# C2C Channel Equalization with Several Eta0

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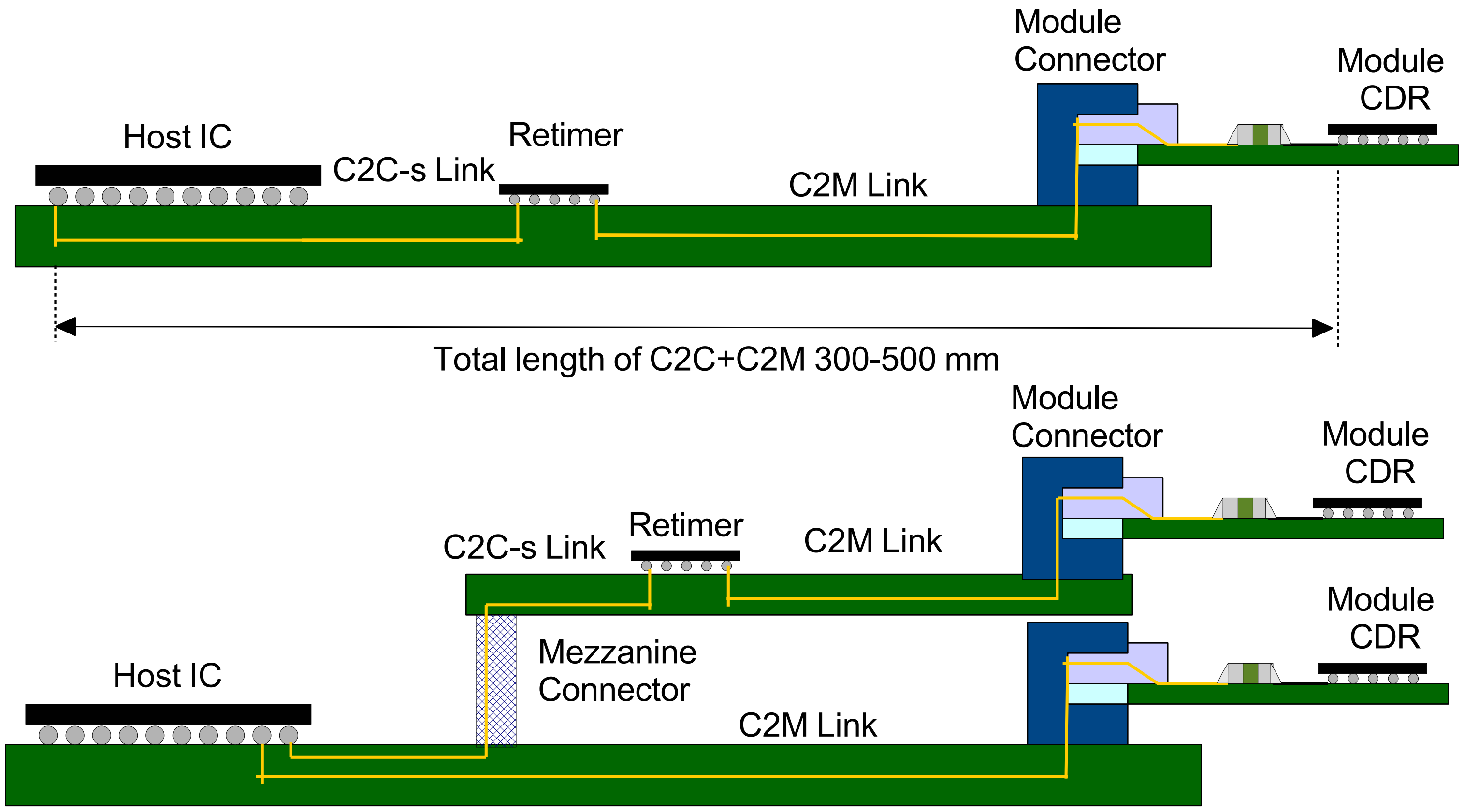
# Overview

- **C2C COM analysis**
  - 4 Lim channels between 16.5 to 17.5 dB loss
  - 1 Gore PCB channel with 20 dB loss
  - 1 Gore cabled channel with 20 dB loss
- **Equalizer considered 6T DFE**
  - Result are with 1x, 2.5x, 5x, and 10x of eta_0 (8.2e-9) for more representative receive noise
  - Case I - [13, 11] mm package
  - Case II – [31, 29] mm package
- **COM 2.9.3 key difference with COM 2.7.6**
  - ERL result with COM 2.9.3 are 3-8 dB lower than ERL results from COM 2.7.6
- **Addressing D1.2 comments 187 and 188.**

# Two Common C2C Applications

- **These two common C2C applications can satisfied with ~300 mm trace and by repurposing 16 dB C2M budget**
  - Connecting to far-side of the ASIC IO may require retimer
  - Modules mounted on mezzanine card.



# COM 2.9.3 Table for C2C

| Table 93A-1 parameters | | | |
|---|---|---|---|
| Parameter | Setting | Units | Information |
| f_b | 53.125 | GBd | |
| f_min | 0.05 | GHz | |
| Delta_f | 0.01 | GHz | |
| C_d | [1.2e-4 1.2e-4] | nF | [TX RX] |
| L_s | [0.12, 0.12] | nH | [TX RX] |
| C_b | [0.3e-4 0.3e-4] | nF | [TX RX] |
| z_p select | [ 1 2 ] | | [test cases to run] |
| z_p (TX) | [13 31; 1.8 1.8] | mm | [test cases] |
| z_p (NEXT) | [11 29; 1.8 1.8] | mm | [test cases] |
| z_p (FEXT) | [13 31; 1.8 1.8] | mm | [test cases] |
| z_p (RX) | [11 29; 1.8 1.8] | mm | [test cases] |
| C_p | [0.87e-4 0.87e-4] | nF | [TX RX] |
| R_0 | 50 | Ohm | |
| R_d | [ 50 50] | Ohm | [TX RX] |
| A_v | 0.413 | V | |
| A_fe | 0.413 | V | |
| A_ne | 0.608 | V | |
| L | 4 | | |
| M | 32 | | |
| filter and Eq | | | |
| f_r | 0.75 | *fb | |
| c(0) | 0.54 | | min |
| c(-1) | [-0.34:0.02:0] | | [min:step:max] |
| c(-2) | [0:0.02:0.12] | | [min:step:max] |
| c(-3) | [-0.06:0.02: 0] | | [min:step:max] |
| c(1) | [-0.2:0.05:0] | | [min:step:max] |
| N_b | 6 | UI | |
| b_max(1) | 0.85 | | |
| b_max(2..N_b) | 0.2 | | |
| **b_min(1)** | **-0.85** | | |
| **b_min(2..N_b)** | **-0.2** | | |
| g_DC | [-20:1:0] | dB | [min:step:max] |
| f_z | 21.25 | GHz | |
| f_p1 | 21.25 | GHz | |
| f_p2 | 53.125 | GHz | |
| g_DC_HP | [-4:1:0] | | [min:step:max] |
| f_HP_PZ | 0.6640625 | GHz | |

| I/O control | | |
|---|---|---|
| DIAGNOSTICS | 1 | logical |
| DISPLAY_WINDOW | 1 | logical |
| CSV_REPORT | 1 | logical |
| RESULT_DIR | .\results\100GEL_KR_{date}\ | |
| SAVE_FIGURES | 0 | logical |
| Port Order | [1 3 2 4] | |
| RUNTAG | KR_eval_ | |
| COM_CONTRIBUTION | 0 | logical |
| Operational | | |
| COM Pass threshold | 3 | dB |
| ERL Pass threshold | **10.5** | dB |
| DER_0 | 1.00E-05 | |
| T_r | **0.006160714** | ns |
| FORCE_TR | 1 | logical |
| **Local Search** | **2** | |
| TDR and ERL options | | |
| TDR | 1 | logical |
| ERL | 1 | logical |
| ERL_ONLY | 0 | logical |
| TR_TDR | **0.01** | ns |
| N | 2000 | |
| beta_x | 0 | |
| rho_x | 0.618 | |
| fixture delay time | [ 0 0 ] | [ port1 port2 ] |
| TDR_W_TXPKG | 0 | |
| N_bx | **6** | UI |
| Receiver testing | | |
| RX_CALIBRATION | 0 | logical |
| Sigma BBN step | 5.00E-03 | V |
| Noise, jitter | | |
| sigma_RJ | 0.01 | UI |
| A_DD | 0.02 | UI |
| eta_0 | 0.000000082 | V^2/GHz |
| SNR_TX | 33 | dB |
| R_LM | 0.95 | |

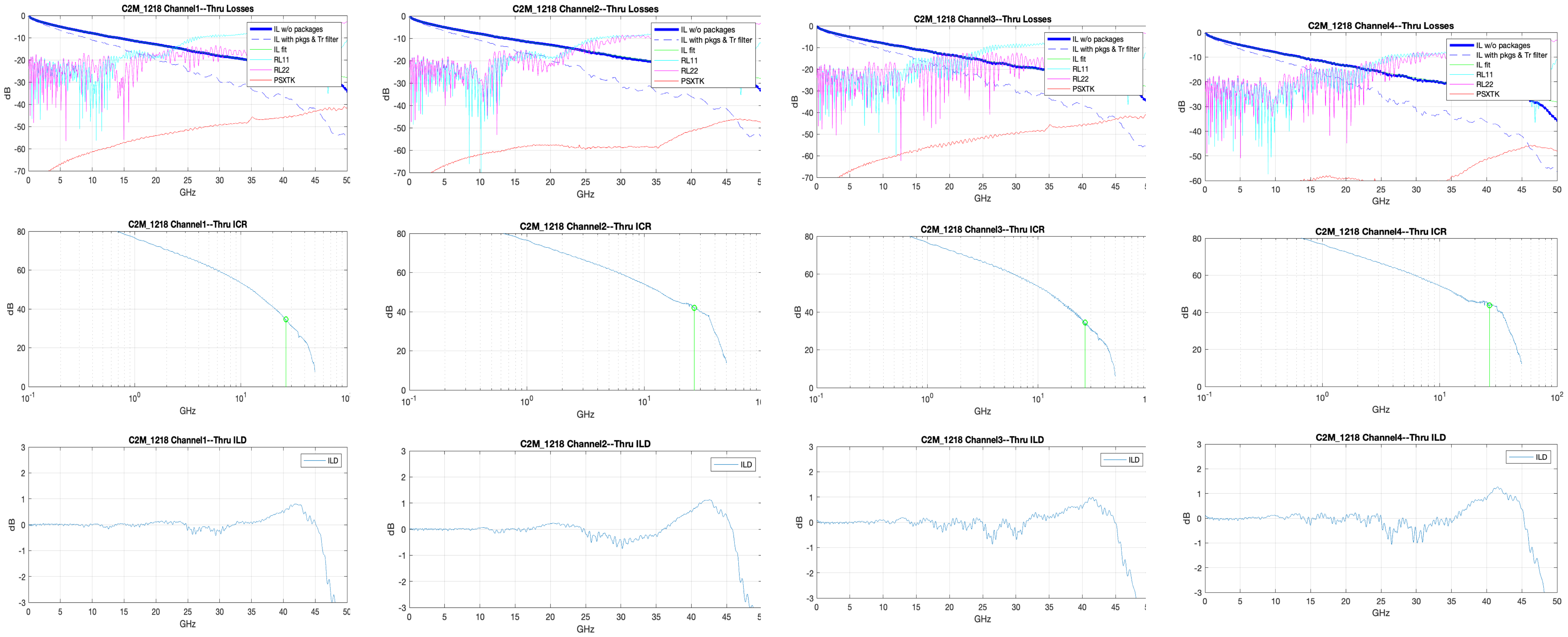
| Table 93A–3 parameters | | |
|---|---|---|
| Parameter | Setting | Units |
| **package_tl_gamma0_a1_a2** | **[0 0.0009909 0.0002772]** | |
| **package_tl_tau** | **6.141E-03** | **ns/mm** |
| **package_Z_c** | **[87.5 87.5 ; 92.5 92.5 ]** | **Ohm** |
| **benartsi_3ck_01_0119 & mellitz_3ck_01_0119** | | |
| Table 92–12 parameters | | |
| Parameter | Setting | |
| *board_tl_gamma0_a1_a2* | *[0 3.8206e-04 9.5909e-05]* | |
| *board_tl_tau* | *5.790E-03* | ns/mm |
| *board_Z_c* | 100 | Ohm |
| *z_bp (TX)* | *110.3* | mm |
| *z_bp (NEXT)* | *110.3* | mm |
| *z_bp (FEXT)* | *110.3* | mm |
| *z_bp (RX)* | *110.3* | mm |
| *C_0* | [0.29e-4] | nF |
| *C_1* | [0.19e-4] | nF |
| **Include PCB** | **0** | **logical** |
| Floating Tap Control | | |
| N_bg | 0 | 0 1 2 or 3 groups |
| N_bf | 0 | taps per group |
| N_f | 40 | UI span for floating taps |
| bmaxg | 0.05 | max DFE value for floating taps |
| B_float_RSS_MAX | 0.02 | rss tail tap limit |
| N_tail_start | 25 | (UI) start of tail taps limit |
| ICN parameters | | |
| f_v | 0.723 | *Fb |
| f_f | 0.723 | *Fb |
| f_n | 0.723 | *Fb |
| f_2 | 39.844 | GHz |
| A_ft | 0.600 | V |
| **A_nt** | **0.600** | V |

| | |
|---|---|
| **TBD in document** | **under consideration** |
| **new** | |

# Lim C2C Channels

- **Total of 4 channels were built with optimized host ASIC, retimer & mezzanine connector footprint (shallow via breakout). Both shallow and long via are considered at connector and retimer footprint.**
  - Channel 1: ASIC BGA footprint (mid via – L17) TX + host trace 7” + Mezzanine footprint & connector (shallow via breakout) + daughtercard trace 4” + Retimer footprint (shallow via) ; including 2 FEXT & 2 NEXT
  - Channel 2: ASIC BGA footprint (mid via – L17) TX + host trace 7” + Mezzanine footprint & connector (shallow via breakout) + daughtercard trace 4” + Retimer footprint (long via); including 2 FEXT & 2 NEXT
  - Channel 3: ASIC BGA footprint (mid via – L17) TX + host trace 7” + Mezzanine footprint & connector (long via breakout) + daughtercard trace 4” + Retimer footprint (shallow via) ; including 2 FEXT & 2 NEXT
  - Channel 4: ASIC BGA footprint (mid via – L17) TX + host trace 7” + Mezzanine footprint & connector (long via breakout) + daughtercard trace 4” + Retimer footprint (long via) ; including 2 FEXT & 2 NEXT
  - http://www.ieee802.org/3/ck/public/tools/c2c/lim_3ck_05_0719_c2c.zip.

# Lim C2C Channels



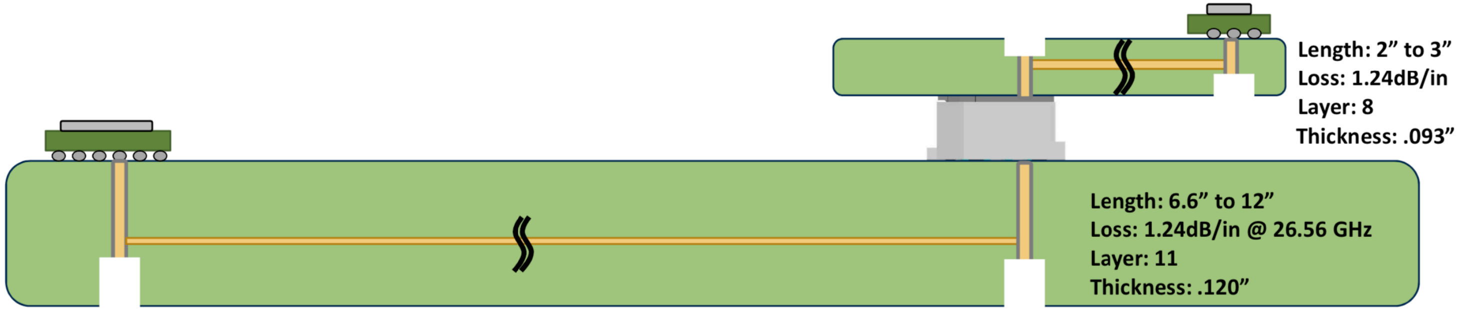
# COM Summary for Lim C2C Channels for Several Eta_0

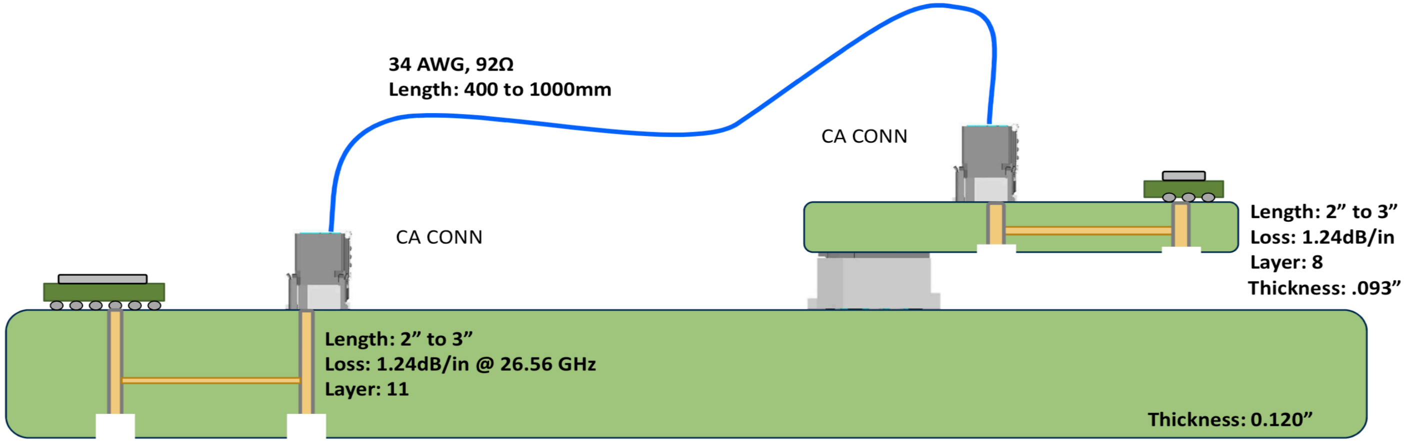
| Lim C2C Channel 1 | Eta_0 Noise (V^2/GHz) | Actual DFE Taps (Largest taps case I or II) | Fitted IL at 26.55 GHz (dB) | Total IL w PKG at 26.55 GHz (dB) | COM Case I | COM Case II |
|---|---|---|---|---|---|---|
| Lim C2C Channel 1<br>FOM ILD=0.06<br>ICN=1.87 mV<br>ERL11=14.1 (18.4)*<br>ERL22=13.4 (17.4)* | 1x=8.2E-9 | [0.346, 0.061, 0.052, 0.033, 0.032, 0.007] | 16.6 | 24.7 | 4.2 | 5.1 |
| | 2.5x-=2.05E-8 | [0.356, 0.03, 0.008, 0.012, 0.021, 0.004] | 16.6 | 24.0 | 3.9 | 4.3 |
| | 5x=4.1E-8 | [0.455, 0.04, 0.028, 0.025, 0.03, 0.009] | 16.6 | 24.0 | 3.4 | 3.5 |
| | 10x=8.2E-8 | [0.50, 0.08, 0.05, 0.038, 0.038, 0.015] | 16.6 | 25.4 | 2.7 | 2.2 |
| Lim C2C Channel 2<br>FOM ILD=0.095<br>ICN=1.34 mV<br>ERL11=14.0 (18.4)*<br>ERL22=13.1 (16.2)* | 1x=8.2E-9 | [0.385, -0.012, 0.012, 0.004, 0.025, 0.012] | 16.4 | 28.2 | 5.1 | 5.3 |
| | 2.5x-=2.05E-8 | [0.442, 0.007, 0.008, 0.013, 0.025, 0.013] | 16.4 | 28.2 | 4.6 | 4.5 |
| | 5x=4.1E-8 | [0.487, 0.032, 0.035, 0.016, 0.033, 0.018] | 16.4 | 28.2 | 3.9 | 3.6 |
| | 10x=8.2E-8 | [0.53, 0.07, 0.058, 0.03, 0.041, 0.024] | 16.4 | 28.2 | 3.1 | 2.3 |
| Lim C2C Channel 3<br>FOM ILD=0.108<br>ICN=1.81 mV<br>ERL11=13.1 (17.3)*<br>ERL22=12.5 (15.4)* | 1x=8.2E-9 | [0.322, -0.067, -0.036, -0.069, 0.009, -0.007] | 16.7 | 27.4 | 3.7 | 4.5 |
| | 2.5x-=2.05E-8 | [0.42, -0.028, -0.02, 0.003, 0.016, 0.002] | 16.7 | 27.4 | 3.4 | 3.9 |
| | 5x=4.1E-8 | [0.518, 0.144, 0.086, 0.058, 0.046, 0.014] | 16.7 | 27.4 | 3.1 | 3.02 |
| | 10x=8.2E-8 | [0.53, 0.07, 0.058, 0.03, 0.041, 0.024] | 16.7 | 27.4 | 2.4 | 1.8 |
| Lim C2C Channel 4<br>FOM ILD=0.125<br>ICN=1.18 mV<br>ERL11=13.0 (17.1)*<br>ERL22=11.2 (14.4)* | 1x=8.2E-9 | [0.322, -0.067, -0.036, -0.069, 0.009, -0.007] | 16.8 | 29.3 | 4.6 | 4.7 |
| | 2.5x-=2.05E-8 | [0.45, -0.038, -0.015, -0.006, 0.019, 0.007] | 16.7 | 27.4 | 4.2 | 4.1 |
| | 5x=4.1E-8 | [0.49, 5e-4, 0.007, 0.006, 0.027, 0.012] | 16.7 | 27.4 | 3.7 | 3.2 |
| | 10x=8.2E-8 | [0.64, 0.06, 0.03, 0.02, 0.037, 0.021] | 16.7 | 27.4 | 2.8 | 1.9 |

* ERL results with COM 2.7.6 are lower.

# Gore C2C Channels

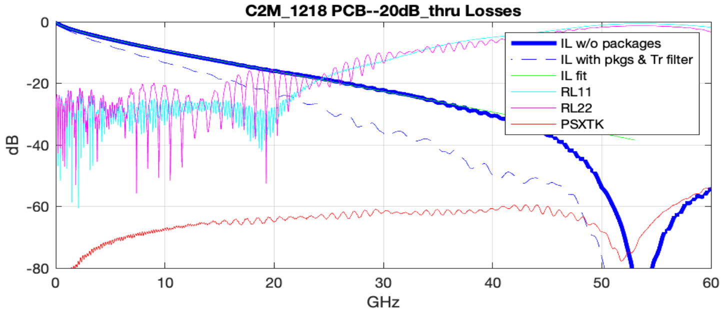
- **Construction of C2C channels based on PCB and cable construction provided by Brandon Gore**
  - http://www.ieee802.org/3/ck/public/19_05/gore_3ck_01a_0519.pdf

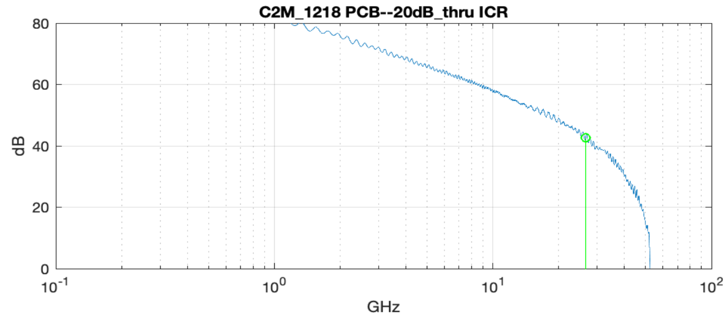


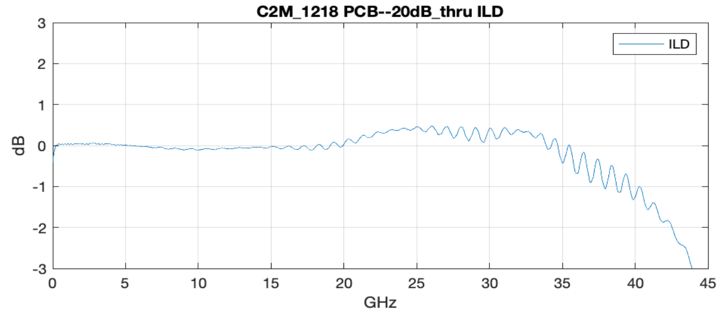



# Gore C2C 20 dB Channels

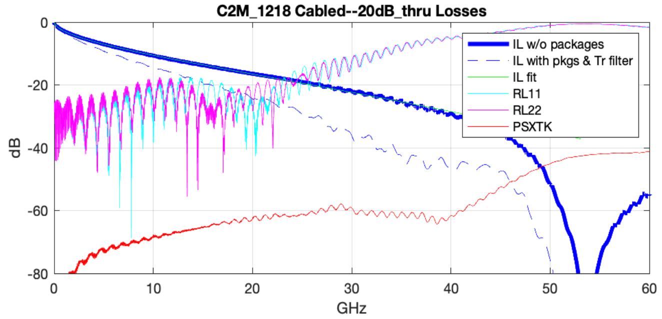
## PCB Channel

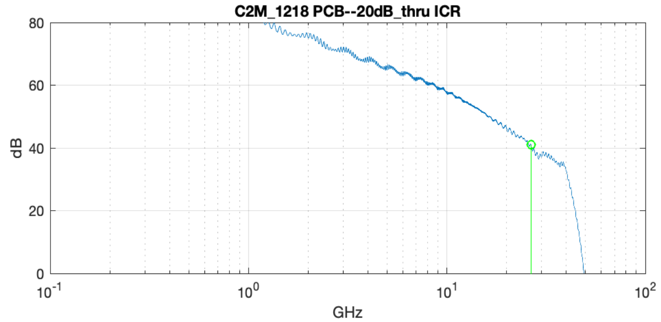


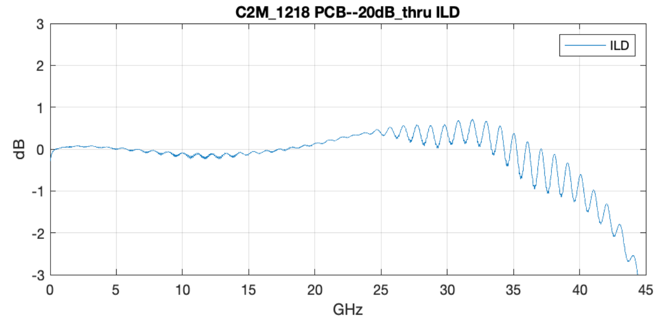




## Cabled Channel



# Core C2C Channel

| Lim C2C Channel 1 | Eta_0 Noise (V^2/GHz) | Actual DFE Taps (Largest taps case I or II) | Fitted IL at 26.55 GHz (dB) | Total IL w PKG at 26.55 GHz (dB) | COM Case I | COM Case II |
|---|---|---|---|---|---|---|
| Core C2C Channel 1<br>FOM ILD=0.13<br>ICN=0.69 mV<br>ERL11=14.7 (22.8)*<br>ERL22=14.9 (15.8)* | 1x=8.2E-9 | [0.331, -0.057, -0.036, -0.016, 0.003, -0.004] | 20.2 | 30.1 | 5.3 | 5.3 |
| | 2.5x-=2.05E-8 | [0.53, 0.015, -0.013, -0.012, 0.02, -0.005] | 20.2 | 30.1 | 4.5 | 4.1 |
| | 5x=4.1E-8 | [0.53, 0.015, -0.013, -0.012, 0.02, -0.005] | 20.2 | 30.1 | 3.6 | 2.8 |
| | 10x=8.2E-8 | [0.65, 0.11, 0.04, 0.022, 0.042, 0.01] | 20.2 | 30.1 | 2.4 | 1.1 |
| Core C2C Channel 2<br>FOM ILD=0.118<br>ICN=0.69 mV<br>ERL11=14.0 (22.8)*<br>ERL22=13.1 (15.8)* | 1x=8.2E-9 | [0.385, -0.012, 0.012, 0.004, 0.025, 0.012] | 20.2 | 30.1 | 5.1 | 4.9 |
| | 2.5x-=2.05E-8 | [0.428, -0.026, 0.016, -0.005, 0.011, 0.002] | 20.2 | 30.1 | 4.3 | 3.6 |
| | 5x=4.1E-8 | [0.428, 0.026, -0.016, 0.005, 0.011, 0.002] | 20.2 | 30.1 | 3.3 | 2.2 |
| | 10x=8.2E-8 | [0.54, 0.079, 0.05, 0.034, 0.035, 0.016] | 20.2 | 30.1 | 1.9 | 0.4 |

* ERL results with COM 2.7.6 are lower.

# Summary

- **Eta_0 of 8.2e-9 produces only 0.577 mV RMS noise assuming 40 GHz BW which is several time lower than practical low power C2C receiver**
- **The analysis considered several eta_0 values for Lim and Gore channels**
  - 1x currently in draft 1.2 - all Lim and Gore Channels pass with significant margin above 3 dB COM
  - 2.5x 0.3-1 dB of COM penalty - all Lim and Gore Channels pass 3 dB COM
  - 5.0x 1- 2 dB of COM penalty – all Lim Channels pass 3 dB COM but some instance of Gore channel fail 3 dB COM
  - 10x 2-4 dB of COM penalty – Both Lim and Gore channels fail 3 dB COM
  - Eta_0 COM penalty is somewhat higher because Lim channels have an ICN<1.87 mV and Gore channels ICN are <0.7 mV
- **Recommend to go with eta_0=4.1E-8 (5x) for C2C which equates to about 1.3 mV of RMS noise**
  - C2M also uses the same eta_0=4.1E-8.