Transmitter Functional Symbol Error Mask Test Proposal Update

IEEE P802.3 Interim Session

802.3dj Task Force Meeting

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Comments: 227, 228, 233, 315, 448, 450, 510 through 516 inclusive

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Outline

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Introduction

- 802.3dj TF adopted D2.1 with additional test of 200G/lane Ethernet transmit optics
  - Proposal defined FRx as a compliant optical hardware receiver
  - Definition changed during July Plenary, which now requires variable changes
- Test parameters
  - Starting-point in this presentation based on measurements by Roberto Rodes
  - Require confirmation or updating based on further measurements
  - Consensus values will be in a final proposal at a future meeting
- Over-fiber test, mainly for chromatic dispersion penalty (CD) limit compliance
  - Discussion started by the Author Team prior to July Plenary
  - Deferred to after the meeting to limit initial proposal complexity.

DRn BtB Test: 180.9.7 & 182.9.7 Format & Name Changes

- During the July Plenary meeting the definition of Functional Receiver (FRx) was changed, from compliant Optical Receiver (ORx), to VOA followed by ORx
- Equation (180-1) D2.1 specifies VOA output OMA (input to the ORx)
  - This proposal specifies VOA level, i.e. the attenuation terms in (180-1) D2.1
- Tx_TECQ, Tx_TDECQ, Tx_test_margin are repetitive
  - From: *Tx_TECQ* To: *DUT_TECQ*
  - From: *Tx_TDECQ* To: *DUT_TDECQ*
  - From: *Tx_test_margin* To: *Test_margin*
- New variables *VOA_level*, *Tx_DUT_power_budget*, *Test_SMF_power_budget*, and *ORx_TECQ_allocation* added for clarity, with no change in functionality
- Final format and names deferred to the Editors.

DRn BtB Test: 180.9.7 & 182.9.7 Changes (1)

[Tx DUT] → short Test SMF → [FRx = VOA → ORx]

- Tx DUT complies with characteristics in Table 180-7 (or 182-7)
- ORx complies with characteristics in Table 180-8 (or 182-8)
- *FRx_OMA = Tx_DUT_OMA* (description only)
- *ORx_OMA = FRx_OMA - VOA_level* (description only)

  VOA_level = Tx_DUT_power_budget - Test_SMF_power_budget

  - ORx_TECQ_allocation - Test_margin **(180-1)**
- *Tx_DUT_power_budget* added to *RxS_OMA@TECQ=0* gives Tx_DUT_OMA(min) in Table 180-7 (or 182-7)

  Tx_DUT_power_budget = Channel_insertion_loss + MPI+DGD_penalty_allocation

  + max(DUT_TDECQ, DUT_TECQ) **(180-2)**

DRn BtB Test: 180.9.7 & 182.9.7 Changes (2)

- *Test_SMF_power_budget* = 0 **(180-3)**
- *ORx_TECQ_allocation* is the delta between *ORx_RxS* at *DUT_TECQ* (test condition), and *RxS_OMA* extrapolated to *TECQ* = 0 in Table 180-8 (or 182-8) for TECQ >= 0.9dB

  (Using D2.1 terms: *ORx_TECQ_allocation = DUT_TECQ - RxS_TECQ_correction*)

  ORx_TECQ_allocation = ORx_RxS@DUT_TECQ - RxS_OMA@TECQ=0 **(180-4)**
- *Test_margin* increases *ORx_OMA* away from noise limit
- *E*xample showing full equivalence to attenuation terms in equation (180-1) in D2.1

  VOA_level = Channel_insertion_loss

  + MPI+DGD_penalty_allocation

  + max(DUT_TDECQ, DUT_TECQ) - DUT_TECQ + RxS_TECQ_correction

  - Test_margin

Starting-point Test Parameters

- Test_margin = 1.5dB
- Operating BER = 2.40E-5
- Symbol Error Mask

Test symbol errors per test block, *k* (see 174A.8.5)	Probability *Hmax*(*k*)
1	1.15 × 10–1
2	7.47 × 10–3
3	3.24 × 10–4
4	1.05 × 10–5
5	2.73 × 10–7
6	5.88 × 10–9
7	1.08 × 10–10

8	1.75 × 10–12
9	3.50 x 10-13
10	3.50 x 10-13
11	3.50 x 10-13
12	3.50 x 10-13
13	3.50 x 10-13
14	3.50 x 10-13
15	3.50 x 10-13
16	3.50 x 10-13

FR4 & LR4 Over-fiber Test: Mainly for CD Limit Compliance

- Same as BtB test:
  - Descriptions
  - Equations
  - *Test_margin*
  - Operating BER
  - Symbol Error Mask
- Different than BtB test, highlighted in green:
  - Tx DUT connected to FRx by longer Test SMF, or emulator mainly for chromatic dispersion penalty (CD), with channel specifications in Table 181-14 (or 183-16)
  - *Test_SMF_budget,* in equation 180-3, is non-zero.

FR4 & LR4 Over-fiber Test: 181.9.7 & 183.9.7 Changes (1)

[Tx DUT] → longer Test SMF → [FRx = VOA → ORx]

- Tx DUT complies with characteristics in Table 181-5 (or 183-6)
- ORx complies with characteristics in Table 181-6 (or 183-7)
- *FRx_OMA = Tx_DUT_OMA - Test_SMF_loss* (description only)
- *ORx_OMA = FRx_OMA - VOA_level* (description only)

  VOA_level = Tx_DUT_power_budget - Test_SMF_power_budget

  - ORx_TECQ_allocation - Test_margin **(180-1)**
- *Tx_DUT_power_budget* added to *RxS_OMA@TECQ=0* gives Tx_DUT_OMA(min) in Table 181-5 (or 183-6)

  Tx_DUT_power_budget = Channel_insertion_loss + MPI+DGD_penalty_allocation

  + max(DUT_TDECQ, DUT_TECQ) **(180-2)**

FR4 & LR4 Over-fiber Test: 181.9.7 & 183.9.7 Changes (2)

- *Test_SMF _power_budget* = *Test_SMF_loss + Test_SMF_MPI+DGD_penalty*

  + Test_SMF_DUT_CD **(180-3)**

- *ORx_TECQ_allocation* is the delta between *ORx_RxS* at *DUT_TECQ* (test condition), and *RxS_OMA* extrapolated to *TECQ* = 0 in Table 181-6 (or 183-7) for TECQ >= 0.9dB

  ORx_TECQ_allocation = ORx_RxS@DUT_TECQ - RxS_OMA@TECQ=0 **(180-4)**

- *Test_margin* increases *ORx_OMA* away from noise limit

- *E*xample with *ORx_RxS = RxS_OMA(max)* for all *TECQ*

  VOA_level = Channel_insertion_loss - Test_SMF_loss

  + MPI+DGD_penalty_allocation - Test_SMF_MPI+DGD_penalty

  + max(DUT_TDECQ, DUT_TECQ) - DUT_TECQ - Test_SMF_DUT_CD

  - Test_margin

Proposal Text

- Proposal text is in issenhuth_3dj_01_2509, or later revision if any.

Appx 1: FR4-500 (Clause 181) Over-fiber & BtB Test Examples

CL 181		RxS_OMA(max)@TECQ=0 -4.1				Channel_insertion_loss 3.5				MPI+DGD_penalty_allocation 0.6			Tx_OMA(min)@TECQ=0 0.0				
Case		Tx_DUT (per Table 181-5)					Test_SMF (per Table 181-7)						FRx (per 181.9.7)				
No.	Test_SMF actual DUT_CD	TECQ	TDECQ	max(TECQ, TDECQ)	margin	OMA dBm	actual			estimated			ORx_RxS @DUT _TECQ	Test _margin	VOA _level	ORx _OMA dBm	Test _margin _error
							loss	MPI+DGD	DUT_CD	loss	MPI+DGD	DUT_CD					
1	max pos penalty	2.0	3.0	3.0	1.0	4.0	3.5	0.6	1.0	3.5	0.6	1.0	-2.1	1.5	-1.5	2.0	0.0
2		2.0	3.0	3.0	0.0	3.0	3.5	0.6	1.0	3.5	0.6	1.0	-2.1	1.5	-1.5	1.0	0.0
3		2.0	3.0	3.0	1.0	4.0	2.0	0.3	1.0	2.0	0.3	1.0	-2.1	1.5	0.3	1.7	0.0
4	typ. pos	2.0	3.0	3.0	0.0	3.0	2.0	0.3	0.7	2.0	0.3	0.7	-2.1	1.2	0.9	0.1	0.0
5	0 penalty	2.0	3.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	-2.1	1.5	3.6	-0.6	0.0
6		2.0	2.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	-2.1	1.5	2.6	0.4	0.0
7		3.0	2.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.1	1.5	2.6	0.4	0.0
8	min neg penalty	3.0	2.0	3.0	1.0	4.0	2.0	0.3	-1.0	2.0	0.3	-1.0	-1.1	1.5	1.3	0.7	0.0
9		3.0	2.0	3.0	0.0	3.0	3.5	0.6	-1.0	3.5	0.6	-1.0	-1.1	1.5	-0.5	0.0	0.0
10		3.0	2.0	3.0	1.0	4.0	3.5	0.6	-1.0	3.5	0.6	-1.0	-1.1	1.5	-0.5	1.0	0.0

Test_margin_error = (ORx_OMA = Tx_DUT_OMA - Test_SMF_actual_loss - VOA_level) - (ORx_RxS@actual_TECQ + Test_SMF_actual_MPI+DGD+DUT_CD_penalty + Tx_margin + Test_margin)

Appx 1: LR4 (Clause 183) Over-fiber & BtB Test Examples

CL 183		RxS_OMA(max)@TECQ=0 -6.9					Channel_insertion_loss 6.3			MPI+DGD_penalty_allocation 1.1			Tx_OMA(min)@TECQ=0 0.5				
Case		Tx_DUT (per Table 183-5)					Test_SMF (per Table 183-7)						FRx (per 183.9.7)				
No.	Test_SMF actual DUT_CD	TECQ	TDECQ	max(TECQ, TDECQ)	margin	OMA dBm	actual			estimated			ORx_RxS @DUT _TECQ	Test _margin	VOA _level	ORx _OMA dBm	Test _margin _error
							loss	MPI+DGD	DUT_CD	loss	MPI+DGD	DUT_CD					
1	max pos penalty	2.0	3.5	3.5	1.0	5.0	6.3	1.1	1.5	6.3	1.1	1.5	-4.9	1.5	-1.5	0.2	0.0
2		2.0	3.5	3.5	0.0	4.0	6.3	1.1	1.5	6.3	1.1	1.5	-4.9	1.5	-1.5	-0.8	0.0
3		2.0	3.5	3.5	0.0	4.0	5.3	0.5	1.5	5.3	0.5	1.5	-4.9	1.5	0.1	-1.4	0.0
4		2.0	**5.5**	5.5	1.0	7.0	5.3	0.5	1.5	5.3	0.5	**3.5**	-4.9	1.5	0.1	1.6	**2.0**
5		2.0	**3.5**	3.5	1.0	5.0	5.3	0.5	1.5	5.3	0.5	**1.5**	-4.9	1.5	0.1	-0.4	**0.0**
6	typ. pos	2.0	3.5	3.5	1.0	5.0	5.3	0.5	1.0	5.3	0.5	1.0	-4.9	0.5	1.6	-1.9	0.0
7	0 penalty	2.0	3.5	3.5	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	-4.9	1.5	7.4	-3.4	0.0
8		2.0	2.5	2.5	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	-4.9	1.5	6.4	-3.4	0.0
9		**4.0**	2.5	4.0	1.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	**-2.9**	1.5	5.9	-0.4	**2.0**
10		**2.0**	2.5	2.5	1.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	**-4.9**	1.5	6.4	-2.4	**0.0**

Test_margin_error = (ORx_OMA = Tx_DUT_OMA - Test_SMF_actual_loss - VOA_level) - (ORx_RxS@actual_TECQ + Test_SMF_actual_MPI+DGD+DUT_CD_penalty + Tx_margin + Test_margin)

Appx 2: "Simplified" Tx Functional Test Proposal Problems (1)

- Fully accurate page 12 *VOA_level* equation "simplified" by removing red lined terms

  VOA_level = - *Test_margin* + *Channel_insertion_loss* - *Test_SMF_loss*

  + *MPI+DGD_penalty_allocation* ~~- *Test_SMF_MPI+DGD_penalty*~~

  ~~+ *max(DUT_TDECQ, DUT_TECQ) - DUT_TECQ - Test_SMF_DUT_CD*~~

  - Full equation can always be "simplified"
  - A "simplified" equation can never be expanded; full accuracy is lost
- No *Test_SMF_MPI+DGD_penalty* term problem:
  - *Test_SMF_MPI+DGD_penalty* is never zero for longer Test SMF like 2km or 10km, i.e. zero is always a bad estimate
  - 0 < *Test_SMF_MPI+DGD_penalty* < *MPI+DGD_penalty(max)* is always better

Appx 2: “Simplified” Tx Functional Test Proposal Problems (2)

- No (*max(DUT_TDECQ, DUT_TECQ) - DUT_TECQ + Test_SMF_DUT_CD*) term problems:
  - Excess *Tx_DUT_OMA* when (*TDECQ - TECQ)* > *Test_SMF_DUT_CD* is not a beneficial “credit”

    Negates solving high TDECQ field problems which cause excess *Tx_DUT_OMA*; a major reason for the functional test proposal
  - Test over three fiber types, with complex, costlier set-up and 3x the test time replacing automatic computer VOA level adjustment is not a simplification

    It is an equation simplification and a test complication.

Transmitter Functional Symbol Error Mask Test Proposal Update

Thank you