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APPLICATION NOTE

HDBaseT™ 5Play™

Cabling system for HDBaseT™

P | Cabling

HDBaseT™* 5Play™* Digital Multimedia

Cabling System for HDBaseT™

1. Management Summary

This report explains the next generation of multimedia contents in connection with HDBaseT™ and its functions. What is the function of structured building cabling? What role does it play in the transmission of HDBaseT™ Digital Multimedia contents? To answer these questions, the functions, background, application examples and comparisons of structured cabling for HDBaseT™ are described.

* HDBaseT™ and 5Play™ are trademarks of the HDBaseT™ Alliance.

2. 4K Ultra High Definition

2.1 General

Connecting several terminals to one another within a network becomes more and more common in private housing environments, in the education sector, in office buildings, hotels, airports, trade shows, or shopping centers. For example, different TV terminals, beamers, projectors or other displays are distributed in the respective building and then supplied with media contents by a central blu-ray player, a computer, a media player or an NAS.

2.2 Resolution

In the resolution of image and video files, a new standard called 4K Ultra High Definition TV (UHD TV) has now been developed, which constitutes a new dimension in terms of picture sharpness. 4K Ultra High Definition (UHD) has four times the resolution of Full HD (2K, 1920 x 1080 pixels). It thus offers an even sharper and more natural display high in details, making it the new reference in the world of digital images. In addition, 3D displays with polfilter technology can fully exploit HD resolution.

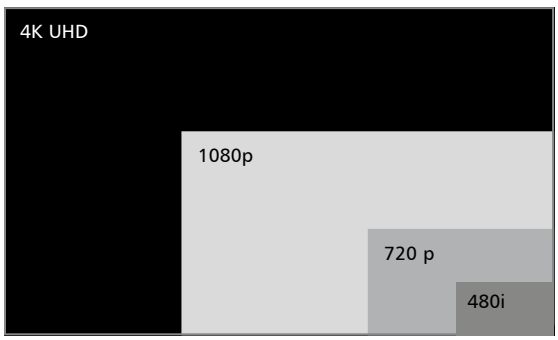


Figure 1: Resolution of various video/ image formats

	Resolution in pixels (width x height)	Format (aspect ratio)	Description
2K	1920 x 1080	1,78:1 (16:9)	Full HD
4K	3840 x 2160	1,78:1 (16:9)	UHD
4K	4096 x 2160	1,90:1 (≈17:9)	4K DCI (Digital Cinema Initiatives) used in film production or commercials

Table 1: Resolution and formats of 2K and 4K

The designation of UHD in terms of 4K is based on the number of horizontal pixels, i.e., 4K ≈ 4000p (3840–4096 pixels, UHD 16:9), whereas in Full HD the vertical pixels were counted for reference. HD with 1080p (1920 x 1080 pixels, Full HD 16:9) or 720p (1280 x 720 pixels, HD 16:9).

2.3 Frame and transmission rates

The transmission of 4K video contents requires an enormous bandwidth and transmission rate of up to 10 Gbits/s. 2K Full HD at 60 fps (frames per second) requires a data rate of 4.46 Gbits/s. For 4K UHD (i. e. 4 times higher resolution and the same frame rate as 2K) it theoretically requires a data rate of 17.84 Gbits/s, i. e., with the same coding the data rate quadruples.

At the moment 4K devices are limited to 30 fps or less, which results in a bisection of the data rate to 8,91 Gbit/s. Half the frame rate is of no consequence in films, since the raw material (source) usually contains 24 fps. The challenge is how to deal with systems of 50 and 60 frames per second. One solution is to compress the color information, causing the transmission speed for 4K UHD video contents at 60 fps to return to approx. 8.91 Gbit/s.

With the help of Chroma technology (used with Blu-ray) the 'chrominance' (color information) is compressed while the luminance (brightness information, brilliance) remains the same. For the human eye, however, this does not result in losses in quality or deterioration of the images, since the human eye has lower visual acuity for color differences and does not perceive those differences as readily as it does differences in brightness or light intensity. The data rate for 4K videos of 60 fps at this compression is then equivalent to about 9 Gbit/s.

Resolution	Color information	Frame rate (frames per second)	Transmission rate
2K	4:4:4	60 fps	4,46 Gbit/s
4K	4:4:4	24 or 30 fps	8,91 Gbit/s
4K	4:2:0 (chroma)	50 or 60 fps	8,91 Gbit/s

Table 2: Coding, frame and transmission rates for 2K and 4K

X:X:X = Color information

Chroma subsampling: Process for storing a sampling rate with reduced chrominance (color information) compared with luminance (brightness information) ➜ Reduction of the occupied memory space or of the data transmission rate.

2.4. Advantages and disadvantages of 4K

Advantages	Disadvantages
The 4K technology becomes more and more wide-spread in the end consumer market	Lack of contents
Transformation from a purely prestigious product (4K television sets) to a high-end television set that despite being expensive is no longer unaffordable	No television signals or blue-ray films with 4K material or the relevant resolution
From the experience of previous transformations of television sets, they will become more affordable with time and with the number of sets available on the market	
Private homes have a clear tendency toward UHD	

Table 3: Advantages and disadvantages of 4K

3. HDBaseT™ for the transmission of 5Play™ Digital Multimedia

3.1 HDBaseT™

HDBaseT™ is a connectivity standard for uncompressed HD multimedia contents. HDBaseT™ 2.0 is the latest technology published by HDBaseT™ Alliance for a complete multimedia entertainment center for transmitting 5Play™ digital multimedia contents via twisted-pair copper cables.

HDBaseT™ facilitates a cost-effective and simply plug-and-play solution using standard twisted-pair cables and RJ45 connectors in the categories Cat. 5e, 6, 6_A, 7 or 7_A** for a fully comprehensive multimedia system.

HDBaseT™ comprises several functions, marketed under the name 5Play™. They form the base for HDBaseT™. 5Play™ groups together uncompressed Full-HD or UHD video contents, audio, 100BASE-T Ethernet, energy supply by Power over Ethernet (PoE) respectively Power over HDBaseT™ (PoH) of up to 100 W and various control signals in a single technology. Communication between the devices (TV, the sound system, the computer and other electronic entertainment devices) and access to stored multimedia contents (music and video streaming) is made possible by 100 Mbit Ethernet (100BASE-T Ethernet) via a standard twisted-pair copper cable over a distance of up to 100 m. Thus, HDBaseT™ can use a cost-efficient cabling infrastructure: different cables for a new installation or retrofitting are avoided and in new buildings the required cables may already be present, since all 5Play™ functions are transmitted via a single cable.

Since HDBaseT™ comprises the 5Play™ functions and thus also in particular the transmission of highresolution video contents, the focus in the previous chapter was placed especially on the enormous data volumes for these HD and UHD contents. The reason for this is the cabling infrastructure, which comes up against its limits in terms of transmission capability and length restriction. This is why, here at HDBaseT™, the decision was taken in favor of twisted-pair cables. Their use and specifications for different HDMI versions and twisted-pair categories will be explained in more detail in one of the following chapters.

** Cabling system, category and class are described in ISO/IEC 11801.

3.2 HDBaseT™ 2.0 compared with HDBaseT™ 1.0

HDBaseT™ 2.0	HDBaseT™ 1.0
Adjustment to all seven layers of the OSI 7 model • support of time-critical audio, video and other applications of high data throughput	Only physical and data link layers
Includes networking, switching and control-point capabilities	
Connection between several point	Point-to-point connection
Offers several interfaces • USB 2.0, infrared,… • no additional devices necessary for these interfaces	Requires several devices for different interfaces
HDBaseT™ 2.0 forms the specification (HomePlay Switches) for the control and distribution of multimedia in the entire home sector of the consumers	Defined for the support of transmitting 5Play™

Table 4: HDBaseT™ 2.0 compared with HDBaseT™ 1.0

4. 5Play™

HDBaseT™ comprises several functions, marketed under the name 5Play™. They form the base for HDBaseT™. 5Play™ groups together uncompressed Full-HD or UHD video contents, audio, 100BASE-T Ethernet, energy supply by Power over Ethernet (PoE) respectively Power over HDBaseT™ (PoH) of up to 100 W and various control signals in a single technology and thus also in a single cabling type.

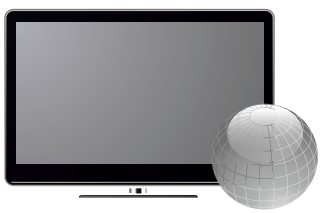
4.1 Video

HDBaseT™ transmits 2K Full HD, 3D and 4K UHD videos uncompressed from the source unidirectional to the network of devices (point-to-several-points) or to a single device (point-to-point). The video conversion is achieved by going through an HDMI chip set.

4.2 Audio

Like the video contents, the audio contents are also converted via an HDMI chip set and transmitted unidirectionally from the source to the receiver. All standard audio formats are supported.

4.3 100BASE-T Ethernet



Communication between the TV, the sound system, the computer and other electronic entertainment devices and access to stored multimedia contents (music and video streaming) are made possible bidirectional by 100 Mbit Ethernet (100BASE-T Ethernet) via a common twisted-pair copper cable with Cat.5e/6/6_A/7/7_A cables and RJ45 connectors.

For transmission, an asymmetric process for sending video and audio contents, Ethernet and control from the source to the receiver is used, of which only 100 Mbit (for Ethernet and control) are transmitted back. For a better transmission quality of the different data (audio, video, control, Ethernet) and for minimizing the expenditure for protecting video contents, which require the highest bandwidth, a special coding process was developed. HDBaseT™ uses a proprietary pulse/amplitude modulation, in which digital data are represented as coding schemes with different direct current levels at high speeds. This enables 5Play™ Digital Multimedia contents to be transmitted over a single Cat.5e/6/6_A/7/7_A cable over a distance of up to 100 m, without any adverse effects of the electrical characteristics of the wires on performance.

Even though HDBaseT™ uses the coding technology as Ethernet and has one Ethernet channel, the package-based technology differs from the customary Ethernet packages. HDBaseT™ uses the same physical cabling and thus a cost-efficient cabling infrastructure.

4.4 Control signals

5Play™ allows several control signals unidirectionally from the source to the receiver for different purposes: Consumer Electronic Controls (CEC), Recommended Standard (RS-) 232, USB, infrared and IP control, creating a large number of options.

4.5 Energy supply

As part of 5Play™, HDBaseT™ supports the transmission of up to 100 W of direct current via the same Cat.5e/6/6_A/7/7_A cable. To accomplish this, HDBaseT™ refers to IEEE-802.at-2009 Power-over-Ethernet-Plus-(PoE+)-Standard, that can deliver approx. 25 W via two pairs of cables for PoE+ devices. Power over HDBaseT™ delivers up to 100 W using all four pairs. This transmits the current from the energy source at the end of the transmitter to the receiver unit via the HDBaseT™ connection, i.e., the Ethernet cabling. This is why no further cables and sockets are required.

5. Why HDBaseT™ Cabling System?

- Distance of up to 100 m
- HDBaseT™ transmits video, audio, 100 Mbit Ethernet, control signals and power supply through a single cable
- High-quality uncompressed 4K UHD videos and all 3D video standards
- Simple cabling with Cat.5e/6/6_A/7/7_A installation cables and Cat.5e/6/6_A RJ45 connectors
- Cost efficiency through low-cost class D/E/E_A infrastructure and low installation costs due to theoretically a single cable for all applications
- Low costs for the electric infrastructure through up to 100 W with Power over HDBaseT™ (PoH) energy transmission within HDBaseT™
- HDBaseT™ as standard: makes official conditions available to its members, which guarantee product compatibility and standard conformity for different manufacturers

Advantages of the HDBaseT™ Cabling System

- high quality and reliability
- power over long distances (up to 100 m)
- backward compatibility
- support of older devices
- standard twisted-pair copper cabling
- simple installation
- cost-efficient cabling infrastructure via a single cable
- flexibility
- plug & play through RJ45 connectors and HDBaseT™ devices

HDBaseT™ customer requirements

- affordable costs
- single cabling for many/all applications
- elegance, design, no cable mess
- plug & play
- scalable and future-proof

Figure 2: Advantages and customer requirements for HDBaseT™

6. HDBaseT™ Application Examples

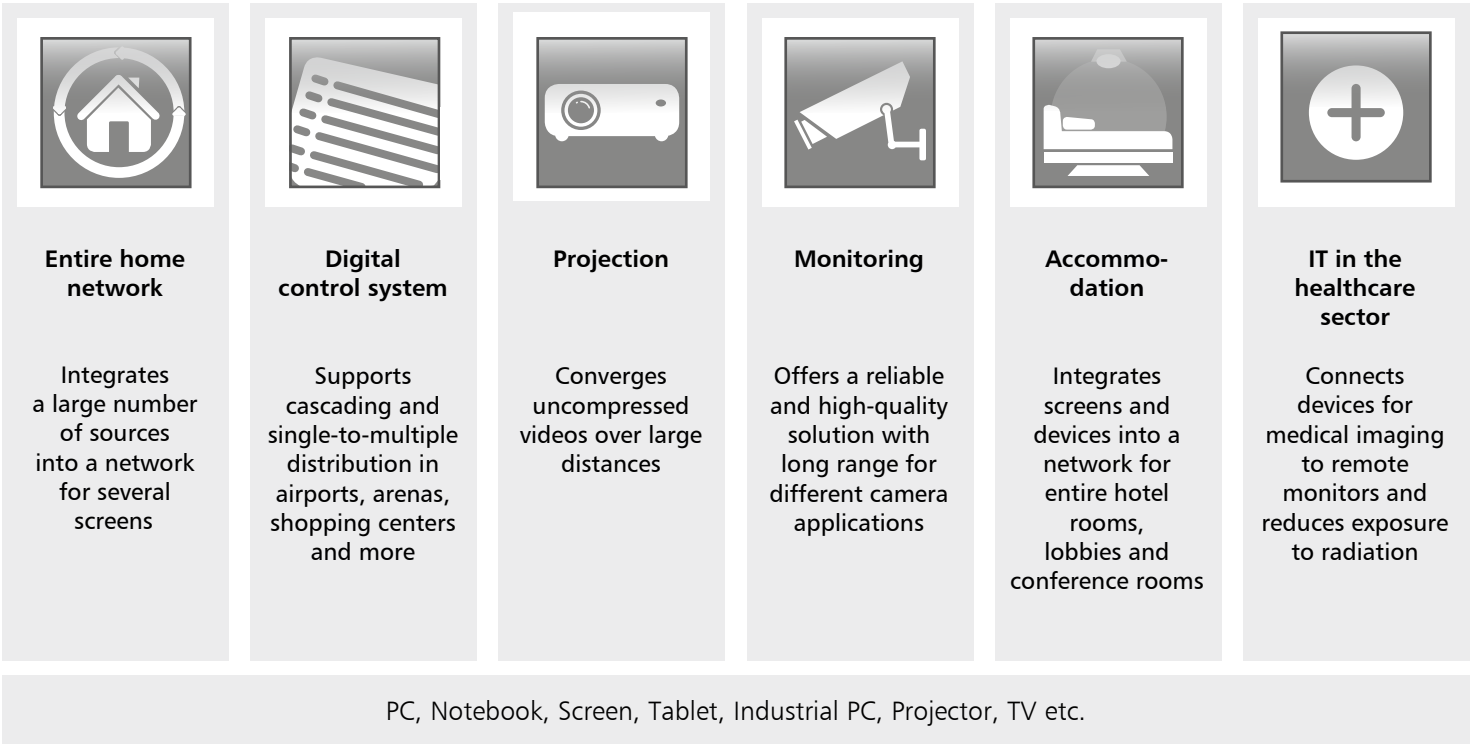


Figure 3: Examples of HDBaseT™ fields of application

6.1 Structure

Typically, HDBaseT™ matrix converters and transmitters are used, in order to collect several sources, input devices/interfaces and then to transmit the 5Play™ functions via HDBaseT™ receivers to receivers such as displays or directly to HDBaseT™-compliant devices and/or digital media where the signals can be played back. The connection between the source and the playback devices/displays is made via the twisted-pair cables according to ISO/IEC 11801 of class D/E/E_A with components of category 5e/6/6_A/7/7_A. This means that only a single cable is necessary for connecting the HDBaseT™ devices and transmitting all functions of 5Play™ over a distance of up to 100 m.

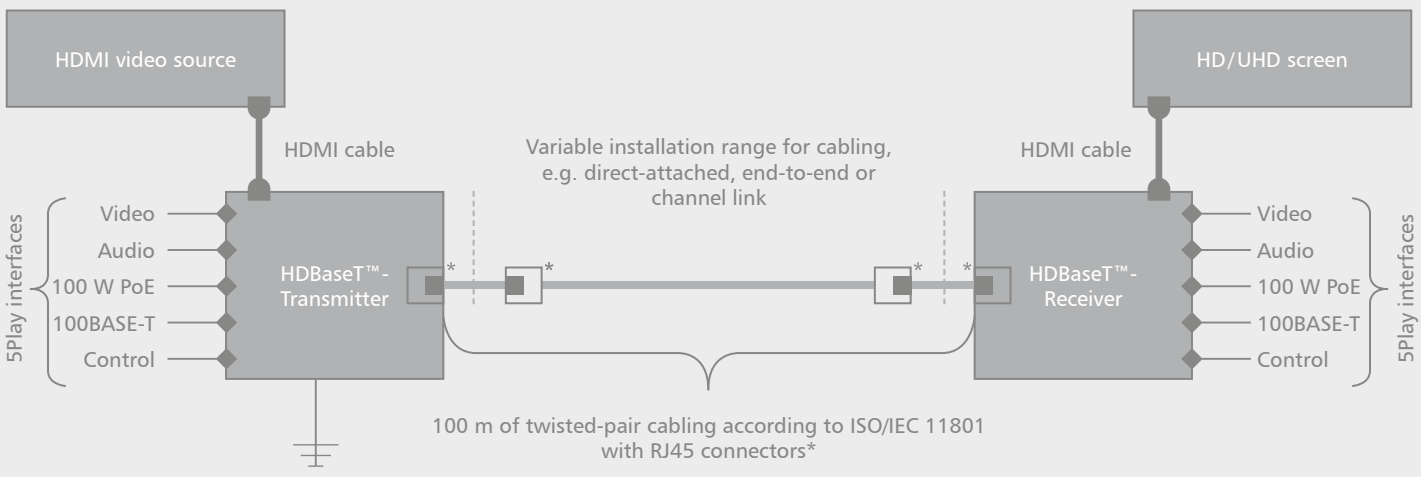


Figure 4: General structure of cabling and interfaces for HDBaseT™

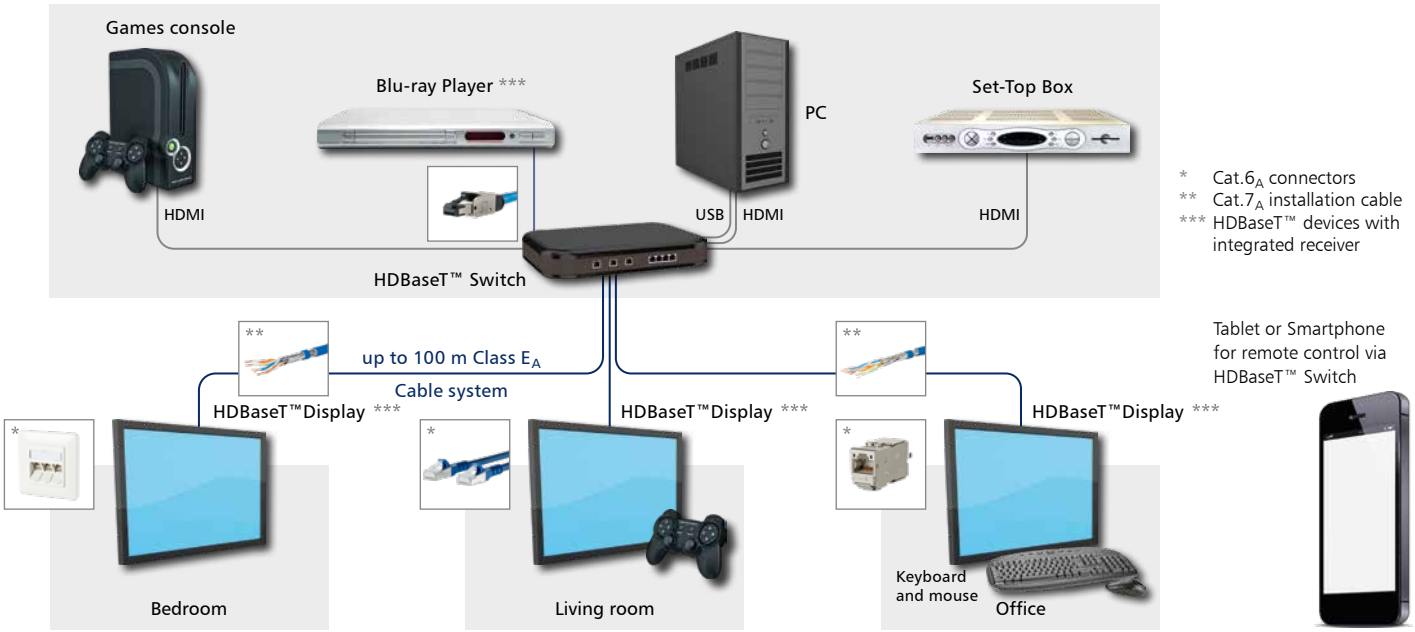


Figure 5: Application example for HDBaseT™ system

6.2 Cabling of several HDBaseT™ devices

Figure 4 shows the principle of connecting a multimedia, more precisely a video, source to a playback device (screen) via HDBaseT™ and a single twisted-pair cable. This principle can be used to connect further HDBaseT™ switches, transmitters and receivers or devices capable of HDBaseT™. Basically, nothing changes in the structure, except that with each connection a twisted-pair cable is added. The next section illustrates how to implement the cabling for several devices that are interconnected across various locations by means of the HDBaseT™ switch. It is also possible to collect the sources at an HDBaseT™ switch and then connect it to the HDBaseT™ receivers or directly to HDBaseT™-compliant devices at different locations and in different rooms, as illustrated in Figure 5.

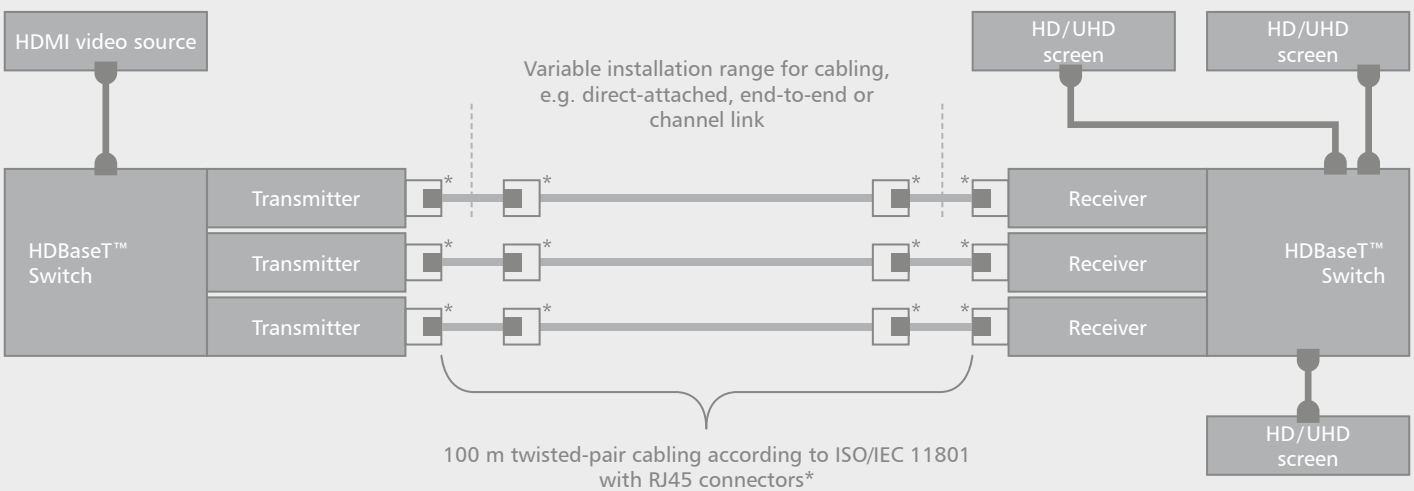


Figure 6: Cabling of several HDBaseT™ devices

6.3 Assembly of the network infrastructure in a building with connection of HDBaseT™ via different cabling solutions

There are many solutions for how to implement cabling in a wide range of fields of application. A few examples based on different components and the number of user are shown below. To connect the HDBaseT™ system to the network and internet, the HDBaseT™ switch or transmitter can be connected to the switch or router directly via a patch cable during network distribution.

The receiver devices (HDBaseT™ receivers or HDBaseT™-compliant devices) are not shown in the following graphics, although the cabling is shown up to the point where it can, for example, be connected up to the patch cable.

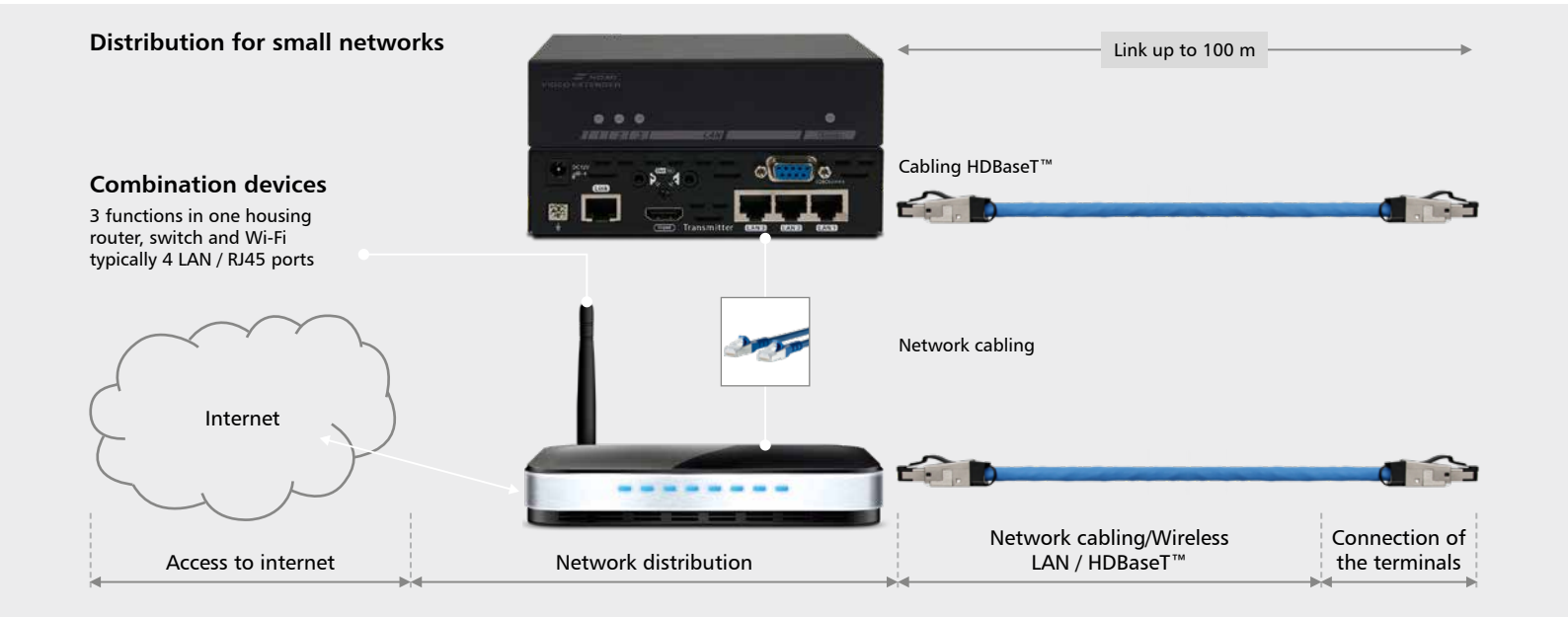


Figure 7: Cabling infrastructure with field-assembled connectors on both sides

Network distribution and HDBaseT™ distribution via field-assembled RJ45 connectors, which are connected directly to the network switch and the HDBaseT™ switch and at the other end directly to the terminals and thus represent a direct connection. The following illustration shows the cabling infrastructure in isolation between the active devices.

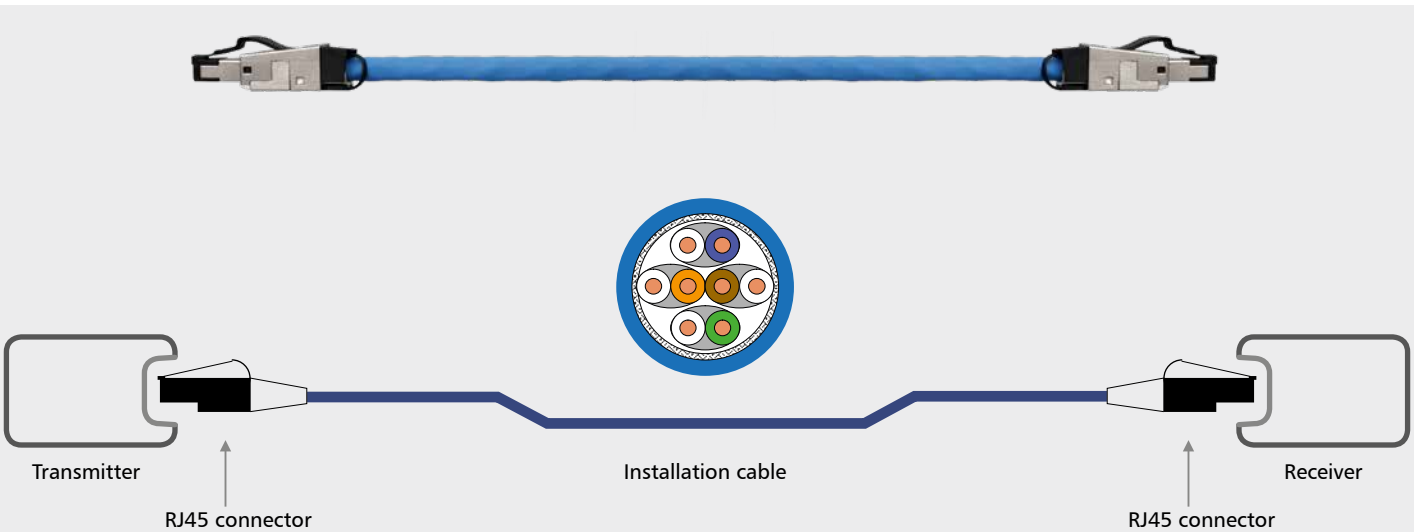


Figure 8: End-to-End-Link with field assembled RJ45 plugs on both sides

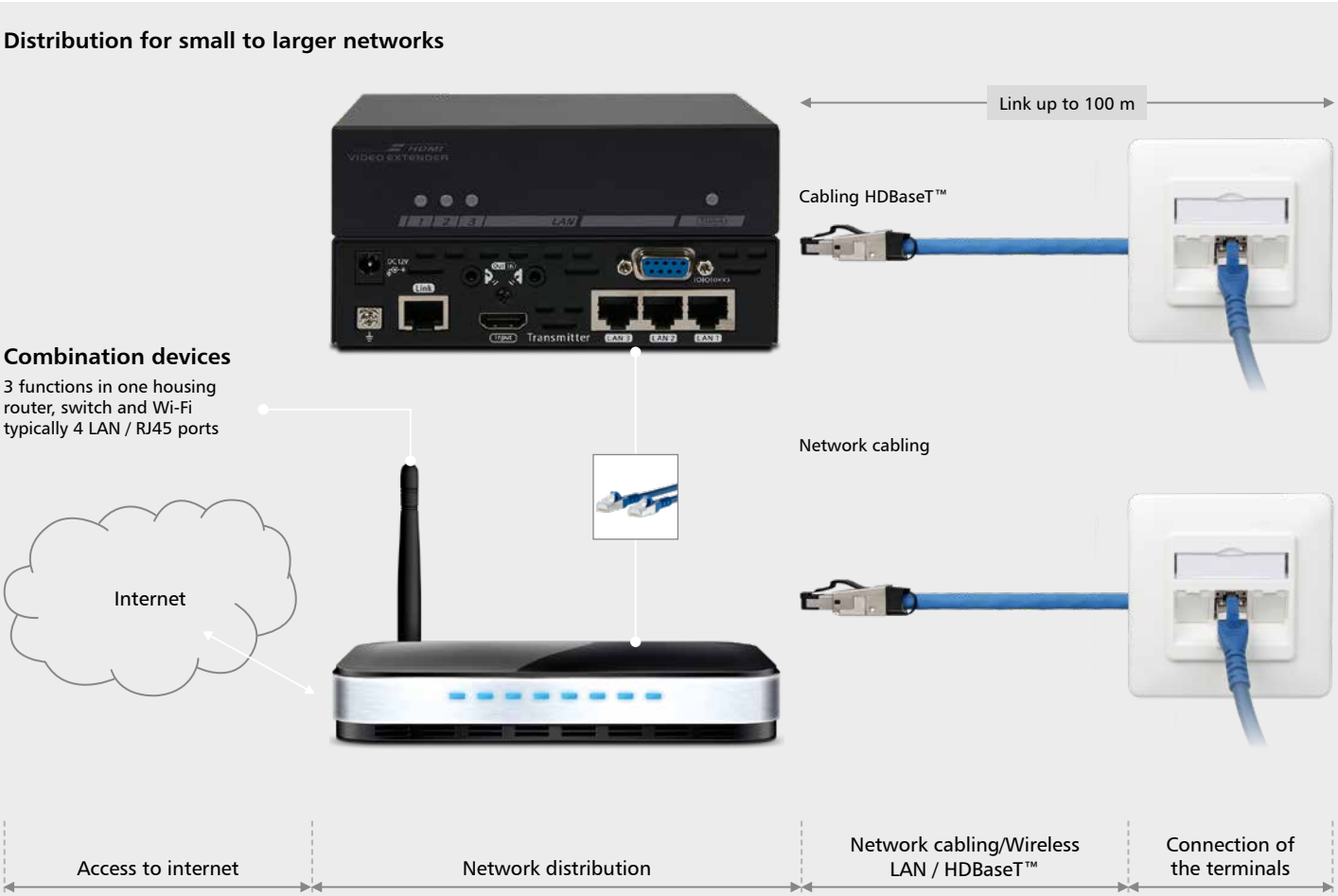


Figure 9: Cabling infrastructure with field-assembled RJ45 connectors on wall outlets

Network distribution and HDBaseT™ distribution via field-assembled RJ45 connectors, which are connected directly to the network switch and the HDBaseT™ switch. On the other side, there is a RJ45 jack installed, for example in a wall outlet. The receivers, such as the HDBaseT™ receiver and the HDBaseT™ switch or a terminal with HDBaseT™ chip, can then be connected from the wall outlet with a patch cable. The following illustration shows the cabling infrastructure in isolation between the active devices. can then be connected from the wall outlet with a patch cable.

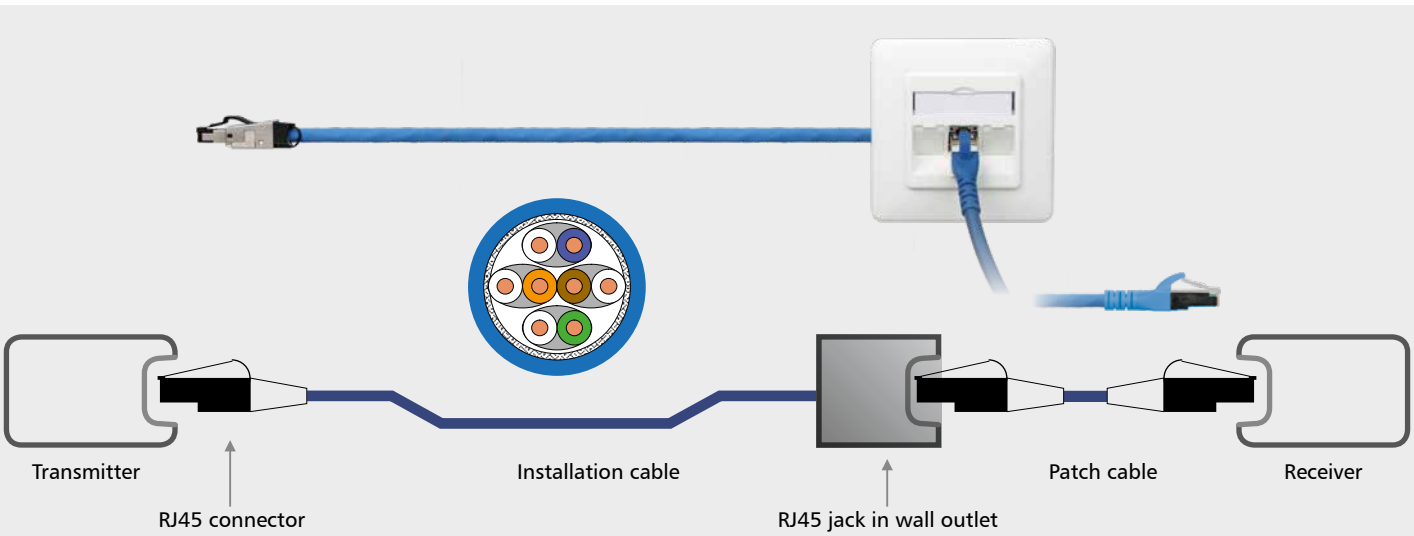


Figure 10: Direct, attached, link cabling with field-assembled RJ45 connector, jack and patch cable

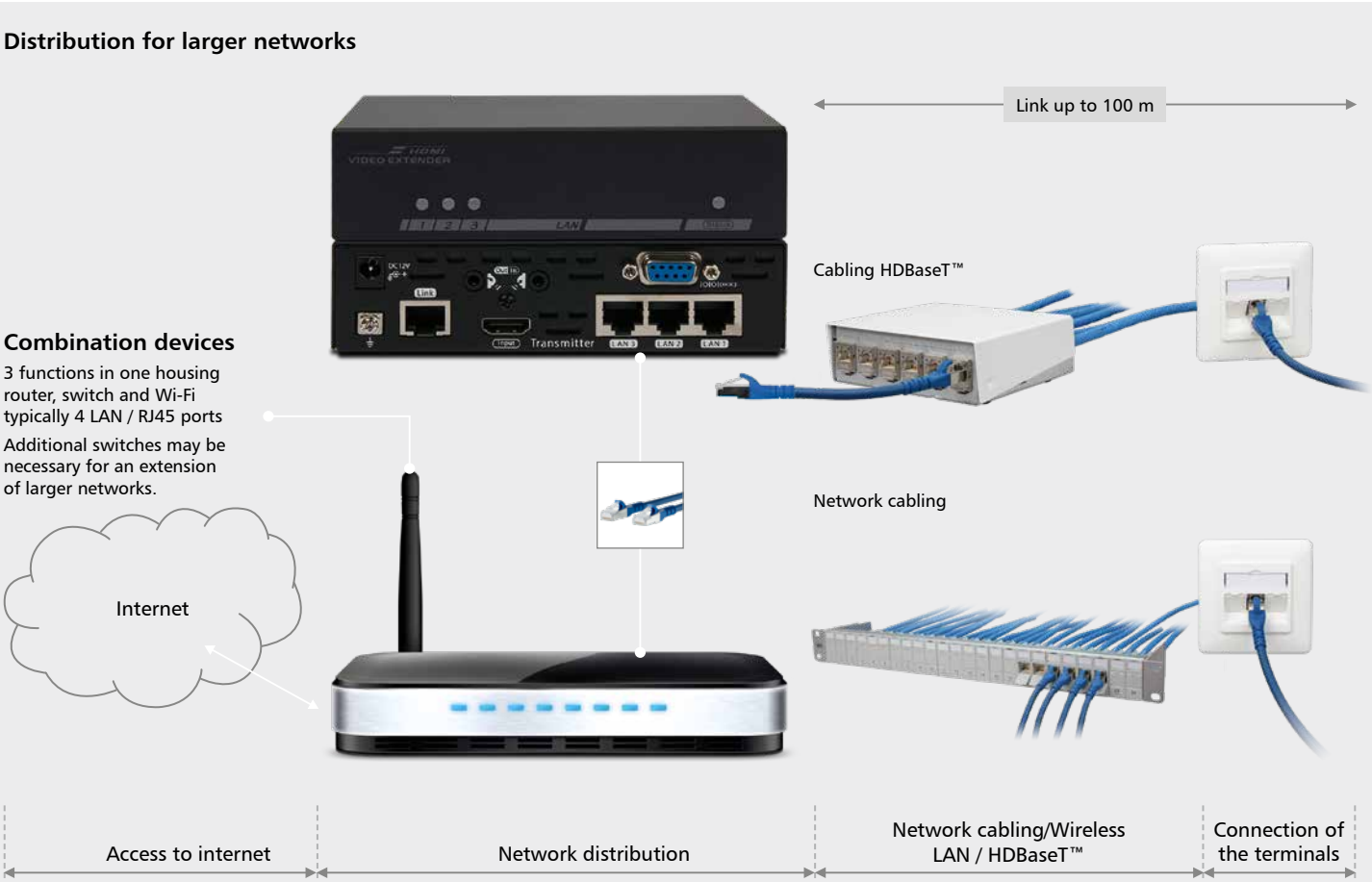


Figure 11: Cabling infrastructure according to a 2-connector channel

Network distribution and HDBaseT™ distribution via patch panels or surface-mounted distributors connected to the active devices via a flexible patch cable and permanently installed to one another with installation cables containing RJ45 jacks on both ends from the patch panel to the wall outlet (or from patch panel to patch panel). The receivers, such as the HDBaseT™ receiver and the HDBaseT™ switch or a terminal with HDBaseT™ chip, can then be connected from the wall outlet with a patch cable. The following illustration shows the cabling infrastructure in isolation between the active devices.

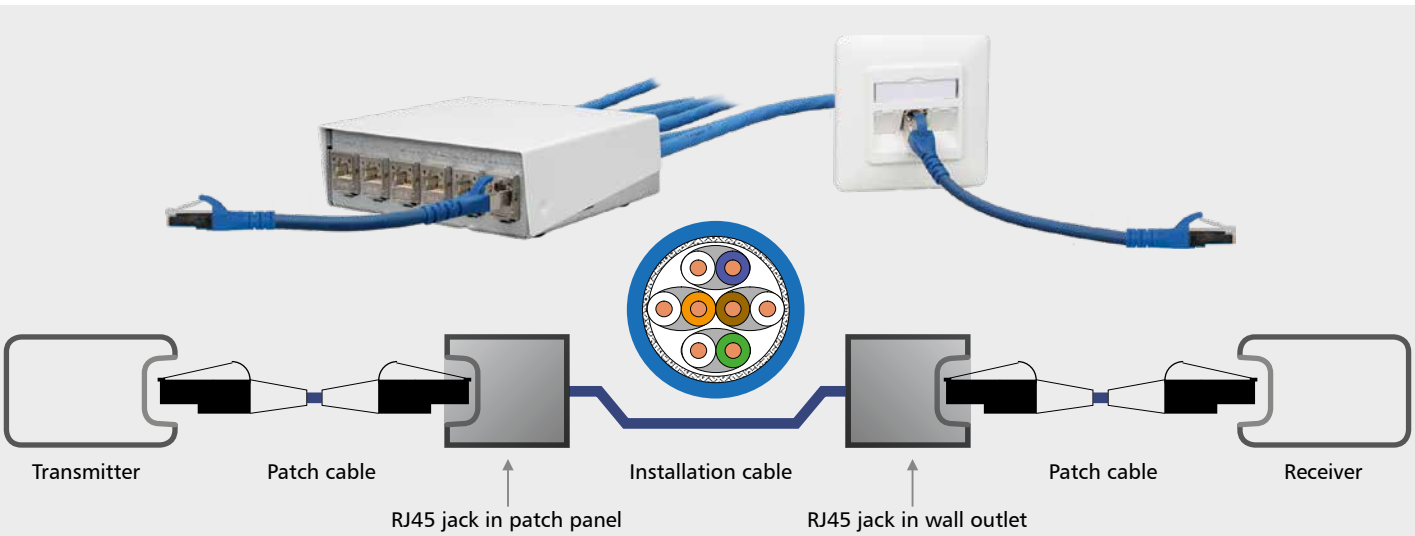


Figure 12: 2-Connector channel cabling with field-assembled RJ45 connector, patch panel, jack and patch cable

7. Achieving a data transmission rate of up to 10GBits/s for HDBaseT™ 5Play™

7.1 Data transmission rate for HDBaseT™

HDBaseT™ via copper supports the HDBaseT™ Alliance specifications in respect of compatibility with other HDBaseT™ devices via twisted-pair cables. Also due to the reduced frame rate and the chroma subsampling, 4K requires an enormous bandwidth, resulting in extremely high cabling and also length requirements.

Resolution	HDMI interfaces specification	Color information	Frame rate (frames per second)	Transmission rate
2K	HDMI 1.4	4:4:4	60 fps	4.46 Gbit/s
4K	HDMI 1.4	4:4:4	30 fps	8.91 Gbit/s
4K	HDMI 1.4 or 2.0	4:2:0 (chroma)	60 fps	8.91 Gbit/s

Table 5: Transmission rate for 2K and 4K via HDMI

7.2 Length restriction for HDBaseT™ HDMI cabling

Unlike the HDMI specifications for interfaces, HDMI cables are divided into five cable types:

- standard HDMI cables
- standard HDMI cables with Ethernet
- standard automotive HDMI cables
- high-speed HDMI cables
- high-speed HDMI cables with Ethernet

Every one of the above-mentioned cables meets a certain performance standard. According to the HDMI organization, the cables may no longer be advertised as before with the HDMI version or specification numbers and the supported interfaces must be listed in the product description. The reason for this is that the version numbers do not necessarily distinguish the performance of the cables or devices, but only the supported functions or interfaces. This is why a system that does not require all functions only requires one cable of a certain performance category.

- Up to now, the HDMI organization provides a max. length of 15 m.
- Longer cables must exhibit better high-frequency properties, in order to guarantee error-free data retrieval in the receiver.
- Cable quality and receiver properties of the HDMI receiver are decisive.
- Up to 5 m, lower-quality components are also sufficient (problematical in conference rooms or the like, for example, with monitors or projectors, etc.).
- From 10 m onwards, transmission errors must be expected in the area of high-resolution and ultrahigh-resolution images.
- Longer distances are possible by using signal repeaters, but these devices incur higher costs, which can be avoided by using cabling without devices connected inbetween (twisted-pair copper cables).
- Likewise, longer distances can be made possible by means of extenders on fiber optic cables.
- HDMI 2.0 defines no new cables or connectors, although current high-speed-cables are capable of transmitting the bandwidth.

Cable type	Data rate/ bandwidth	Max. video/ image formats	Full HD 3D	Ethernet	Deep Color	Connector type
Standard HDMI cables	min. 1.782 Gbit/s 74.25 MHz	1080i or 720p 60 Hz				Type A
Standard HDMI cables with Ethernet		1080i or 720p 60 Hz		■		
Standard automotive HDMI cable		1080i or 720p 60 Hz				Type E
High-speed HDMI cable	min. 8.16 Gbit/s 340 MHz	2160p (4K) 24 Hz	■		■	Types A, C, D
High-speed HDMI cable with Ethernet		2160p (4K) 24 Hz	■	■	■	

Table 7: HDMI cable types

7.3 Length restriction for HDBaseT™ twisted-pair cabling

Transmission via Cat.5e/6_A through PAM (phase/amplitude modulation) coding with 100 MHz:

- Due to the insertion loss and the low coupling resistance for interferences between the wires and external interferences, the length restriction for unshielded Cat.5e UTP (AWG 24) cables (and unshielded connectors) is approx. 50 m.
- For Cat.5e S/UTP (or F/UTP) AWG 24, the max. length restriction is approx. 70 m.
- Using Cat.$7/7_A$ S/FTP AWG 22 and 23 cables and Cat.6_A connectors, distances of up to 100 m can be achieved, since on the one hand the insertion due to the diameter (AWG 22 und 23) at the same distance is smaller, the coupling resistance due to the shielding is larger and thus the interference signals are reduced. The same useful signal can be used at a larger distance.

Connector	Cables	Shielding	AWG	Transmission distance with 2K (1080p)	Transmission distance with 4K
Cat.5e	Cat.5e	U/UTP	24	100 meters	50 meters
Cat.5e	Cat.5e	S/UTP	24	100 meters	70 meters
Cat.6_A	Cat.7	S/FTP	23	100 meters	85 meters
Cat.6_A	Cat.7_A	S/FTP	22	100 meters	100 meters

Table 8: Transmission distance of different copper cabling components

Whereas the possible cable distance with Cat.5e and Cat.6 products could be clearly below 100 m for the bandwidth of 4K UHD video contents, links with Cat.6_A components or higher allow up to 100 m.

7.4 Fiber optic compared to copper cabling

Some HDBaseT™ devices have an interface for fiber optic cables, allowing the devices to be connected to one another over longer distances while still achieving a bandwidth of 10 Gbits/s. In the following chapters, the advantages of fiber optic cables compared with copper cabling and the lengths achieved with the corresponding components are explained.

- high bandwidth
  - large data volumes at high speed
- large range
  - signal processing at larger intervals

- electrically non-conducting
  - no EMC measures or galvanic isolation between transmitter and receiver required
  - routing next to and within high-voltage lines
- can be used in hazardous areas
- no crosstalk
- high tapping security
- low space requirement, low weight
- unlimited resources

7.5 Achievable lengths with fiber optic cables

Multi-mode fiber		MaxCap-BB-OM2	MaxCap-BB-OM3	MaxCap-BB-OM4
ISO/IEC 11801 / EN 50173		OM2	OM3	OM4
IEC 60793-2-10		A1.a.1	A1.a.2	A1.a.3
TIA/ANSI-492		AAAB	AAAC	AAAD
Range	100BASE	2000 m	2000 m	2000 m
	1000BASE SX	550 m	1000 m	1000 m
	1000BASE LX	550 m	550 m	550 m
	10GBASE SW/SR	82 m	300 m	550 m
	10GBASE LX4	300 m	300 m	300 m
	40GBASE SR4	-	100 m	150 m
	100GBASE SR10	-	100 m	150 m

Table 9: Achievable lengths with different fiber optic cable multi-mode fibers

Single-mode fiber		BendBright XS
ISO/IEC 11801 / EN 50173		OS2
IEC 60793-2-50		B.1.3 and B6_b
Range	1000BASE-LX	5 km
	10GBASE-L	10 km
	10GBASE-EW/ER	40 km
	40GBASE-LR4	10 km
	100GBASE-ER4	10 km

Table 10: Achievable lengths with fiber optic cable single-mode fiber OS2

Ethernet protocols (IEEE 802.E)		Number of fibres per direction	Type	Wavelength	Insertion loss	Range	Class
10 Gbit/s Ethernet	10GBASE-SR	1	OM2	850 nm	1,8 dB	82 m	
	10GBASE-SR	1	OM3	850 nm	2,6 dB	300 m	OF-300
	10GBASE-LR	1	OS2	1310 nm	6,2 dB	10–25 km	OF-10000

Table 11: Suitable fiber optic cable multi- and single-mode fibers with range for HDBaseT™

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