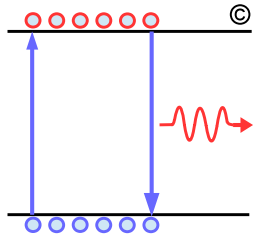


Feasibility of 30 dB Channel at 50 Gb/s

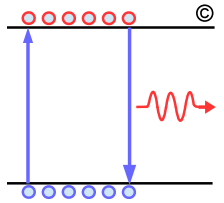
Ali Ghiasi

Ghiasi Quantum LLC

50 GbE & NGOATH Plenary Meeting

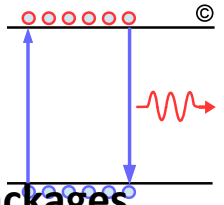
March 16, 2016

List of supporters



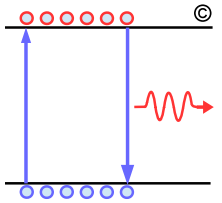
- **Upen Reddy Kareti – Cisco**
- **Vipul Bhatt – Inphi**
- **James Fife - eToups**

Overview

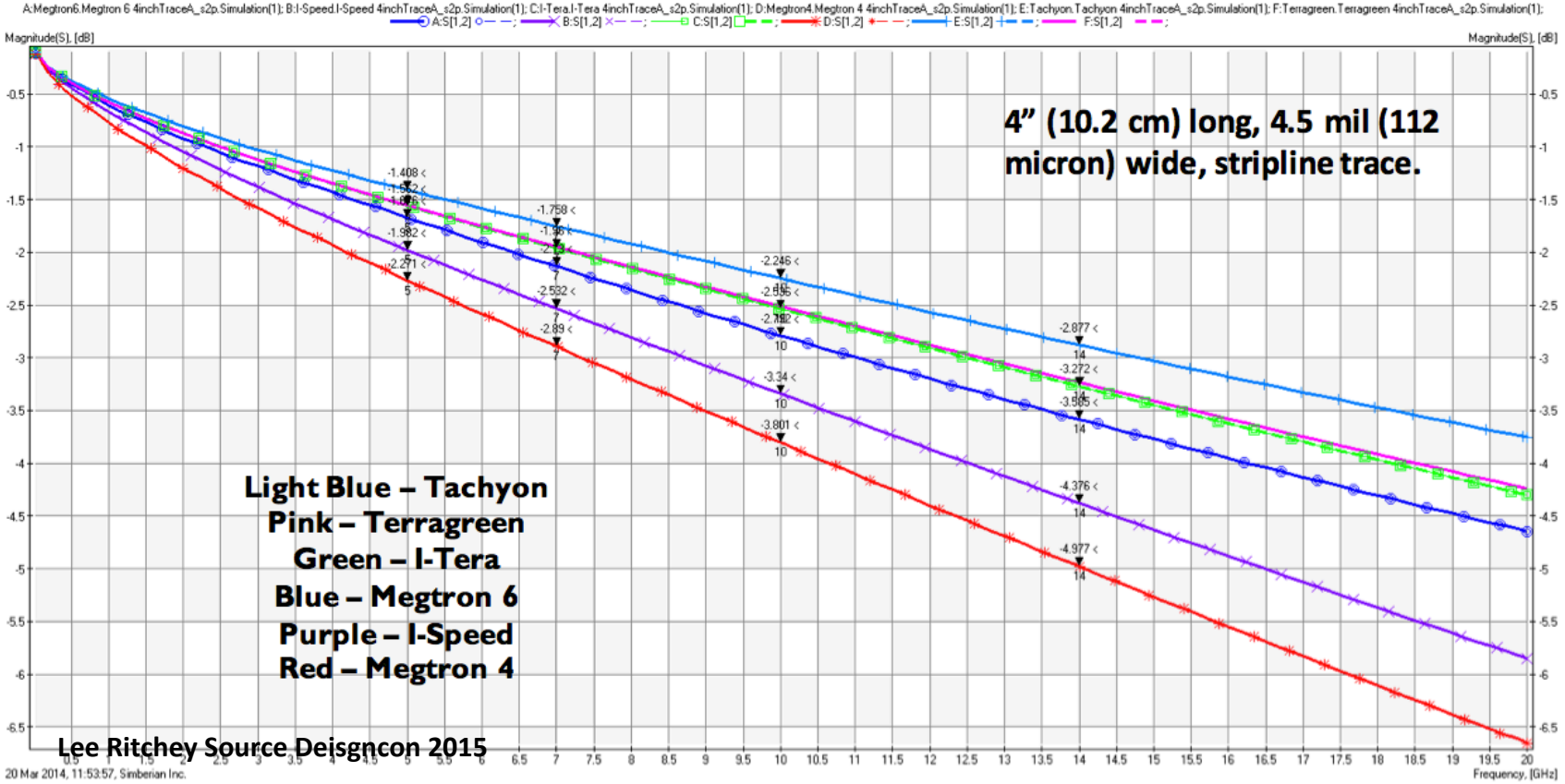


- **IEEE COM package is ~0.6 dB more pessimistic than representative GZ-41 packages with similar length**
- **Baseline CDAUI-8 C2C COM parameters were tightening to provide 2+ dB of COM margin on following 30 dB channels**
  - TE Whisper Std 1 m backplane
  - TE Whisper 1 m backplane with Embedded Cap PAM4
  - IBM 1 m backplane
  - IBM 30 dB backplane
- **TE Whisper has 4 FEXT and 4 NEXT aggressors**
  - Typical system will group the TX and RX pairs in effect reducing the NEXT aggressors
  - IBM backplane based on older connector is performing as good as TE Whisper because of the TX and RX lanes group therefore eliminating NEXT
- **IBM channels were based on older system and connector, since then there are several new improved connector in the market**
  - Molex Impel and Impel+
  - FCI ExaMax
- **Newer 3 m AWG 26 have end-end loss of 27.5 dB**
  - Considering stack connector excess loss and crosstalk 30 dB is good target to support 3 m cables
- **Typical 50G PAM4 receiver will use CTLE/Long FFE and possibly followed by 1-2 tap DFE is a significant deviation from current COM models**
  - Current COM model indicates the need for large pre-cursors but real receiver with long FFE does not need the pre-cursor instead needs more post-cursors!

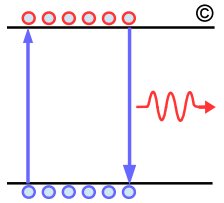
More Advance PCB Material Only Modestly Improves the Backplane Loss



- **Even moving from Megtron 6 DF~0.005 to Tachyon DF~0.0021 the loss only improves by ~20%**
  - With DF≤ 0.005 loss is now dominated by conductor size and roughness
  - 1 m Backplane reach support is required.

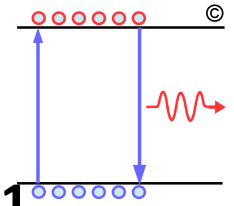


Changes Made to Baseline CDAUI-8 C2C COM parameter for 50G KP4



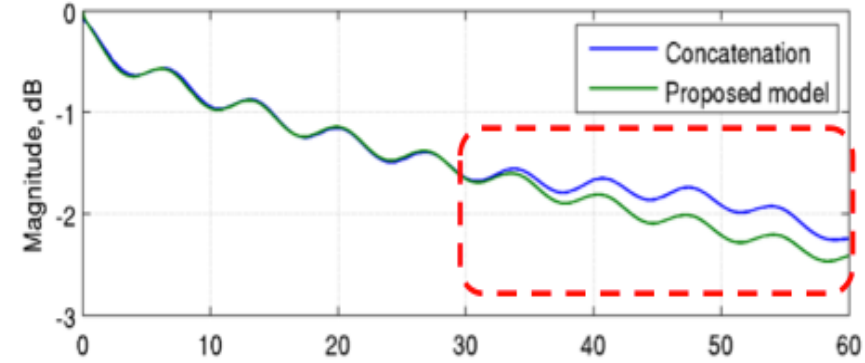
Parameters	CDAUI-8 C2C COM Parameters	50G KP4 COM Parameters
Baudrate	26.5625 GBd	26.5625 GBd
Device Capacitance Cd [TX, RX]	[0.28, 0.28] pf	[0.2, 0.2] pf
BGA pad Cp [TX, RX]	[0.11, 0.11] pf	[0.11, 0.11] pf
CTLE Gain	15 dB	18 dB
G_DC_HP	4 dB	6 dB
TX SNR	31.1 dB	32 dB
DER	1E-5	1E-4
# of taps N_b	10	16, 20, 24
B_max(1)	0.5	0.75
B_max(2..N_b)	0.2	0.375
C(0)	0.6	0.6
C(1)	0.35	NA (did not help & to speed up)
C(-1)	-0.15	-0.24 (max value used for channels)
C(-2)	NA	+0.06 (max value used for channels)
Package Zc impedance	85 Ω	90 Ω
COM threshold	3 dB	2 dB

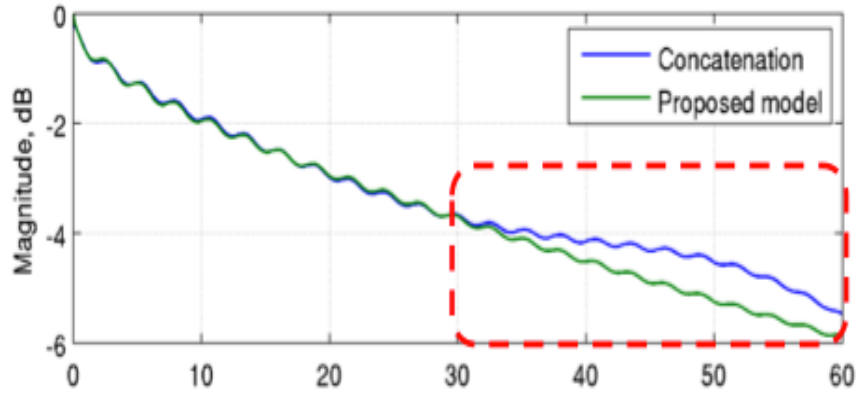
IEEE Package Model



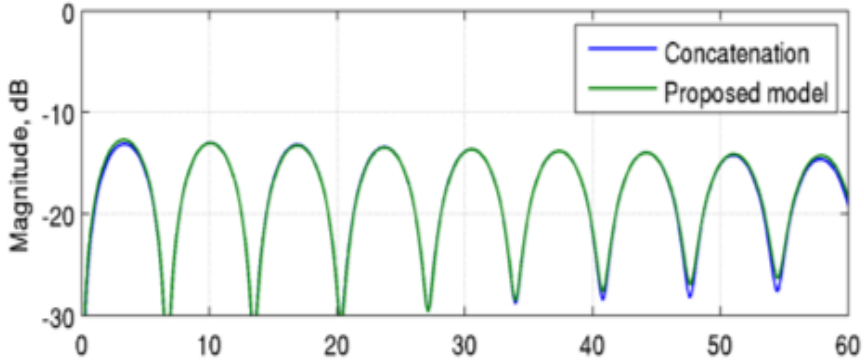
- **IEEE package has strong ripple in the return loss and SDD21**
  - Representative GZ-41 packages have more than 0.6 dB of COM margin compare to IEEE package.

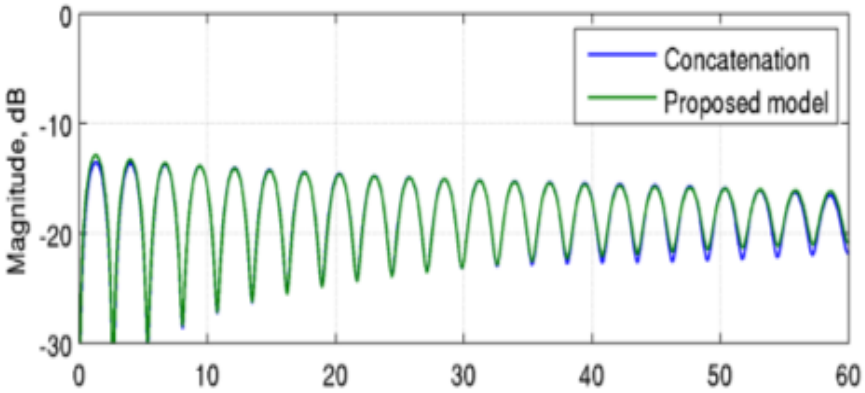
s21



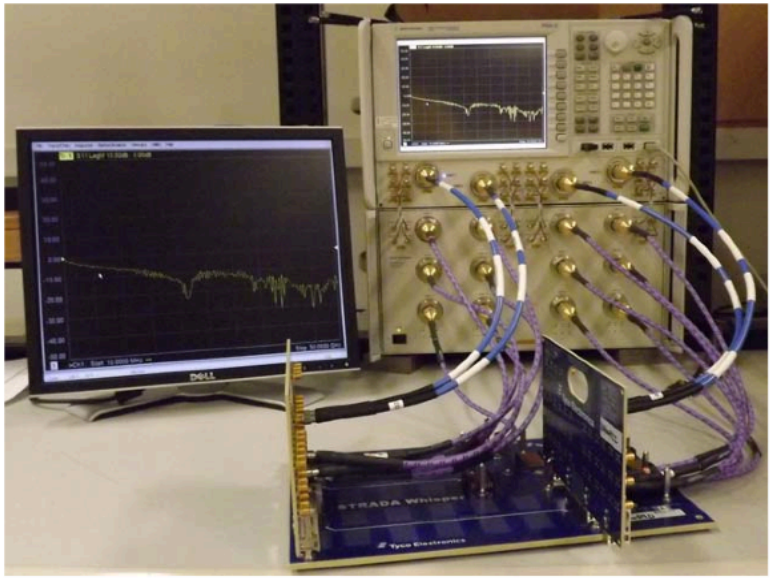


s11





TE Whisper 40” Backplane



H11-H12	H14-H15	H17-H18
G11-G12	G14-G15	G17-G18
F11-F12	F14-F15	F17-F18

- All data is measured and includes 2.4mm test points
- Measurements are pair G14-G15 centric .s4p files
- 4 Near-End and 4 Far-End measurements
- Data is from 0-30GHz in 10MHz steps

DAUGHTER CARD

- Board Material = Megtron6 VLP
- Trace length = 5”
- Trace geometry = Stripline
- Trace width = 6 mils
- Differential trace spacing = 9 mils
- PCB thickness = 110mils, 14 layers
- Counterbored vias, up to 6mil stub
- Test Points = 2.4mm (included in data)

BACKPLANE

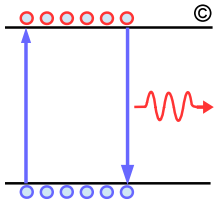
- Board Material = Megtron6 HVLP
- Trace length = 30”
- Trace geometry = Stripline
- Trace width = 6 mils
- Differential trace spacing = 9 mils
- PCB thickness = 200 mils, 20 layers
- Counterbored vias, up to 6mil stub

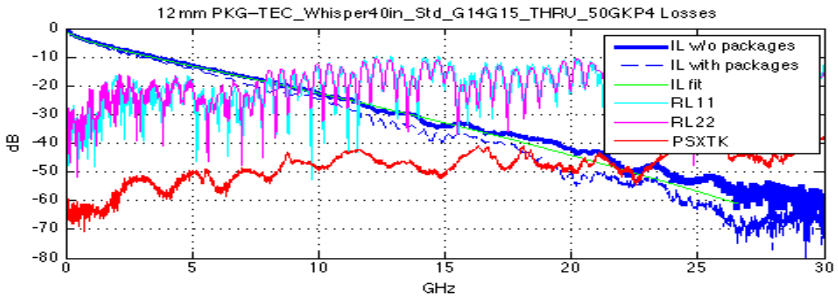
CONNECTORS

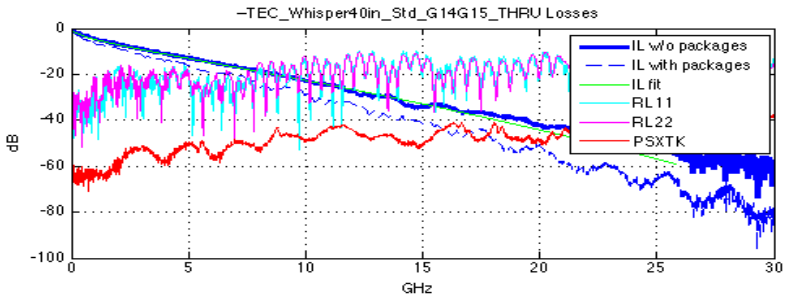
Use
- Dataset 1 includes
  - Mated standard STRADA Whisper connector at each end
- Dataset 2 includes
  - Mated Embedded Capacitor STRADA Whisper connector at one end and,
  - Mated standard STRADA Whisper connector at other end

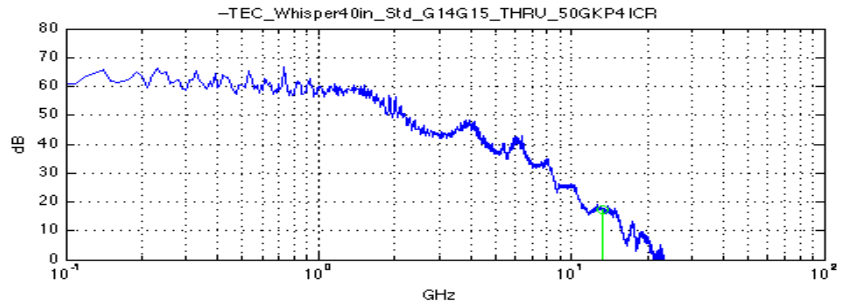
TE Whisper 1 m Std Backplane

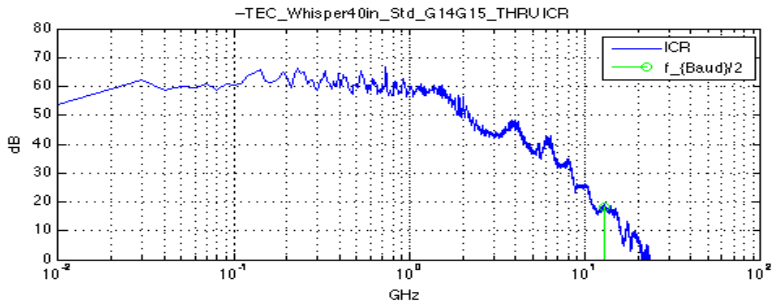
http://www.ieee802.org/3/bj/public/jul13/tracy_3bj_01_0713.pdf

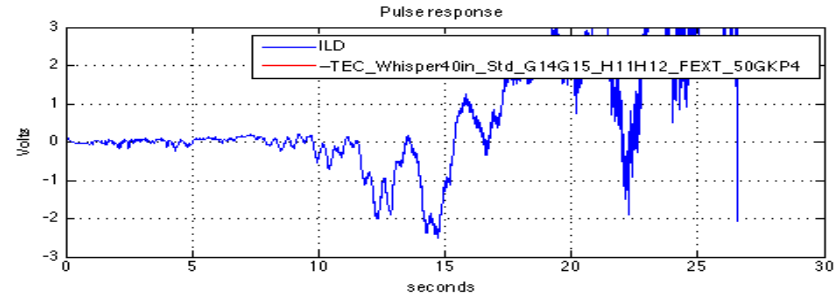


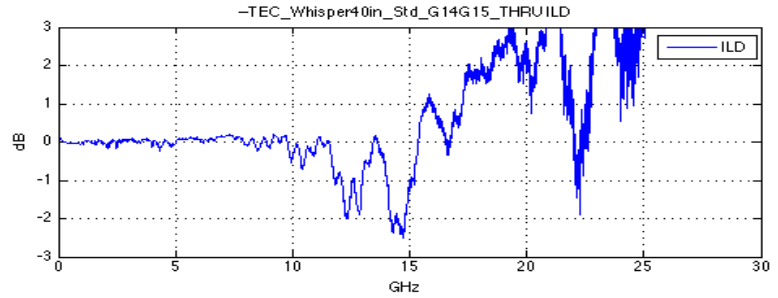






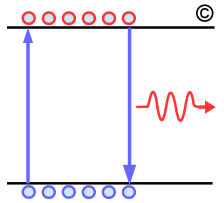


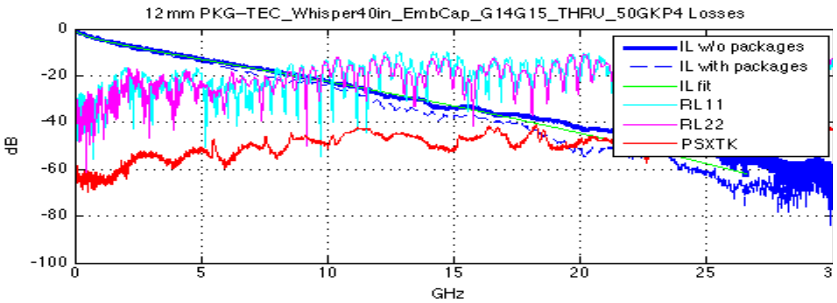


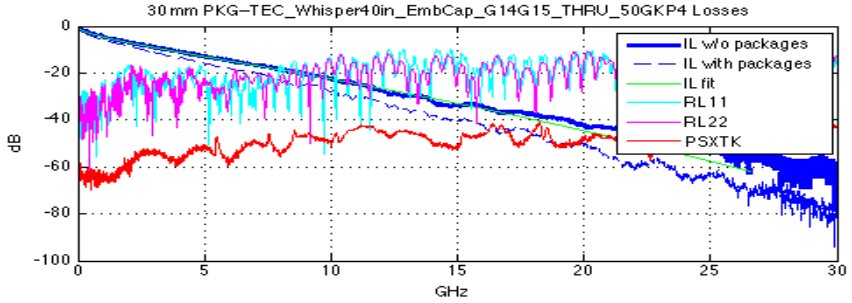


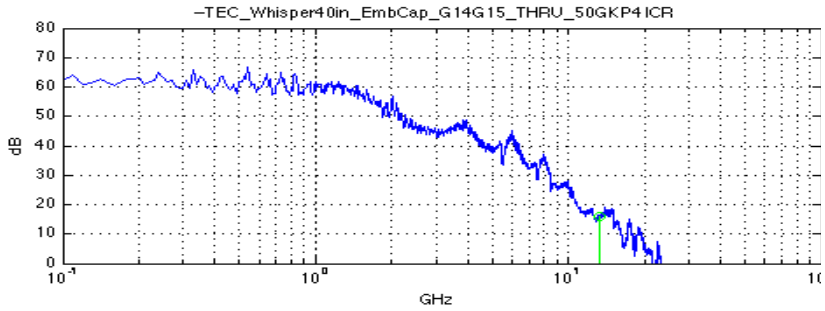
TE Whisper 1 m Backplane with Imbedded Cap

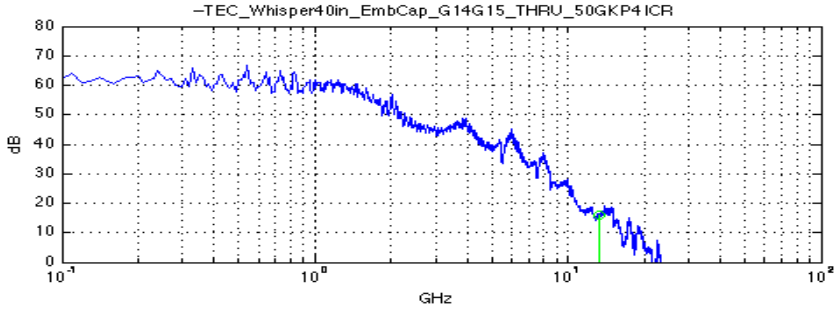
http://www.ieee802.org/3/bj/public/jul13/tracy_3bj_01_0713.pdf

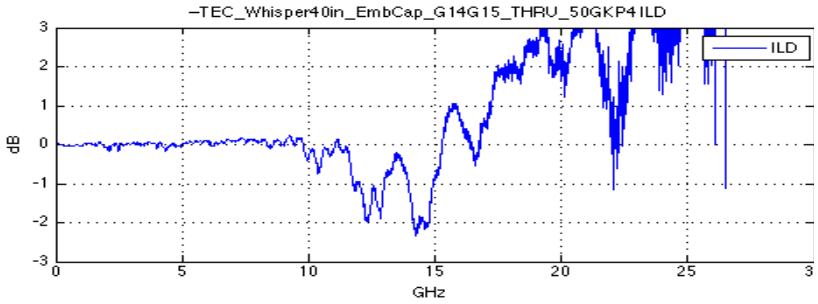


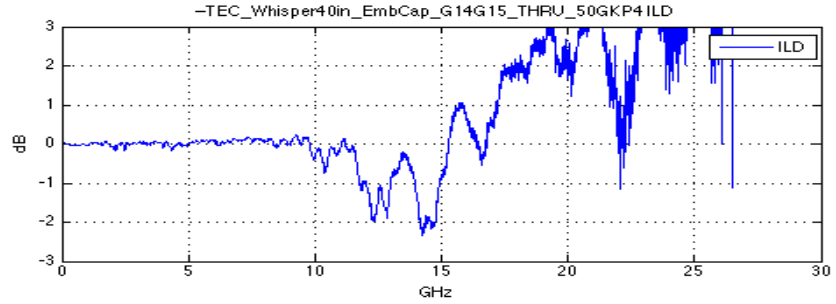




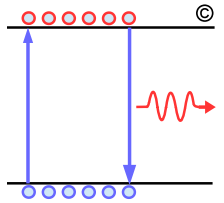








Summary Results for TE Whisper 1 m Backplane

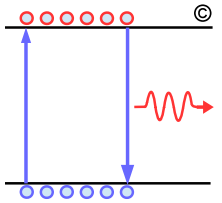


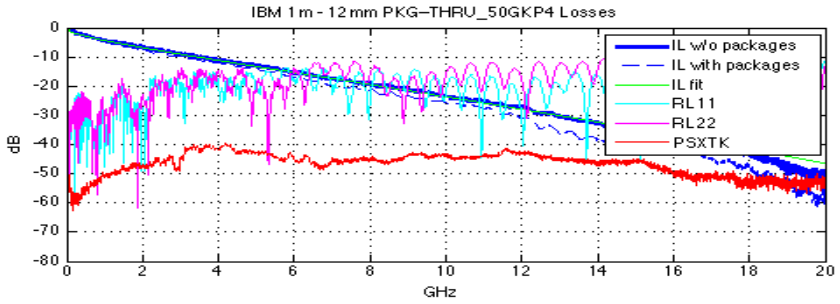
- **To safely say a channel passes 2 dB of COM margin is required!**
  - Pre $C(-2)_{max}$=0.04, $C(-1)_{min}$=-0.22

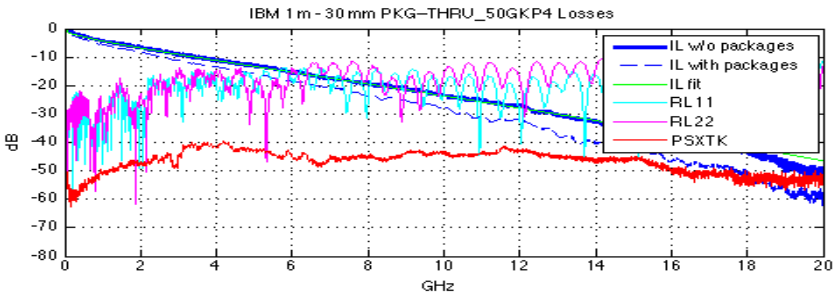
Test Cases	Channel IL (dB)	DFE	ISI/Noise/ XTALK	ILD	ICN (mV)	PSXT (mV)	COM (dB)
Std Backplane IEEE 12 mm Package	29.8	24	35/65/0%	0.39	0	0	5.05
Std Backplane IEEE 30 mm Package	29.8	24	28/72/0%	0.39	0	0	4.58
Std Backplane IEEE 12 mm Package	29.8	24	22/40/39%	0.37	1.63	3.22	2.82
Std Backplane IEEE 30 mm Package	29.8	24	21/41/38%	0.37	1.63	2.63	2.23
Std Backplane IEEE 12 mm Package	29.8	20	23/39/38%	0.37	1.67	3.22	2.75
Std Backplane IEEE 30 mm Package	29.8	20	22/41/37%	0.37	1.67	2.66	2.2
Std Backplane IEEE 12 mm Package	29.8	16	23/39/38%	0.37	1.67	3.19	2.66
Std Backplane IEEE 30 mm Package	29.8	16	22/41/37%	0.37	1.67	2.66	2.17
ImbCap Backplane IEEE 12 mm Package	29.8	16	24/41/35%	0.40	1.58	3.03	3.09
ImbCap Backplane IEEE 30 mm Package	29.8	16	19/44/37%	0.43	1.58	2.49	2.44

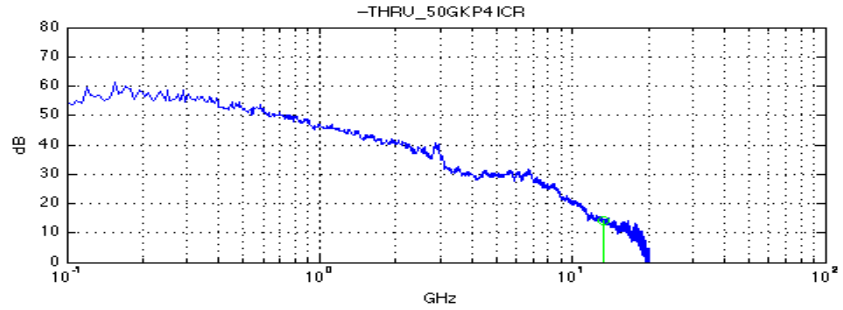
IBM- 1 m Backplane

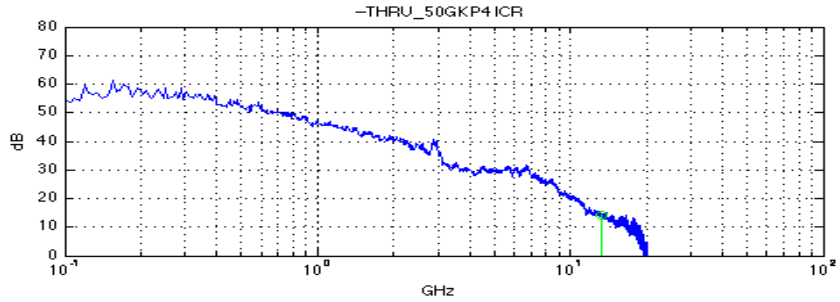
http://www.ieee802.org/3/100GCU/public/ChannelData/ibm_11_0909/patel_02_0911.pdf

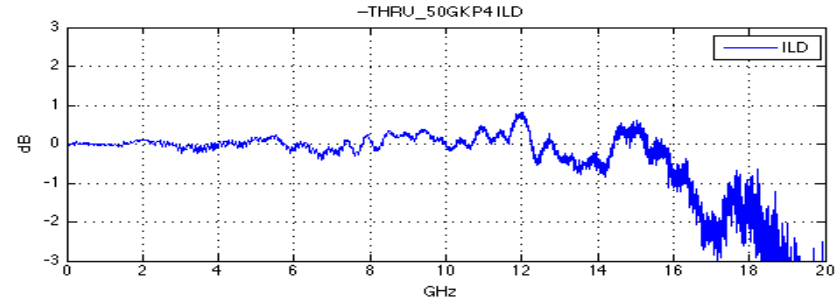


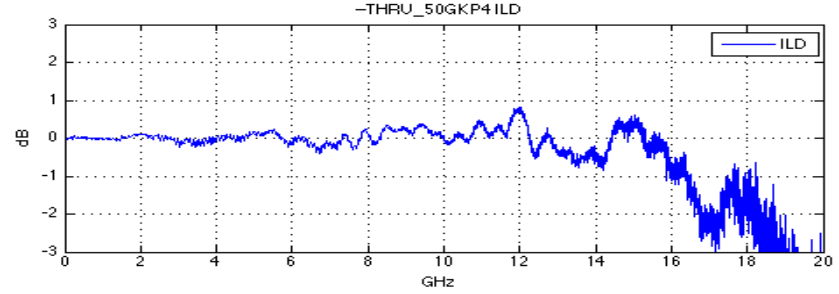






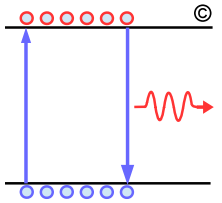


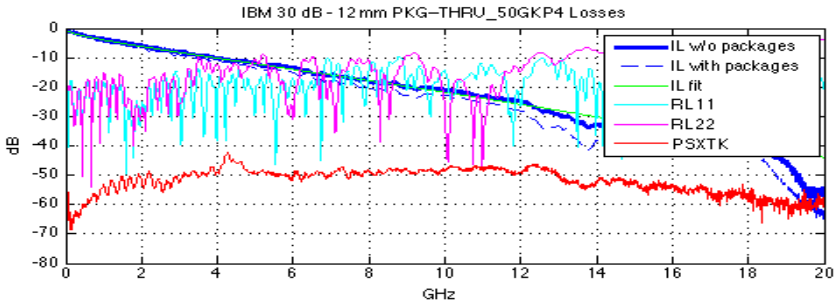


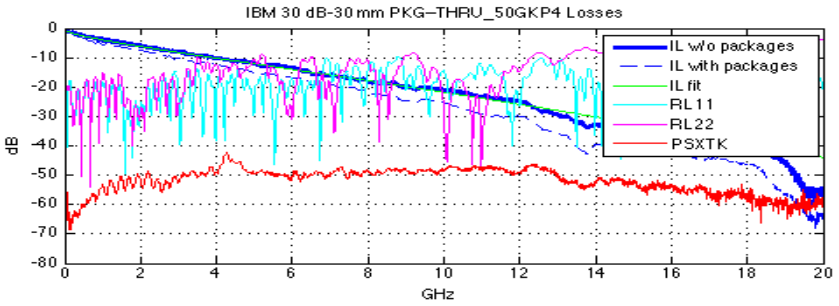


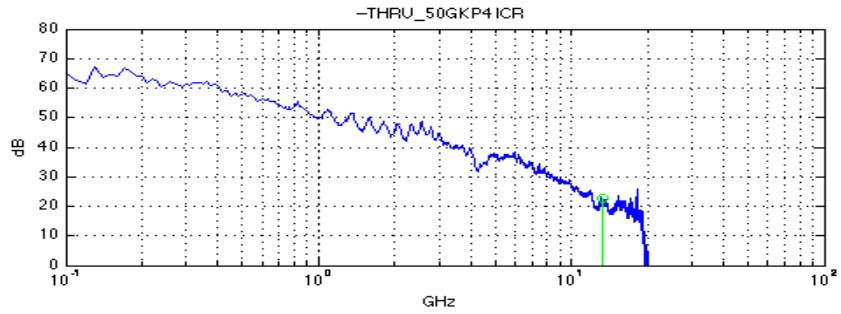
IBM- 30 dB Backplane

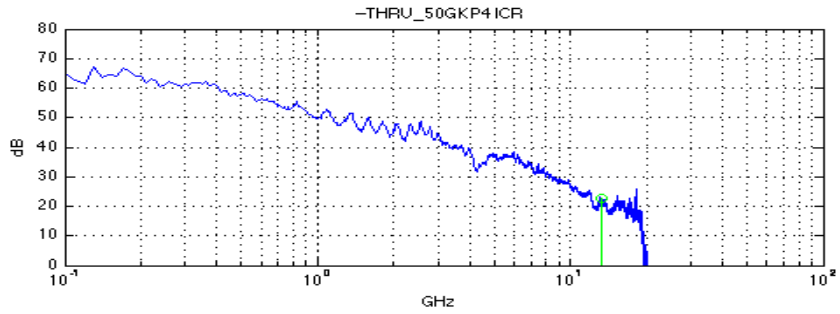
http://www.ieee802.org/3/100GCU/public/ChannelData/IBM_11_0518/patel_02_0511.pdf

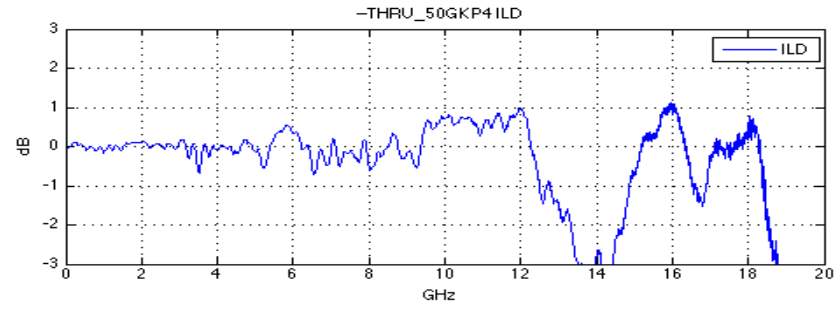


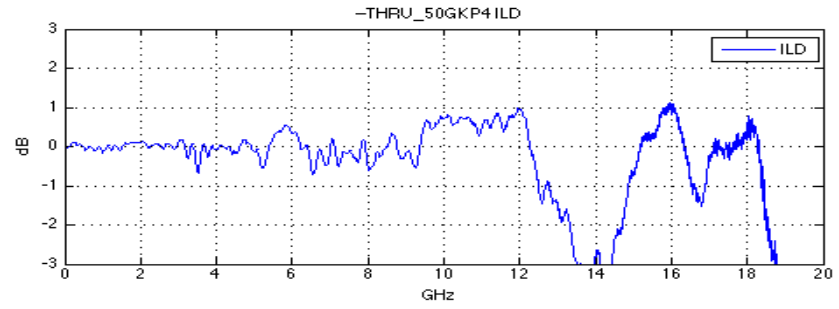




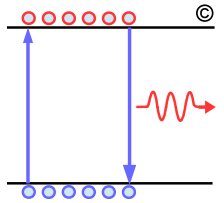








Summary Results for IBM 1 m and 30 dB Backplanes



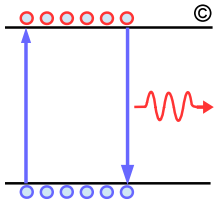
- **To safely say a channel passes 2 dB of COM margin is required!**
  - Pre $C(-2)_{max}$=0.06, $C(-1)_{max}$=-0.24

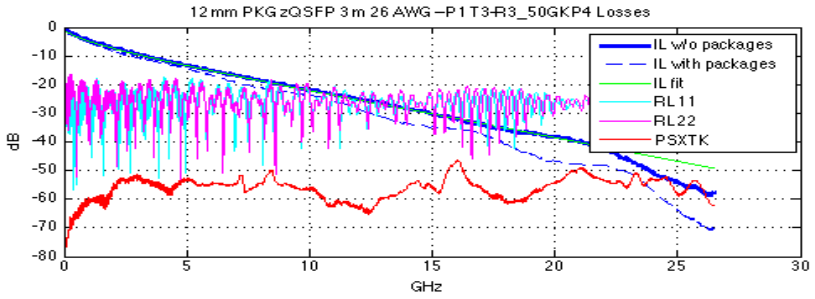
Test Cases	Channel IL (dB)	DFE	ISI/Noise/ XTALK	ILD	ICN (mV)	PSXT (mV)	COM (dB)
Patel_02_09* 1m IEEE 12 mm Package	31.1	16	24/38/38%	0.35	2.72	2.88	2.56
Patel_02_09 1m IEEE 30 mm Package	31.1	16	21/44/34%	0.35	2.72	2.20	2.21
Patel_02_09 1m IEEE 12 mm Package	31.1	20	23/38/38	0.35	2.73	2.88	2.59
Patel_02_09 1m IEEE 30 mm Package	31.1	20	20/45/35	0.35	2.73	2.22	2.28
Patel_02_05 30 dB IEEE 12 mm Package	30.4	16	47/43/10%	0.71	1.54	1.65	3.56
Patel_02_05 30 dB IEEE 30 mm Package	30.4	16	40/51/10%	0.71	1.54	1.22	3.52
Patel_02_05 30 dB IEEE 12 mm Package	30.4	20	47/43/10%	0.71	1.54	1.65	3.56
Patel_02_05 30 dB IEEE 30 mm Package	30.4	20	40/51/10%	0.71	1.54	1.22	3.52

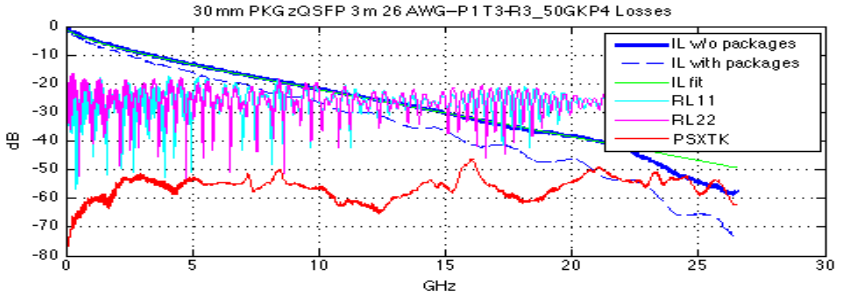
* Patel_02_09 frequency range stops at 20 GHz and may result in some truncation error.

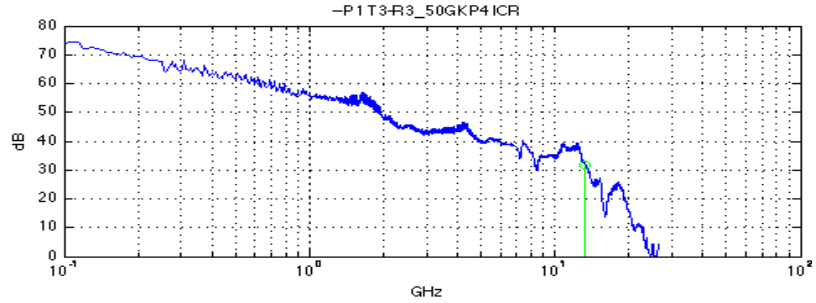
Molex Newer zQSFP 3 m 26 AWG TX3-RX3

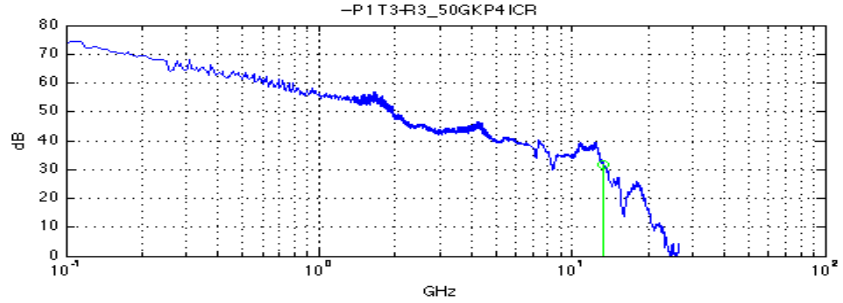
http://www.ieee802.org/3/50G/public/Jan16/roth_50GE_NGOATH_01a_0116.pdf

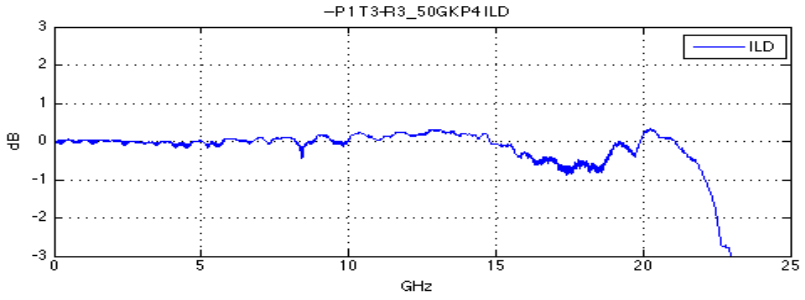


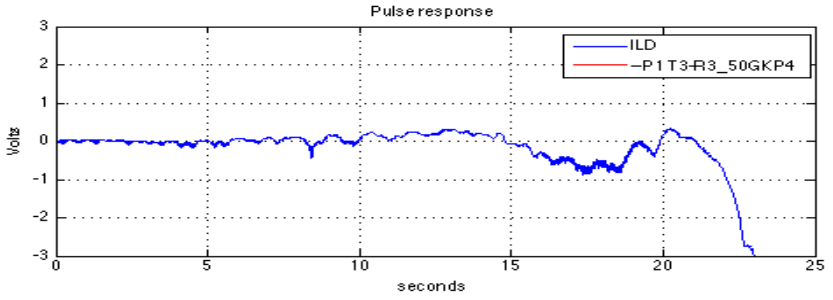






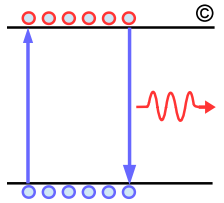


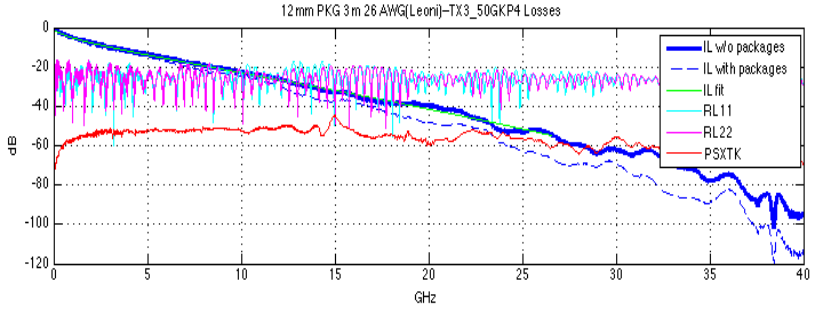


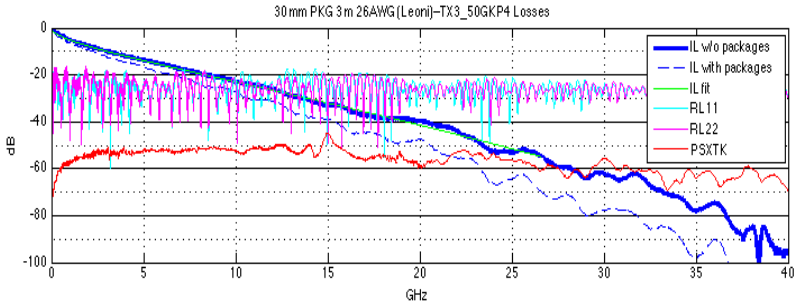


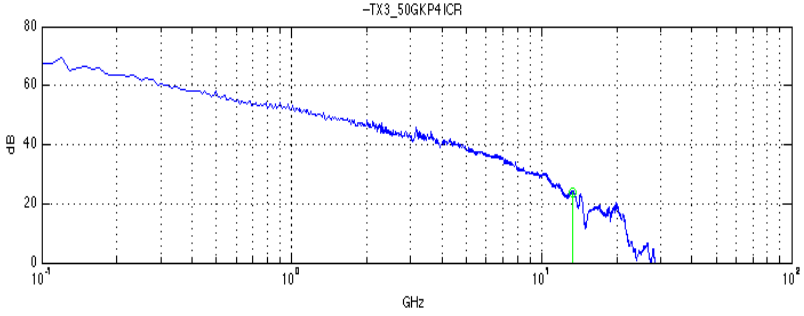
Molex Older zQSFP 3 m 26 AWG TX3-RX3 with Leoni Cable

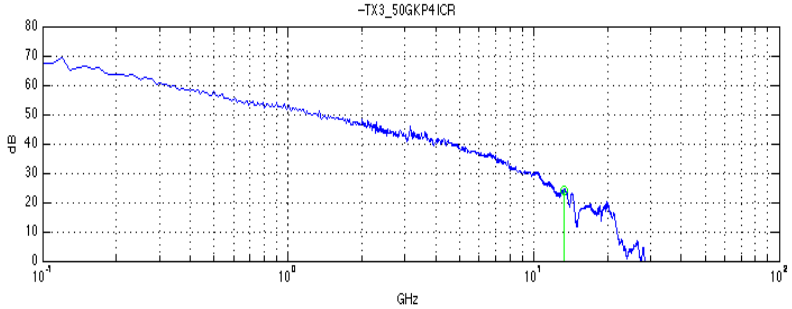
http://www.ieee802.org/3/100GCU/public/ChannelData/Molex_11_0516/bugg_02_0511.zip

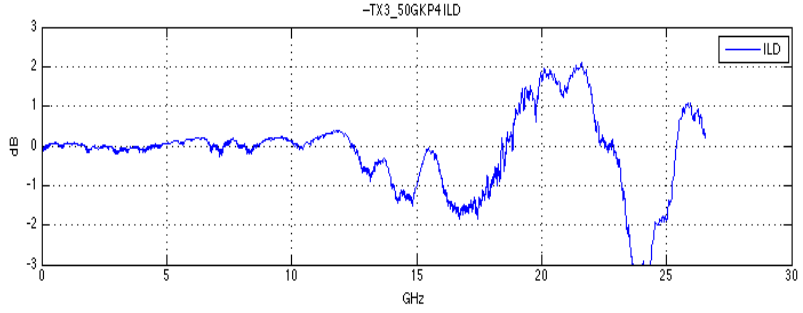


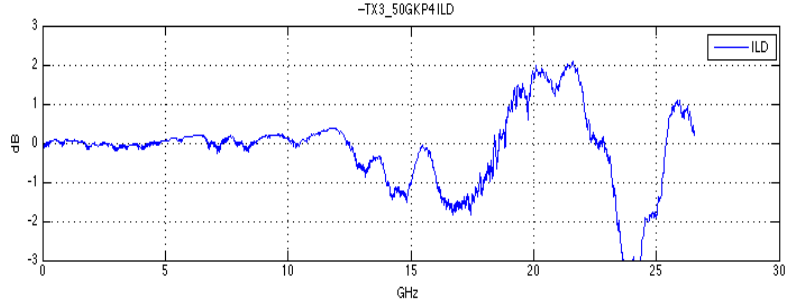




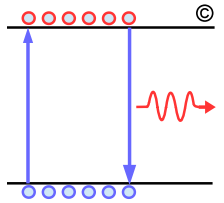








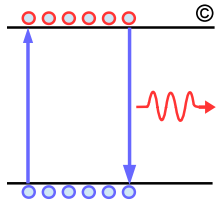
Molex 3 m 26 AWG Cables Results



- **It might be feasible to even support 3 m 28 AWG cables with 3 dB COM margin!**
  - Older 3 m 26 AWG cable have loss of ~29.5 dB newer cable ~27.5 dB
  - Stack connectors add ~1 dB of loss and have higher crosstalk
  - 30 dB channel loss provides margin to support stack connectors with newer cables
  - Pre $C(-2)_{max}$=0.04, $C(-1)_{max}$=-0.2

Test Cases	Cable IL (dB)	Channel IL (dB)	ISI/Noise/ XTALK	ILD	ICN (mV)	PSXT (mV)	COM (dB)
zQSFP T3-R3 3 m 26 AWG (Leoni Cable)	16.4	29.4	23/65/12%	0.26	1.09	1.30	4.82
zQSFP T3-R3 3 m 26 AWG (Leoni Cable)	16.4	29.4	20/70/10%	0.26	0.79	1.02	4.26
zQSFP T4-R4 3 m 26 AWG (Leoni Cable)	16.6	29.5	27/64/9	0.23	1.09	1.27	4.97
zQSFP T4-R4 3 m 26 AWG (Leoni Cable)	16.6	29.5	22/69/9	0.23	1.09	0.99	4.39
zQSFP T3-R3 3 m 26 AWG (Newer Cable P1)	14.3	27.3	24/69/6%	0.13	0.79	1.03	5.87
zQSFP T3-R3 3 m 26 AWG (Newer Cable P1)	14.3	27.3	24/71/5%	0.13	0.79	0.83	5.29
zQSFP T4-R4 3 m 26 AWG (Newer Cable P2)	14.4	27.3	19/75/6%	0.10	0.66	0.89	6.00
zQSFP T4-R4 3 m 26 AWG (Newer Cable P2)	14.4	27.3	24/72/4%	0.10	0.66	0.72	5.40

Summary



- **COM analysis show feasibility of operating at 50 Gb/s over representative 802.3bj backplane and 3 m Cu cables with ~30 dB loss**
  - The TE Whisper channel do not have TX and RX grouping and with TX/RX grouping COM margin will improve
  - IBM backplane are legacy 6+ years old and some of the 30 dB channels have more than 3 dB of COM margins
    - Since these system were built two generation of improved connectors have been introduced to the market
  - Older 3 m AWG 26 cables have loss of ~29.5 dB but newer cable have nominal loss of ~27.5 dB
    - Newer cable material may allow using less bulky cables based on 28 AWG
  - COM package has ~0.6 dB higher penalty than representative GZ-41 packages with similar length
- **Typical 50G PAM4 receiver will use CTLE/Long FFE and possibly followed by 1-2 tap DFE a significant deviation from current COM models**
  - Current COM model will indicates the need for large pre-cursors but real receiver with long FFE does not need the pre-cursor instead needs more post-cursors!
- **50GbE & NGOATH objective should be based on single PHY with 30 dB loss for operation over 1 m backplane and 3 m Cu cables**
  - During study phase channel parameters and COM will be further refined.