Transmitter Functional Symbol Error Mask Test Proposal Update

IEEE P802.3dj Task Force Joint Electrical, Logic & Optics Ad Hoc

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Supporters

- Not requested for Ad Hoc presentations
- Will be requested for Sept. Interim presentation

Outline

- Introduction
- DRn BtB Test: 180.9.7 & 182.9.7 Changes
- Starting-point Test Parameters
- FR4 & LR4 Over-fiber Test: 181.9.7 & 183.9.7 Changes
- Proposed Text
- Appx 1: Over-fiber Test Examples
- Appx 2: Equation 180-3 Derivation
- Appx 3:

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 name changes.
- Test parameters in D2.1
  - Require updates based on further measurements
  - Starting-point test parameters in this presentation are based on measurements presented by Roberto Rodes.
  - Consensus test parameters will be in a final proposal.
- 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: Name Changes in 180.9.7 & 182.9.7

- During the July Plenary meeting the definition of Functional Receiver (FRx) was changed from compliant Optical Receiver (ORx) to VOA & compliant ORx.
- FRx_OMA name now means input to the VOA, whereas equation 180-1 defines the output of the VOA.
  - From: *FRx_OMA* To: *ORx_OMA*
- 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*
- *VOA_level* and *Test_SMF_correction* added for clarity, with same functionality.
- Final names and format deferred to the Editors.

DRn BtB Test: 180.9.7 & 182.9.7 Changes

- [Tx DUT] → short Test SMF → [FRx = VOA → ORx]
  - *FRx_OMA = Tx_DUT_OMA*
  - *Tx_DUT_OMA* complies with characteristics in Table 180-7 (or 182-7)
    181-1: *ORx_OMA = FRx_OMA - VOA_level*
- where (abbreviated):
    180-2: *VOA_level = Test_SMF_correction + RxS_TECQ_correction - Test_margin*
  - *Test_SMF_correction* for delta from parameter values in Table 180-9 (or 182-9):
    180-3: *Test_SMF_correction = Channel_insertion_loss*
    + MPI+DGD_penalty_allocation
    + max(DUT_TDECQ - DUT_TECQ, 0)
  - *RxS_TECQ_correction* for delta from RxS_OMA(max) in Figure 180-4 (or 182-4):
    180-4: *RxS_TECQ_correction = RxS_OMA(max) - ORx_RxS (both @DUT_TECQ)*
  - *Test_margin* increases *ORx_OMA* away from noise limit.

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 in 180.9.7:
  - Equation 181-1 (or 183-1) (*ORx_OMA*)
  - Equation 181-2 (or 183-2) (*VOA_level*)
  - Equation 181-4 (or 183-4) (*RxS_TECQ_correction*)
  - *Test_margin*
  - Operating BER
  - Symbol Error Mask
- Different than in 180.9.7, highlighted in green:
  - Tx DUT connected to FRx by longer Test SMF, or emulator mainly for chromatic dispersion penalty (CD)
  - Equation 181-3 (or 183-3) (*Test_SMF_correction*), on next page

FR4 & LR4 Over-fiber Test: 181.9.7 & 183.9.7 Changes

- [Tx DUT] → longer Test SMF → [FRx = VOA → ORx]
  - *FRx_OMA = Tx_DUT_OMA - Test_SMF_loss*
  - *Tx_DUT_OMA* complies with characteristics in Table 181-5 (or 183-6)

    181-1: *ORx_OMA = FRx_OMA - VOA_level*
- where (abbreviated):

  181-2: *VOA_level = Test_SMF_correction + RxS_TECQ_correction - Test_margin*
  - *Test_SMF_correction* for delta from parameter values in Table 181-7 (or 183-8):

    181-3: *Test_SMF_correction = Channel_insertion_loss - Test_SMF_loss*
    + MPI+DGD_penalty_allocation - Test_SMF_MPI+DGD_penalty
    + max(DUT_TDECQ - DUT_TECQ, 0) - Test_SMF_DUT_CD
  - *RxS_TECQ_correction* for delta from RxS_OMA(max) in Figure 181-4 (or 183-4):

    181-4: *RxS_TECQ_correction = RxS_OMA(max) - ORx_ RxS (both @DUT_TECQ)*
  - *Test_margin* increases *ORx_OMA* away from noise limit.

Proposal Text

- Proposal text in Draft Standard format will be added in this section, working with Optics Track Chair and Editor
- Similar to proposed text addition in cole_3dj_01e_2507.pdf made during the July Plenary, except done prior to the Sept. Interim.

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

RxS_OMA@TECQ=0	-4.1	RxS_TECQ_correction	0.0	Channel_insertion_loss	3.5	MPI+DGD_penalty_allocation	0.6	Tx_OMA@TECQ=0	0.0

Case		Tx_DUT						Test_SMF						FRx			
								actual			estimated						
No.	Test_SMF actual DUT_CD	TECQ	TDECQ	max(TECQ, TDECQ)	max(TDECQ - TECQ, 0)	margin	OMA dBm	loss	MPI+DGD	DUT_CD	loss	MPI+DGD	DUT_CD	Test _margin	VOA _level	ORx _OMA dBm	Test _margin _error
1	max pos penalty	2.0	3.0	3.0	1.0	1.0	4.0	3.5	0.6	1.0	3.5	0.6	1.0	1.5	-1.5	2.0	0.0
2		2.0	3.0	3.0	1.0	0.0	3.0	3.5	0.6	1.0	3.5	0.6	1.0	1.5	-1.5	1.0	0.0
3		2.0	3.0	3.0	1.0	1.0	4.0	2.0	0.3	1.0	2.0	0.3	1.0	1.5	0.3	1.7	0.0
4	typ. pos	2.0	3.0	3.0	1.0	0.0	3.0	2.0	0.3	0.7	2.0	0.3	0.7	1.2	0.9	0.1	0.0
5	0 penalty eq.181-3 = 180-3	2.0	3.0	3.0	1.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	3.6	-0.6	0.0
6		2.0	2.0	2.0	0.0	1.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	2.6	0.4	0.0
7		3.0	2.0	3.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	2.6	0.4	0.0
8	min neg penalty	3.0	2.0	3.0	0.0	1.0	4.0	2.0	0.3	-1.0	2.0	0.3	-1.0	1.5	1.3	0.7	0.0
9		3.0	2.0	3.0	0.0	0.0	3.0	3.5	0.6	-1.0	3.5	0.6	-1.0	1.5	-0.5	0.0	0.0
10		3.0	2.0	3.0	0.0	1.0	4.0	3.5	0.6	-1.0	3.5	0.6	-1.0	1.5	-0.5	1.0	0.0

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

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

RxS_OMA@TECQ=0	-6.9	RxS_TECQ_correction	0.0	Channel_insertion_loss	6.3	MPI+DGD_penalty_allocation	1.1	Tx_OMA@TECQ=0	0.5

Case		Tx_DUT						Test_SMF						FRx			
								actual			estimated						
No.	Test_SMF actual DUT_CD	TECQ	TDECQ	max(TECQ, TDECQ)	max(TDECQ - TECQ, 0)	margin	OMA dBm	loss	MPI+DGD	DUT_CD	loss	MPI+DGD	DUT_CD	Test _margin	VOA _level	ORx _OMA dBm	Test _margin _error
1	max pos penalty	2.0	3.5	3.5	1.5	1.0	5.0	6.3	1.1	1.5	6.3	1.1	1.5	1.5	-1.5	0.2	0.0
2		2.0	3.5	3.5	1.5	0.0	4.0	6.3	1.1	1.5	6.3	1.1	1.5	1.5	-1.5	-0.8	0.0
3		2.0	3.5	3.5	1.5	1.0	5.0	5.3	0.5	1.5	5.3	0.5	1.5	1.5	0.1	-0.4	0.0
4		2.0	**5.5**	5.5	3.5	1.0	7.0	5.3	0.5	1.5	5.3	0.5	3.5	1.5	0.1	1.6	**2.0**
5		2.0	**5.5**	5.5	**1.5**	1.0	**5.0**	5.3	0.5	1.5	5.3	0.5	1.5	1.5	0.1	-0.4	**0.0**
6	typ. pos	2.0	3.5	3.5	1.5	1.0	5.0	5.3	0.5	1.0	5.3	0.5	1.0	1.0	1.1	-1.4	0.0
7	0 penalty eq.181-3 = 180-3	2.0	3.5	3.5	1.5	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	7.4	-3.4	0.0
8		2.0	2.5	2.5	0.5	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	6.4	-3.4	0.0
9		**4.0**	2.5	4.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	1.5	5.9	-1.4	**2.0**
10		**4.0**	2.5	4.0	**0.5**	0.0	**3.0**	0.0	0.0	0.0	0.0	0.0	0.0	1.5	6.4	-3.4	**0.0**

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

Appx 2: Eq. 180-3 Derivation of *max(DUT_TDECQ - DUT_TECQ, 0)*

- Tx_OMA:
  - *Tx_DUT_OMA = Tx_OMA@TECQ=0 + max(DUT_TECQ, DUT_TDECQ) + Tx_margin*
- ORx_OMA:

  180-1: *ORx_OMA = FRx_OMA - VOA_level*

  180-2: *VOA_level = Test_SMF_correction + RxS_TECQ_correction - Test_margin*

  180-3: *Test_SMF_correction = Channel_insertion_loss + MPI+DGD_allocation + X*
- ORx_OMA_target:
  - *ORx_OMA_target = actual_ORx_RxS + actual_MPI+DGD+DUT_CD_penalty + Tx_margin + Test_margin*
- ORx_OMA = ORx_OMA_target:
  - *Tx_OMA@TECQ=0 + max(DUT_TECQ, DUT_TDECQ) + Tx_margin - (Channel_insertion_loss + MPI+DGD_allocation + X + RxS_TECQ_correction - Test_margin)*

    =

    actual_ORx_RxS + actual_MPI+DGD+DUT_CD_penalty + Tx_margin + Test_margin
  - *max(DUT_TECQ, DUT_TDECQ) - X = DUT_TECQ*
  - *X = max(DUT_TDECQ - DUT_TECQ, 0)*

Appx 3: Problems with Simplified Tx Functional Test Proposal

- Fully accurate *Test_SMF_correction* equation with proposed simplification red lines

  181-3: *Test_SMF_correction = Channel_insertion_loss - Test_SMF_loss*
  + MPI+DGD_penalty_allocation ~~- Test_SMF_MPI+DGD_penalty~~
  ~~+ max(DUT_TDECQ - DUT_TECQ, 0) - Test_SMF_DUT_CD~~

- Simplification Problem 1: *Test_SMF_MPI+DGD_penalty = 0*
  - MPI+DGD penalty is never zero, especially for longer Test SMF like 10km.
  - Even if MPI+DGD penalty is not measurable, zero is a bad estimate.
  - Estimate between zero and maximum MPI+DGD penalty is always better
- Simplification Problem 2: *Test_SMF_DUT_CD = max(DUT_TDECQ - DUT_TECQ, 0)*
  - If TDECQ > TECQ, *Test_SMF_DUT_CD* must be TDECQ-TECQ which is often wrong
    - even no-fiber, BtB tests are not supported
  - If TECQ > TDECQ, estimated *Test_SMF_DUT_CD* correction is missing from 181-3
    - negative dispersion penalty are therefore not supported.

Transmitter Functional Symbol Error Mask Test Proposal Update

Thank you