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TECHNICAL SPECIFICATION

**Access, Terminals, Transmission and Multiplexing (ATTM);
Plastic Optical Fibres;
Part 1: Plastic Optical Fibre System Specifications for
100 Mbit/s and 1 Gbit/s;
Sub-part 1: Application requirements for physical layer
specifications for high-speed operations over
Plastic Optical Fibres**

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

The present document is part 1, sub-part 1 of a multi-part deliverable covering Plastic Optical fibre, as identified below:

Part 1: " Plastic Optical Fibre System Specifications for100 Mbit/s and 1 Gbit/s";

Sub-part 1: "Application requirements for physical layer specifications for high-speed operations over Plastic Optical Fibres";

Sub-part 2: "1 Gbit/s and 199 Mbit/s physical later for Plastic Optical Fibres".

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1 Scope

The present document provides a compendium of application requirements for full-duplex 100 Mbit/s and 1 Gbit/s Ethernet based home networking infrastructures based on Plastic Optical Fibre (POF) transmission media. The description of applications covers different network topologies as well as different field particularities.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 105 175-1 (V2.0.0): "Access, Terminals, Transmission and Multiplexing (ATTM); Plastic Optical Fibre System Specifications for 100 Mbit/s and 1 Gbit/s".

[2] IEC 60793-2:2011: "Optical fibres - Part 2: Product specifications - General".

[3] IEC 60793-2-40: "Optical fibres - Part 2-40: Product specifications - Sectional specification for category A4 multimode fibres".

[4] IEC 60794-2-40: "Optical fibre cables - Part 2-40: Indoor optical fibre cables - Family specification for A4 fibre cables".

[5] ETSI TS 105 175-1-2: "Access, Terminals, Transmission and Multiplexing (ATTM); Plastic Optical Fibres; Part 1: Plastic Optical Fibre System Specifications for 100 Mbit/s and 1 Gbit/s; Sub-part 2: 1 Gbit/s and 100 Mbit/s physical layer for Plastic Optical Fibres".

[6] CENELEC EN 50173-1:2011: "Information technology - Generic cabling systems - Part 1: General requirements".

[7] CENELEC EN 50173-4:2007: "Information technology - Generic cabling systems - Part 4: Homes".

[8] IETF RFC 2544: "Benchmarking Methodology for Network Interconnect Devices".

[9] IEEE™ 802.3: "IEEE™ Standard for Ethernet".

[10] Recommendation ITU-T Y.1564: "Ethernet service activation test methodology".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long-term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Recommendation ITU-T G.9960: "Unified high-speed wire-line based home networking transceivers - System architecture and physical layer specification".

[i.2] IEEE™ 802.3z: "Media Access Control Parameters, Physical Layers, Repeater and Management Parameters for 1,000 Mb/s Operation, Supplement to Information Technology - Local and Metropolitan Area Networks - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications".

[i.3] IEEE™ 802.3u: "Local and Metropolitan Area Networks-Supplement - Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units and Repeater for 100Mb/s Operation, Type 100BASE-T (clauses 21-30)".

[i.4] IEEE™ 802.1Q: "IEEE™ Standard for Local and Metropolitan Area Networks - Virtual Bridged Local Area Networks".

[i.5] IEEE™ 802.1p: "IEEE™ Standard for Local and Metropolitan Area Networks - Supplement to Media Access Control (MAC) Bridges: Traffic Class Expediting and Dynamic Multicast Filtering".

[i.6] IEEE™ 802.1D: "IEEE™ Standard for Local and metropolitan area networks: Media Access Control (MAC) Bridges".

[i.7] IEEE™ 802.11a -1999: "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications. High-speed Physical Layer in the 5 GHz Band".

[i.8] European Council Document 12608: "The potential dangers of electromagnetic fields and their effect on the environment".

[i.9] Broadband Forum TR-069 Amendment 4: "CPE WAN Management Protocol".

[i.10] IETF RFC from 3410 to 3418: "Internet Management Protocol. SNMPv3".

[i.11] Broadband Forum TR-143: "Enabling Network Throughput Performance Tests and Statistical Monitoring".

[i.12] ICT ALPHA [PUBLIC] D1.1p: "Architectures for flexible Photonic Home and Access Networks' - "End user future services in access, mobile and in building networks".

[i.13] ANSI/TIA/EIA-568: "Commercial Building Telecommunications Cabling Standards".

[i.14] ISO/IEC 9314-3:1990: "Information processing systems -- Fibre distributed Data Interface (FDDI) -- Part 3: Physical Layer Medium Dependent (PMD)".

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

B2B	Business-to-Business
BER	Bit Error Rate
BW	Bandwidth
CAT	Category
CPE	Customer Premises Equipment
DECT	Digital Enhanced Cordless Telecommunications
DVB-X	Digital Video Broadcasting technology
ECG	Electro Cardio Gram
EHC	Electronic Health Care
EHG	Electro Hystero Gram
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Immunity
EU	European Union
FDDI	Fibre Distributed Data Interface
FEC	Forward Error Correction
FER	Frame Error Rate
FTTH	Fibre To The Home
GOF	Glass Optical Fibre
HD	High Definition

HDTV	High Definition Television
ICT	Information and Communication Technologies
IEC	International Electrotechnical Commission
IP	Internet Protocol
IPTV	IP Television
IT	Information Technology
ITU	International Telecommunication Union
ITU-T	ITU Telecommunication Standardization Sector
LC	Lucent Connector
MAC	Media Access Control
MDI	Medium Dependent Interface
MDU	Multi Dwelling Units
MIC	Media Interface Connector
MMOG	Massively Multiplayers Online Games
MTRJ	Mechanical Transfer Registered Jack
MTTFPA	Mean Time To False Packet Acceptance
MTU	Maximum Transfer Unit
NA	Not Applicable
NDIM	Neighbouring Domain Interference Mitigation
NIR	Near Infra Red
NRZ	Non Return to Zero
NRZI	Non Return to Zero Inverted
OFDM	Orthogonal Frequency De-multiplexing
PAM	Pulse Amplitude Modulation
PCS	Physical Coding Sublayer
PDA	Personal Digital Assistant
PHY	Physical
PLC	Power Line Communications
PMA	Physical Medium Attachment
PMD	Physical Medium Dependent
POF	Plastic Optical Fibre
RFC	Request for Comments (RFC) is a publication of the Internet Engineering Task Force
RJ	Registered Jack
RX	Reception
SC	Subscriber Connector
SI-POF	Step Index Plastic Optical Fibre
ST	Straight Tip connector
STB	Set Top Box
STB/TV	Set Top Box / Television
TC	Technical Committee
TV	Television
TX	Transmission
UHDTV	Ultra High Definition TV
UPA	Universal Powerline Association
US	United States of America
VDE	VDE, the Association for Electrical, Electronic &Information Technologies
VLAN	Virtual Local Area Network
VPN	Virtual Private Network
xDSL	Generic Digital Subscriber Line technology

4 New home networking application requirements

4.1 Introduction

In the past, POF has been used in the networking market with limited success. The main reasons for that are:

- xDSL was bringing up to 20 Mbit/s to the home.
- PLC and Wi-Fi™ already fulfilled the requirement for the home networking.

In Europe, since 2009, and much earlier in Japan, South Korea and US, the situation has changed. Telecom operators are in a competitive race of bit rates and prices and are using different access technologies as marketing slogans. In parallel with this market push effort, bit rate demand is steadily increasing due to new services like HD-IPTV, Clouding, VPN, and life/work styles (Remote jobs, self-employment, etc.).

This competitive landscape has forced telecom operators to invest on massive FTTH deployment projects.

- At the end of 2011 > 75 million FTTH subscribers worldwide. At 2020, up to 50 % of EU households should have 100 Mbit/s.

The bitrate race has started from 20 Mbit/s (xDSL/Cable) to 50 Mbit/s, 100 Mbit/s and 200 Mbit/s. Rather than price reduction as a strategy, telecom operators are offering more and more bit-rates supporting new services.

To fulfil this trend, a robust, reliable, stable and flexible network topology is needed within the house. The customer needs to be able to use the total provided bit-rate in any point of the house as well as have a remaining extra bandwidth to be used for services like file sharing and local video streaming.

A hybrid mixture of networking technologies, offering Fixed-Wired-Reliable network and a Wi-Fi Flexible-Mobility-Ubiquity, is demanded. Tablets, Laptops and smart-phones require a Mobile network. Fixed PCs, Multimedia hard-drives, IPTV set-top-boxes and routers are normally wire connected.

New wire installations may reuse mains conduits within a daisy chain/tree topology. This is the easiest, less expensive and fastest way to introduce a new wiring either in green (new construction) or brown (already constructed) fields. Moreover, wired networks are naturally more "Energy Efficient" than wireless. Energy efficiency is an important topic in the society for two reasons: environmental care arguments are forcing the use of an Energy Efficient infrastructure. Secondly, health reasons are starting to force the limitation in transmitted power in the Wi-Fi network, limiting the high-speed coverage to a single room (see Council of Europe. Document 12608 [i.8] May 6th 2011).

4.2 FTTH deployment

Even when Asia-Pacific countries are leading the FTTH deployment, North America is following with a big growth rate. Europe is following the tendency.

This deployment multiplies by 2, 4 or even 10 times the available bitrates in the home. New services are offered in parallel to just the Internet connection. This increase of the services is seen by the Internet Providers as a fundamental requirement in todays competitive market. The Internet Provider offers the bit rate and the services. That is why the quality of the access network, as well as the quality of the home network is a major requirement of this deployment.

Home networking has to accommodate to the required performance, robustness, and feasibility of the offered services. The Internet providers are the main supporters of a high quality home networking.

4.3 Internet based services

To the traditional World Wide Web surfing and e-mail services, other services have been added to the public Internet offer:

- **Voice over IP:** Traditional analogue phone lines are being replaced more and more with VoIP digital technology. Nevertheless, the requirements of this service are more related with signal jitter and latency than with bit rates. A low packet error rate is required to avoid artefacts in the sound.

- **Video over IP, or IPTV:** Consists on providing video services over IP networks, within a local network, or via the Internet. Currently the IPTV business is growing and competing with Satellite, Cable and Terrestrial TV. The biggest added value of IPTV over its competitors is the Pay-Per-View service. IPTV requires high bandwidths up to 16 Mbit/s for a very high quality HD compressed video. Multi room IPTV (several TVs in a home) is now becoming a popular service offered in most of the provider portfolio. Jitter is typically an important metric for this type of service, whereas latency is not. There is an increase in demand for HDTV as well as more than one HDTV terminal per household. Each HDTV service requires around 4 Mbit/s to 20 Mbit/s depending on the quality issued and programme type (news, sports, etc.).

- **Telework:** Home-based Businesses and Remote employment opportunities. Remote access to office networks requires bitrates in the order of 1 Mbit/s to 10 Mbit/s. But home workers will appreciate speeds as fast as possible, even 100 Mbit/s, to have the same work experience as in the office. Telework is growing in US and Europe as a consequence of the economic downturn and the increasing cost of transportation. Work-life balance is also playing an important role in Telework growth.
- **Telehealth:** Access to Healthcare Professionals and "multiplication of specialists". Consists mainly in video traffic, requiring low latency and 2 Mbit/s speed.
- **Tele-education:** Specialized courses, retention of impacted workers and enhancement of classroom training. Typical requirements are around 1 Mbit/s to 2 Mbit/s speed.
- **E-Government:** Access to forms and applications, communication to representatives, citizen involvement, intelligent first-responders.
- **File storing in the "cloud":** The requirement is "as fast as possible". Pictures and videos represents multi gigabyte source of information in a house nowadays. Moving all this information may take forever if speed is not high enough.
- **Online gaming:** Requirements of 1 Mbit/s and low latency is needed for this service.
- **Sustainability:** Energy management systems within the home and the future Smart Grid deployment will also add to the demand for higher bandwidth at home.

In table 1 a summary of the main needs of current Internet services is shown (see ICT Alpha [i.12]).

Table 1: Needs of Internet services

Service	Bit rate	Delay	Jitter	Packet loss	Mobility	Traffic Priority	Security
Internet	1 Mbit/s to 100 Mbit/s	Relaxed specification	< 10 ms	None (BER < 10^{-8})	Yes	Low	No
Music	5 kbit/s to 128 kbit/s	Buffer dependent	Buffer dependent	< 1 %	Yes	High	No
File sharing (peer-to-peer)	1 Mbit/s to 100 Mbit/s	Relaxed specification	< 10 ms	None (BER < 10^{-8})	Yes	Low	No
Web3D	10 Mbit/s to 1 Gbit/s	Relaxed specification	< 10 ms	None (BER < 10^{-8})	Yes	Low	No

4.4 Current in-home networking services

The communication networks essentially allow an exchange of information between persons, between persons and equipment (e.g. a video server), and between equipment (e.g. a sensor and an actuator). Based on the type of the information exchange and the inherent service requirements, the following groups/classes of services can be identified (see ICT Alpha [i.12]):

- Basic communication such as telephony, e-mail, and instant messaging.
- Internet-related services such as general browsing, e-banking, e-shopping and similar; including file sharing.
- Video-related services such as Video on Demand, IPTV, video conferencing and similar.
- Online Virtual Environments such as social network or gaming.
- Remote Technical services such as the ability to remotely control/survey your home.
- Remote Health services such as remote health monitoring.

From the above classification, video-related services are among the most bandwidth demanding services with presence today at the home. A few examples follow:

- IPTV.

- Video on Demand, multimedia content production and delivery.
- Video conferencing and video telephony.
- Video streaming/Home Theatre.
- TV Broadcast (DVB-X).

Table 2 summarizing the demands for these applications follows (see ICT Alpha [i.12]).

Table 2: New application demands

Service	Bit rate	Delay	Jitter	Packet loss	Mobility	Traffic Priority	Security
IPTV	2 Mbit/s to 20 Mbit/s (for HD)	< 400 ms; 200 ms recommended	< 50 ms	< 1 %; < 0,1 % recommended	Yes	High	No
VoD	2 Mbit/s to 1 Gbit/s	< 400 ms; 200 ms recommended	< 50 ms	< 1 %; < 0,1 % recommended	Yes	High	No
Videoconference	128 kbit/s to 4 Mbit/s	< 400 ms; 200 ms recommended	< 50 ms	< 1 %; < 0,1 % recommended	Yes	High	No
Video Streaming (uncompressed)	128 kbit/s to 10 Gbit/s	< 400 ms; 200 ms recommended	< 50 ms	< 1 %; < 0,1 % recommended	No	High	No
TV Broadcast (DVB-IP)	96 kbit/s to 45 Mbit/s (HD)	< 400 ms	< 20 ms	None (or use FEC)	Yes	High	No
TV Broadcast (DVB-x, non IP based)	N/A rather BW occupied up to 8 MHz	< 400 ms	< 20 ms	None (or use FEC)	Yes	High	No
Immersive TV (e.g. UHDTV)	24 Gbit/s uncompressed; < 640 Mbit/s compressed	< 400 ms; < 150 ms recommended	< 20 ms	< 0,4 %	No	High	No
Immersive Videoconference using UHDTV	< 640 Mbit/s compressed	< 400 ms; < 150 ms recommended	< 20 ms	< 0,2 %	No	High	No
Stereoscopic TV	62,5 Mbit/s to 320 Mbit/s	< 400 ms; < 150 ms recommended	< 20 ms	< 0,4 %	No	High	No
Free Viewpoint TV	937,5 Mbit/s	< 400 ms; < 150 ms recommended	< 20 ms	< 0,4 %	No	High	No

4.5 Current home networking technologies

4.5.1 Introduction

The main classification criteria for home networking technologies is the one based on wired versus no wired home networks. The flexibility provided by no wired networks has to be well balanced with other advantages provided by the wired technologies. These advantages are summarized in the following paragraph:

- Wired networks are more stable and dependable than wireless and channel interference in wired network from other devices is non-existent (or other access points operating in the same channel).
- Wired networks are faster than their wireless counterparts with, multi-media, voice, video, network games and other real time applications performing better in a wired network.
- Wired networks are more secure despite the existence of encryption in wireless networks. It is still possible for a determined hacker to access the network with the right tools or awareness of vulnerabilities in the network but wired networks can only be connected from within the home thus making it difficult for the hacker to access.