# Considerations for Crystal-less PHY

## IEEE 802.3dm

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# Introduction

- Crystal-less operation of 802.3dm PHY is desirable to achieve lower relative costs in sensor applications*

- This contribution looks at several factors impacting ability of PHY RX to operate in a crystal-less manner

- Simple <u>no transistor</u> model used for an ACT analog implementation in SPICE

- BCI noise was injected**


- References
    - * https://www.ieee802.org/3/dm/public/0525/Ng_3dm_01_05122025.pdf
    - ** https://www.ieee802.org/3/dm/public/1124/Pischl_3dm_01a_1124.pdf

# PHY RX considerations

- Clock must be extracted from incoming low frequency data
  - Eye diagram should be maximally open for ease of clock extraction
- Some factors impacting eye closure
  - Return Loss, Insertion Loss of MDI and Cable
  - BCI noise
  - Jitter in Clock/Data signals of SER and DES (not addressed here)
  - Residual supply noise through PoC inductors (not addressed here)
  - Implementation losses (not addressed here)

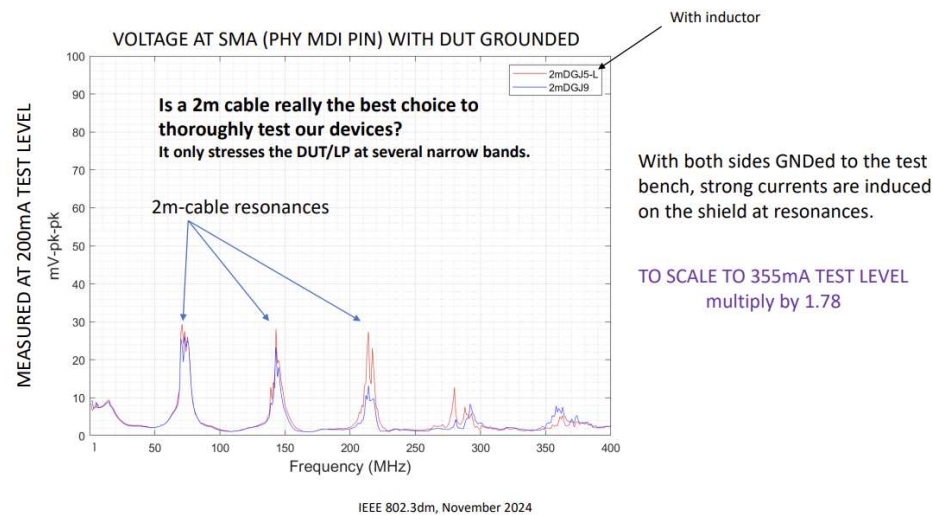# MDI and Cable models

- Cable RL and IL

- MDI RL and IL

**3.8m Cable RL**
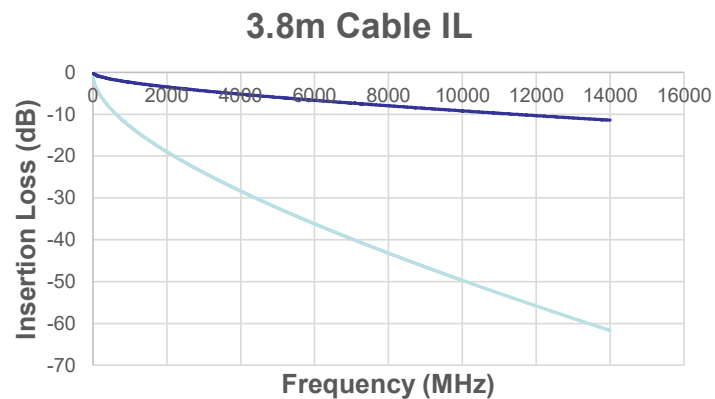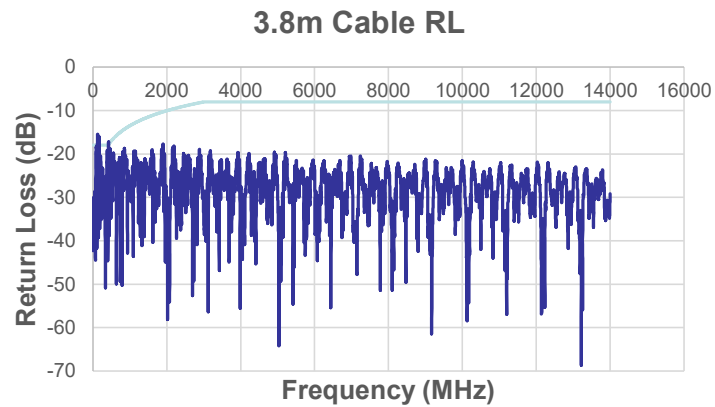


**3.8m Cable IL**
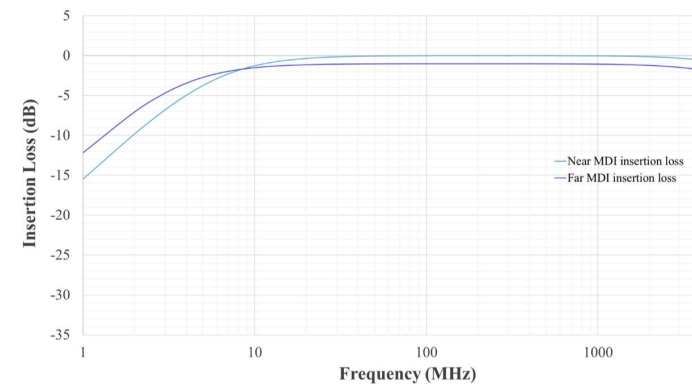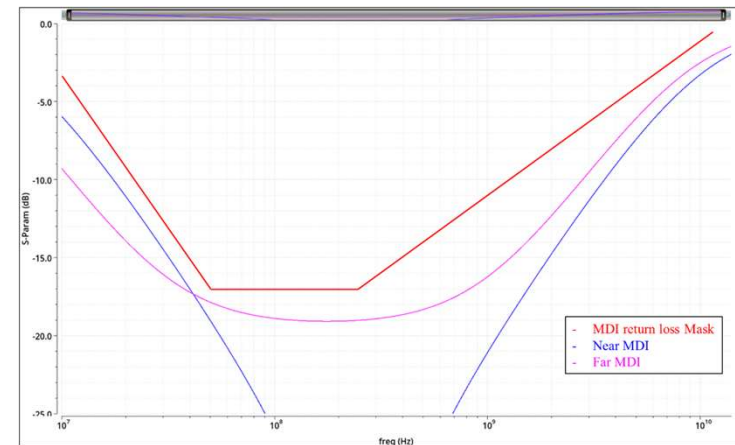
# BCI Noise Levels

- Injected BCI 2m noise levels from Pischl_3dm_01a_1124 excerpted below
  - Lowest grounded DUT noise level in presentation
  - Did not scale up to 355mA test level
  - Used the lower non-inductor peak-to-peak noise level
  - Used the lowest 3 noise frequencies

## 2m-Cable, DUT GNDed



VOLTAGE AT SMA (PHY MDI PIN) WITH DUT GROUNDED

With inductor

2mDGJ5-L
2mDGJ9

Is a 2m cable really the best choice to thoroughly test our devices?
It only stresses the DUT/LP at several narrow bands.

2m-cable resonances

With both sides GNDed to the test bench, strong currents are induced on the shield at resonances.

TO SCALE TO 355mA TEST LEVEL
multiply by 1.78

MEASURED AT 200mA TEST LEVEL
mV-pk-pk

Frequency (MHz)

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# Link Model

- PAM4 5.625GSps ↓, 234Mbps ↑
  - 0.65Vppse, 0.32Vppse TX output swings
- 50 Ω TX/RX, 500 Ω resistive Hybrid
- MDI limits already assume losses from coupling cap and PoC
- 30MHz HPF and 2 Pole 234MHz LPF post Hybrid
- Implemented in differential fashion, but using single ended Coax
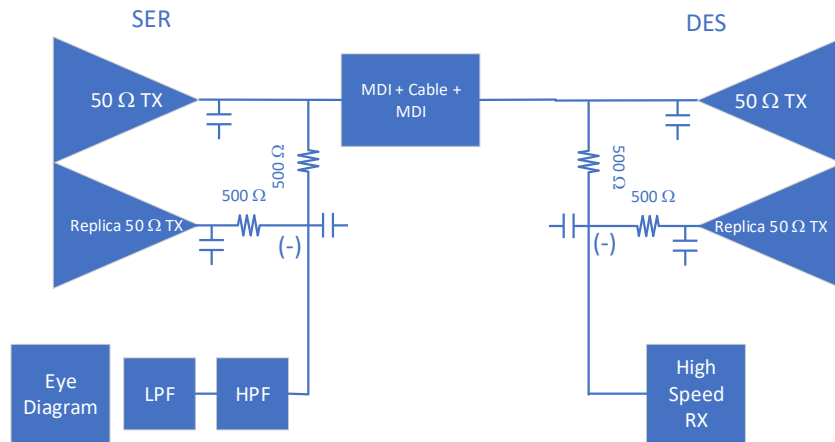
| Cable Segment Characteristics | Char Impedance (Ohms) |
|---|---|
| RG174 – 0.35m | 48 |
| RTK031 – 0.4m | 52 |
| RTK031 – 2.4m | 48 |
| RTK031 – 0.35m | 52 |
| RG174 – 0.35m | 48 |

# Observed Eye

- ~100us of ACT upstream data
- One eye is basically closed
- Jitter as simulated ~ 2.8ns
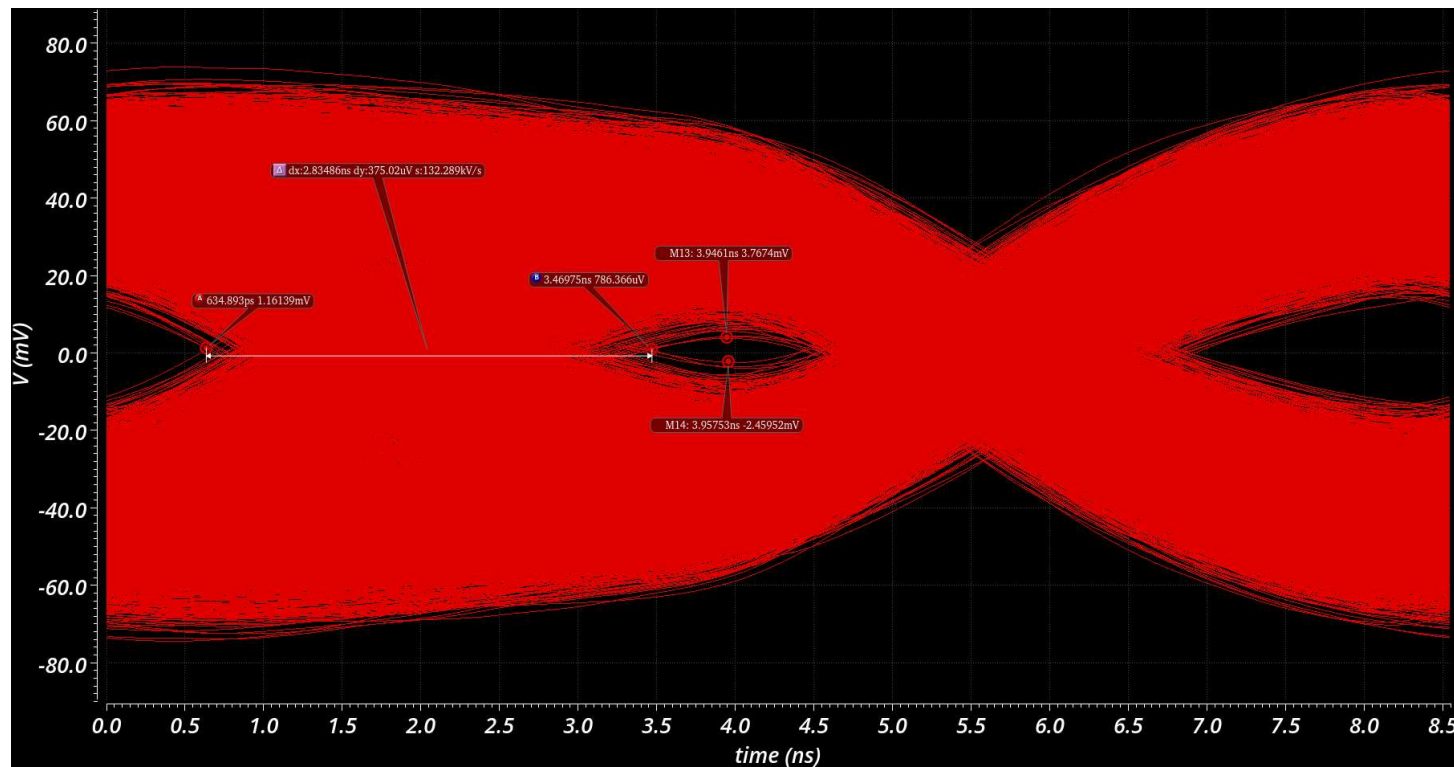
# Summary

- Simple analog model of ACT RX shows eye closure
  - Other impairments not added
- Lower level of BCI noise used
- Easy IL channel. Cable RL peaks above limit of proposed mask.
- High speed TX jitter requirements expected to be in 1ps rms range.
- For crystal-less operation, the CDR has to recover a clean clock from the eye
  - Is a simple receiver architecture sufficient for ACT RX ?

# Thank You!