25 GE 3m NO FEC Consensus Building

IEEE 802.3by 25Gb/s Ethernet
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Consensus Building Discussions

- Not easy to do for anything worth doing.
- The following people got together to have some difficult and candid discussions:
  - Kapil Shrikhande; Vineet Salunke; Tom Palkert; Nathan Tracy; Richard Mellitz; Adee Ran; Upen Reddy Kareti; Mark Nowell; Matt Brown; Mike Dudek; Vittal Balasubramanian; Vivek Telang; Rob Stone; Vasudevan Parthasarathy; Joel Goergen; Megha Shanbhag
- In the coming slides are some thoughts on how to achieve 3m no FEC.

There is Consensus that …

With no changes to specifications, we can not make a 3m no-FEC cable work across solutions smaller then 24awg SFP to SFP with no crosstalk.

Applications need to cover QSFP to QSFP and QSFP to SFP solutions.

Summary of things discussed that could change – p1

- Tx amplitude (Av~ 0.43V or 0.46V, Afe / Ane~ 0.645V or 0.690V) Why not 0.43V or 0.46V for Afe and Ane?
- SNR_tx (28.4dB to 31dB, with current baseline at 27dB. Note bj is currently 31dB for pam4, nrz is 27dB.)
- Package C (Cd ~ 200ff, Cp ~ 130ff, base line is 250 and 180.)
- Package length (Could not find much common ground here to adjust. Main issues coming from C and Z.)
- Package (Z_c) (Z_c~85 Ohms, baseline currently at 78.2 Ohms.)
- CTLE boost (16dB to 20dB boost from base line of 12dB.)

Summary of things discussed that could change – p2

- COM passing point 3.0 (Adjust parameters so 3.0 could remain the same. Could be lowered to 2.5dB but may not be necessary. There is resistance to change com of 3dB with all the other changes.)
- Rx noise spectral density (could not find much common ground here to adjust.)
- Dj (could not find much common ground here to adjust.)
- Cable CA-N could change from 16.48dB to 15.48dB.
- PCB trace loss (Could not find much common ground here to adjust.)

Running the TE 3m 28ga Pair 1 in COM

- TE 3m 28AWG 16.48dB cable assembly QSFP-SFP before any changes …
  - COM = 1.63dB
  - 30mm, Av=.4V, Afe=.4V, Ane=.6V, Cd=250ff, Cp=180ff, CTLE~12dB, Z_c=78.2ohms, SNR_tx~27dB, board_Z_c=109.8ohms
- TE 3m 28AWG 16.48dB cable assembly QSFP-SFP with changes except cable loss and CTLE ...
  - COM = 2.563dB
  - 30mm, Av=.43V, Afe=.43V, Ane=.645V, Cd=200ff, Cp=130ff, CTLE~12dB, Z_c=85ohms, SNR_tx~28.4dB, board_Z_c=109.8ohms
- TE 3m 28AWG 16.48dB cable assembly QSFP-SFP with changes except cable loss …
  - COM =3.211dB
  - 30mm, Av=.43V, Afe=.43V, Ane=.645V, Cd=200ff, Cp=130ff, CTLE~16dB, Z_c=85ohms, SNR_tx~28.4dB, board_Z_c=109.8ohms
- TE 3m 28AWG 16.48dB cable assembly QSFP-SFP with changes except cable loss, die cap, package cap and package impedance …
  - COM = 2.698dB / COM = 2.952 if board_Z_c=100ohms
  - 30mm, Av=.43V, Afe=.43V, Ane=.645V, Cd=250ff, Cp=180ff, CTLE~16dB, Z_c=78.2ohms, SNR_tx~28.4dB, board_Z_c=109.8ohms
- TE 3m 28AWG 16.48dB cable assembly QSFP-SFP with changes except cable loss, die cap, package cap …
  - COM = 2.819dB
  - 30mm, Av=.43V, Afe=.43V, Ane=.645V, Cd=250ff, Cp=180ff, CTLE~16dB, Z_c=85ohms, SNR_tx~28.4dB, board_Z_c=109.8ohms

If We Were to Make Changes …
Our Possible Recommendation for Changes to COM parameters are:

1) Av~0.43V, Afe~0.43V, Ane~0.645V

2) SNRtx~28.4dB

Above changes already are required to meet the 100Gbase - CR4 TP2 specifications

3) CTLE~16dB

Nothing else changes … the host receiver needs to be better. Improved capability over IEEE802.3bj receiver. The way one achieves better receiver performance is up to the vendor.

Running the TE 3m 28ga Pair 1 in COM

- Before any changes were made …
  - 28AWG (16.48dB cable assembly QSFP-SFP) COM margin is = 1.63dB
- After our possible recommendations ...
  - 28AWG (16.48dB cable assembly QSFP-SFP) COM margin is = 2.698dB

Improving the Host Receiver Performance

- The vendor can choose any or a combination of the following for improving the receiver performance
    - Increasing the CTLE
    - Increasing the package impedance
    - Reducing the package length
    - Reducing the host board length
    - Reducing the package capacitance, die capacitance
    - Reducing receiver noise
- The improved receiver performance is not necessarily a chip performance, but an equivalent improvement to CTLE AC/DC gain of 16dB.

Summary Slide

- We have identified a number of approaches that have strong potential for allowing us to specify 3m no FEC cable operation without breaking existing implementations by taking advantage of known flexible parameters.
    - Recommend straw polling for continued direction
    - Recommend the chair provide guidance towards creating a proposal

Thank you!

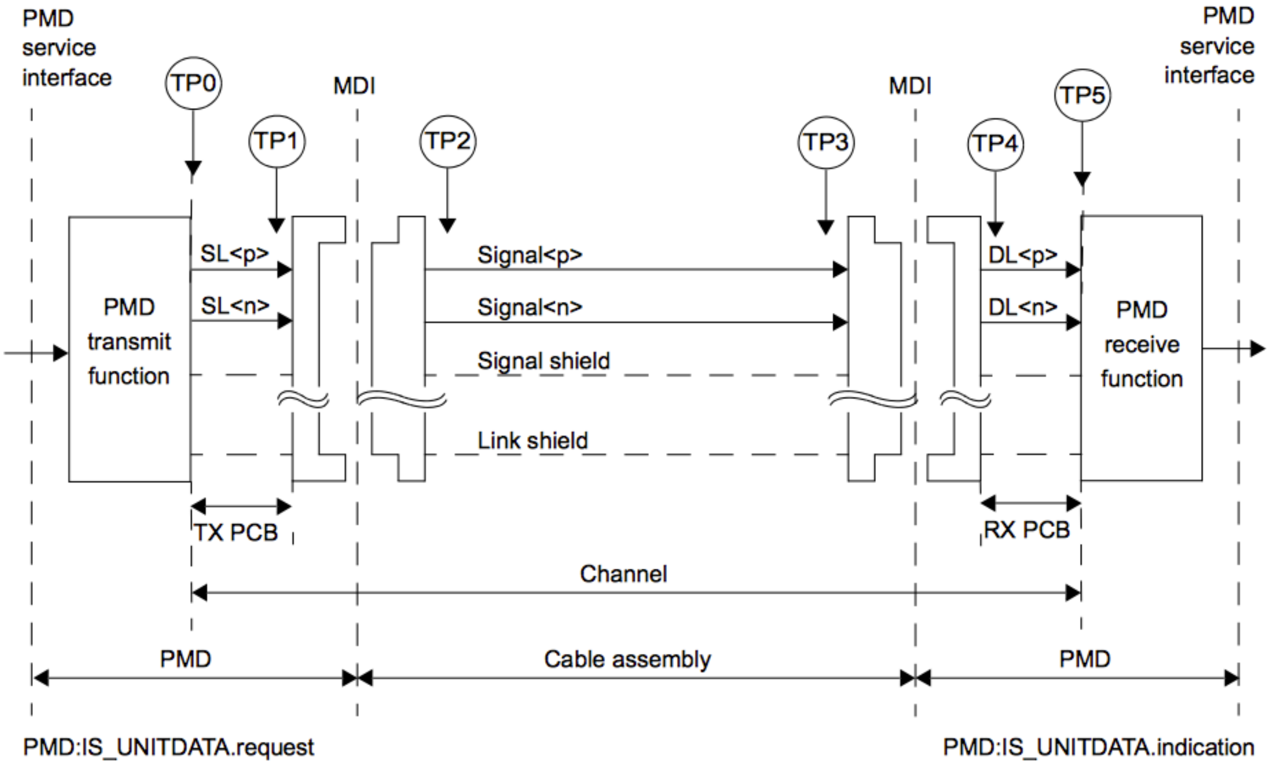
From:

The Following Back-up Slides …

The following slides are a collection of the parameters we could adjust, more or less.

These parameters come from IEEE802.3by work and are quick pasted for reference

One direction of a 25GBASE-CR or 25GBASE-CR-S link is shown in Figure 110–2.



IEEE P802.3by D1.0

Table 92–6—Transmitter characteristics at TP2 summary

Parameter	Subclause reference	Value	Units
Differential peak-to-peak output voltage (max.) with Tx disabled	92.8.3.1	35	mV
DC common-mode voltage (max.)	92.8.3.1	1.9	V
AC common-mode output voltage, v_{cmi} (max., RMS)	92.8.3.1	30	mV
Differential peak-to-peak voltage, v_{di} (max.)	92.8.3.1	1200	mV
Differential output return loss (min.)	92.8.3.2	See Equation (92–1)	dB
Common-mode to differential mode output return loss (min.)	92.8.3.3	See Equation (92–2)	dB
Common-mode to common-mode output return loss (min.)	92.8.3.4	See Equation (92–3)	dB
Transmitter steady-state voltage, v_f (min.) Transmitter steady-state voltage, v_f (max.)	92.8.3.5.2	0.34 0.6	V
Linear fit pulse peak (min.)	92.8.3.5.2	$0.45 \times v_f$	V
Transmitted waveform abs coefficient step size (min.) abs coefficient step size (max.) minimum precursor full-scale ratio minimum post cursor full-scale ratio	 92.8.3.5.4 92.8.3.5.4 92.8.3.5.5 92.8.3.5.5	 0.0083 0.05 1.54 4	
Signal-to-noise-and-distortion ratio (min.)	92.8.3.7	26	dB
Output jitter (max.) Even-odd jitter, peak-to-peak Effective bounded uncorrelated jitter, peak-to-peak Effective total uncorrelated jitter, peak-to-peak	 92.8.3.8.1 92.8.3.8.2 92.8.3.8.2	 0.035 0.1 0.18	 UI UI UI
Signaling rate, per lane	92.8.3.9	25.78125±100 ppm	GBd
Unit interval nominal	92.8.3.9	38.787879	ps

Table 92–7—Receiver characteristics at TP3 summary

Parameter	Subclause reference	Value	Units
Receiver input amplitude tolerance	92.8.4.1	1200 mV as measured at TP2	mV
Differential input return loss (min)	92.8.4.2	Equation (92–20)	dB
Differential to common-mode input return loss	92.8.4.3	Equation (92–21)	dB
Interference Tolerance	92.8.4.4	Table 92–8	—
Signaling rate, per lane	92.8.4.6	25.78125 ± 100 ppm	GBd
Unit interval (UI) nominal	92.8.4.6	38.787879	ps

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Table 92–8—100GBASE-CR4 interference tolerance parameters

Parameter	Test 1 values	Test 2 values	Units
RS-FEC symbol error ratio[a]	10^{-4}	10^{-4}	
Fitted insertion loss coefficients	$a_1 = 1.7$ $a_2 = 0.546$ $a_4 = 0.01$	$a_1 = 4.3$ $a_2 = 0.571$ $a_4 = 0.04$	dB/√GHz dB/GHz dB/GHz^2
Applied SJ[b] (peak-to-peak)	0.1	0.1	UI
Applied RJ (RMS)	0.01	0.01	UI
Even-odd jitter	0.035	0.035	UI
COM (max)	3	3	dB

[a] The FEC symbol error ratio is measured in step 11 of the receiver interference tolerance method defined in 93C.2.

[b] Applied SJ frequency >100 MHz, specified at TP0.

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Table 110–7—25GBASE-CR and 25GBASE-CR-S interference tolerance parameters, no-FEC mode

Parameter	Test 1 (low loss)	Test 2 (high loss)	Units
Test pattern	Scrambled idle or PRBS31		
Bit error ratio required[a]	$< 10^{-12}$		
Fitted insertion loss coefficients a_1 a_2 a_4	 1.7 0.546 0.01	 3 0.29 0.02	 dB/√GHz dB/GHz dB/GHz^2
Approximate fitted loss at 12.89 GHz[b]	14.8	17.57	dB
Applied SJ[c] (peak-to-peak)	0.1		UI
Applied RJ (RMS)	0.01		UI
Even-odd jitter	0.035		UI
COM (max)	3		dB
b_{max} used in COM calculation	0.5		
DER_0 used in COM calculation	10^{-12}		

[a]The bit error ratio is measured using the PCS errored blocks counter (see 49.2.14.2) or the PMA PRBS31 error counter (see 109.4.5.4) as appropriate.
[b]Fitted insertion loss between the two test reference points (see Figure 92–10).
[c]Applied SJ frequency >100 MHz, specified at TP0.

Table 110–9—Cable assembly characteristics summary

Description	Reference	CA-L	CA-S	CA-N	
Maximum insertion loss at 12.8906 GHz	110.10.2	22.48	16.48	12.98	dB
Minimum insertion loss at 12.8906 GHz	110.10.2		8		dB
Minimum differential return loss at 12.8906 GHz	110.10.3		6		dB
Differential to common-mode return loss	110.10.4		Equation (92–28)		dB
Differential to common-mode conversion loss	110.10.5		Equation (92–29)		dB
Common-mode to common-mode return loss	110.10.6		Equation (92–30)		dB

Maybe 15.48dB

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Table 110–10—COM parameter values

Parameter	Symbol	CA-N	CA-S	CA-L	Units
Maximum start frequency	f_{min}	0.05	0.05	0.05	GHz
Maximum frequency step	Δf	0.05	0.01	0.01[a]	GHz
Device package model					
Single-ended device capacitance	C_d	2.5×10^{-4}			nF
Transmission line length, Test 1	z_p	12			mm
Transmission line length, Test 2	z_p	30			mm
Single-ended package capacitance at package-to-board interface	C_p	1.8×10^{-4}			nF
Transmitter differential peak [illegible]					
Victim	[illegible]	[illegible]0.4			V
Alien far-end aggressor	A_{fe}	[illegible]0.6			V
Near-end aggressor	A_{ne}	0.6			V
Normalized DFE coefficient magnitude limit, for $n = 1$ to N_b	$b_{max}(n)$	0.5	0.5	1	—
Target detector error ratio	DER_0	10^{-12}	10^{-8}	10^{-5}	—

[a]For cable lengths greater than 4 m, a frequency step (Δf) no larger than 5 MHz is recommended.

Av~.43V / .46V

Afe~.43 / .645V / .690V

Ane~.645V / .690V

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COM - ran_com_3bj_3bm_01_1114-3

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	25.78125	GBd	
f_min	0.05	GHz	
Delta_f	0.005	GHz	
C_d	[2.5e-4 2.5e-4]	nF	
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 30]	mm	[test cases]
z_p (NEXT)	[12 12]	mm	[test cases]
z_p (FEXT)	[12 30]	mm	[test cases]
z_p (RX)	[12 30]	mm	[test cases]
C_p	[1.8e-4 1.8e-4]	nF	
R_0	50	Ohm	
R_d	[55 55]	Ohm	[TX RX]
f_r	0.75	*fb	
c(0)	0.62		min
c(-1)	[-0.18:0.02:0]		[min:step:max]
c(1)	[-0.38:0.02:0]		[min:step:max]
g_DC	[-12:1:0]	dB	
f_z	6.4453125	GHz	
f_p1	6.4453125	GHz	
f_p2	25.78125	GHz	

A_v	0.4	V	
A_fe	0.4	V	
A_ne	0.6	V	
L	2		
M	32		
N_b	14	UI	
b_max(1)	1		
b_max(2..N_b)	1		
sigma_RJ	0.01	UI	
A_DD	0.05	UI	
eta_0	5.20E-08	V^2/GHz	
SNR_TX	27		
R_LM	1		
DER_0	1.00E-05		
Operational control			
COM Pass threshold	3		
Include PCB	1	logical	

- 200ff (C_d)
- 130ff (C_p)
- 16dB~20dB (g_DC)
- 28.4dB~31dB (SNR_TX)
- Maybe 2.5dB (COM Pass threshold)

COM - ran_com_3bj_3bm_01_1114-3

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical
SAVE_FIGURE_to_CSV	0	logical
RESULT_DIR	.\test_results_C92\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
IDEAL_TX_TERM	0	logical
T_r	8.00E-03	ns

Non standard control options		
INC_PACKAGE	1	logical
IDEAL_RX_TERM	0	logical
INCLUDE_CTLE	1	logical
INCLUDE_TX_RX_FILTER	1	logical

Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	78.2	Ohm

85 Ohms

Table 92–12 parameters		
Parameter	**Setting**	
board_tl_gamma0_a1_a2	[0 4.114e-4 2.547e-4]	
board_tl_tau	6.191E-03	ns/mm
board_Z_c	109.8	Ohm
z_bp (TX)	151	mm
z_bp (NEXT)	72	mm
z_bp (FEXT)	72	mm
z_bp (RX)	151	mm