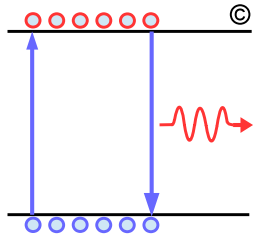


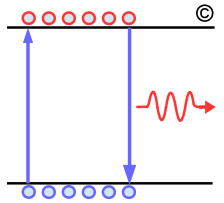
# Feasibility of 30 dB Channel at 50 Gb/s

**Ali Ghiasi**
**Ghiasi Quantum LLC**

**NGOATH Plenary Meeting**

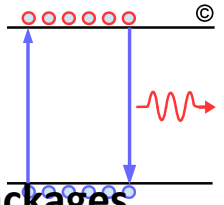
**March 16, 2016**

# List of supporters



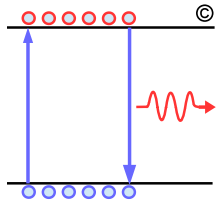
- **Upen Reddy Kareti – Cisco**
- **Vipul Bhatt - Inphi**

# Overview

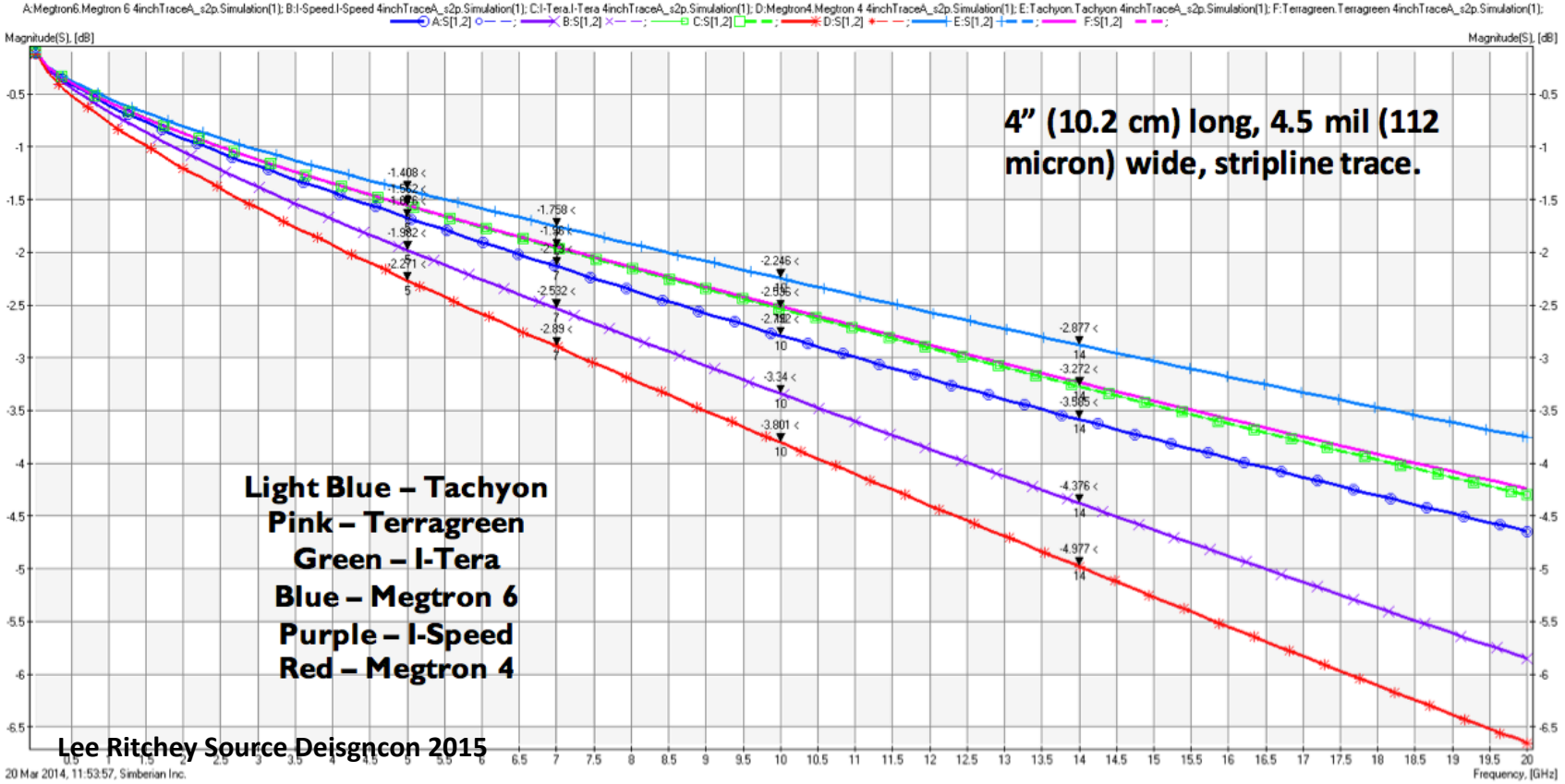


- **IEEE COM package is ~0.6 dB more pessimistic than representative GZ-41 packages with similar length**
- **Baseline CDAUI-8 C2C COM parameters were tightening to provide 2+ dB of COM margin on following 30 dB channels**
  - TE Whisper Std 1 m backplane
  - TE Whisper 1 m backplane with Embedded Cap 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!

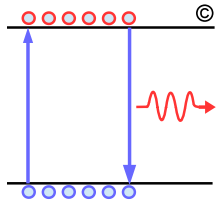
# More Advance PCB Material Only Modestly Improves the Backplane Loss



- **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.

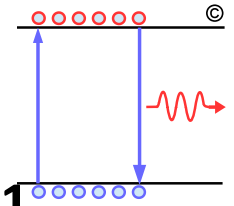


# Changes Made to Baseline CDAUI-8 C2C COM parameter for 50G KP4



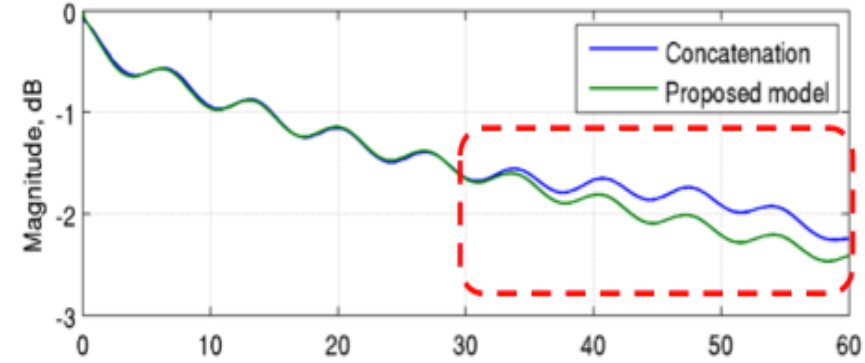
| Parameters | CDAUI-8 C2C COM Parameters | 50G KP4 COM Parameters |
|---|---|---|
| Baudrate | 26.5625 GBd | 26.5625 GBd |
| Device Capacitance Cd [TX, RX] | [0.28, 0.28] pf | [0.2, 0.2] pf |
| BGA pad Cp [TX, RX] | [0.11, 0.11] pf | [0.11, 0.11] pf |
| CTLE Gain | 15 dB | 18 dB |
| G_DC_HP | 4 dB | 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 |

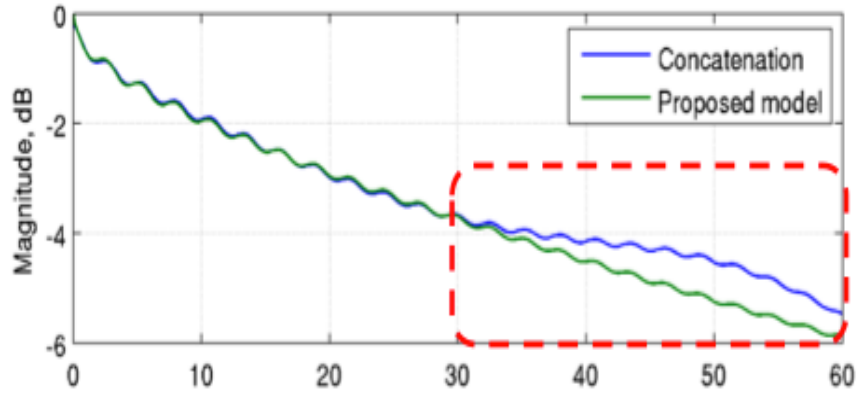
# IEEE Package Model



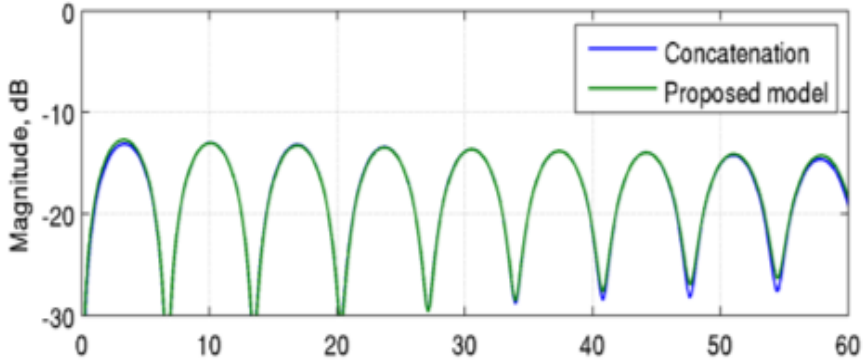
- **IEEE package has strong ripple in the return loss and SDD21**
  - Representative GZ-41 packages have more than 0.6 dB of COM margin compare to IEEE package.

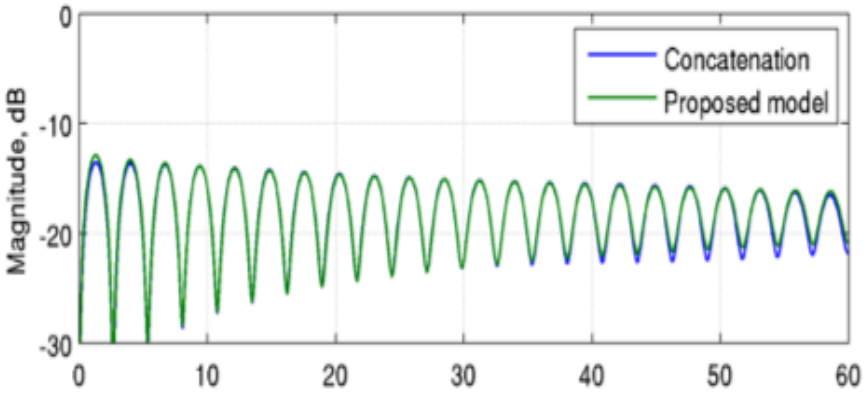
**s21**



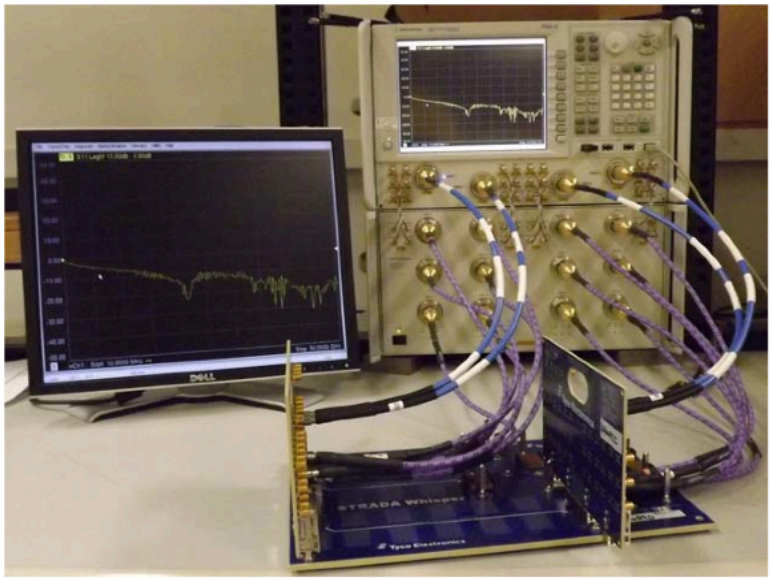




**s11**



# 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

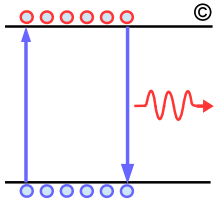
- Board Material = Megtron6 HVLP
- Trace length = 30”
- Trace geometry = Stripline
- Trace width = 6 mils
- Differential trace spacing = 9 mils
- PCB thickness = 200 mils, 20 layers
- Counterbored vias, up to 6mil stub

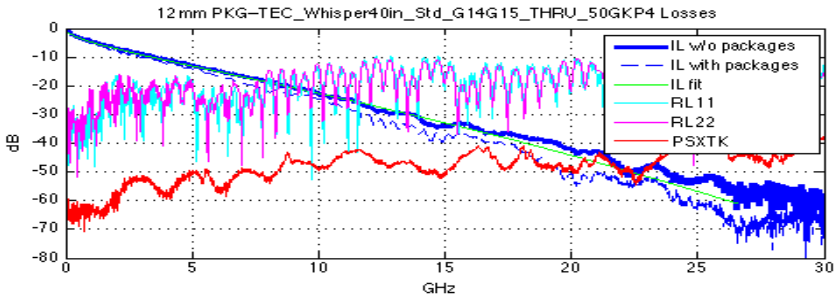
## CONNECTORS

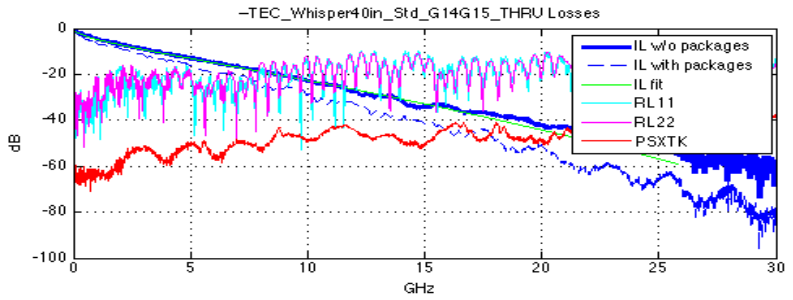
Use
- Dataset 1 includes
  - Mated standard STRADA Whisper connector at each end
- Dataset 2 includes
  - Mated Embedded Capacitor STRADA Whisper connector at one end and,
  - Mated standard STRADA Whisper connector at other end

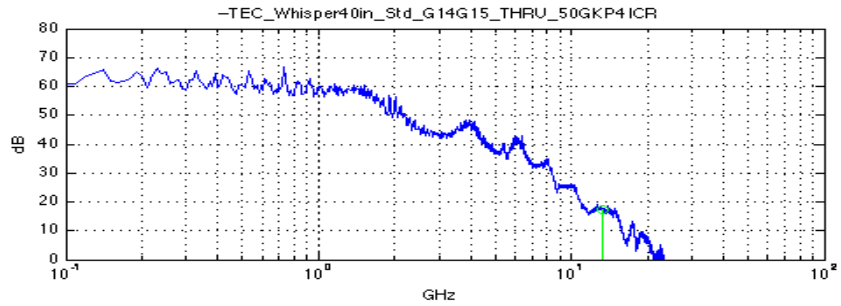
# TE Whisper 1 m Std Backplane

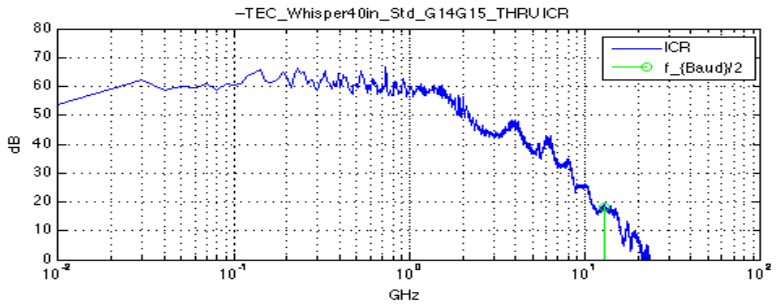
http://www.ieee802.org/3/bj/public/jul13/tracy_3bj_01_0713.pdf

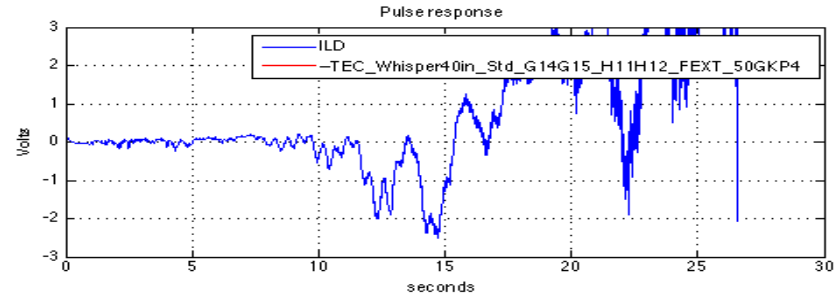


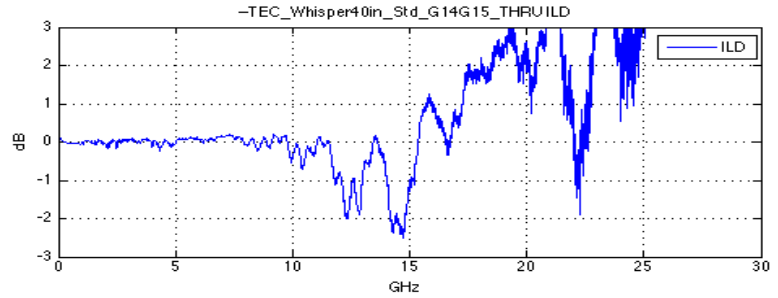


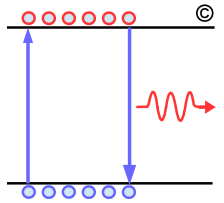



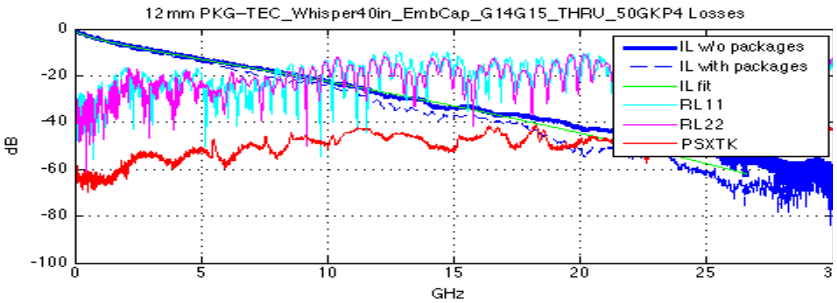



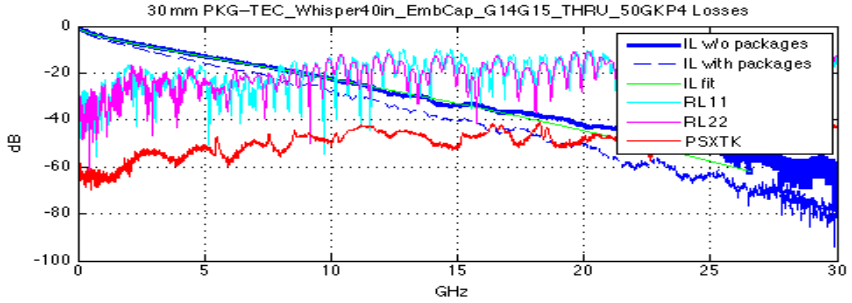



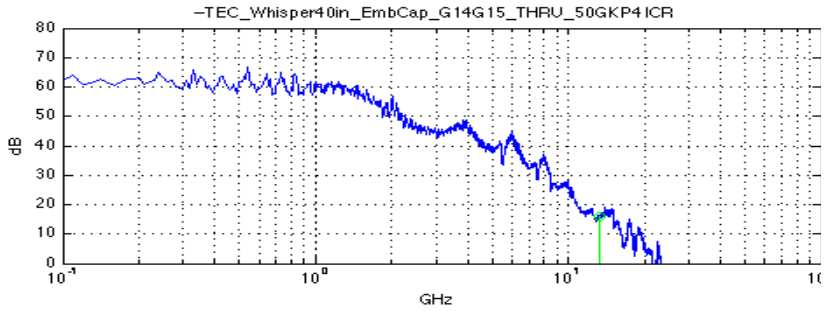
# TE Whisper 1 m Backplane with Imbedded Cap

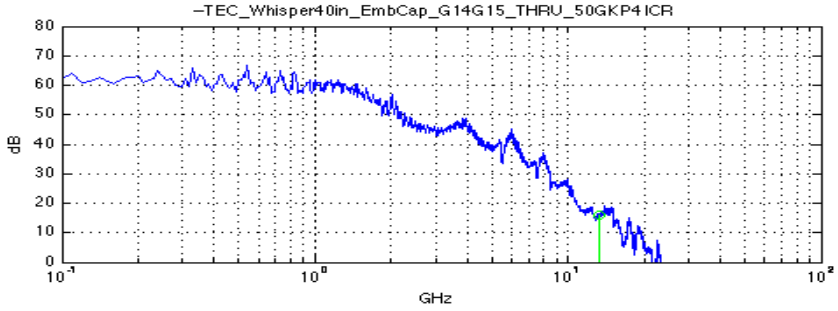
http://www.ieee802.org/3/bj/public/jul13/tracy_3bj_01_0713.pdf

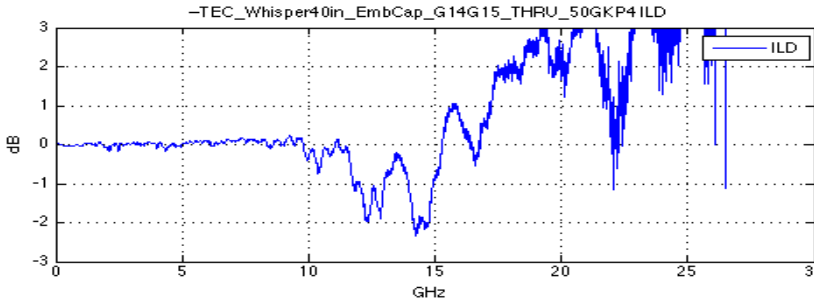


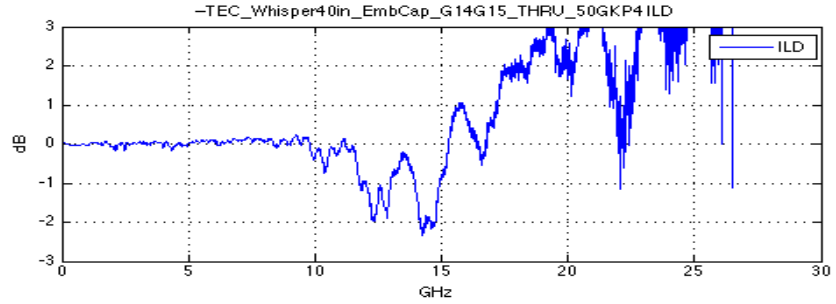


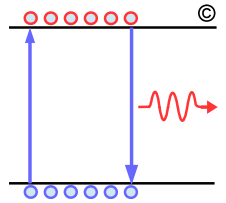



# Summary Results for TE Whisper 1 m Backplane

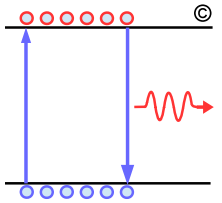


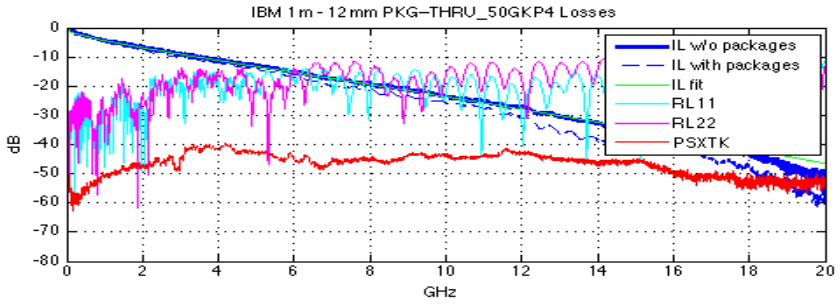
- **To safely say a channel passes 2 dB of COM margin is required!**
  - Pre $C(-2)_{max}$=0.04, $C(-1)_{min}$=-0.22

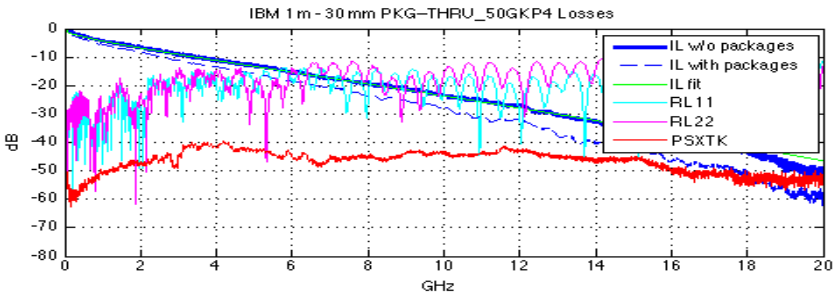
| Test Cases | Channel IL (dB) | DFE | ISI/Noise/ XTALK | ILD | ICN (mV) | PSXT (mV) | COM (dB) |
|---|---|---|---|---|---|---|---|
| Std Backplane IEEE 12 mm Package | 29.8 | 24 | 35/65/0% | 0.39 | 0 | 0 | 5.05 |
| Std Backplane IEEE 30 mm Package | 29.8 | 24 | 28/72/0% | 0.39 | 0 | 0 | 4.58 |
| Std 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 |

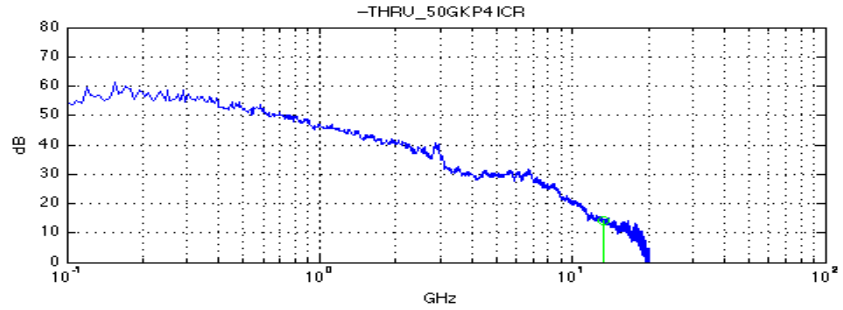
# IBM- 1 m Backplane

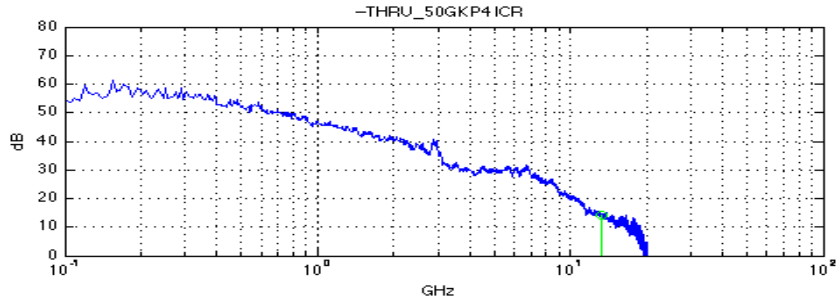
http://www.ieee802.org/3/100GCU/public/ChannelData/ibm_11_0909/patel_02_0911.pdf

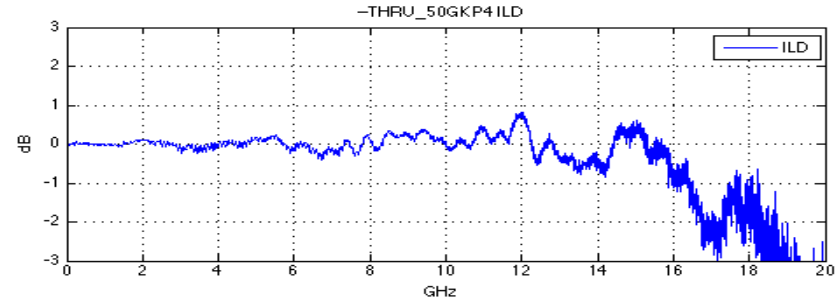


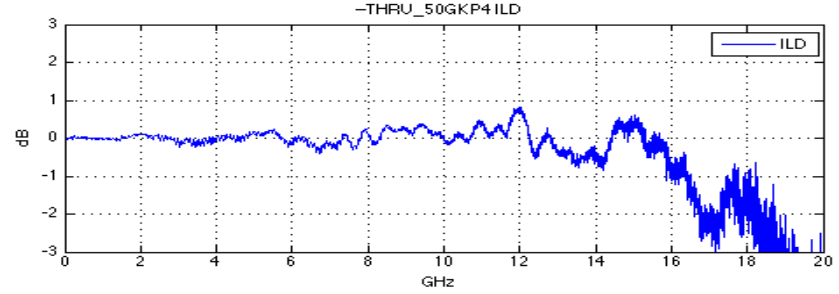


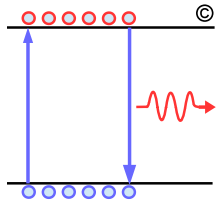



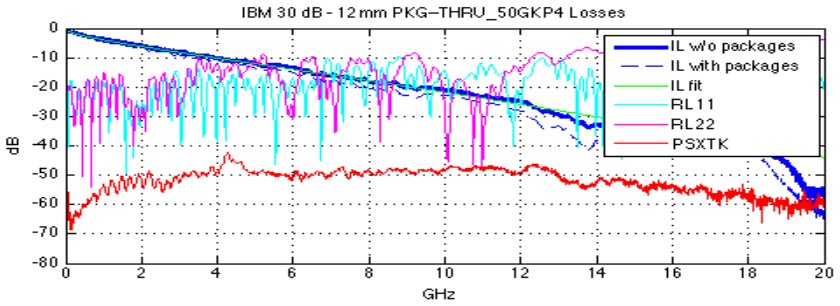



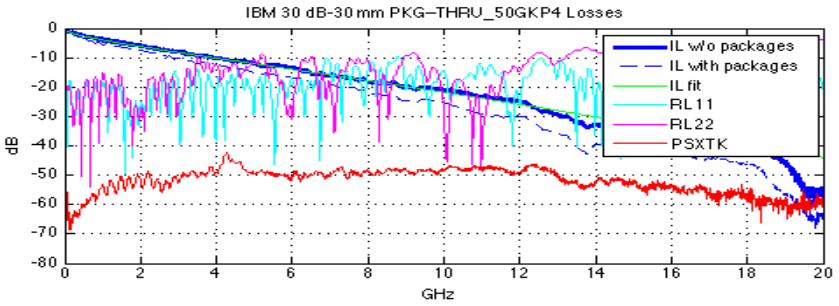



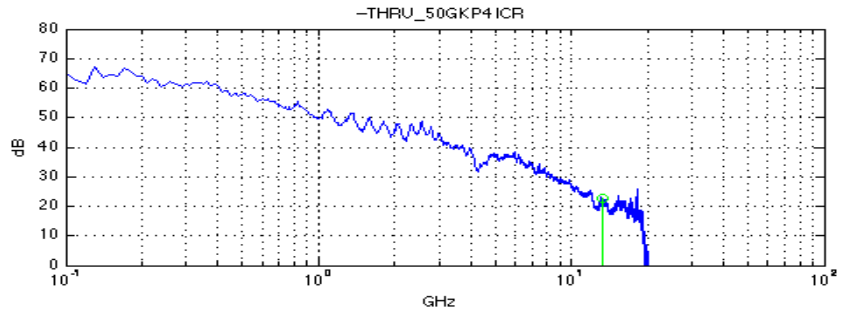
# IBM- 30 dB Backplane

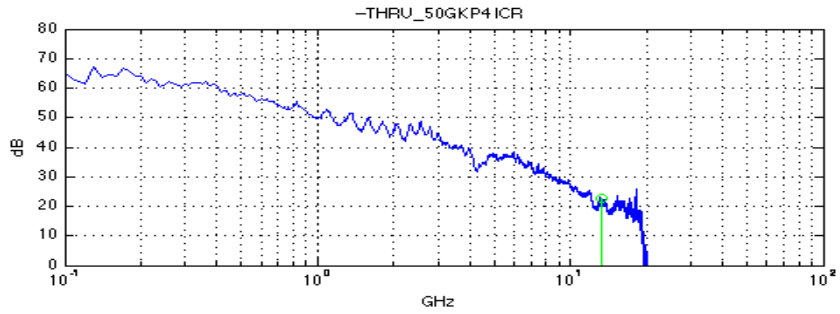
http://www.ieee802.org/3/100GCU/public/ChannelData/IBM_11_0518/patel_02_0511.pdf

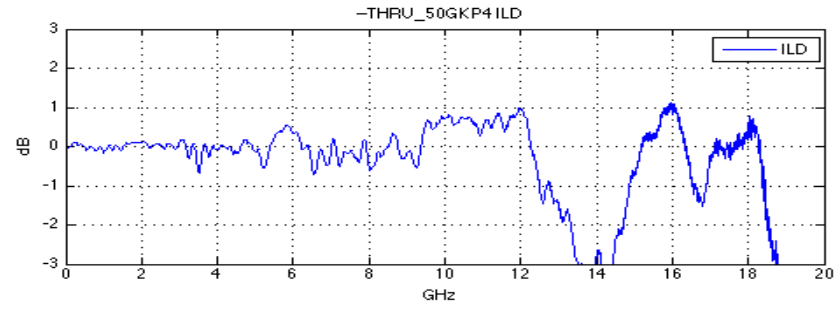


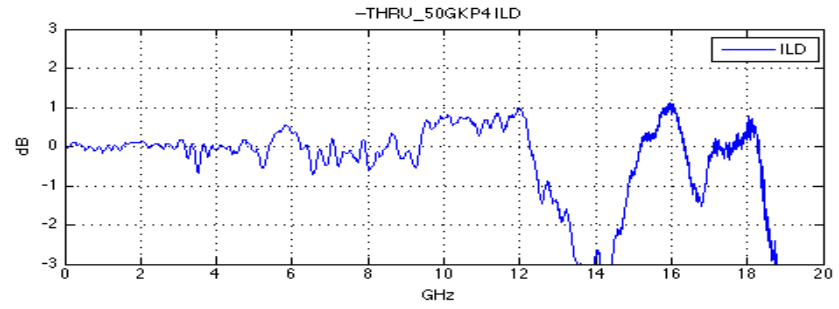


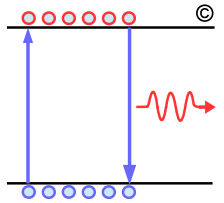



# Summary Results for IBM 1 m and 30 dB Backplanes



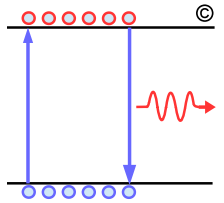
- **To safely say a channel passes 2 dB of COM margin is required!**
  - Pre $C(-2)_{max}$=0.06, $C(-1)_{max}$=-0.24

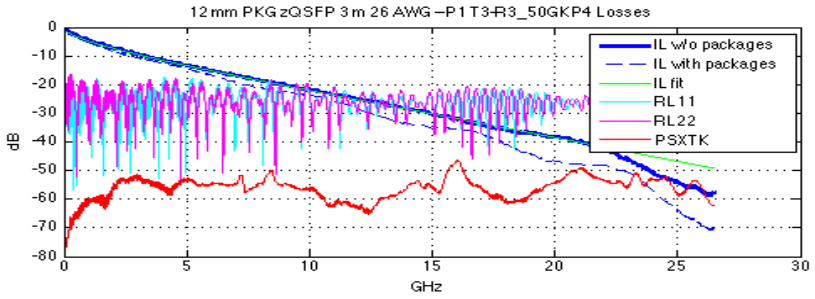
| Test Cases | Channel IL (dB) | DFE | ISI/Noise/ XTALK | ILD | ICN (mV) | PSXT (mV) | COM (dB) |
|---|---|---|---|---|---|---|---|
| Patel_02_09* 1m IEEE 12 mm Package | 31.1 | 16 | 24/38/38% | 0.35 | 2.72 | 2.88 | 2.56 |
| Patel_02_09 1m IEEE 30 mm Package | 31.1 | 16 | 21/44/34% | 0.35 | 2.72 | 2.20 | 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 |

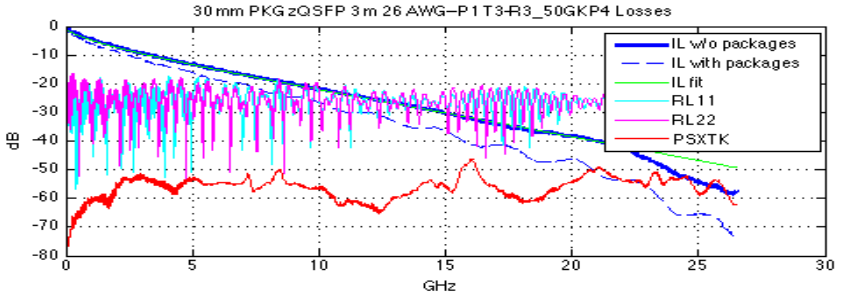
* Patel_02_09 frequency range stops at 20 GHz and may result in some truncation error.

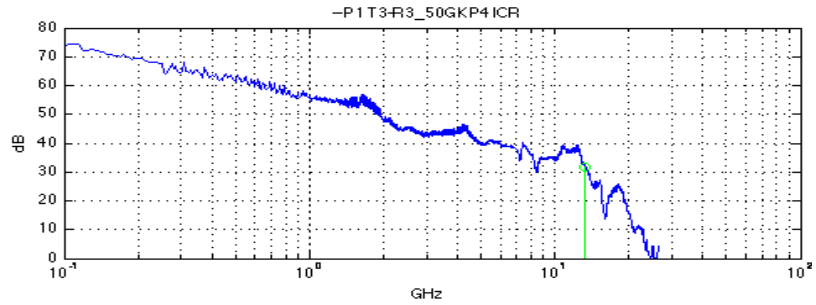
# Molex Newer zQSFP 3 m 26 AWG TX3-RX3

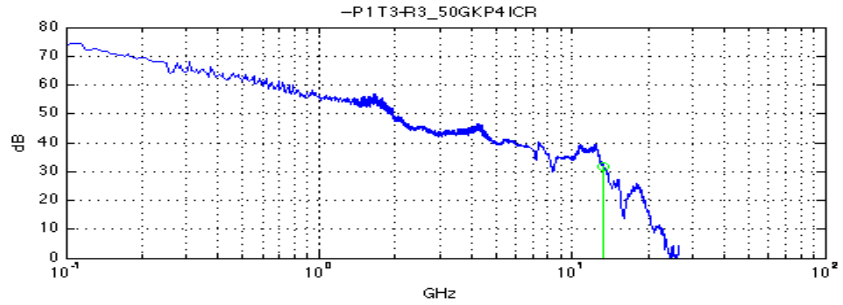
http://www.ieee802.org/3/50G/public/Jan16/roth_50GE_NGOATH_01a_0116.pdf

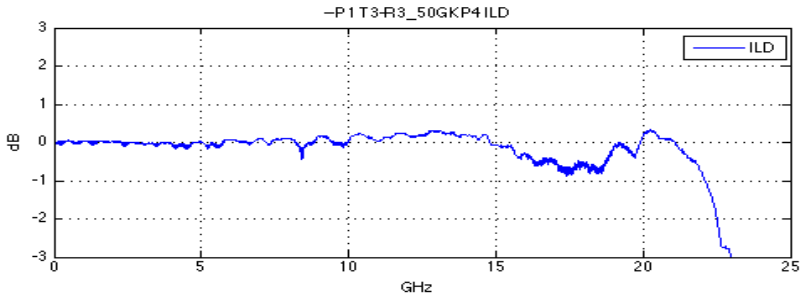


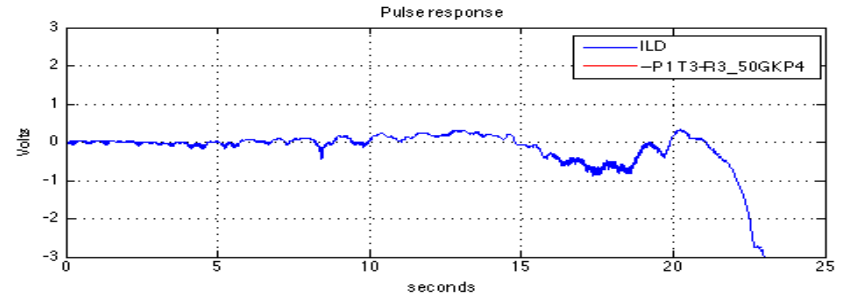


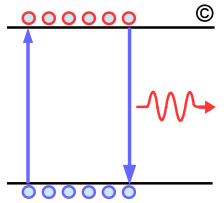



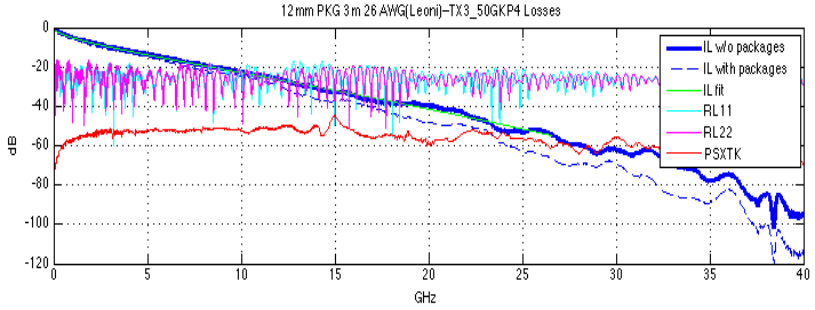



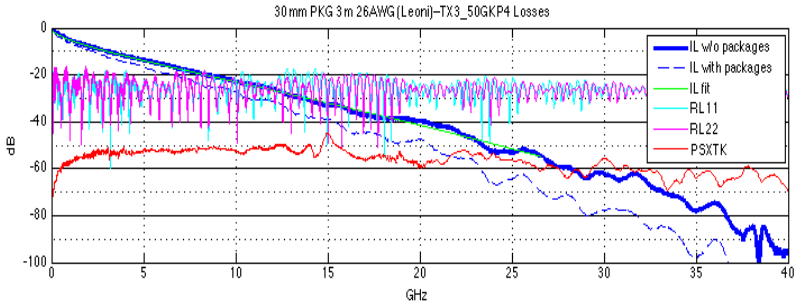



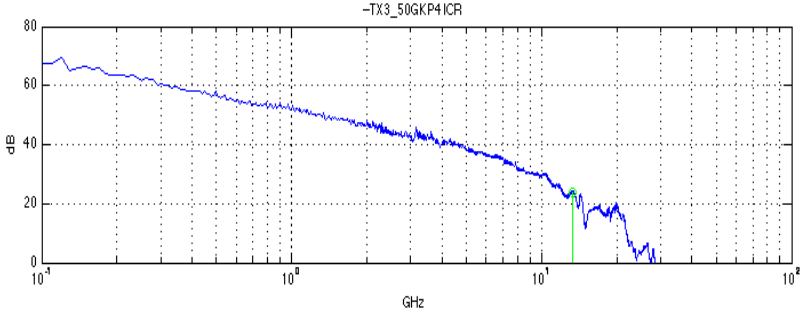
# Molex Older zQSFP 3 m 26 AWG TX3-RX3 with Leoni Cable

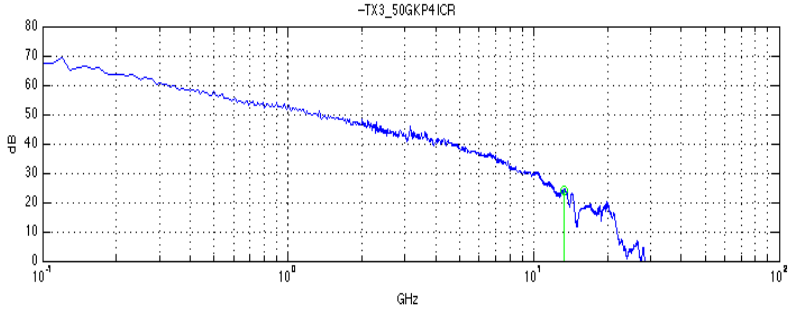
http://www.ieee802.org/3/100GCU/public/ChannelData/Molex_11_0516/bugg_02_0511.zip

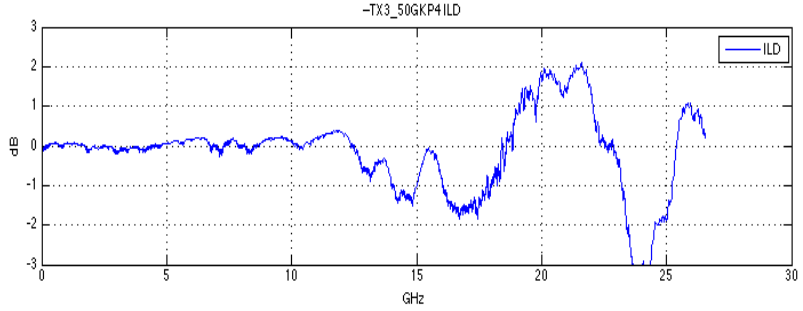


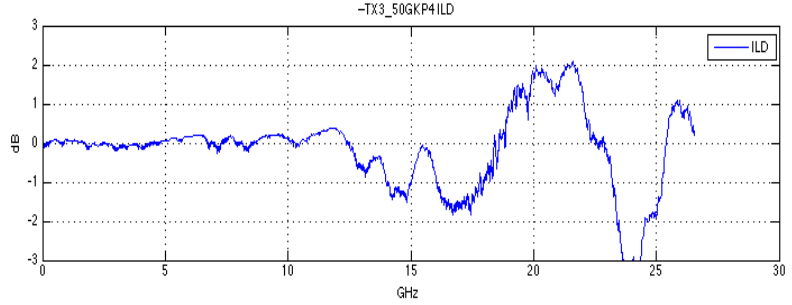


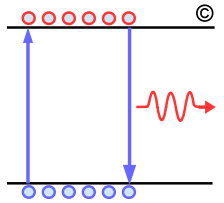



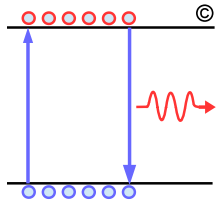
# Molex 3 m 26 AWG Cables Results



- **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.