IEEE 802.3bj: 100GBASE-CR4 Test Points and Parameters

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Supporters

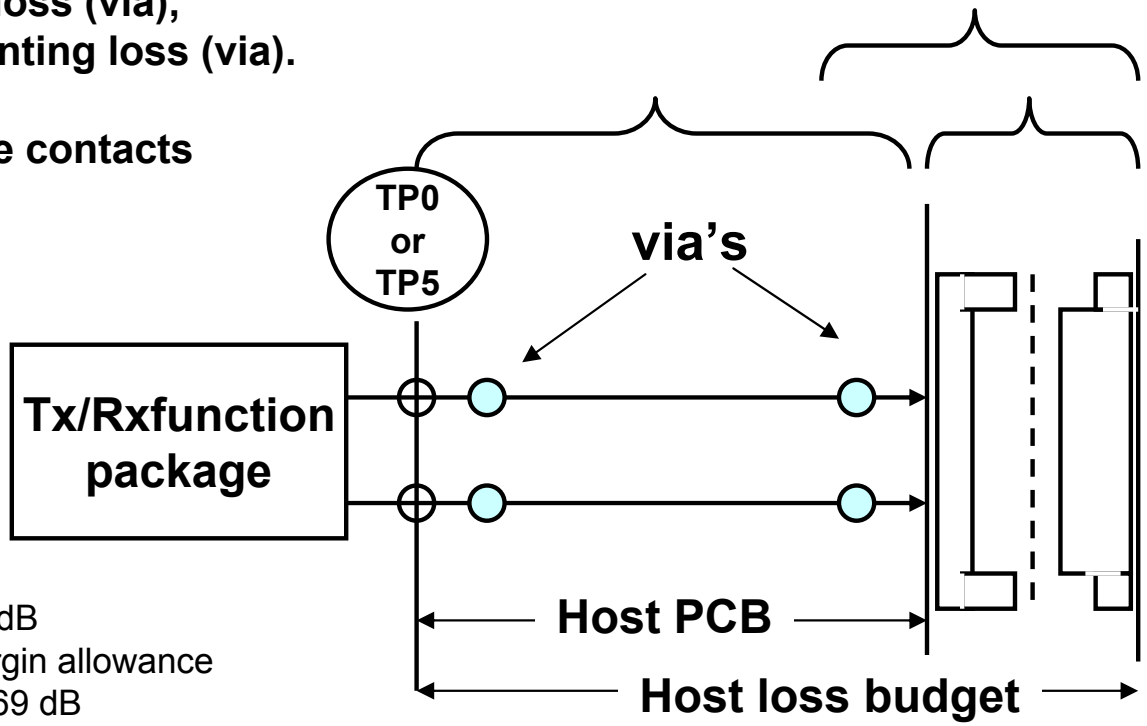
- Mark Bugg, Tom Palkert, Patrick Casher Molex
- Beth Kochuparambil, Joel Goergen – Cisco
- Olindo Savi - Hitachi Cable Manchester, Inc.
- Adee Ran, Rich Melitz - Intel
- Rick Rabinovich - Alcatel-Lucent
- Bernd Jansen, Cattalen Pelard - LEONI Cables & Systems
- Paul Vanderlaan - Nexans
- Marc Dupuis, Megha Shanbhag, Nathan Tracy – TE Connectivity
- Sterling Vaden - Optical Cable Corporation (OCC)
- Mark Gustlin, Xilinx
- Vivek Telang, Ali Ghiasi - Broadcom
- Bob Wagner - Panduit Corporation
- Atul Sharma - Volex
- Valerie Maguire - Siemon Company

Purpose

- Specifications for the 100GBASE-CR4.
- Host loss Budget.
- 100GBASE-CR4 channel loss budget
  - 5 m and 3.5 m meter cable assembly
  - 4” host trace
- Cable Assembly Characteristics
  - IL, RL, ICN
- 100GBASE-CR4 channel IL
- Test fixture
  - loss budget
  - ICN

Host loss budget IL proposal

Host loss budget includes
- **Chip/ball mounting loss (via),**
- **MDI receptacle mounting loss (via).**
- **MDI receptacle**
- **Plug connector edge contacts**



Note: recommend 0.62 dB
host connector loss margin allowance
1.07 dB + 0.62 dB = 1.69 dB

Reference	Host PCB	Mated Connector	Host loss budget - 12.89 GHz	Host loss budget – 14 GHz
CEI-28G-VSR Nov11	7.3 dB 14 GHz (PCB+2 via's) (2 via's[0.5 dB] + host trace[6.8 dB]) (4" N4000-13 or slightly worse material (up to 1.7dB/in) at 14GHz	1.2 dB @ 14 GHz	8.5 dB	8.50 dB
Diminico_01_0312.pdf	6.36 dB @ 12.89 GHz (1.59 dB/in) 6.8 dB @ 14.00 GHz (1.7 dB/in) (2 via's[0.45 dB] @ 12.89 GHz (2 via's[0.50 dB] @ 14.00 GHz	1.07 dB @ 12.89 GHz 1.20 dB @ 14.00 GHz 0.62 dB @ 12.89 GHz*	8.5 dB	8.50 dB

PCB losses

Attenuation* (dB/in) at:	1 GHz	6.5 GHz	7 GHz	12.89 GHz	14 GHz
Meg6_LowSR – Wide	0.0951	0.4159	0.4433	0.7562	0.8127
Meg6_LowSR – Narrow	0.1466	0.5849	0.6205	1.0152	1.0847
Meg6_HighSR – Wide	0.1175	0.5960	0.6367	1.0891	1.1688
Meg6_HighSR – Narrow	0.1856	0.8971	0.9557	1.5924	1.7020
ImpFR4_LowSR – Wide	0.1202	0.6096	0.6541	1.1772	1.2734
ImpFR4_LowSR – Narrow	0.1717	0.7794	0.8323	1.4410	1.5512
ImpFR4_HighSR – Wide	0.1427	0.7904	0.8484	1.5158	1.6367
ImpFR4_HighSR – Narrow	0.2106	1.0930	1.1692	2.0283	2.1813

PROPOSED PARAMETERS; GRAPHS ON PREVIOUS SLIDE

*using Algebraic Model v2.02a – see backup slides for values entered in Model

Proposal for Defining Material Loss 26-Jan 12	Elizabeth Kochuparambil Joel Goergen	Cisco

http://www.ieee802.org/3/bj/public/jan12/kochuparambil_01a_0112.pdf

100GBASE-CR4 channel insertion loss

1. Channel insertion loss budget of 35 dB is proposed (slide 6) on the basis that;

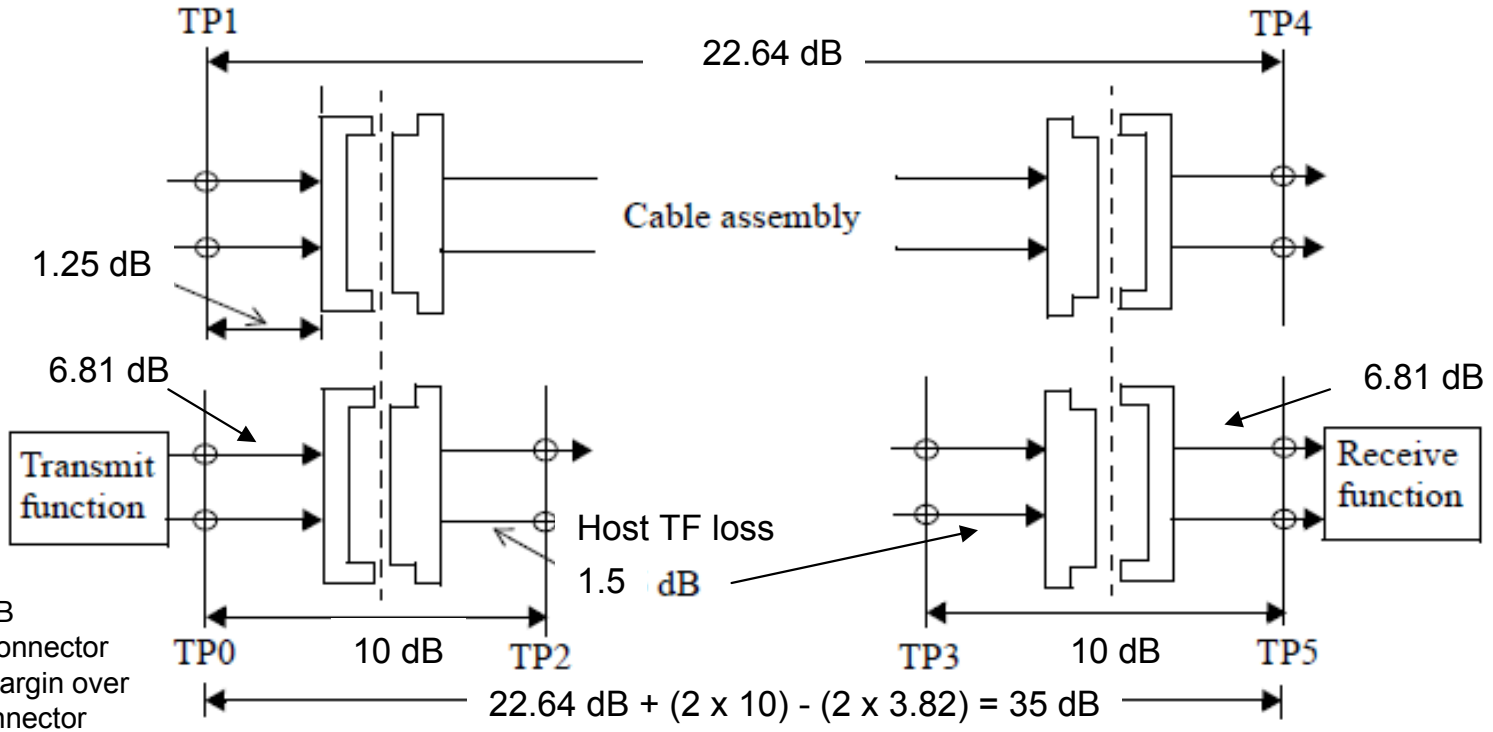
   - FEC is specified to meet the 5 m cable assembly reach objective (mandatory).

   - The option to turn off FEC to achieve lower power/latency mode of operation for ~~3.5 m is specified.

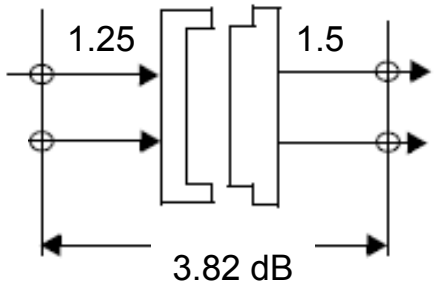
2. Given bullet 1 is accepted the channel insertion loss budget of 30 dB is proposed (slide 7).

Channel insertion loss – 35 dB – 5 m cable assembly

Illustration of channel insertion loss budget at 12.89 GHz



10-(6.81+1.5) = 1.69 dB
1.69-1.07 = 0.62 host connector loss margin over TF connector



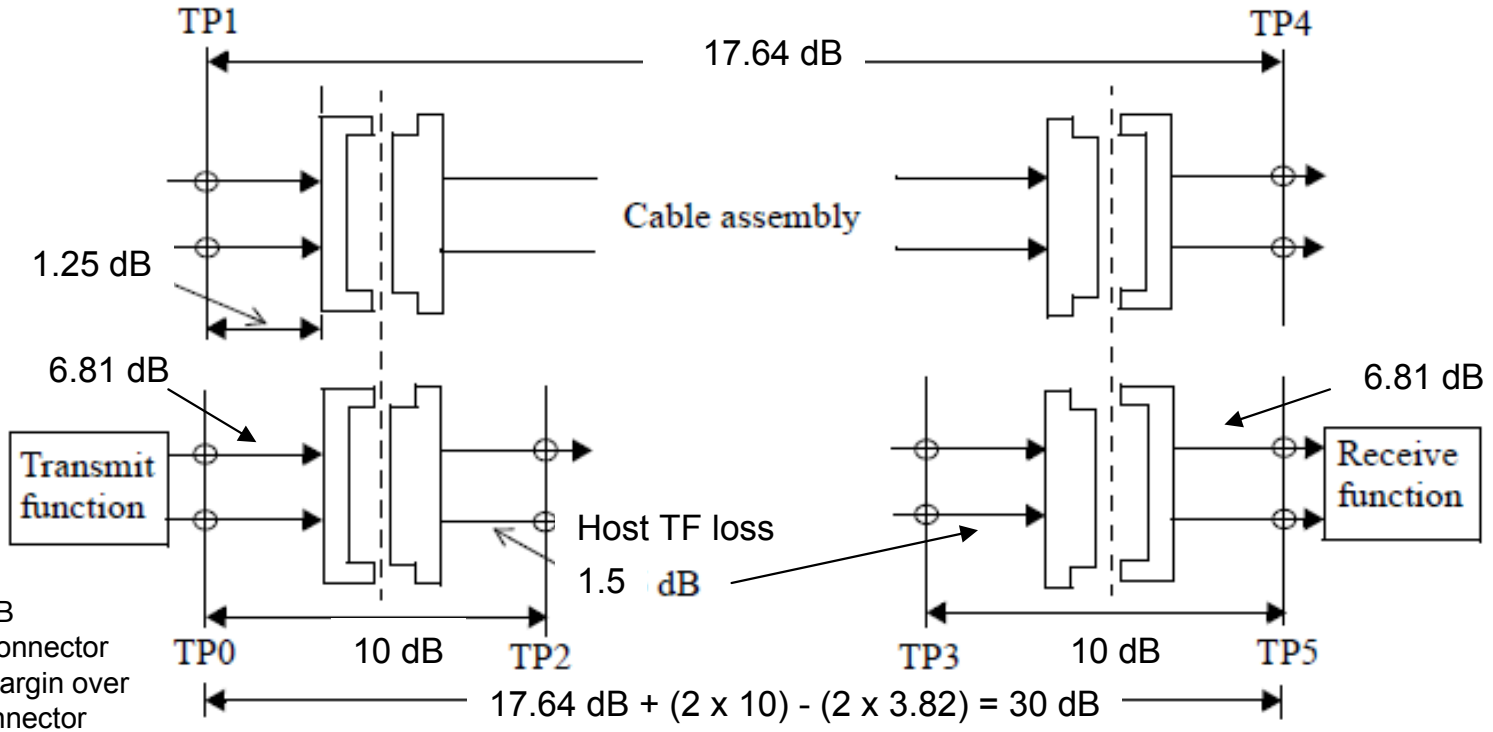
Mated cable assembly and test point test fixture

3.82-(1.25+1.5) = 1.07 dB
1.07 assumed connector loss

Cable	3.4 dB/m	17 dB
Paddle card	0.5 dB	1 dB
Connector	1.07 dB	2.14 dB
CA-TF loss	1.25 dB	2.5 dB
Cable assembly		22.64 dB

Channel insertion loss – 30 dB – ~3.5 m cable assembly

Illustration of channel insertion loss budget at 12.89 GHz



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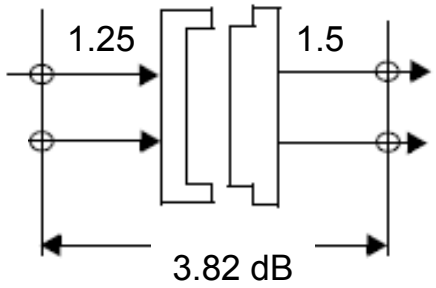


Mated cable assembly and test point test fixture

3.82-(1.25+1.5) = 1.07 dB
1.07 assumed connector loss

Cable	3.4 dB/m	12 dB
Paddle card	0.5 dB	1 dB
Connector	1.07 dB	2.14 dB
CA-TF loss	1.25 dB	2.5 dB
Cable assembly		17.64 dB

Channel Loss Budget – 35 dB – 5 m cable assembly

Host Loss			Cable Assembly IL		
1.59 db/in	6.36		cable	3.4 dB/m	17
2 via's 0.45 dB	0.45		paddle card	0.5 per plug	1
connector	1.07		connector	1.07 per side	2.14
TF loss	1.5		TF	1.25 per side	2.5
Host connector allowance	0.62		Total Cable Assembly Loss		22.64
Total Host Loss	10				
			Channel Loss	(22.64)+(2*10)-(2*3.82)	
Test fixture loss (TF)			35		
Host-TF	1.5				
Cable assembly-TF	1.25				
Connector	1.07				
Total TF Loss	3.82				

Channel Loss Budget – 30 dB – ~3.5 m cable assembly

Host Loss			Cable Assembly IL		
1.59 db/in	6.36		cable	3.4 dB/m	12
2 via's 0.45 dB	0.45		paddle card	0.5 per plug	1
connector	1.07		connector	1.07 per side	2.14
TF loss	1.5		TF	1.25 per side	2.5
Host connector allowance	0.62		Total Cable Assembly Loss		17.64
Total Host Loss	10				
			Channel Loss	(17.64)+(2*10)-(2*3.82)	
Test Fixture loss (TF)			30		
Host-TF	1.5				
Cable assembly-TF	1.25				
connector	1.07				
Total TF Loss	3.82				

802.3bj cable assembly characteristics and test points

- **Adopt Table 85-9 and 85.10.1 cable characteristic parameter set as baseline for 802.3bj cable characteristic parameter set.**

- **Extend frequency and adjust limits as necessary to meet objectives.**

TP1 to TP4	All cable assembly measurements are to be made between TP1 and TP4 as illustrated in Figure 85–2. The cable assembly test fixture of Figure 85–13 or its functional equivalent, is required for measuring the cable assembly specifications in 85.10 at TP1 and TP4.

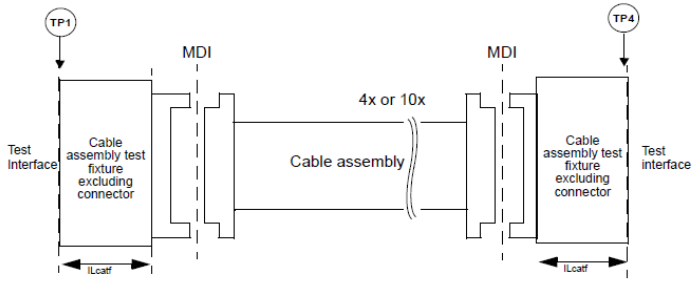


Figure 85–13—Cable assembly test fixtures

Table 85–9—Cable assembly differential characterist

Description	Reference	Value	Unit
Maximum insertion loss at 5.15625 GHz	85.10.2	17.04	dB
Minimum insertion loss at 5.15625 GHz		3	dB
Insertion loss deviation at 5.15625 GHz	85.10.3	max = 1.73 min = –1.73	dB
Minimum return loss at 5.15625 GHz	85.10.4	6.66	dB
MDNEXT loss	85.10.5	Equation (85–26)	dB
MDFEXT loss	85.10.6	Equation (85–27)	dB
Maximum integrated crosstalk noise	85.10.7	Equation (85–33)	mV

85.10.1 Characteristic impedance and reference impedance

The nominal differential characteristic impedance of the cable assembly is 100 Ω. The differential reference impedance for cable assembly specifications shall be 100 Ω.

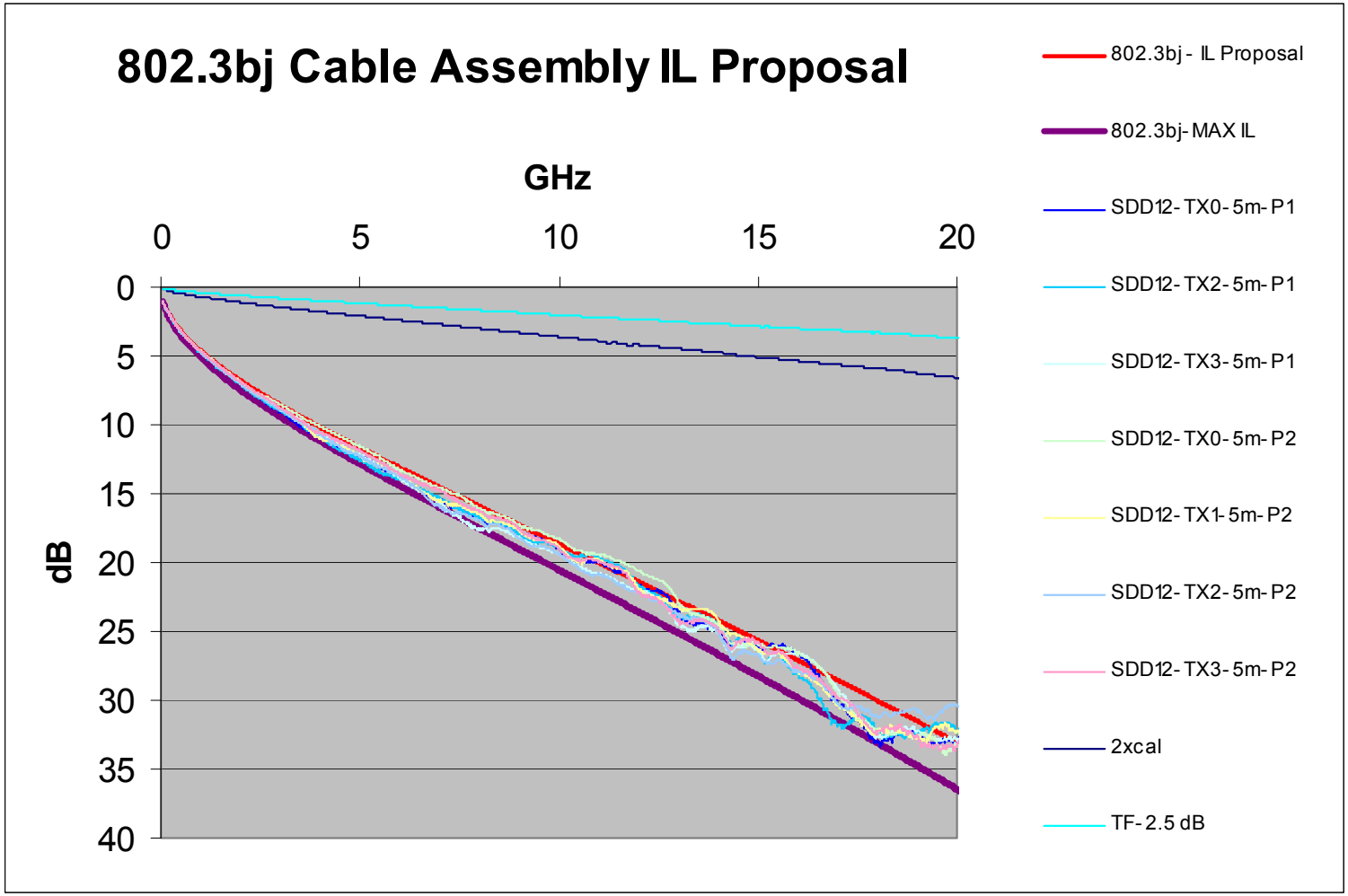
Cable assembly characteristics

- Table XX–X—Cable assembly differential characteristics summary

Description	Reference	Value	Unit	Frequency Range of specification (GHz)
Maximum insertion loss at 12.8906 GHz	85.10.2	22.64 dB (slide 13) Revise Table 85–10	dB	0.05 ≤ f ≤ 18.75
Minimum insertion loss at 12.8906 GHz		4 dB	dB	0.05 ≤ f ≤ 18.75
Insertion loss deviation at 12.8906 GHz	85.10.3	Min= -2.97 dB (slide 15) Max= +2.97 dB (slide 15)	dB	0.05 ≤ f ≤ 18.75 0.05 ≤ f ≤ 18.75
Minimum return loss at 12.8906 GHz	85.10.4	6 dB (slide 14)	dB	0.05 ≤ f ≤ 25
MDNEXT loss	85.10.5	(slide 16)	dB	0.05 ≤ f ≤ 20
MDFEXT loss	85.10.6	(slide 16)	dB	0.05 ≤ f ≤ 20
Maximum integrated crosstalk noise	85.10.7	(slide 17)	mV	Equation reference 85.10.7

Note: 85.10.7 Cable assembly integrated crosstalk noise (ICN) ++++3 dB reference receiver bandwidth, which is set to 7.5 GHz.

Cable Assembly IL – 5 m – 24 AWG

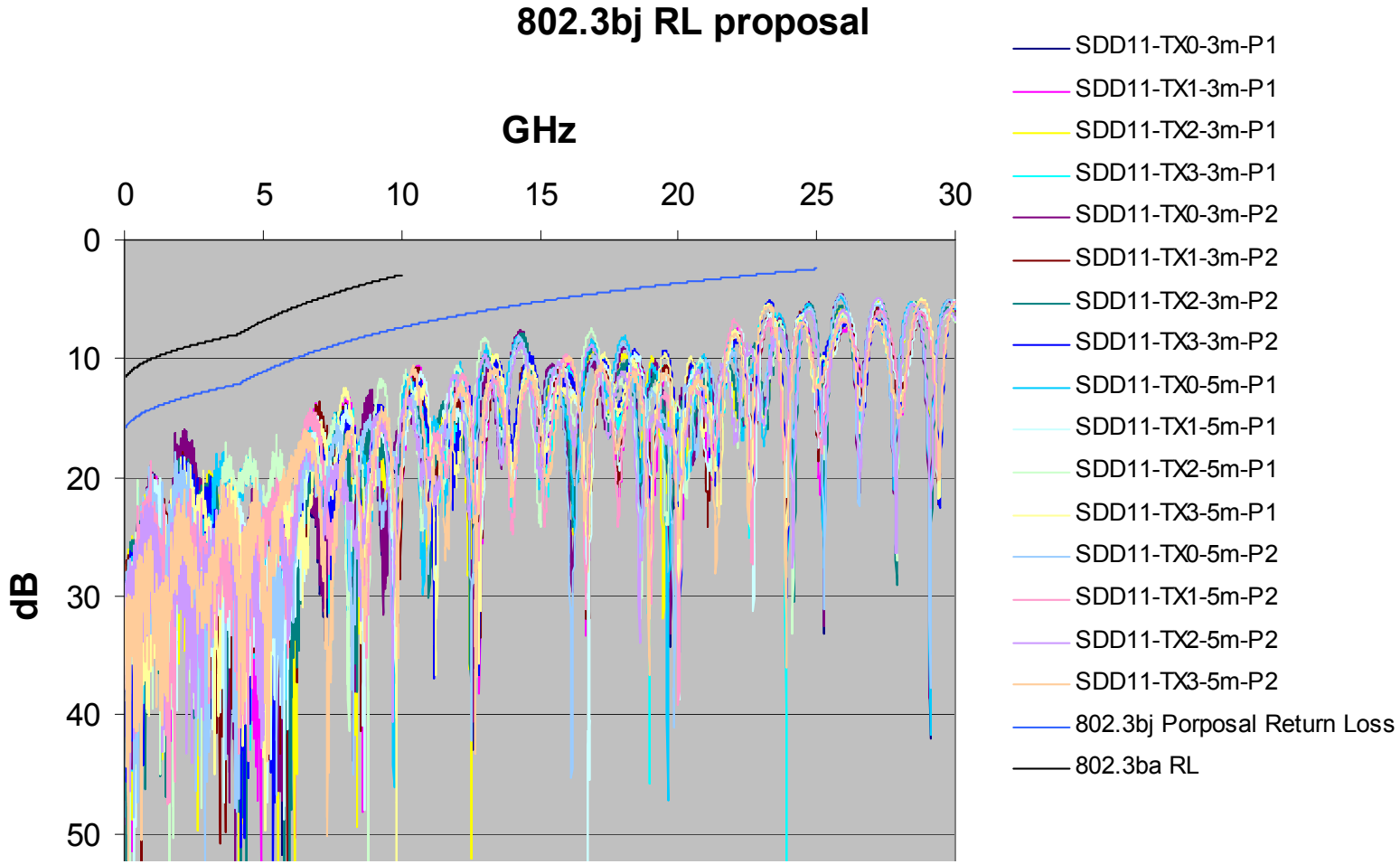


802.3bj IL Proposal = 4.28*SQRT(f)+0.325*f+0.0185*f^2 = 22.64 @ 12.89 GHz

http://www.ieee802.org/3/100GCU/public/channel.html

Mark Bugg- Molex Full ZQSFP Cable Assembly, including Test Fixture(10-Feb 11)
5m: All (40M),
P1_RX0, P1_RX1, P1_RX2, P1_RX3,
P2_RX0, P2_RX1, P2_RX2, P2_RX3
Calibration file (23-Feb 2-11 633k)
Reference (6-Jan-11 1.2M)

Cable Assembly RL Proposal

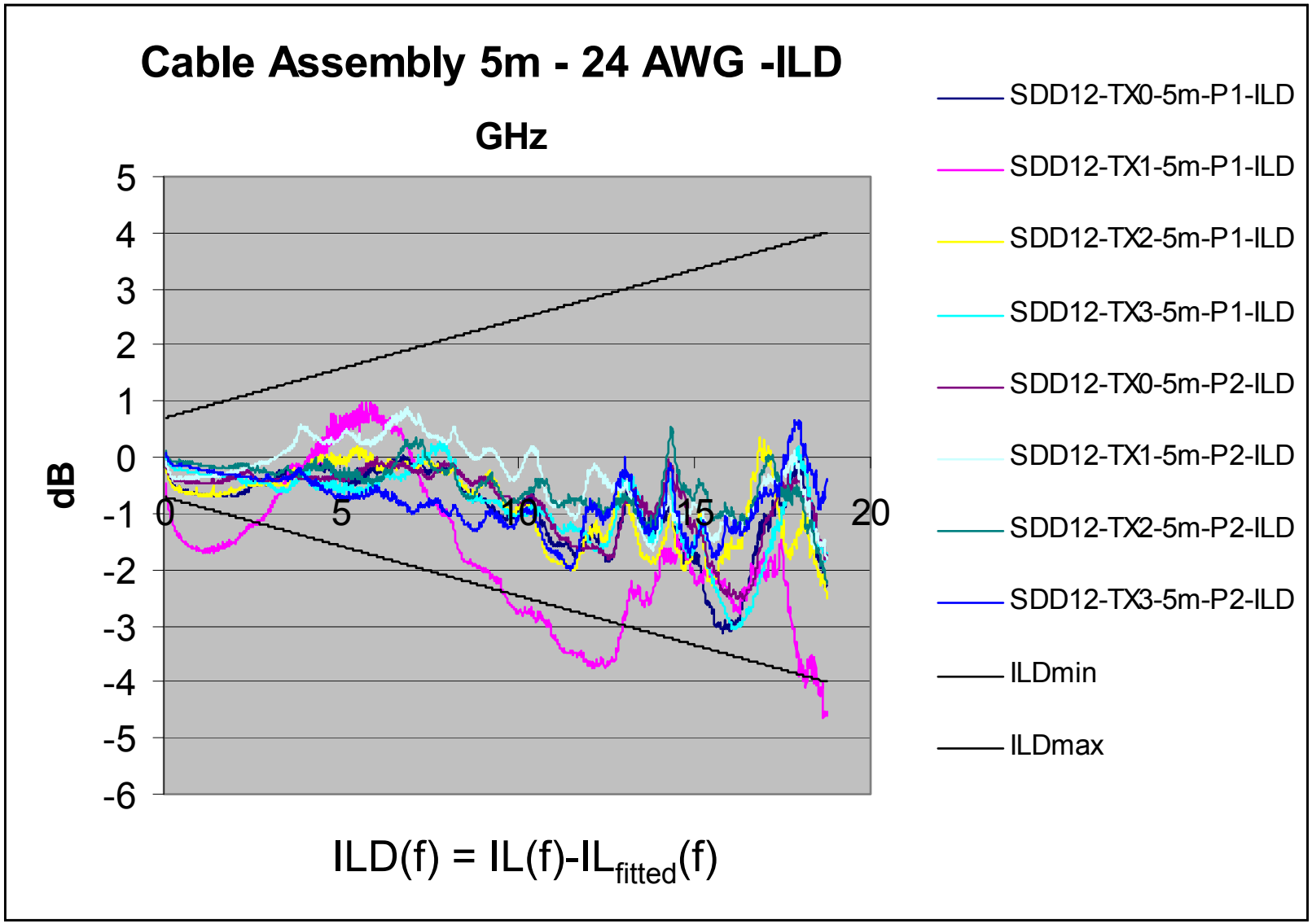


$$\text{Return\_loss}(f) \geq \begin{cases} 16.20 - 2\cdot\sqrt{f} \text{ dB} & 0.05 \leq f < 4.1 \\ 10.59 - 13\cdot\log_{10}(f/5.5) \text{ dB} & 4.10 \leq f \leq 25 \end{cases}$$

http://www.ieee802.org/3/100GCU/public/channel.html

Mark Bugg- Molex Full ZQSFP Cable Assembly, including Test Fixtures (10-Feb 11)
5m and 3m cable assembly measurments

Cable Assembly ILD Proposal



$ILD(f) \geq ILD(f)_{min} = -0.7 - 0.176*f$ dB $0.05 \leq f(GHz) \leq 18.75$

$ILD(f) \geq ILD(f)_{max} = 0.7 + 0.176*f$ dB $0.05 \leq f(GHz) \leq 18.75$

Cable Assembly MDNEXT – MDFEXT

$$MDNEXT\_loss(f) = -10\log_{10}\left(\sum_{i=0}^{i=3} 10^{-NLi(f)/10}\right) \text{(dB)}$$

where

MDNEXT_loss(f) is the MDNEXT loss at frequency *f*
$NL_i(f)$ is the NEXT loss at frequency *f* of pair combination *i*, in dB
f is the frequency in MHz
i is the 0 to 3 (pair-to-pair combination)

$$MDFEXT\_loss(f) = -10\log_{10}\left(\sum_{i=0}^{i=2} 10^{-NLi(f)/10}\right) \text{(dB)}$$

where

MDFEXT_loss(f) is the MDFEXT loss at frequency *f*
$NL_i(f)$ is the FEXT loss at frequency *f* of pair combination *i*, in dB
f is the frequency in MHz
i is the 0 to 2 (pair-to-pair combination)

For 50 ≤ f(MHz) ≤ 20000

Cable Assembly Integrated crosstalk parameters

Table 85–11—Cable assembly integrated crosstalk parameters

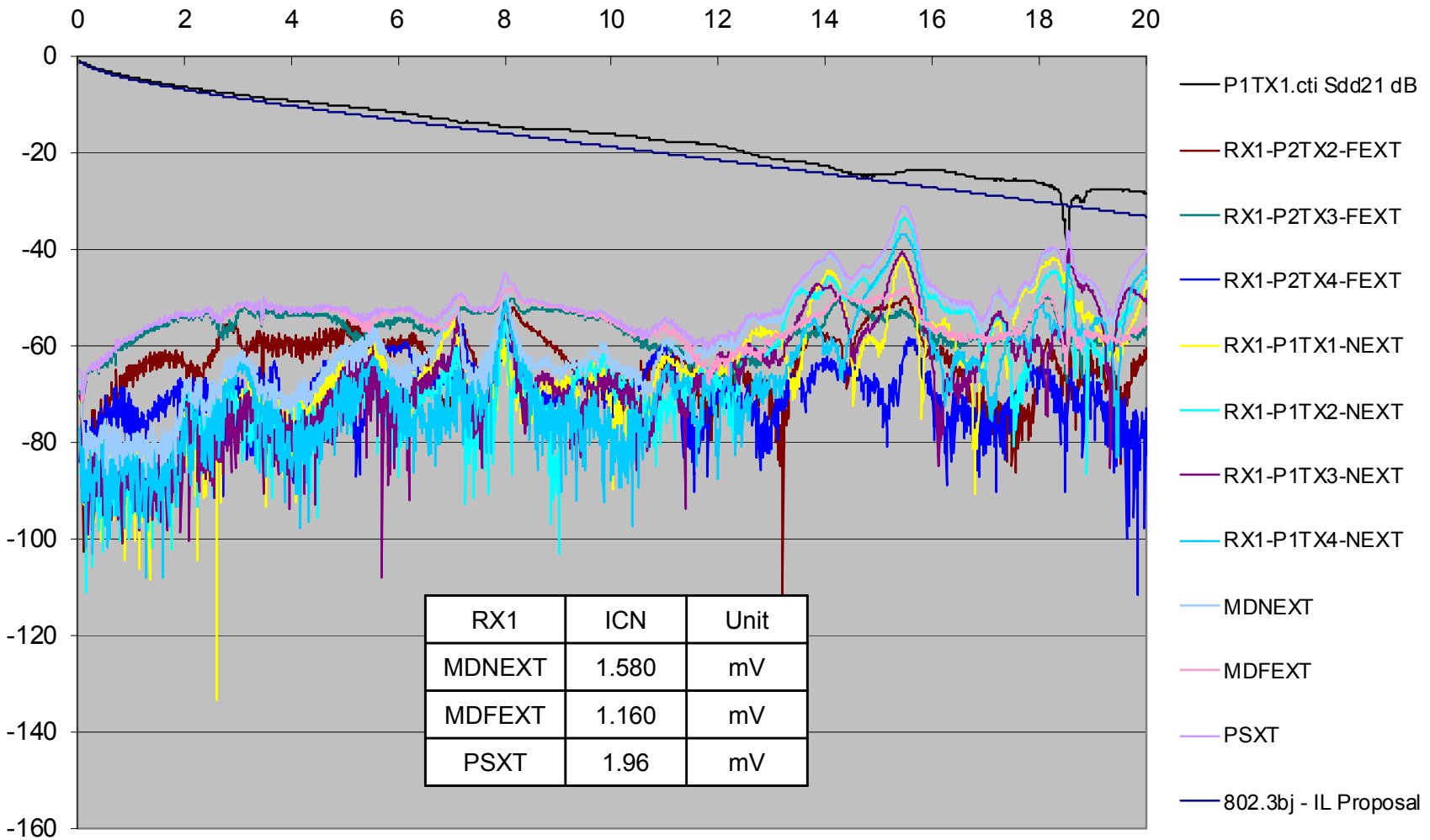
Description	Symbol	Value	Units
Symbol rate	f_b	10.3125	GBd
Near-end disturber peak differential output amplitude	A_{nt}	600	mV
Far-end disturber peak differential output amplitude	A_{ft}	600	mV
Near-end disturber 20% to 80% rise and fall times	T_{nt}	24	ps
Far-end disturber 20% to 80% rise and fall times	T_{ft}	24	ps

Description	Symbol	Value	Unit
Symbol rate	f_b	**25.78125**	**GBd**
Near-end disturber peak differential output amplitude	A_{nt}	**600**	**mV**
Near-end disturber peak differential output amplitude	A_{ft}	**600**	**mV**
Near-end disturber 20% to 80% rise and fall time	T_{nt}	**9.6**	**ps**
Far-end disturber 20% to 80% rise and fall time	T_{ft}	**9.6**	**ps**

fr is the 3 dB reference receiver bandwidth, set to 20 GHz.

Cable Assembly ICN – 5 m – 24 AWG

26 GBd – crosstalk disturbers
1200 mV P-P
Rise time (20%-80%) 9.6 ps
4 NEXT, 3 FEXT



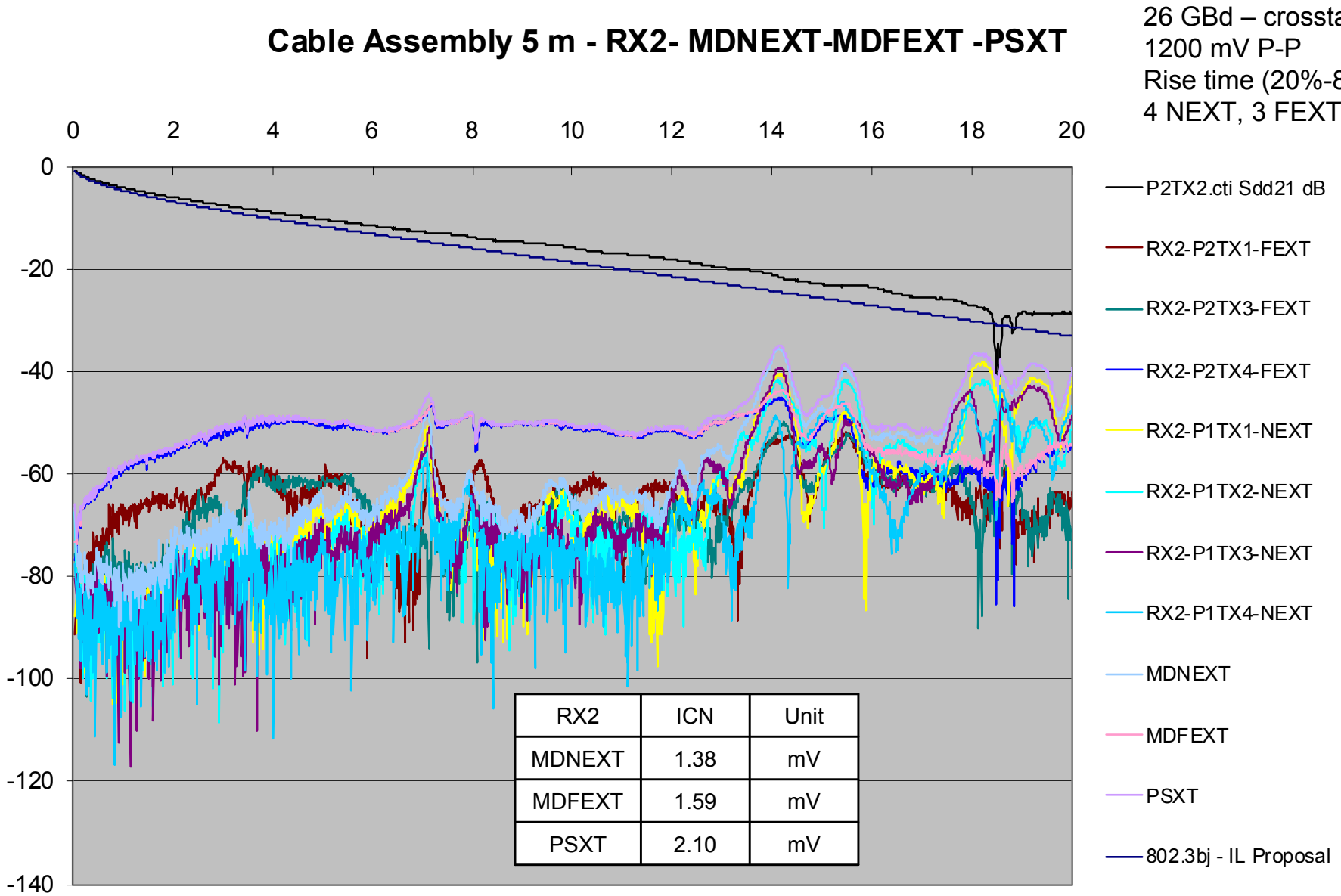
RX1	ICN	Unit
MDNEXT	1.580	mV
MDFEXT	1.160	mV
PSXT	1.96	mV

test fixtures included

3 dB reference receiver bandwidth, set to 20 GHz.

measurement data in cooperation with Mark Bugg– Molex

Cable Assembly ICN – 5 m – 24 AWG



RX2	ICN	Unit
MDNEXT	1.38	mV
MDFEXT	1.59	mV
PSXT	2.10	mV

26 GBd – crosstalk disturbers
1200 mV P-P
Rise time (20%-80%) 9.6 ps
4 NEXT, 3 FEXT

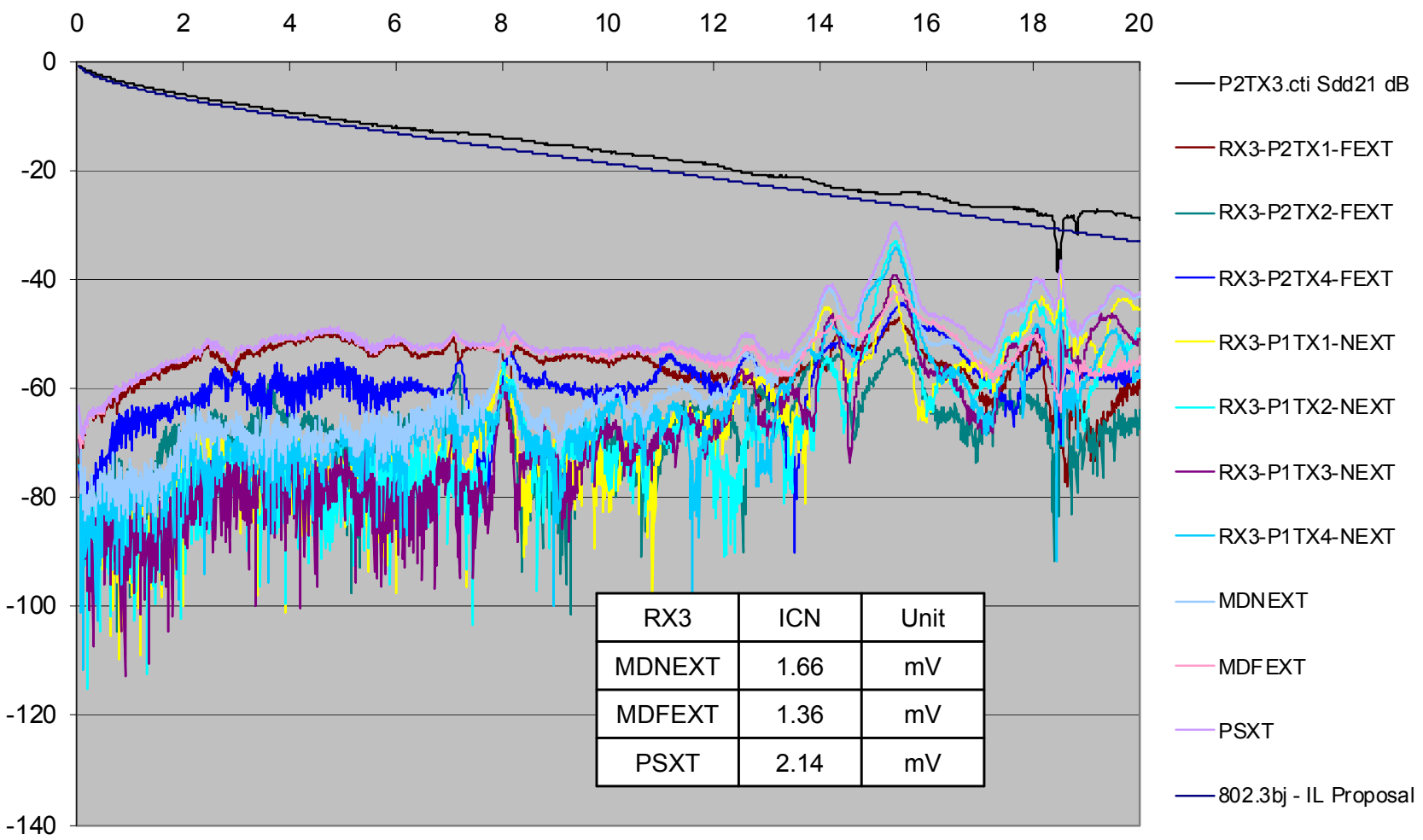
Test fixtures included

3 dB reference receiver bandwidth, set to 20 GHz.

measurement data in cooperation with Mark Bugg– Molex

Cable Assembly ICN – 5 m – 24 AWG

26 GBd – crosstalk disturbers
1200 mV P-P
Rise time (20%-80%) 9.6 ps
4 NEXT, 3 FEXT



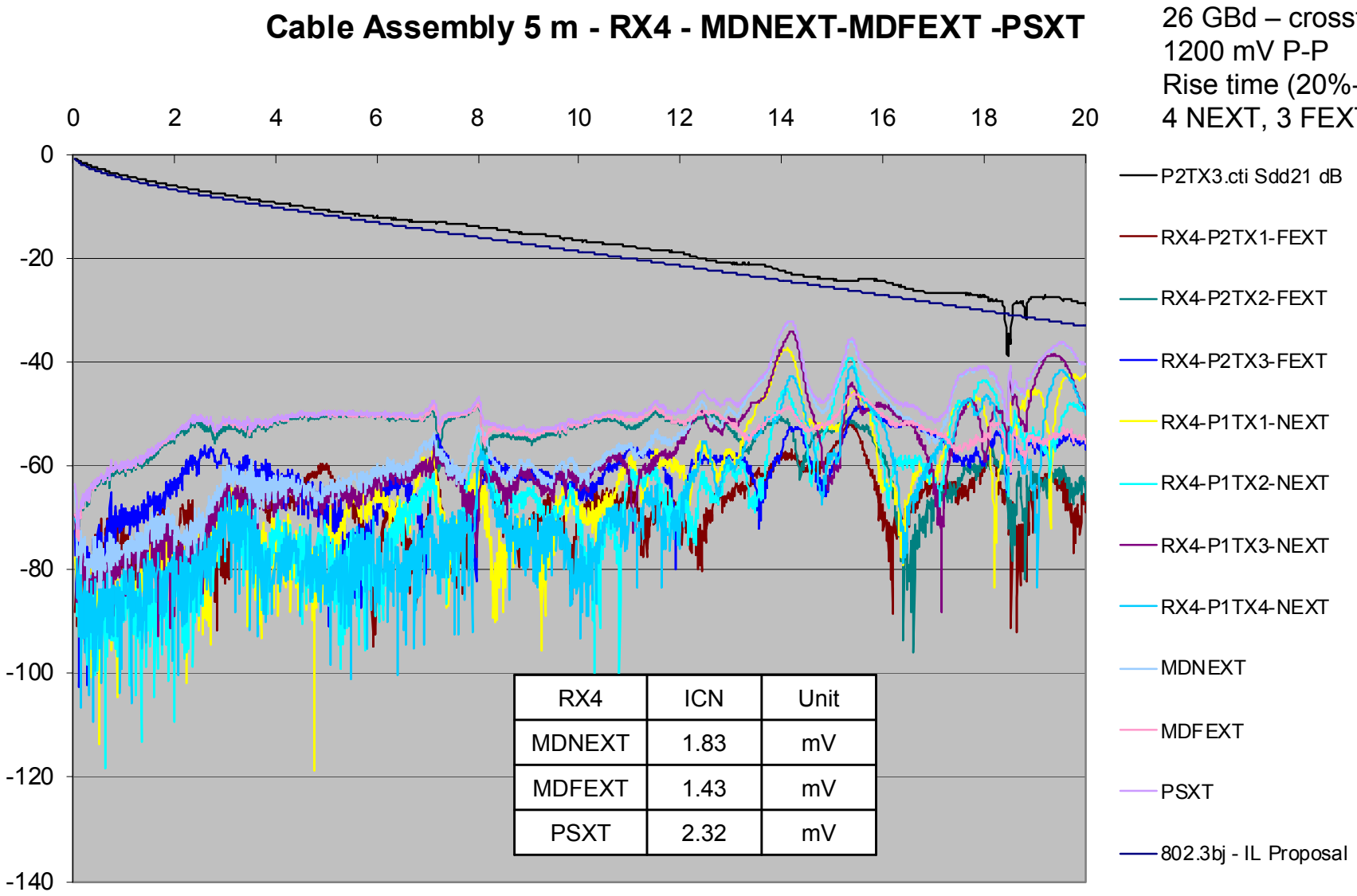
RX3	ICN	Unit
MDNEXT	1.66	mV
MDFEXT	1.36	mV
PSXT	2.14	mV

test fixtures included

3 dB reference receiver bandwidth, set to 20 GHz.

measurement data in cooperation with Mark Bugg– Molex

Cable Assembly ICN – 5 m – 24 AWG



RX4	ICN	Unit
MDNEXT	1.83	mV
MDFEXT	1.43	mV
PSXT	2.32	mV

26 GBd – crosstalk disturbers
1200 mV P-P
Rise time (20%-80%) 9.6 ps
4 NEXT, 3 FEXT

test fixtures included

3 dB reference receiver bandwidth, set to 20 GHz.

measurement data in cooperation with Mark Bugg– Molex

Cable Assembly ICN – 5 m – 24 AWG

RX1	ICN	Unit
MDNEXT	1.580	mV
MDFEXT	1.160	mV
PSXT	1.96	mV

RX2	ICN	Unit
MDNEXT	1.38	mV
MDFEXT	1.59	mV
PSXT	2.10	mV

RX3	ICN	Unit
MDNEXT	1.66	mV
MDFEXT	1.36	mV
PSXT	2.14	mV

RX4	ICN	Unit
MDNEXT	1.83	mV
MDFEXT	1.43	mV
PSXT	2.32	mV

Proposal: Maximum integrated crosstalk noise for maximum cable assembly insertion loss of 22.64 dB at 12.89 GHz.	Revise Equation 85A-6	3.5	mV

The total integrated crosstalk RMS noise voltage of the channel is recommended to meet the values determined using Equation (85A–6) illustrated in Figure 85A–2.

$$\sigma_{x,ch} \leq \begin{cases} 10 & 3 \leq IL \leq 7.5 \\ 13.4 - 0.45IL & 7.5 < IL \leq 24.44 \end{cases} \quad \text{(mV)} \qquad \text{(85A–6)}$$

where IL is the value of the channel insertion loss in dB at 5.15625 GHz.

Host Tx and Rx PCB losses

- **Transmitter and receiver differential printed circuit board trace loss…Closed form equation to follow in update.**

GHz	dB/in
1	0.1856
6.5	0.8971
7	0.9557
12.89	1.5924
14	1.702

Attenuation* (dB/in) at:	1 GHz	6.5 GHz	7 GHz	12.89 GHz	14 GHz
Meg6_LowSR – Wide	0.0951	0.4159	0.4433	0.7562	0.8127
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26-Jan 12

Elizabeth Kochuparambil
Joel Goergen

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http://www.ieee802.org/3/bj/public/jan12/kochuparambil_01a_0112.pdf

Channel Insertion loss

- **To be derived from cable assembly, Tx and Rx PCB and test fixtures losses…**

85A.5 Channel insertion loss

This subclause provides information on channel insertion losses for intended topologies ranging from 0.5 m to 7 m in length. The maximum channel insertion loss associated with the 7 m topology is determined using Equation (85A–3). The channel insertion loss associated with the 0.5 m topology and a maximum host channel is determined by Equation (85A–4). The channel insertion loss budget at 5.15625 GHz is illustrated in Figure 85A–1.

The maximum channel insertion loss is determined using Equation (85A–3). The maximum channel insertion loss is 24.44 dB at 5.15625 GHz.

$$IL_{Chmax}(f) = IL_{Camax}(f) + 2IL_{Host}(f) - 2IL_{MatedTF}(f) \text{ (dB)} \quad (85A–3)$$

for 50 MHz ≤ f ≤ 7500 MHz.

where

f	is the frequency in MHz
$IL_{Chmax}(f)$	is the maximum channel insertion loss between TP0 and TP5
$IL_{Camax}(f)$	is the maximum cable assembly insertion loss using Equation (85–19)
$IL_{Host}(f)$	is the maximum insertion loss from TP0 to TP2 or TP3 to TP5 using Equation (85–14)
$IL_{MatedTF}(f)$	is the maximum insertion loss of the mated test fixture using Equation (85–36)

The channel insertion loss between TP0 and TP5 representative of a 0.5 m cable assembly and a maximum host channel is determined using Equation (85A–4).

$$(IL_{Ch0.5m}(f) = 0.275IL_{Camax}(f) + 2IL_{Host}(f) - 2IL_{MatedTF}(f) \text{ (dB)} \quad (85A–4)$$

for 50 MHz ≤ f ≤ 7500 MHz.

where

f	is the frequency in MHz

Test Fixture Crosstalk

MCB-ICN-RX1
RX1-MDFEXT-RX2,RX3,RX4
RX1-MDNEXT-TX1,TX2,TX3,TX4

MCB-ICN-RX2
RX2-MDFEXT-RX1,RX3,RX4
RX2-MDNEXT-TX1,TX2,TX3,TX4

MCB-ICN-RX3
RX3-MDFEXT-RX1,RX2,RX4
RX3-MDNEXT-TX1,TX2,TX3,TX4

MCB-ICN-RX4
RX4-MDFEXT-RX1,RX2,RX3
RX4-MDNEXT-TX1,TX2,TX3,TX4

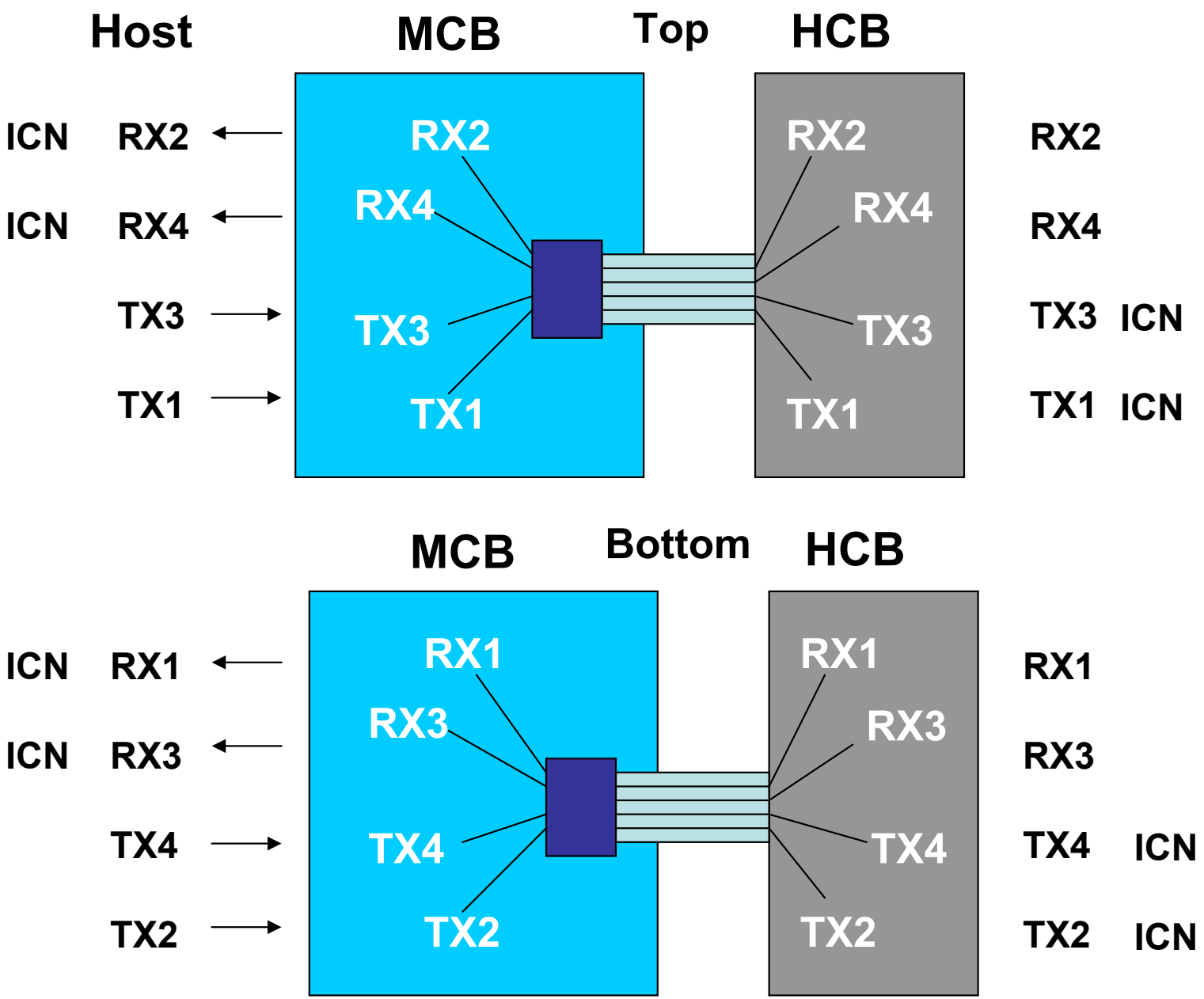
HCB-ICN-TX1
TX1-MDFEXT-TX2,TX3,TX4
TX1-MDNEXT-RX1,RX2,RX3,RX4

HCB-ICN-TX2
TX2-MDFEXT-TX1,TX3,TX4
TX2-MDNEXT-RX1,RX2,RX3,RX4

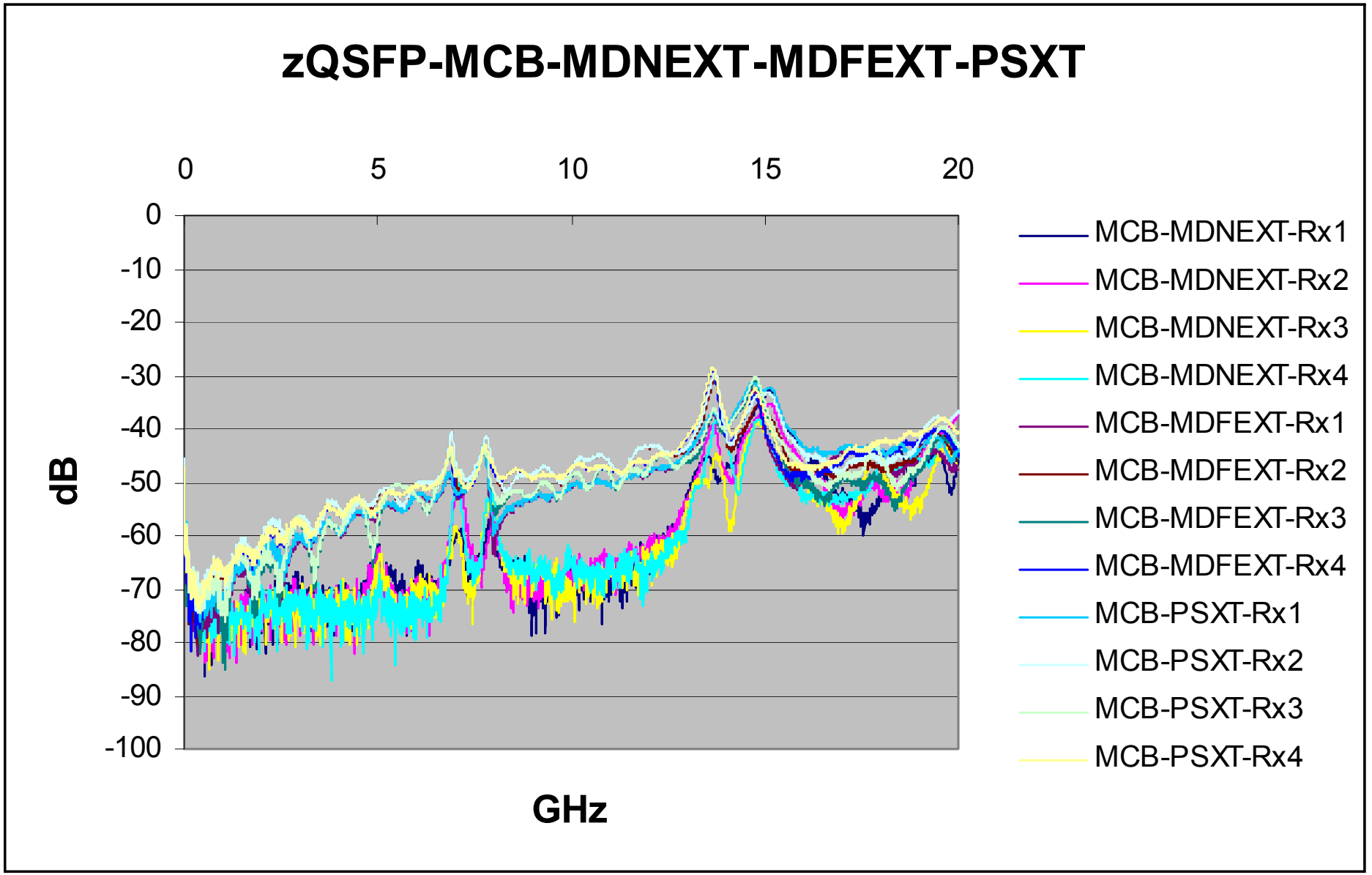
HCB-ICN-TX3
TX3-MDFEXT-TX2,TX3,TX4
TX3-MDNEXT-RX1,RX2,RX3,RX4

HCB-ICN-TX4
TX4-MDFEXT-TX1,TX2,TX3
TX4-MDNEXT-RX1,RX2,RX3,RX4

Test Fixture Crosstalk

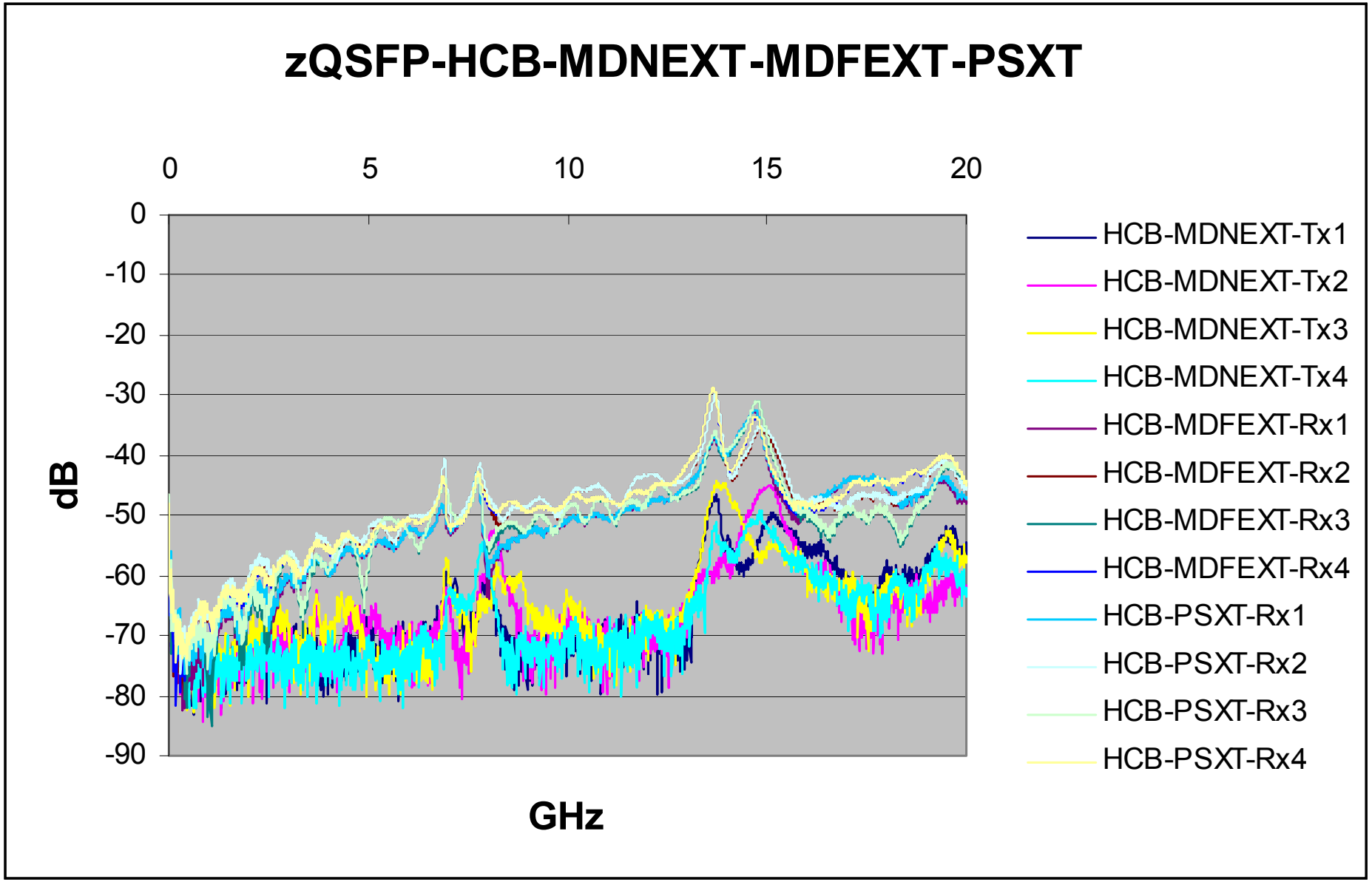


MCB side – Integrated Crosstalk Noise



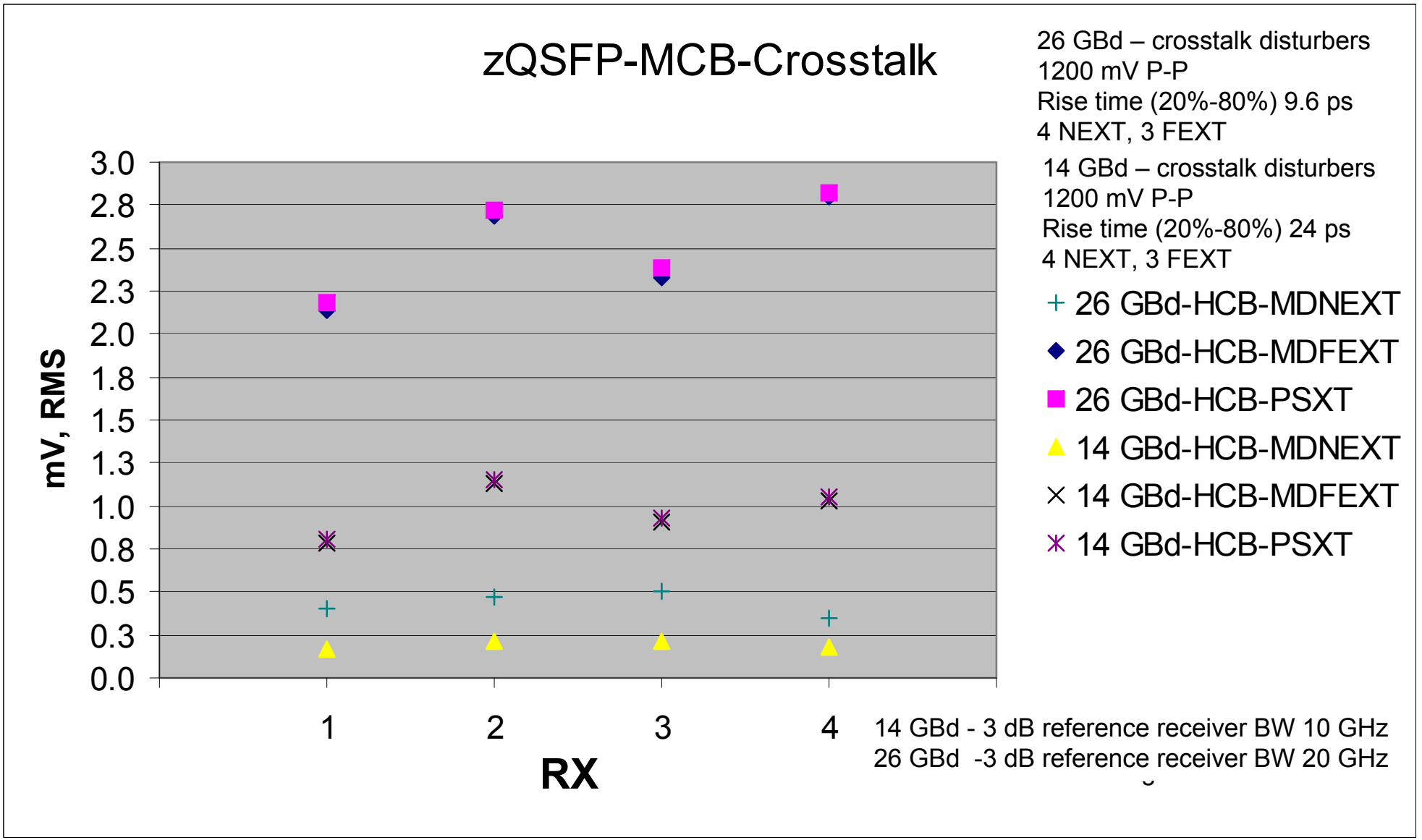
Molex zQSFP – S4P measurement data provided by Michael Rost – Molex

HCB side – Integrated Crosstalk Noise



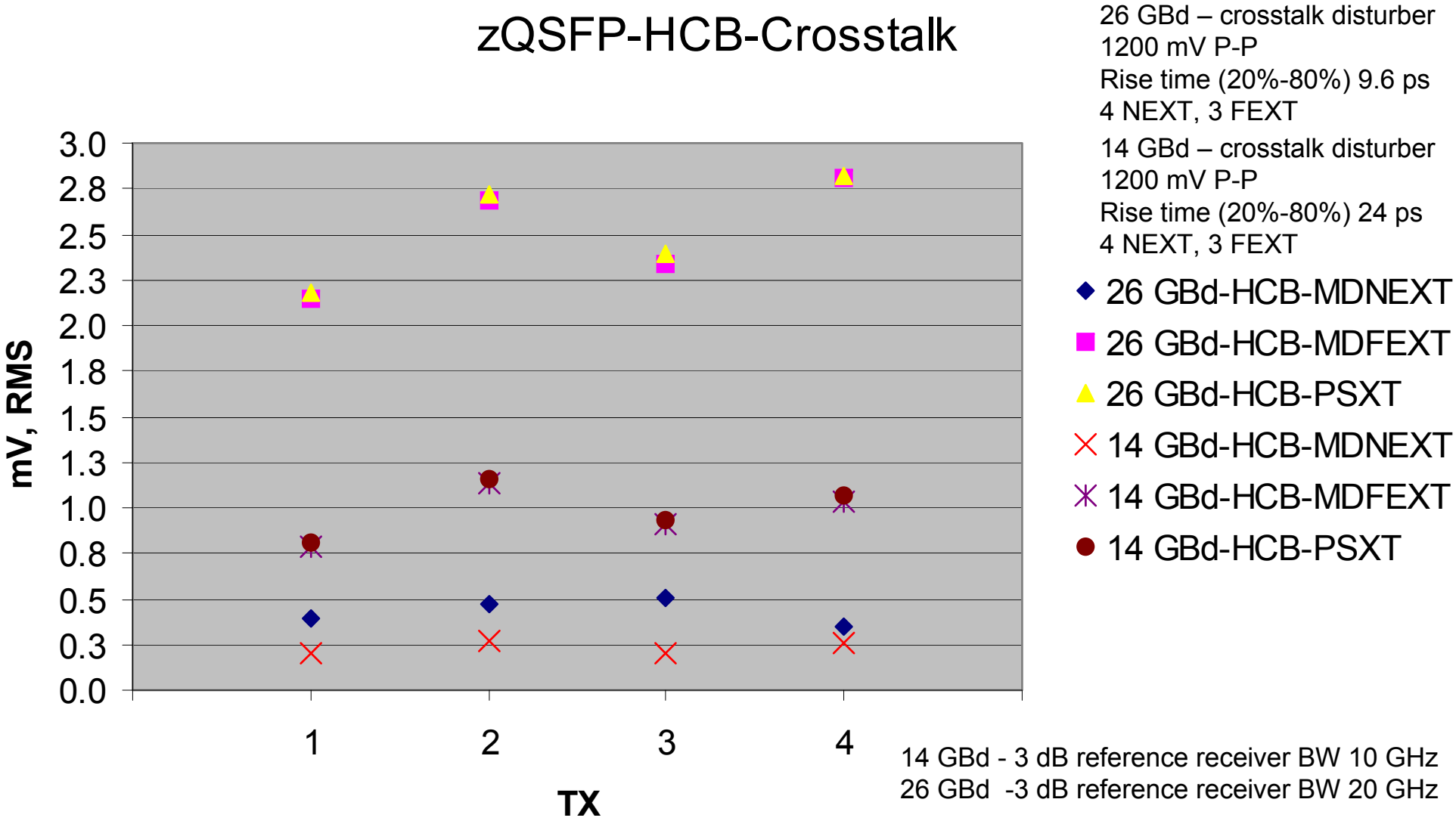
Molex zQSFP – S4P measurement data provided by Michael Rost – Molex

MCB side – Integrated Crosstalk Noise



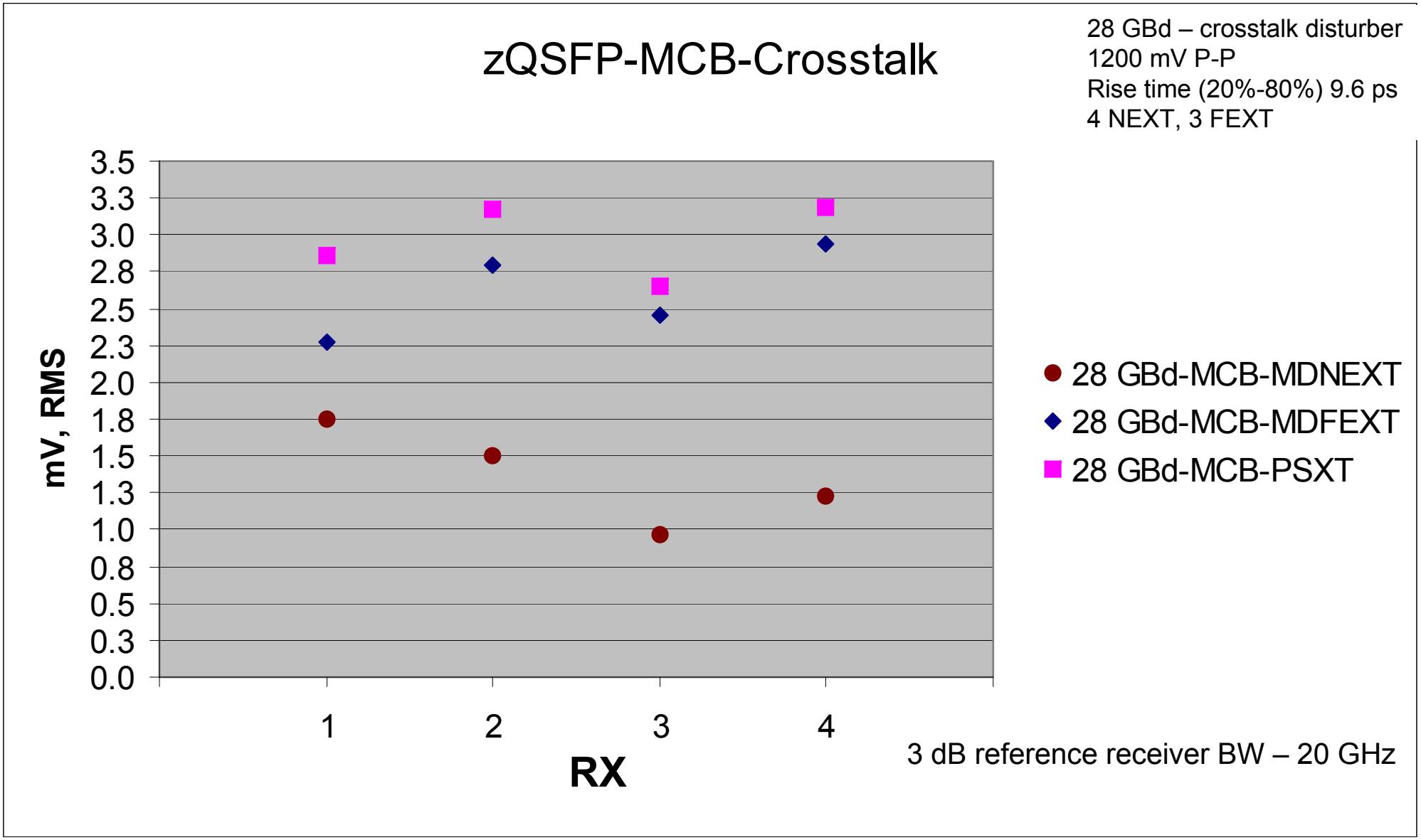
Molex zQSFP – S4P measurement data provided by Michael Rost – Molex

HCB side – Integrated Crosstalk Noise



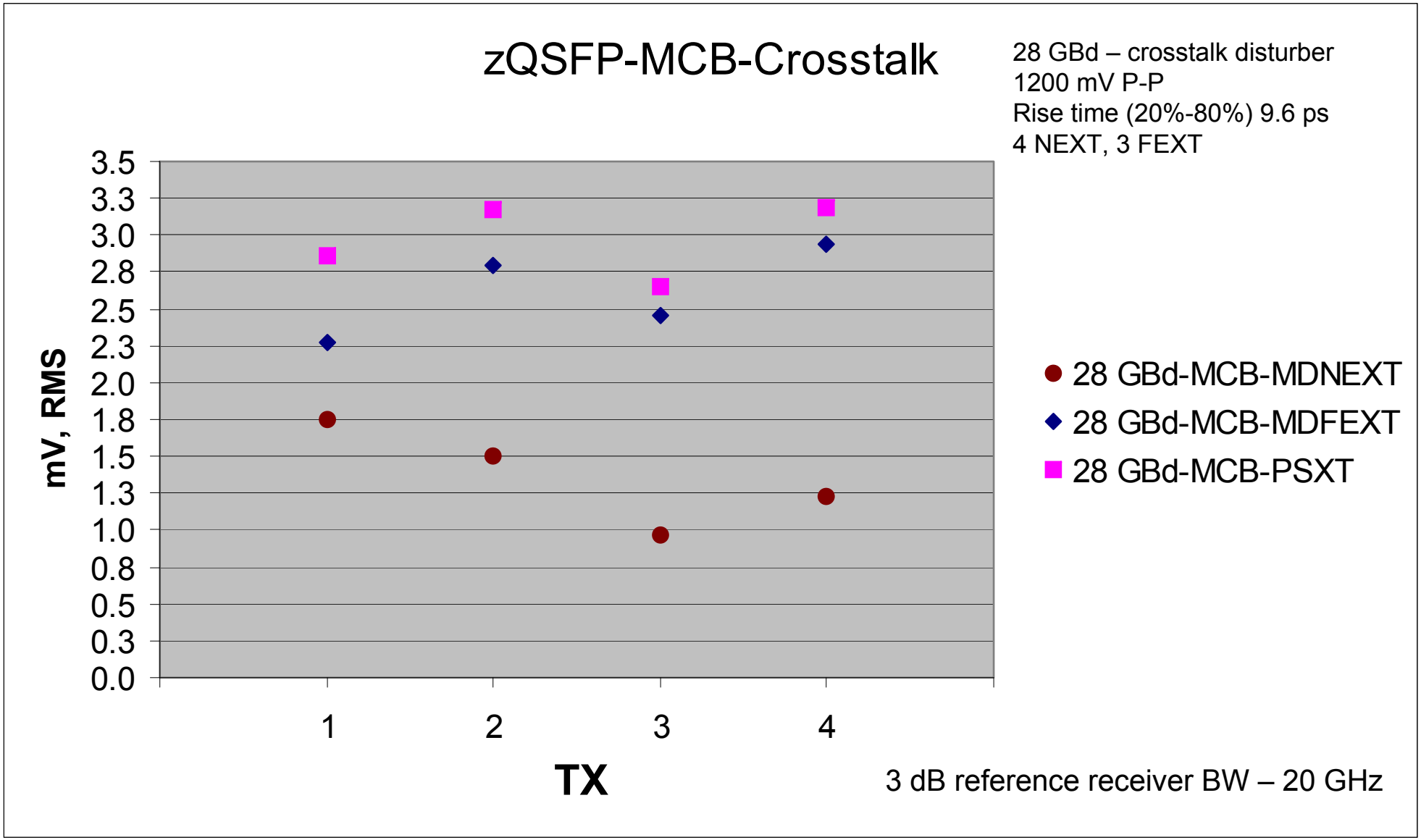
Molex zQSFP – S4P measurement data provided by Michael Rost – Molex

MCB side – Integrated Crosstalk Noise



Molex zQSFP – S4P measurement data provided by Michael Rost – Molex

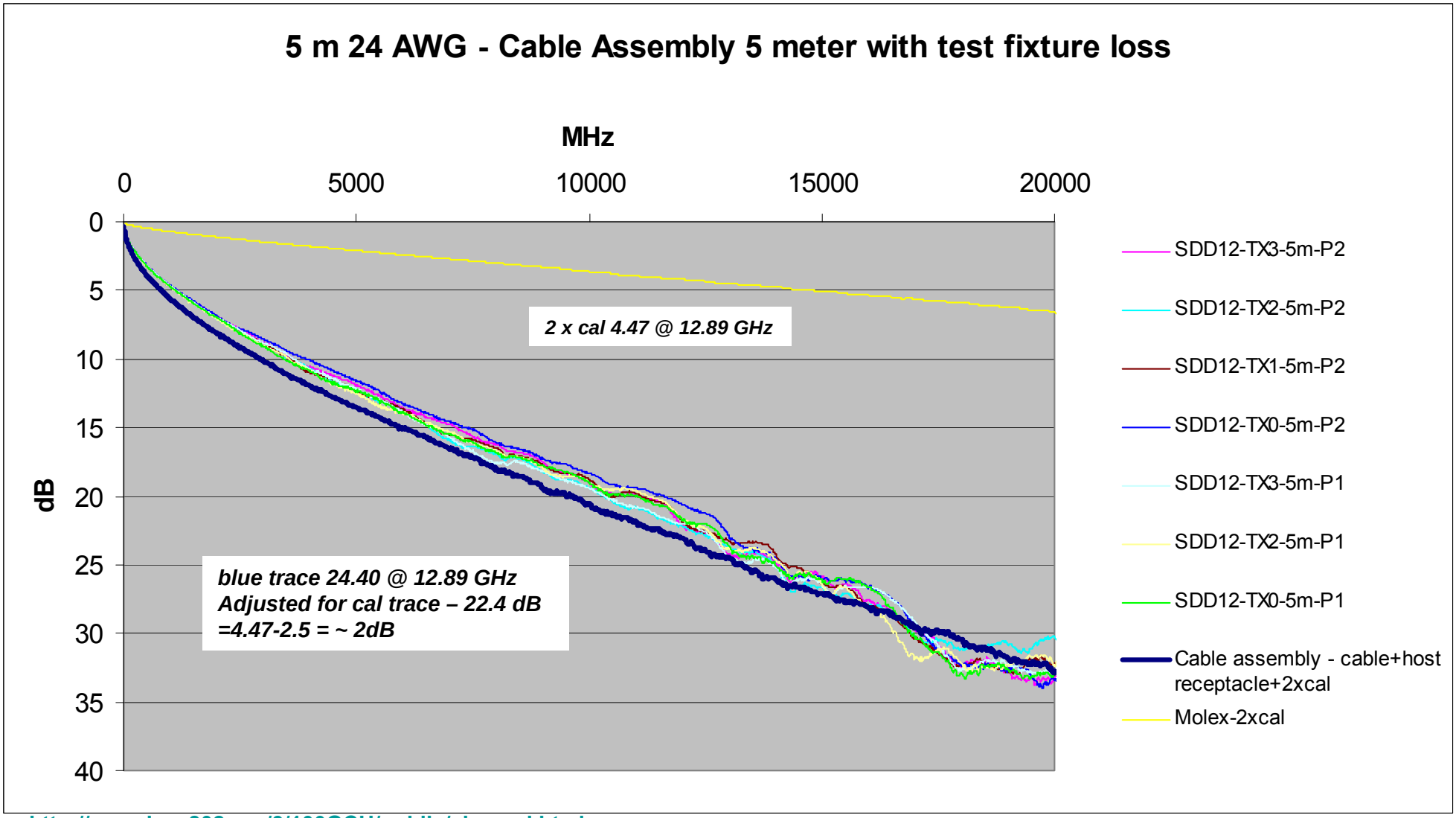
HCB side – Integrated Crosstalk Noise



Molex zQSFP – S4P measurement data provided by Michael Rost – Molex

BACKUP

Cable Assembly IL – 5 m



http://www.ieee802.org/3/100GCU/public/channel.html

Mark Bugg- Molex Full ZQSFP Cable Assembly, including host boards (10-Feb 11)
5m: All (40M),
P1_RX0, P1_RX1, P1_RX2, P1_RX3,
P2_RX0, P2_RX1, P2_RX2, P2_RX3
Calibration file (23-Feb 2-11 633k)
Reference (6-Jan-11 1.2M)