

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R BT.1367-2 (10/2015)

Serial digital fibre transmission system for signals conforming to Recommendations ITU-R BT.656, ITU-R BT.799, ITU-R BT.1120 and ITU-R BT.2077 (Part 3)

BT Series
Broadcasting service
(television)



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Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

Electronic Publication
Geneva, 2015

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RECOMMENDATION ITU-R BT.1367-2

Serial digital fibre transmission system for signals conforming to Recommendations ITU-R BT.656¹, ITU-R BT.799², ITU-R BT.1120³ and ITU-R BT.2077 (Part 3)⁴

(Question ITU-R 42/6)

(1998-2007-2015)

Scope

This Recommendation provides information relating to the use of single and multi-mode fibre optical cable carrying the serial data defined in Recommendations ITU-R BT.656, ITU-R BT.799, ITU-R BT.1120 (270 Mbit/s through 2.97 Gbit/s) and ITU-R BT.2077 (Part 3).

This Recommendation also provides information concerning the connectors that should be used.

Keywords

Optical interface, fibre optics, optical wavelengths

The ITU Radiocommunication Assembly,

considering

- a) that the development of digital production facilities has resulted in the increasing use of serial digital interfaces;
- b) that a worldwide compatible digital approach will permit the development of equipment with many common features, permit operating economies and facilitate the international exchange of programmes;
- c) that to implement the above objectives, agreement has been reached on the digital image format parameters of digital television for studios in the form of Recommendations ITU-R BT.601, ITU-R BT.709, ITU-R BT.2020, ITU-R BT.1847 and ITU-R BT.1543;
- d) that to implement the above objectives, agreement has been reached on the transmission of signals in their electrical serial digital form in the form of Recommendations ITU-R BT.656, ITU-R BT.799, ITU-R BT.1120 and ITU-R BT.2077 (Part 3);
- e) that in the practical implementation of Recommendations ITU-R BT.656, ITU-R BT.799 and ITU-R BT.1120 it is desirable that interfaces be defined also in an optical interface form;
- f) that optical interfaces allow a higher noise immunity for the signals to be transmitted and the transmission of signals over greater distances than with electrical interfaces,

¹ Recommendation ITU-R BT.656 – Interface for digital component video signals in 525-line and 625-line television systems operating at the 4:2:2 level of Recommendation ITU-R BT.601.

² Recommendation ITU-R BT.799 – Interface for digital component video signals in 525-line and 625-line television systems operating at the 4:4:4 level of Recommendation ITU-R BT.601.

³ Recommendation ITU-R BT.1120 – Digital interfaces for HDTV studio signals.

⁴ Recommendation ITU-R BT.2077 – Real-time serial digital interfaces for UHD TV signals.

recommends

that where optical interfaces are required for conformity with Recommendations ITU-R BT.656, ITU-R BT.799, ITU-R BT.1120 and ITU-R BT.2077 (Part 3) they should be in accordance with Annex 1.

Annex 1

1 Introduction

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met.

2 Normative references

The following Standards/Recommendations contain provisions which, through reference in this text, constitute provisions of this Recommendation:

- Recommendation ITU-R BT.656;
- Recommendation ITU-R BT.799;
- Recommendation ITU-R BT.1120;
- Recommendation ITU-R BT.2077 (Part 3);
- IEC 61169-8 (2007-2) – Part 8: Sectional specification – RF coaxial connectors with inner diameter of outer conductor 6.5 mm (0.256 in) with bayonet lock-characteristic impedance 50 Ω (type BNC), Annex A (Normative) Information for interface dimensions of 75 Ω characteristic impedance connector with unspecified reflection factor⁵;
- Recommendation ITU-T G.651 (2007) – Characteristics of a 50/125 μ m multimode graded index optical fibre cable for the optical access network;
- Recommendation ITU-T G.652 (2009) – Characteristics of a single-mode optical fibre and cable;
- IEC 60793-2 (2011) Part 2: Product Specifications – General;
- IEC 60825-1 (2014), ed. 3, Safety of laser products – Part 1: Equipment classification and requirements;
- IEC 61754-20 (2012), Fibre Optic Connector Interfaces – Part 20: Type LC Connector Family.
- IEC 60793-1-1 (2008), Measurement methods and test procedures – General and guidance;
- IEC 60793-1-40 (2001-07), Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation.

⁵ Please note that the title of this normative reference may be misleading. This Recommendation requires the use of the 75-ohm connector defined in this reference.

3 Optical transmission system specifications

(See Appendix G for definition of fibre terms used in this Recommendation or related normative references.)

3.1 Physical packaging and connectors of transmitter and receiver units

3.1.1 The preferred Tx and Rx unit optical domain connectors and their mating input and output cable sections should be LC/PC as per IEC 61754-20.

Other application specific connector types, such as SC, ST, FC, MU, etc. may optionally be specified.

3.1.2 The preferred Tx and Rx unit optical domain connector polish should be PC.

Other application specific connector polishes such as SPC, UPC and APC may optionally be specified, provided the polish is clearly labelled as described in §§ 3.3.1 and 3.5.

The Tx/Rx unit product documentation should include detailed specifications for the required optical connector polish.

NOTE – While angle polish connectors (i.e. APC) and flat polish connectors (i.e. PC, SPC, UPC) of the same type (e.g. LC) can be mechanically mated, they are not optically compatible. System designers and system installers are therefore advised to ensure compatibility of cable, connector type and polish throughout the installation.

3.1.3 A short pigtail of single-mode fibre as specified in Recommendation ITU-T G.652 should be used to connect the Tx unit light source to its output optical connector if the light source is not physically installed and connected in a receptacle.

A short pigtail of multi-mode 50/125 fibre as specified in Recommendation ITU-T G.651 is acceptable if the Tx unit is intended exclusively for multi-mode link applications.

The Tx unit or its product documentation should indicate which type of pigtail, if any, is installed.

3.1.4 A short pigtail of 62.5/125 multi-mode fibre specified in IEC 60793-2-10 should be used to connect the Rx unit optical receiver to its input optical connector if the receiver is not physically installed and connected in a receptacle.

The Rx unit or its product documentation should indicate which type of pigtail, if any, is installed.

3.2 Transmitter unit for low-power (short-haul), medium-power (medium-haul) or high-power (long-haul) links

3.2.1 The transmitter unit should produce an intensity-varying optical output signal in accordance with the relevant low-power (short-haul), medium-power (medium-haul) or high-power (long-haul), link parameters in Table 1, when modulated by an electrical signal defined by Recommendation ITU-R BT.656, or Recommendation ITU-R BT.799, Recommendation ITU-R BT.1120 and Recommendation ITU-R BT.2077 (Part 3).

Refer to informative Appendix D for link budget calculations and information.

TABLE 1

Transmitter unit output signal specifications

	High-power (long-haul) link	Medium-power (medium-haul) link	Low-power (short-haul) link	
Transmission circuit fibre ⁽¹⁾	SM (9.0/125 μm)	SM (9.0/125 μm)	SM (9.0/125 μm)	MM ⁽²⁾ (50.0/125 μm, 62.5/125 μm)
Light source type ^{(3), (4)}	Laser	Laser	Laser	Laser or LED ^{(5), (6)}
Optical wavelength	1 310 nm ± 40 nm	1 310 nm ± 40 nm	1 310 nm ± 40 nm	1 310 nm ± 40 nm
	1 550 nm ± 40 nm	1 550 nm ± 40 nm	1 550 nm ± 40 nm	850 nm ± 30 nm
Maximum spectral line width between half-power points for up to 3 Gbit/s interfaces	≤ 1 nm	≤ 2 nm	≤ 8 nm	≤ 30 nm
Maximum spectral line width between half-power points for 6 and 12 Gbit/s interfaces	≤ 1 nm	≤ 2 nm	≤ 4 nm	≤ 30 nm
Maximum spectral line width between half-power points for 24 Gbit/s interfaces	≤ 1nm			
Maximum optical power for up to 3 Gbit/s interfaces ⁽⁷⁾	+10 dBm	0 dBm	−3 dBm	
Minimum optical power for up to 3 Gbit/s interfaces ⁽⁷⁾	0 dBm	−3 dBm	−12 dBm	
Maximum optical Power for 6 and 12 Gbit/s interfaces	+10 dBm	+0.5 dBm	−3 dBm	
Maximum optical power for 24 Gbit/s interfaces	+10 dBm	+3 dBm	−3 dBm	
Minimum optical power for 6 and 12 Gbit/s interfaces	0 dBm	−3 dBm	−12 dBm	
Minimum optical power for 24 Gbit/s interfaces	0 dBm	−1 dBm	−12 dBm	
Minimum extinction ratio ⁽⁸⁾	5:1 (10:1 preferred)			
Rise and fall times for Recs ITU-R BT.656 and ITU-R BT.799 ⁽⁹⁾	As defined by Recommendations ITU-R BT.656, ITU-R BT.799 for the electrical signal < 1.5 ns (20% to 80%)			
Rise and fall times for Rec. ITU-R BT.1120	As defined by Recommendation ITU-R BT.1120 for the electrical signal 1.5 Gbit/s < 270 ps (20% to 80%), for 3.0 Gbit/s < 135 ps (20%-80%)			

TABLE 1 (*end*)

	High-power (long-haul) link	Medium-power (medium-haul) link	Low-power (short-haul) link
Rise and Fall times for Rec. ITU-R BT.2077 (Part 3)	As defined by Recommendation ITU-R BT.2077 (Part 3) For a 6G interface < 80 ps and should not differ by more than 30 ps (20%-80%) For a 12G interface < 45 ps and should not differ by more than 18 ps (20%-80%) For a 24G interface < 28 ps and should not differ by more than 8 ps (20%-80%)		
Maximum intrinsic jitter (optical)	As specified in Recommendations ITU-R BT.656, ITU-R BT.799, ITU-R BT.1120, ITU-R BT.2077 (Part 3)		
Maximum reflected power	−14 dB		
Electrical/optical transfer function	Logic “1” maximum intensity/Logic “0” minimum intensity		

- (1) Optical fibre specification defined by IEC 60793-2 (2011).
- (2) See Recommendation ITU-T G.651 and IEC 60793-2-(2011) – Part 2: Product Specifications – General.
- (3) Lasers are all class 1 as defined in IEC 60825-1 (2014).
- (4) A laser warning label that is clearly visible during maintenance, operations, and servicing should be present on equipment. Text borders and symbols must be black on a yellow background. The laser warning label should be as illustrated:
- (5) LEDs may not function reliably at higher bit rates specified in Recommendations ITU-R BT.656, ITU-R BT.799, ITU-R BT.1120 and ITU-R BT.2077 (Part 3).
- (6) Tx units intended solely for multi-mode transmission link applications should be so marked.
- (7) Power is average power measured with an average-reading power meter.
- (8) Is the ratio between the maximum and minimum output power of the transmitter.
- (9) Rise/fall times are measured following a fourth-order Bessel-Thompson filter with a 3 dB point at $0.75 \times \text{data rate in MHz}$, i.e. $0.75 \times 270 \text{ Mbit/s} = 203 \text{ MHz}$.

NOTE – Refer to Appendix C for further information.

3.3 Transmitter unit labelling

3.3.1 Transmitter units should be labelled to indicate the application (low-power, medium-power or high-power), the polish of the connector, the payload types they support and the wavelength they use. The labelling should have the format <application>-<polish>-<signal type>-<wavelength>.

The element <application> should have the value:

- H for high-power (long-haul) link applications
- M for medium-power (medium-haul) link applications
- L for low-power (short-haul) link applications.

The element <polish> should have the value:

- PC for Physical Contact (flat polished) Connectors – preferred
- SPC for Super Physical Contact (flat polished) Connectors – optional
- UPC for Ultra Physical Contact (flat polished) Connectors – optional
- APC for Angle Physical Contact (angle polished) Connectors – optional.

For each supported signal type, the element <signal type> should have the value:

- S to indicate support of Recommendation ITU-R BT.656
- P to indicate support of Recommendation ITU-R BT.799
- H to indicate support of Recommendation ITU-R BT.1120
- E to indicate support of Recommendation ITU-R BT.2077 (Part 3) 6G signals
- F to indicate support of Recommendation ITU-R BT.2077 (Part 3) 12G signals
- G to indicate support of Recommendation ITU-R BT.2077 (Part 3) 24G signals.

The element <wavelength> should have the value:

- 850 for 850 nm transmitters
- 1 310 for 1 310 nm transmitters
- 1 550 for 1 550 nm transmitters
- 1 310-1 550 nm transmitters.

NOTE 1 – Equipment designed in compliance with previous revisions of this Recommendation may not conform to this label requirement.

3.4 Receiver unit

The receiver unit should output an electrical signal as per Recommendations ITU-R BT.656, ITU-R BT.799, ITU-R BT.1120 and ITU-R BT.2077 (Part 3) when receiving an optical signal per Table 2.

TABLE 2
Optical receiver input signal specifications

Transmission circuit fibre	Single-mode	Multi-mode ⁽¹⁾
Minimum input overload power ^{(2), (3)}	–7.5 dBm, 0 dBm preferred (270 Mb/s-3 Gbit/s) + 0.5 dBm (6, 12 and 24 Gbit/s)	
Minimum input power	–20 dBm (270 Mb/s-1.5 Gbit/s) –17 dBm (3 Gbit/s) –14 dBm (6 Gbit/s) –14 dBm (12 Gbit/s) –9 dBm (24 Gbit/s)	
Detector damage threshold ⁽³⁾	+1 dBm (minimum)	

⁽¹⁾ Multi-mode fibre is not recommended for high-power (long-haul), or medium-power (medium-haul), link applications for Recommendation ITU-R BT.1120.

⁽²⁾ Within the receiver input range, a BER < 10^{–12} is the recommended minimum value. A BER < 10^{–14} is a desired target.

⁽³⁾ Depending on product implementation, optical attenuators may need to be used to meet specified overload and detector damage performance. See informative Appendices E and F for further information.

3.5 Receiver unit labelling

Receivers should be labelled to indicate the polish of the connector and the payload types they support. The labelling should have the format <polish>-<signal type>-<wavelength range>.

- a) The element <polish> should have the value:
 - PC for Physical Contact (flat polished) Connectors – preferred
 - SPC for Super Physical Contact (flat polished) Connectors – optional
 - UPC for Ultra Physical Contact (flat polished) Connectors – optional
 - APC for Angle Physical Contact (angle polished) Connectors – optional
- b) For each support signal type, the element <signal type> should have the value:
 - S to indicate support of Recommendation ITU-R BT.656
 - P to indicate support of Recommendation ITU-R BT.799
 - H to indicate support of Recommendation ITU-R BT.1120
 - E to indicate support of Recommendation ITU-R BT.2077 (Part 3) 6G signals
 - F to indicate support of Recommendation ITU-R BT.2077 (Part 3) 12G signals
 - G to indicate support of Recommendation ITU-R BT.2077 (Part 3) 24G signals
- c) The element <wavelength range> should have the value:
 - 850 for 850 nm transmitters
 - 1 310 for 1 310 nm transmitters
 - 1 550 for 1 550 nm transmitters
 - 1 310-1 550 nm transmitters

Example: A PC polished receiver that supports Recommendation ITU-R BT.656 signals at a wavelength of 850 nm only is labelled PC-S-850.

3.6 Optical fibre circuit and connector specifications

3.6.1 Optical fibre type options

The user may use single-mode fibre for medium-power/medium-haul applications and either single-mode or multi-mode fibre for low-power/short-haul link applications, to establish a point-to-point optical circuit between the transmitter and receiver optical connectors. A point-to-point circuit may consist of one or multiple serially interconnected sections of the selected type of optical fibre in cables, jumpers, and/or patch cords. Mixing fibre types in the multiple sections of a point-to-point circuit is physically possible, but technically unacceptable and would not be in compliance with this Recommendation.

Single-mode optical fibre should comply with Recommendation ITU-T G.652 (2009; Characteristics of a single-mode Optical Fibre Cable).

Multi-mode optical fibre should comply with IEC 60793-2 (2011) Optical Fibres – Part 2: Product Specifications – General.

NOTE – For multi-mode fibres, the maximum distance may be limited by the signal dispersion, which can be expressed as a bit-rate-length product. For 50/125 fibre, typical bit-rate-length product values are in the range of 500 MHz*km to 2 GHz*km, and for 62.5/125 fibre typical values are in the range of 200 MHz*km to 400 MHz*km respectively. These values may vary with wavelength. As a consequence, the dispersion of specific multi-mode fibres may be optimized for specific wavelengths.

3.7 Optical connector return loss

3.7.1 Optical connectors should have optical return losses as follows, with measurements performed at 23° C ±5° C, in accordance with IEC 60793-1-40 (2001-07) Measurement methods and test procedures – Attenuation.