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OF TELEVISION, SOUND PROGRAMME AND OTHER
MULTIMEDIA SIGNALS

Digital transmission of television signals - Part 4

**Cable network requirements for RF and IP
secondary distribution of television
programmes**

Recommendation ITU-T J.481

ITU-T



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Cable network requirements for RF and IP secondary distribution of television programmes

Summary

A cable television system is required to provide a set of high quality multichannel video programmes using hybrid fibre coaxial (HFC) or fibre optic cables. These are now mostly in an RF format, but as cable television infrastructure migrates to support IP, the signal format should support both IP and RF formats. The use of an IP format, as compared to the RF format, is expected to grow in the future.

Recommendation ITU-T J.481 defines the requirements and architecture of a cable television system able to provide video services in both RF and IP formats. This Recommendation is expected to support cable operators to continue their current cable television business during the transition to IP and in mixed RF and IP environments.

History

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Recommendation ITU-T J.481

Cable network requirements for RF and IP secondary distribution of television programmes

1 Scope

Cable television provides a set of multichannel video programmes that can be perceived with equivalent quality as the video channels being broadcast over the air. The signals have been in an RF format for a long time, using hybrid fibre coaxial (HFC) or fibre optic cables; but, with the introduction of IP technology, some cable operators have started to carry them in an IP format as well. This migration to IP will continue in the future, but the quality and user experience of cable television should not change.

To continue the operation of cable television in mixed RF and IP environments in the future, this Recommendation defines the requirements and system architecture of cable television secondary distribution networks which carry high quality video signals in both RF and IP formats.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

None.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CM	Cable Modem
CMTS	Cable Modem Termination System
DOCSIS	Data Over Cable Systems Interface Specifications
DPoE	DOCSIS Provisioning of E-PON
E-PON	Ethernet-PON
FEC	Forward Error Correction
FTTH	Fibre To The Home
G-PON	Gigabit PON

HD	High Definition
HEVC	High Efficiency Video Coding
HFC	Hybrid Fibre-Coaxial
HLG	Hybrid Log Gamma
IGMP	Internet Group Management Protocol
IP	Internet Protocol
IPLR	IP Packet Loss Ratio
MLD	Multicast Listener Discovery Protocol
MMT	MPEG Media Transport
OFDM	Orthogonal Frequency Division Multiplex
OLT	Optical Line Terminal
ONU	Optical Network Unit
OTT	Over-The-Top
PON	Passive Optical Network
PQ	Perceptual Quantization
QAM	Quadrature Amplitude Modulation
RF	Radio Frequency
SCM	Subcarrier Multiplexing
STB	Set-Top Box
TLV	Type Length Value

5 Conventions

In this Recommendation:

The keywords "**is required to**" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "**is recommended**" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

The keywords "**is prohibited from**" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "**can optionally**" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

In the body of this document and its annexes, the words *shall*, *shall not*, *should*, and *may* sometimes appear, in which case they are to be interpreted, respectively, as *is required to*, *is prohibited from*, *is recommended*, and *can optionally*. The appearance of such phrases or keywords in an appendix or in material explicitly marked as *informative* are to be interpreted as having no normative intent.

6 Overview of RF and IP network for cable television

6.1 Background

Cable television operators have been providing multichannel retransmission of over the air television channels or other video channels. In the secondary distribution network, or cable access network, these are now provided mostly in the RF format, using HFC or fibre optic cables, but as the cable access infrastructure evolves to IP environments, some of them will have to migrate to an IP format in the future.

In the meantime, cable operators' IP networks are already carrying IP video streams for OTT service providers and broadcasters, but these are sometimes low bit rate streams for mobile devices, and not necessarily suitable for viewing by large screen television sets. Moreover, in most cases these are provided using "open internet", competing with other data traffic without traffic control. In the context of a traditional cable television service offering, they do not meet the quality of service and are not part of cable operators' core business.

6.2 Overall requirements for cable television RF and IP network

For cable operators to continue to provide high quality video services to end users in the future, regardless of its format being RF or IP, operators' core (primary distribution) and access (secondary distribution) networks have to support both RF and IP videos. This network will be used during the transition from RF to IP and in mixed RF and IP environments in the future.

The requirements for this network include, among others, the following:

- The network should support the multiple of HD, 4K and 8K channels.
- When video signals are encoded by ITU-T H.265/HEVC, each channel has an average bit rate of 4-6, 20-30, and 70-90 Mbit/s for HD, 4K and 8K, respectively. This bit rate will be reduced with the introduction of new encoding schemes in the future.
- For linear services, when IP is used, each channel should use a multicast protocol to reduce the required bandwidth.
- When IP is used for linear services, dedicated (reserved) bandwidth assignment or priority control should be used to maintain video quality equivalent to RF video.
- Performance objectives should be established and monitored for quality control purposes.

7 Requirements

7.1 General

Cable-rf-ip-Gen-01: A Cable television network is required to support high quality video services in HD and UHD formats, as well as various other high functionality services in a flexible way.

Cable-rf-ip-Gen-02: A cable television network is required to support the best available technology of the time, and have the flexibility and scalability to implement new and additional services in the future.

Cable-rf-ip-Gen-03: A cable television network is required to maintain the interoperability with current broadcasting and other digital media, and be compatible with interactive services that make use of telecommunications.

Cable-rf-ip-Gen-04: A cable television network is required to make use of existing equipment and terminals, and make use of ongoing operational practices as much as possible.

7.2 Transmission capacity

Cable-rf-ip-Cap-01: A cable television core network is required to have bandwidth sufficient to carry all the programme channels that the cable television network has to provide.

Cable-rf-ip-Cap-02: A cable television access network is required to have bandwidth sufficient to carry all the programme channels that the cable STB has to receive.

Cable-rf-ip-Cap-03: When a cable television network is shared with other services including telecommunications, it is required to provide cable television services in a stable manner without interruption.

7.3 Physical layer specifications

Cable-rf-ip phy: To meet specific service requirements, a cable television network should select and employ appropriate physical layer specifications. Examples of physical layer specifications are given in Appendix I.

7.4 Performance

(1) RF

Cable-rf-perf-01: The bit error rate (BER) of the input signal to the cable headend (point 'A' in Figure II.1) is required to be 1×10^{-4} or less before FEC in case of RS (204, 188), or 1×10^{-11} or less after FEC in case of other FEC methods.

(2) IP

Cable-ip-perf-01: The bit error rate of the input signal to the cable headend (point "A" in Figure II.2) is required to be 1×10^{-11} or less.

Cable-ip-perf-02: The IP packet loss ratio (IPLR) of the received signal at the input to cable STB (point 'B' in Figure II.2) is required to be 1×10^{-7} or less. This corresponds to a bit error rate of 1×10^{-11} or less. When forward error correction (FEC) is applied to transmitted IP packets, the packet error ratio after the error correction is applicable.

Cable-ip-perf-03: The IP packet delay is required to be 1.0 second or less. This does not include delay caused by source coding. It is considered that a delay exceeding this value will make a viewer feel that a programme is not real-time or linear.

Cable-ip-perf-04: The IP packet delay variations (jitter) is required to be 100 ms or less.

7.5 Requirements specific to IP broadcasting

The following subclauses apply if IP broadcasting is used to deliver high quality video signals.

7.5.1 Use of multicast

Cable-ip-req-01: To maintain the same bandwidth requirement as RF broadcasting, the cable IP network should implement IP multicast protocols, such as Internet Group Management Protocol (IGMP) for IPv4, or Multicast Listener Discovery (MLD) Protocol for IPv6.

Cable-ip-req-02: The cable IP network should consider using other multicast options available today or in the future.

7.5.2 Performance management

Cable-ip-req-03: The cable IP network is required to employ either of the following two methods to provide cable television services in a managed manner.

- Set a higher priority to IP packets for broadcasting;
- provide dedicated bandwidth for IP packets for broadcasting.

7.6 Performance measurement

Cable-rf-measurement-01: The carrier to noise ratio (C/N) is required to be measured for corresponding RF signal performance as defined in clause 7.4.

Cable-ip-measurement-01: IP packets are required to be sequentially numbered and timestamped at the cable headend, and measured for packet loss ratio, delay, and jitter at the input of the cable STB (point 'B' in Figure II.2) based on the sequence number and the timestamp.

Cable-ip-measurement-02: IP packet measurement may be based on [b-ITU-T Y.1540] and [b-ITU-T Y.1541] and other relevant Recommendations.

7.7 Other considerations

Cable-ip-other req: Cable television IP network is required to support interactive services such as time-shift, start-over, and video on demand in addition to linear services.

Cable-rf-ip-mixed: Transmission of cable television IP packets is required not to interfere with cable RF transmission, or vice versa.

8 System architecture

Examples of the general system architecture of a cable network, consisting of RF and/or IP systems, on which the requirements defined in clause 7 are to be achieved, are found in Appendix II.

Appendix I

Examples of physical layer specifications for cable television RF and IP networks

(This appendix does not form an integral part of this Recommendation.)

The following tables list physical layer specifications for use with cable television RF and IP networks. They list relevant technologies available at the time of writing, but as technologies advance, older ones may be deleted, and new ones added as appropriate.

I.1 Table I.1 – Source coding

Technology	Specific technology/Specification	Reference
Video encoding	HEVC	[b-ITU-T H.265]
	MPEG-4 AVC	[b-ITU-T H.264]
	MPEG2	[b-ITU-T H.262]
Audio encoding	MPEG2-AAC	[b-ISO/IEC 13818-7]
	MPEG4-AAC	[b-ISO/IEC 14496-3]
	MPEG4-ALS	[b-ISO/IEC 14496-3 Subpart 11]
Video format	UHDTV: 4320P (8K), 2160P (4K)	[b-ITU-R BT.2020-2]
	HD: 1080P (2K), 1080i (2K), and others	
High dynamic range video	Hybrid log gamma (HLG)	[b-ITU-R BT.2100-2]
	Perceptual quantization (PQ)	[b-ITU-R BT.2100-2], [b-SMPTE ST 2084]

I.2 Table I.2 – Multiplexing

Multiplexing	MPEG-2 TS	[b-ITU-T H.222.0]
	MPEG media transport (MMT)	[b-ISO/IEC 23008-1]
	TLV/MMT	[b-ITU-T J.288]

I.3 Table I.3 – Channel coding

RF modulation	64QAM/256QAM	[b-ITU-T J.83]
	Multiple transport streams in one QAM channel, Channel bonded 64/256QAM	[b-ITU-T J.183]
	OFDM (DVB-C2)	[b-ITU-T J.382]
DOCSIS	DOCSIS 2.0	[b-ITU-T J.122]
	DOCSIS 3.0	[b-ITU-T J.222.0] to [ITU-T J.222.3]
	DOCSIS 3.1	[b-ITU-T J.225]
	DOCSIS 4.0	[b-ITU-T J.224]
Optical modulation	Subcarrier multiplexing (SCM)	[b-ITU-T J.186]
	Frequency modulation	[b-ITU-T J.185]
PON	G-PON (1G)	[b-ITU-T G.984.1]
	XG-PON (10G)	[b-ITU-T G.987]

	GE-PON (1G)	[b-IEEE 802.3ah]
	10G-EPON (10G)	[b-IEEE 802.3av]

I.4 Table I.4 RF/IP performance and measurement

Performance	RF system performance – Coaxial system	[b-IEC 60728-101]
	RF system performance – Optical system	[b-IEC 60728-113]
	IP packet transfer and availability performance parameters	[b-ITU-T Y.1540]
	IP network performance objectives	[b-ITU-T Y.1541]
Measurement	RF signal measurement	[b-JCTEA-STD-025-1.0]
	IP signal measurement	[b-JLabs SPEC-040]

Appendix II

Examples of system architecture

(This appendix does not form an integral part of this Recommendation.)

This appendix provides examples of general system architecture of cable networks, consisting of RF and/or IP systems, on which the requirements defined in clause 7 are to be achieved.

II.1 Cable RF systems

Cable-rf-system: The cable RF system uses either a hybrid fibre coaxial (HFC) or fibre optic system such as fibre to the home (FTTH), as illustrated in Figure II.1 as an example.

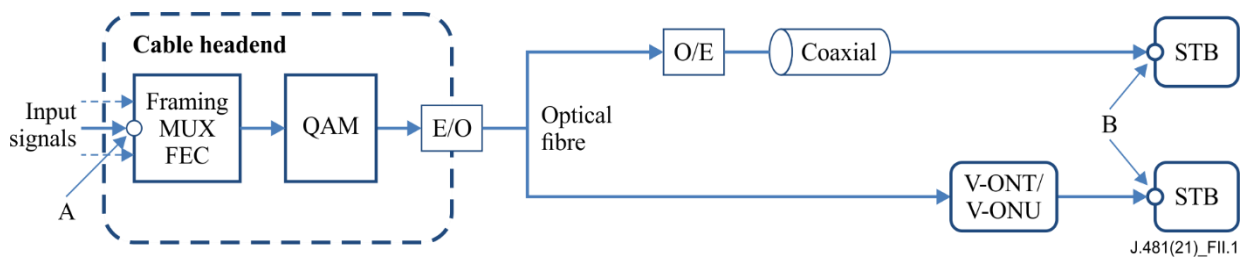


Figure II.1 – Cable television RF system example

II.2 Cable IP systems

Cable-ip-system: The cable IP system uses either DOCSIS over HFC or passive optical network (PON), as illustrated in Figure II.2 as an example. The router, as well as CMTS and OLT in the figure, have either priority control or bandwidth management functions as defined in clause 7.5.2.

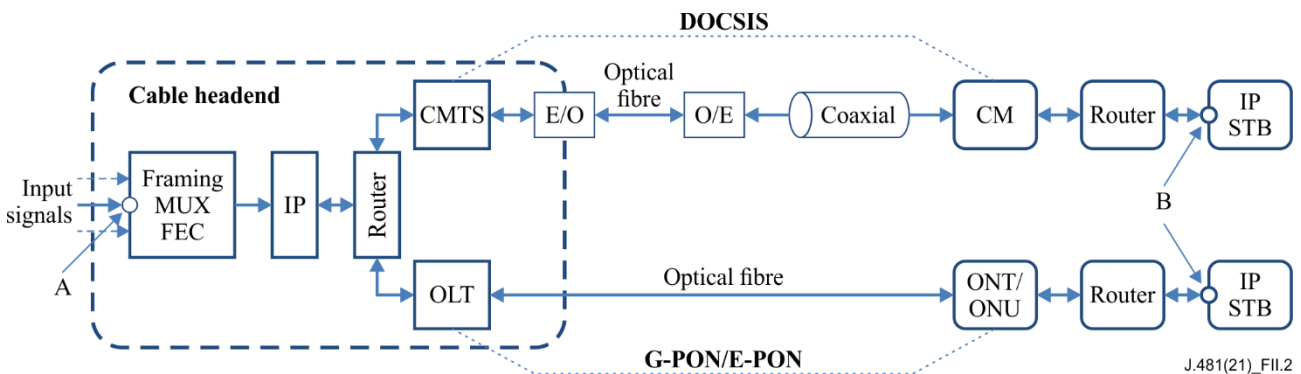


Figure II.2 – Cable television IP system example

II.3 Mixed RF and IP systems

Cable-rf-ip-system: The cable RF and IP system uses an RF video system over HFC or optical fibre, as well as an IP video system using DOCSIS over HFC or PON, as illustrated in Figure II.3 as an example.

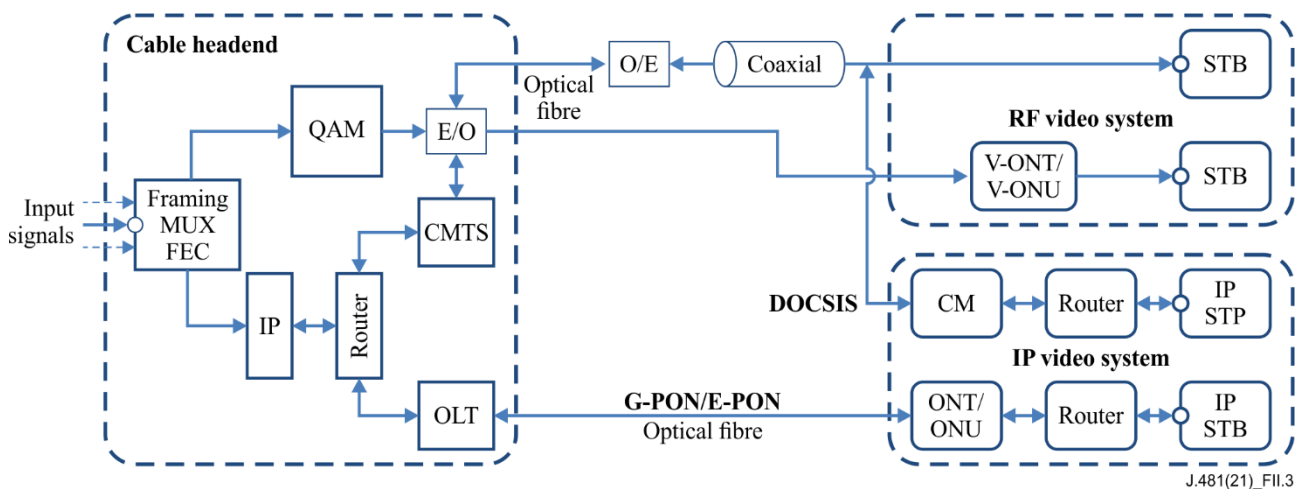


Figure II.3 – Cable television mixed RF and IP system example

For IP video system, cable modem (CM) for DOCSIS and ONU for PON system may either be managed separately, or in a unified way as in DPoE (DOCSIS Provisioning of E-PON).

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