

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Cable networks for television signals, sound signals and interactive services –
Part 101: System performance of forward paths loaded with digital channels only**

**Réseaux de distribution par câbles pour signaux de télévision, signaux de
radiodiffusion sonore et services interactifs –
Partie 101: Performances des systèmes de voie directe soumis à une charge de
porteuses exclusivement numériques**



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**CABLE NETWORKS FOR TELEVISION SIGNALS,
SOUND SIGNALS AND INTERACTIVE SERVICES –****Part 101: System performance of forward paths
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The text of this standard is based on the following documents:

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100/2641/FDIS	100/2668/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 the differences in some countries, see Annex E.

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INTRODUCTION

Standards and deliverables of the IEC 60728 series deal with cable networks including equipment and associated methods of measurement for headend reception, processing and distribution of television and sound signals and for processing, interfacing and transmitting all kinds of data signals for interactive services using all applicable transmission media. These signals are typically transmitted in networks by frequency-multiplexing techniques.

This includes for instance

- regional and local broadband cable networks,
- extended satellite and terrestrial television distribution systems,
- individual satellite and terrestrial television receiving systems,

and all kinds of equipment, systems and installations used in such cable networks, distribution and receiving systems.

The extent of this standardization work is from the antennas and/or special signal source inputs to the headend or other interface points to the network up to the terminal input of the customer premises equipment.

The standardization work will consider coexistence with users of the RF spectrum in wired and wireless transmission systems.

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

The reception of television signals inside a building requires an outdoor antenna and a distribution network to convey the signal to the TV receivers.

The installation of an outdoor antenna for each TV receiver should be avoided for technical, economical and practical reasons.

In a building divided into apartment blocks, the installation of a master antenna television system for terrestrial (MATV) and/or satellite (SMATV) reception, as shown in Figure 1, Figure 2, Figure 3, Figure 4 and Figure 5, describing as an example the various parts of the system is usual. Most of the terms used in the IEC 60728 series can be referred to these figures.

When signals to be conveyed to the TV receivers are picked up far away, for geographical reasons, and the number of users (subscribers) is very high, the installation of a cable network using coaxial cables and/or fibre optic cables is used, as indicated in Figure 4, describing as an example the various parts of the system.

A system model of a cable network is shown in Figure 5, where the main parts of the systems are indicated, as defined in Clause 3.

This standard deals with digital signals only.

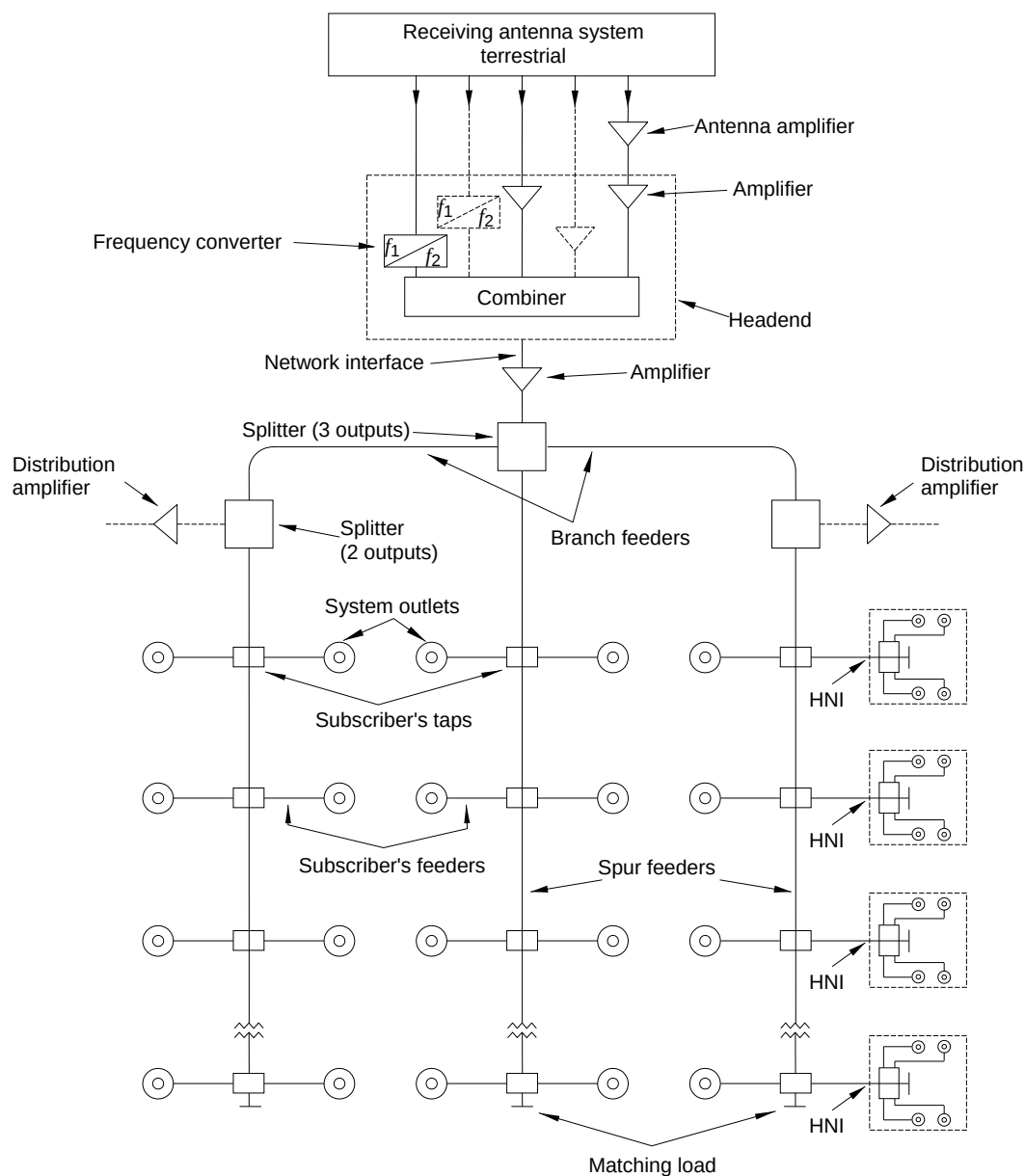
For forward path analogue signals refer to IEC 60728-1. For return paths signals (analogue and digital) refer to IEC 60728-10.

Clause 4 defines the methods of measurement of the system performance parameters at the system outlet.

Clause 5 defines the system performance limits which will, with an unimpaired input, (headend input signal), produce picture and sound signals (at system outlets) where the quality requirement is a quasi-error-free (QEF) reception.

Appropriate performance requirements for the signals at the receiving antennas site are given in Clause 6 in order to provide, at the input of the headend of the cable network, for digital television signals with suitable quality.

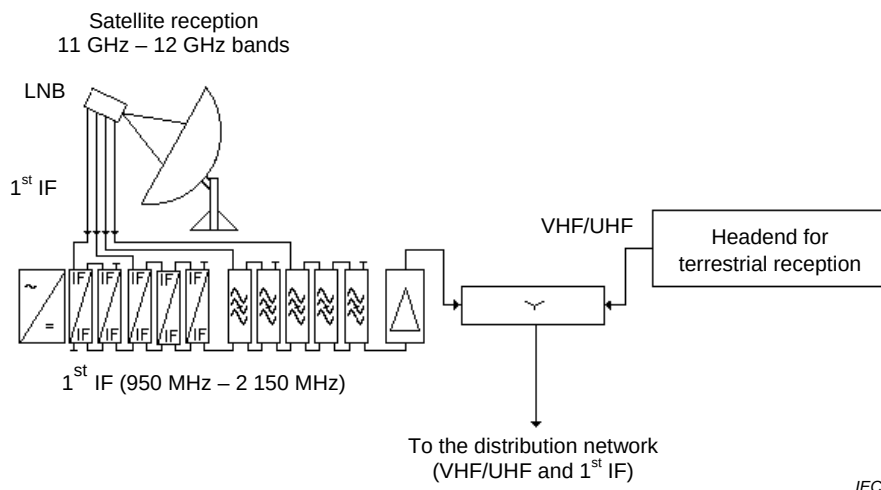
Clause 7 is applicable to home networks (including those of individual receiving systems) using coaxial cables, balanced cables or optical cables and is primarily intended for television signals, sound signals and interactive services, operating between about 30 MHz and 3 000 MHz. Clause 7 also considers basic operational characteristics of a home network, specifies the requirements with respect to the home network interface (HNI) taking into account the performance requirements given at the system outlet or at the terminal input.



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Some apartments (dwelling units) are served with a home network (HN), interfaced to the MATV system by the home network interface (HNI).

Figure 1 – Example of a master antenna television system (MATV) for terrestrial reception



NOTE Distribution at the 1st IF on the same cable as terrestrial VHF/UHF channels.

Figure 2 – Example of the headend of a master antenna television system for satellite (SMATV) reception

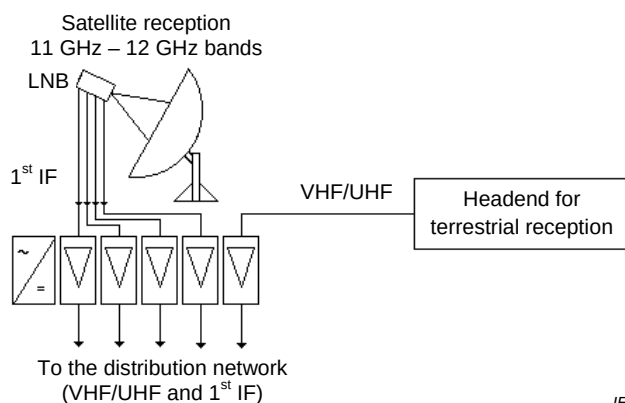


Figure 3a – Headend for terrestrial and satellite reception using multicable distribution

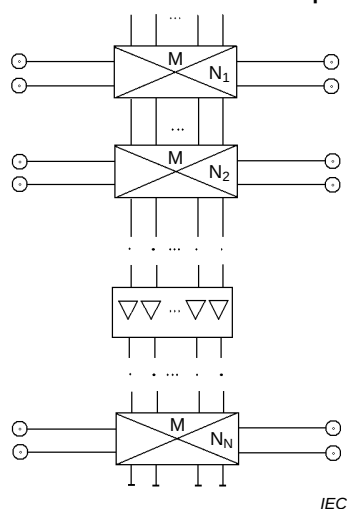


Figure 3b – Distribution with switching matrix at each flat

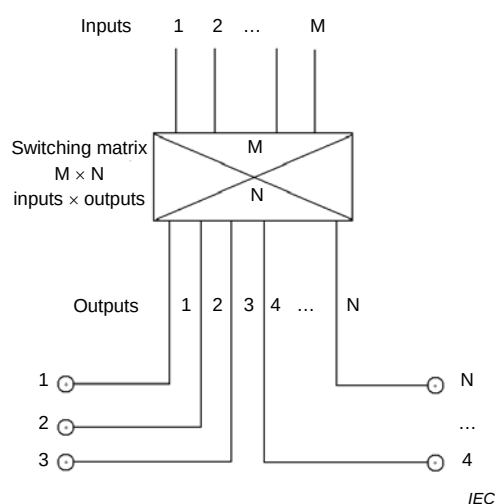


Figure 3c – Distribution with switching matrix: star configuration

NOTE Distribution at the 1st IF using multicable and multi-switch technique.

Figure 3 – Example of a master antenna television system for terrestrial and satellite (SMATV) reception

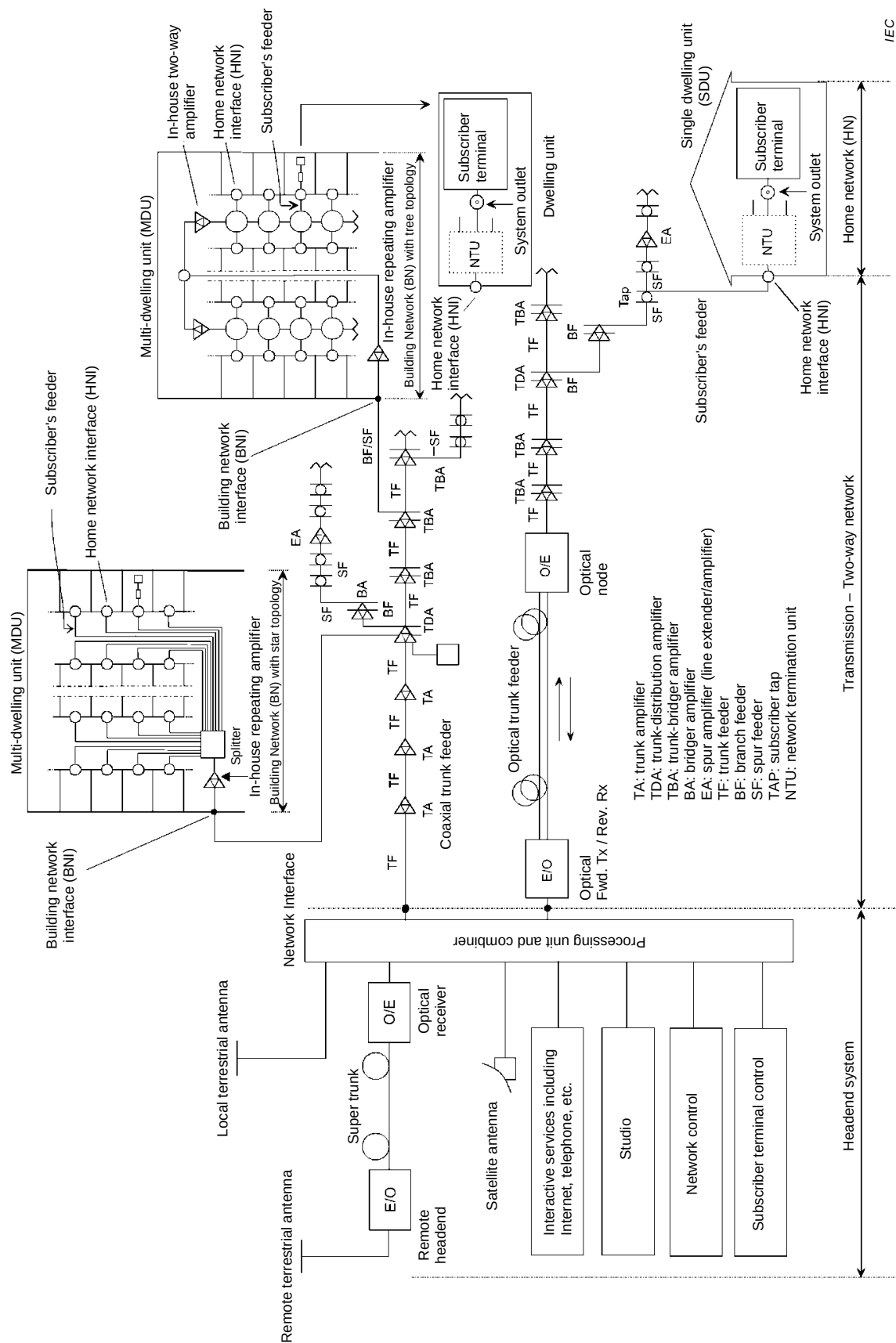


Figure 4 – Example of a cable distribution system for television and sound signals

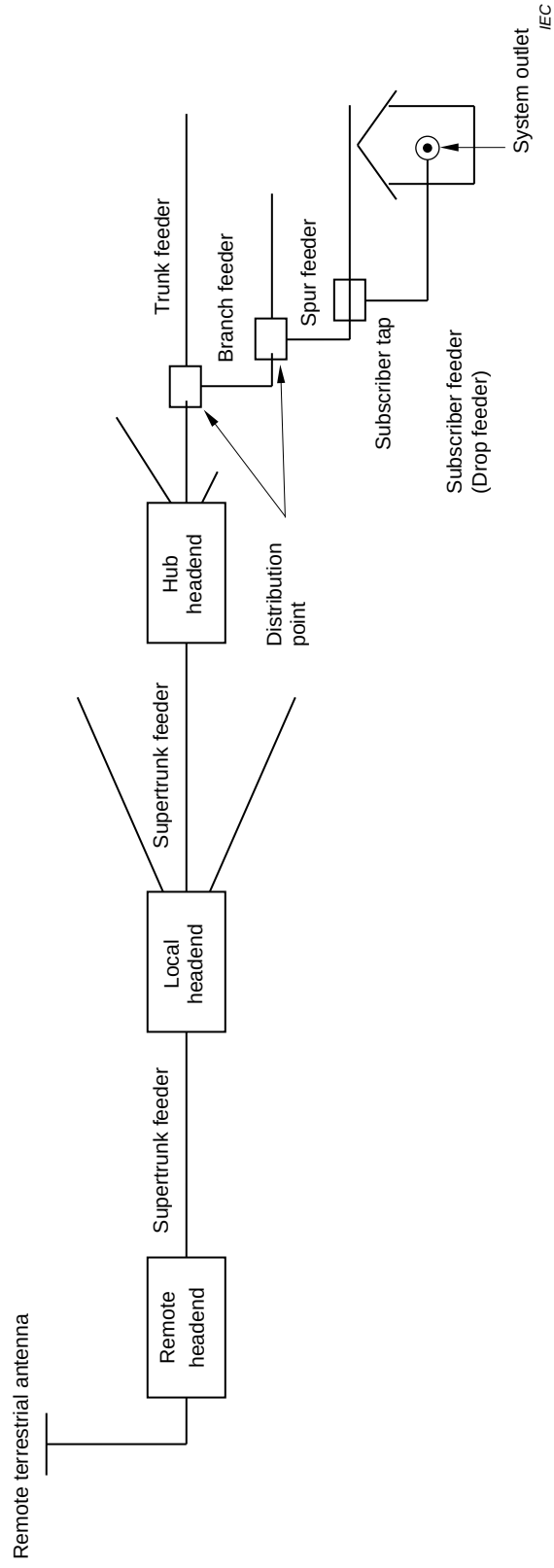


Figure 5 – System model for downstream direction of a cable network for television and sound signals (CATV)

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

Part 101: System performance of forward paths loaded with digital channels only

1 Scope

This part of IEC 60728 is applicable to any cable network (including individual receiving systems) distributing only digital channels having in the forward path a coaxial cable output and primarily intended for television and sound signals operating between about 30 MHz and 3 000 MHz.

This standard specifies the basic methods of measurement of the operational characteristics of a cable network having coaxial cable outputs in order to assess the performance of these systems and their performance limits.

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 60050-705, *International Electrotechnical Vocabulary – Chapter 705: Radio wave propagation*

IEC 60050-712, *International Electrotechnical Vocabulary – Chapter 712: Antennas*

IEC 60050-725, *International Electrotechnical Vocabulary – Chapter 725: Space radiocommunications*

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

IEC 60728-1-1, *Cable networks for television signals, sound signals and interactive services – Part 1-1: RF cabling for two way home networks*

IEC 60728-1-2, *Cable networks for television signals sound signals and interactive services – Part 1-2: Performance requirements for signals delivered at the system outlet in operation*

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

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

IEC 60728-3-1, *Cable networks for television signals, sound signals and interactive services – Part 3-1: Active wideband equipment for cable networks – Methods of measurement of non-linearity for full digital channel load with DVB-C signals*

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

IEC 60728-10, *Cable networks for television signals, sound signals and interactive services – Part 10: System performance of return paths*

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

IEC 60728-12, *Cabled distribution systems for television and sound signals – Part 12: Electromagnetic compatibility of systems*

IEC 60966-2-4, *Radio frequency and coaxial cable assemblies – Part 2-4: Detail specification for cable assemblies for radio and TV receivers – Frequency range 0 MHz to 3 000 MHz, IEC 61169-2 connectors*

IEC 60966-2-5, *Radio frequency and coaxial cable assemblies – Part 2-5: Detail specification for cable assemblies for radio and TV receivers – Frequency range 0 MHz to 1 000 MHz, IEC 61169-2 connectors*

IEC 60966-2-6, *Radio frequency and coaxial cable assemblies – Part 2-6: Detail specification for cable assemblies for radio and TV receivers – Frequency range 0 MHz to 3 000 MHz, IEC 61169-24 connectors*

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*

ISO/IEC 14496-1, *Information technology – Coding of audio-visual objects – Part 1: Systems*

ISO/IEC 14496-2, *Information technology – Coding of audio-visual objects – Part 2: Visual*

ISO/IEC 14496-3, *Information technology – Coding of audio-visual objects – Part 3: Audio*

EN 50248, *Characteristics of DAB receivers*

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 300 748, *Digital Video Broadcasting (DVB) – Multipoint Video Distribution Systems (MVDS) at 10 GHz and above*

ETSI EN 300 749, *Digital Video Broadcasting (DVB) – Microwave Multipoint Distribution Systems (MMDS) below 10 GHz*

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*

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 EN 302 769, *Digital Video Broadcasting (DVB) – Frame structure channel coding and modulation for a second generation digital transmission system for cable systems (DVB-C2)*

ETSI ETS 300 784, *Satellite Earth Stations and Systems (SES) – TeleVision Receive-Only (TVRO) satellite earth stations operating in the 11/12 GHz frequency bands*

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

ETSI TR 101 290, *Digital Video Broadcasting (DVB) – Measurement guidelines for DVB systems*

ETSI TS 102 831, V1.1.1 (2010-10), *Digital Video Broadcasting (DVB) – Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2)*

ETSI TS 102 991, V1.2.1 (2011-06), *Digital Video Broadcasting (DVB) – Implementation guidelines for a second generation digital cable transmission system (DVB-C2)*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-705, IEC 60050-712 and IEC 60050-725, as well as the following apply.

NOTE The most important definitions are repeated below.

3.1.1

active antenna

antenna incorporating active devices

[SOURCE: IEC 60050-712:1992, 712-03-29]

3.1.2

active home network

home network that uses active equipment (for example, amplifiers) in addition to passive equipment like splitters, taps, system outlets, cables and connectors up to the coaxial RF interface (input and/or output) of the terminal equipment for distributing and combining RF signals

[SOURCE: IEC 60728-1:2014, 3.1.2]

3.1.3

antenna

part of a radio transmitting or receiving system which is designed to provide the required coupling between a transmitter or a receiver and the medium in which the radio wave propagates

Note 1 to entry: In practice, the terminals of the antenna or the points to be considered as the interface between the antenna and the transmitter or receiver are specified.

Note 2 to entry: If the transmitter or receiver is connected to its antenna by a feeder line, the antenna is considered to be a transducer between the guided radio waves of the feeder line and the radiated waves in space.

Note 3 to entry: See also IEC 60728-1:2014, 3.1.3, IEC 60728-1-1:2014, 3.1.2 and IEC 60728-1-2:2014, 3.1.2.

[SOURCE: IEC 60050-712:1992, 712-01-01, modified – The deprecated term "aerial" has been deleted, in Note 1 "should be specified" has been replaced by "are specified", Note 2 has been clarified and a Note 3 giving additional references has been added.]

3.1.4

antenna amplifier

amplifier (often a low-noise type) associated with an antenna

[SOURCE: IEC 60728-1:2014, 3.1.4]

3.1.5

attenuation

ratio of the input power to the output power of an equipment or system

Note 1 to entry: The ratio is expressed in decibels.

[SOURCE: IEC 60728-1:2014, 3.1.5]

3.1.6

automatic gain control

AGC

automatic control of a device to maintain constant the level of the signal at its output, using that signal as the control stimulus

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

[SOURCE: IEC 60728-1:2014, 3.1.6]

3.1.7

bit error ratio

BER

ratio between erroneous bits and the total number of transmitted bits

[SOURCE: IEC 60728-1:2014, 3.1.9]

3.1.8

branch amplifier

amplifier to compensate for the attenuation in a branch feeder

[SOURCE: IEC 60728-1:2014, 3.1.10]

3.1.9

branch feeder

feeder used for connecting a distribution point to spur feeders

[SOURCE: IEC 60728-1:2014, 3.1.11]

3.1.10

bridger amplifier

amplifier for connection in a trunk or branch feeder to energize a distribution point or one or more branch or spur feeders

[SOURCE: IEC 60728-1:2014, 3.1.12]

3.1.11

broadcast and communication technologies

BCT

group of applications including RF distribution of sound signals and video signals

Note 1 to entry: In the light of this standard, this is a group of applications using the HF band (3 MHz to 30 MHz), the VHF band (30 MHz to 300 MHz) and the UHF band (300 MHz to 3000 MHz) for transmission of television signals, sound signals and interactive services, as well as for in-home inter-networking.

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

[SOURCE: IEC 60728-1:2014, 3.1.13]

3.1.12

building network

BN

network for transmission of television signal, sound signals and interactive services inside a building (multi-dwellings)

[SOURCE: IEC 60728-1:2014, 3.1.14]

3.1.13**building network interface****BNI**

interface to the network for the transmission of television signal, sound signals and interactive services inside a building (multi-dwellings)

Note 1 to entry: This point is also called “transfer point” or “external network interface”.

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

[SOURCE: IEC 60728-1:2014, 3.1.15, modified – Note 1 has been added (Note 2 is for information only).]

3.1.14**CATV network**

regional and local broadband cable networks designed to provide sound and television signals as well as signals for interactive services to a regional or local area

Note 1 to entry: Originally defined as Community Antenna Television network.

[SOURCE: IEC 60728-1-1:2014, 3.1.9 and IEC 60728-1-2:2014, 3.1.8]

3.1.15**combiner**

device in which signals arriving at two or more input ports are fed to a single output port

Note 1 to entry: Some forms of this device may be used in the reverse direction as splitters.

[SOURCE: IEC 60728-1:2014, 3.1.19]

3.1.16**common phase error****CPE**

error in OFDM systems caused by phase noise which affects all carriers simultaneously

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

3.1.17**decibel ratio**

ten times the logarithm to the base 10 of the ratio of two quantities of power P_1 and P_2 , i.e.

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

Note 1 to entry: This ratio may also be expressed in terms of voltages, on the condition that both U_1 and U_2 is the same (e.g. 75 Ω).

$$20 \lg \frac{U_1}{U_2} \quad \text{in dB}$$

[SOURCE: IEC 60728-1:2014, 3.1.24, modified – Note 1 to entry clarified.]

3.1.18**designed receiving antenna**

antenna that has the gain, the directivity and the polarization for receiving the wanted signal at the headend site with the required performance

[SOURCE: IEC 60728-1:2014, 3.1.25]

3.1.19**directional coupler**

passive signal splitting device, with minimum signal loss between the input port and the output port (through loss), a specified coupling loss between the input port and the tap port (tap loss), and very high loss between the output port and tap port (isolation)

[SOURCE: IEC 60728-1:2014, 3.1.26.]

3.1.20

directivity

attenuation between output port and interface or tap port minus the attenuation between input port and interface or tap port, of any equipment or system

[SOURCE: IEC 60728-1:2014, 3.1.27]

3.1.21

distribution amplifier

amplifier designed to feed one or more branch or spur feeders

Note 1 to entry: This is a general term embracing branch amplifier and spur amplifier.

[SOURCE: IEC 60728-1:2014, 3.1.28]

3.1.22

distribution point

point where signals are taken from the trunk feeder to energize branch and/or spur feeders

Note 1 to entry: In some cases, a distribution point may be directly connected to the headend.

[SOURCE: IEC 60728-1:2014, 3.1.29]

3.1.23

DOCSIS

standards defining interface specifications for cable modems and cable modem termination systems for high-speed data communication over RF cable networks

[SOURCE: IEC 60728-1:2014, 3.1.30, modified – The second preferred term has been deleted.]

3.1.24

dwelling unit

DU

home or office where television and sound signals are distributed and where is access to interactive services

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

[SOURCE: IEC 60728-1:2014, 3.1.31]

3.1.25

E_b/N_0

ratio between the energy per bit (E_b) and the noise power density (N_0)

[SOURCE: IEC 60728-1:2014, 3.1.32]

3.1.26

equaliser

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

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

[SOURCE: IEC 60728-1:2014, 3.1.34]

3.1.27

extended satellite television distribution network or system

distribution network or system designed to provide sound and television signals received by 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 (e.g. MoCA or WiFi) in the return path direction.

[SOURCE: IEC 60728-1:2014, 3.1.35]

3.1.28**extended terrestrial television distribution network or system**

distribution network or system designed to provide sound and television signals received by 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 (e.g. MoCA or WiFi) in the return path direction.

[SOURCE: IEC 60728-1:2014, 3.1.36]

3.1.29**FECFRAME**

frame processed by the FEC coding subsystem

[SOURCE: IEC 60728-1:2014, 3.1.37]

3.1.30**feeder**

transmission path forming part of a cable network

Note 1 to entry: Such a path may consist of a metallic cable, optical fibre, waveguide, or any combination of them.

Note 2 to entry: By extension, the term is also applied to paths containing one or more radio links.

[SOURCE: IEC 60728-1:2014, 3.1.38]

3.1.31**amplitude response**

gain or loss between two ports of an equipment or system plotted against frequency

[SOURCE: IEC 60728-1:2014, 3.1.39, modified – The term "frequency amplitude response" has been changed to "amplitude response".]

3.1.32**frequency converter**

device for changing the carrier frequency of one or more signals

[SOURCE: IEC 60728-1:2014, 3.1.40]

3.1.33**gain**

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

Note 1 to entry: Gain is expressed in decibels.

[SOURCE: IEC 60728-1:2014, 3.1.42]

3.1.34**headend**

equipment which is connected between receiving antennas or other signal sources and the remainder of the cable networks, to process the signals to be distributed

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

[SOURCE: IEC 60728-1:2014, 3.1.43]

3.1.35**headend for individual reception**

headend supplying an individual household

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

[SOURCE: IEC 60728-1:2014, 3.1.44]

3.1.36

headend input

interface of the headend where the signals received by antennas or individual feeder lines are applied for signal processing

[SOURCE: IEC 60728-1:2014, 3.1.45]

3.1.37

home network

HN

RF cable network inside a single dwelling (one-family house or one unit of a multi-dwelling building) in the SOHO (Small Offices Home Offices) environments or in the rooms of hotels, hospitals

Note 1 to entry: the preferred topology of this network is a star.

Note 2 to entry: This network carries television signals, sound signals and interactive services up to the coaxial RF interface (input and/or output) of the terminal equipment. It may comprise active equipment, passive equipment, cables and connectors.

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

[SOURCE: IEC 60728-1:2014, 3.1.48]

3.1.38

home network interface

HNI

interface for access to the network for transmission of television signal, sound signals and interactive services inside a home (single dwelling)

[SOURCE: IEC 60728-1:2014, 3.1.49]

3.1.39

intercarrier interference

ICI

interference in OFDM systems caused by phase noise

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

3.1.40

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 (e.g. MoCA or WiFi) in the return path direction.

[SOURCE: IEC 60728-1:2014, 3.1.51]

3.1.41

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 (e.g. MoCA or WiFi) in the return path direction.

[SOURCE: IEC 60728-1:2014, 3.1.52]

3.1.42

intermodulation

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

[SOURCE: IEC 60728-1:2014, 3.1.53]

3.1.43**isolation**

attenuation between two output, tap or interface ports of any equipment or system

[SOURCE: IEC 60728-1:2014, 3.1.54]

3.1.44**level**

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

$$10 \lg \frac{P_1}{P_0} \quad \text{in dB}$$

[SOURCE: IEC 60728-1:2014, 3.1.55.1, modified – Notes 1 and 2 have been deleted.]

3.1.45**level**

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

$$20 \lg \frac{U_1}{U_0} \quad \text{in dB}$$

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.

[SOURCE: IEC 60728-1:2014, 3.1.55.2, modified – Note 1 has been deleted and former Note 2 has become Note 1.]

3.1.46**local broadband cable network**

network designed to provide sound and television signals as well as signals for interactive services to a local area (e.g. one town or one village)

[SOURCE: IEC 60728-1:2014, 3.1.56]

3.1.47**local headend**

headend which is connected directly to the system trunk feeders or to a short-haul trunk feeder replacement link

[SOURCE: IEC 60728-1:2014, 3.1.57]

3.1.48**looped system outlet**

device through which the spur feeder passes and to which is connected a receiver lead, without the use of a subscriber feeder

Note 1 to entry: For special conditions In Norway, see Clause E.1.

[SOURCE: IEC 60728-1:2014, 3.1.58]

3.1.49**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

[SOURCE: IEC 60728-1:2014, 3.1.59]

3.1.50**MATV network**

extended terrestrial television distribution networks or systems designed to provide sound and television signals received by terrestrial receiving antennas to households in one or more buildings

Note 1 to entry: Originally defined as Master Antenna Television network.

Note 2 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 3 to entry: This kind of network or system could also carry other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

[SOURCE: IEC 60728-1:2014, 3.1.60]

3.1.51 **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

Note 1 to entry: The result being expressed as a power ratio in decibel, as follows.

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

[SOURCE: IEC 60728-1:2014, 3.1.61]

3.1.52 **MPEG-2** refers to the ISO/IEC 13818 series

Note 1 to entry: For system coding, see ISO/IEC 13818-1. For video coding, see ISO/IEC 13818-2. For audio coding, see ISO/IEC 13818-3.

[SOURCE: IEC 60728-1:2014, 3.1.62]

3.1.53 **MPEG-4** refers to the ISO/IEC 14496 series

Note 1 to entry: For system coding, see ISO/IEC 14496-1. For video coding, see ISO/IEC 14496-2. For audio coding, see ISO/IEC 14496-3.

[SOURCE: IEC 60728-1:2014, 3.1.63]

3.1.54 **multi-dwelling unit** **MDU**

building with many homes or offices used by single owners where television signals, sound signals are distributed and where is access to interactive services

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

[SOURCE: IEC 60728-1:2014, 3.1.64]

3.1.55 **multiplex**

signals from several separate sources assembled into a single composite signal for transmission over a common transmission channel

Note 1 to entry: See also IEC 60728-1:2014, 3.1.65.

[SOURCE: IEC 60050-701:1988, 701-03-10, modified – Term and definition have been changed to describe the result of the multiplexing process.]

3.1.56**mutual isolation**

attenuation between two specified system outlets at any frequency within the range of the system under investigation which is always specified, for any particular installation, as the minimum value obtained within specified frequency limits

[SOURCE: IEC 60728-1:2014, 3.1.66]

3.1.57**network interface****NI**

interface to the network for transmission of television signal, sound signals and interactive services

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

[SOURCE: IEC 60728-1:2014, 3.1.67]

3.1.58**network termination unit****NTU**

equipment for access to the cable network for television signal, sound signals and interactive services

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

[SOURCE: IEC 60728-1:2014, 3.1.68]

3.1.59**outdoor unit**

part of the TVRO installed in a position within line of sight to the satellite(s) to be received

Note 1 to entry: An outdoor unit normally comprises two main parts:

- a) the antenna sub-system which converts the incident radiation field into a guided wave;
The antenna sub-system consists of

- the main reflector, the secondary reflectors (if any) and the radiator,
- the feeder network, which may include optional polarizing devices, to receive orthogonal linear polarizations, in a simultaneous or exclusive way.

Instead of reflector(s)/feeder network subsystem, other types of antennas may be used, for example, flat array antennas

- b) the LNB(s), which may include an optional filter, is a device with very low internal noise that amplifies the received signals in the RF band and converts them to intermediate frequencies, (often called the 1st IF), for transmission to one or more indoor units where tuning, demodulation and decoding of the received signals are performed.

[SOURCE: IEC 60728-1:2014, 3.1.69]

3.1.60**out-of-band emissions**

emissions on a frequency or on frequencies outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions

[SOURCE: IEC 60728-1:2014, 3.1.70]

3.1.61**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.

[SOURCE: IEC 60728-1:2014, 3.1.72]

3.1.62 receiver lead

lead which connects the system outlet to the subscriber's equipment

Note 1 to entry: The definition of a receiver lead includes any filters or/and balun transformers in addition to the cable.

[SOURCE: IEC 60728-1:2014, 3.1.74, modified – The Note 1 has been refined.]

3.1.63 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

[SOURCE: IEC 60728-1:2014, 3.1.75]

3.1.64 remote headend

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

[SOURCE: IEC 60728-1:2014, 3.1.76]

3.1.65 satellite master antenna television system SMATV

system which is designed to provide sound and television signals to the outlets of a building or a 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.

[SOURCE: IEC 60728-1:2014, 3.1.77]

3.1.66 separator

device in which the signal energy, covering a frequency band, at one input port is divided between two or more output ports each of which covers a part of that frequency band

Note 1 to entry: For example, a diplexer is a two-output separator.

Note 2 to entry: Some forms of this device may be used in the reverse direction for combining.

[SOURCE: IEC 60728-1:2014, 3.1.78]

3.1.67 S/I_N

signal-to-intermodulation and noise ratio for a digitally modulated signal in the RF band

3.1.68 S/N

signal-to-noise ratio for a digitally modulated signal in the RF band

[SOURCE: IEC 60728-1:2014, 3.1.80, modified – The subscripts of the symbol have been deleted.]

3.1.69
single dwelling unit
SDU

home or office used by a single owner where television signals, sound signals are distributed and there is access to interactive services

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

[SOURCE: IEC 60728-1:2014, 3.1.81]

3.1.70
slope

difference in gain or attenuation at two specified frequencies between any two points in a system

[SOURCE: IEC 60728-1:2014, 3.1.85]

3.1.71
SMATV headend

headend in block of flats or in built-up sites to feed TV channels received by satellite into the house network or the spur network

Note 1 to entry: In some cases, a distribution point may be connected directly to the headend.

[SOURCE: IEC 60728-1:2014, 3.1.86]

3.1.72
SMATV network

extended distribution networks or systems designed to provide sound and television signals received by satellite receiving antenna to households in one or more buildings

Note 1 to entry: Originally defined as satellite master antenna television network.

Note 2 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 3 to entry: This kind of network or system could also carry control signals for satellite switched systems or other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.

[SOURCE: IEC 60728-1:2014, 3.1.87]

3.1.73
splitter

spur unit

device in which the signal power at the (input) port is divided equally or unequally between two or more (output) ports

Note 1 to entry: Some forms of this device may be used in the reverse direction for combining signal energy.

[SOURCE: IEC 60728-1:2014, 3.1.88]

3.1.74
spur amplifier

line extender

amplifier to compensate for the attenuation in a spur feeder

[SOURCE: IEC 60728-1:2014, 3.1.89]

3.1.75
spur feeder

feeder to which splitters, subscriber taps, or looped system outlets are connected

[SOURCE: IEC 60728-1:2014, 3.1.90]

3.1.76
spurious emissions

emissions on a frequency or frequencies which are outside the necessary bandwidth and whose level may be reduced without affecting the corresponding transmission of information

Note 1 to entry: Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products but exclude out of band emissions.

[SOURCE: IEC 60728-1:2014, 3.1.91]

3.1.77

standard reference power

P_0

<in cable networks> 1/75 pW

Note 1 to entry: This is the power dissipated in a 75 Ω resistor with a voltage drop of 1 μ V RMS across it.

[SOURCE: IEC 60728-1:2014, 3.1.92]

3.1.78

subscriber feeder

feeder connecting a subscriber tap to a system outlet or, where the latter is not used, directly to the subscriber equipment

Note 1 to entry: A subscriber feeder may include filters and balun transformers.

[SOURCE: IEC 60728-1:2014, 3.1.93]

3.1.79

subscriber equipment

equipment at the subscriber premises such as receivers, tuners, decoders, video recorders

[SOURCE: IEC 60728-1:2014, 3.1.94]

3.1.80

subscriber tap

device for connecting a subscriber feeder to a spur feeder

[SOURCE: IEC 60728-1:2014, 3.1.95]

3.1.81

subscriber terminal

ST

equipment able to receive the distributed signals or to send (via a cable modem) return signals for interactive services

EXAMPLE Television receiver, radio receiver, set-top box, etc.

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

[SOURCE: IEC 60728-1:2014, 3.1.96]

3.1.82

supertrunk feeder

connects only between headends or between a headend and the first distribution point

[SOURCE: IEC 60728-1:2014, 3.1.97]

3.1.83

system outlet

SO

device for interconnecting a subscriber feeder and a receiver lead

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

[SOURCE: IEC 60728-1:2014, 3.1.99]

3.1.84

transport stream

TS

data structure defined in ISO/IEC 13818-1

Note 1 to entry: It is the basis of the digital video broadcasting (DVB) related standards.

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

[SOURCE: IEC 60728-1:2014, 3.1.100]

3.1.85

trunk feeder

feeder used for the transmission of signals between a headend and a distribution point or between distribution points

[SOURCE: IEC 60728-1:2014, 3.1.101]

3.1.86

trunk amplifier

amplifier to compensate for the attenuation in a trunk feeder

[SOURCE: IEC 60728-1:2014, 3.1.102]

3.1.87

trunk-bridger amplifier

amplifier to compensate for the attenuation in a trunk feeder and also to energize a distribution point

[SOURCE: IEC 60728-1:2014, 3.1.103]

3.1.88

unwanted emissions

spurious emissions and out-of-band emissions

[SOURCE: IEC 60728-1:2014, 3.1.104]

3.1.89

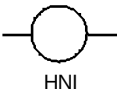
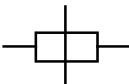
well-matched

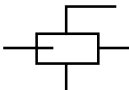
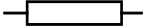
matching condition when the return loss of the equipment complies with the requirements of Table 1 of IEC 60728-3:2010

[SOURCE: IEC 60728-1:2014, 3.1.105]

3.2 Symbols

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

Symbols	Terms
	Attenuator [IEC 60617-S01244 (2001:07)]
	Sine-wave generator [IEC 60617-S01226 (2001:07)]
	Band pass filter [IEC 60617-S01249 (2001:07)]
	Amplifier [IEC 60617-S01239 (2001:07)]
	Oscilloscope [IEC 60617-S00059 (2001:07)] [IEC 60617-S00922 (2001:07)]
	Directional coupler [IEC 60617-S01340 (2001:07)]
	Modulator [IEC 60617-S01278 (2001:07)]
	Home Network Interface (HNI)
	Subscriber tap
	Receiver lead
	RF-choke [IEC 60617-S00583 (2001:07)]

Symbols	Terms
	Variable attenuator [IEC 60617-S01245 (2001:07)]
	Low pass filter [IEC 60617-S01248 (2001:07)]
	Variable band-pass filter [IEC 60617-S01249 (2001:07)] [IEC 60617-S00081 (2001:07)]
	Detector
	Spectrum analyser [IEC 60617-S00059 (2001:07)] [IEC 60617-S00910 (2001:07)]
	Mixer
	Demodulator [IEC 60617-S01278 (2001:07)]
	System Outlet (SO) [IEC 60617-S00438 (2001:07)]
	Splitter
	Resistor [IEC 60617-S00555 (2007:01)]

3.3 Abbreviations

AC	alternating current	AFC	automatic frequency control
AGC	automatic gain control	AI	amplitude imbalance
ALC	automatic level control	AM	amplitude modulation
ANTC	antenna coefficient	APSK	amplitude and phase shift keying
ASCII	American standard code for information interchange	AWGN	additive white Gaussian noise
		BAT	bouquet association table
BCH	Bose-Chaudhuri-Hocquenghem multiple error correction binary block code	BCT	broadcast and communication technologies
BCT B	BCT supported by balanced cabling	BCT C	BCT supported by coaxial cabling
BEP	bit error probability	BER	bit error ratio
BICM	bit interleaved and code modulation	BNI	building network interface
BPSK	binary phase shift keying	bslbf	bit string, left bit first
BW	bandwidth		
		CA	conditional access
CATV	community antenna television	CENELEC	Comité Européen de Normalisation Electrotechnique
CEPT	Conférence Européenne des Administrations des Postes et des Télécommunications	COFDM	coded orthogonal frequency division multiplex
CPE	common phase error	CRC	cyclic redundancy check
CS	carrier suppression	CW	continuous wave
D/A	digital-to-analogue converter	DAB	digital audio broadcasting
DC	direct current	DFT	discrete Fourier transformation
DOCSIS	Data Over Cable Service Interface Specification	DTH	direct to home
DVB	digital video broadcasting	DVB-C	digital video broadcasting baseline system for digital cable television (ETSI EN 300 429)
DVB-C2	digital video broadcasting baseline system for digital cable television second generation (ETSI EN 302 769)	DVB-CS	digital video broadcasting baseline system for SMATV distribution systems (ETSI EN 300 473)
DVB-MC	digital video broadcasting baseline system for multi-point video distribution systems below 10 GHz (ETSI EN 300 749)	DVB-MS	digital video broadcasting baseline system for multi-point video distribution systems at 10 GHz and above (ETSI EN 300 748)
DVB-S	digital video broadcasting baseline system for digital satellite television (ETSI EN 300 421)	DVB-S2	digital video broadcasting baseline system for digital satellite television second generation (ETSI EN 302 307)

DVB-T	digital video broadcasting baseline system for digital terrestrial television (ETSI EN 300 744)	DVB-T2	digital video broadcasting baseline system for digital terrestrial television second generation (ETSI EN 302 755)
EB	error block	EIT	event information table
EMM	entitlement management message	EN	European norm
ENB	equivalent noise bandwidth	END	equivalent noise degradation
ETR	ETSI technical report	ETS	European telecommunication standard
ETSI	European Telecommunications Standards Institute		
FDM	frequency division multiplex	FEC	forward error correction
FFT	fast Fourier transform	FIFO	first-in, first-out shift register
FM	frequency modulation	FSL	field strength level
HBES	home and building electronic systems		
HD	home distributor	HDTV	high-definition television
HES	home electronic systems	HEX	hexadecimal notation
HN	home network	HNI	home network interface
HP	high priority bit stream	ICI	intercarrier interference
IF	intermediate frequency	IFFT	inverse fast Fourier transform
IRE	Institute of Radio Engineers	ITS	insertion test signal
ITU	International Telecommunication Union	LDPC	low-density parity check (codes)
LDTV	low-definition television	LNB	low noise block converter (frequency converter in the focal point of a parabolic antenna)
LO	local oscillator	LP	low-priority bit stream
LSB	least significant bit	MATV	master antenna television
MDU	multi-dwelling unit	MER	modulation error ratio
MMDS	microwave multipoint distribution systems	MoCA	Multimedia over Coax Alliance
MPEG	moving picture experts group	MSB	most significant bit
MSPS	mega symbols per second	MUX	multiplex
MVDS	microwave video distribution systems	NICAM	near-instantaneously companded audio multiplex
NM	noise margin	OCT	octal notation
OFDM	orthogonal frequency division multiplex	PAPR	peak-to-average power ratio
PCR	programme clock reference	PER	packet error ratio
PID	packet identifier	PLP	physical layer pipe
PRBS	pseudo-random binary sequence	PSK	phase shift keying
QAM	quadrature amplitude modulation	QEF	quasi-error-free

QPSK	quaternary phase shift keying	RF	radio frequency
RMS	root mean square	RS	Reed-Solomon
RSBW	resolution bandwidth	SDTV	standard definition television
SDU	single dwelling unit	SFN	single frequency network
SM	signal margin		
SMATV	satellite master antenna television	S/IIN	signal-to-intermodulation noise ratio
S/N	signal-to-noise ratio	SO	system outlet
SOHO	small office, home office	SSLA	sectional slope of active coaxial home network
		T-STD	Standard television
SSLP	sectional slope of passive coaxial home network		
TC8PSK	trellis coded 8-phase shift keying	TI	terminal input
TPS	transmission parameter signalling	TS	transport stream
TV	television	TVRO	television receive only
UHF	ultra-high frequency	uimsbf	unsigned integer, most significant bit first
UTC	universal time coordinated	VHF	very high frequency
		WiFi	synonym of WLAN

4 Methods of measurement at system outlet

4.1 General

The methods of measurement listed below are applicable to digitally modulated signals as indicated in Table 1.

Table 1 – Application of the methods of measurement

Methods of measurement Subclause reference	Modulation of signals			
	Digital television			Digital radio
	PSK, APSK	QAM	OFDM	DAB
4.3 Signal level	x	x	x	x
4.4 RF signal-to-intermodulation and noise ratio <i>S/IIN</i>	x	x	x	x
4.5 Bit error ratio (<i>BER</i>)	x	x	x	x
4.6 <i>BER</i> versus <i>S/N</i>	x	x	x	x
4.7 System operating levels and margins	x	x	x	x
4.8 Modulation error ratio (<i>MER</i>)	x	x	x	
4.9 Phase jitter		x		
4.10 Phase noise of an RF carrier	x	x	x	
4.11 Mutual isolation between system outlets	x	x	x	x
4.12 Amplitude response within a channel	x	x	x	x
4.13 Non-linear distortion	x	x	x	x

The methods of measurement for digitally modulated signals take into account the following main characteristics of the signals:

- a) the carrier is not present in the modulated signal and therefore cannot be measured (e.g. in DVB systems using PSK, APSK or QAM modulation) or there are thousands of carriers (e.g. in DVB systems using COFDM 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.

4.2 Basic assumptions and measurement interfaces

The methods of measurement for digitally modulated signals are based on the assumption that:

- a) the MPEG-2/MPEG-4 transport stream (TS) is the specified input and output signal for all the baseline systems, i.e. for satellite, cable, SMATV, MMDS/MVDS and terrestrial distribution;
- b) the digitally modulated signals received by satellite are modulated in the PSK/APSK formats, i.e. according to ETSI EN 300 421 and ETSI EN 302 307 for the various PSK/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 or ETSI EN 302 769;
- d) the digitally modulated signals received from terrestrial broadcasting in the OFDM format may be distributed in SMATV systems in the same OFDM format or in CATV systems in DVB-C or DVB-C2 format via baseband demodulation and remodulation;
- e) a I/Q baseband signal source for PSK, QAM or OFDM formats is available, as described in Figure 6, Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11; appropriate interfaces are accessible and are consistent with the DVB-SI documents (see document ETSI TR 101 211 and ETSI EN 300 468);

NOTE 1 The null transport stream packet generator can be replaced by a pseudo-random bit sequence generator (PRBS).

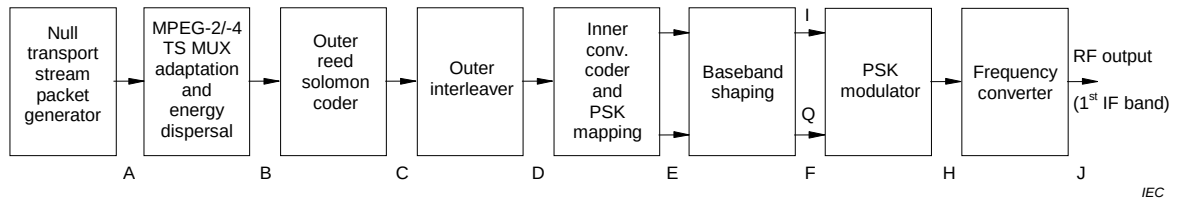


Figure 6 – PSK modulation (QPSK, BPSK or TC8PSK)

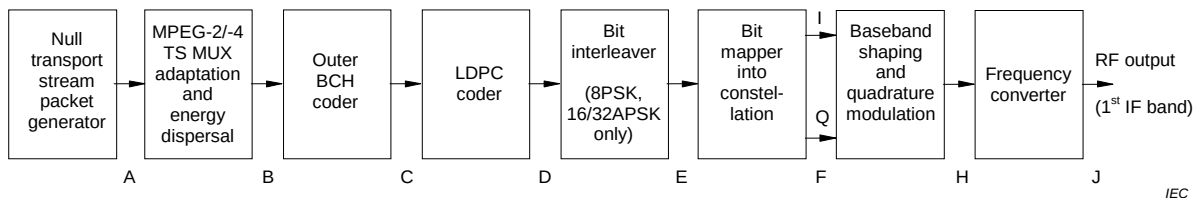


Figure 7 – DVB-S2 modulation (QPSK, 8PSK, 16APSK, 32APSK)

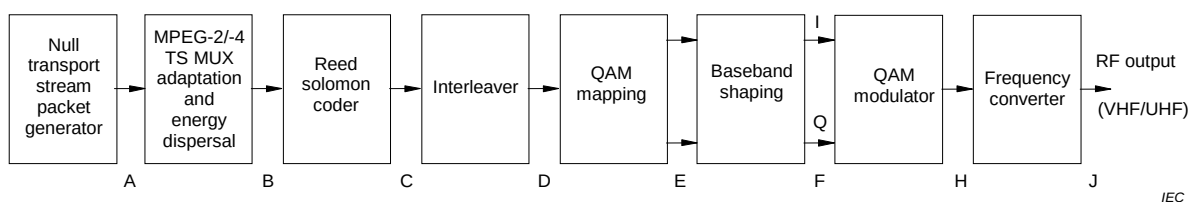


Figure 8 – DVB-C QAM modulation

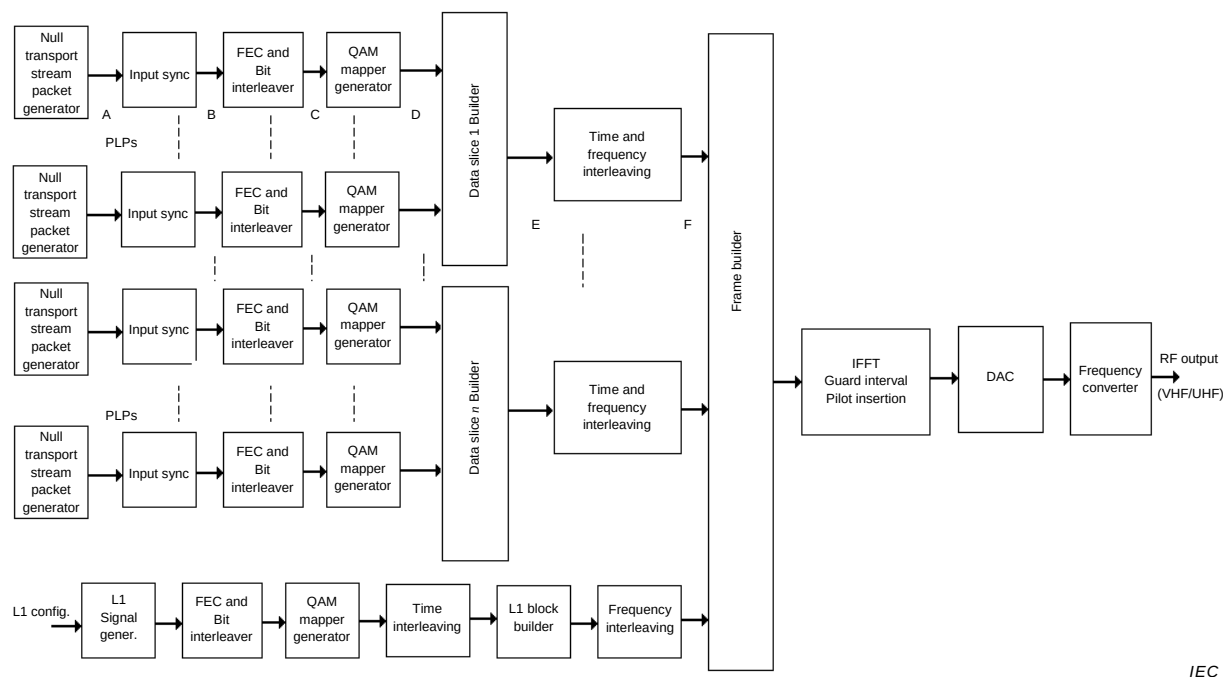


Figure 9 – DVB-C2 QAM modulation

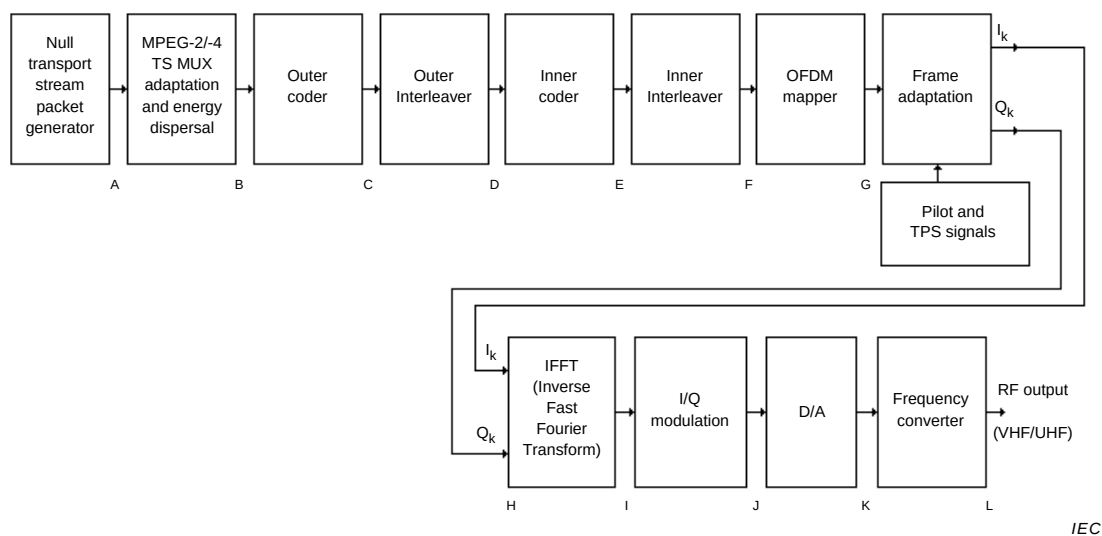


Figure 10 – DVB-T OFDM modulation

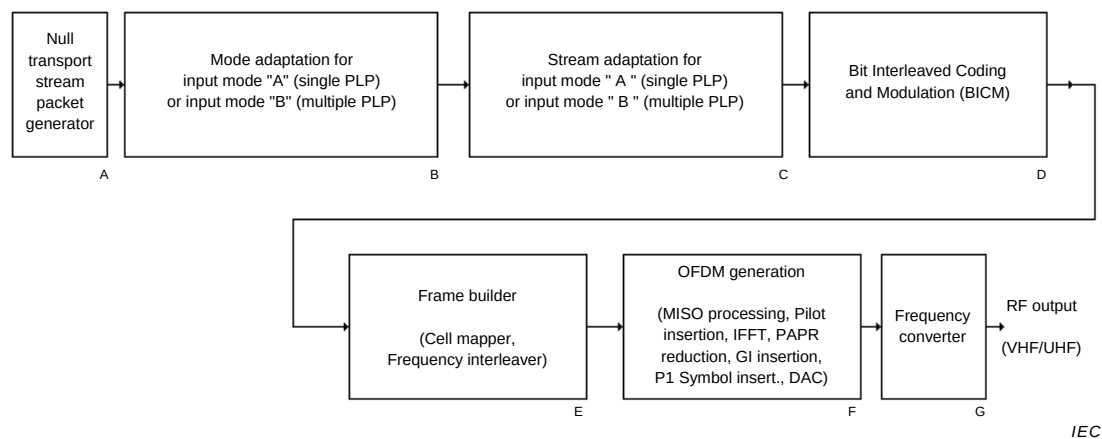


Figure 11 – DVB-T2 OFDM modulation

- f) a reference receiver for PSK, APSK, QAM or OFDM formats is available as described in Figure 12, Figure 13, Figure 14, Figure 15, Figure 16 and Figure 17, where appropriate interfaces are indicated;

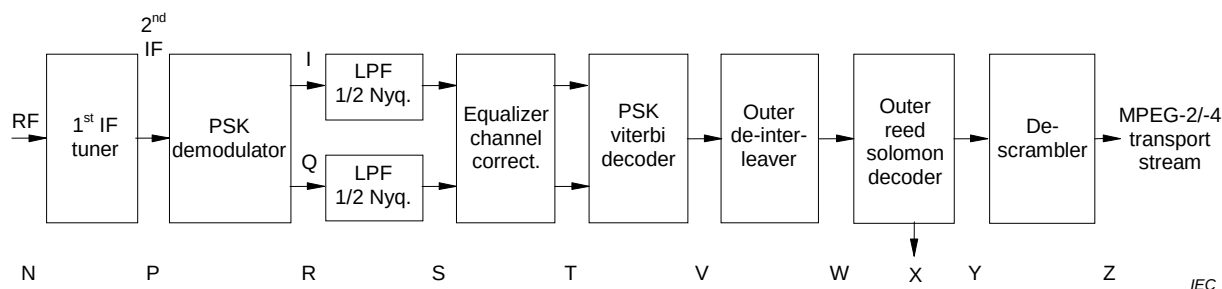


Figure 12 – Reference receiver for PSK demodulation (QPSK, BPSK or TC8PSK)

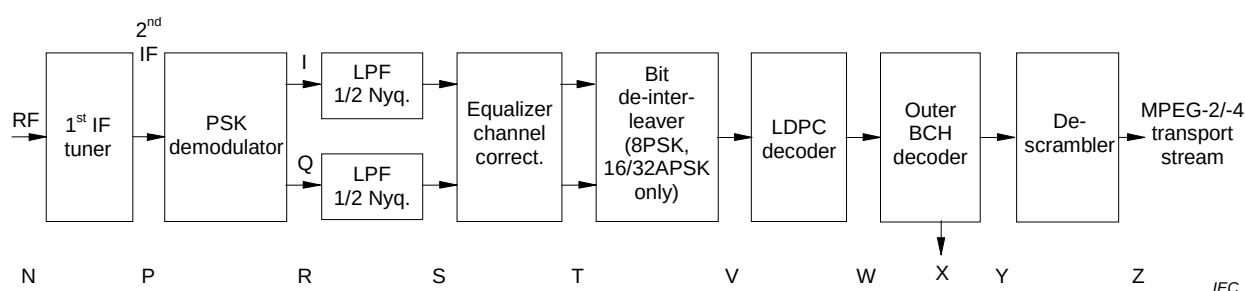


Figure 13 – Reference receiver for DVB-S2 demodulation (QPSK, 8PSK, 16APSK, 32APSK)

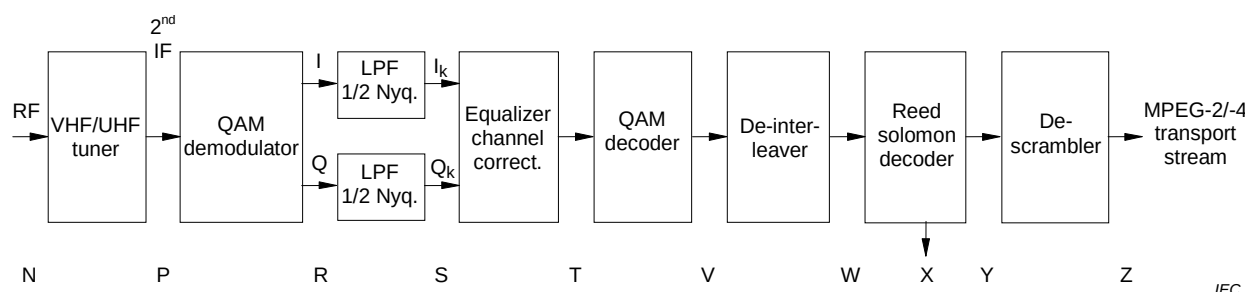


Figure 14 – Reference receiver for DVB-C QAM demodulation

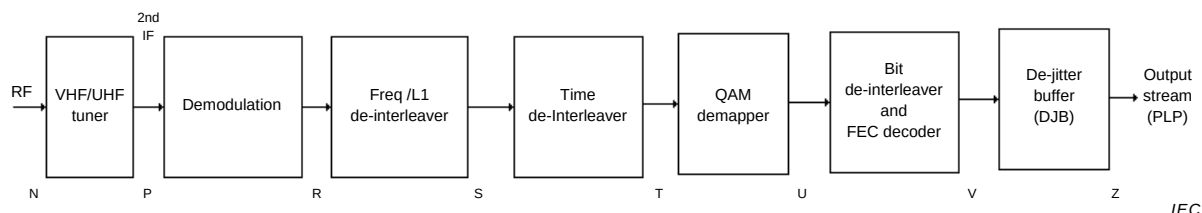


Figure 15 – Reference receiver for DVB-C2 demodulation

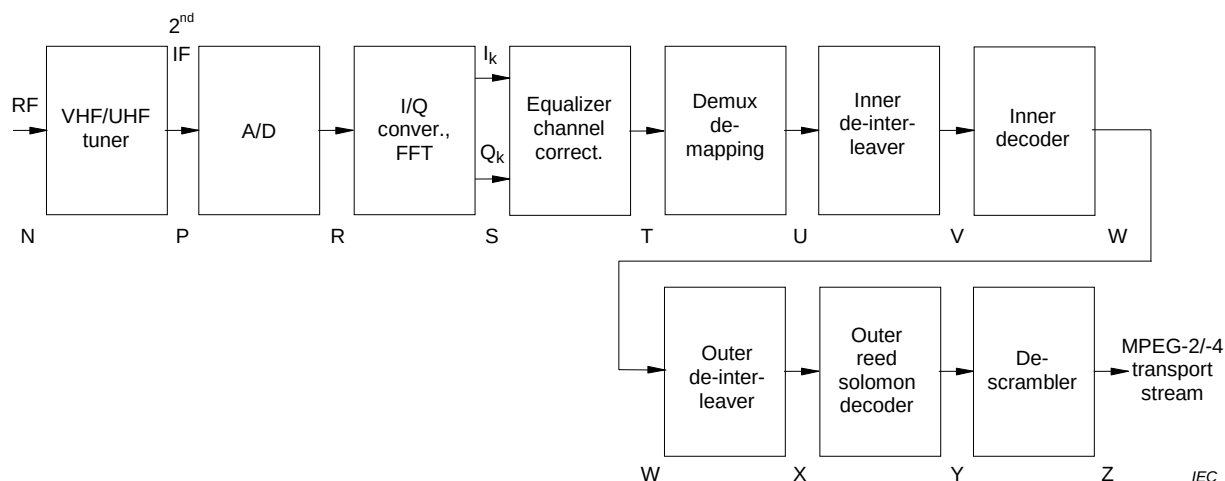


Figure 16 – Reference receiver for DVB-T OFDM demodulation

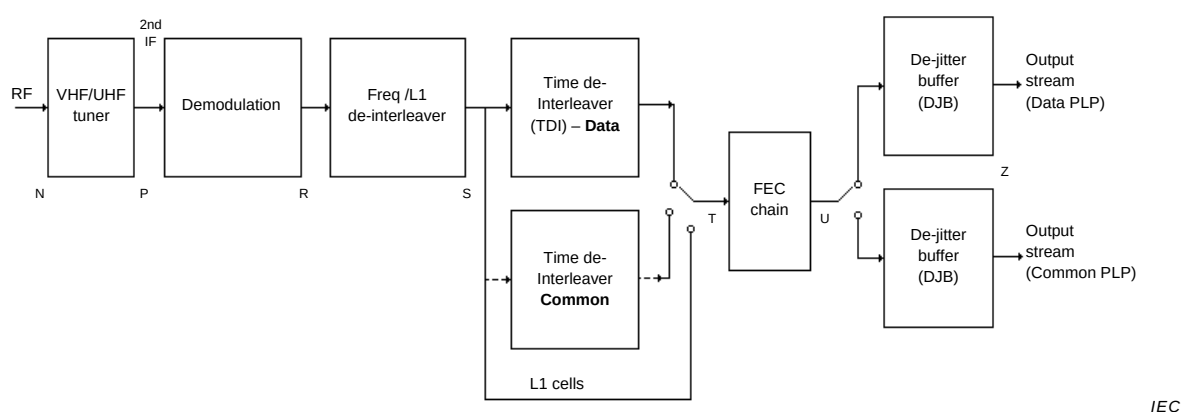


Figure 17 – Reference receiver (buffer model) for DVB-T2 OFDM demodulation

NOTE 2 The frequency range of the bands for the 1st IF and for VHF/UHF tuners depends on the frequency allocation plan of each country. Examples are given below:

1st IF: 950 MHz to 2 150 MHz

VHF/UHF: 47 MHz to 862 MHz (Europe)

90 MHz to 770 MHz (Japan)

- 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).

4.3 Signal level

4.3.1 General

The level of a digitally modulated signal is given by the RMS power of the signal within the equivalent noise bandwidth and can be expressed in dB(mW) or in dB(μV) referred to 75 Ω.

This measuring method applies to the measurement of the level of digitally modulated signals using the modulation methods:

- PSK (ETSI EN 300 421);
- PSK, APSK (ETSI EN 302 307);
- QAM (ETSI EN 300 429, ETSI EN 300 473);
- and COFDM (ETSI EN 300 744, ETSI EN 302 755 and ETSI EN 302 769).

This method of measurement can also be used for DAB and NICAM signals.

Because the modulated signal is similar in characteristics to white noise in the frequency domain, 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 in dB(mW/Hz). The signal level in dB(mW) or in dB(μV) can be calculated if the bandwidth is known.

NOTE Also a vector signal analyser can be used or a suitable measuring set designed and calibrated for signal level measurement of digitally modulated signals.

The measurement can be performed at the system outlet, at the output of a distribution equipment (passive or active), at the output of the headend or at the output of an outdoor unit (SHF receiver) for satellite reception.

4.3.2 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 be preferably within ±0,5 dB and shall be stated with the results.

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

4.3.3 Connection of the equipment

Connect the measuring equipment to the system outlet or to the point where the measurement shall be performed, using suitable cable and connectors, taking care to maintain correct impedance matching.

4.3.4 Measurement procedure

The measurement procedure is as follows.

- a) When signal levels are to be measured where a high ambient electromagnetic 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(ies) and on the meter ranges to be used.
- b) Tune the spectrum analyser on 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. Examples of the equivalent signal bandwidth *BW* for digitally modulated signals are indicated in Annex C.
- c) Set the resolution bandwidth *RSBW* of the spectrum analyser to 100 kHz and set the video bandwidth to 100 Hz or lower to obtain a smooth display.
- d) Measure the level *SL* 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.
- e) Measure on the displayed channel the two frequencies at which the level is 3 dB lower than the maximum level *SL*; the difference between these two frequencies is assumed to be the equivalent signal bandwidth *BW* expressed in Hz.
- f) Calculate level *S* of the signal using the following formula:

$$S = SL + 10 \lg \left[\frac{BW}{RSBW} \right] + K_{sa}$$

where

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

SL is the flat top signal level in dB(μV) or in dB(mW);

BW is the equivalent signal bandwidth of the channel in Hz (Annex C);

RSBW is the resolution bandwidth of the spectrum analyser in Hz;

K_{sa} is the correction factor of the spectrum analyser in dB.

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 Annex D).

The correction factor is not necessary if the measuring equipment can be set to display the level in dB(mW/Hz) units. In this case, level S of the signal can be obtained from the measured maximum level SL using the following formula, where BW shall be expressed in Hz:

$$S = SL + 10 \lg (BW)$$

NOTE This measuring method actually measures the $S + N$ level. The contribution of noise is considered negligible if the level of noise displayed outside the equivalent signal bandwidth is at least 15 dB lower than the maximum level displayed within the equivalent signal bandwidth. This noise level includes that of the measuring equipment (spectrum analyser) which will affect the result unless it is at least 10 dB lower than the noise level displayed outside the channel band. 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 SL (see Annex A).

4.3.5 Presentation of the results

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

4.4 RF signal-to-intermodulation and noise ratio S/IN

4.4.1 General

In a cable network, two distortion signals occur: thermal noise and intermodulation products associated with the non-linear behaviour of equipment and components. In a single measurement of the noise signal, the two distortion signals cannot be distinguished. Therefore, in this clause, they are taken together as intermodulation and noise signals (IN).

For this measuring method, the composite network load of all input channels as used during normal service conditions shall be applied. The intermodulation signal will depend on the signal level throughout the cascade. Therefore, a measured S/IN ratio is meaningful only when all signal levels are specified.

This measuring method applies to the measurement of the RF signal-to-intermodulation and noise ratio S/IN of digitally modulated signals using PSK, APSK, QAM, OFDM formats.

Because the modulated signal is similar to intermodulation and noise signal distributed in the bandwidth of the channel, 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 densities of both the signal and the noise.

NOTE A vector signal analyser can also be used.

The measurement can be performed at the system outlet, at the output of a distribution equipment (passive or active), at the output of the headend or at the output of an outdoor unit (SHF receiver) for satellite reception.

The measured S/IN will depend on the signal-to-noise (S/N) of the composite input signal and on the ratio of the signal to the intermodulation noise added by the cable network. Using a standard network input load of signals may thus limit the measurement range of the method of measurement up to the S/N ratio of the input load. As an alternative, an input source with notch filters to reduce the S/N of the measurement signals can be used, similar to the source signal used in IEC 60728-3-1.

4.4.2 Equipment required

The equipment required is a spectrum analyser having a calibrated display of the tuned signal.

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

4.4.3 Connection of the equipment

Connect the measuring equipment to the system outlet or to the point where the measurement shall be performed, using suitable cable and connectors, taking care to maintain correct impedance matching.

4.4.4 Measurement procedure

The measurement procedure is as follows.

- a) Tune the spectrum analyser on 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. Examples of the equivalent signal bandwidth (BW) for digitally modulated signals are indicated in Annex C.
- b) Set the resolution bandwidth of the spectrum analyser to 100 kHz and the video bandwidth low enough to obtain a smooth display (100 Hz, if available). If a different setting is used, this shall be the same when measuring the signal level and the intermodulation and noise level.
- c) Measure the maximum level S of the flat top of the displayed signal in dB(μ V) or in dB(mW) using the display line cursor if this feature is available.

If the spectrum of the signal is not flat, due to echoes, measure the signal level at the centre frequency of the channel.

- d) Switch off the channel at the input of the system or at the input of the device 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 intermodulation and noise level IN in the same units as the signal level (in dB(μ V) or in dB(mW) or in dB(mW/Hz)).

When switching off the input signal, all equipment with built-in AGC will show a different behaviour. In this case, the intermodulation and noise level should be measured in-between the channels.

- e) Calculate the signal to intermodulation and noise ratio S/IN by the following formula:

$$S/IN = S - IN$$

where

S/IN is the signal-to-intermodulation-and-noise ratio in dB;

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

IN is the intermodulation and noise level in dB(μ V), in dB(mW) or in dB(mW/Hz).

NOTE This method of measurement actually measures the $(S + IN)/IN$ ratio. The measuring equipment (spectrum analyser) will affect the result unless it has a noise level of at least 10 dB lower than the intermodulation and noise level displayed outside the channel band. Otherwise, the contribution of the measuring equipment noise in the measurement of the intermodulation and noise level (IN) needs to be taken into account (see Annex A, Clause A.2).

4.4.5 Presentation of the results

The measured signal-to-noise ratio S/IN shall be expressed in dB.

4.5 Bit error ratio (BER)

4.5.1 General

This method of measurement applies to the measurement of bit error ratio (BER) of digitally modulated signals using PSK, APSK, QAM, OFDM formats. BER is the primary parameter, which describes the quality of the digital transmission link.

The bit error ratio is defined as the ratio between erroneous bits and the total number of transmitted bits.

For OFDM formats (DVB-T/T2) the BER measurement can be done on data or pilots. The measurement condition should be stated with the results.

If *BER* before Reed Solomon is ranging from 10^{-2} to 10^{-4} (or before BCH from 10^{-4} to 10^{-6}) the measurement can be made in a reasonable amount of time. Above a *BER* of 10^{-2} , the result is assumed to be inaccurate.

The measurement is performed at the system outlet of a cable network or at other points of interest in the system. The number of the modulated signals shall be equal to that used in normal operating conditions of the system or distribution network.

This measuring method shall be performed under out of service conditions. If the measurement is to be made during the normal operating conditions of the network under test, all input channels shall be maintained except the channel to be measured, that shall be replaced at the headend input using the equipment indicated in 4.5.2 a) and b) and measurements done on that channel only, keeping all the other channels running. For in-service measurement of *BER*, see also ETSI TR 101 290.

4.5.2 Equipment required

The equipment required is listed below:

- a) I/Q baseband signal sources for PSK, APSK, QAM, OFDM modulation format;
- b) RF modulators for PSK, APSK, QAM, OFDM modulation format (Figure 6, Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11);
- c) noise source;
- d) a combiner for the output signals of the modulators with negligible distortion;
- e) adjustable attenuator;
- f) power combiner;
- g) power splitter;
- h) spectrum analyser able to tune the nominal frequency range of the system;
- i) reference receiver (Figure 12, Figure 13, Figure 14, Figure 15, Figure 16 and Figure 17) with good equaliser (influence of linear distortion of the cable network to the *BER* measurement should be negligible);
- j) *BER* counter connected at the appropriate interface of the reference receiver (e.g. interface V of Figure 12, Figure 13, Figure 14, interface Z of Figure 15 or interface U of Figure 16), depending where *BER* shall be evaluated. If it is connected after the Reed-Solomon or BCH decoder, decoding should be deactivated in order to reduce the duration of the measurement.

4.5.3 Connection of the equipment

The measuring set-up for *BER* measurement is shown in Figure 18. The measuring equipment shall be connected taking care to maintain correct impedance matching and suitable cables and connectors.

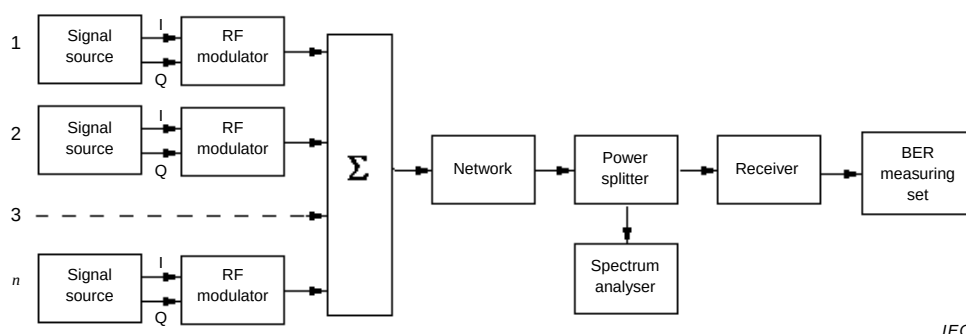


Figure 18 – Test set-up for *BER* measurement

4.5.4 Measurement procedure

The measurement procedure is as follows.

- a) Set the signal source (base band) to generate a sequence defined as the null transport stream packet in ISO/IEC 13818-1 with all bytes set to 0x00 (see Annex B), a sequence of four bytes followed by a PRBS can also be used.

NOTE The null transport stream packet is defined as the four-byte sequence 0x47, 0x1F, 0xFF, 0x10, followed by 184 zero bytes (0x00). This sequence can be available as an encoding system option.

- b) Apply the signal source I and Q channels at the input of each RF modulator to obtain the desired PSK, APSK, QAM, or OFDM modulation format.
- c) Set the carrier frequency of each RF modulator to that of each channel used in normal operating conditions of the system or network to be measured.
- d) Adjust the output signal level of each RF modulator to obtain the same level at the system outlet as in normal operating conditions.
- e) Tune the receiver on the channel to be tested.
- f) Measure the *BER* counting the error bits for a sufficiently long time to count at least 100 error bits and refer this number to the total number of transmitted bits in that time.

4.5.5 Presentation of the results

The measured *BER* is indicated with reference to the channel tuned. The point where the measurement of *BER* has been performed shall be indicated with the results.

4.6 *BER* versus *SIN*

4.6.1 General

This measuring method applies to the measurement of bit error ratio (*BER*) of digitally modulated signals using PSK, APSK, QAM, OFDM formats. The measurement of *BER* versus *S/N* enables a graph to be drawn which shows the implementation loss of the system over a range of bit error ratios. The residual *BER* at high *S/N* values is an indicator of possible network problems. The *BER* range of interest is 10^{-7} to 10^{-3} .

The measurement is performed at the system outlet of a cable network, while the modulated signals with the appropriate format are applied at the input of the headend or at the input of the network, depending which part of the system is to be measured. The number of the modulated signals shall be equal to that used in normal operating conditions of the system or distribution network.

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

The performance requirements given in 5.9 are applicable to the measured values of *S/N* values.

This measuring method shall be performed under out of service conditions. If the measurement is to be made during the normal operating conditions of the network under test, all input channels shall be maintained except the channel to be measured, that shall be replaced at the headend input using the equipment indicated in 4.6.2 a) and b) and measurements done on that channel only, keeping all the other channels running.

4.6.2 Equipment required

The equipment required is listed below:

- a) I/Q baseband signal sources for PSK, APSK, QAM, OFDM modulation format;
- b) RF modulators for PSK, APSK, QAM, OFDM modulation format (Figure 6, Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11);
- c) noise source;
- d) a combiner for the output signals of the modulators with negligible distortion;
- e) adjustable attenuator;
- f) power combiner;
- g) power splitter;
- h) spectrum analyser able to tune the nominal frequency range of the system;

- i) reference receiver (Figure 12, Figure 13, Figure 14, Figure 15, Figure 16 and Figure 17) with good equaliser (influence of linear distortion of the cable network to the BER measurement should be negligible);
- j) BER counter connected at the appropriate interface of the reference receiver (e.g. interface V of Figure 12, Figure 13, Figure 14, interface Z of Figure 15, or interface U of Figure 16), depending where BER shall be evaluated. If it is connected after the Reed-Solomon or BCH decoder, decoding should be deactivated in order to reduce the duration of the measurement.

4.6.3 Connection of the equipment

The measuring set-up for *BER* versus or *S/N* measurement is shown in Figure 19.

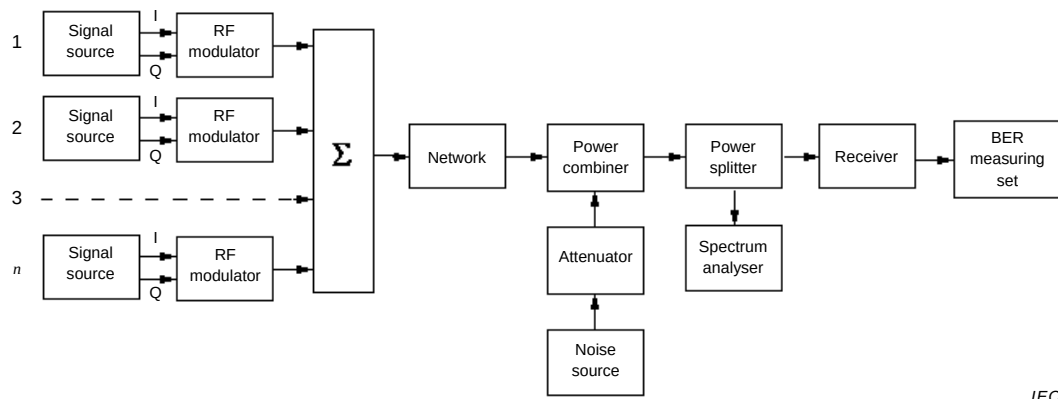


Figure 19 – Test set-up for BER measurement versus *S/N*

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

4.6.4 Measurement procedure

The measurement procedure is as follows.

- a) Set the signal source (base band) to generate a sequence defined as the null transport stream packet in ISO/IEC 13818-1 with all bytes set to 0x00 (see Annex B). A sequence of four bytes followed by a PRBS can also be used.

NOTE 1 The null transport stream packet is defined as the four-byte sequence 0x47, 0x1F, 0xFF, 0x10, followed by 184 zero bytes (0x00). This sequence can be available as an encoding system option.

- b) Apply the signal source I and Q channels at the input of each RF modulator to obtain the desired PSK, APSK, QAM, or OFDM modulation format.
- c) Set the carrier frequency of each RF modulator to that of each channel used in normal operating conditions of the system or network to be measured.
- d) Adjust the output signal level of each RF modulator to obtain the same level at the system outlet as in normal operating conditions.
- e) Tune the receiver and the spectrum analyser on the channel to be measured. Select the centre frequency of the spectrum analyser, the span and level settings to show the whole channel.
- f) Set the resolution bandwidth *RSBW* of the spectrum analyser to 100 kHz and the video bandwidth to 100 Hz or lower to obtain a smooth display.
- g) With the noise generator switched-off, measure the *BER* at the receiver output.
- h) Measure the RF signal level *S* in dB(μV) or in dB(mW), according to 4.3.

NOTE 2 In the case of QAM modulated signals, the RF signal level *S* is assumed to be that measured according to 4.3, because the RF signal level upon switching off the modulation does not coincide with the signal peak level.

- i) Switch-off the modulation and measure the noise level *N* beside the centre channel frequency ($\Delta f \geq 0,5$ MHz) in the same units as the signal level (in dB(μV) or in dB(mW)).

Attention should be paid to the amplitude response of the noise spectrum within the channel. If it is not white Gaussian spectrum (flat amplitude response), care should be taken not to measure at maximum or minimum frequency points, but at the frequency points where the energy of noise reaches its average.

- j) Calculate the RF signal-to-noise ratio S/N by the following formula:

$$S/N = S - N - 10 \lg (BW/RSBW) - K_{sa} \text{ dB}$$

where

S/N is the RF signal-to-noise ratio in dB;

S is the RF signal level in dB(μ V) or in dB(mW);

N is the noise level in dB(μ V) or in dB(mW);

BW is the equivalent signal bandwidth of the channel in Hz (Annex C);

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

K_{sa} is the correction factor of the spectrum analyser in dB.

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 Annex D).

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 S/N ratio can be obtained from the following formula:

$$S/N = S - N - 10 \lg(BW) \text{ dB}$$

- k) Switch on the modulation and the noise generator, add noise changing the attenuator setting and measure again the BER at the receiver output and S/N at the input of the receiver. Repeat this step several times to obtain the plot of BER versus S/N .

4.6.5 Presentation of the results

The measured BER is plotted versus S/N (dB). An example of measurement of BER versus S/N is shown in Figure 20. The interface point where the measurement of BER has been performed shall be indicated with the results.

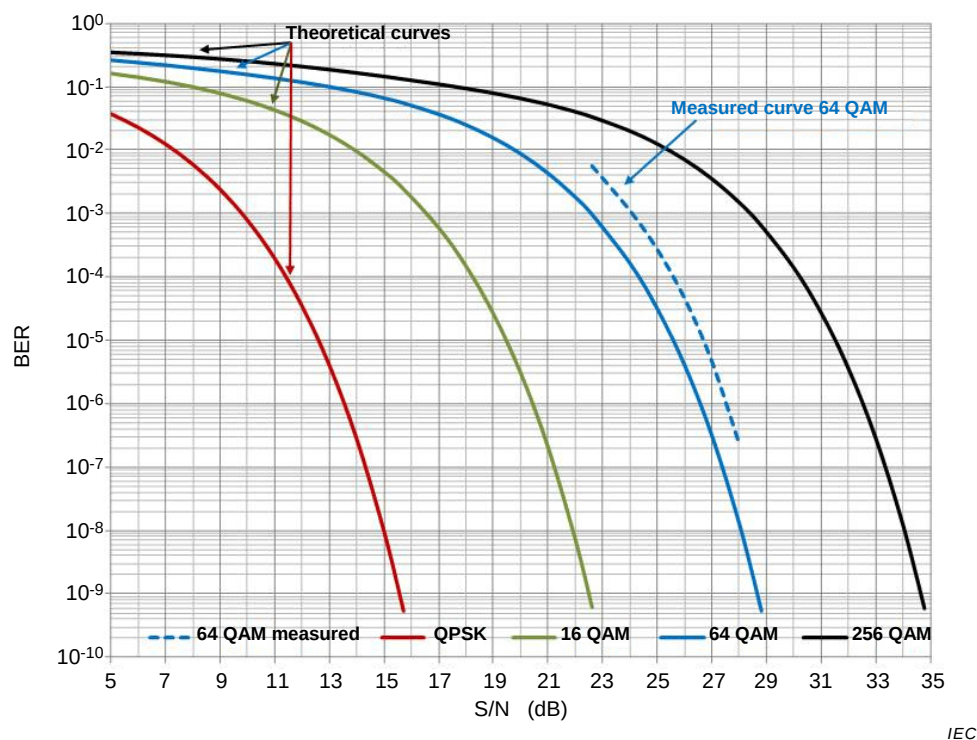


Figure 20 – Example of *BER* measurement versus *S/N*

4.7 System operating levels and margins

4.7.1 General

The performance of a system depends not only on the channels level S and S/IN , but also on the operating signal level margin with respect to white noise (signal margin white noise, SM_{WN}) and the signal level margin with respect to intermodulation noise (signal margin intermodulation noise SM_{IN}).

If S/IN and BER are plotted versus the signal level S at the output of the system, the curves indicated in Figure 21 can be obtained. Figure 21 shows the linear and non-linear range and the dynamic range as defined by the minimum signal level (S_{min}) and the maximum signal level (S_{max}). Provided that the network is properly designed, the Normal Operating Condition (NOC) will be situated somewhere between S_{min} and S_{max} with a suitable white noise signal margin (SM_{WN}) and intermodulation noise signal margin (SM_{IN}).

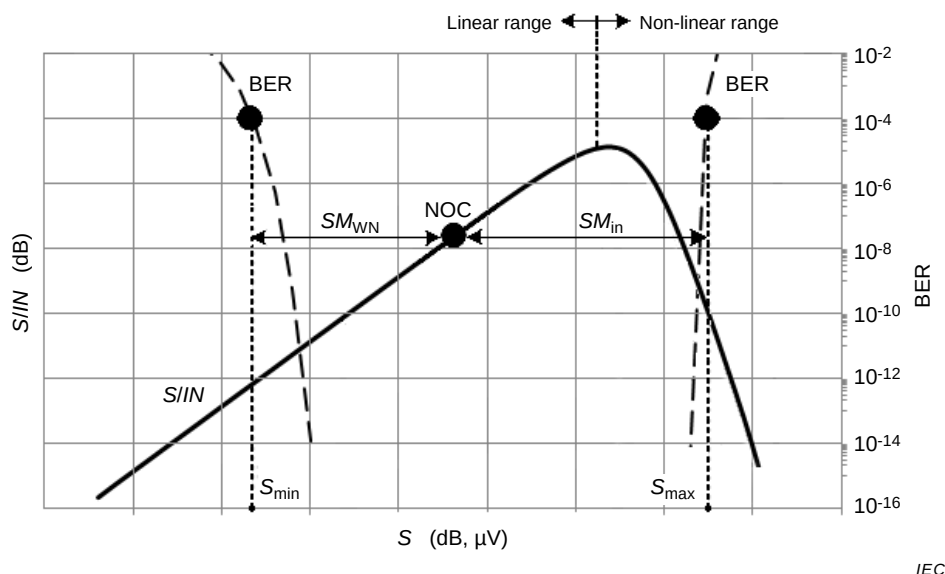


Figure 21 – Example of S/IIN and BER versus signal level S for a cable network without optical link

For a network with an optical link, the top of the curve of Figure 21 will be levelled off due to the limited S/IIN of the optical link.

In this method of measurement, the electrical signal levels S_{max} and S_{min} are established by respectively raising or lowering the signal level throughout the system. Thus, the complete transmission system is characterized.

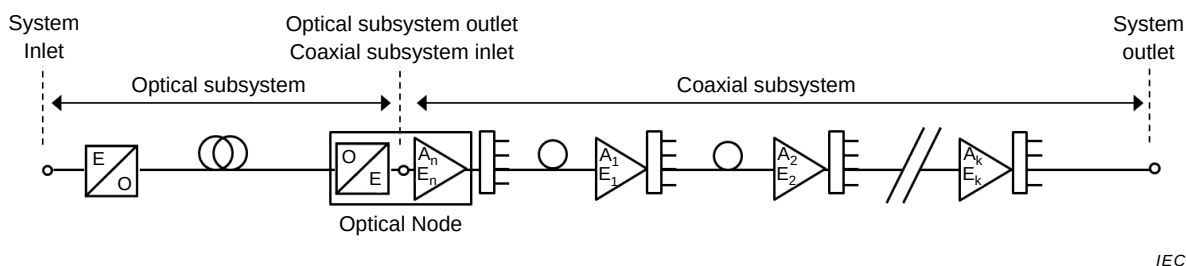


Figure 22 – Optical and coaxial subsystems of an HFC network

In Figure 22 the distinction is shown between the optical subsystem and coaxial subsystem of an HFC network. The optical modulation index and the output power of the optical transmitter should be kept constant. The proposed method of measurement reveals even more system information, if it is separately applied to both, the optical and the coaxial subsystem. When first, the S/IIN and BER at optical subsystem output versus optical transmitter input level is measured, the NOC for the optical subsystem may be checked and optimized independently from the coaxial subsystem with high precision. Likewise, a second measurement of S/IIN and BER at system outlet versus coaxial subsystem inlet allows for separate and independent coaxial subsystem characterization and optimization.

In networks in service, raising or lowering the signal level may appear impossible or risky because of the use of automatic level control techniques. In a laboratory measurement, the network may be configured in conformance with the physical design and the signal level design whereas automatic level control is switched off. The signal level can be raised or lowered by increasing or lowering the electrical gain of the optical node.

4.7.2 White noise signal margin (SM_{WN})

4.7.2.1 General

This measuring method applies to the measurement of white noise signal margin (SM_{WN}) in the actual operating point of digitally modulated signals using PSK, APSK, QAM or OFDM formats.

The purpose of this measuring method is to provide an indication of the reliability of the transmission channel. The white noise signal margin measurement is a more useful measure of system operating margin than a direct *BER* (bit error ratio) measurement due to the steepness of the *BER* curve versus *S/IN* ratio.

The measurement is performed at the system outlet of a cable network, while the modulated signals with the appropriate format are applied at the input of the headend or at the input of the network, depending which part of the system is to be measured. The number of the modulated signals shall be equal to that used in normal operating conditions of the system or distribution network.

The headend can include modulation converters (from PSK or OFDM to QAM format).

This measuring method shall be performed under out-of-service conditions. If the measurement is to be made during the normal operating conditions of the network under test, all input channels shall be maintained except the channel to be measured, that shall be replaced at the headend input using the equipment indicated in 4.7.2.2 a) and b) and measurements done on that channel only, keeping all the other channels running.

4.7.2.2 Equipment required

The equipment required is listed below:

- a) I/Q baseband signal source for PSK, APSK, QAM or OFDM modulation format (Figure 6, Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11);
- b) RF modulators for PSK, APSK, QAM or OFDM modulation format (Figure 6, Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11);
- c) a combiner for the output signals of the modulators with negligible distortion;
- d) a wide band amplifier with suitable linearity and gain in the level range of the system to be measured;
- e) adjustable attenuators (1 dB steps) to be placed before and after the network to be measured;
- f) power combiner;
- g) power splitter;
- h) spectrum analyser able to tune the nominal frequency range of the system;
- i) reference receiver (Figure 12, Figure 13, Figure 14, Figure 15, Figure 16 and Figure 17) with good equaliser (influence of linear distortion of the cable network to the *BER* measurement should be negligible);
- j) *BER* counter connected at the appropriate interface of the reference receiver (e.g. interface V of Figure 12, Figure 13, Figure 14, interface Z of Figure 15, or interface U of Figure 16), depending where *BER* shall be evaluated. If it is connected after the Reed-Solomon or BCH decoder, decoding should be deactivated in order to reduce the duration of the measurement.

4.7.2.3 Connection of the equipment

The measuring set-up for white noise signal margin measurement is the same as that for the measurement of *intermodulation noise signal margin* and is shown in Figure 23.

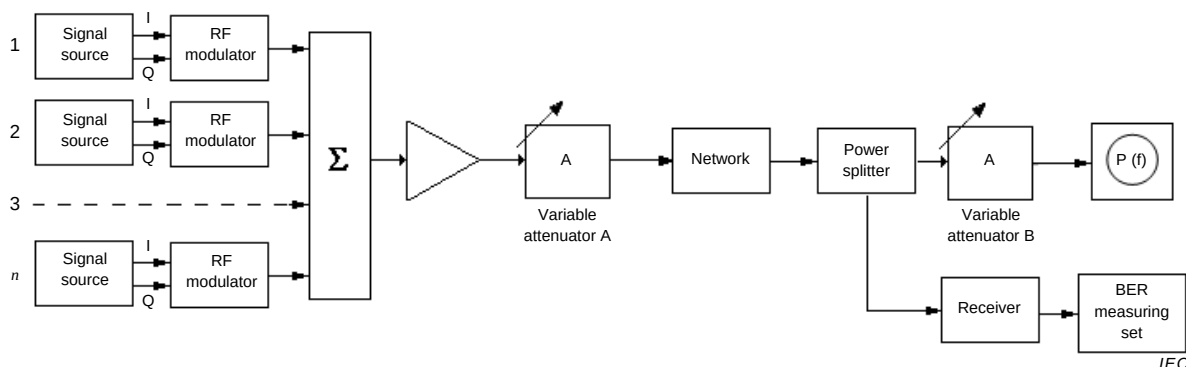


Figure 23 – Test set-up for SM_{WN} and SM_{IN} measurement

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

4.7.2.4 Measurement procedure

The measurement procedure is as follows.

- a) Set the signal source (base band) to generate a sequence of four bytes followed by a PRBS.

NOTE The null transport stream packet is defined as the four-byte sequence 0x47, 0x1F, 0xFF, 0x10, followed by 184 zero bytes (0x00). This sequence can be available as an encoding system option.

- b) Apply the signal source I and Q channels at each modulator to obtain the desired PSK, APSK, QAM or OFDM modulation format.
- c) Set the carrier frequency of each RF modulator to that of each channel used in normal operating conditions of the system or network to be measured.
- d) Adjust the output signal level of each RF modulator to obtain the same level at the system outlet as in normal operating conditions.
- e) Tune the receiver and the spectrum analyser to the channel to be measured. Select the centre frequency of the spectrum analyser, the span and level settings to show the whole channel. Record the measured channel signal level in this normal operating condition as S_{NOC} .
- f) Using attenuator A decrease the level of the modulated signals applied to the cable network input and measure *BER* at the cable network output until *BER* is 10^{-4} . Record the measured channel signal level in this maximum noise condition as S_{min} .
- g) Calculate the white noise signal margin SM_{WN} by the following formula:

$$SM_{WN} = S_{NOC} - S_{min} \quad \text{in dB.}$$

4.7.2.5 Presentation of the results

The measured white noise signals margin (SM_{WN}) shall be expressed in dB. The interface point where the measurement of *BER* has been performed shall be indicated with the results.

4.7.3 Intermodulation noise signal margin (SM_{IN})

4.7.3.1 General

This measuring method applies to the measurement of intermodulation noise signal margin (SM_{IN}) in the actual operating point of digitally modulated signals using PSK, APSK, QAM or OFDM formats.

The purpose of this measuring method is to provide an indication of the reliability of the transmission channel. The intermodulation noise signal margin measurement is a useful measure of the system operating margin.