

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Cable networks for television signals, sound signals and interactive services –
Part 101-1: RF cabling for two-way home networks with all-digital channels load**

**Réseaux de distribution par câbles pour signaux de télévision, signaux de
radiodiffusion sonore et services interactifs –
Partie 101-1: Câblage RF pour réseaux domestiques bidirectionnels soumis à
une charge de porteuses exclusivement numériques**



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2023 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications preview. With a subscription you will always have access to up-to-date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Cable networks for television signals, sound signals and interactive services –
Part 101-1: RF cabling for two-way home networks with all-digital channels load**

**Réseaux de distribution par câbles pour signaux de télévision, signaux de
radiodiffusion sonore et services interactifs –
Partie 101-1: Câblage RF pour réseaux domestiques bidirectionnels soumis à
une charge de porteuses exclusivement numériques**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 33.040.20, 33.160.01

ISBN 978-2-8322-7109-4

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	9
2 Normative references	10
3 Terms, definitions, symbols and abbreviated terms.....	10
3.1 Terms and definitions.....	10
3.2 Symbols.....	19
3.3 Abbreviated terms.....	20
4 Methods of measurement for the home network.....	21
5 Performance requirements of the home network	21
5.1 General.....	21
5.2 Impedance	22
5.3 Performance requirements at the terminal input	22
5.3.1 General	22
5.3.2 Signal level.....	22
5.3.3 Other parameters	22
5.4 Performance requirements at system outlets.....	22
5.4.1 Minimum and maximum RF signal levels	22
5.4.2 Mutual isolation between system outlets	22
5.4.3 Isolation between individual outlets in one household	22
5.4.4 Isolation between forward and return paths	23
5.4.5 Long-term frequency stability of distributed signals at any system outlet.....	23
5.5 Performance requirements at the HNI	23
5.5.1 Minimum and maximum signal levels at HNI1	23
5.5.2 Minimum and maximum RF signal levels at HNI2 and HNI3	23
5.6 RF signal level differences in the home network from HNI to system outlet	23
5.7 Frequency response within a television channel in the home network	23
5.7.1 General	23
5.7.2 Amplitude response	23
5.7.3 Group delay.....	24
5.8 Random noise produced in the home network.....	25
5.8.1 General	25
5.8.2 Maximum amplifier noise figure	25
5.9 Interference produced into downstream channels within a home network	25
5.9.1 General	25
5.9.2 Multiple frequency intermodulation interference	25
5.9.3 Intermodulation noise	26
6 Home network design and examples.....	26
6.1 General.....	26
6.2 Basic design considerations.....	26
6.2.1 General	26
6.2.2 System outlet (SO) or terminal input (TI) specifications.....	26
6.2.3 Home network interface (HNI) specifications.....	26
6.2.4 Requirements for the home network	27
6.3 Implementation considerations.....	27
6.4 Home networks with coaxial and balanced cables	28

6.4.1	General	28
6.4.2	Network examples	28
6.4.3	Calculation examples	29
6.4.4	General considerations	40
6.4.5	Home network design in a MATV system	41
6.4.6	Return path examples	41
6.5	Different home network type (HNI3 case C) (glass or plastic fibre optic network)	41
6.6	Different home network type (HNI3 case D)	42
6.6.1	General	42
6.6.2	Wireless links inside the home network	42
6.6.3	Applications of ISO/IEC/IEEE 8802-11 (WLAN)	43
6.6.4	Available bands in the 2 GHz to 6 GHz frequency range	44
6.6.5	Main characteristics of a WLAN signal	44
6.6.6	Main characteristics of coaxial cables	45
6.6.7	Characteristics of WLAN signals at system outlet	46
6.6.8	Characteristics of signals at the TV system outlet	46
6.6.9	Example of diplexers and power splitters near the HNI	46
6.6.10	Example of system outlet for coaxial TV connector and WLAN antenna	47
6.6.11	Examples of WLAN connection into home networks	47
Annex A (informative)	Wireless links versus cable links	53
A.1	General	53
A.2	Wireless links	53
A.3	Cable links	55
Annex B (informative)	Isolation between radiating element and system outlet	56
Annex C (informative)	MIMO techniques of IEEE 802.11n	58
C.1	General	58
C.2	MIMO techniques	58
Annex D (informative)	MU-MIMO Protocol for IEEE 802.11ax (Wi-Fi 6)	60
Annex E (informative)	CMU-MIMO Protocol for IEEE 802.11be (Wi-Fi 7)	61
E.1	CMU-MIMO protocol	61
E.2	Contention algorithm	61
E.3	Antennas' communication with members' algorithm	62
E.4	Transmission algorithm	63
Annex F (informative)	Frequency and maximum EIRP of Radio LAN (in Japan)	64
Bibliography	68
Figure 1	Examples of RF home network types	8
Figure 2	Examples of location of HNI for various home network types	14
Figure 3	Examples of home network implementation using coaxial or balanced cables	29
Figure 4	Signal levels at HNI1 (flat splitter response)	31
Figure 5	Signal levels at HNI1 (+6 dB compensating splitter slope)	32
Figure 6	Signal levels at HNI2 (L_1) (flat splitter/amplifier response)	33
Figure 7	Signal levels at HNI2 (+6 dB compensating splitter/amplifier slope)	33
Figure 8	Signal levels at HNI3 (flat splitter/amplifier response)	37
Figure 9	Signal levels at HNI3 (+6 dB compensating splitter/amplifier slope)	37
Figure 10	Example of a home network using optical fibres	41

Figure 11 – Example of a home network using cable connection and cable/wireless connection	43
Figure 12 – Example of a coupler (two cascaded symmetric couplers) to insert WLAN signals into the home distribution network.....	47
Figure 13 – Example of system outlet for coaxial TV connector and WLAN antenna.....	47
Figure 14 – Assumed properties of the filters in the system outlet.....	48
Figure 15 – Reference points for the examples of calculation of link loss or link budget.....	48
Figure B.1 – Required isolation and attenuation of a cut-off waveguide, with cut-off frequency of 2 275 MHz and a length (L) of 25 cm or 15 cm.....	57
Figure C.1 – Principle of MIMO techniques according to IEEE 802.11n.....	58
Figure E.1 – Flow diagram of CMU-MIMO algorithm.....	60
Figure E.2 – Antennas communication with members algorithm	63
Figure E.3 – Transmission algorithm	63
Figure F.1 – Wi-Fi channel layout (IEEE 802.11b).....	65
Figure F.2 – Wi-Fi channel layout (IEEE 802.11g).....	65
Figure F.3 – Wi-Fi channel layout (IEEE 802.11n).....	66
Figure F.4 – Wi-Fi channel layout (5 GHz: W52, W53)	66
Figure F.5 – Wi-Fi channel layout (5 GHz: W56)	66
Figure F.6 – 60 GHz band frequency allocation and ISO/IEC/IEEE 802-11 (IEEE 802.11ad) / WiGig channel allocation in major countries	67
Table 1 – Methods of measurement of IEC 60728-101 applicable to the home network.....	21
Table 2 – Amplitude response variation in the home network	24
Table 3 – Group delay variation in the home network.....	24
Table 4 – Example of home network implementation with coaxial cabling (passive) from HNI1 to system outlet	34
Table 5 – Example of home network implementation with coaxial cabling (active) from HNI2 to system outlet	34
Table 6 – Example of home network implementation with balanced pair cables (active) from HNI3 to coaxial terminal point (case A)	38
Table 7 – Example of home network implementation with balanced pair cables (active) from HNI3 to coaxial system outlet (case B).....	39
Table 8 – Maximum EIRP according to CEPT ERC Recommendation 70-03 (2021)	44
Table 9 – Available throughput of the WLAN signal.....	45
Table 10 – Minimum signal level at system outlet (WLAN antenna).....	46
Table 11 – Loss from the system outlet to WLAN base station	49
Table 12 – Direct connection between two system outlets (TV outlets).....	49
Table 13 – Link budget between WLAN equipment and the WLAN base station	50
Table 14 – Wireless connection between two pieces of WLAN equipment.....	51
Table 15 – Connection from a SO to a WLAN equipment	52
Table A.1 – Maximum distance for a wireless link (WLAN) in free space or inside a home	55
Table A.2 – Maximum length of the cable.....	55
Table C.1 – MCSs that are mandatory in IEEE 802.11n	59
Table F.1 – Frequency and maximum EIRP of Radio LAN (Japan).....	64

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**CABLE NETWORKS FOR TELEVISION SIGNALS,
SOUND SIGNALS AND INTERACTIVE SERVICES –****Part 101-1: RF cabling for two-way home networks
with all-digital channels load**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use, and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, accept IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60728-101-1 has been prepared by technical area 5: Cable networks for television signals, sound signals and interactive services, of IEC technical committee 100: Audio, video and multimedia systems and equipment. It is an International Standard.

This International Standard is to be used in conjunction with IEC 60728-101:2016.

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

Draft	Report on voting
100/3904/FDIS	100/3945/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts of the IEC 60728 series, under the general title *Cable networks for television signals, sound signals and interactive services*, can be found on the IEC website.

The reader's attention is drawn to the fact that Annex F lists all of the "in-some-country" clauses on differing practices of a less permanent nature relating to the subject of this document.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to this specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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.

This part of the IEC 60728 deals with the requirements and implementation guidelines for a home network that can be realised with different techniques. The following types of home networks (HN) are possible:

- passive coaxial home network;
- active coaxial home network;
- different home network types (cases A to D shown in Figure 1).

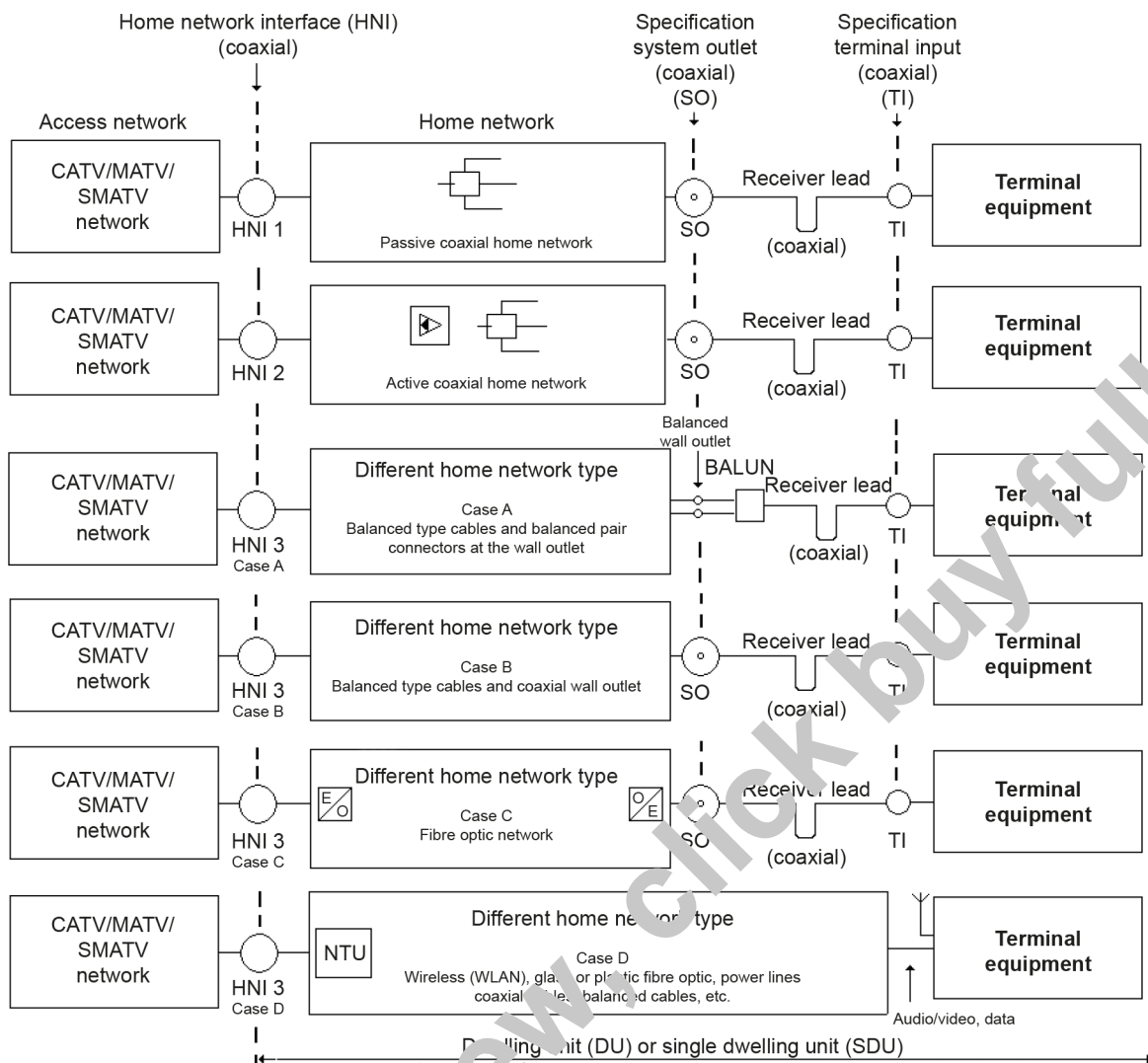
Figure 1 shows typical situations that are possible when considering RF home networks.

The RF home network can be realised using coaxial cables, balanced cables, optical cables or radio links.

This document considers digital signals only and is based on IEC 60728-101 dealing with system performance of forward paths loaded with digital channels only. For RF cable systems loaded with analogue and digital signals, refer to IEC 60728-1-1 ED2.

Figure 4 to Figure 9 have been amended to take into account the level requirement for digital signals only.

Although the upper frequency range of terrestrial broadcast signals depends on the allocation frequency plan of each region (e.g. in Europe it is 694 MHz, the 700 MHz and 800 MHz bands being assigned to telecommunication services), the upper frequency range into the cable networks can be maintained at 862 MHz in order to maximise the number of channels to be distributed in the cable networks, assuming that sufficient immunity (screening efficiency) to signals radiated in the 700 MHz and 800 MHz bands is provided.



IEC

Figure 3 – Examples of RF home network types

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

Part 101-1: RF cabling for two-way home networks with all-digital channels load

1 Scope

This part of IEC 60728-101 provides the requirements and describes the implementation guidelines of RF cabling for two-way home networks; it is applicable to any home network that distributes signals provided by CATV/MATV/SMATV cable networks (including individual receiving systems) having a coaxial cable output. It is also applicable to home networks where some part of the distribution network uses wireless links, for example in place of the receiver cord.

This part of IEC 60728 is therefore applicable to RF cabling for two-way home networks with wired cords or wireless links inside a room and primarily intended for television and sound signals operating between about 5 MHz and 3 300 MHz. The frequency range is extended to 6 000 MHz for distribution techniques that replace wired cords with a wireless two-way communication inside a room (or a small number of adjacent rooms) that uses the 5 GHz to 6 GHz band.

In a building divided into apartment blocks, the distribution of the signals inside the home starts from the home network interface (HNI) up to the system outlet or terminal input. The requirements at the system outlet are given in IEC 60728-101:2016, Clause 5 and the requirements at the HNI are given in IEC 60728-101:2016, Clause 7. In Clause 5 of this document, additional requirements are given.

This document deals with various possibilities to distribute signals in a home network, using coaxial cables, balanced pair cables, fibre optic cables (glass or plastic) and also wireless links inside a room (or a small number of adjacent rooms) to replace wired cords.

This document gives references to basic methods of measurement of the operational characteristics of the home cable network in order to assess its performance.

All requirements refer to the performance limits, which are obtained between the input(s) at the home network interface (HNI) and the output at any system outlet when terminated in a resistance equal to the nominal load impedance of the system, unless otherwise specified. Where system outlets are not used, the above applies to the terminal input.

The present document also provides limits for the accumulation of degradations if the home network is subdivided into a number of parts, using different transmission media (e.g. coaxial cabling, balanced cabling, optical cabling, wireless links).

NOTE Performance requirements of return paths as well as special methods of measurement for the use of the return paths in cable networks are described in IEC 60728-10.

Clause 5 defines the performance limits measured at system outlet or terminal input for an unimpaired (ideal) test signal applied at the HNI. Under normal operating conditions for any digital channel and meeting these limits, the cumulative effect of the impairment of any single parameter at the HNI and that due to the home network produces signals not worse than the requirements given in IEC 60728-101-2. For digitally modulated signals, the quality requirement is a QEF (quasi error-free) reception.