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

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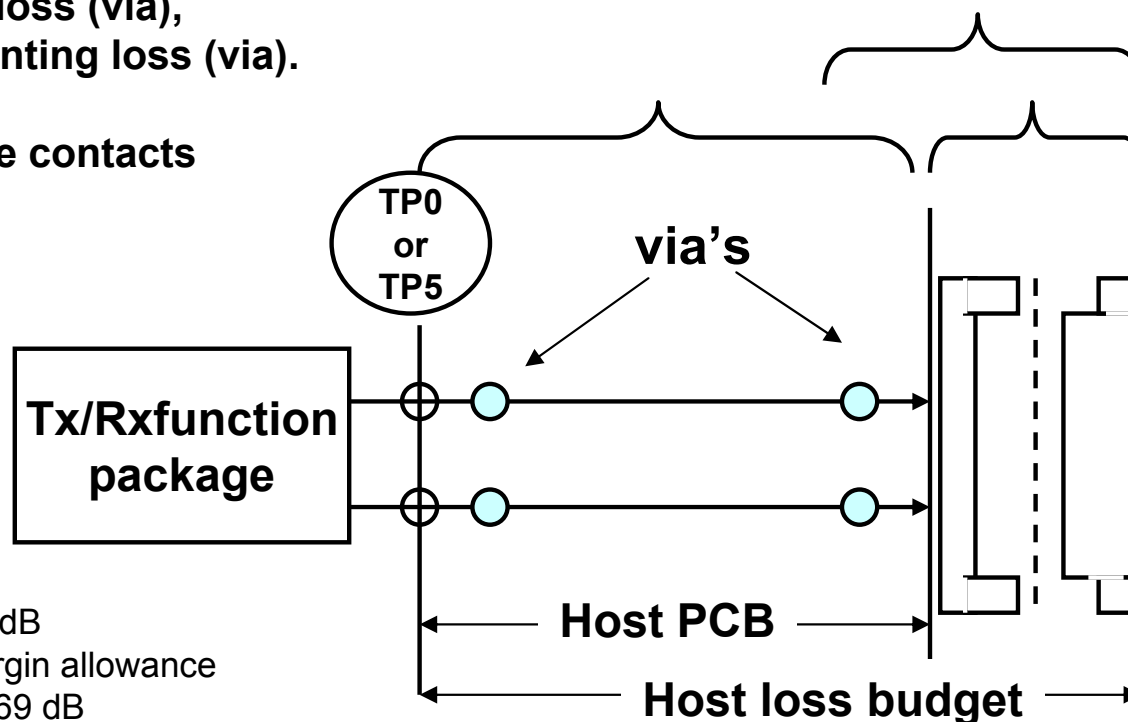
Purpose

- **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
 $1.07 \text{ dB} + 0.62 \text{ dB} = 1.69 \text{ dB}$

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

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

PROPOSED PARAMETERS;
GRAPHS ON PREVIOUS SLIDE

Proposal for Defining
Material Loss

26-Jan 12

Elizabeth
Kochuparambil
Joel Goergen

Cisco

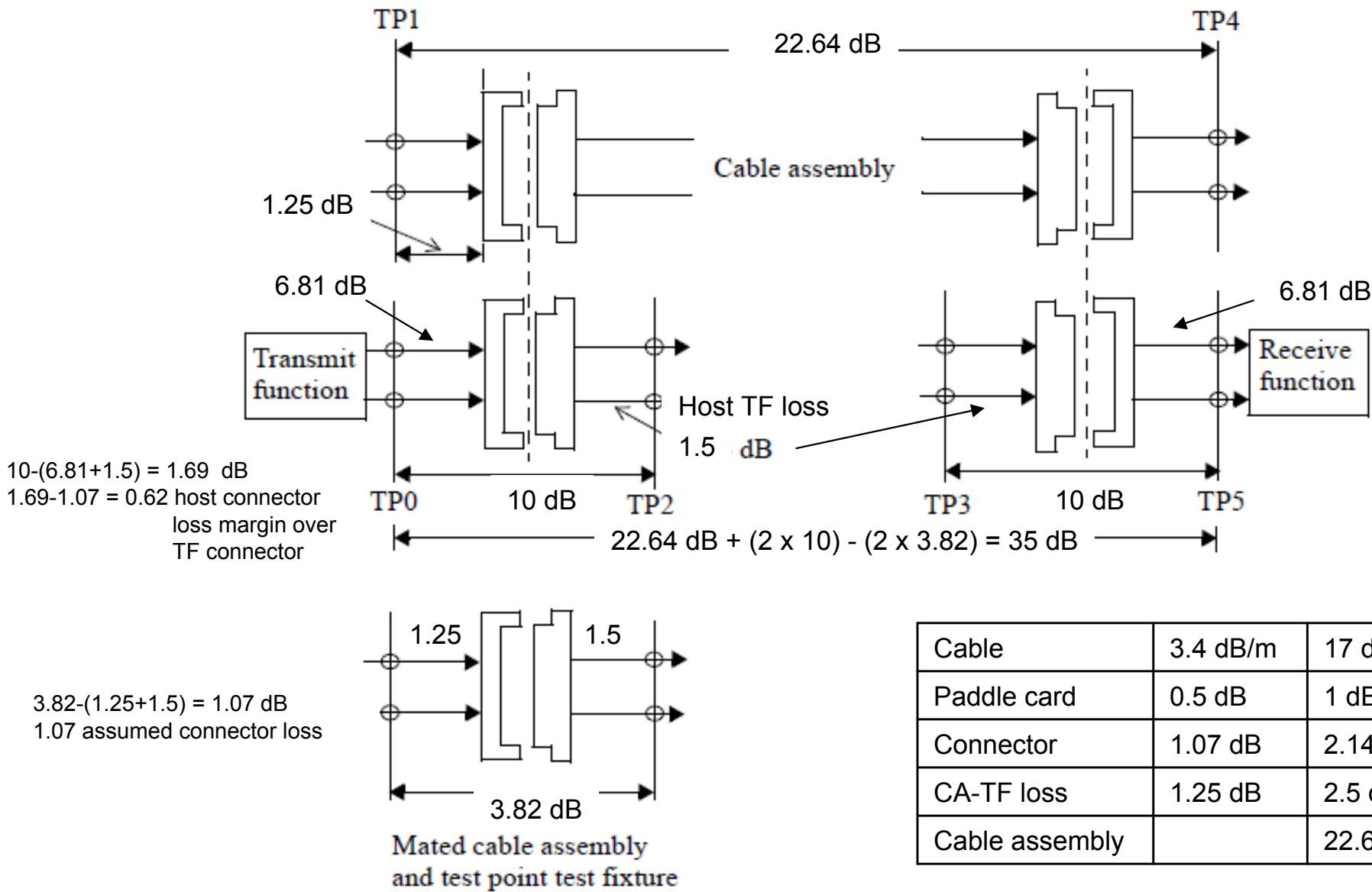
http://www.ieee802.org/3/bj/public/jan12/kochuparambil_01a_0112.pdf

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).

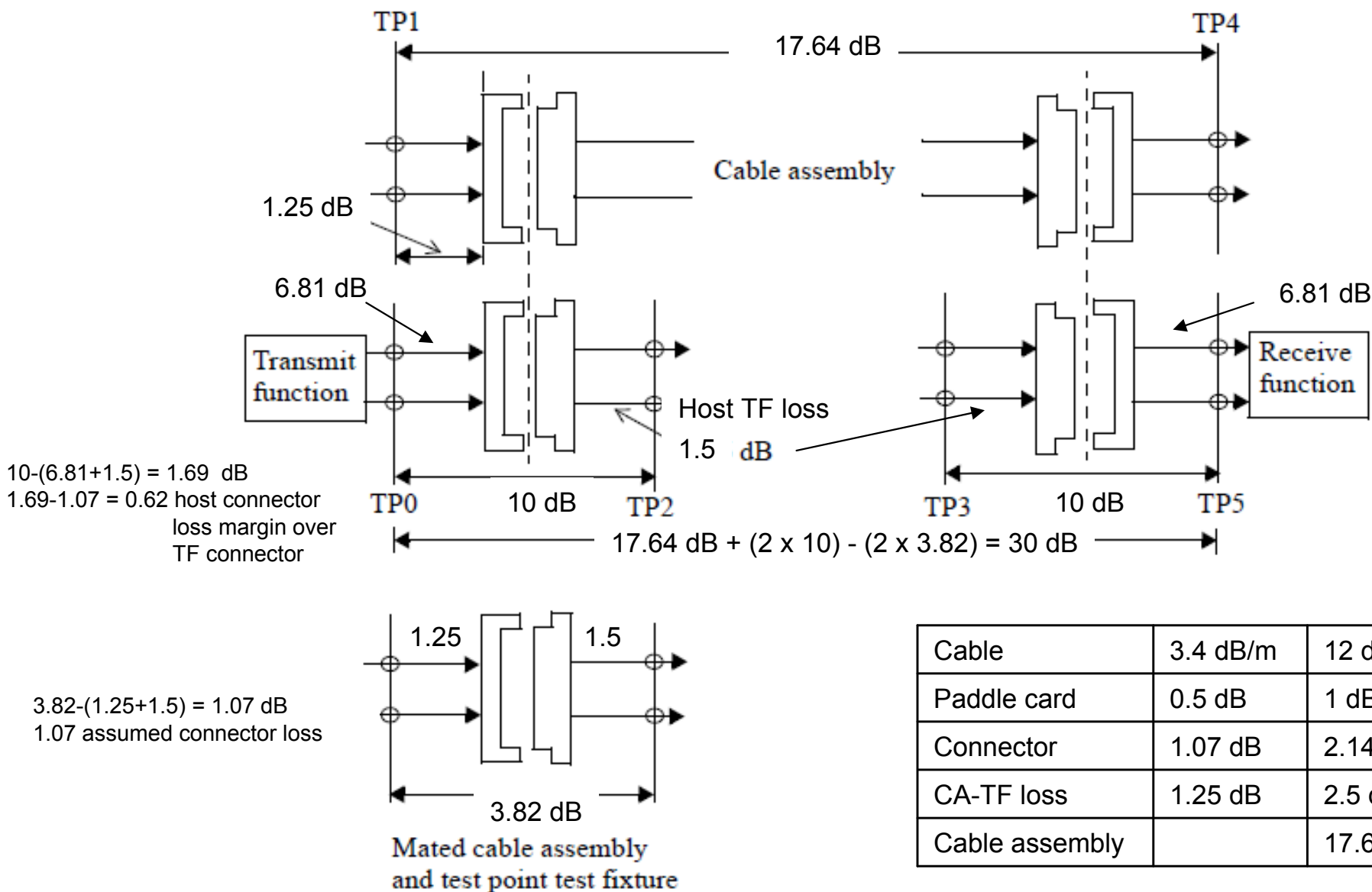
Channel insertion loss – 35 dB – 5 m cable assembly

Illustration of channel insertion loss budget at 12.89 GHz



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

Illustration of channel insertion loss budget at 12.89 GHz



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	$(22.64) + (2 \times 10) - (2 \times 3.82)$	
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.
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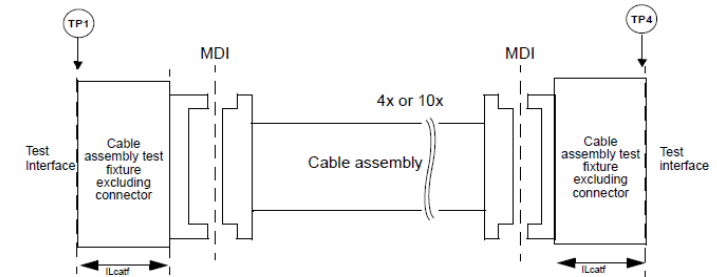


Table 85-9—Cable assembly differential characterist

Figure 85-13—Cable assembly test fixtures

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 .

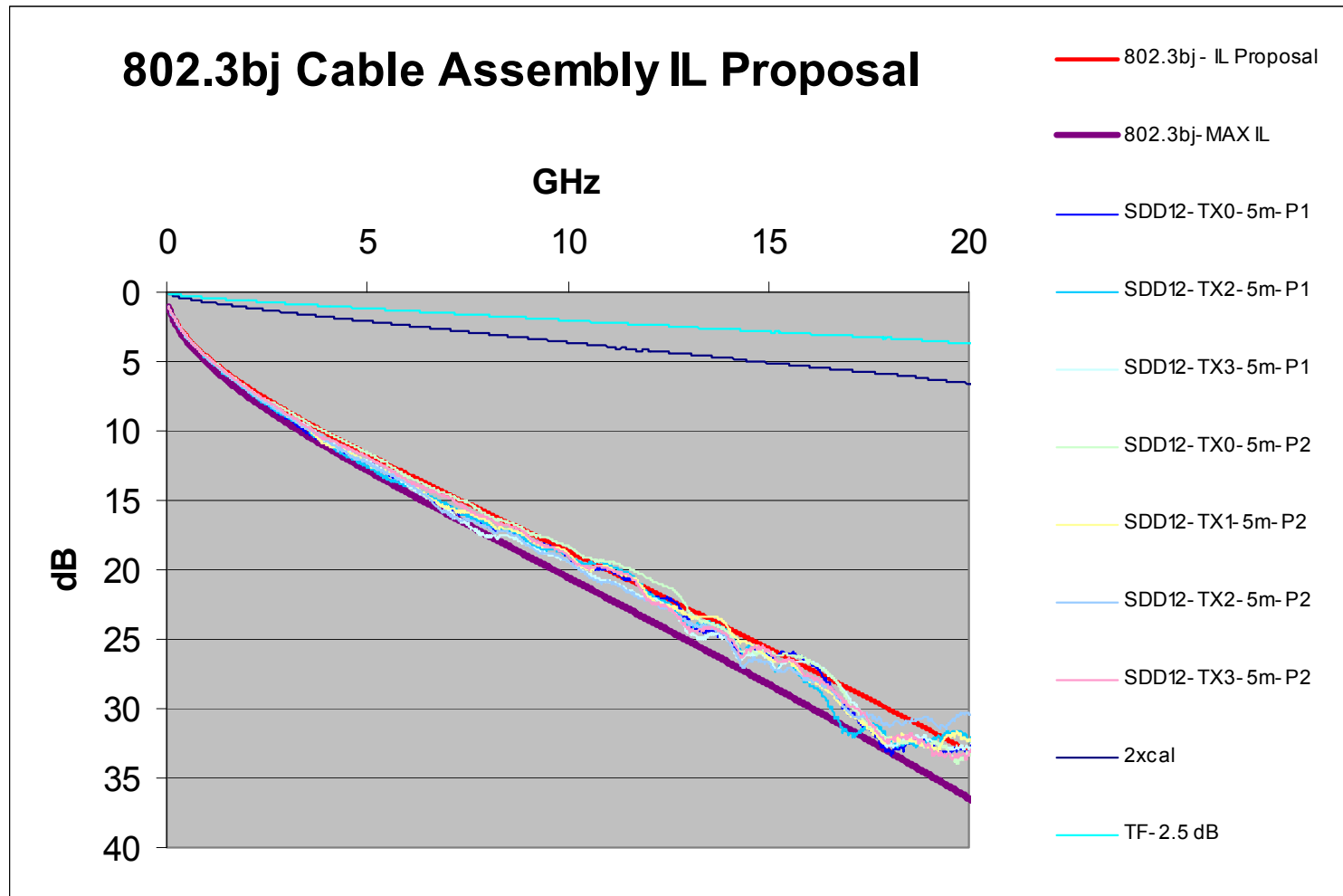
Cable assembly characteristics

•Table XX–X—Cable assembly differential characteristics summary

Description	Reference	Value	Unit	Frequency Range of specification (GHz)
Maximum fitted insertion loss at 12.8906 GHz	85.10.2	22.64 dB	dB	$0.05 \leq f \leq 18.75$
Minimum insertion loss at 12.8906 GHz		TBD dB	dB	$0.05 \leq f \leq 18.75$
Insertion loss deviation at 12.8906 GHz	85.10.3	Min= -2.97 dB Max= +2.97 dB	dB	$0.05 \leq f \leq 18.75$ $0.05 \leq f \leq 18.75$
Minimum return loss at 12.8906 GHz	85.10.4	6 dB	dB	$0.05 \leq f \leq 25$
MDNEXT loss	85.10.5	(slide 12)	dB	$0.05 \leq f \leq 20$
MDFEXT loss	85.10.6	(slide 12)	dB	$0.05 \leq f \leq 20$
Maximum integrated crosstalk noise	85.10.7	(slide 18)	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 = $4.28 \cdot \text{SQRT}(f) + 0.325 \cdot f + 0.0185 \cdot f^2 = 22.64 \text{ @ } 12.89 \text{ GHz}$

<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,

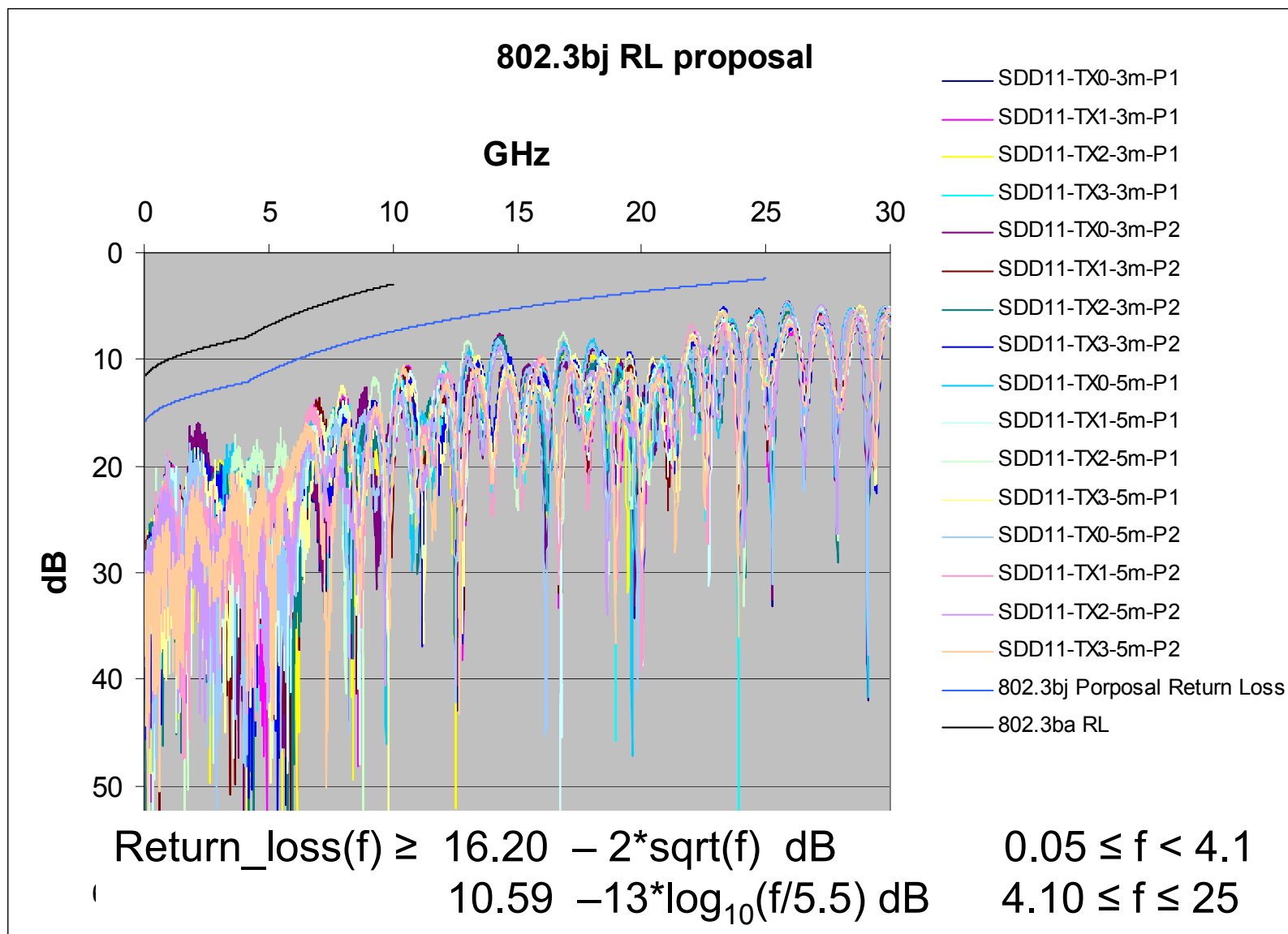
P2_RX0, P2_RX1, P2_RX2, P2_RX3

Calibration file (23-Feb 2-11 633k)

Reference (6-Jan-11 1.2M)

802.3bj Cu specifications

Cable Assembly RL Proposal

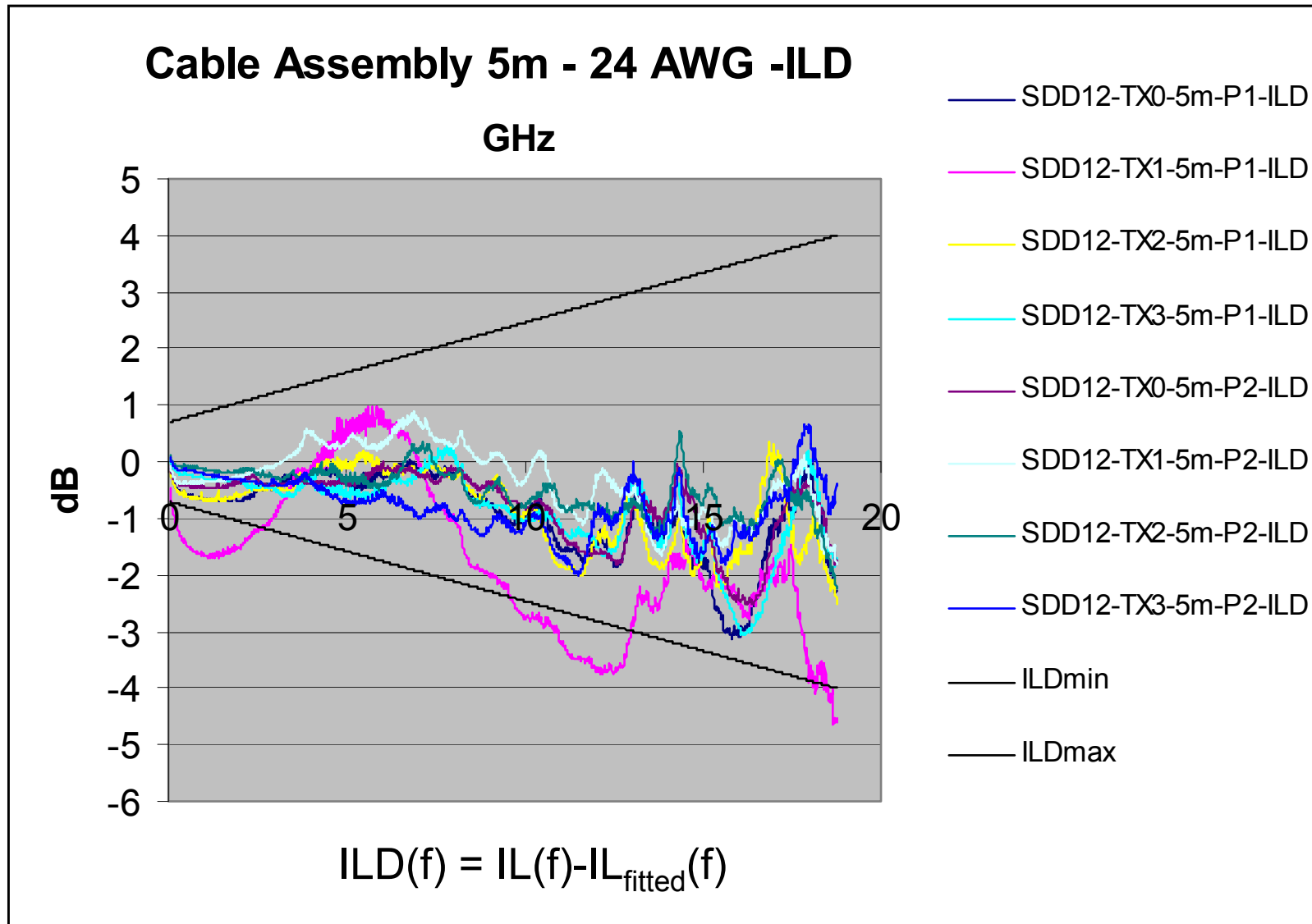


<http://www.ieee802.org/3/100GCU/public/channel.html>

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

802.3bj Cu specifications

Cable Assembly ILD Proposal



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

$$ILD(f) \leq ILD(f)_{max} = 0.7 + 0.176 \cdot f \text{ dB} \quad 0.05 \leq f(\text{GHz}) \leq 18.75$$

Cable Assembly MDNEXT – MDFEXT

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

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)

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

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 $50 \leq f(\text{MHz}) \leq 20000$

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

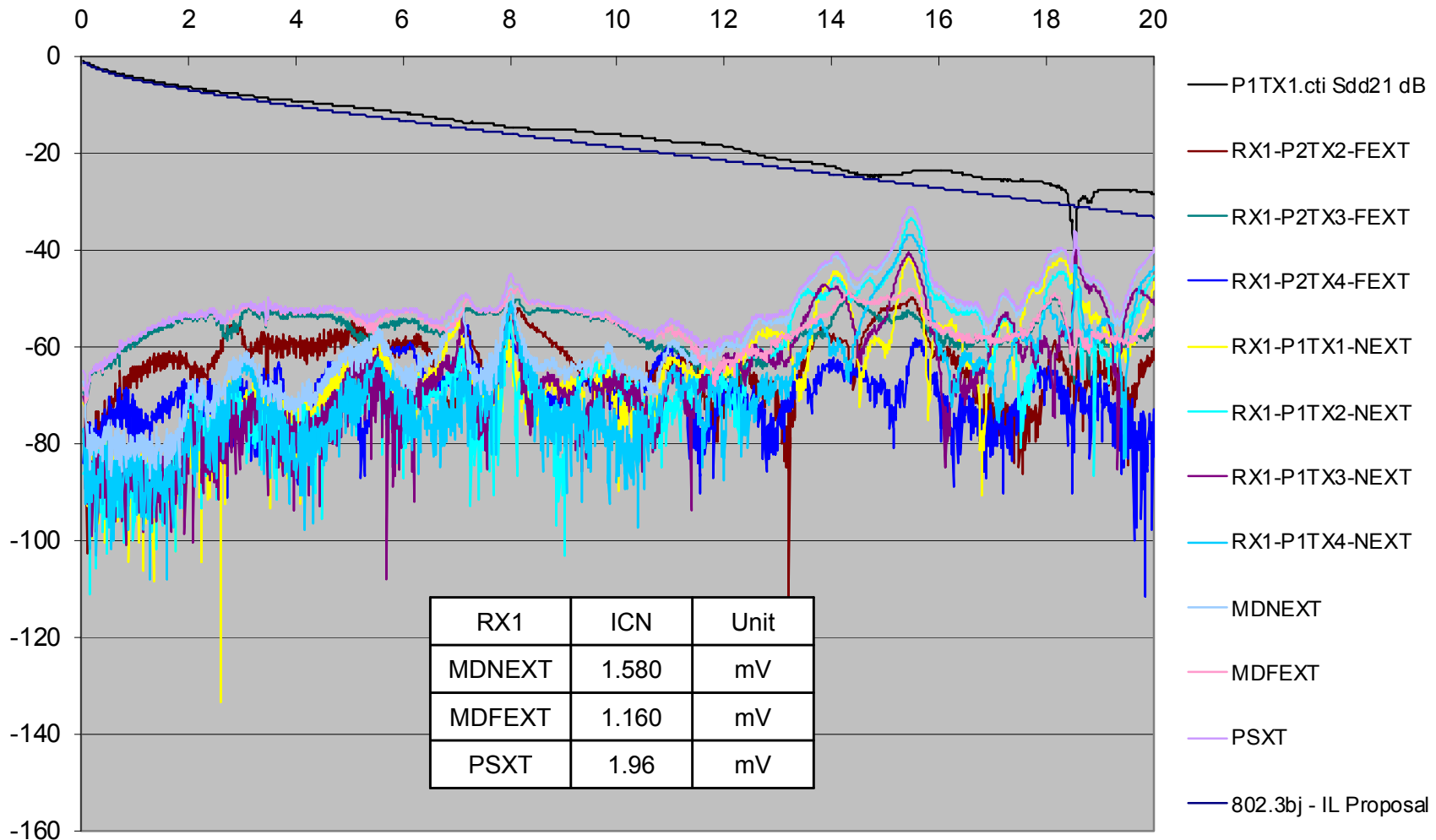
Description	Symbol	Value	Unit
Symbol rate	f_b	25.78125	GBd
Near-end disturber peak differential output amplitude	A_{nt}	600	mV
Near-end disturber peak differential output amplitude	A_{ft}	600	mV
Near-end disturber 20% to 80% rise and fall time	T_{nt}	9.6	ps
Far-end disturber 20% to 80% rise and fall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

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

Cable Assembly ICN – 5 m – 24 AWG

Cable Assembly 5 m - RX1- MDNEXT-MDFEXT -PSXT

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.

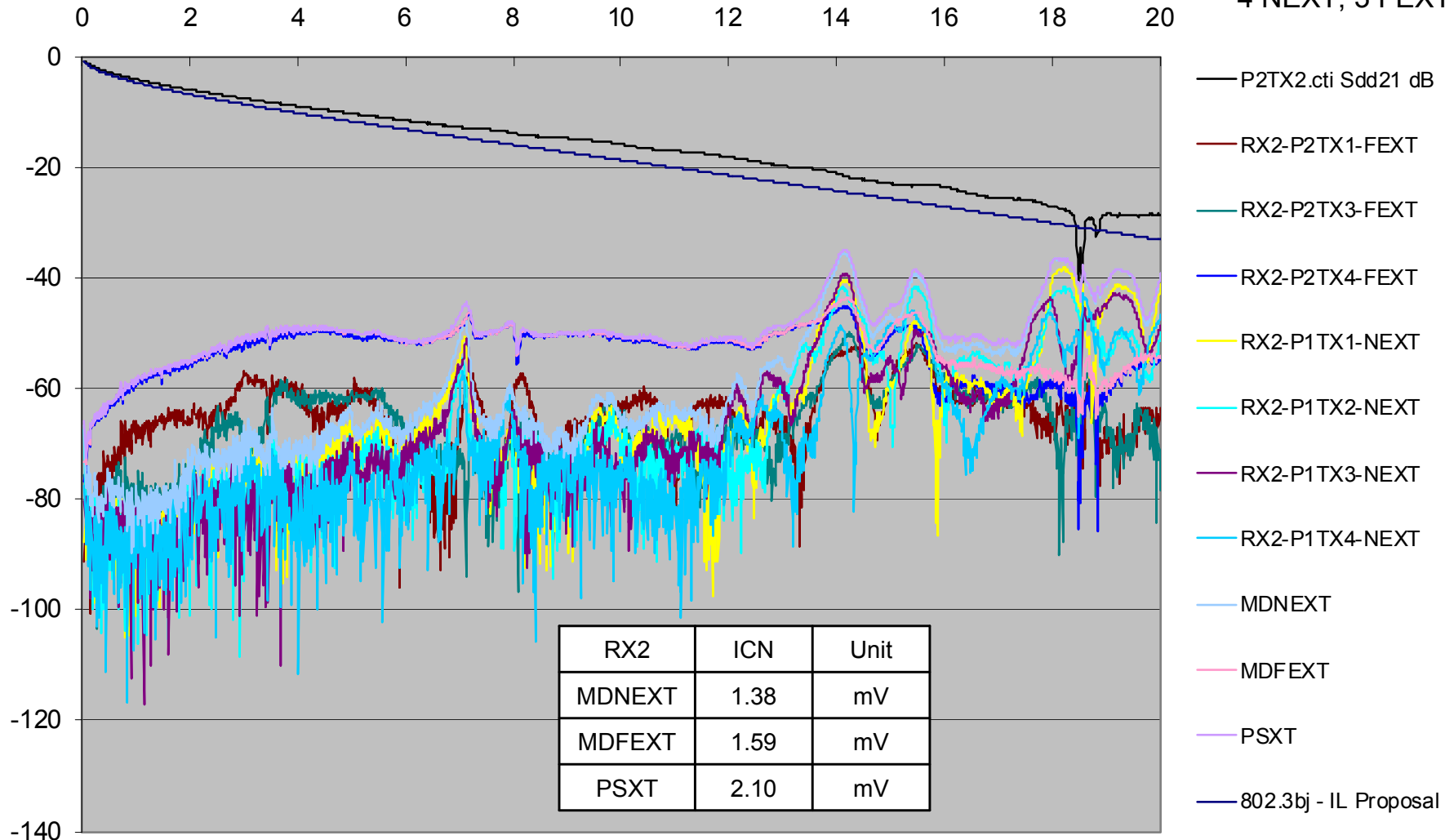
measurement data in cooperation with Mark Bugg– Molex

802.3bj Cu specifications

Cable Assembly ICN – 5 m – 24 AWG

Cable Assembly 5 m - RX2- MDNEXT-MDFEXT -PSXT

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.

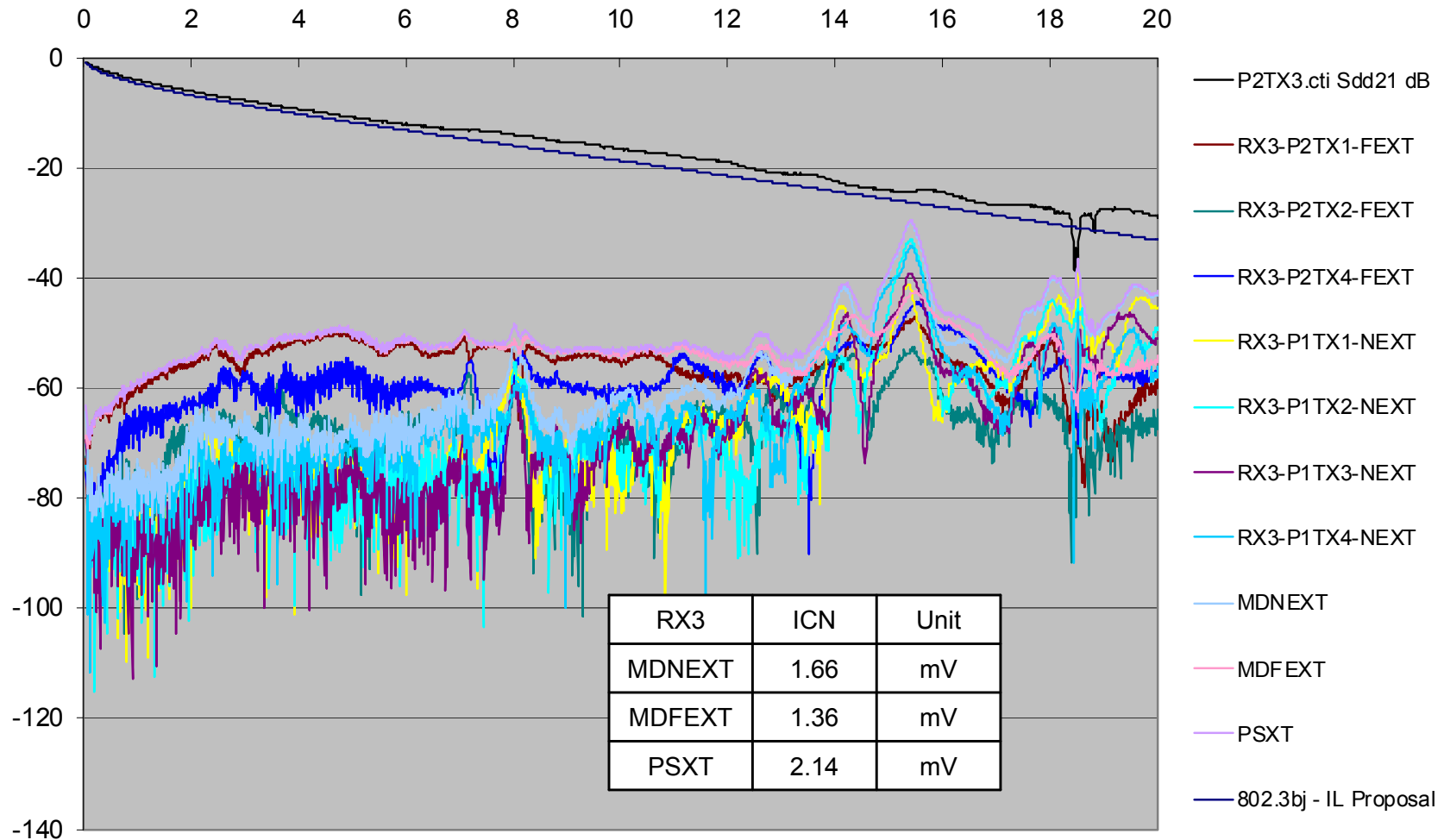
measurement data in cooperation with Mark Bugg– Molex

802.3bj Cu specifications

Cable Assembly ICN – 5 m – 24 AWG

Cable Assembly 5 m - RX3 - MDNEXT-MDFEXT -PSXT

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.

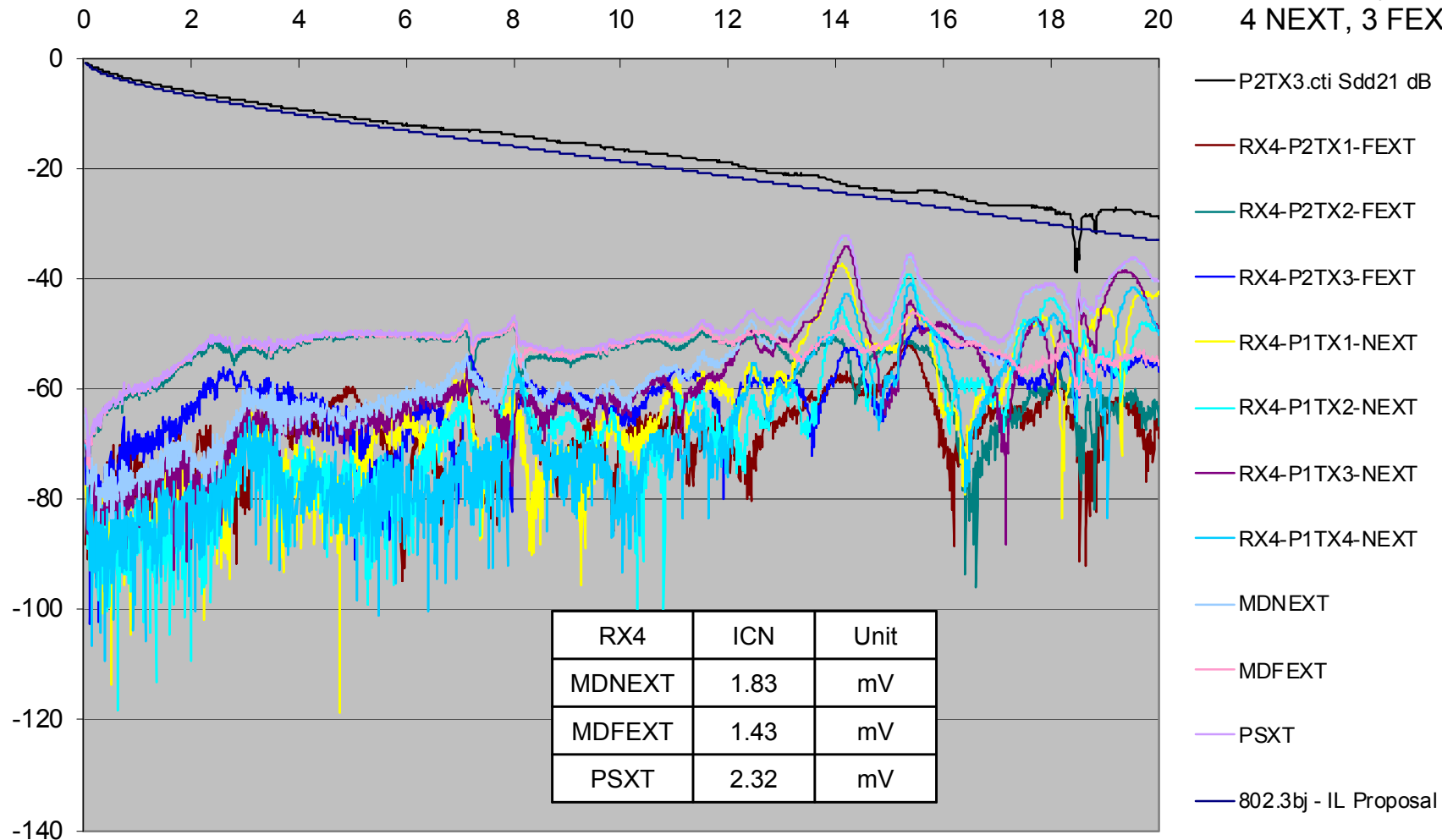
measurement data in cooperation with Mark Bugg– Molex

802.3bj Cu specifications

Cable Assembly ICN – 5 m – 24 AWG

Cable Assembly 5 m - RX4 - MDNEXT-MDFEXT -PSXT

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

802.3bj Cu specifications

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
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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.

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

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
Meg6_LowSR – Narrow	0.1466	0.5849	0.6205	1.0152	1.0847
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*using Algebraic Model v2.02a – see backup slides for values entered in Model

PROPOSED PARAMETERS;
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[Proposal for Defining
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http://www.ieee802.org/3/bj/public/jan12/kochuparambil_01a_0112.pdf

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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 $50 \text{ MHz} \leq f \leq 7500 \text{ MHz}$.

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 $50 \text{ MHz} \leq f \leq 7500 \text{ MHz}$.

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

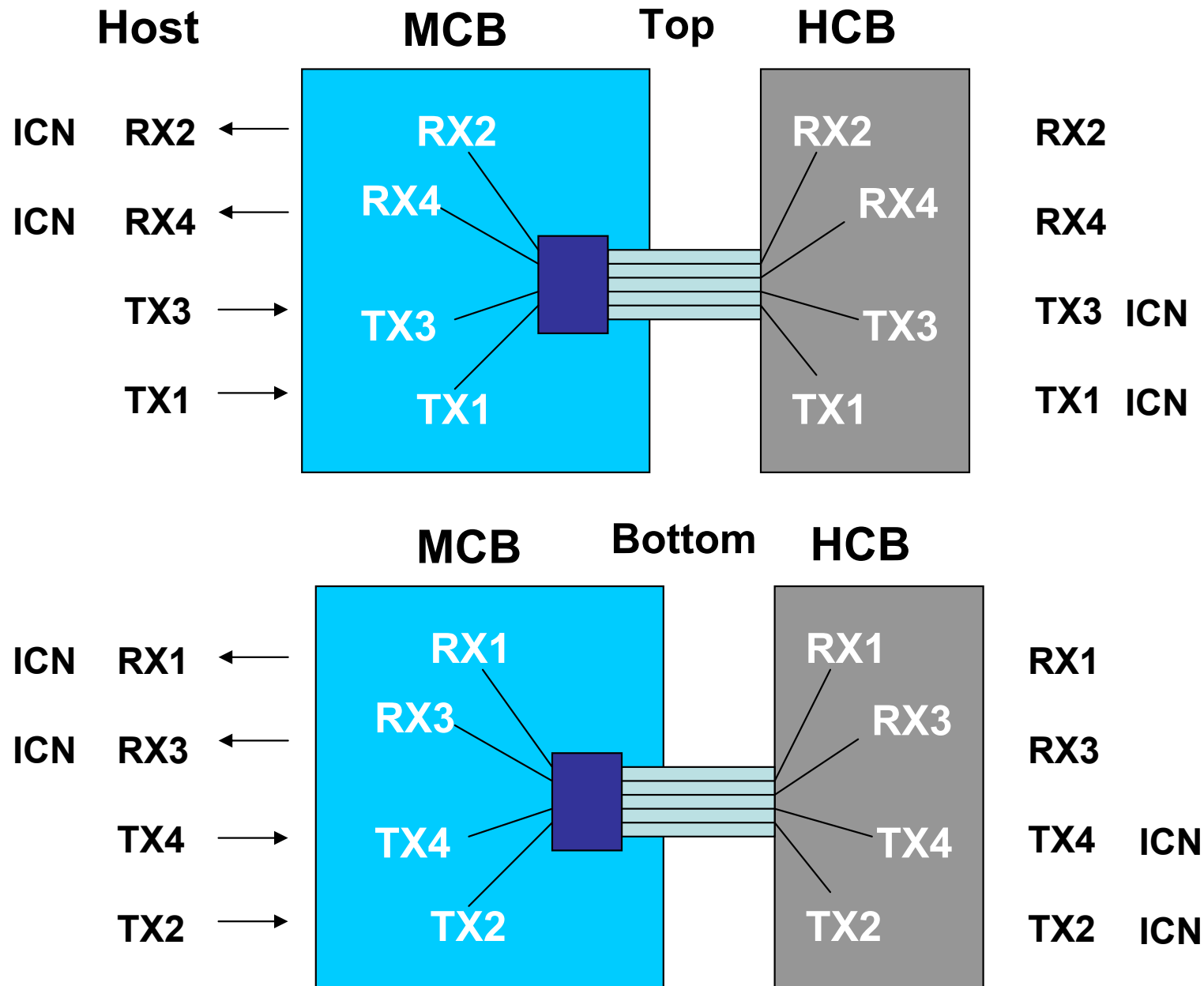
TX3-MDNEXT-RX1,RX2,RX3,RX4

HCB-ICN-TX4

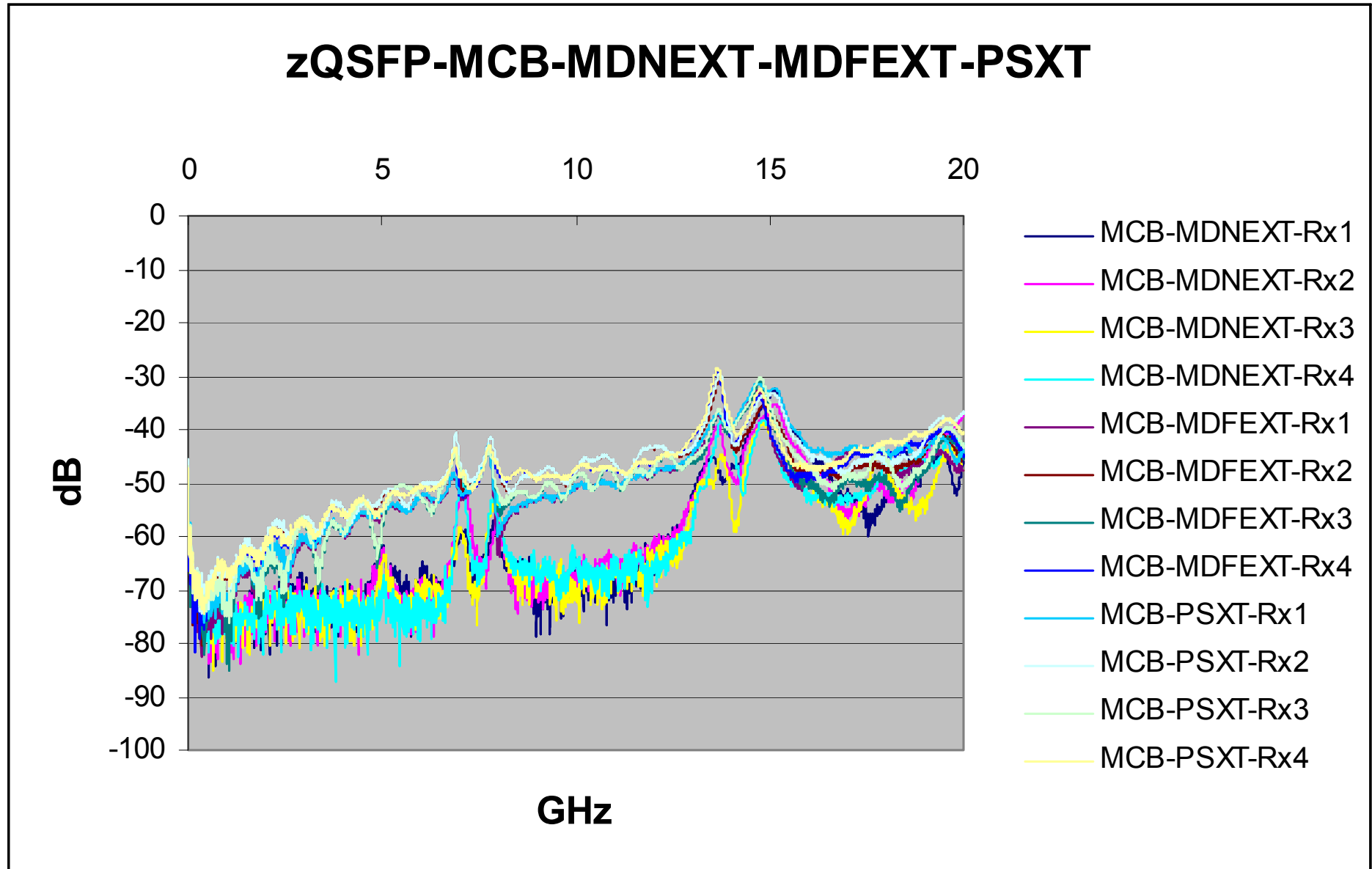
TX4-MDFEXT-TX1,TX2,TX3

TX4-MDNEXT-RX1,RX2,RX3,RX4

Test Fixture Crosstalk

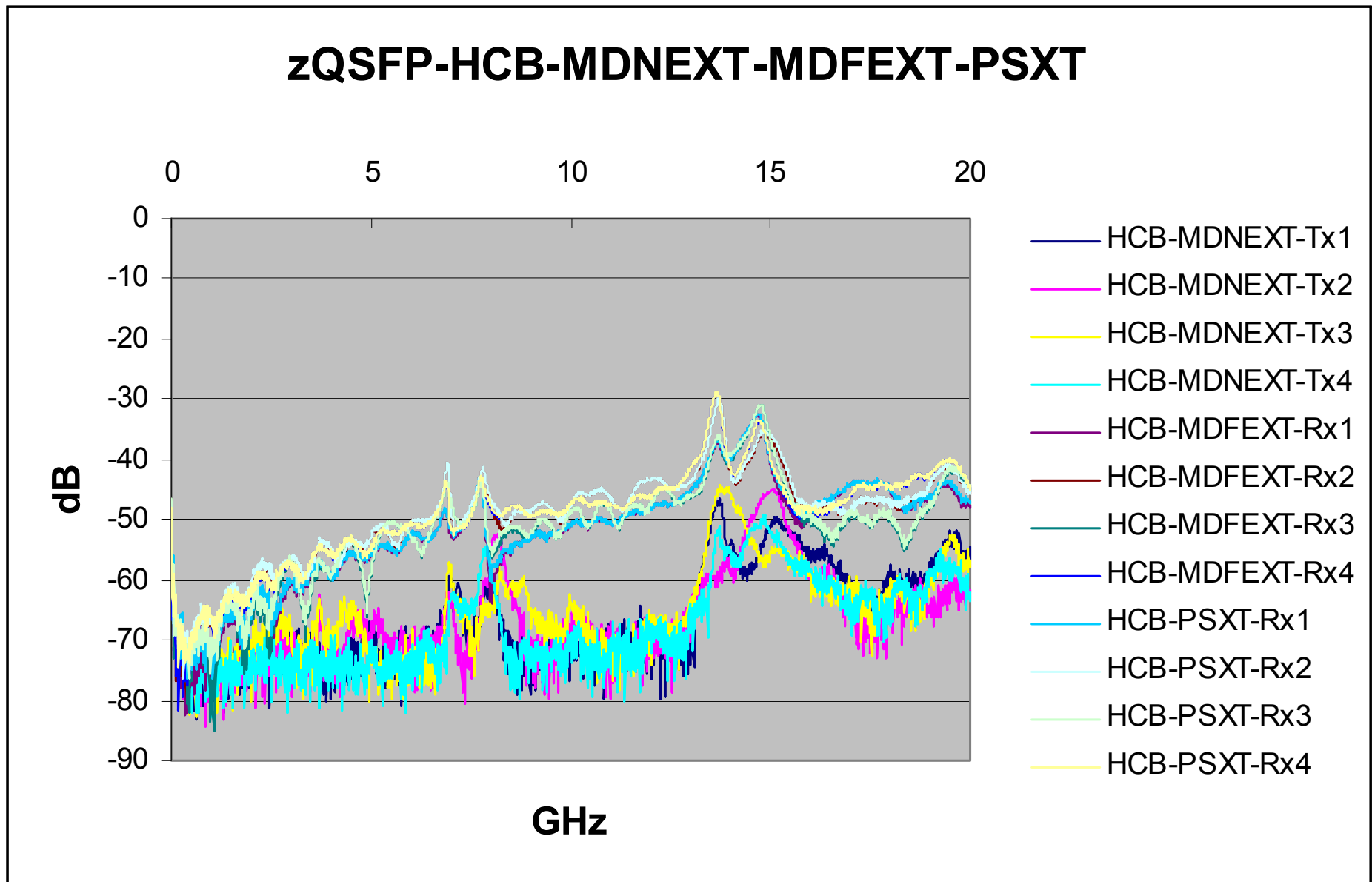


MCB side – Integrated Crosstalk Noise



Molex zQSFP – S4P measurement data provided by Michael Rost – Molex 26

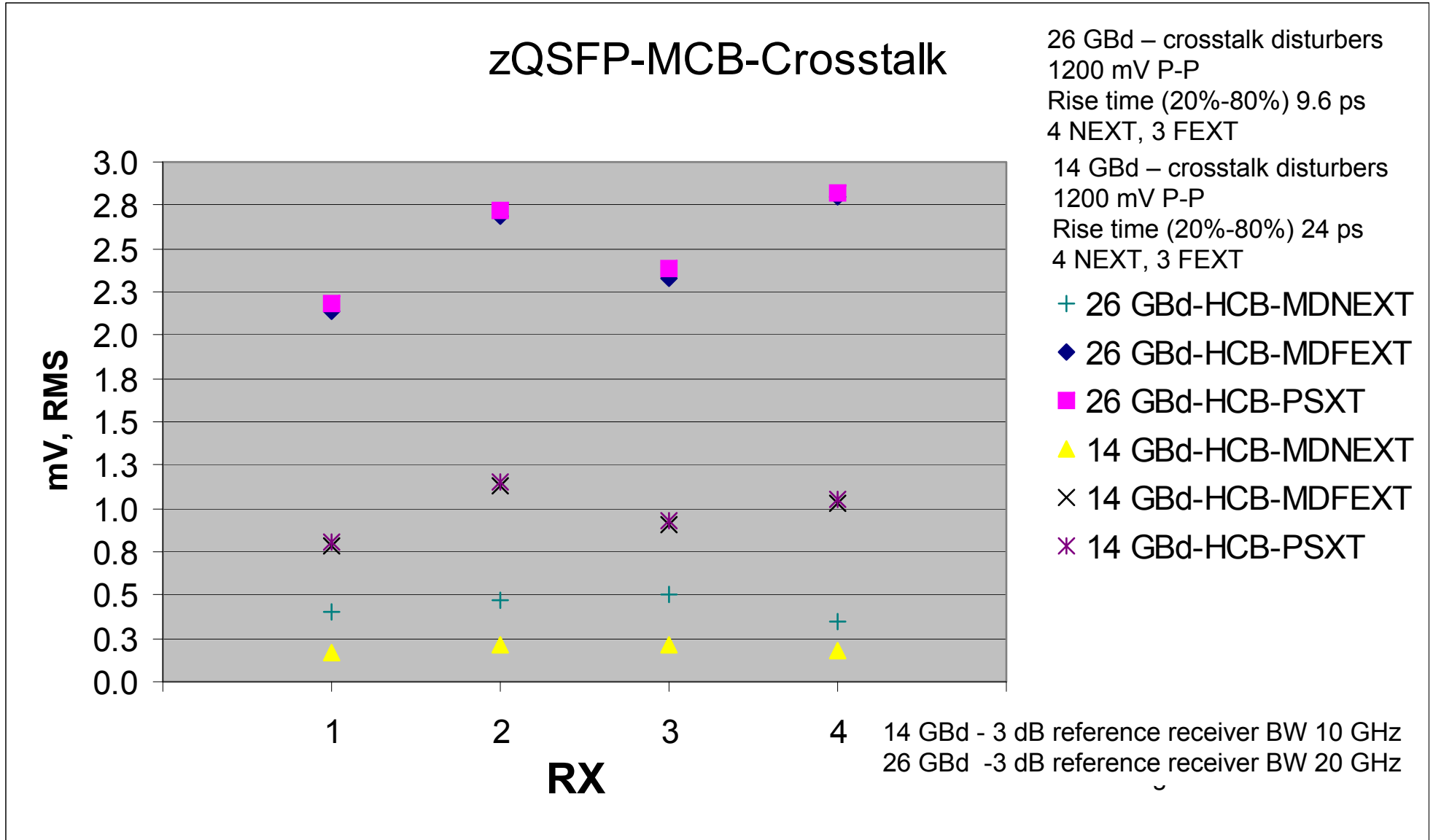
HCB side – Integrated Crosstalk Noise



Molex zQSFP – S4P measurement data provided by Michael Rost – Molex 27

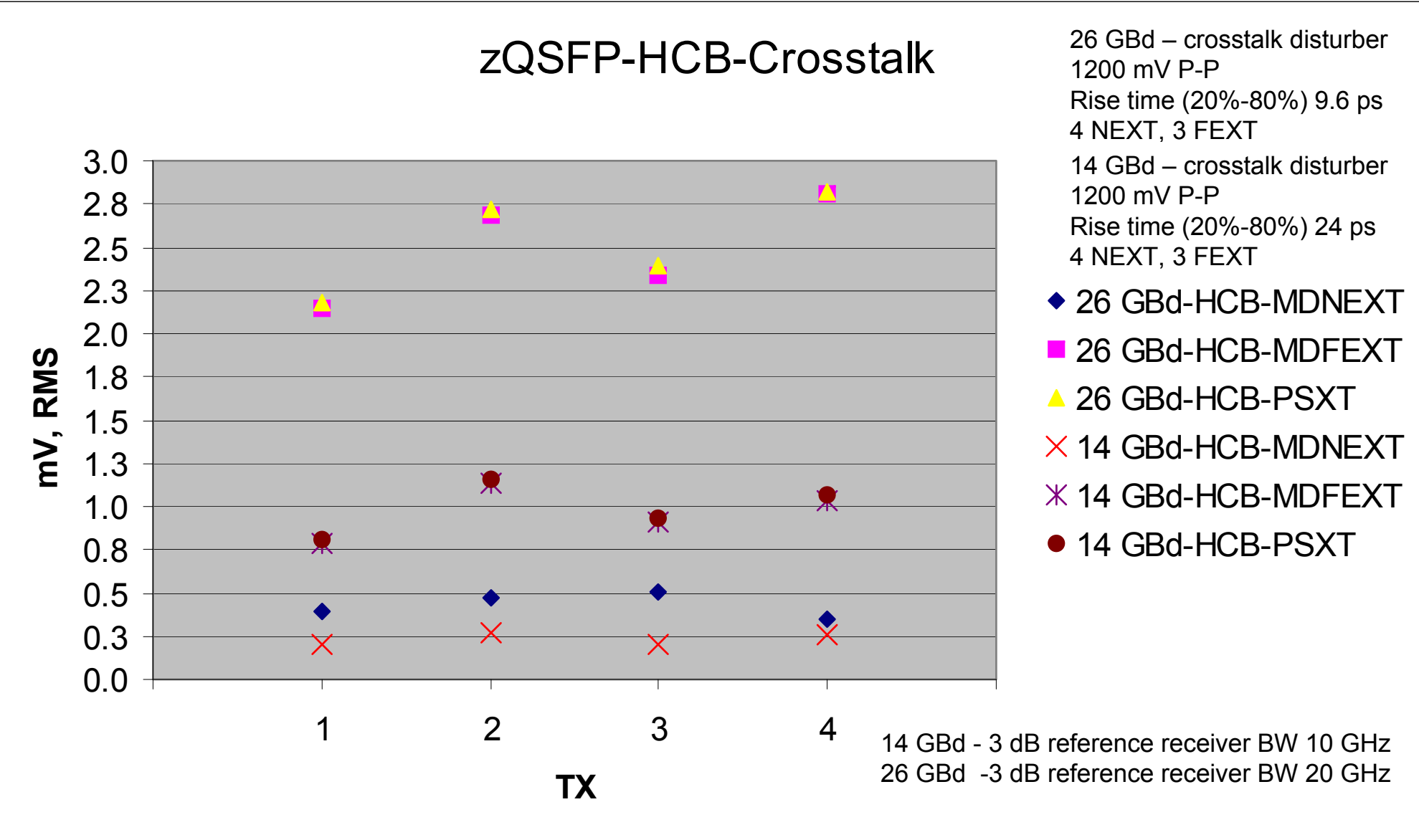
802.3bj Cu specifications

MCB side – Integrated Crosstalk Noise



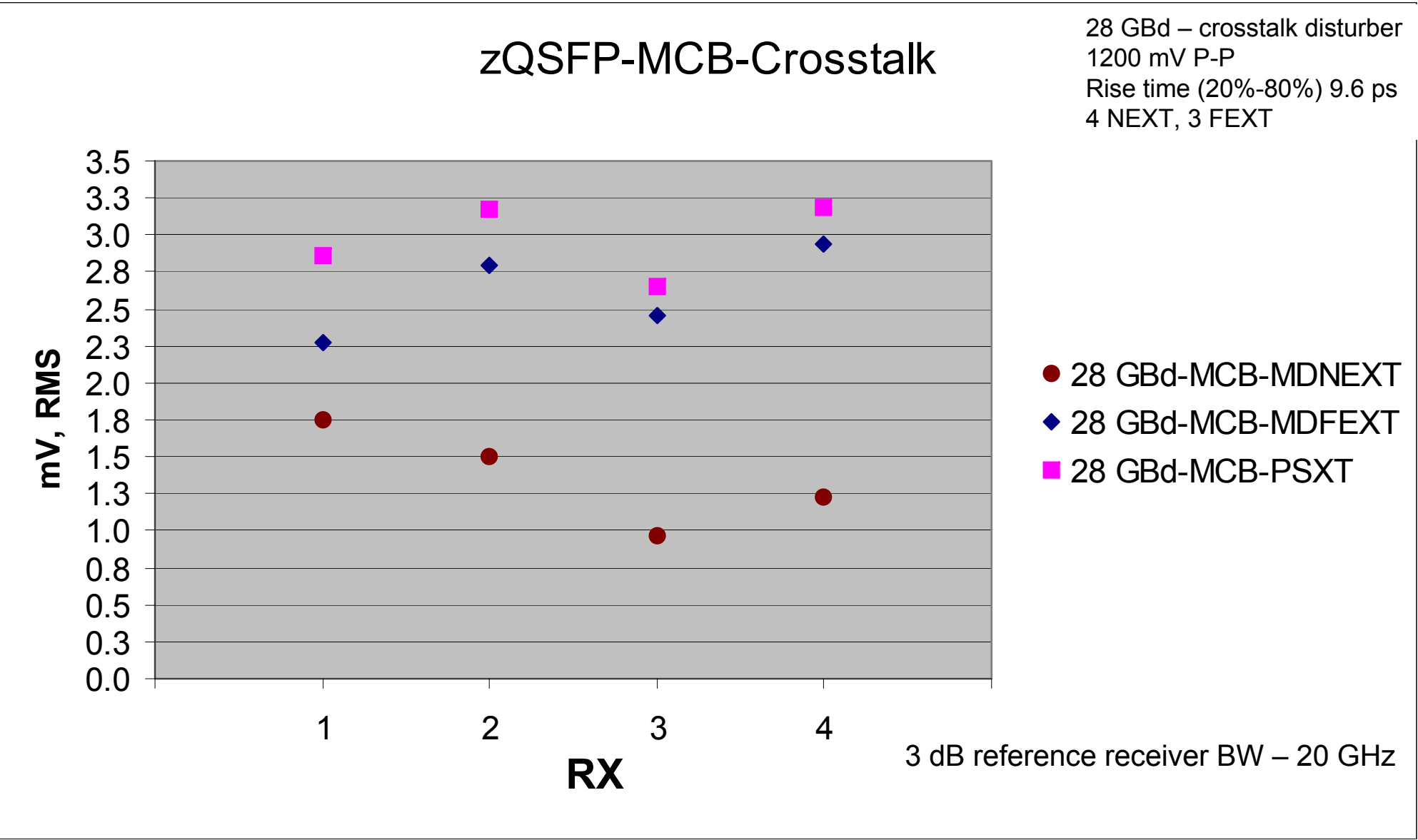
Molex zQSFP – S4P measurement data provided by Michael Rost – Molex 28

HCB side – Integrated Crosstalk Noise



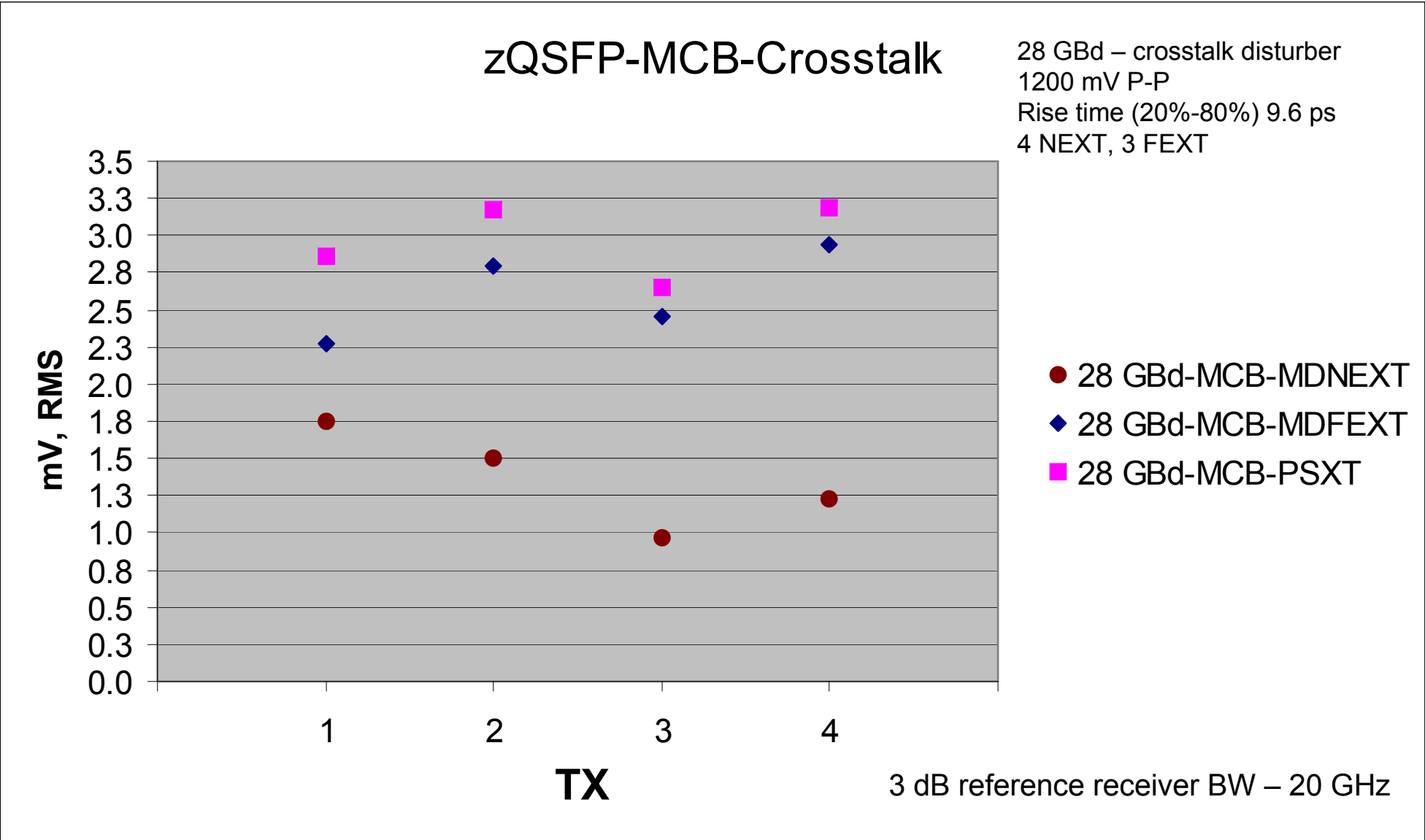
Molex zQSFP – S4P measurement data provided by Michael Rost – Molex 29

MCB side – Integrated Crosstalk Noise



Molex zQSFP – S4P measurement data provided by Michael Rost – Molex 30

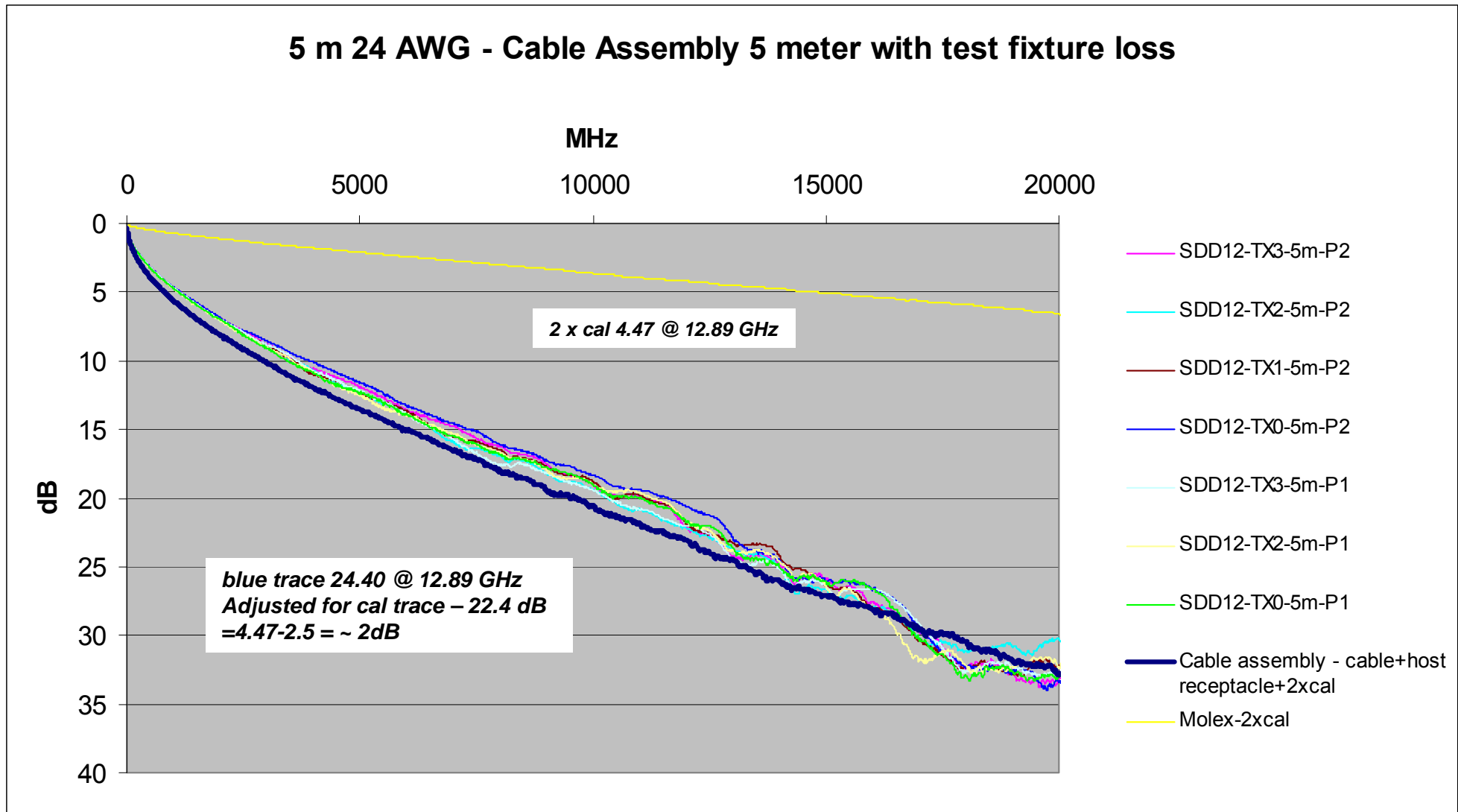
HCB side – Integrated Crosstalk Noise



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)

802.3bj Cu specifications