SMPTE ST 435-3:2012
Revision of
SMPTE 435-3-2009

SMPTE STANDARD

10 Gb/s Serial Signal/Data Interface — Part 3: 10.692[1] Gb/s Optical Fiber Interface

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[1]Nominal bit rate. The interface is also capable of transmitting streams with the data rate of 10.692/1.001 Gb/s.

Approved
April 18, 2012

Foreword

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SMPTE ST435-3 was prepared by Technology Committee 32NF.

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SMPTE draws attention to the fact that it is claimed that compliance with this Standard may involve the use of one or more patents or other intellectual property rights (collectively, "IPR"). The Society takes no position concerning the evidence, validity, or scope of this IPR.

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1 Scope

This Standard defines the optical fiber interface for the serial stream operating at data rates of 10.692 Gb/s and 10.692/1.001 Gb/s. The interface specification defined in this part applies to implementations covering a distance up to 2 km using single-mode fiber.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or text that contains the conformance language keywords: "shall," "should," or "may." Informative text is text that is potentially helpful to the user, but not indispensable, and that can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:".

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and, in addition, indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE RP 184:2004, Specification of Jitter in Bit-Serial Digital Systems

IEC 60793-2 Ed. 5.0:2003, Optical Fibres — Part 2: Product Specifications — General

IEC 61754-20 (2002-08), Fibre Optic Connector Interfaces — Part 20: Type LC Connector Family

Recommendation ITU-T G.694.1, Spectral Grids for WDM Applications: DWDM Frequency Grid

Recommendation ITU-R BT.1729, Common 16 × 9/4 × 3 Aspect Ratio Digital Television Reference Test Pattern

4 Serial Fiber Interface Optical and Electrical Specifications

The interface consists of one transmitter and one receiver in a point-to-point connection.

4.1 The optical transmitter characteristics at nominal wavelengths of 1310nm and 1550nm shall be as defined in Table 1. The optical transmitter characteristics for DWDM (Dense Wavelength Division Multiplexing) at the nominal wavelength of 1550nm shall be as specified in Table 1. The spectral grids for DWDM applications shall be in conformance with 100 GHz and above defined in Recommendation ITU-T G.694.1.

The eye pattern shall be measured with respect to the mask of the eye using a receiver with a fourth-order Bessel-Thomson response with a 3 dB frequency of 0.75 × 10.692 GHz = 8 GHz. See Annex A.

Table 1 – Optical transmitter characteristics

Nominal Wavelength	**1310 nm**	**1550 nm**	**1550 nm DWDM applications**
Optical Wavelength	1260 nm to 1355 nm	1530 nm to 1565 nm	1530 nm to 1565 nm
Wavelength accuracy	NA (Not Applicable)	NA	-100 pm to +100 pm
-20 dB spectral width (max)	1 nm	1 nm	1 nm
Average launch power (max) (Note 1)	+0.5 dBm	+4 dBm	+4 dBm
Average launch power (min) (Note 1)	-5.5 dBm	-4.7 dBm	-1 dBm
Extinction Ratio (min)	6 dB	6 dB	8.2 dB
Maximum reflected power (Note 1)	-12 dB	-21 dB	-21 dB
Output optical eye mask (Note 2)	See Figure 1		
Input electrical eye mask (Note 2)	See Figure 2 and Table 2		
Jitter	See Section 5.1		
Electrical/optical transfer function	Logic ”1” = Higher optical power / Logic “0” = Lower optical power		

Note 1: Power is average power measured with an average-reading power meter.

Note 2: One thousand accumulated waveforms is recommended for transmitter optical output eye mask compliance test.

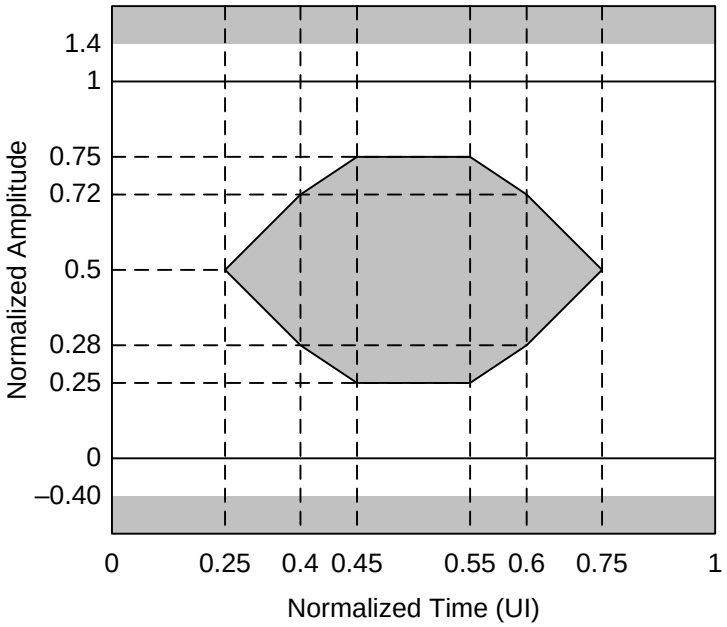

Figure 1 – Transmitter output optical eye mask

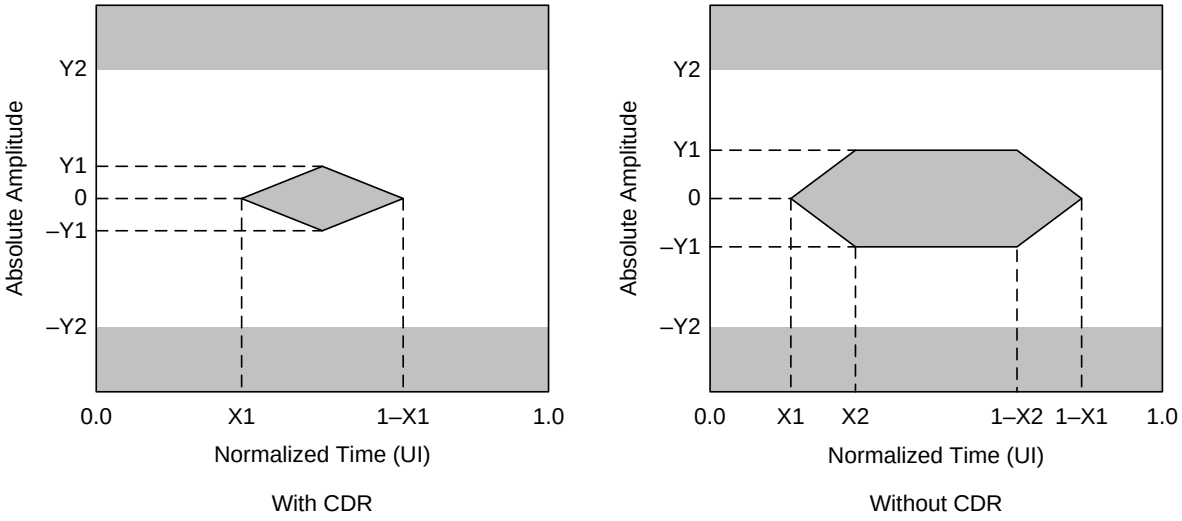

Figure 2 – Transmitter differential input electrical eye mask

Table 2 – Transmitter differential input electrical eye mask specifications

Application		With CDR	Without CDR
Eye Mask	X1	0.305 UI max	0.12 UI max
Eye Mask	X2	NA	0.33 UI max
Eye Mask	Y1	60 mV min	95 mV min
Eye Mask	Y2	410 mV max	350 mV max

4.2 Optical fiber characteristics shall be as defined in Table 3.

The specified connectors for the optical transceiver shall be LC/PC simplex/duplex as defined by IEC 61754-20. The connectors on the other side of adapter cables installed between the optical transceivers and patch panels may optionally be specified as SC, ST, FC, MU etc.

Table 3 – Optical fiber link characteristics

Fiber type	Single mode (as defined by IEC 60793-2)
Connector	LC/PC simplex/duplex (as defined by IEC 61754-20)

Receiver characteristics shall be as defined in Table 4.

The electrical output with and without CDR (Clock Data Recovery) at the connector of a receiver module on a host board shall be as defined in Figure 3, Table 4, Table 5 and Table 6**.**

Within the receiver input range a BER < 10^{-12} shall be achieved with the test signals defined in Recommendation ITU-R BT.1729 or PRBS 2^{31}-1 pattern (when testing system components with BER testers).

A BER < 10^{-14} is recommended.

Note: The PRBS2^{31}-1 pattern generator is defined in IEEE 802.3ae–2002 listed in Annex A.

Table 4 – Optical receiver characteristics

Nominal Wavelength	**1310 nm**	**1550 nm**	**1550 nm DWDM applications**
Average receive power (max) (Note 1)	0.5 dBm	-1 dBm	-1 dBm
Average receive power (min) (BER = 10^{-12}) (Note 1, 2)	-13.5 dBm	-13.5 dBm	-15.5 dBm
Detector damage threshold (min) (Note 3)	+1 dBm	+4 dBm	+4 dBm
Output electrical eye mask (Note 4)	See Figure 3, Table 5 and Table 6		
Jitter	See Section 5.1		
Optical/electrical transfer function	Higher optical power = Logic “1” / Lower optical power = Logic “0”		
Note 1: Power is average power measured with an average-reading power meter. Note 2: Measurement for 5 minutes is recommended for verifying BER = 10^{-12} when using a BER-based test equipment. Note 3: To avoid the receiver damage when connected to the 1550 nm transmitter, the Detector damage threshold of greater than +4 dBm is recommended. Note 4: One thousand accumulated waveforms is recommended for receiver electrical output eye compliance test.			

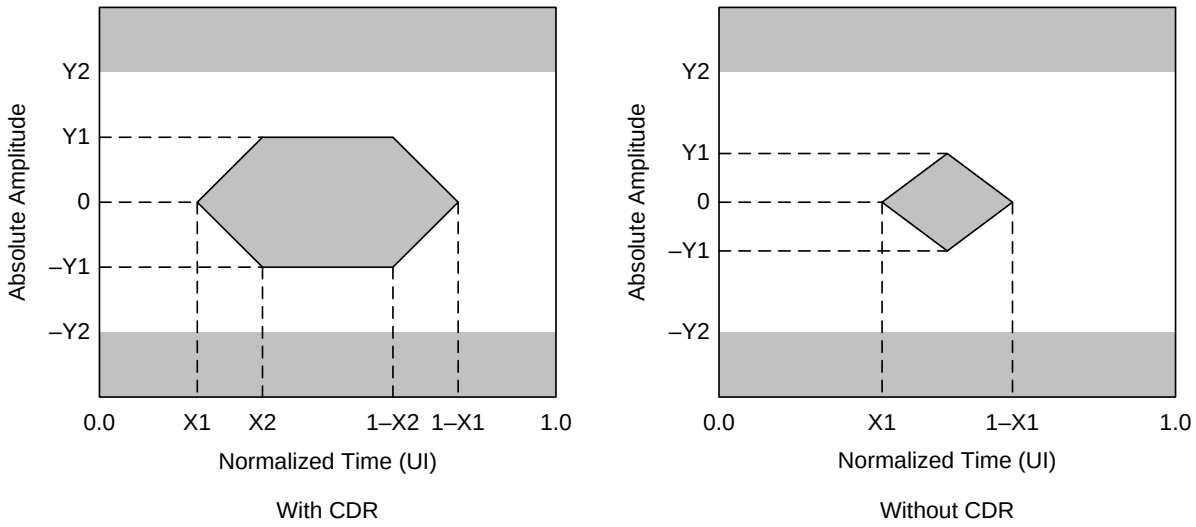

Figure 3 – Receiver differential output electrical eye mask

Table 5 – Optical transceiver input, receiver output electrical specifications

<table>
<tr><th>Application</th><th>With CDR</th><th>Without CDR</th></tr>
<tr><td>Differential Input / Output Impedance (typ)</td><td>100 ohm</td><td>100 ohm</td></tr>
<tr><td>Termination Mismatch (max)</td><td>5%</td><td>5%</td></tr>
<tr><td rowspan="3">Differential Input / Output Return Loss (min)
SDD11 / SDD22</td><td>20 dB (0.05 – 0.1 GHz)</td><td rowspan="2">Note 2 (0.01 – 4.1 GHz)</td></tr>
<tr><td>8 dB (0.1 – 5.5 GHz)</td></tr>
<tr><td>Note 1 (5.5- 12GHz)</td><td rowspan="2">Note 3 (4.1 – 11.1 GHz)</td></tr>
<tr><td rowspan="2">Common Mode Input / Output Return Loss (min)
SCC11 (Note 5) / SCC22</td><td rowspan="2">3 dB (0.1 – 15 GHz)</td><td>Note 4 (0.01 – 2.5 GHz)</td></tr>
<tr><td>3 dB (2.5 – 11.1 GHz)</td></tr>
<tr><td colspan="3">Note 1: Differential return loss is given by the equation SDD11 (dB) and SDD22 (dB) = 8 – 20.66 × $\log_{10}$ (f / 5.5), with f in GHz.
Note 2: Differential return loss is given by the equation SDD11 (dB) and SDD22 (dB) = 12 – 2 × SQRT(f), with f in GHz.
Note 3: Differential return loss is given by the equation SDD11 (dB) and SDD22 (dB) = 6.3 – 13 × $\log_{10}$ (f/5.5), with f in GHz.
Note 4: Common mode output return loss is given by the equation SCC22 (dB) = 7 – 1.6 × f, with f in GHz.
Note 5: Common mode input return loss SCC11 is not specified for the input characteristics of applications without CDR.</td></tr>
</table>

Table 6 – Receiver differential output electrical eye mask specifications

Application		With CDR	Without CDR
Eye Mask	X1	0.17 UI max	0.35 UI max
Eye Mask	X2	0.42 UI max	NA
Eye Mask	Y1	170 mV min	150 mV min
Eye Mask	Y2	425 mV max	425 mV max

5 Serial Fiber Interface Jitter Specifications

5.1 Jitter in the timing of transitions of the data signal shall be measured in accordance with SMPTE RP 184. Measurement parameters are defined in SMPTE RP 184 and shall have the values defined in Table 7. Jitter specification defined in this section shall be applied to the optical receivers equipped with CDR.

Table 7 – Jitter specifications

Parameter	Value	Description
f1	10 Hz	Low-frequency specification limit
f2	20 kHz	Upper band edge for A1
f3	4 MHz	Lower band edge for A2
f4	> 1/10 the clock rate	High-frequency specification limit
A1	10 UI	Timing jitter: Sinusoidal jitter amplitude shall be less than $2 \times 10^5 / f + 0.1$ UI at 20 kHz < f ≤ 4 MHz.
A2	0.15 UI	Alignment jitter: Sinusoidal jitter amplitude shall be less than 0.15 UI at f > 4 MHz.
Error criterion	BER = 10^{-12}	Criterion for onset of errors
Test signal	PRBS 2^{31}-1 or ITU-R Test Signal	Data rate of PRBS 2^{31}-1 shall be 10.692 Gb/s or 10.692/1.001 Gb/s or ITU-R BT 1729 Test signal encoded into each basic stream according to part 2 of this standard. (Notes 1, 2)

Note 1: Any of applicable image system and mapping mode can be used for the measurement.

Note 2: ITU-R Test signal is chosen for on-site jitter measurements.

Note 3: See SMPTE RP 184 for definition of jitter terms.

5.2 Optical transmitter and receiver shall meet the requirements defined in Table 8 and Table 9.

Table 8 – Optical Module Transmitter Requirements

Parameter	Symbol	Conditions	Min	Typ	Max
Jitter Transfer Bandwidth	BW	PRBS 2^{31}-1			8 MHz
Jitter Peaking		Frequency > 50 kHz			1 dB

Table 9 – Optical Module Receiver Requirements

Parameter	Symbol	Conditions	Min	Typ	Max
Jitter Transfer Bandwidth	BW	PRBS 2^{31}-1			8 MHz
Jitter Peaking		Frequency > 50 kHz			1 dB

Annex A Bibliography (Informative)

SMPTE ST 435-1:2012, 10 Gb/s Serial Signal/Data Interface — Part 1: Basic Stream Derivation

SMPTE ST 435-2-2:2012, 10 Gb/s Serial Signal/Data Interface — Part 2: 10.692 Gb/s Stream — Basic Stream Data Mapping

XFP MSA, XFP (10 Gigabit Small Form Factor Pluggable Module) Specification Revision 4.5 : 2005

SFP+ MSA, SFF-8431, Specifications for Enhanced Small Form Factor Pluggable Module SFP+ Revision 4.1 : 2009

IEEE 802.3ae–2002, Amendment: Media Access Control (MAC) Parameters, Physical Layers, and Management Parameters for 10 Gb/s Operation

ITU-T Recommendation G.959.1, Optical Transport Network Physical Layer Interfaces