



# 100G C2M Channel Model Update (Module-to-Host)

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# Contributors

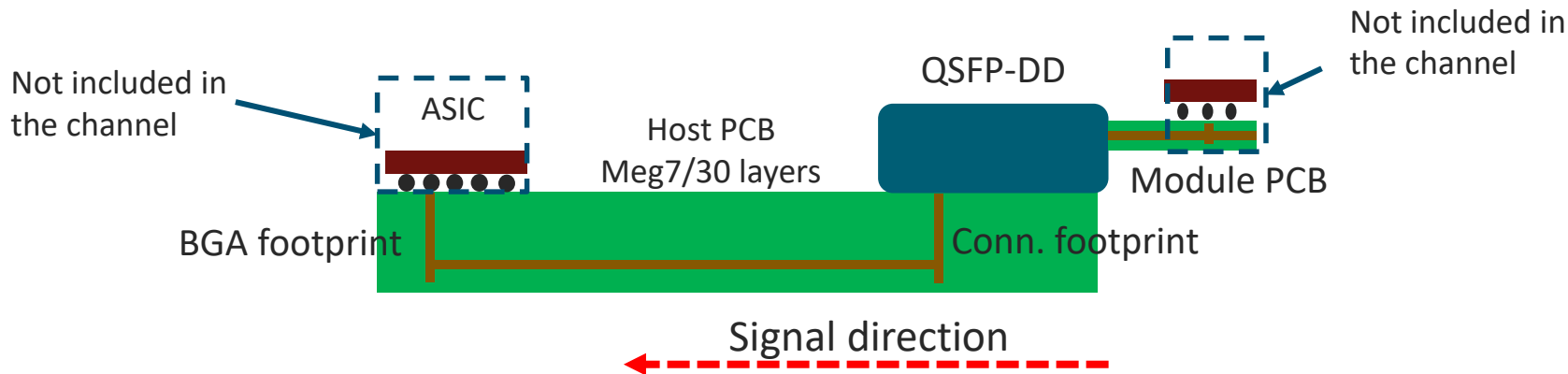
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# C2M Channel Model Update

- At March Vancouver meeting, lim\_3ck\_01a\_0319 analyzed 16 dB C2M Host to module channels at TP1a, using 112G QSFPDD SMT connector, 6 sets of channels are provided on March 3<sup>rd</sup>, 2019
- [http://www.ieee802.org/3/ck/public/tools/c2m/lim\\_3ck\\_01\\_0319\\_c2m.zip](http://www.ieee802.org/3/ck/public/tools/c2m/lim_3ck_01_0319_c2m.zip)
- This presentation provides Module-to-Host channels at TP4 and TP5, with optimized BGA & connector footprint
- Use COM scripts 2.60, to be consistent with what was used in March's presentation

# Model Overview

- 16 pairs (8 Tx, 8 Rx) QSFP-DD SMT Connector and host PCB footprint are solved as one piece in HFSS
- PCB stackup is 30 layers, 150mil thick, with Meg7 material
- PCB via stub length is modelled as 10mil
- Diff pair trace width/spacing is 4.5mil/8.5mil, 2 different trace lengths are used (2" & 9")
- ASIC footprint are simulated with actual BGA ball-out using the same PCB stackup
- Module CDR footprint is not included in the channel



# Model package assumptions

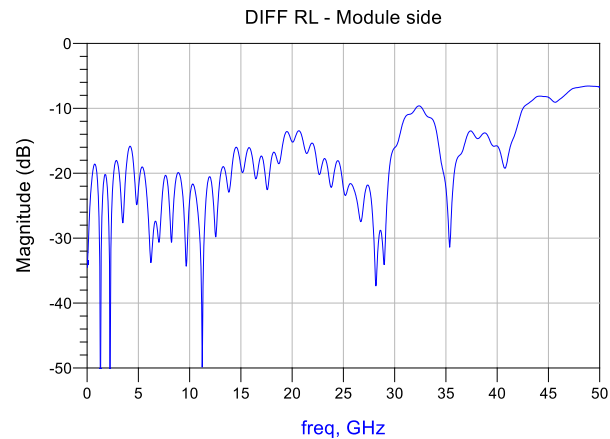
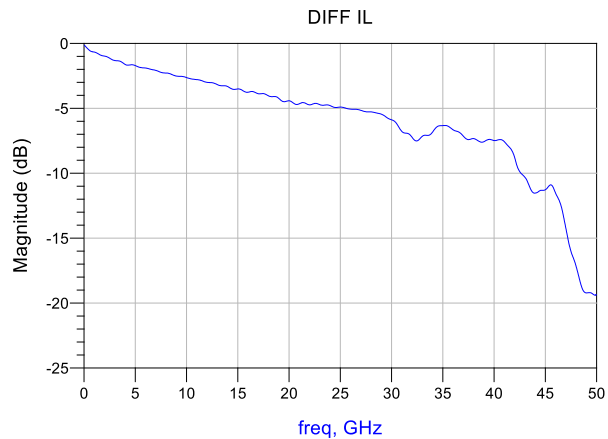
- $C_d = 0.85e-4$  nF;  $C_p = 0.87e-4$  nF
- Package trace length = 2mm & 8mm; Package PTH = 0
- Use Reference receivers B & C currently in C2M consideration (see sun\_3ck\_01\_0519)
  - Rx B: 5-tap FFE with 1-tap DFE (FFE4post with DFE b1max=0.5)
  - Rx C: 5-tap FFE
- Use COM script 2.60 (see backup slide for config\_file)

# Module-to-Host Channels

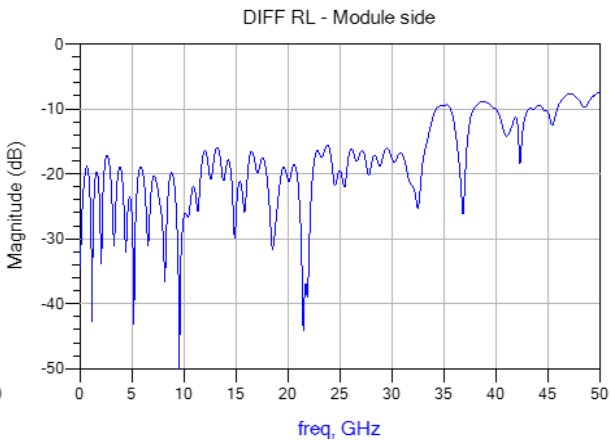
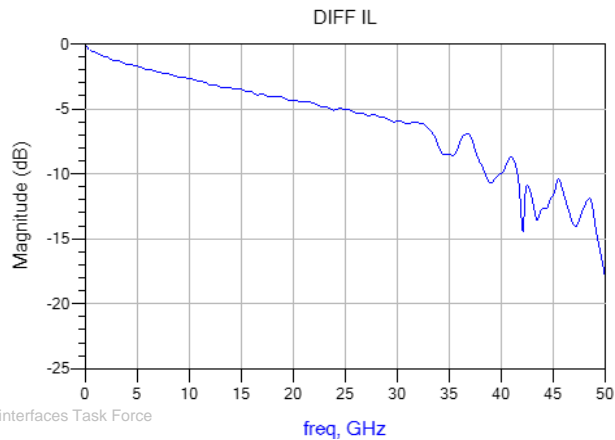
- Total 10 channels were built:
  - Channel 1a (TP4): Module PCB + QSFP-DD footprint & connector (new pair) + Host trace 2"; including 5 FEXT & 3 NEXT
  - Channel 1b (TP5): Module PCB + QSFP-DD footprint & connector (new pair) + Host trace 9" + Improved ASIC BGA footprint (long via) RX; including 5 FEXT & 3 NEXT
  - Channel 1c (TP5): Module PCB + QSFP-DD footprint & connector (new pair) + Host trace 2" + Improved ASIC BGA footprint (long via) RX; including 5 FEXT & 3 NEXT
  - Channel 1d (TP5): Module PCB + QSFP-DD footprint & connector (new pair) + Host trace 2" + Improved Retimer BGA footprint (short via) RX; including 2 FEXT & 2 NEXT
  - Channel 1e (TP5): Module PCB + QSFP-DD footprint & connector (new pair) + Host trace 2" + Improved Retimer BGA footprint (long via) RX; including 2 FEXT & 2 NEXT
  
  - Channel 2a (TP4): Module PCB + QSFP-DD footprint & connector (legacy pair) + Host trace 2"; including 5 FEXT & 3 NEXT
  - Channel 2b (TP5): Module PCB + QSFP-DD footprint & connector (legacy pair) + Host trace 9" + Improved ASIC BGA footprint (long via) RX; including 5 FEXT & 3 NEXT
  - Channel 2c (TP5): Module PCB + QSFP-DD footprint & connector (legacy pair) + Host trace 2" + Improved ASIC BGA footprint (long via) RX; including 5 FEXT & 3 NEXT
  - Channel 2d (TP5): Module PCB + QSFP-DD footprint & connector (legacy pair) + Host trace 2" + Improved Retimer BGA footprint (short via) RX; including 2 FEXT & 2 NEXT
  - Channel 2e (TP5): Module PCB + QSFP-DD footprint & connector (legacy pair) + Host trace 2" + Improved Retimer BGA footprint (long via) RX; including 2 FEXT & 2 NEXT

# Channel 1a/2a: Insertion Loss, Return Loss

**Channel 1a, TP4  
(new pair)**

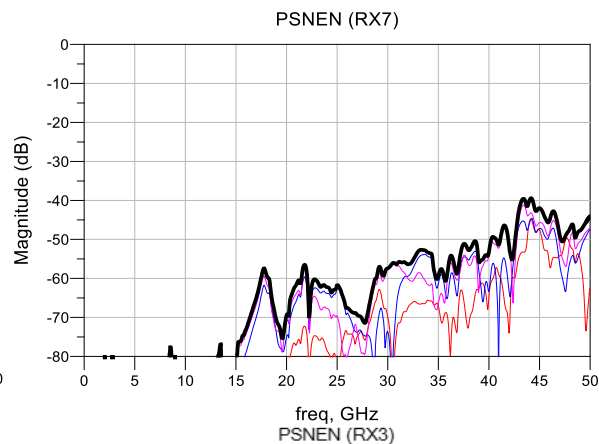
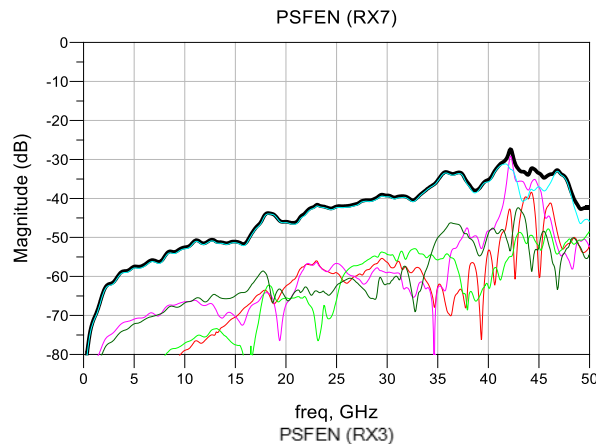


**Channel 2a, TP4  
(legacy pair)**

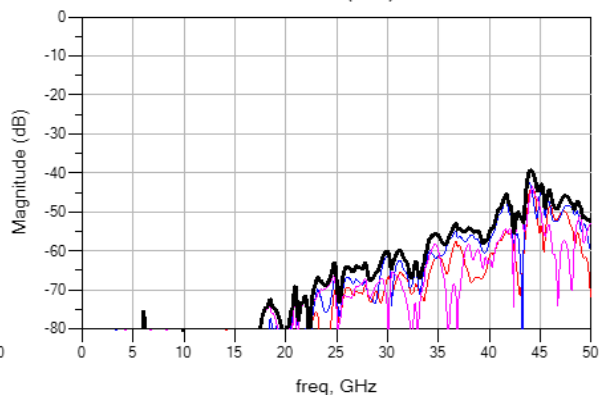
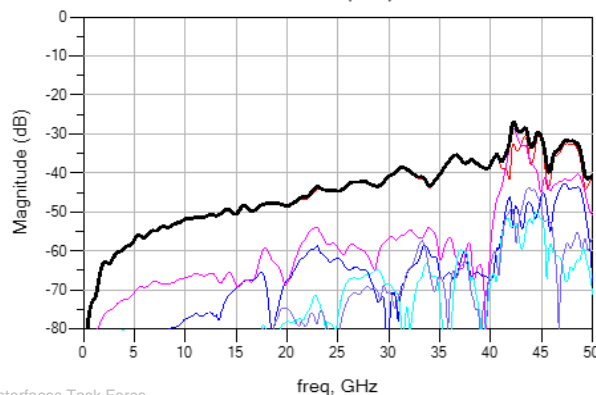


# Channel 1a/2a: Far-end and Near-end Crosstalk

Channel 1a, TP4  
(new pair)



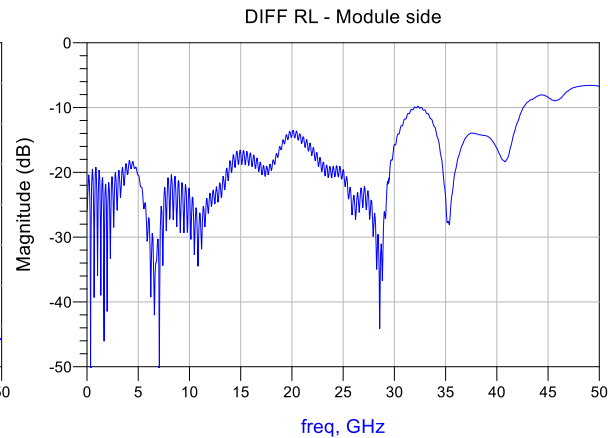
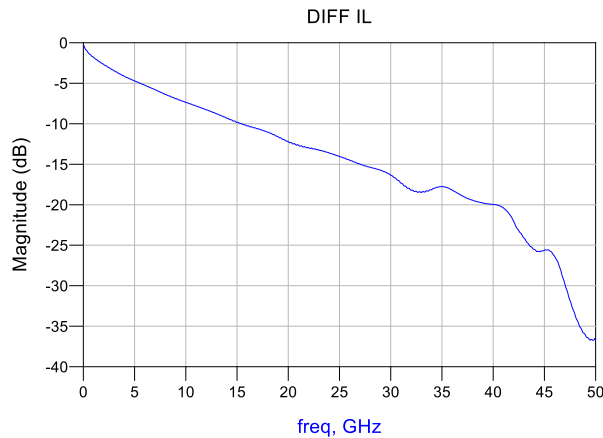
Channel 2a, TP4  
(legacy pair)



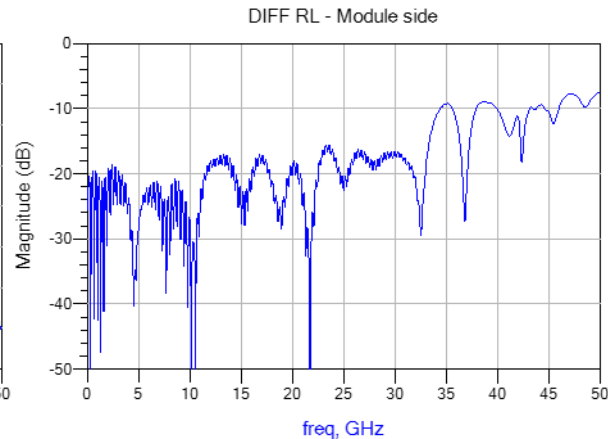
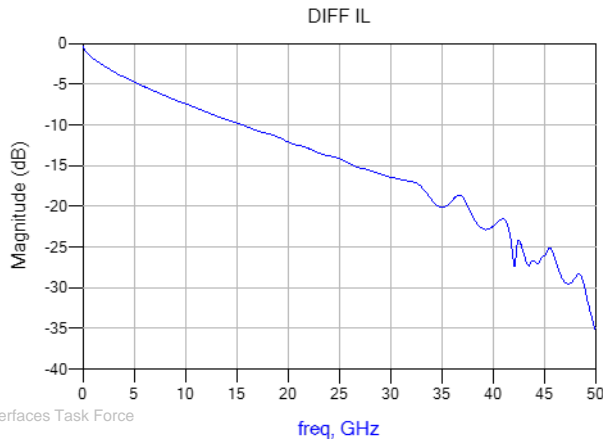


# Channel 1b/2b: Insertion Loss, Return Loss

**Channel 1b, TP5  
(new pair)**

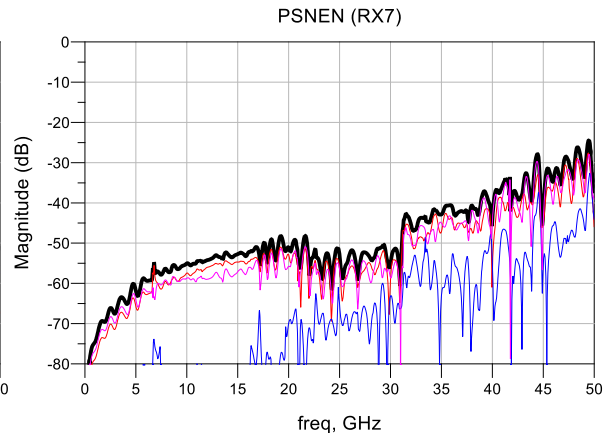
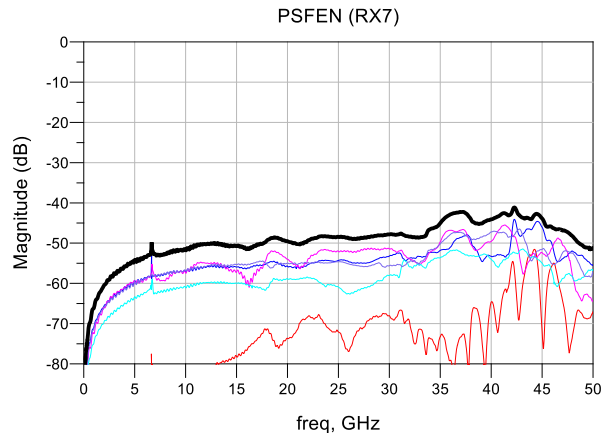


**Channel 2b, TP5  
(legacy pair)**

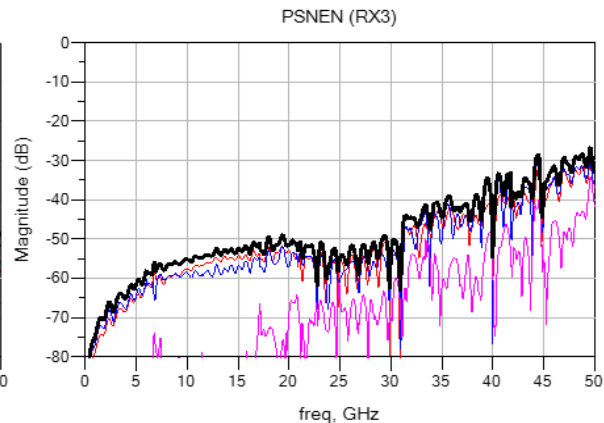
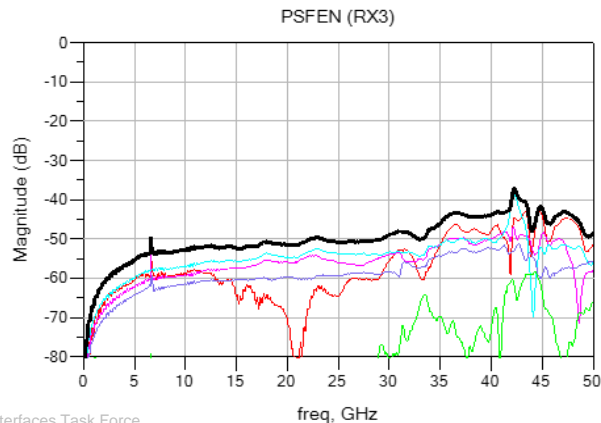


# Channel 1b/2b: Far-end and Near-end Crosstalk

Channel 1b, TP5  
(new pair)

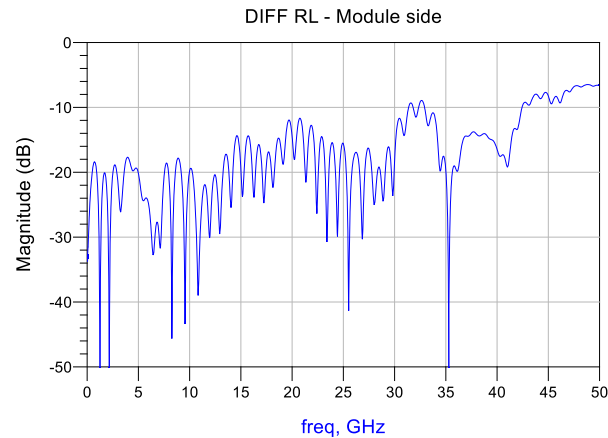
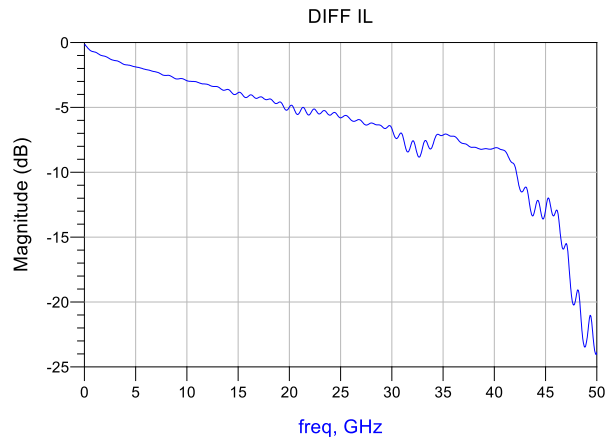


Channel 2b, TP5  
(legacy pair)

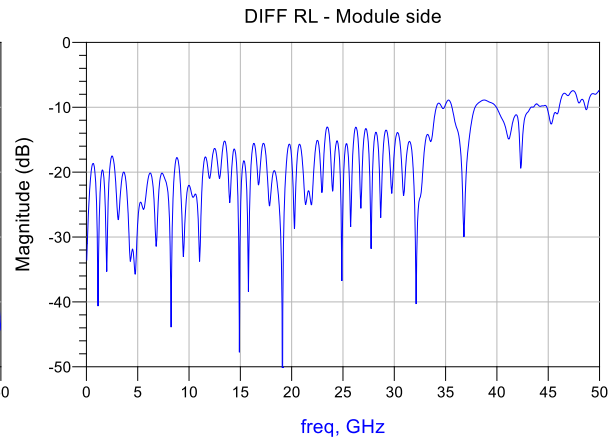
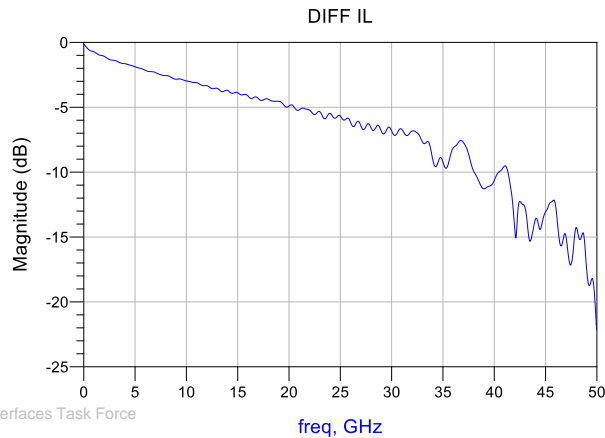


# Channel 1c/2c: Insertion Loss, Return Loss

**Channel 1c, TP5  
(new pair)**

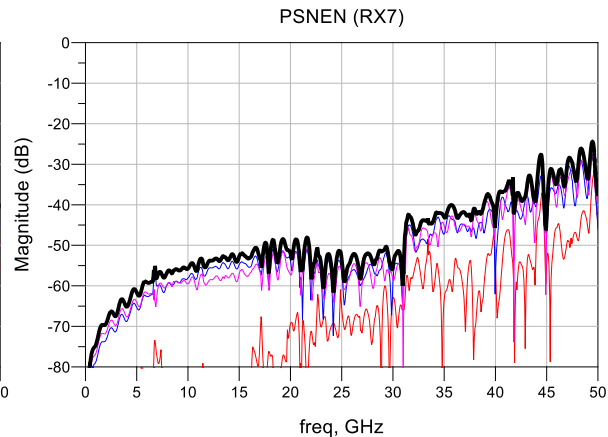
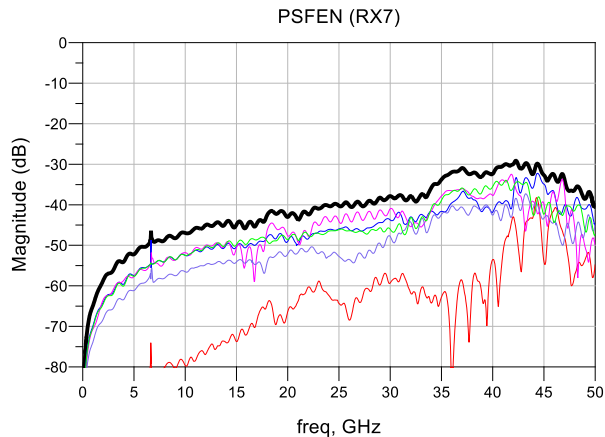


**Channel 2c, TP5  
(legacy pair)**

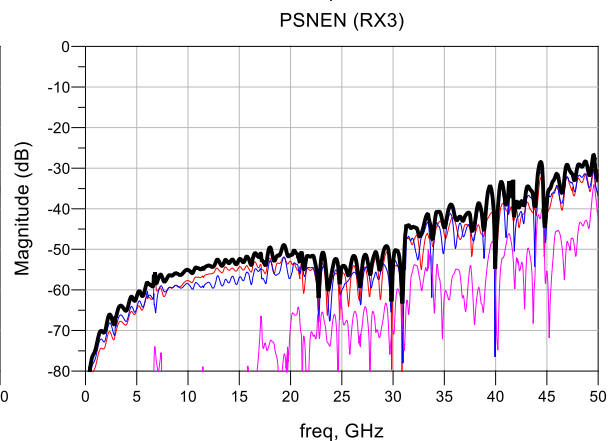
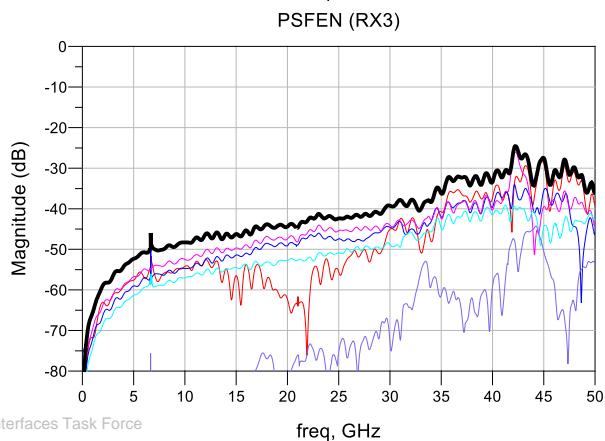


# Channel 1c/2c: Far-end and Near-end Crosstalk

Channel 1c, TP5  
(new pair)

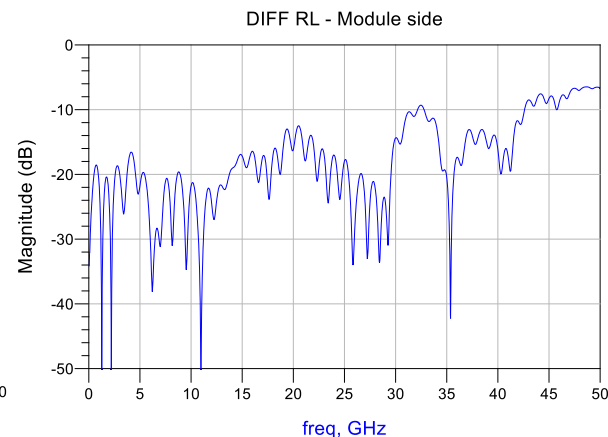
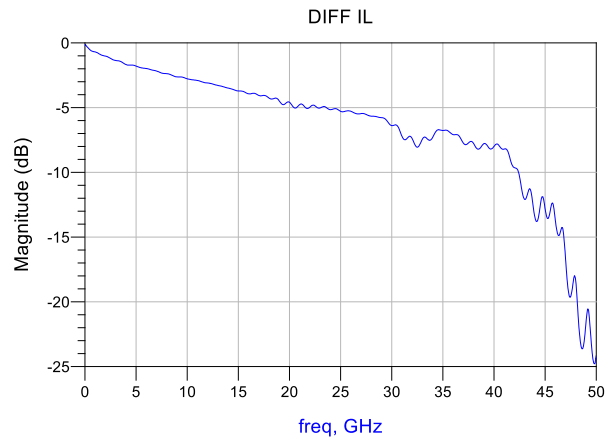


Channel 2c, TP5  
(legacy pair)

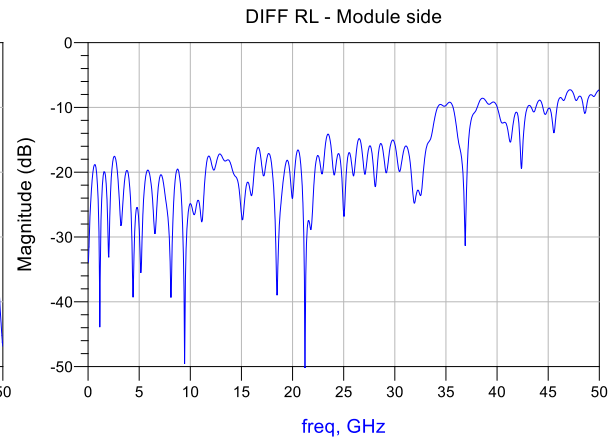
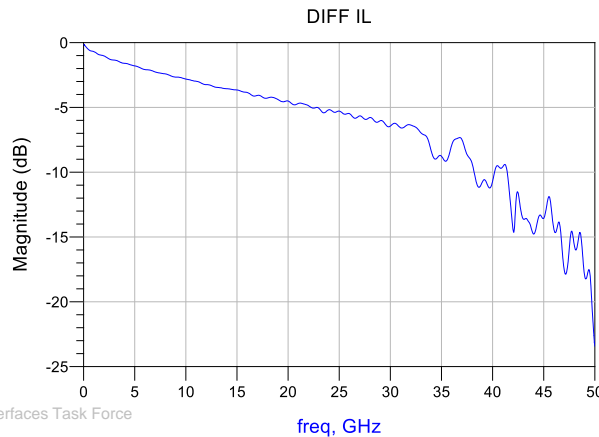


# Channel 1d/2d: Insertion Loss, Return Loss

**Channel 1d, TP5  
(new pair)**

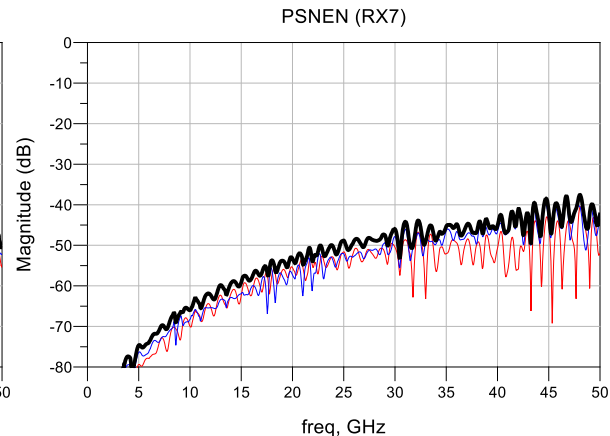
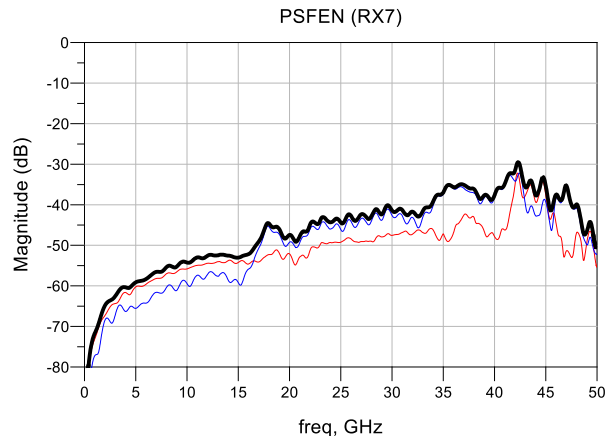


**Channel 2d, TP5  
(legacy pair)**

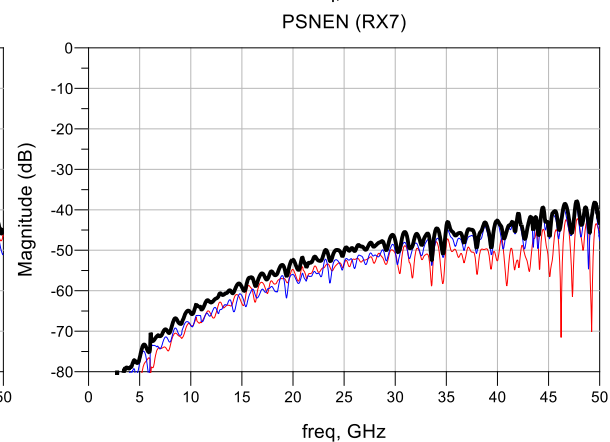
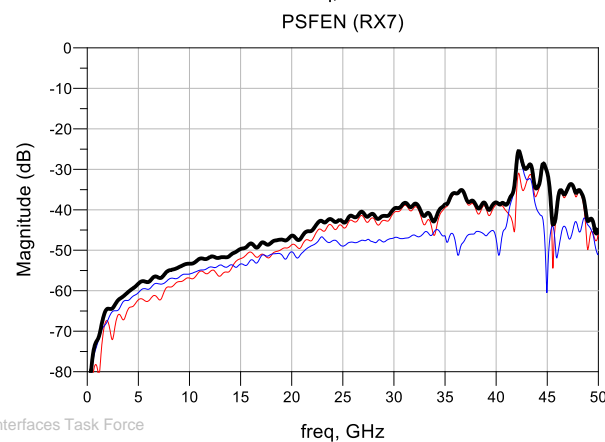


# Channel 1d/2d: Far-end and Near-end Crosstalk

Channel 1d, TP5  
(new pair)

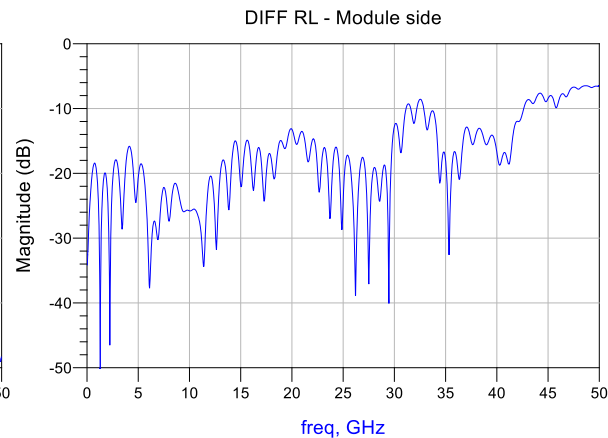
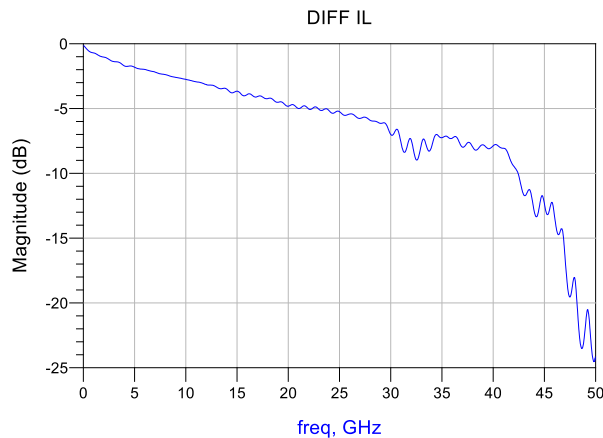


Channel 2d, TP5  
(legacy pair)

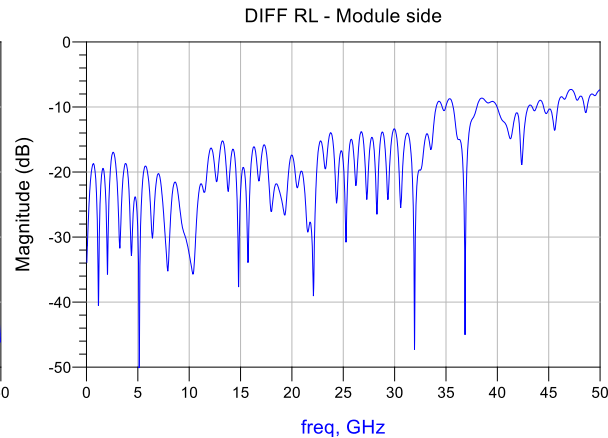
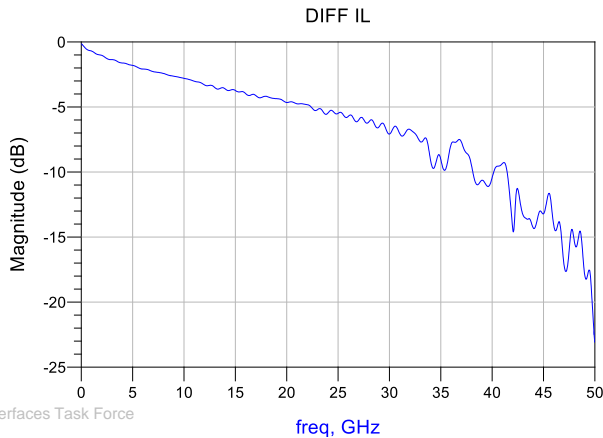


# Channel 1e/2e: Insertion Loss, Return Loss

**Channel 1e, TP5  
(new pair)**

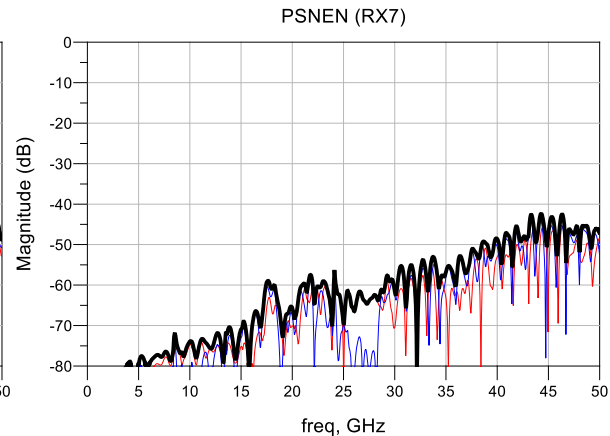
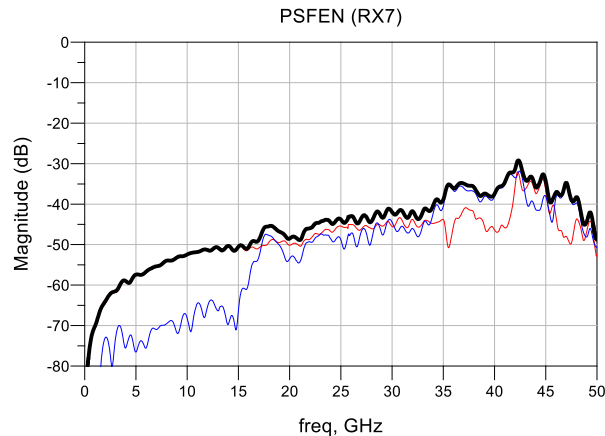


**Channel 2e, TP5  
(legacy pair)**

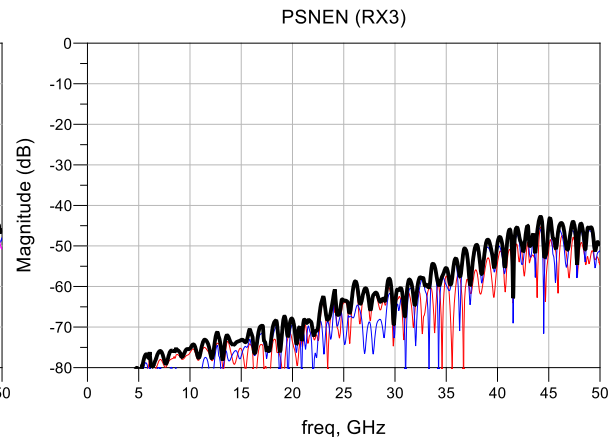
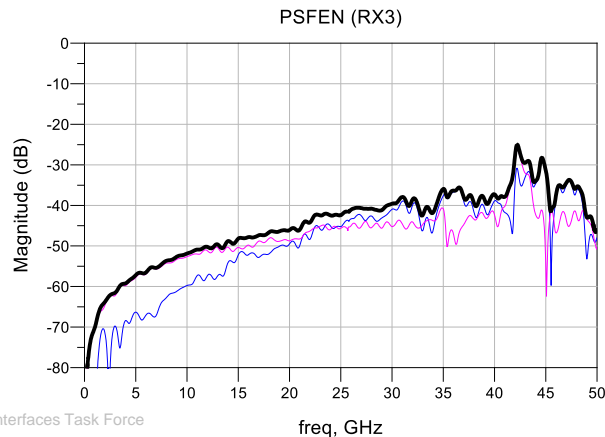


# Channel 1e/2e: Far-end and Near-end Crosstalk

Channel 1e, TP5  
(new pair)



Channel 2e, TP5  
(legacy pair)





# TP4/TP5 COM Results – 2 Ref. Rx (B & C)

| DUT        | COM<br>Case1 (2mm)<br>Rx B/Rx C (dB) | COM<br>Case2 (8mm)<br>Rx B/Rx C (dB) | ERL11<br>(dB) | ERL22<br>(dB) | ICN<br>(mV) | FOM <sub>ILD</sub><br>(dBrms) | IL@26G ball-<br>to-ball<br>(dB) |
|------------|--------------------------------------|--------------------------------------|---------------|---------------|-------------|-------------------------------|---------------------------------|
| Channel 1a | 6.36/6.79                            | 5.45/5.47                            | 11.49         | 9.30          | 2.21        | 0.18                          | 5.07                            |
| Channel 1b | 5.91/5.56                            | 5.30/4.43                            | 12.10         | 9.79          | 1.92        | 0.17                          | 14.76                           |
| Channel 1c | 5.42/5.88                            | 4.26/4.51                            | 11.28         | 7.40          | 3.25        | 0.20                          | 6.00                            |
| Channel 1d | 6.19/6.60                            | 5.18/5.25                            | 11.54         | 8.67          | 2.12        | 0.19                          | 5.47                            |
| Channel 1e | 6.03/6.55                            | 5.00/5.13                            | 11.60         | 8.35          | 1.81        | 0.20                          | 5.60                            |
| Channel 2a | 6.40/6.76                            | 6.17/6.34                            | 12.54         | 9.77          | 1.83        | 0.17                          | 5.34                            |
| Channel 2b | 6.16/5.90                            | 5.64/5.17                            | 13.06         | 9.80          | 1.85        | 0.16                          | 15.04                           |
| Channel 2c | 6.10/6.39                            | 5.48/5.65                            | 12.10         | 7.88          | 2.99        | 0.18                          | 6.18                            |
| Channel 2d | 6.38/6.73                            | 6.00/6.23                            | 12.32         | 9.06          | 2.22        | 0.20                          | 5.83                            |
| Channel 2e | 6.45/6.79                            | 5.72/5.90                            | 12.35         | 8.83          | 2.08        | 0.17                          | 5.97                            |

Rx B = Ref. Rx with 5FFE + 1DFE; Rx C = Ref. Rx with 5FFE only, as listed in sun\_3ck\_01\_0519

# Summary

- C2M TP4 and TP5 channels are built with optimized BGA and connector footprints including 112G QSFP-DD connector
- Both TP4 and TP5 channels can pass COM with margin using either ref. receiver B (5 tap FFE + 1 DFE tap) or ref. receiver C (5 tap FFE)
  - Ref. receiver C shows better COM values on all the short channels built with 2" trace
- Although TP4 channel 1a/2a has much less IL (~5dB) vs. TP5 channel 1b/2b (~15dB), COM is only ~0.3dB higher
  - TP4 and TP5 channels have similar ICN values (TP4 channel 1a/2a has higher FEXT, TP5 channel 1b/2b has higher NEXT)
- Channel 1c/2c have worse COM among the 10 channels due to more worse ILD & ICN with shorter trace and long via at the receiver end

*Backup Slides*

# Ref Receiver B

| 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                    | [0.85e-4 0]   | nF      | [TX RX]             |
| z_p select             | [ 1 2]        |         | [test cases to run] |
| z_p (TX)               | [2 8 ; 0 0]   | mm      | [test cases]        |
| z_p (NEXT)             | [0 0 ; 0 0]   | mm      | [test cases]        |
| z_p (FEXT)             | [2 8 ; 0 0]   | mm      | [test cases]        |
| z_p (RX)               | [0 0 ; 0 0]   | mm      | [test cases]        |
| C_p                    | [0.87e-4 0]   | nF      | [TX RX]             |
| R_0                    | 50            | Ohm     |                     |
| R_d                    | [ 45 50]      | Ohm     | [TX RX]             |
| A_v                    | 0.41          | V       |                     |
| A_fe                   | 0.41          | V       |                     |
| A_ne                   | 0.6           | V       |                     |
| L                      | 4             |         |                     |
| M                      | 32            |         |                     |
| filter and Eq          |               |         |                     |
| f_r                    | 0.75          | *fb     |                     |
| c(0)                   | 0.6           |         | min                 |
| c(-1)                  | [-0.2:0.02:0] |         | [min:step:max]      |
| c(-2)                  | [0:.02:0.1]   |         | [min:step:max]      |
| c(-3)                  | 00:00.0       |         | [min:step:max]      |
| c(1)                   | [-0.1:0.05:0] |         | [min:step:max]      |
| N_b                    | 1             | UI      |                     |
| b_max(1)               | 0.5           |         |                     |
| b_max(2..N_b)          | 0.2           |         |                     |
| g_DC                   | [-14:0.5:-4]  | dB      | [min:step:max]      |
| f_z                    | 18.5534       | GHz     |                     |
| f_p1                   | 28.2          | GHz     |                     |
| f_p2                   | 53.125        | GHz     |                     |
| g_DC_HP                | [-3:..0.5:0]  |         | [min:step:max]      |
| f_HP_PZ                | 1.328125      | GHz     |                     |
| ffe_pre_tap_len        | 0             | UI      |                     |
| ffe_post_tap_len       | 4             | UI      |                     |
| Include PCB            | 0             | logical |                     |
| ffe_tap_step_size      | 0             |         |                     |
| ffe_main_cursor_min    | 0.7           |         |                     |
| ffe_pre_tap1_max       | 0.3           |         |                     |
| ffe_post_tap1_max      | 0.3           |         |                     |
| ffe_tapn_max           | 0.125         |         |                     |
| ffe_backoff            | 1             |         |                     |

| I/O control         |                             |                     |
|---------------------|-----------------------------|---------------------|
| DIAGNOSTICS         | 1                           | logical             |
| DISPLAY_WINDOW      | 1                           | logical             |
| CSV_REPORT          | 1                           | logical             |
| RESULT_DIR          | .\results\100GEL_WG_(date)\ |                     |
| SAVE_FIGURES        | 0                           | logical             |
| Port Order          | [ 1 3 2 4]                  |                     |
| RUNTAG              | C2M_1218                    |                     |
| COM_CONTRIBUTION    | 0                           | logical             |
| Operational         |                             |                     |
| COM Pass threshold  | 3                           | dB                  |
| ERL Pass threshold  | 10.5                        | dB                  |
| DER_0               | 1.00E-05                    |                     |
| T_r                 | 6.16E-03                    | ns                  |
| FORCE_TR            | 1                           | logical             |
| Include PCB         | 0                           | logical             |
| TDR and ERL options |                             |                     |
| TDR                 | 1                           | logical             |
| ERL                 | 1                           | logical             |
| ERL_ONLY            | 0                           | logical             |
| TR_TDR              | 0.01                        | ns                  |
| N                   | 300                         |                     |
| TDR_Butterworth     | 1                           | logical             |
| beta_x              | 1.70E+09                    |                     |
| rho_x               | 0.18                        |                     |
| fixture delay time  | 0                           |                     |
| TDR_W_TXPKG         | 1                           |                     |
| 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               | 8.20E-09                    | V <sup>2</sup> /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          | 6.1400E-03                | ns/mm |
| package_Z_c             | [87.5 87.5 ; 92.5 92.5]   | Ohm   |
| Table 92-12 parameters  |                           |       |
| Parameter               | Setting                   | Units |
| board_tl_gamma0_a1_a2   | [0 3.8206e-04 9.5909e-05] |       |
| board_tl_tau            | 5.790E-03                 | ns/mm |
| board_Z_c               | 90                        | Ohm   |
| z_bp (TX)               | 119                       | mm    |
| z_bp (NEXT)             | 119                       | mm    |
| z_bp (FEXT)             | 119                       | mm    |
| z_bp (RX)               | 119                       | mm    |

# Ref Receiver C

| 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                    | [0.85e-4 0]   | nF      | [TX RX]             |
| z_p select             | [ 1 2]        |         | [test cases to run] |
| z_p (TX)               | [2 8 ; 0 0]   | mm      | [test cases]        |
| z_p (NEXT)             | [0 0 ; 0 0]   | mm      | [test cases]        |
| z_p (FEXT)             | [2 8 ; 0 0]   | mm      | [test cases]        |
| z_p (RX)               | [0 0 ; 0 0]   | mm      | [test cases]        |
| C_p                    | [0.87e-4 0]   | nF      | [TX RX]             |
| R_0                    | 50            | Ohm     |                     |
| R_d                    | [ 45 50]      | Ohm     | [TX RX]             |
| A_v                    | 0.41          | V       |                     |
| A_fe                   | 0.41          | V       |                     |
| A_ne                   | 0.6           | V       |                     |
| L                      | 4             |         |                     |
| M                      | 32            |         |                     |
| filter and Eq          |               |         |                     |
| f_r                    | 0.75          | *fb     |                     |
| c(0)                   | 0.6           |         | min                 |
| c(-1)                  | [-0.2:0.02:0] |         | [min:step:max]      |
| c(-2)                  | [0:.02:0.1]   |         | [min:step:max]      |
| c(-3)                  | 00:00.0       |         | [min:step:max]      |
| c(1)                   | [-0.1:0.05:0] |         | [min:step:max]      |
| N_b                    | 0             | UI      |                     |
| b_max(1)               | 0.5           |         |                     |
| b_max(2..N_b)          | 0.2           |         |                     |
| g_DC                   | [-14:0.5:-4]  | dB      | [min:step:max]      |
| f_z                    | 18.5534       | GHz     |                     |
| f_p1                   | 28.2          | GHz     |                     |
| f_p2                   | 53.125        | GHz     |                     |
| g_DC_HP                | [-3:..0.5:0]  |         | [min:step:max]      |
| f_HP_PZ                | 1.328125      | GHz     |                     |
| ffe_pre_tap_len        | 0             | UI      |                     |
| ffe_post_tap_len       | 4             | UI      |                     |
| Include PCB            | 0             | logical |                     |
| ffe_tap_step_size      | 0             |         |                     |
| ffe_main_cursor_min    | 0.7           |         |                     |
| ffe_pre_tap1_max       | 0.3           |         |                     |
| ffe_post_tap1_max      | 0.3           |         |                     |
| ffe_tapn_max           | 0.125         |         |                     |
| ffe_backoff            | 1             |         |                     |

| I/O control         |                             |                     |
|---------------------|-----------------------------|---------------------|
| DIAGNOSTICS         | 1                           | logical             |
| DISPLAY_WINDOW      | 1                           | logical             |
| CSV_REPORT          | 1                           | logical             |
| RESULT_DIR          | .\results\100GEL_WG_(date)\ |                     |
| SAVE_FIGURES        | 0                           | logical             |
| Port Order          | [ 1 3 2 4]                  |                     |
| RUNTAG              | C2M_1218                    |                     |
| COM_CONTRIBUTION    | 0                           | logical             |
| Operational         |                             |                     |
| COM Pass threshold  | 3                           | dB                  |
| ERL Pass threshold  | 10.5                        | dB                  |
| DER_0               | 1.00E-05                    |                     |
| T_r                 | 6.16E-03                    | ns                  |
| FORCE_TR            | 1                           | logical             |
| Include PCB         | 0                           | logical             |
| TDR and ERL options |                             |                     |
| TDR                 | 1                           | logical             |
| ERL                 | 1                           | logical             |
| ERL_ONLY            | 0                           | logical             |
| TR_TDR              | 0.01                        | ns                  |
| N                   | 300                         |                     |
| TDR_Butterworth     | 1                           | logical             |
| beta_x              | 1.70E+09                    |                     |
| rho_x               | 0.18                        |                     |
| fixture delay time  | 0                           |                     |
| TDR_W_TXPKG         | 1                           |                     |
| 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               | 8.20E-09                    | V <sup>2</sup> /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          | 6.1400E-03                | ns/mm |
| package_Z_c             | [87.5 87.5 ; 92.5 92.5]   | Ohm   |
| 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               | 90                        | Ohm   |
| z_bp (TX)               | 119                       | mm    |
| z_bp (NEXT)             | 119                       | mm    |
| z_bp (FEXT)             | 119                       | mm    |
| z_bp (RX)               | 119                       | mm    |