International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Series J
Supplement 11
(04/2021)

SERIES J: CABLE NETWORKS AND TRANSMISSION OF TELEVISION, SOUND PROGRAMME AND OTHER MULTIMEDIA SIGNALS

Guidelines for installing a digital television service for cable networks based on ITU-T Recommendations

ITU-T J-series Recommendations – Supplement 11

ITU-T

Supplement 11 to ITU-T J-series Recommendations

Guidelines for installing a digital television service for cable networks based on ITU-T Recommendations

Summary

Several developing countries are planning to deploy fibre optic facilities and advanced digital transmission over hybrid fibre/coaxial (HFC) with the objective of introducing digital cable television services on their infrastructure. Supplement 11 to the ITU-T J-series provides guidelines to be considered by countries developing their system based on ITU-T Recommendations.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T J Suppl. 11	2021-04-28	9	11.1002/1000/14640

Keywords

Cable networks, deployment, digital TV, HFC, hybrid fibre/coaxial, implementation, optical fibres.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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Introduction

Many developing countries are in the process of deploying fibre optics, therefore deployment of digital television (TV) over fibre optics is envisaged. Digital TV signals carried over fibre optics would conform to Recommendations ITU-T J.185, J.186, J.83, J.382, among others, but the proper selection of Recommendations is essential to meet the requirements of each country.

Supplement 11 to ITU-T J-series Recommendations

Guidelines for installing a digital television service for cable networks based on ITU-T Recommendations

1 Scope

This Supplement provides a list of existing Recommendations and their usage to help with the deployment of digital television services on cable networks based on fibre optics and hybrid fibre coaxial (HFC) networks.

2 References

[ITU-T J.83]	Recommendation ITU-T J.83 (2007), *Digital multi-programme systems for television, sound and data services for cable distribution*.
[ITU-T J.94]	Recommendation ITU-T J.94 (2016), *Service information for digital broadcasting in cable television systems*.
[ITU-T J.183]	Recommendation ITU-T J.183 (2016), *Time-division multiplexing of multiple MPEG-2 transport streams and generic formats of transport streams over cable television systems*.
[ITU-T J.185]	Recommendation ITU-T J.185 (2012), *Transmission equipment for transferring multi-channel television signals over optical access networks by frequency modulation conversion*.
[ITU-T J.186]	Recommendation ITU-T J.186 (2008), *Transmission equipment for multi-channel television signals over optical access networks by sub-carrier multiplexing (SCM)*.
[ITU-T J.288]	Recommendation ITU-T J.288 (2019), *Encapsulation of type length value (TLV) packet for cable transmission systems*.
[ITU-T J.382]	Recommendation ITU-T J.382 (2018), *Advanced digital downstream transmission systems for television, sound and data services for cable distribution*.
[ITU-R BT.1869]	Recommendation ITU-R BT.1869 (2010), *Multiplexing scheme for variable-length packets in digital multimedia broadcasting systems*.
[IEC 60728-x]	IEC 60728 (all parts), *Cable networks for television signals, sound signals and interactive services*.
[ISO/IEC/IEEE 8802-3]	ISO/IEC/IEEE 8802-3:2021, *Telecommunications and exchange between information technology systems – Requirements for local and metropolitan area networks – Part 3: Standard for Ethernet*.

3 Definitions

None.

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Supplement

None.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

ADSL	Asymmetric Digital Subscriber Line
CAS	Conditional Access System
CATV	Cable Television
CM	Cable Modem
CMTS	Cable Modem Terminating System
CPE	Customer Premises Equipment
DOCSIS	Data Over Cable Service Interface Specifications
DVB	Digital Video Broadcasting
END	Equivalent Noise Degradation
EPON	Ethernet Passive Optical Network
EVM	Error Vector Magnitude
FDM	Frequency Division Multiplexing
FEC	Forward Error Correction
FTTH	Fibre to the Home
FM	Frequency Modulation
GPON	Gigabit Passive Optical Network
GSE	Generic Stream Encapsulation
HD	High Definition
HFC	Hybrid Fibre/Coaxial
IF	Intermediate Frequency
IM	Intensity Modulation
IPVB	IP Video Broadcasting
IP	Internet Protocol
IPTV	Internet Protocol Television
LDPC	Low Density Parity Check code
MER	Modulation Error Ratio
MDU	Multi-Dwelling Units
MPEG	Moving Picture Expert Group
NM	Noise Margin
OFDM	Orthogonal Frequency Division Multiplexing
ONT/ONU	Optical Network Termination/Unit
OTT	Over the Top
PD	Photo Detector
PON	Passive Optical Network
QAM	Quadrature Amplitude Modulation

RF	Radio Frequency
SCM	Sub-Carrier Multiplexing
SI	Service Information
STB	Set Top Box
TDM	Time Division Multiplexing
UDP	User Diagram Protocol
TLV	Type Length Value
TS	Transport Stream
UHD	Ultra-High Definition
VOD/VoD	Video on Demand
V-ONT	Video-optical Network Terminal
VSB	Vestigial SideBand
WDM	Wavelength Division Multiplexing

5 Conventions

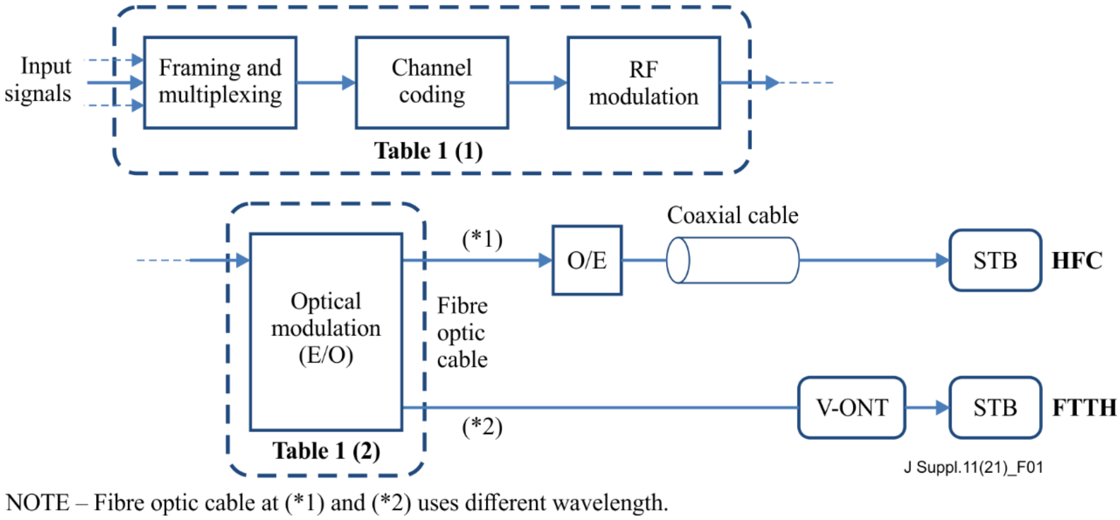
None.

6 ITU-T Recommendations for digital TV over cable networks

Digital cable TV signals are carried either through hybrid fibre/coaxial (HFC) facilities or full fibre optics facilities such as fibre to the home (FTTH). Figure 1 illustrates the components that form those facilities.

In both HFC and fibre optics headend, one or more digital cable TV signals, usually in the form of MPEG-2 transport stream (TS), are multiplexed in a frame structure, then modulated to the radio frequency (RF) signal, usually below 770 MHz, depending on the regulations of each country. A number of RF signals of different frequencies are placed in a form of frequency division multiplexing (FDM), and this bundle of RF signals is converted to optical signal for transmission over fibre optic cables.

In the HFC system, this optical signal is converted back to an electrical signal for transmission through coaxial cables that serve the last miles of the subscriber access line. In the full fibre optic facilities such as FTTH, the original optical signal is fed directly to the customer's premises.



NOTE – Fibre optic cable at (*1) and (*2) uses different wavelength.

Figure 1 – Cable television HFC and FTTH facilities

Table 1 shows a list of ITU-T Recommendations applicable to these facilities.

These can be grouped into two categories. The first group of Recommendations concerns the functions from framing to RF modulation, and the second group deals with optical modulation of this RF signal.

Table 1 – ITU-T Recommendations applicable to digital cable television services based on fibre optics and HFC networks

(1) Framing to RF modulation

	Title	**Description**
ITU-T J.83	Digital multi-programme systems for television, sound and data services for cable distribution	Single MPEG-2 transport stream over a QAM channel
ITU-T J.183	Time-division multiplexing of multiple MPEG-2 transport streams and generic formats of transport streams over cable television systems	TDM of multiple MPEG-2 transport streams, and framing structure for high-speed transmission by channel-bonding
ITU-T J.288	Encapsulation of type length value (TLV) packet for cable transmission systems	Encapsulation of TLV over an ITU-T J.83 and ITU-T J.183 cable channel to transmit variable length packets such as IP packets
ITU-T J.382	Advanced digital downstream transmission systems for television, sound and data services for cable distribution	Advanced digital cable transmission with high spectral efficiency using OFDM and LDPC, known also as DVB-C2

(2) Optical modulation

	Title	Description
ITU-T J.185	Transmission equipment for transferring multi-channel television signals over optical access networks by frequency modulation conversion	Frequency modulation before intensity modulation
ITU-T J.186	Transmission equipment for multi-channel television signals over optical access networks by sub-carrier multiplexing (SCM)	Intensity modulation

In addition, digital television signals can be sent in the form of IP packets through HFC using data over cable system (DOCSIS) or FTTH passive optical network (PON) system. This use case is not the main topic of this Supplement, but a brief description of DOCSIS and PON is found in Appendix I.

6.1 Summary of Recommendations

(1) Recommendation ITU-T J.83

[ITU-T J.83] covers the definition of the framing structure, channel coding and modulation for digital multi-programme signals for television, sound and data services distributed by cable networks.

This Recommendation has four annexes (Annexes A, B, C and D) that provide the specifications for the four digital television cable systems used in different regions. Annexes A, B and C are for cable systems which carry a single MPEG-2 transport stream over a QAM channel, and Annex D is for 16-VSB digital transmission. This Recommendation recommends that those implementing new digital multi-programme services on existing and future cable networks should use one of the systems whose framing structure, channel coding and modulation are specified in Annexes A, B, C and D.

(2) Recommendation ITU-T J.183

[ITU-T J.183] describes a time-division multiplexing (TDM) format for transmitting multiple MPEG-2 transport streams and/or generic formats of transport streams by using a simple implementation of MPEG-2 systems physical interface on cable television systems. The TDM frame encapsulates the MPEG-2 transport streams and/or generic formats of transport streams, which are packetized into 188-byte length prior to transmission. It also describes the framing structure for high-speed transmission by channel bonding technology.

The frame format enables a cable television operator to pack multiple TSs into a single channel or multiple channels. Operation of a cable distribution network would become flexible if services could be integrated on the basis of the TS.

(3) Recommendation ITU-T J.288

[ITU-T J.288] proposes an encapsulation scheme of type length value (TLV) specified in ITU-R BT.1869 for cable transmission systems being designed on the basis of [ITU-T J.83].

Many of the existing digital broadcasting systems transfer MPEG-2 TS as their input stream format. In contrast, variable-length packets formats such as TLV are specified for transmitting IP packets efficiently over broadcasting channels as aggregates of variable-length packets. In order to transmit TLV with the existing ITU-T J.83 transmission system, it is necessary that variable-length TLV packets should be fragmented and encapsulated into fixed-length 188-byte packets.

(4) Recommendation ITU-T J.382

[ITU-T J.382] provides specifications that should be considered for advanced digital cable downstream transmission technologies to provide high spectral efficiency schemes saving transmission resources for downstream in hybrid fibre coax (HFC) based networks. This Recommendation covers the common definition of framing structure, channel coding and modulation for television, sound and data services including high quality broadcast and multicast services distributed through HFC based networks.

[ITU-T J.382] is equivalent to DVB-C2, the second-generation digital multi-programme transmission system for cable developed by digital video broadcasting project (DVB) of Europe. It increases the transmission capacity of cable channel by the use of a powerful forward error correction (FEC) code called low density parity check (LDPC), and orthogonal frequency division multiplexing (OFDM) modulation. It supports TS, any packetized and continuous input formats as well as generic stream encapsulation (GSE).

(5) Recommendation ITU-T J.186

[ITU-T J.186] describes a transmission method for multi-channel television signals over optical access networks. ITU-T J.186 transmission equipment is capable of transmitting multi-channel 64-QAM, and 256-QAM and other video signals by using sub-carrier multiplexing (SCM).

In the SCM technique, the main carrier is the optical frequency signal carrier; the sub-carriers transfer the electrically multiplexed FDM video signals in the optical sideband. The format of the signals output by the photo detector (PD) of the optical network terminal (ONT) is the same as that of the signals input to the modulator of the optical transmitter. The SCM method is used in the trunk line of hybrid fibre-coax (HFC) systems.

(6) Recommendation ITU-T J.185

[ITU-T J.185] describes a transmission method for transferring multi-channel television signals over optical access networks. ITU-T J.185 transmission equipment is capable of realizing multi-channel 64-QAM, and 256-QAM and other video signal transmission through the use of frequency modulation (FM) conversion.

In this FM transmission system, multi-channel frequency-division multiplexing (FDM) television signals are simultaneously converted into one single wideband FM signal. This FM signal is then transmitted through the optical access network by using the intensity modulation technique. The video-optical network terminal (V-ONT) at the customer premises converts the received single FM signal into the original multi-channel FDM video signals for coaxial cable television. The interface for this FM transmission system is the same as that of the amplitude modulation sub-carrier multiplexing (AM-SCM) system defined by [ITU-T J.186].

6.2 Selection of Recommendations

(1) Multiplexing of digital multi-programme television signals

To send digital multi-programme television signal using a cable QAM channel, either [ITU-T J.83] or [ITU-T J.183] is used depending on how the multi-programme signal is composed.

[ITU-T J.83] takes a single MPEG2 transport stream (TS) as an input and sends out a single QAM channel. This TS contains one or more digital television and sound programmes. Each programme is distinguished by service ID which is one of the service information (SI) contained in the framing of [ITU-T J.83]. Details on service information is found in Recommendation ITU-T J.94 "Service information for digital broadcasting in cable television systems."

When MPEG2 transport streams originate from different sources such as television stations, it will have different TS ID from each other. When each stream is of the size (bitrate) that occupies a single QAM channel, [ITU-T J.83] is used. However, if the total bitrates of two or more transport streams combined is within what can be sent over a QAM channel, it is reasonable to multiplex them together, using [ITU-T J.183], to occupy a single QAM channel. [ITU-T J.183] defines "Transport Steam Multiplexing Frame (TSMF)" which multiplexes two or more MPEG2 transport streams to form a single stream to be transmitted over a single QAM channel.

[ITU-T J.83] has four annexes. Annex A is mostly used in Europe, Africa, Asia and South America, Annex B in North America, and Annex C in Japan. Annex D is for 16-VSB for North America, but it is not used. The proper selection of the annex that is applicable is required in consideration of interoperability among different operators in the area and other factors.

(2) Optical transmission systems

To transmit QAM-modulated RF signal over fibre portion of HFC or FTTH, it must be converted from electrical form to optical form, using either [ITU-T J.186] or [ITU-T J.185].

[ITU-T J.186] is titled "Transmission equipment for multi-channel television signals over optical access networks by sub-carrier multiplexing (SCM)." The term "SCM" is used here to describe a system where a multiple cable television RF signals (sub-carriers) are frequency division multiplexed (FDM), and then intensity modulated by a single wavelength optical signal.

On the other hand, [ITU-T J.185] applies frequency modulation (FM) to the FDM signal before it is intensity modulated by a single wavelength optical signal as in [ITU-T J.186].

Table 2 compares the characteristics of IM (ITU-T J.186) and FM (ITU-T J.185). In summary, use of frequency modulation adds complexity to the equipment and cost, but reduces degradation from noise and distortion. The final decision to use either [ITU-T J.186] or [ITU-T J.185] should be made after comparison of those factors.

Table 2 – Comparison of ITU-T J.186 with ITU-T J.185

	ITU-T J.186	**ITU-T J.185**
Modulation	Intensity modulation (IM)	Frequency modulation (FM) before IM
Device complexity	Simple	Complicated
Susceptibility to	Susceptible to noise, thus – requires higher signal strength at receiver – requires more repeaters	Resilient to noise, thus – requires lower signal strength at receiver – requires less repeaters for long haul transmission
Susceptibility to distortion	– Susceptible to distortion – Requires high quality optical amplifier	– Not susceptible to distortion – Can use standard quality optical amplifier
Bandwidth	Up to 3.2 GHz	Up to 1.0 GHz

To design and deploy ITU-T J.186 based optical transmission system, IEC 60728 series of international standards give practical information such as system configuration, basic system parameters, methods of measurement, and so on. Appendix I outlines these documents. Note that while [ITU-T J.186] is applicable to both analogue and digital video signals, Appendix I deals with IEC 60728 standards for digital modulated signals only.

Appendix I

Optical system for transmission of digital video broadcast signals

(IEC 60728 series)

I.1 Introduction

[IEC 60728-x] series of international standards, "Cable networks for television signals, sound signals and interactive services", describe the system configuration, system specifications, methods of measurement and design considerations for practical service systems that are designed and deployed based on the transmission equipment defined in [ITU-T J.186].

Some of these standards, including Part 113 and Part 115, are applicable to optical transmission systems for broadcast signal transmission that consist of headend equipment, optical transmission lines, in-house wirings and system outlets. Unlike [ITU-T J.186] which deals with both analogue and digital video signals, most recent IEC standards are primarily intended for television signals using digital transmission technology only. They also specify the basic system parameters and methods of measurement for optical distribution systems between headend equipment and system outlets in order to assess the system performance and its performance limits. In these standards, the upper signal frequency is limited to about 3 300 MHz.

These standards describe RF transmission for fully digitalized broadcast and narrowcast (limited area distribution of broadcast) signals over FTTH and introduces xPON system as a physical layer media. The detailed description of the physical layer is out of the scope of these standards. The scope is limited to RF signal transmission over FTTH, thus, they do not include IP transport technologies, such as IP multicast and associate protocols, but are also applicable to broadcast signal transmission using a telecommunication network if they satisfy the optical portion of these standards.

I.2 Optical system reference model

Figure I.1 shows the FTTH system reference model for broadcast signal transmission. Although the numbers of optical amplifiers and optical splitters depend on the scale of the optical system, or on the number of subscribers to be connected, the fundamental network configuration shall follow the system reference model. In addition, the optical levels in operation required for the system are relatively high, and hence, special attention for safety shall be paid in accordance with [IEC 60825-1], [IEC 60825-2] and [IEC 60825-12].

Generally, there are two solutions for constructing an optical transmission system: one-fibre and two-fibre solutions. The reference model as shown in Figure I.1 includes the broadcast signal transmission system and the data signal transmission system. A data signal transmission system uses both ways of transmission over the optical fibre with different optical wavelengths. Both systems are combined by wavelength division multiplexing (WDM) filters at input and output of the distribution network as an example. The distribution network shall consist of passive optical components such as optical fibres and optical power splitters only, considering maintenance and future system expansion.

In some cases, a one-fibre solution triple-play optical network unit (ONU) (ONU for V-ONU, data-ONU and telephone terminal) is used. In some cases, ONUs are located outside of subscribers' houses (Note – ONU/Optical network unit is used in IEC standards in place of ONT/Optical network termination used in ITU-T Recommendations.)

There are several ways to connect multi-dwelling units (MDU) with FTTH systems (see Figure I.1). One is to connect an MDU with an electrical port after V-ONU output and another one is to connect an MDU with an optical port from an outside plant.

In the one-fibre solution, it is required to avoid optical and electrical crosstalk.

Optical crosstalk between the downstream data signal transmitted on 1 490 nm wavelength and the cable television (CATV) downstream signal is generated if the 1 550 nm WDM does not provide sufficient isolation from the 1 490 nm signal.

Electrical crosstalk between the 1 310 nm data driver signal and the 1 550 nm CATV PD receiver input signal occurs due to electromagnetic radiation in the very compact triplexer housing.

Optical wavelengths and electrical frequency bands listed in Table I.1 and Table I.2 are considered to be used.

Table I.1 – Optical wavelength for FTTH system

Optical signal	Wavelength	Document
Video transmission	1 550 nm	[IEC 60728-113]
RF return (RFoG)	1 610 nm	[IEC 60728-14]
Data (Downstream)	1 490 nm/1 577 nm	[ISO/IEC/IEEE 8802-3]
Data (Upstream)	1 310 nm/1 270 nm	[ISO/IEC/IEEE 8802-3]

Table I.2 – Frequency range

Frequency band	Document
47 MHz to 862 MHz (only digitally modulated signals)	[IEC 60728-101], [IEC 60728-113] [IEC 60728-115]
950 MHz to 3 300 MHz (satellite signal transmission)	[IEC 60728-13-1], [IEC 60728-115]

NOTE – [IEC 60728-113 Ed1] (Frequency range: 47 MHz to 862 MHz) and [IEC 60728-13-1 Ed2] (Frequency range: 950 MHz to 3 300 MHz) will be merged in a few years as [IEC 60728-113 Ed2] (Frequency range: 47 MHz to 3 300 MHz).

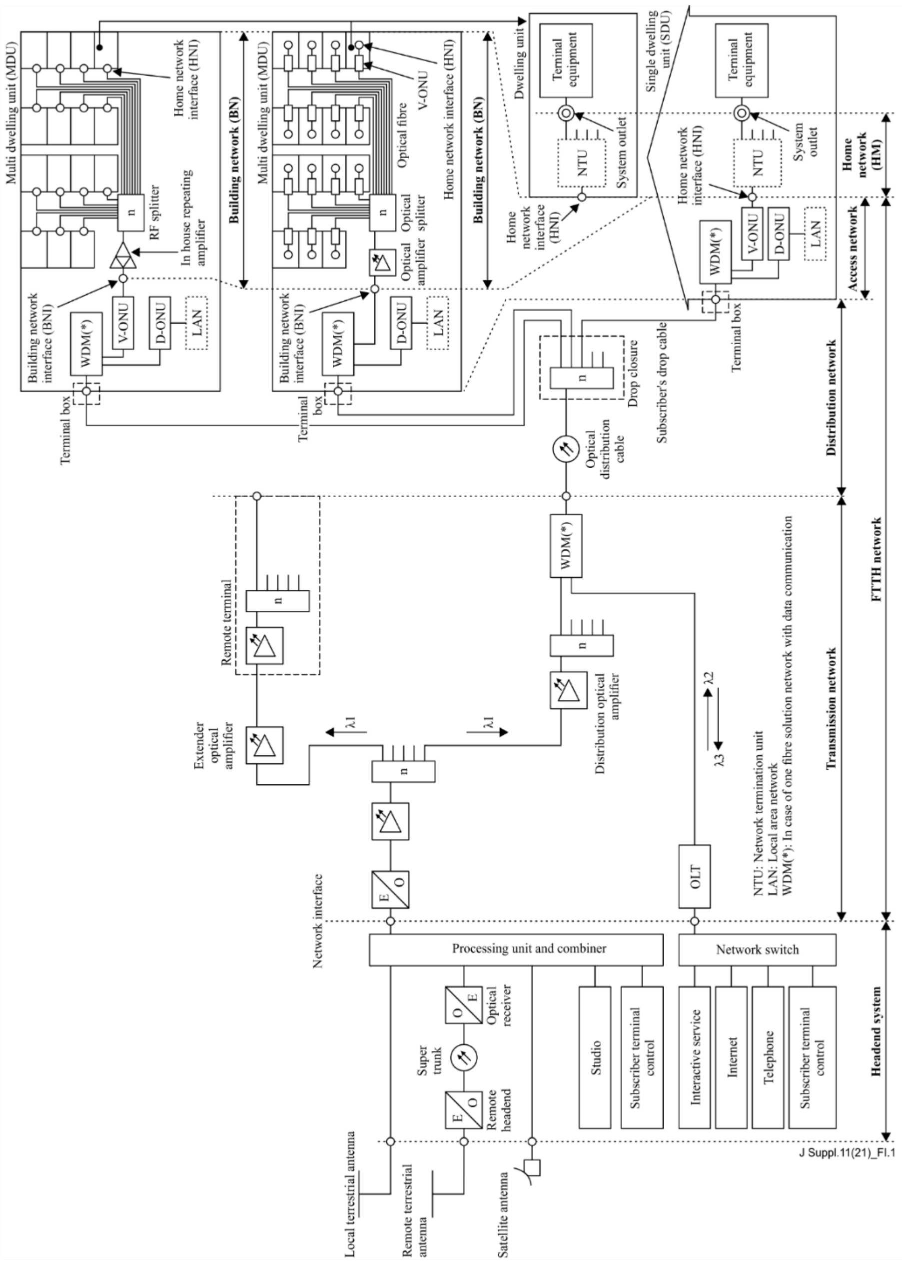


Figure I.1 – Example of FTTH system for television and sound signal

The points of performance specification of the optical system are shown in Figure I.2.

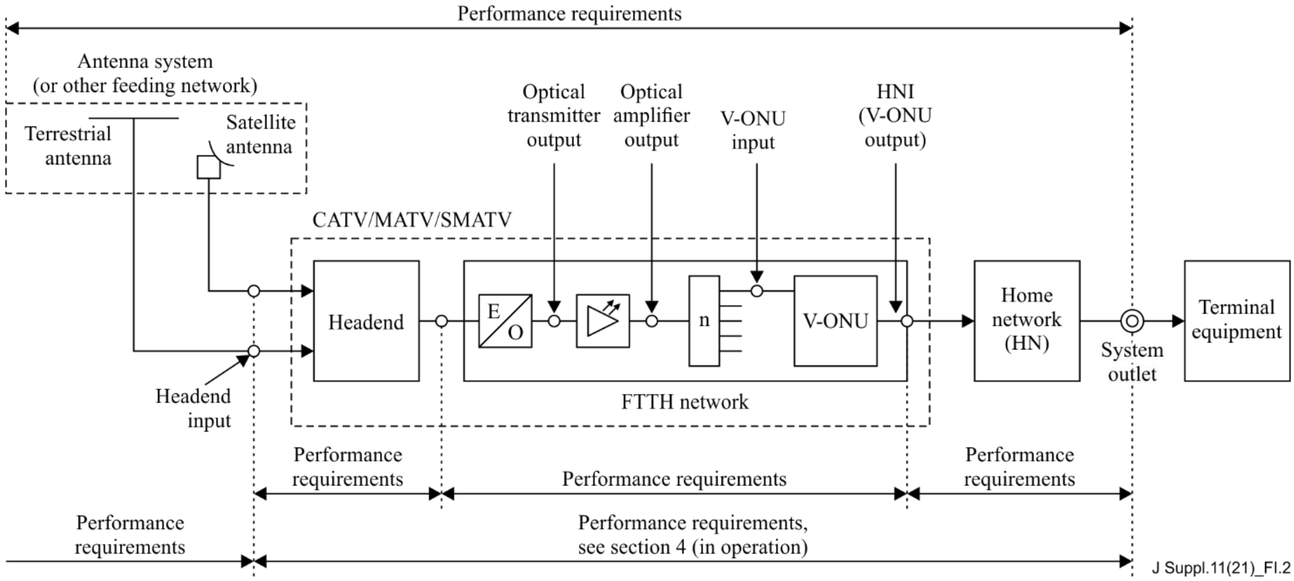


Figure I.2 – Points of performance specification of the FTTH system

I.3 Measuring points and items

This clause describes methods of measurement specifically designed for FTTH system.

The measurement points described in this Supplement are limited to the part of the system that is ranging from the output terminal of the optical transmitter to the system outlet.

I.3.1 Measuring points

It is required to measure the optical power at points (1) to (5), and the electrical signal level at points (6) and (7) of Figure I.3 to ensure total system performance. Points (5), (6) and (7) shall be measured to guarantee the system performance at the end point of the optical section and at the interface point to the customer premises. RIN (Relative Intensity Noise) should be measured at points (1) to (5) and S/N (electrical signal) at points (6) and (7).

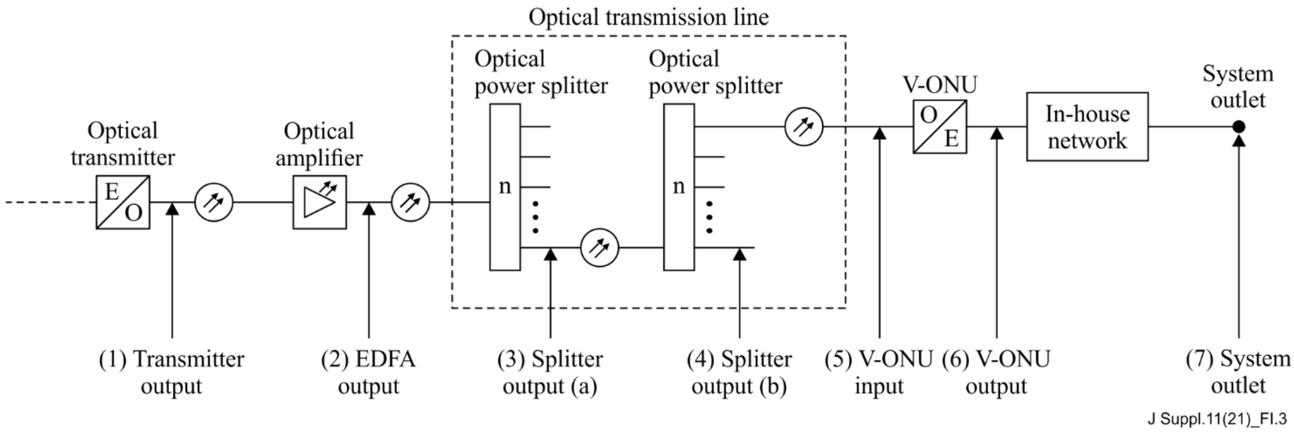


Figure I.3 – Measurement points of video distribution system

I.3.2 Measuring items

Measuring points and measured parameters are summarized in Table I.3.

The measurement at points (5), (6) and (7) is mandatory, while measurement at other points is required to ensure the system performance.

Table I.3 – Measuring points and measured parameters

Measured parameters (Examples)	Measuring points						
	(1) Transmitter output	(2) EDFA output	(3) Power splitter output(a)	(4) Power splitter output(b)	(5) V-ONU input	(6) V-ONU output	(7) System outlet
Optical power	○	○	○	○	○	–	–
S/N (electrical)	–	–	–	–	–	○	○
S/N (RIN) (see Note)	○	○	Δ	Δ	Δ	–	–
BER, MER	–	–	–	–	–	○	○
○ Measurements are possible at these points.							
Δ Measurements are possible at these points when the optical power is higher than −3 dB (mW).							
NOTE – Theoretical estimation of S/N at (6), at the output of V-ONU, is based on the measurement results of individual pieces of equipment.							

I.4 Specification of the optical system for broadcast signal transmission

For digital broadcast services over optical networks the modulation methods 64/256 QAM or OFDM with 256/1 024/4 096 QAM are mainly used. Figure I.2 shows the performance specified points of the typical FTTH system. It also depicts the measuring points (same as performance specified points) and additional measuring points in order to check the operating performance of the optical system. The minimum S/N ratio at the headend output, V-ONU output and system outlet with section S/N ratio for transmission line and in-house network are indicated in Table I.4. (It is for the SDU case, while there is another table for the MDU case in IEC 60728-113.)

For digitally modulated signals the bit error ratio (BER) shall be used as a specification parameter at the headend input only. 1×10^{-4} is required for digitally modulated broadcast signals before FEC in the case of RS (204, 188). In the case of other FEC methods, 1×10^{-11} is required after FEC. As supplement parameters at the headend input, equivalent noise degradation (END), noise margin (NM), modulation error ratio (MER) and error vector magnitude (EVM) can be used.

Table I.4 – Minimum S/N requirements in operation (47 MHz – 1 000 MHz SDU case)

Broadcast signal			S/N at H/E output	S/N at optical transmission line (5)	S/N at V-ONU output (6)	S/N at in-house network interface	S/N at system outlet (7)
System	Modulation	Sub-carrier	dB	dB	dB	dB	dB
ISDB-T	OFDM	64 QAM	27	30	25	45	24
ISDB-C [ITU-T J.83]	64 QAM	–	35	28	27	45	26
	256 QAM	–	43	37	36	51	32
ISDB-C2 [ITU-T J.382]	OFDM	256 QAM	35	28	27	45	26
		1 024 QAM	42	36	35	51	33
		4 096 QAM(4/5)	46	39	38	53	37

Table I.4 – Minimum S/N requirements in operation (47 MHz – 1 000 MHz SDU case)

Broadcast signal			S/N at H/E output dB	S/N at optical transmission line (5) dB	S/N at V-ONU output (6) dB	S/N at in-house network interface dB	S/N at system outlet (7) dB
System	**Modulation**	**Sub-carrier**					
		4 096 QAM(5/6)	49	42	41	55	40
DVB-T	COFDM	64 QAM	27	–	25	–	24
DVB-T2	COFDM	256 QAM	33	–	31	–	30
DVB-C	64 QAM	–	36	–	29	–	28
	256 QAM	–	42	–	35	–	34
DVB-C2	COFDM	256 QAM	35	–	29	–	28
		1 024 QAM	42	–	35	–	34
		4 096 QAM(5/6)	46	–	38	–	37
		4 096 QAM(9/10)	49	–	41	–	40
NOTE – These specification values show an example of a single dwelling unit (SDU) with a frequency range of 1 GHz or less.							

I.5 IEC standards

The following is a list of IEC standards useful for building and operating an FTTH system. However, most of the information in this appendix is found in [IEC 60728-113] and [IEC 60728-13-1].

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60728-13-1:2017, Cable networks for television signals, sound signals and interactive services – Part 13-1: Bandwidth expansion for broadcast signal over FTTH system

IEC 60728-101:2016, Cable networks for television signals, sound signals and interactive services – Part 101: System performance of forward paths loaded with digital channels only

IEC 60728-106 (under development), Optical equipment for systems loaded with digital channels only

IEC 60728-113:2018, Cable networks for television signals, sound signals and interactive services – Part 113: Optical systems for broadcast signal transmissions loaded with digital channels only

IEC 60728-115:2021, Cable networks for television signals, sound signals and interactive services – Part 115: In-Building Optical systems for broadcast signal transmission

IEC 60068-1:1988, Environmental testing – Part 1: General and guidance

IEC 60825-1, Safety of laser products – Part 1: Equipment classification and requirements

IEC 60825-2, Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)

IEC 60825-12, Safety of laser products – Part 12: Safety of free space optical communication systems used for transmission of information

IEC 61755-1:2005, Fibre optic connector optical interfaces – Part 1: Optical interfaces for single mode non-dispersion shifted fibres – General and guidance

IEC TR 61930, Fibre optic graphical symbology

IEC TR 61931:1998, Fibre optic – Terminology

NOTE 1 – IEC 60728-113 Ed.2, which is to be completed in 2022, will include a frequency band up to 3.3 GHz for transmitting satellite IF signals, but [IEC 60728-13] and [IEC 60728-13-1] for analogue signal transmission will remain unchanged.

NOTE 2 – IEC 60728-115 is currently under development. This work is expected to be completed by the end of 2021.

NOTE 3 – IEC 60728-106 is currently under development. This work is expected to be completed by the end of 2022.

I.6 Affiliate Country Programme of IEC

The Affiliate Country Program is a system that allows members without membership to participate in the IEC.

The IEC launched the Affiliate Country Program in 2001 to encourage developing countries to participate in the work of the IEC and to provide the benefits of technology to developing countries efficiently and at the lowest possible cost. As of 2019, 86 countries are members, and Mr. Rojas Manyame (Namibia) has been the leader since January 2018.

The benefits of participation include the following:

– Obtain electronic version of IEC documents (In addition, you can receive more IEC standards free of charge if you become a member of "Affiliate Plus")
– Installation and use of IEC library
– Simpler adoption method than IEC standard
– No dues required, etc.

Appendix II

Internet protocol television (IPTV) over HFC and FTTH

II.1 Introduction

The main part of this guideline is for digital TV carried over traditional one-way cable television network composed of fibre optics and HFC. However, the cable network is now in the process of migrating to IP based two-way infrastructure, either implementing DOCSIS over HFC or PON system over fibre, and so called "IPTV" is being carried on those networks. This appendix gives an overview of Internet protocol television (IPTV) over FTTH PON and DOCSIS.

II.2 Classification of IPTV

IPTV takes many forms. It may be a linear or real-time service, or a non-linear service such as video on demand (VoD). The services may either be carried over best effort, open internet, or over a managed IP network. These classifications are illustrated in Figure II.1.

Non-linear services always use unicast or one to one connection. Most linear services are presently using unicast, but for bandwidth efficiency, multicast or point to multipoint connection is a better technology for this purpose.

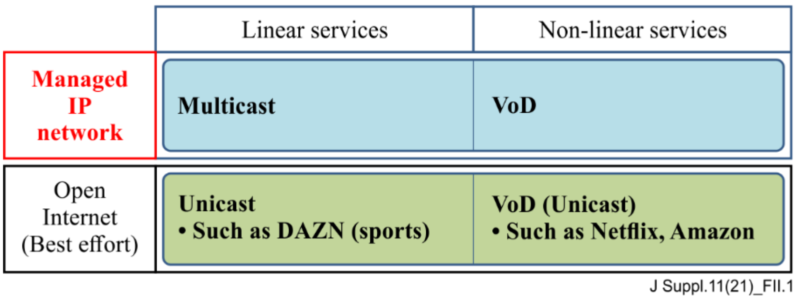


Figure II.1 – Classification of IPTV

II.3 IPTV over PON system

Passive optical network (PON) can mean any optical network consisting of passive devices, but here in this context refers to either GPON or E-PON.

GPON is gigabit-capable passive optical networks defined in [b-ITU-T G.984.x] series of Recommendations and is used as an access network technology to interconnect cable or telecommunication users with the core network. GPON has a downlink bit rate of 2.4 Gbit/s and uplink bit rate of 1.2 or 2.4 Gbit/s (typically 1.2 Gbit/s). It typically serves up to 64 subscribers over a physical reach of 10 and 20 km.

E-PON is "Ethernet-PON" defined by [b-IEEE 802.3ah]. It serves the same purpose as GPON, but the downlink and uplink bit rates are 1.2Gbit/s for a maximum of 32 subscribers.

Both GPON and E-PON have 10 Gbit/s versions of standards and products available today. For example, details of 10 Gigabit G-PON, called XG-PON are found in [b-ITU-T G.987.x] series of Recommendations, and 10 Gigabit E-PON is defined by [b-IEEE 802.3av].

Both GPON and E-PON systems in cable network are composed of an optical line termination (OLT) system at cable headend, and an optical network unit (ONU) at subscribers' premises, with a passive optical distribution network (ODN) interconnecting them. This generic structure is illustrated in Figure II.2.

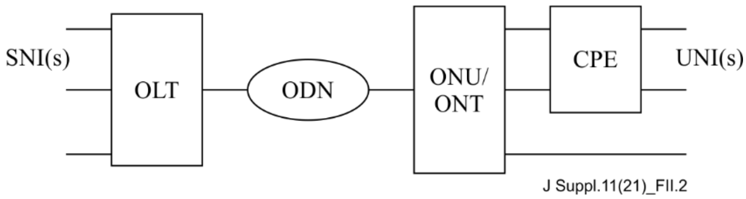


Figure II.2 – Generic GPON system (from ITU-T G.983)

Most ordinary form of IPTV is to send MPEG2 transport stream (MPEG2-TS) using IP protocol by adding IP header to each of the TS packets. This system is called MPEG2-TS over IP.

In both GPON and E-PON systems, subscribers share the downlink and uplink bandwidth. If all the subscribers use the downlink at the same time, each subscriber will have an average bit rate of approximately 30Mbit/s. This is sufficient to send IPTV in good quality, but the use of multicast will reduce the total bandwidth requirements.

II.4 IPTV over DOCSIS

Data over cable service interface specifications (DOCSIS) is being developed by CableLabs, as an access network technology to transmit and receive data over cable HFC network. DOCSIS has been revised several times, and the most recently approved Recommendation is ITU-T H.224 which specifies the fifth generation of high-speed data-over-cable systems. Fifth generation transmission systems introduce a number of new features that build upon what was present in previous ITU-T Recommendations, including the ITU-T J.222.x-series (DOCSIS 3.0) and ITU-T J.225 (DOCSIS 3.1). [b-ITU-T J.224] includes key new features for the physical (PHY) layer and establishes a full duplex (FDX) DOCSIS mode of operation.

The relationship and correspondence between the multiple generations of CableLabs DOCSIS specifications and the ITU-T J-series of DOCSIS-based Recommendations is found in [b-ITU-T J series Sup 10].

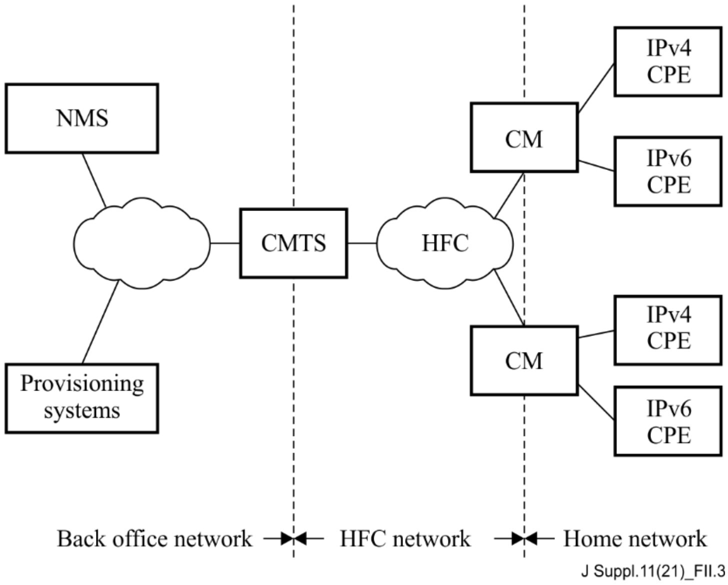


Figure II.3 – DOCSIS network (from [b-ITU-T J.222.1])

As shown in Figure II.3, the DOCSIS system is composed of cable modem terminating system (CMTS) at cable headend, cable modem (CM) at user's premises, and HFC network interconnecting CMTS and CM.

IPTV over DOCSIS is carried in the same way as IPTV over PON systems.

II.5 Other options to send IPTV

(1) IPTV over ADSL

Asymmetric digital subscriber line (ADSL) is an access network technology over metal (copper) wire subscriber lines. It has a higher bit rate on the downlink, and lower bit rate on the uplink, thus called asymmetric.

The first ITU-T Recommendation for ADSL, [b-ITU-T G.992.1], was approved in 1999. This version allows approximately 6 Mbit/s downstream and approximately 640 kbit/s upstream data rates, although the actual data rates depend on factors such as the distance between the central office and subscriber, and so on.

ADSL has since then evolved to support higher data rates, as shown in Table II.2.

Table II.2 – Evolution of ADSL technology

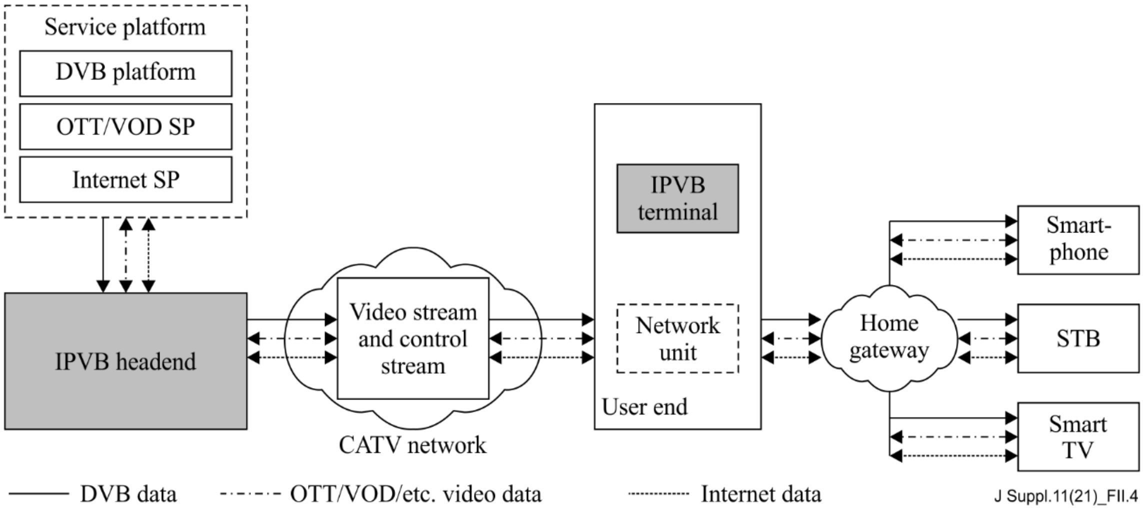
	ITU-T Recommendation	Approved	Data Rates
ADSL	[b-ITU-T G.992.1]	1999	6M/640 kbit/s
ADSL 2+	[b-ITU-T G.992.5]	2009	16M/800 kbit/s
VDSL	[b-ITU-T G.993.1]	2004	52M/2.3 Mbit/s
VDSL 2	[b-ITU-T G.993.2]	2019	100 Mbit/s
G.fast	[b-ITU-T G.9701]	2019	1 Gbit/s (total up and down)

Even the first version of ADSL has enough data rate to carry high definition (HD) video encoded by ITU-T H.265/HEVC with a bit rate around 4 to 6 Mbit/s. However, it is not sufficient to carry multiple channels at the same timeor send higher resolution video such as 4K. ADSL is therefore considered to be an interim solution where full FTTH or HFC access lines are not in place yet.

(2) IP video broadcast (IPVB)

The IPVB is a delivery scheme to support IP-based video services for CATV networks, defined in [b-ITU-T J.1210] and [b-ITU-T J.1211]. It simply adds a one-way IP-based video broadcast system to the existing low-cost bidirectional CATV networks. Combined with the uplink channel provided by current bidirectional access network, it provides the transmission of IP-based high bitrate video service in CATV networks to the home.

The architecture of IPVB is shown in Figure II.4. The IPVB system mainly consists of two parts: The IPVB headend, and The IPVB terminal. Between IPVB headend and IPVB terminal, it makes use of CATV networks in downlink direction only to carry video signals in IP formats.



"Network Unit" should read "Terminal Unit (TU)"

Figure II.4 – IPVB architecture (from ITU-T J.1210)

The service platform encapsulates the DVB programs, service information (SI) tables, and other associated data (e.g., CA information) into user diagram protocol/Internet protocol (UDP/IP) packets, then converges these IP-based data by means of assigning video channels and delivers them to the IPVB headend.

The IPVB headend receives these IP packets such as video streams from the service platform of a DTV system, it will convert the packets' unicast addresses to multicast addresses (when the streams packets have unicast addresses, including VOD, OTT, and other on-demand streams), then, it broadcasts the converged IP data through the downlink broadcast channel of CATV networks to IPVB terminals.

The IPVB terminal is generally embedded in the user terminal. It receives the downlink UDP multicast packets coming from CATV networks, selects and distributes the service packets to the customer premises equipment (CPE) by distinguishing different multicast IP addresses and UDP destination port numbers according to one or more end users' requirements.

As a typical application, IPVB systems can use optical transmission network with 10GE physical layer, the downlink broadcast channel bandwidth of IPVB is 10 Gbps.

When the IPVB system is combined with Ethernet passive optical network (EPON) or gigabit passive optical network (GPON), it can support interactive service such as VOD or OTT video with larger capacity. This system can easily transmit 4K, 8K, VR and other high bit rate live or on-demand videos.

Appendix III

UHDTV (4K/8K) Services

4K ultra high-definition television (UHDTV) service provides better video quality than 2K high- definition television (HDTV) service. It has been already deployed in Europe, North America and Asian countries using satellite, terrestrial and cable broadcasting network, as well as to a variety of media markets such as movies, mobile communications and personal computers.

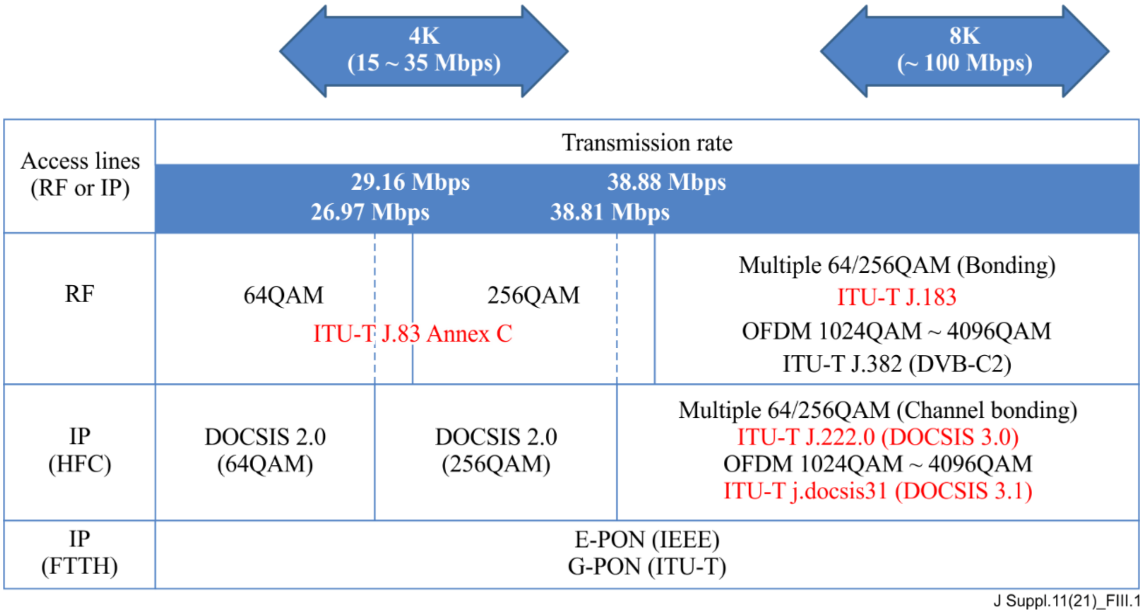
4K service usually utilizes a new video coding method called HEVC [b-ITU-T H.265]. This technology provides twice as much compression efficiency as AVC [b-ITU-T H.264], and often enables transmission of high bitrate 4K video streams using the existing broadcasting media.

In this appendix, use cases of UHDTV (4K/8K) services through HFC and FTTH (RF) infrastructure are described, making reference to [ITU-T J.83] (256QAM) and [ITU-T J.183] (channel bonding), [ITU-T J.186], as well as [b-ITU-T J.297] (4K STB).

The support of HEVC video decoding for 4K resolutions of the Internet protocol television (IPTV) terminal device is specified in [b-ITU-T H.721].

III.1 Transmission of 4K/8K UHDTV service by HFC access lines

Proper transmission method must be selected to transmit HEVC encoded 4K UTHDTV channel which has a bit rate ranging between 15 and 35 Mbit/s, depending on the picture quality desired. Figure III.1 illustrates the maximum bitrate available for different transmission methods. For example, if a 4K channel has a bit rate of 35 Mbit/s, it can be carried by a single 64 QAM channel based on Annexes A and B of [ITU-T J.83], but for systems using Annex C (Japan), either a 256 QAM channel or bonding of 64QAM channels based on [ITU-T J.183] has to be used.



NOTE – For ITU-T J.83 Annex A, transmission rate is 8/6 times (+33%) the above figures.

Figure III.1 – Cable access technology and transmission rate

To transmit an 8K channel which usually has a bit rate of 100 Mbit/s, bonding of 64/256AM channels, or use of OFDM channel based on [ITU-T J.382] is required.

III.2 Transmission of 4K/8K UHDTV service by fibre optic/FTTH access lines

4K/8K services provided by satellite and terrestrial channels can be (re-)transmitted by fibre optic/FTTH cable access lines using sub-carrier multiplexing (SCM) and intensity modulation (IM) based on [ITU-T J.186].

DTH (Direct-to-home) satellite downlink signal usually uses frequency around 12 GHz. To transmit this signal through fibre optic cable access line, it is down-converted to intermediate frequency (IF) from around 1 GHz up to 3.2 GHz at the output of satellite receiving dish. This IF signal in electrical form is converted to optical signal using [ITU-T J.186], transmitted though fibre optic access line, converted back to electrical signal, and fed into 4K/8K STBs, or directly into television sets. To provide this service, an RF over fibre system based on [ITU-T J.186] that supports the maximum frequency range of the satellite IF signal is required.

Since most terrestrial channels use UHF band, it can be carried by cable FTTH access lines without frequency conversion.

III.3 4K STB

To receive 4K service, a 4K compatible STB such as the one defined in [b-ITU-T J.297] is required. Figure III.2 is an example block diagram of a 4K cable STB. One of the most important part of this STB is ITU-T H.265 video decoder and HDMI video output interface in compliance with HDCP2.2 (High Definition Multimedia Interface) which protect the 4K content from piracy.

Conditional access system (CAS) system is another important feature of 4K STB. It should use 128 AES or better, to comply with MoviesLabs (United States) specification for enhance content protection (ECP).

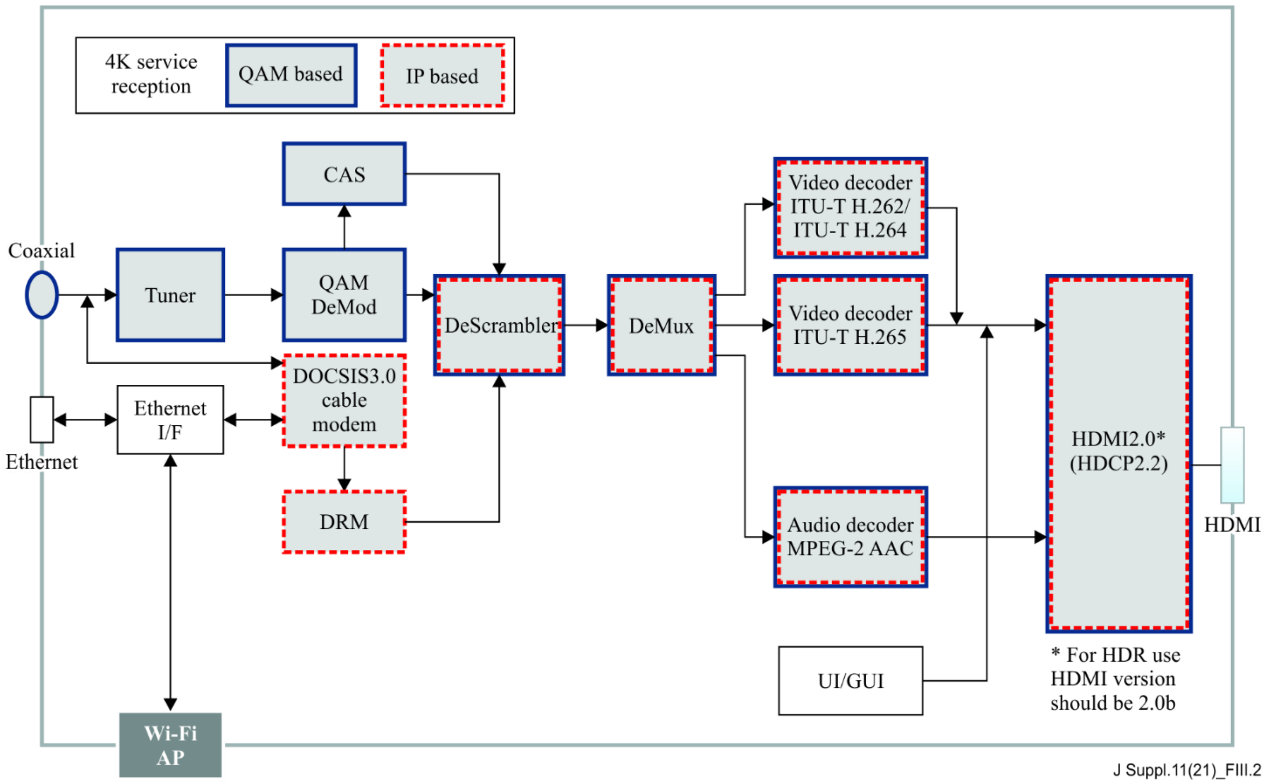


Figure III.2 – Example of 4K cable STB block diagram (from [b-ITU-T J.297[)

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Printed in Switzerland
Geneva, 2021