MACOM™

Partners from RF to Light

RX Reference Receiver

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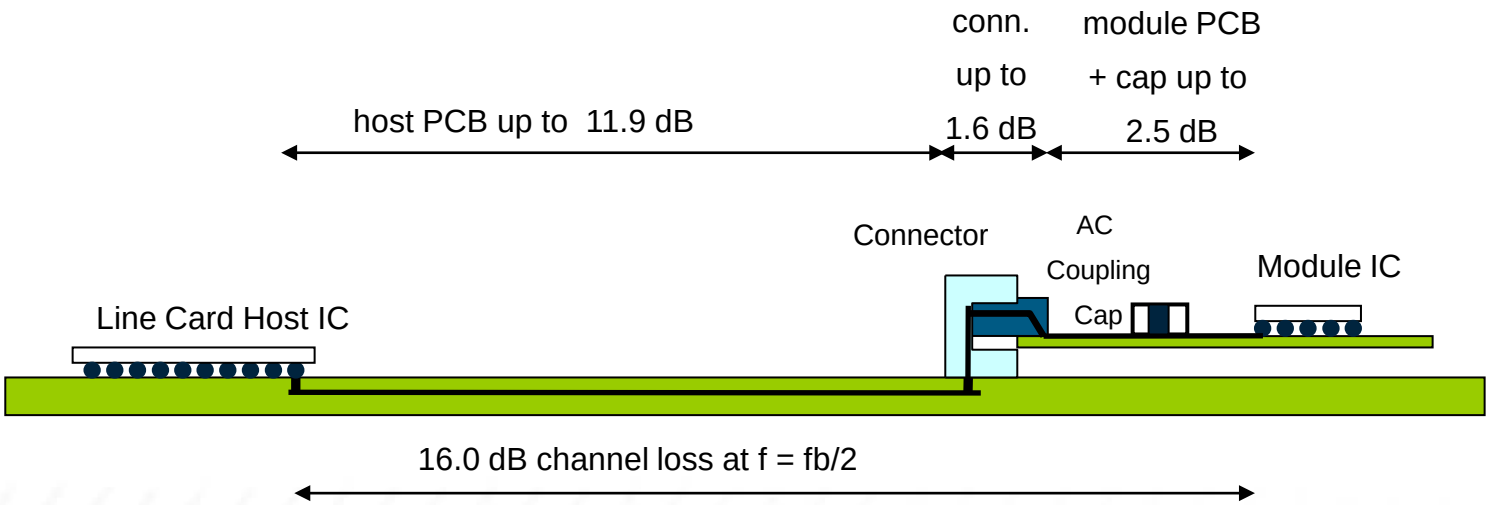
Summary:

- Goal at this meeting is to select a TP1a, TP4, TP5 reference receiver.
- The TP1a reference receiver is the minimal receiver for implementations. In practice the ‘real’ receiver will need to be higher performance to fix module routing and package impairments.
  - The difference between real receivers will vary greatly depending on module designs.
    - Full DSPs will be required for large modules with large packages.
    - Real receivers equivalent to the reference receiver may be used for chip on board small module designs (long traces, no package)
- We still do not have ‘100G’ channels for simulations
  - Better connectors and host layouts are soon to be contributed
  - We have identified some contributed channels as ‘bad’ but they continue to be considered for Reference Rx selection

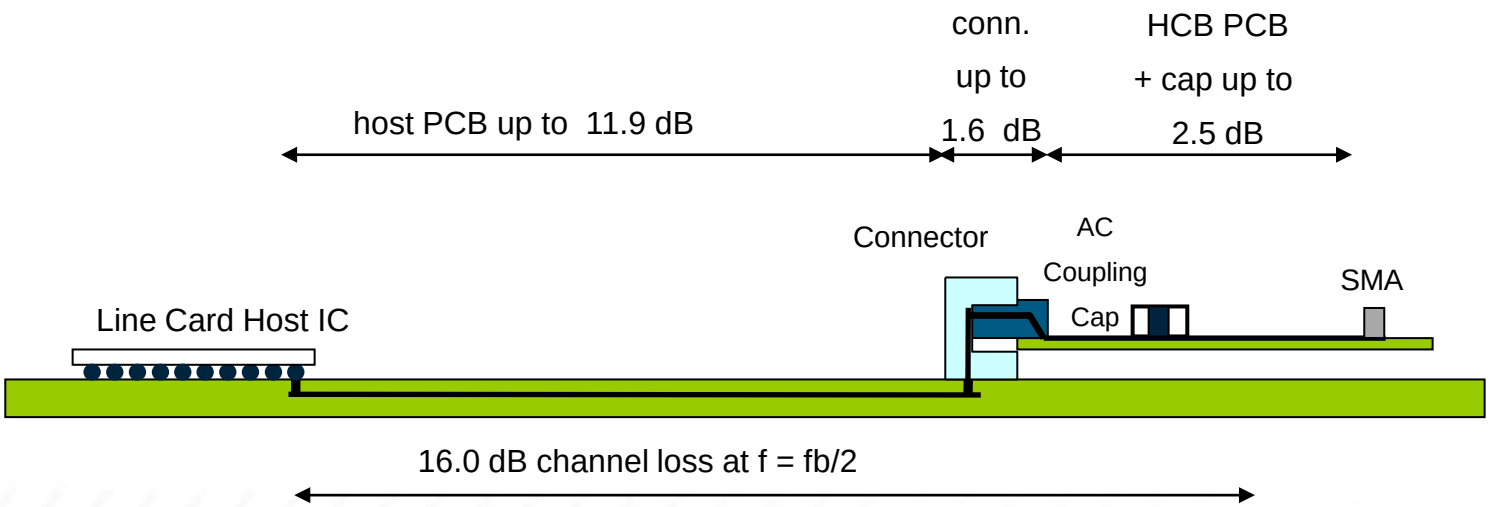
TP1a Reference Rx vs real Rx

- TP1a is probably higher loss than module
- TP1a has matched impedance with no package



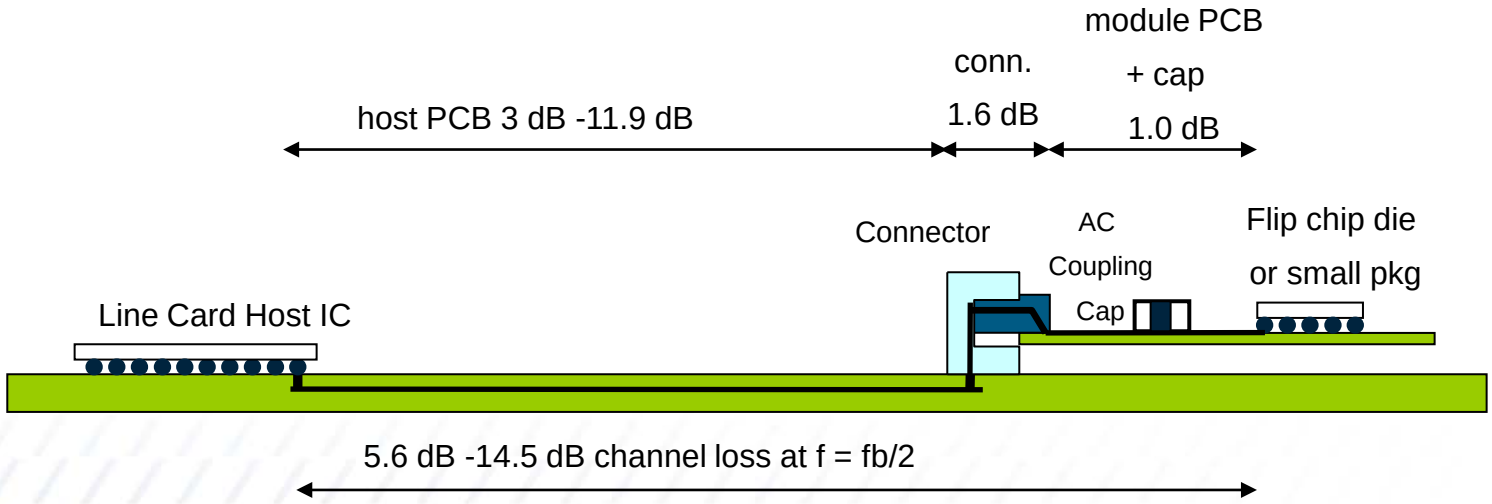
TP1a measurement point

> SMA connector/cable terminated at test equipment instead of package



Best case actual design

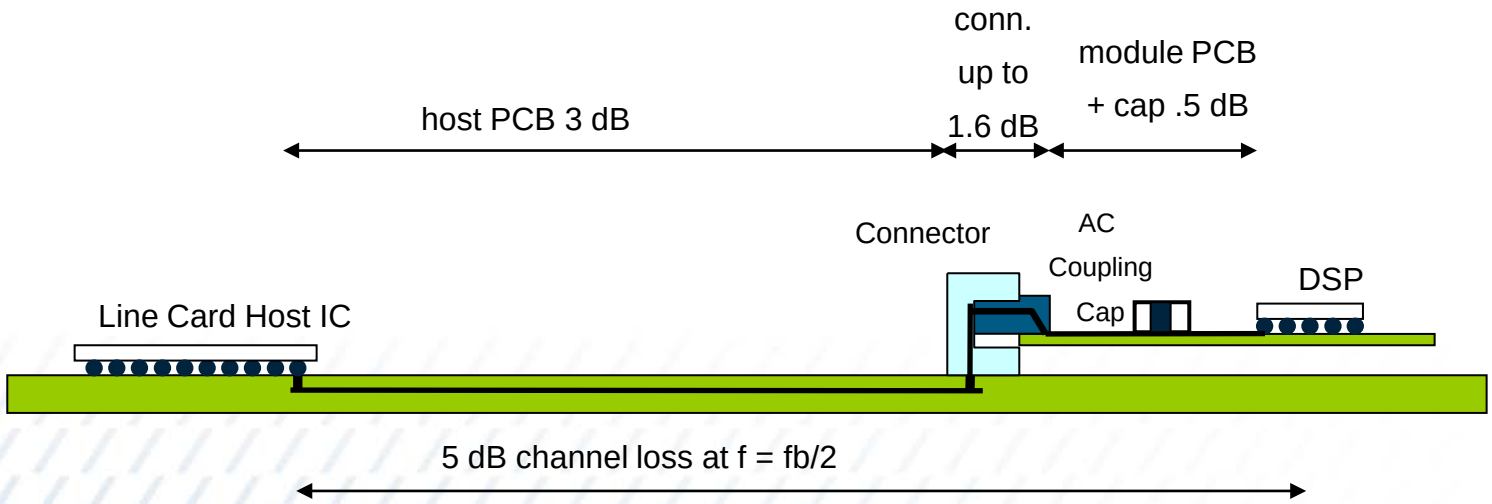
- Long Module traces (high loss)
- No package parasitics (good return loss)
- SFP module (No crosstalk)



- 5 tap FFE works well

Worst case actual design

- Short Module traces (Low loss)
- Non-optimal Package traces (Reflections)
- Large package parasitics (reflections)
- QSFP-DD module (crosstalk, reflections)



- DSP may be required

Channel set: We are not using any 100G channels

ID	Channel Description	Vote in May	IL (dB)	ERL11 (dB)	ERL22 (dB)	ICN (mV)	ILD (dB)
8	mellitz_3ck_01_0518_C2M\9dB	Pass	8.95	16.35	13.56	2.10	0.10
9	mellitz_3ck_01_0518_C2M\10dB	Fail	9.96	7.79	10.91	4.27	0.48
10	mellitz_3ck_01_0518_C2M\11dB	Pass	11.16	18.28	14.64	1.75	0.09
11	mellitz_3ck_01_0518_C2M\12dB	Fail	12.18	8.39	11.64	3.75	0.46
12	mellitz_3ck_01_0518_C2M\13dB	Pass	13.12	20.09	15.25	1.50	0.09
13	mellitz_3ck_01_0518_C2M\14dB	Fail	13.87	8.73	12.80	2.98	0.47
14	tracy_100GEL_02_0118\long_barrel_via\TX5	TBD	16.48	14.98	11.75	0.86	0.28
15	tracy_100GEL_02_0118\long_barrel_via\TX6	TBD	16.08	14.35	12.82	0.86	0.37
16	tracy_100GEL_06_0118\Microvia\RX6	Pass	14.59	15.71	12.74	0.79	0.21
17	tracy_100GEL_06_0118\Microvia\RX5	TBD	14.57	16.20	13.76	0.89	0.23
18	lim_3ck_01_0319_QDD_new_pad\ch1	Pass	14.40	15.83	21.66	0.73	0.20
19	lim_3ck_01_0319_QDD_new_pad\ch2	Pass	14.60	14.51	21.02	0.76	0.19
20	lim_3ck_01_0319_QDD_legacy_pad\ch3	Pass	14.69	16.04	16.42	0.72	0.20
21	llim_3ck_01_0319_QDD_legacy_pad\ch4	Pass	14.84	14.77	16.11	0.81	0.18
22	llim_3ck_01_0319_QDD_new_pad\ch5	TBD	14.77	14.70	21.42	1.34	0.16
23	llim_3ck_01_0319_QDD_legacy_pad\ch6	Pass	15.02	15.01	16.30	1.47	0.17
24	ito_3ck_01\QSFP \bottom normal\	Pass	15.10	12.79	10.92	1.14	0.18
25	ito_3ck_01\QSFP \bottom worst\	TBD	15.58	12.49	10.48	1.09	0.32
26	ito_3ck_01\QSFP \top normal\	Pass	14.53	12.76	11.03	1.19	0.18
27	ito_3ck_01\QSFP \top worst\	TBD	14.49	12.43	10.52	1.14	0.31

Mellitz channels use Flyover with FQSFP connector

Tracy channels use 50G OSFP connector

Lim channels use Unoptimized QSFP-DD connector

Ito channels use 100G QSFP connector with further improvements under study

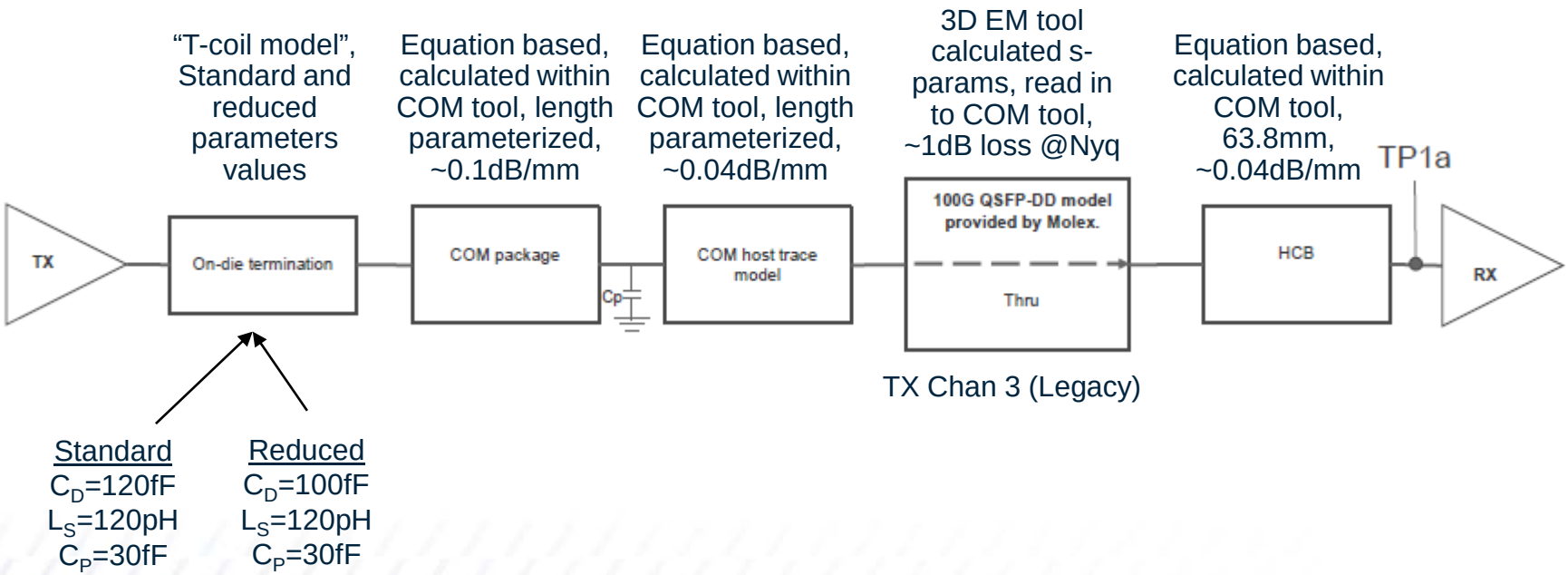
Short channels will have the biggest improvement when we get 100G connectors

- Connector models and host impairments will improve.

ID	Channel Description	IL (dB)	ERL11 (dB)	ERL22 (dB)	ICN (mV)	ILD (dB)
1	lim_3ck_adhoc_01_073119\2inch	5.67	11.93	13.31	3.52	0.16
2	lim_3ck_adhoc_01_073119\3inch	6.94	12.69	14.91	3.05	0.15
3	lim_3ck_adhoc_01_073119\4inch	8.22	13.31	16.36	2.65	0.14
4	lim_3ck_adhoc_01_073119\9inch	14.55	15.17	21.37	1.34	0.13
5	akinwale_3ck_adhoc_01a_08282019\2inch	7.15	12.61	15.48	5.54	0.36
6	akinwale_3ck_adhoc_01a_08282019\3inch	8.37	13.89	17.26	5.24	0.36
7	akinwale_3ck_adhoc_01a_08282019\4inch	9.70	14.11	18.88	5.01	0.36

Simulation Setup
TP1a

- Newer Molex connector model than Dudek used



TX package: 11.5mm

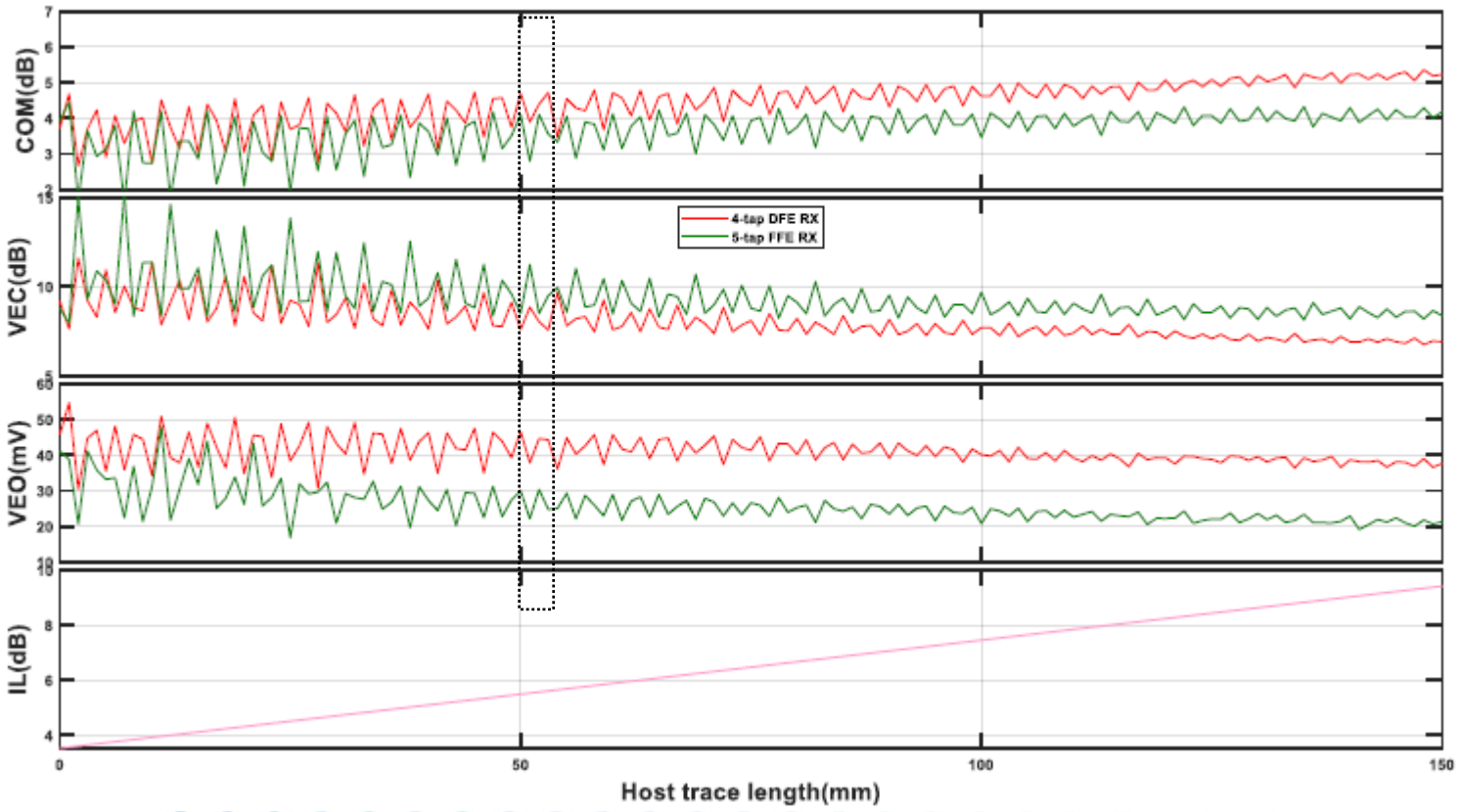
TP1a Standard Parasitics

Dudek 50-100mm Host Trace Length

C_D=120fF
L_S=120pH
C_B=30fF
C_P=87fF

- The biggest problem will be some resonant length between 50 and ~51.65mm
  - UI is covered in about 1.65mm (19ps double transit at ~5.8ps/mm)

TP1a results by equalization

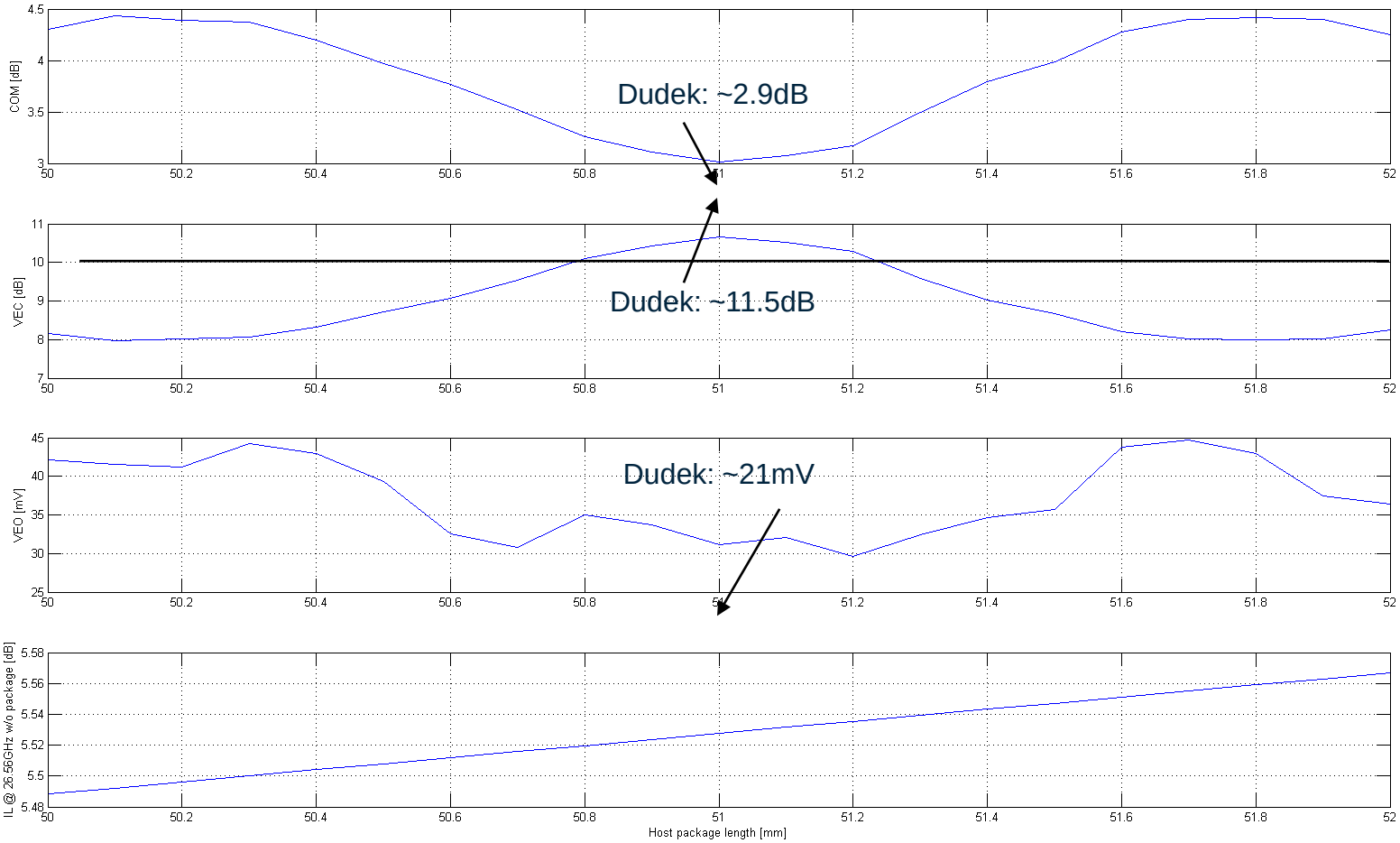


TX package: 11.5mm

TP1a Standard Parasitics
50-52mm Host Trace Length

C_D=120fF
L_S=120pH
C_B=30fF
C_P=87fF

- VEC is marginal (10.7dB) at worst case host trace length (51.0mm)
- VEO is healthy and will make VEC pass if the combined VEC/VEO spec is adopted



TP1a Standard Parasitics
Comparison to Dudek

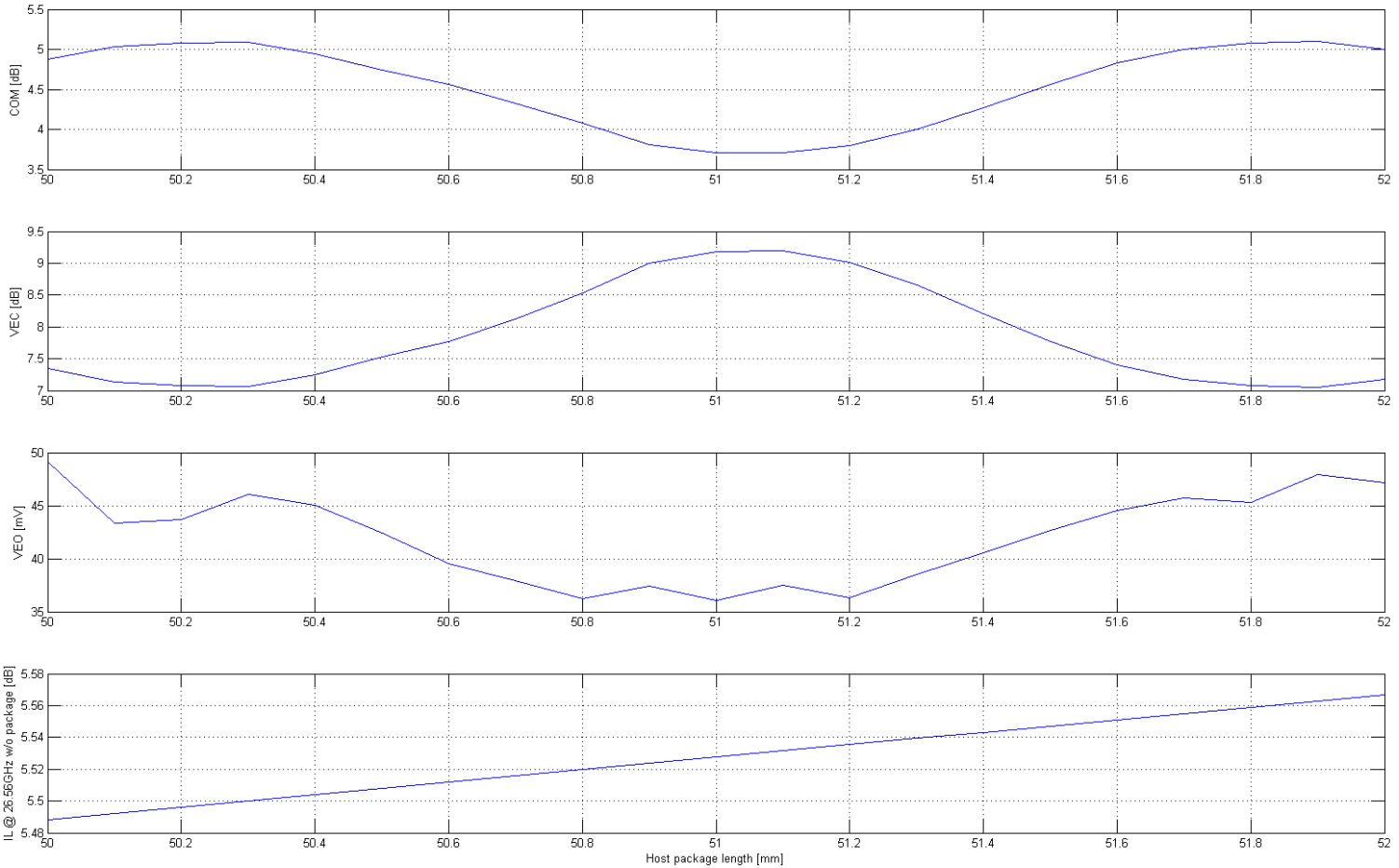
- With the same parasitics as Dudek, the trend is the same, but there is a noticeable performance improvement shift
- The only difference is the updated connector model, so this must be the cause of improvement
    - Makes sense as the biggest double reflection is between the host TX die and connector discontinuities

TX package: 11.5mm

TP1a Reduced Parasitics
50-52mm Host Trace Length

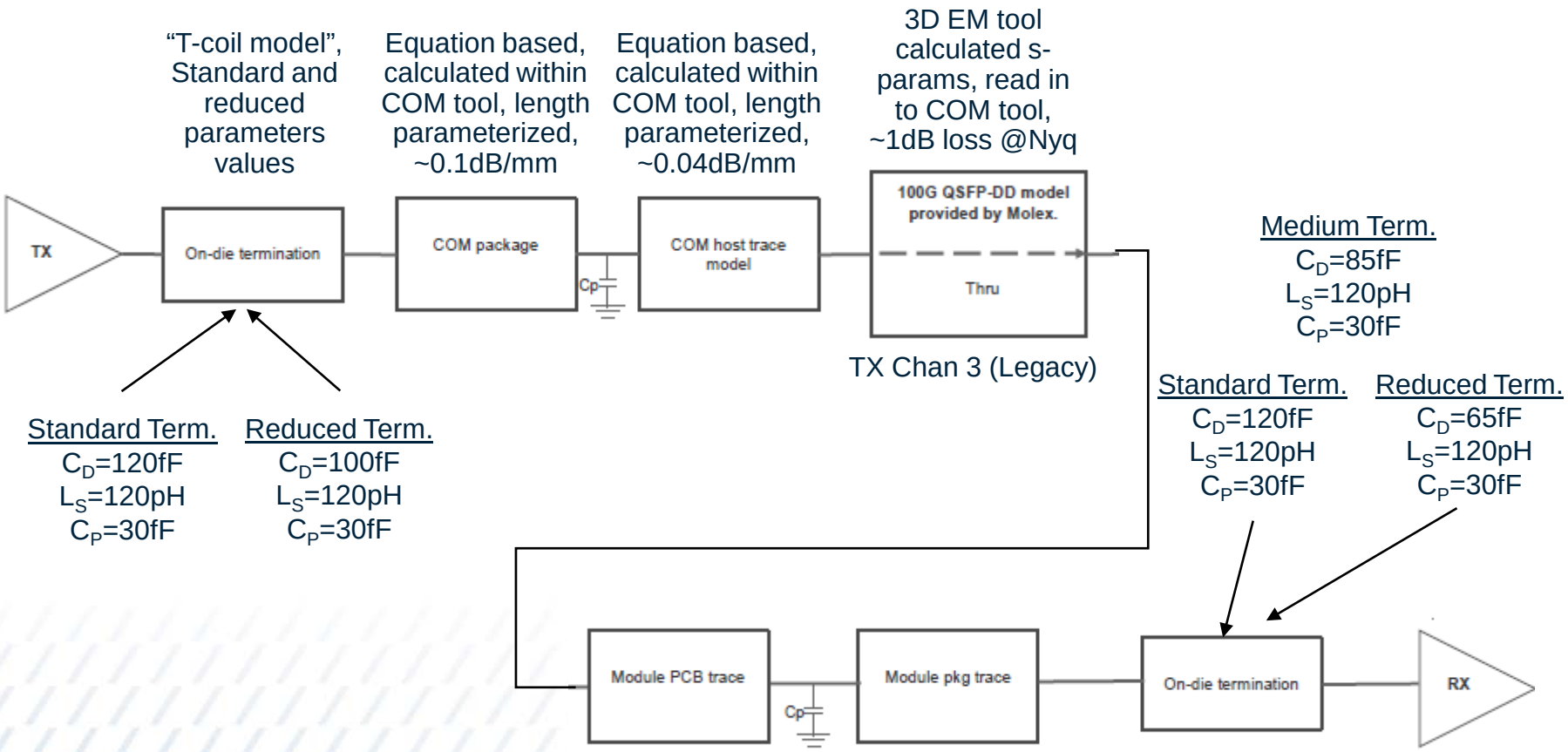
C_D=100fF
L_S=120pH
C_B=30fF
C_P=87fF

- VEC and VEO both pass at worst case host trace length (51.0mm)



Whole Link

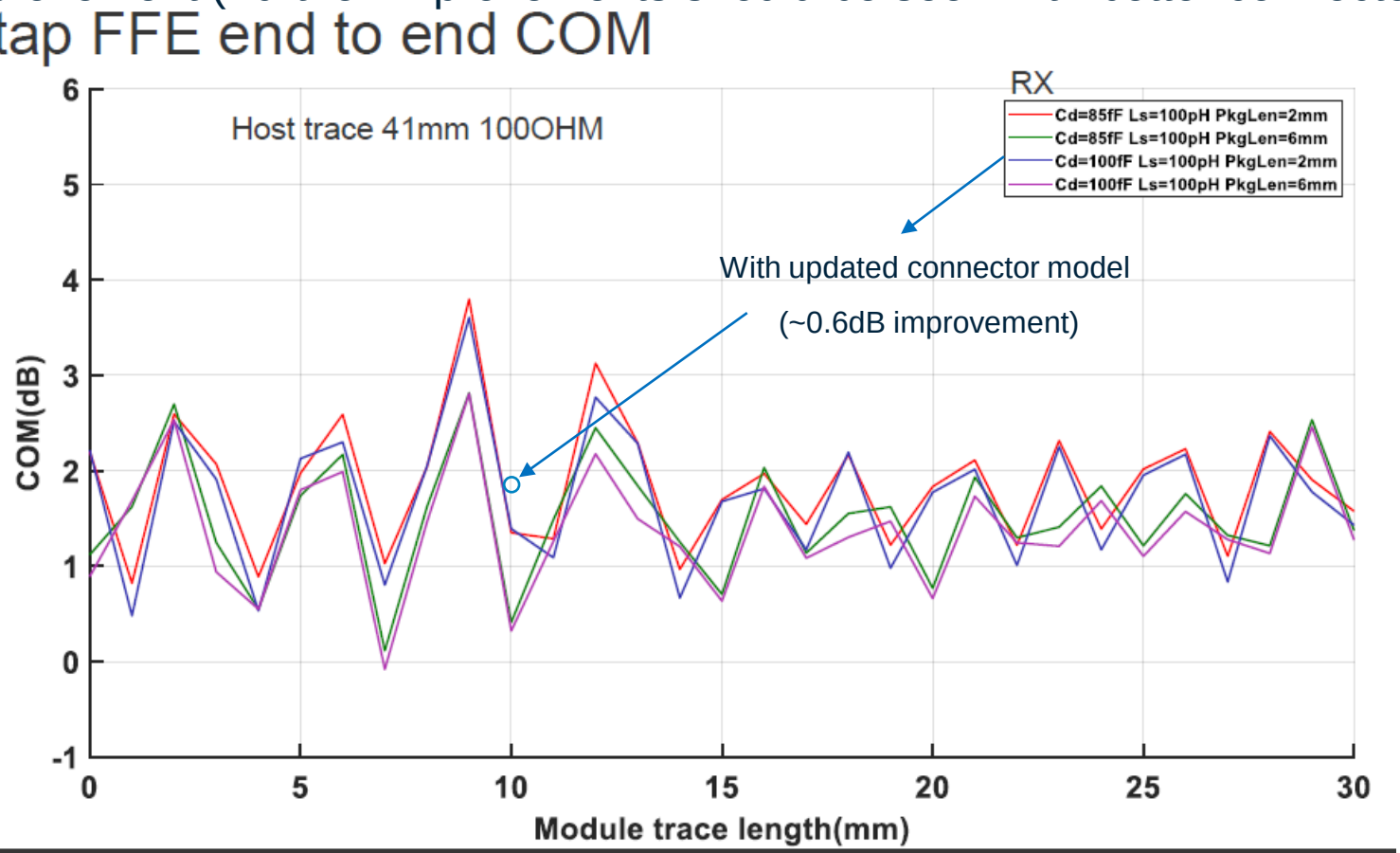
Simulation Setup
Whole link



Whole Link Standard Parasitics

Dudek 0-30mm Module Trace Length

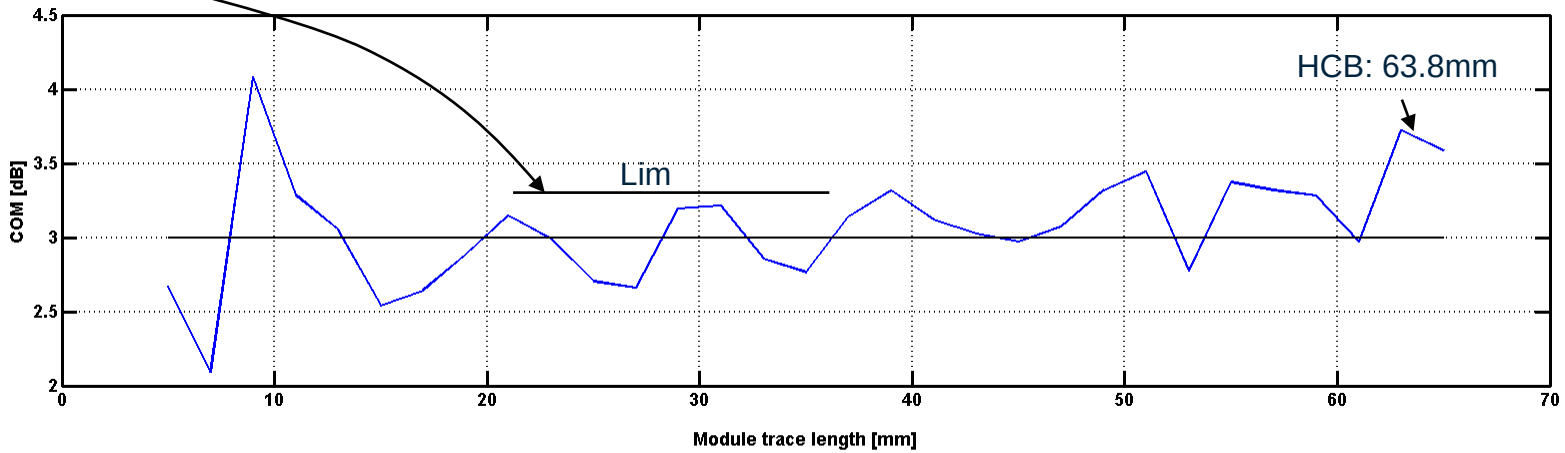
- Dudek sees a negative impact by changing from HCB to shorter module trace, changing it to 92.5Ω, and adding real RX termination
- With updated conn. model under the same conditions, we see .6 dB improvement (Further improvements should be seen with better connectors)



Whole Link Reduced Parasitics
5-65mm Module Trace Length

Package: 11.5/2mm
TX host trace: 51mm
MACOM
C_D=100/65fF
L_S=120/120pH
C_B=30/30fF
C_P=87/75fF
Z_{BP}=100/92.5Ω

- Previous results using HCB as representative of module trace showed sufficient COM
- Lim with unknown module length and ~51mm host trace length passed (COM=3.5dB)
- A sweep of module trace length shows that increasing module trace length helps the same way that increasing host trace length does
  - 63.8mm is unrealistically long and, therefore, too optimistic
- Shortest Lim whole link model (~50.8mm host trace, module trace estimated to be 28mm) COM=3.3dB



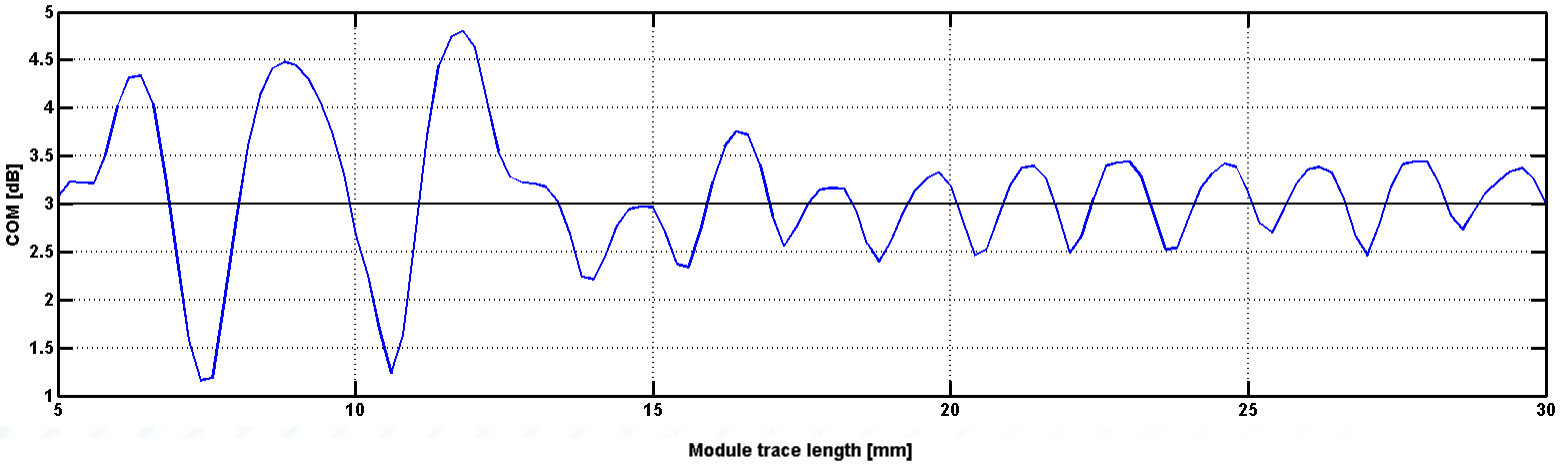
Whole Link Medium Parasitics
5-30mm Host Trace Length

Package: 11.5/2mm
TX host trace: 51mm

MACOM

C_D=100/85fF
L_S=120/120pH
C_B=30/30fF
C_P=87/75fF
Z_{BP}=100/92.5Ω

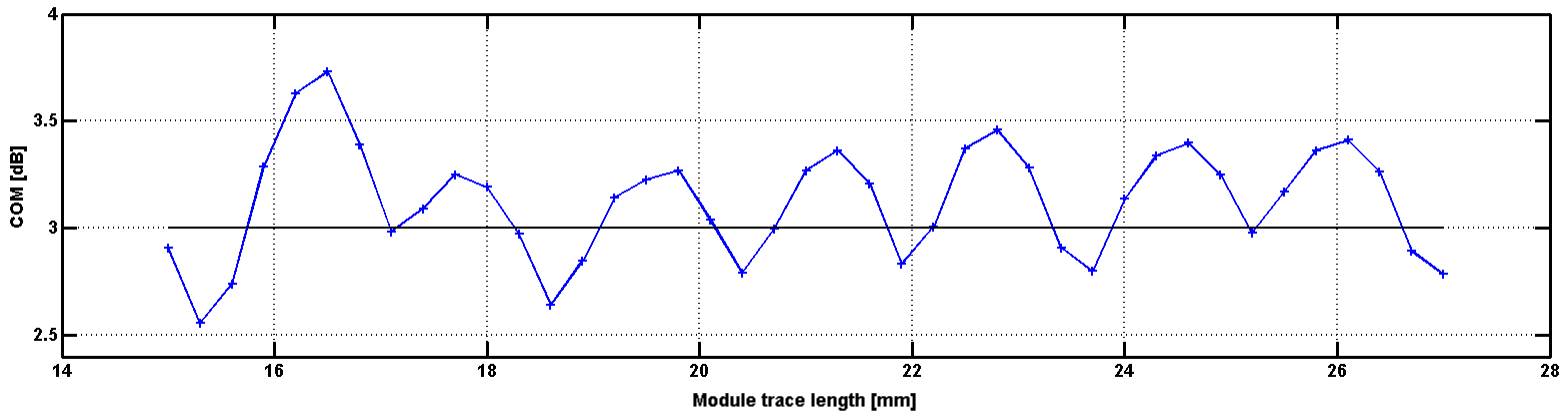
- Doing a fine sweep from 5-30mm shows the picture clearly
- The expected 1.65mm period is seen
- There is also a 2*1.65mm period with very large swing at the lowest lengths



Whole Link Reduced Parasitics
15-27mm Module Trace Length

Package: 11.5/2mm
TX host trace: 51mm
MACOM
C_D=100/65fF
L_S=120/120pH
C_B=30/30fF
C_P=87/75fF
Z_{BP}=100/92.5Ω

- With finer steps, the ~1.65mm module trace COM resonance is clearly visible
  - Same as the host trace case, which is expected since the trace parameters are the same
- We are much closer with:
  - Reduced parasitics
  - Improved connector
  - Module trace >TBDmm



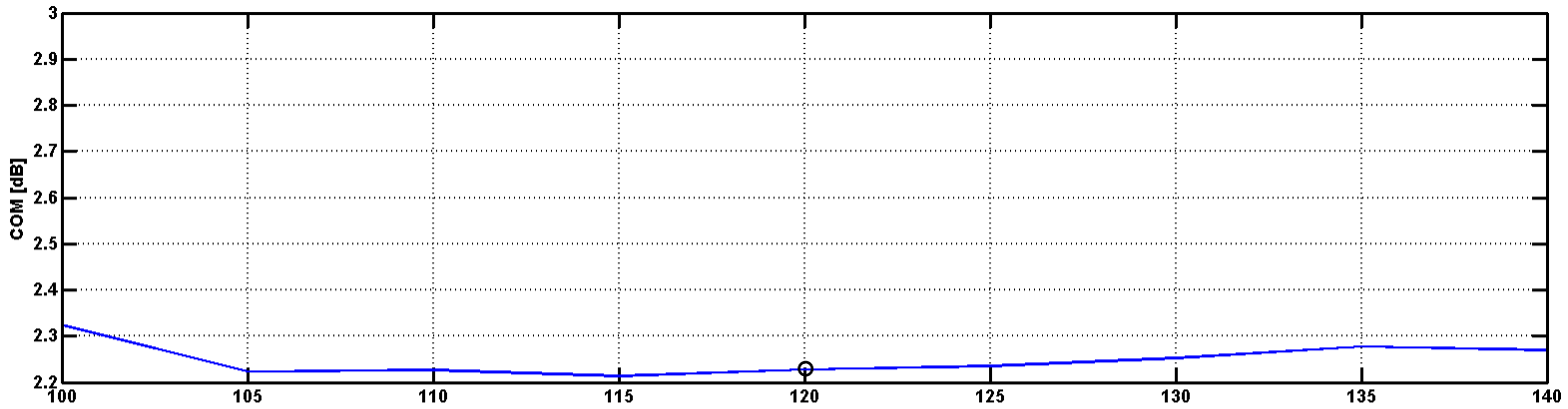
Whole Link Medium Parasitics

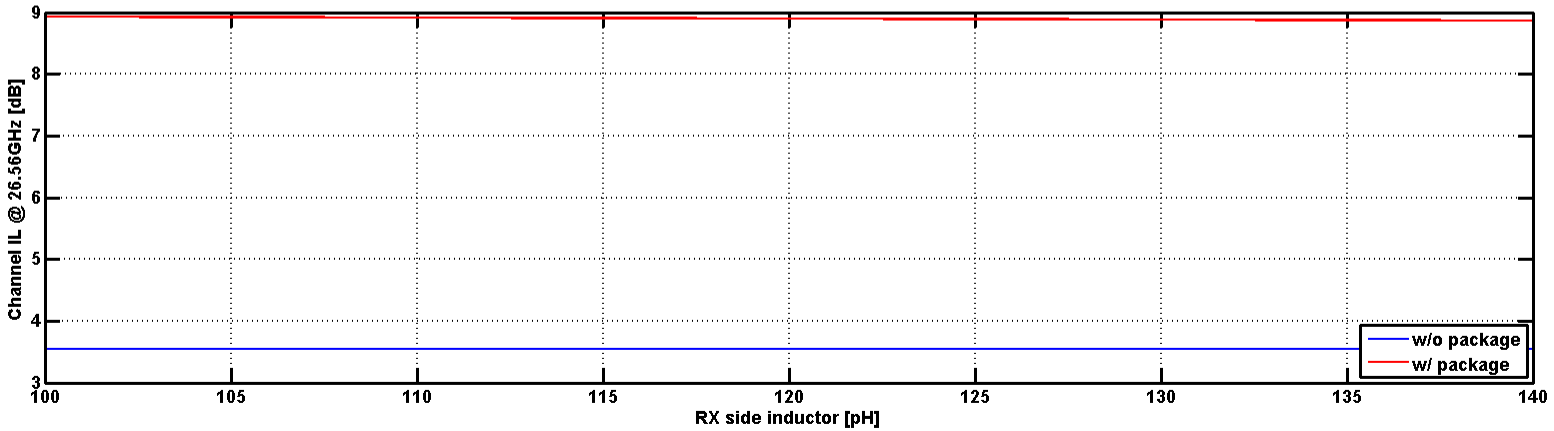
Sweeping RX L_S at Worst Case Mod Trace Length (15.5mm)

Package: 11.5/2mm
TX host trace: 51mm

C_D=100/85fF
L_S=120/Sweep pH
C_B=30/30fF
C_P=87/75fF
Z_{BP}=100/92.5Ω

- About 0.1dB to be gained from reducing L_S to 100pH





Whole Link Medium Parasitics

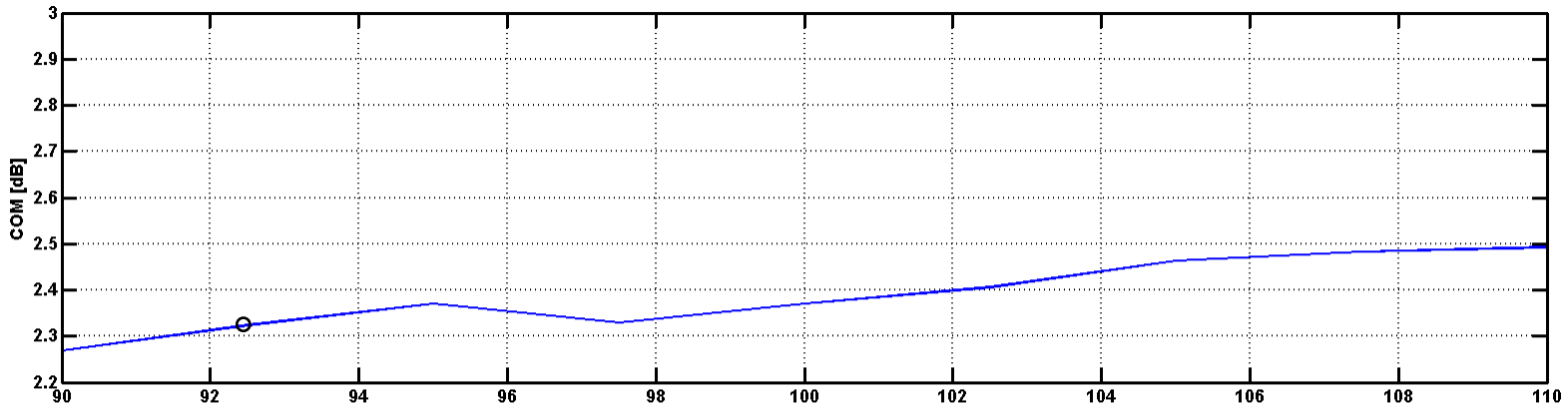
Sweeping Module Trace Impedance at Worst Case Mod Trace Length (15.5mm)

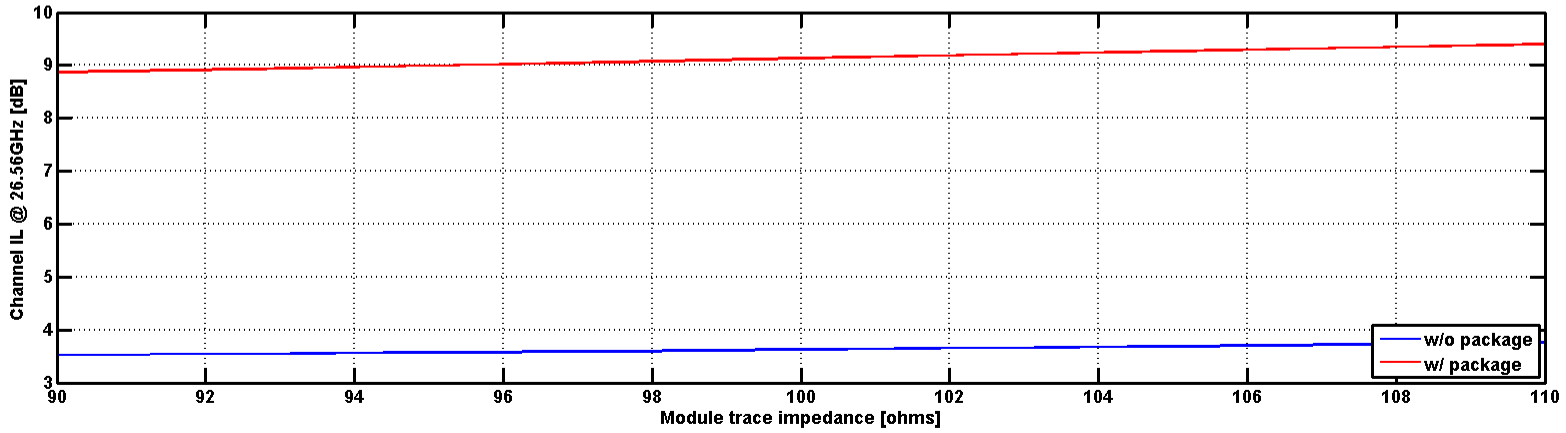
Package: 11.5/2mm
TX host trace: 51mm

MACOM

C_D=100/85fF
L_S=120/100pH
C_B=30/30fF
C_P=87/75fF
Z_{BP}=100/Sweep Ω

- About 0.2dB to be gained from increasing the impedance to 110Ω





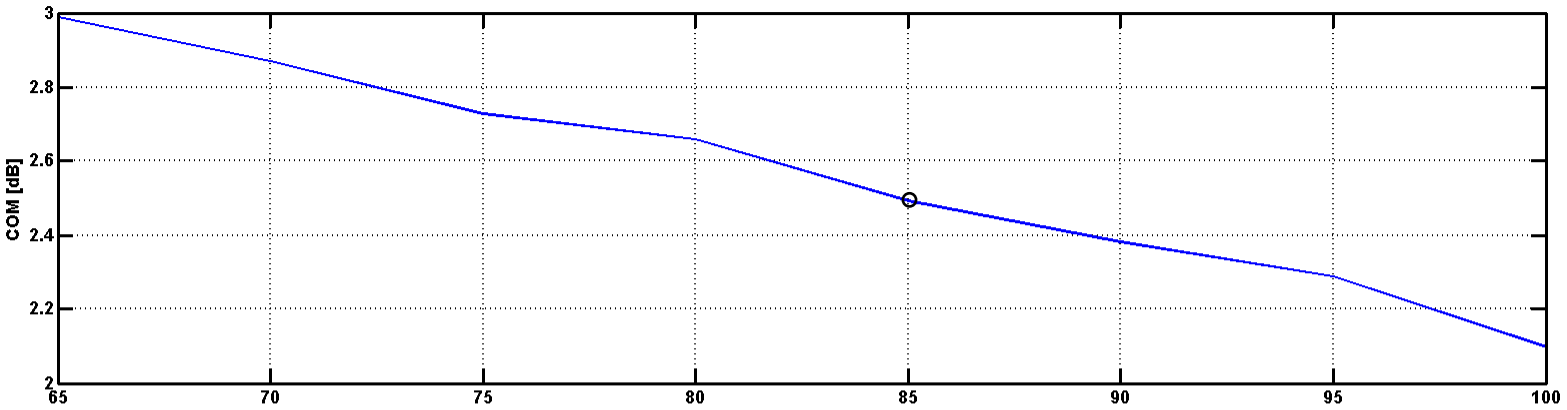
Whole Link Medium Parasitics

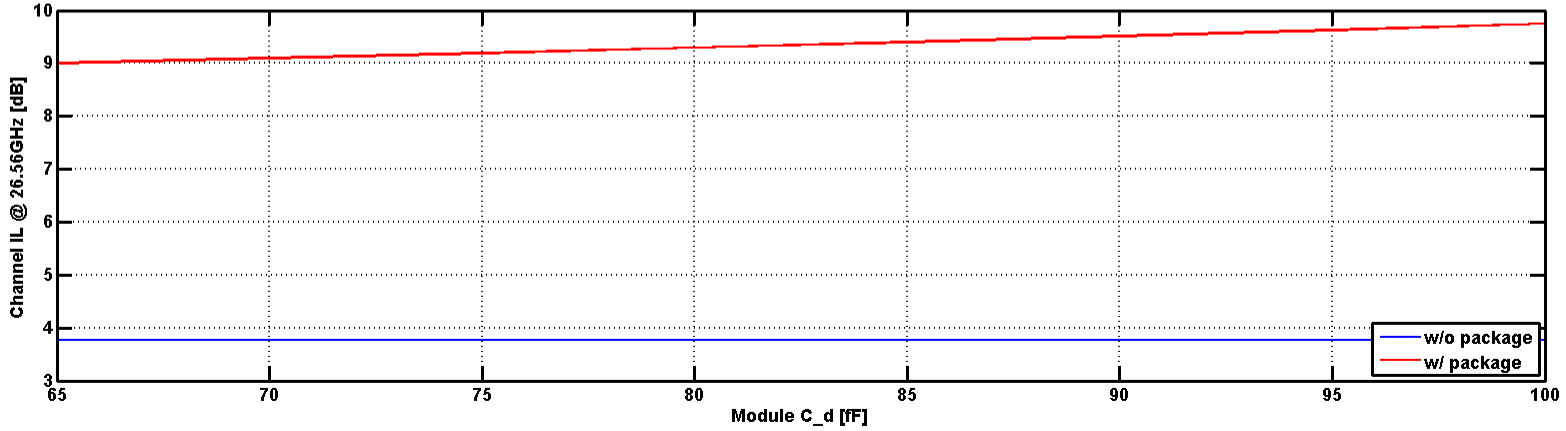
Sweeping RX Die Cap at Worst Case Mod Trace Length (15.5mm)

Package: 11.5/2mm
TX host trace: 51mm

C_D=100/Sweep fF
L_S=120/100pH
C_B=30/30fF
C_P=87/75fF
Z_{BP}=100/110Ω

- About 0.5dB to be gained from decreasing the RX die cap to 65fF





Conclusions

- TP1a 10dB VEC, 10mV VEO spec can be met if :
  - We use the latest improved connector model
  - We can set 50mm as the lower limit on host trace length
  - TX cap reduced from 120fF to 100fF
    - It just barely misses VEC spec even at 120fF
    - It would pass even at 120fF with the spec that relaxes VEC when VEO is healthy
- Whole link:
  - There are problems at shorter module trace lengths
- Whole link COM can be met if:
  - If we can set a lower limit of 15mm module trace length
  - We can assume the medium parasitic values
  - RX die cap value around 65fF