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Dual-Stripline Configuration for Efficient Signal Routing in the Bunch-of-Wires Interface

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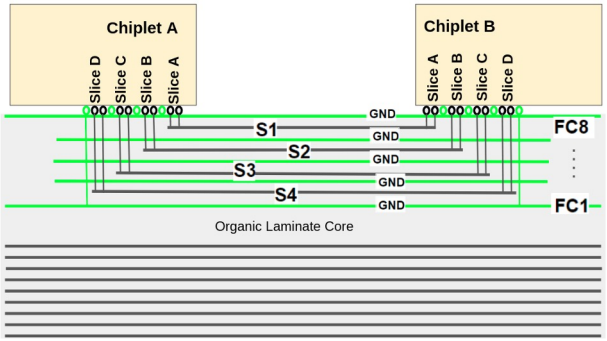
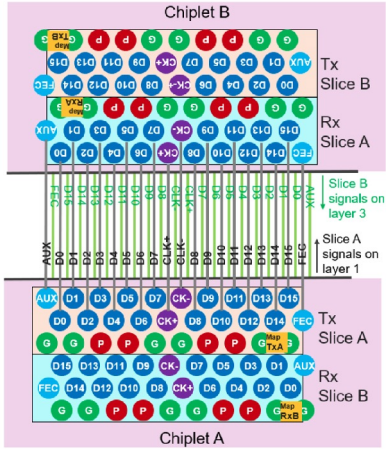
Introduction

- Bunch-of-Wires (BoW) standard supports high-density interconnect routing on organic substrates.
- BoW modes: BoW-32, BoW-64, BoW-128 and BoW-256
- BoW 1-slice: 16 signal lines, max 256 Gbps with 16 Gbaud/wire
- Standard 8-2-8 stackup: Signals routed on striplines in four layers, with BoW-256 providing a throughput of ~1Tbps/mm with 4 slices



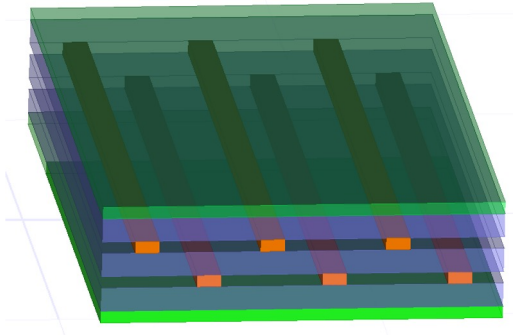
8-2-8 stackup with 4 signal layers



[Image courtesy: BoW spec 2021]

Goal

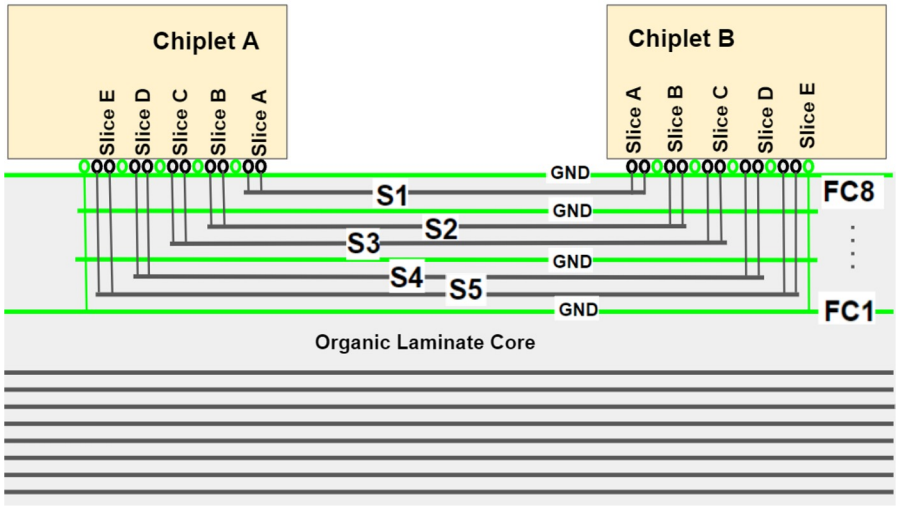
- Increase the routing efficiency in the 8-2-8 stackup
- Sufficient wire-to-wire pitch in the standard BoW bump-map makes it possible to route the signals in the dual-stripline configuration
- In dual-stripline configurations, two vertically adjacent signaling layers used between the reference/ground planes
- Routing density improves by 33%



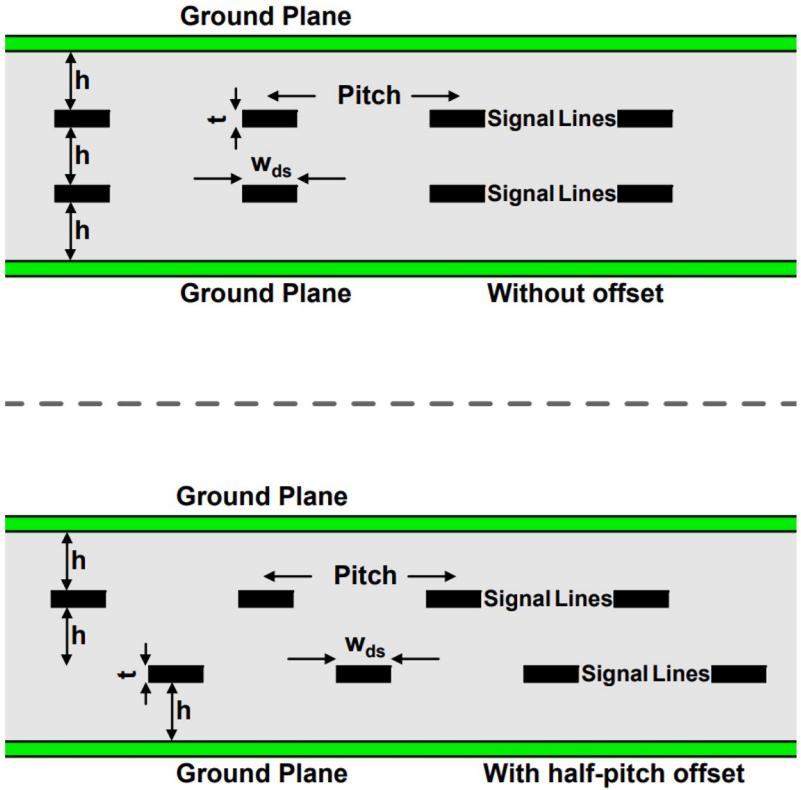
3D view: dual stripline with horizontal offset

- Drawbacks: Increase in crosstalk – signal layers are routed adjacent to one another
- Solution: The signal lines in one layer are offset horizontally by half the wire-to-wire pitch in one of the layers

Dual stripline



8-2-8 stackup with 5 signal layers
(including dual-striplines)



Target specifications: BoW

- Insertion loss: 4dB @8GHz and 12dB @16GHz
- Powersum crosstalk: Below -15dB upto 16GHz

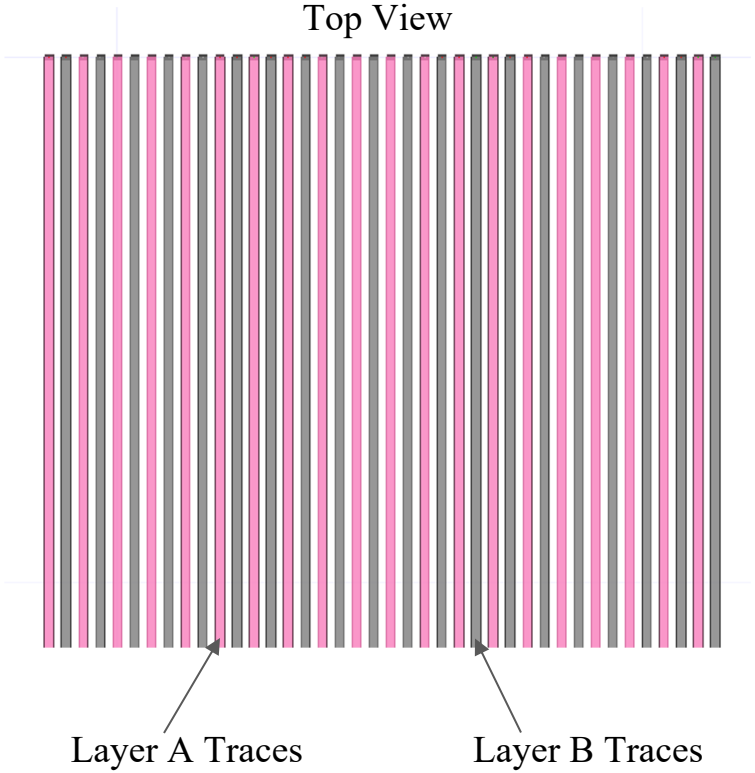
Simulation setup

Requirement:

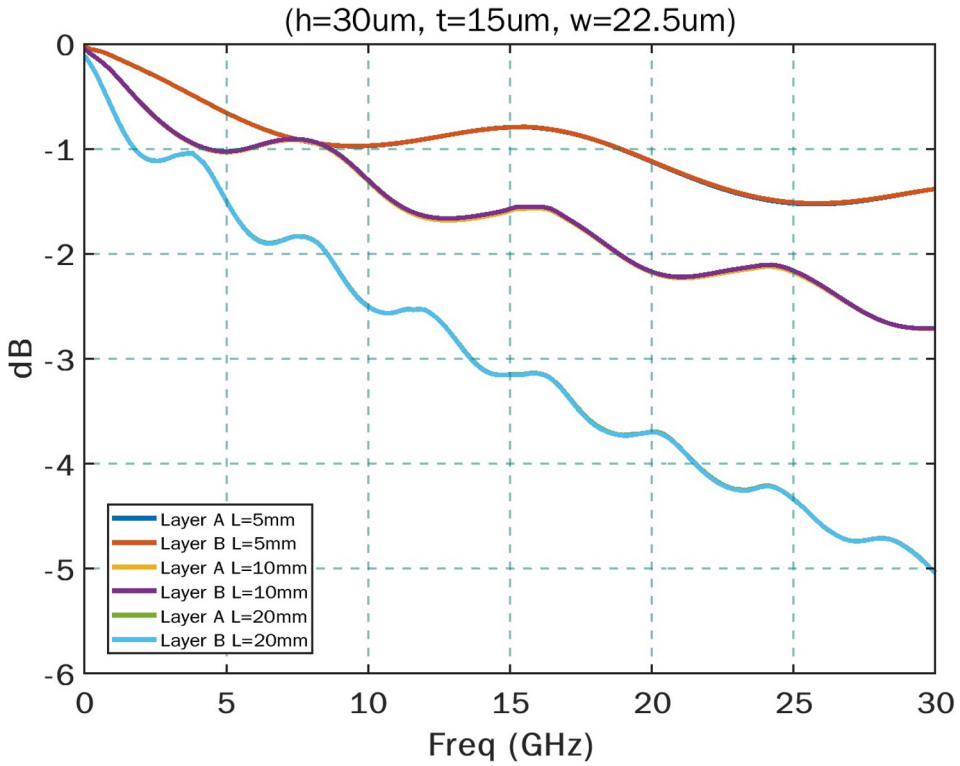
- Insertion loss: less than 4dB @8GHz
- Power-sum crosstalk < -15dB @16GHz
- horizontal eye opening ≅ 0.5UI @BER of 10^{-15}
- Characteristic impedance: 50Ω

Physical parameters and material properties:

Substrate(ABF) height(h): 30µm
Metal thickness(t): 15µm, Trace pitch: 65µm,
Trace length: 20mm, Roughness: 0.4625µm,
Dielectric constant: 3.4, Loss tangent: 0.019
Number of lines: 20 in each layer



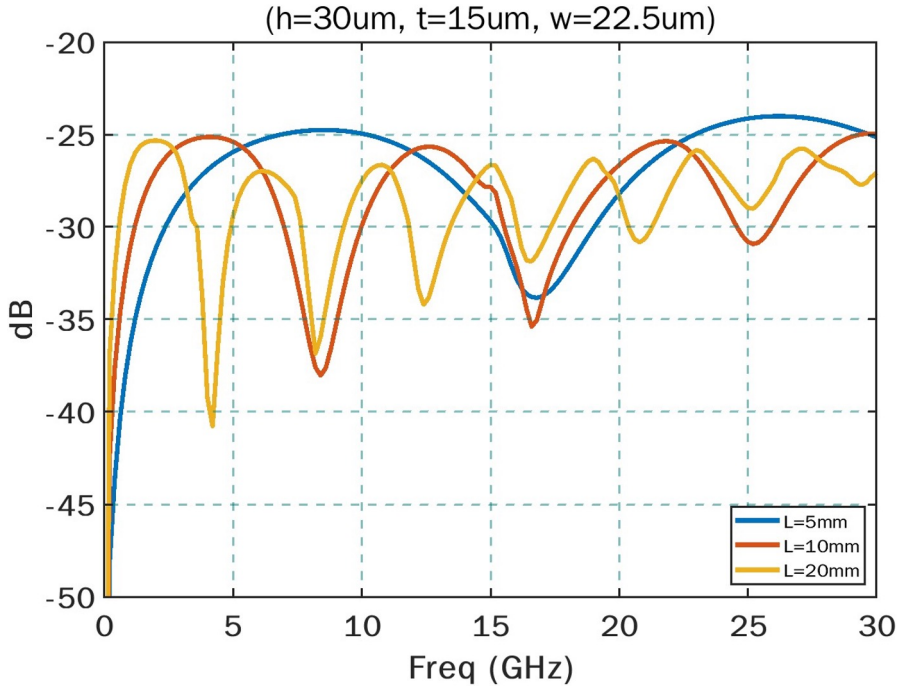
Insertion loss



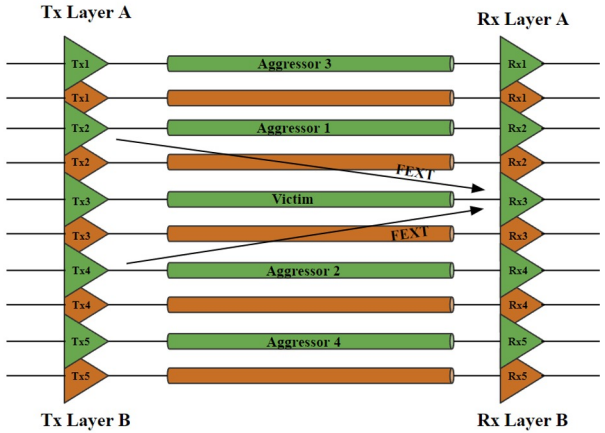
Length (mm)	Insertion Loss @ 8GHz	Insertion Loss @16GHz
5	0.93dB	0.8dB
10	0.93dB	1.55dB
20	1.86dB	3.14dB

The dual-stripline structure meets the insertion loss specification: below 4dB @8GHz and 12dB @16GHz

Powersum crosstalk: Co-propagating signals

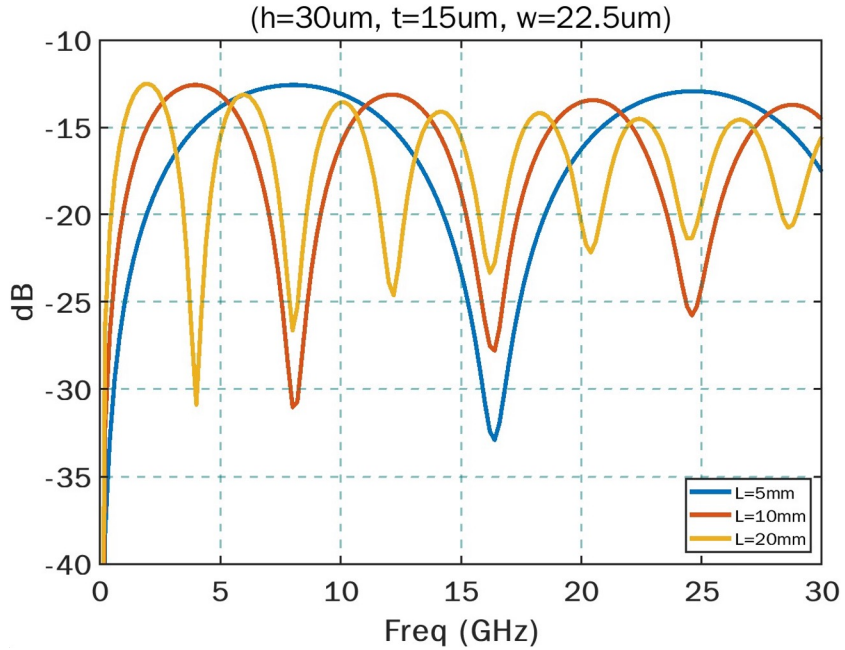


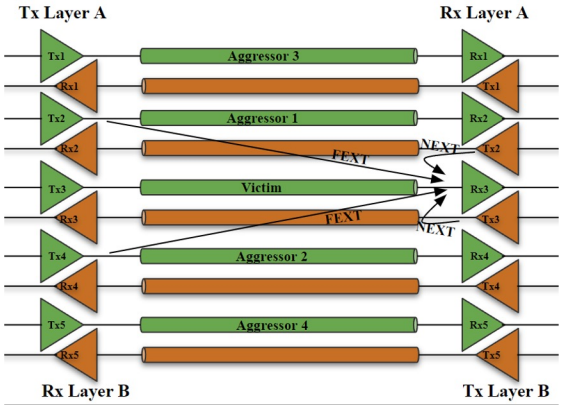
The dual-stripline structure meets the powersum crosstalk specification (below -15dB) for co-propagating signals



Length (mm)	Crosstalk @8GHz	Crosstalk @16GHz	Maximum crosstalk
5	-24.78dB	-32.77dB	-24dB
10	-36.5dB	-32.07dB	-24.94dB
20	-34.42dB	-29.76dB	-25.32dB

Powersum crosstalk: Counter-propagating signals





The dual-stripline structure does not meet the powersum crosstalk specification (of <-15dB) for counter -propagating signals for h=30um (dielectric height)

Length (mm)	Crosstalk @8GHz	Crosstalk @16GHz	Maximum crosstalk
5	-12.57dB	-30.81dB	-12.57dB
10	-31.03dB	-26.16dB	-12.57dB
20	-26.63dB	-22.30dB	-12.50dB

Far end crosstalk

$$FEXT = \frac{V_f}{V_a} = \frac{Len}{RT} \times k_f = \frac{Len}{RT} \times \frac{1}{2v} \times \left(\frac{C_{mL}}{C_L} - \frac{L_{mL}}{L_L} \right)$$

where:

FEXT = far-end cross-talk coefficient

V_f = voltage at the far end of the quiet line

V_a = voltage on the signal line

Len = length of the coupled region between the two lines

k_f = far-end coupling coefficient that depends only on intrinsic terms

v = speed of the signal on the line

C_{mL} = mutual capacitance per length, in pF/inch (C_{12})

C_L = capacitance per length of the signal trace, in pF/inch (C_{11})

L_{mL} = mutual inductance per length, in nH/inch (L_{12})

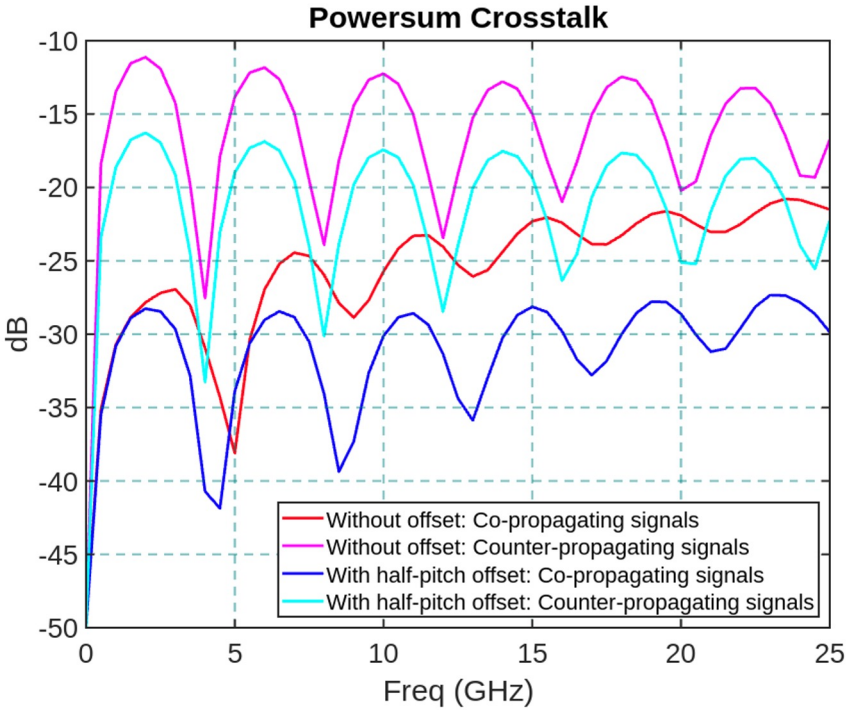
L_L = inductance per length of the signal trace, in nH/inch (L_{11})

RT = signal rise time

Eric Bogatin. (2018). Chapter 10 - Crosstalk in Transmission Lines, Signal and Power Integrity - Simplified, Third Edition. Prentice Hall modern semiconductor design series.

Crosstalk: Dual stripline with reduced height

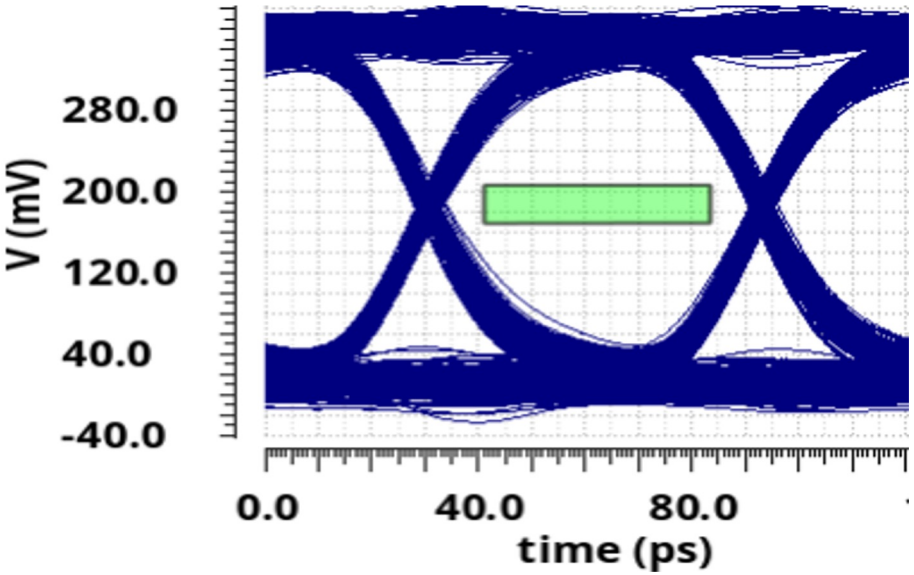
(h = 20um, t= 5um, w = 17um)



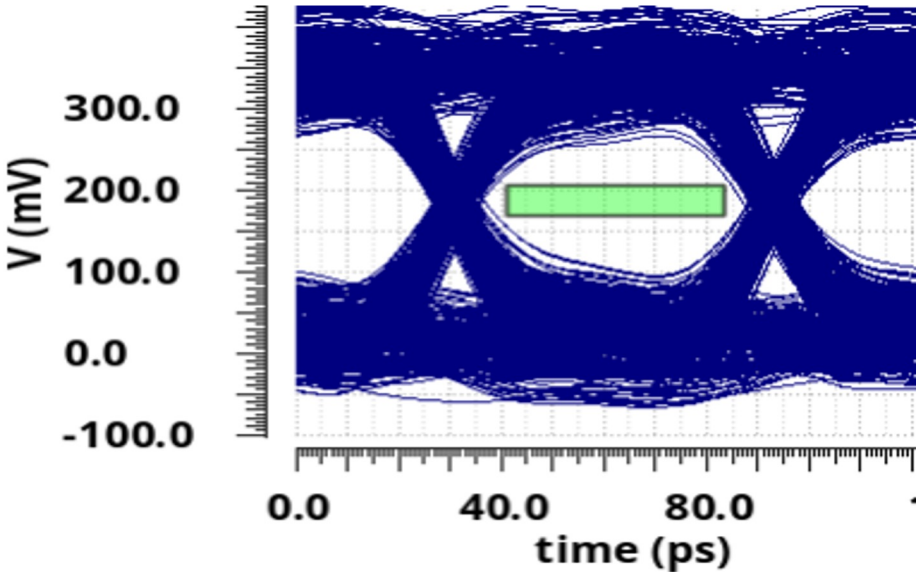
Configurations		Maximum powersum crosstalk (dB)
Without offset	Co-propagating signals	-20.87
	Counter-propagating signals	-11.13
With half-pitch offset	Co-propagating signals	-27.36
	Counter-propagating signals	-16.27

Dual-stripline structure with reduced dielectric height (20um) and half-pitch offset meets the crosstalk specification (below -15dB) with counter propagating signals as well

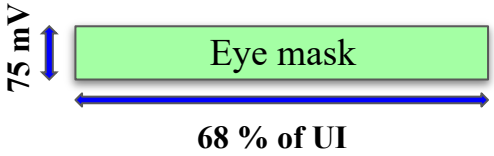
Eye diagram: Transient simulations (h=30um, 20mm channel)



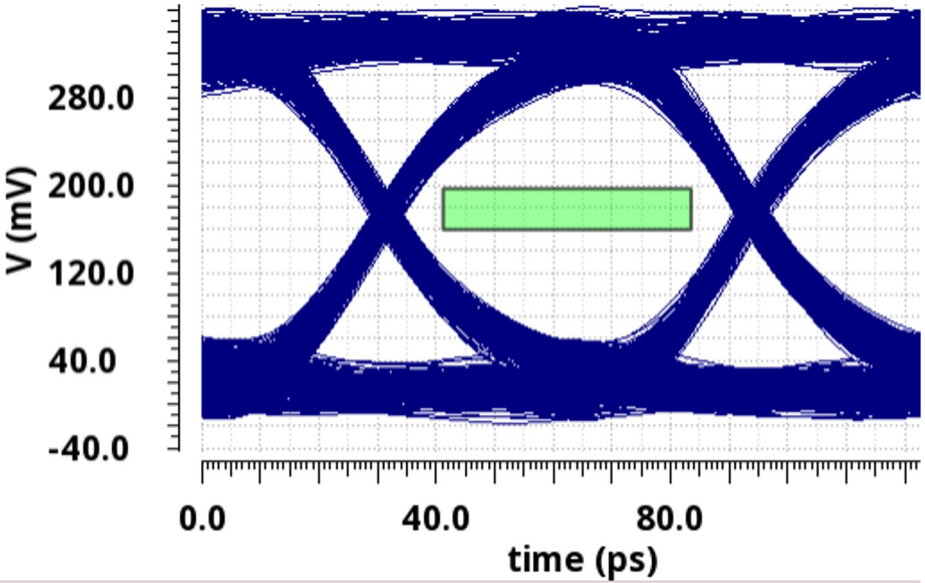
Co-propagating signals



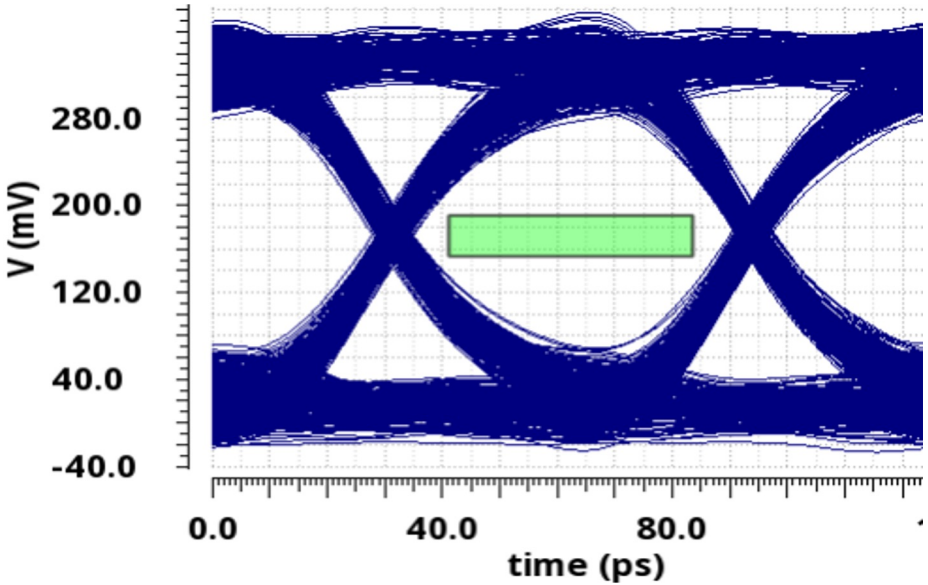
Counter-propagating signals



Eye diagram: Transient simulations (h=20um, 20mm channel)



Co-propagating signals



Counter-propagating signals

Simulations carried out for the dual-stripline configuration indicate that horizontal eye opening specifications (0.68UI) are met

Summary

- Dual Strip line configuration can be adopted for the BoW interface as a viable option to increase the routing density
- Cross talk effect can be reduced by providing half-pitch offset between adjacent layers
- Simulation results validate that performance metrics such as crosstalk and horizontal eye opening requirements are met

References

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Thank you