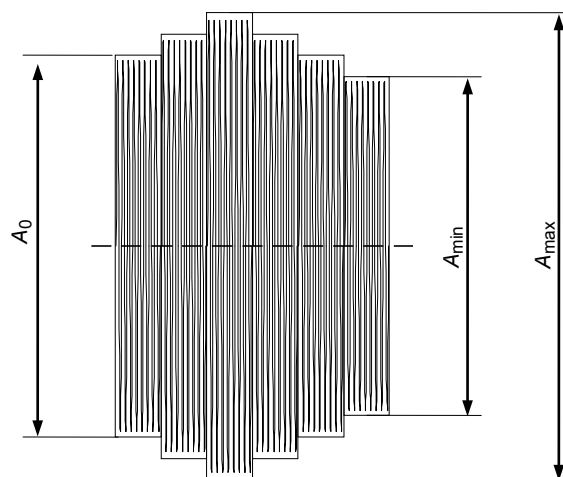


Figure 13 – Example of modified staircase

4.8 Group delay measurements

4.8.1 Group delay variation of analogue TV signals

4.8.1.1 General

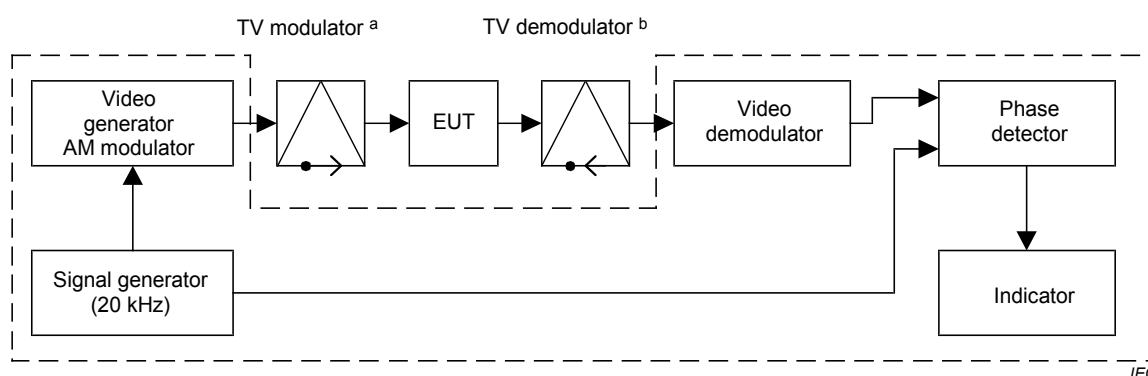
Group delay variation is defined as the deviation from a linear phase-frequency response. This deviation is measured as the difference between the maximum and the minimum slope of the phase-frequency response within the channel.

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

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

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.

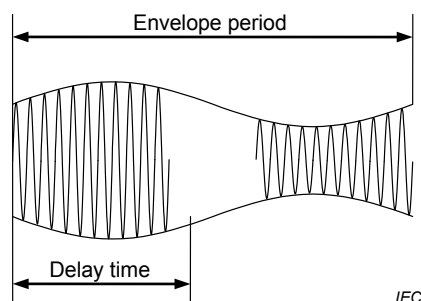


Figure 15 – RF signal (time domain) amplitude-modulated with a split-frequency signal

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 $2f_S$.

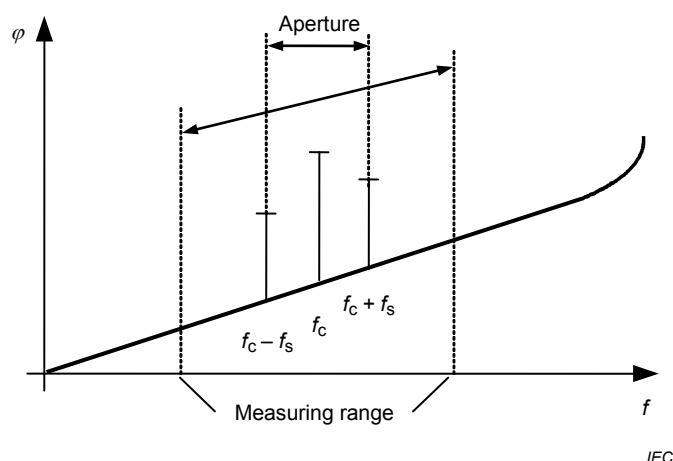


Figure 16 – Spectral presentation of the group delay measurement

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

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

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.

$$\tau_g = \frac{d\varphi}{df} \quad (20)$$

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.

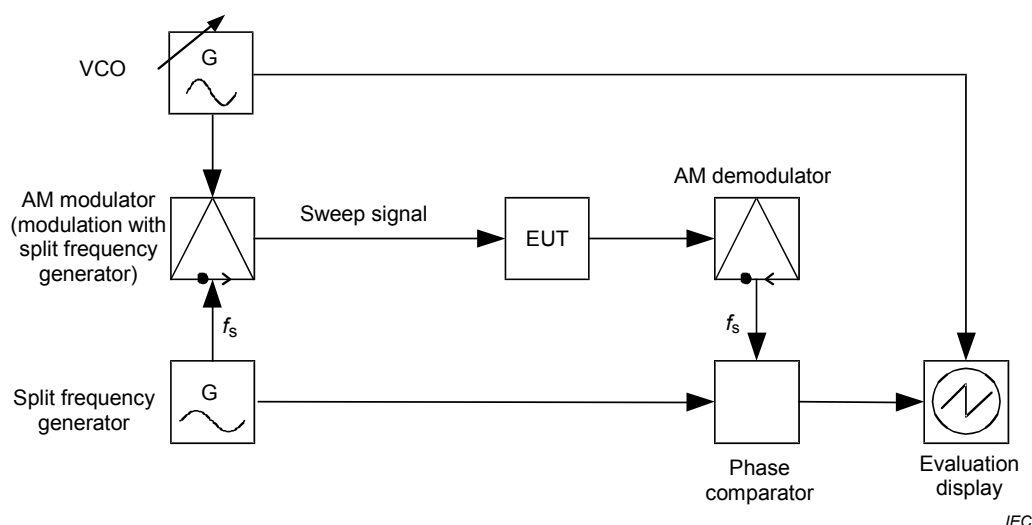


Figure 17 – Description of the measuring set-up

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).

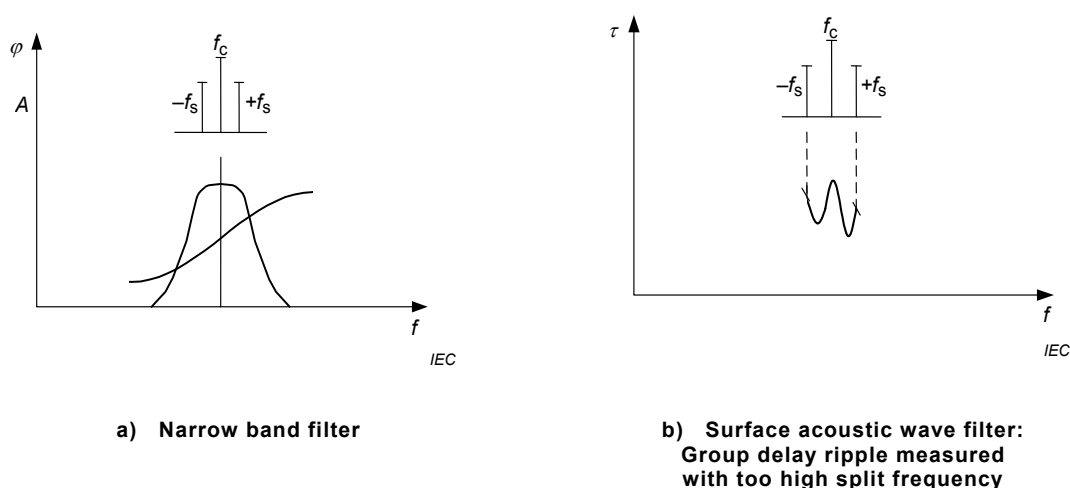


Figure 18 – Choices of measuring aperture (value of the split frequency) for various measurement tests

A split frequency of 20 kHz demands that, at the lower measuring limit of 1 ns, the measurements of a minimum phase angle of $0,01^\circ$ 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.

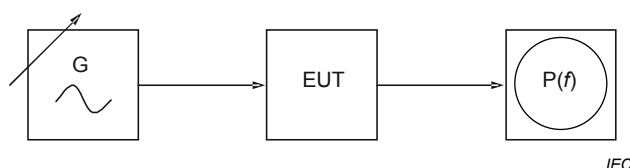


Figure 19 – Test set-up for phase noise measurement

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.

- Set the carrier frequency of the RF signal generator to that of the channel where the measurement shall be performed.
- Adjust the carrier level of the RF signal generator to obtain the same level at the EUT output as in normal operating conditions.
- 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.
- Set the *RSBW* of the spectrum analyser to 300 Hz and the video bandwidth to 30 Hz or 10 Hz.
- Measure the unmodulated carrier level C in dB(mW).
- Measure the level $PN_{(f_m)}$ in dB(mW), of each component in one noise sideband and note its frequency f_m .
- Convert the measured value of PN to one hertz bandwidth, using the following formula:

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

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.

- 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:

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

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 .

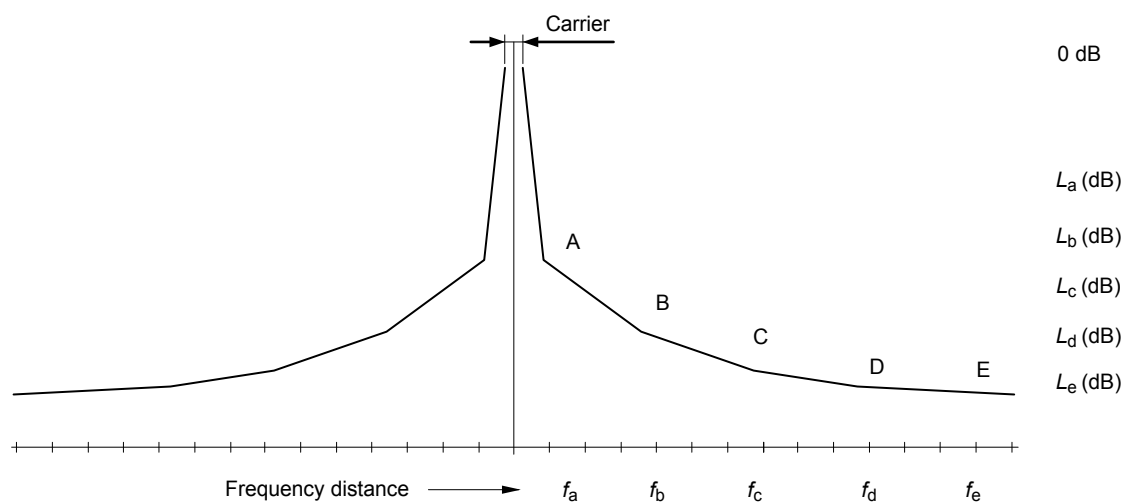
4.9.5 Presentation of the results

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.

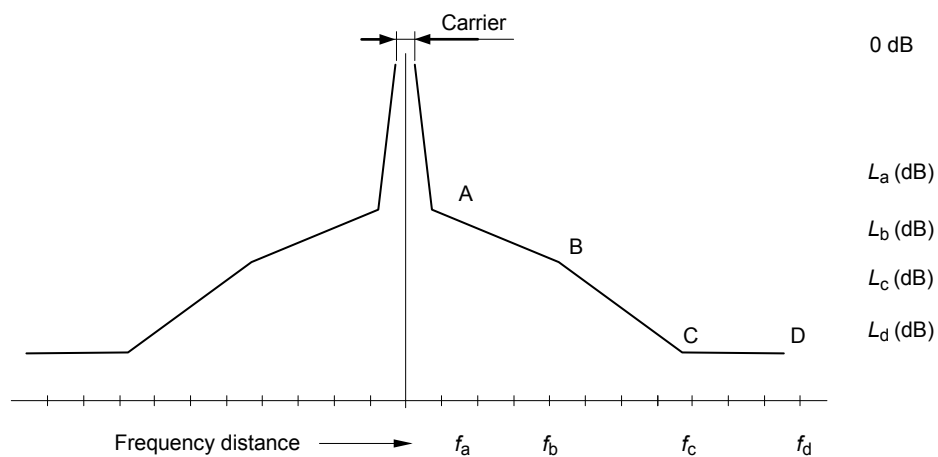
Table 5 – Frequency distances for phase noise measurement

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.



IEC

a) PSK, APSK and QAM formats

IEC

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.

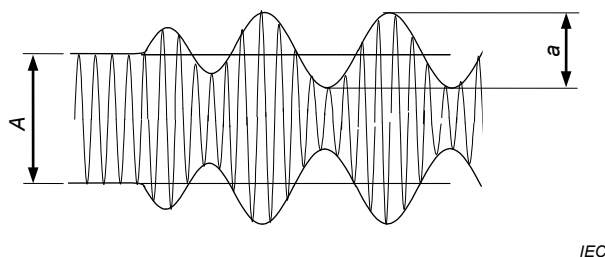


Figure 21 – Carrier/hum ratio

$$\text{Carrier/hum ratio} = 20 \cdot \lg \frac{A}{a} \text{ [dB]} \quad (23)$$

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).