Towards support of 3m no FEC cables

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Outline

- Explore COM drive amplitude parameters
  - Using Tx compliance for 30mm COM package
- Explore the COM 30mm package contribution for Signal-to-noise-and-distortion ratio (SNDR, 92.8.3.7)
- Revisit assumptions for Gaussian noise
- COM results for 3m 26AWG cable
- Break down impact
- Summary, Recommendation, & Discussion

V_f min is 0.4 Volts at TP0a with this test setup

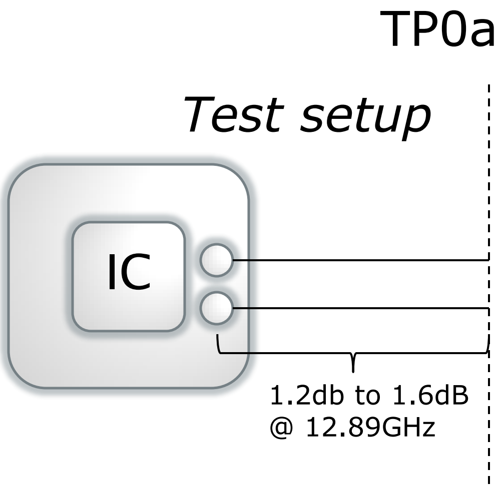
93.8 100GBASE-KR4 electrical characteristics

93.8.1 Transmitter characteristics

Transmitter characteristics measured at TP0a are summarized in Table 93–4.

Table 93–4—Summary of transmitter characteristics at TP0a

Parameter	Subclause reference	Value	Units
Signaling rate	93.8.1.2	25.78125±100 ppm	GBd
Differential peak-to-peak output voltage (max.)	93.8.1.3		
Transmitter disabled		30	mV
Transmitter enabled		1200	mV
DC common-mode output voltage (max.)	93.8.1.3	1.9	V
DC common-mode output voltage (min.)	93.8.1.3	0	V
AC common-mode output voltage (RMS, max.)	93.8.1.3	12	mV
Differential output return loss (min.)	93.8.1.4	Equation (93–3)	dB
Common-mode output return loss (min.)	93.8.1.4	Equation (93–4)	dB
Output waveform			
Steady-state voltage v_f (max.)	93.8.1.5.2	0.6	V
Steady-state voltage v_f (min.)	93.8.1.5.2	0.4	V
Linear fit pulse peak (min.)	93.8.1.5.2	$0.71 \times v_f$	V
Normalized coefficient step size (min.)	93.8.1.5.4	0.0083	—
Normalized coefficient step size (max.)	93.8.1.5.4	0.05	—
Pre-cursor full-scale range (min.)	93.8.1.5.5	1.54	—
Post-cursor full-scale range (min.)	93.8.1.5.5	4	—
Signal-to-noise-and-distortion ratio (min.)	93.8.1.6	27	dB
Output jitter (max.)	93.8.1.7		
Even-odd jitter		0.035	UI
Effective bounded uncorrelated jitter, peak-to-peak		0.1	UI
Effective total uncorrelated jitter, peak-to-peak		0.18	UI



Tx compliance:
Setup to determine V_f for the 30mm Zp package

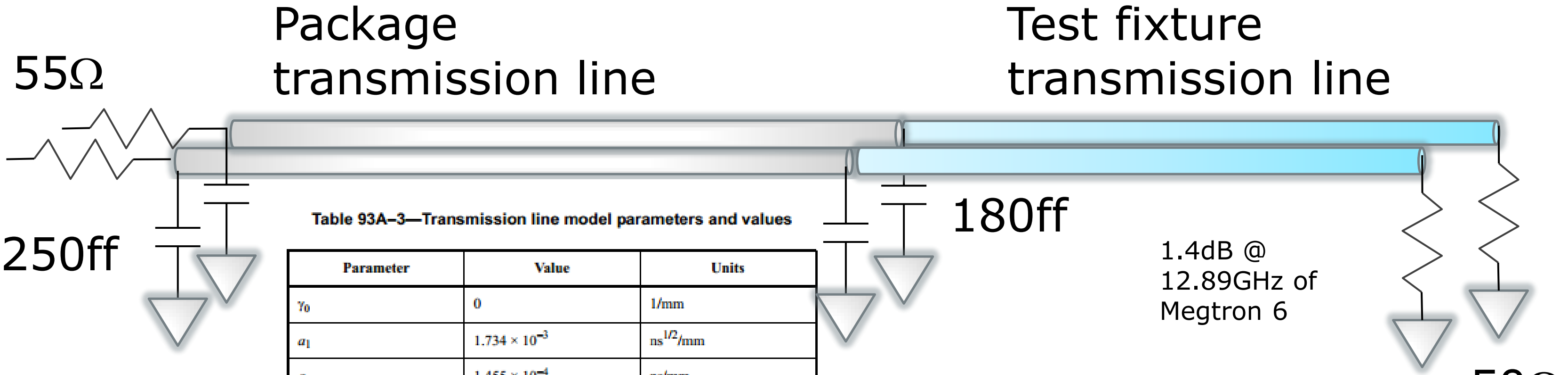


Table 93A–3—Transmission line model parameters and values

Parameter	Value	Units
γ_0	0	1/mm
a_1	1.734×10^{-3}	$ns^{1/2}$/mm
a_2	1.455×10^{-4}	ns/mm
τ	6.141×10^{-3}	ns/mm
Z_c	78.2	Ω

The scattering parameters for a package transmission line of length z_p are defined by Equation (93A–13) and Equation (93A–14). The units of z_p are mm.

$$s_{11}^{(l)}(f) = s_{22}^{(l)}(f) = \frac{\rho(1-\exp(-\gamma(f)2z_p))}{1-\rho^2\exp(-\gamma(f)2z_p)} \qquad (93A–13)$$

$$s_{21}^{(l)}(f) = s_{12}^{(l)}(f) = \frac{(1-\rho^2)\exp(-\gamma(f)z_p)}{1-\rho^2\exp(-\gamma(f)2z_p)} \qquad (93A–14)$$

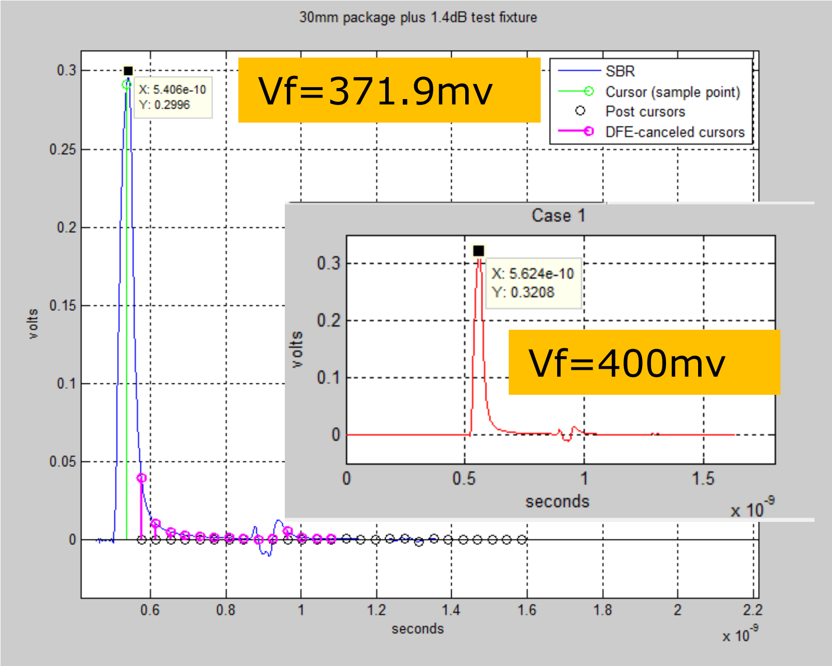
Reference: COM table used on test fixture as channel

Parameter	Setting	Units	Information
f_b	25.78125	GBd	
f_min	0.05	GHz	
Delta_f	0.005	GHz	
C_d	[2.5e-4 0]	nF	[TX RX]
z_p select	[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 0]	mm	[test cases]
z_p (RX)	[12 0]	mm	[test cases]
C_p	[1.8e-4 0]	nF	[TX RX]
R_0	50	Ohm	
R_d	[55 55]	Ohm	[TX RX]
f_r	20	*fb	
c(0)	0.62		min
c(-1)	[0]		[min:step:max]
c(1)	[0]		[min:step:max]
g_DC	[0]	dB	[min:step:max]
f_z	644.53125	GHz	
f_p1	644.53125	GHz	
f_p2	2578.125	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	dB	
R_LM	1		
DER_0	1.00E-03		

DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
Display frequency domain	1	logical
CSV_REPORT	1	logical
SAVE_FIGURE_to_CSV	0	logical
RESULT_DIR	.\result_pkg_test\	
SAVE_FIGURES	0	logical
SAVE_RESP	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	1	logical
INCLUDE_CTLE	0	logical
INCLUDE_TX_RX_FILTER	0	logical

We can use a test fixture and the COM calculations to determine V_f and package component of σ_n

V_f is 371.9mV and V_f(min) spec is 400mV



- steady_state_voltage_mV: 371.8728
  - This is V_f
- To reach a V_f of 400mv
  - It takes a V_a=430.25 mV
  - P_max becomes 320.08

One component of Signal-to-noise-and-distortion ratio (SNDR) is ISI after the DFE reach.

- At a DER of 1e-3 (3 sigma) the peak ISI is 6mV
- 1 sigma is 2 mV
- SNDR= 20*log10(Pmax/noise_sigma)
- If pmax=320.08mv and SNDR is spec'ed at 27 dB, the noise budget sigma is 14.3mV.
- However 2mv is already included for in the spec package.
- The SNR_TX (SNDR) for COM adjusted for the 30 mm package becomes 28.3dB
  - This avoids double counting

92.8.3.7 Transmitter output noise and distortion

Signal-to-noise-and-distortion ratio (SNDR) is measured at the transmitter output using the following method, with transmitters on all PMD lanes enabled and transmitting the same pattern with identical transmit equalizer settings.

Given a configuration of the transmit equalizer, capture at least one complete cycle of the test pattern PRBS9 as specified in 83.5.10 at TP0a per 85.8.3.3.4. Compute the linear fit pulse response $p(k)$ and the linear fit error waveform $e(k)$ from the captured waveform per 85.8.3.3.5 using $N_p = 14$ and $D_p = 2$. Denote the standard deviation of $e(k)$ as σ_e.

Given the same configuration of the transmit equalizer, measure the RMS deviation from the mean voltage at a fixed point in a run of at least 8 consecutive identical bits in a suitable pattern. PRBS9 is an example of a pattern that includes runs suitable to perform the measurement. It is recommended that the deviation is measured within the flattest portion of the waveform at a point where the slope is closest to zero. The RMS deviation is measured for a run of zeros and also a run of ones. The average of the two measurements is denoted as σ_n.

SNDR is defined by Equation (92–9) where p_{max} is the maximum value of $p(k)$.

$$SNDR = 10\log_{10}\left(\frac{p_{max}^2}{\sigma_e^2 + \sigma_n^2}\right)\ \text{dB} \qquad (92\text{–}9)$$

Bounding the SNDR (SNR_TX) Gaussian

- We are not using real distribution and COM is being computed for probabilities much lower than in the ‘bj project.
- Equation 93A–42 is a little pessimistic for a number of reasons.
- Recommendation: limit y to +/- 5 sigma as in Rx interference tolerance testing. Suggest new parameter in COM table for this as G_Q

The amplitude distribution of the Gaussian noise term is defined by Equation (93A–42).

$$p_G(y) = \frac{\exp(-y^2/(2\sigma_G^2))}{\sqrt{2\pi\sigma_G^2}} \qquad (93A\text{–}42)$$

First Resilts: 3 meter cables pass COM

- Recommendation for no FEC COM table for 30mm package
  - G_Q is new

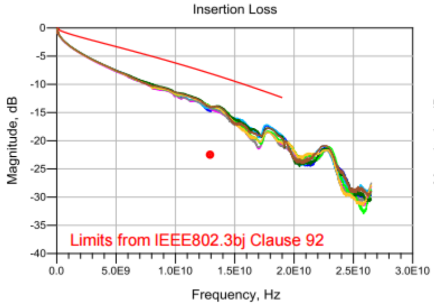
A_v	0.43	V	
A_fe	0.43	V	
SNR_TX	28.4	V	
G_Q	5		

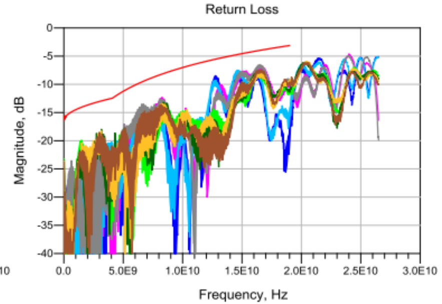
- Sample results from a 3m 26AWG cable
  - shanbhag_020415_25GE_adhoc_v2.pdf
  - COM for 30mm Package becomes 2.71dB
    - G_Q=4 COM: 2.904dB
    - G_Q=3 COM: 3.265dB
  - ½ dB improvement in COM

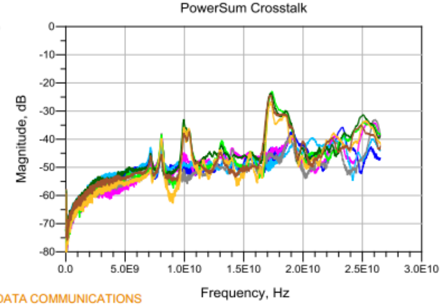
3 Meter, 26AWG, Measurement

QSFP28 – SFP28 Breakout

Cable assembly measurement includes test points







DATA COMMUNICATIONS

QSFP-4SFP, 3m 26AWG						
	DER0 = 1e-5		DER0 = 1e-8		DER0 = 1e-12	
Victim	Case1	Case2	Case1	Case2	Case1	Case2
P1_TX1	7.311	6.496	5.244	4.400	3.583	2.705
P1_TX2	7.154	6.341	5.078	4.240	3.404	2.550
P1_TX3	7.179	6.397	5.115	4.305	3.545	2.620
P1_TX4	7.324	6.480	5.261	4.401	3.595	2.707
P2_TX1	6.953	6.142	4.844	4.008	3.142	2.296
P2_TX2	6.926	6.192	4.808	4.056	3.118	2.343
P2_TX3	6.970	6.061	4.893	3.941	3.219	2.245
P2_TX4	6.951	6.231	4.876	4.126	3.202	2.424
Avg	7.096	6.293	5.015	4.185	3.351	2.486

2.71

- COM Release date 08/14, Revision1.54
- All parameters at default except DER0 which is as stated in table

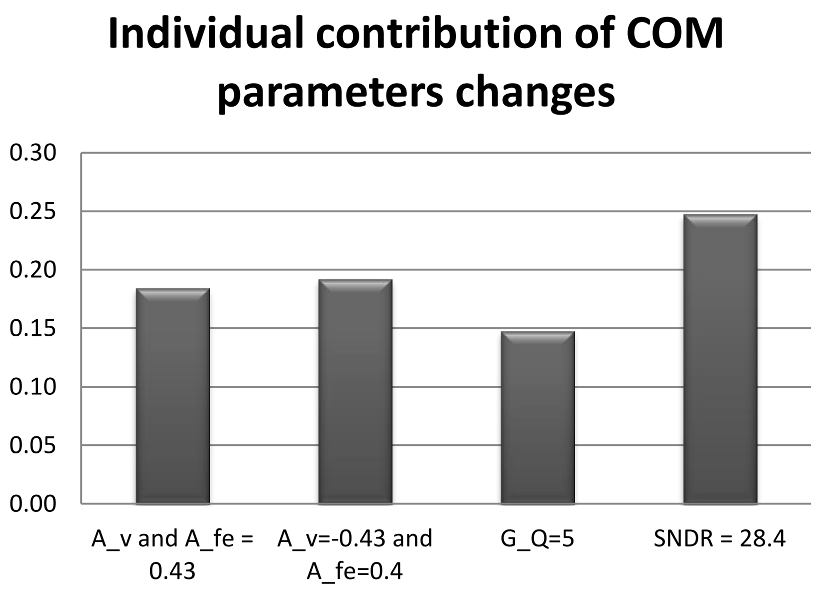
TE connectivity

0.57 dB Average COM Improvement For No FEC Case 2 (30mm package)

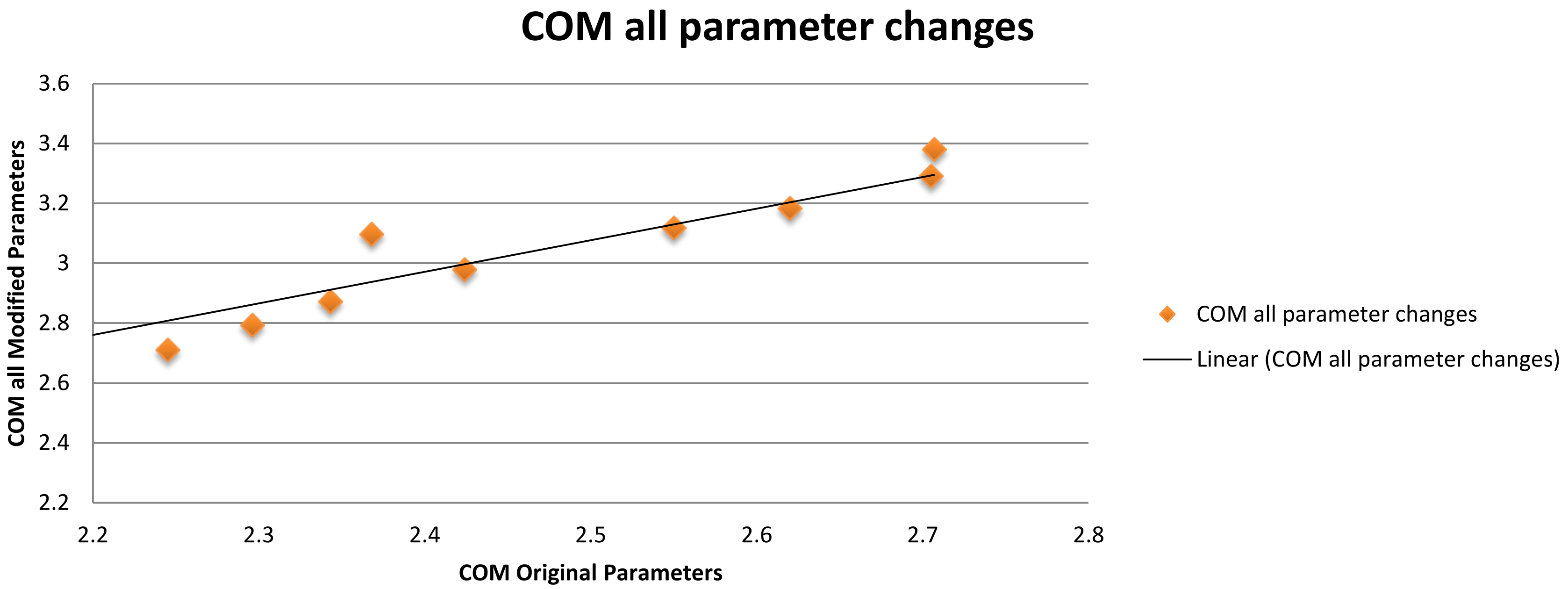
TE QSFP-4SFP, 3m 26AWG Case2 30mm package									
	DER0=1e-5			DER0=1e-8			DER0=1e-12		
A_v	0.4	0.43		0.4	0.43		0.4	0.43	
A_fe	0.4	0.43		0.4	0.43		0.4	0.43	
SNR_TX	27	28.4		27	28.4		27	28.4	
G_Q	-	5		-	5		-	5	
	COM (dB)	COM (dB)	change	COM (dB)	COM (dB)	change	COM (dB)	COM (dB)	change
P1_TX1	6.50	6.84	0.34	4.40	4.81	0.41	2.71	3.29	0.59
P1_TX2	6.34	6.68	0.34	4.24	4.64	0.40	2.55	3.12	0.57
P1_TX3	6.40	6.75	0.36	4.31	4.72	0.41	2.62	3.18	0.56
P1_TX4	6.48	6.86	0.38	4.40	4.86	0.46	2.71	3.38	0.67
P2_TX1	6.14	6.48	0.34	4.01	4.41	0.40	2.30	2.79	0.50
P2_TX2	6.19	6.56	0.37	4.06	4.49	0.43	2.34	2.87	0.53
P2_TX3	6.06	6.38	0.32	3.94	4.31	0.37	2.25	2.71	0.46
P2_TX4	6.23	6.60	0.37	4.13	4.55	0.42	2.42	2.98	0.56
Amphenol 3m 26AWG QSFP-4SFP APN43140033HXJ Case2 30mm package									
P1TX1_P2RX1							1.92	2.40	0.48
P1TX2_P2RX2							2.37	3.10	0.73
P1TX3_P2RX3							2.10	2.62	0.51
P1TX4_P2RX4							1.70	2.36	0.66
avg change in com			0.35			0.41			**0.57**

Impact Breakdown

- Individual parameters impacts don’t necessarily add linearly
- Crosstalk amplitude change has little effect.
- SNDR is the biggest contributor



Plot COM with originals parameters vs. COM tune parameters suggest COM of 2.4 dB for no FEC could be justified.



Summary

- Refining Tx parameters used in COM enable at least some 3 meter cables.
- Decision options and discussion:
  - Change COM pass limit to 2.4 dB for no FEC

  Or

  - Change Tx COM parameters
- The former is the simplest.
- Both raise questions