Line Coding Considerations for 10BASE-T1S

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Objective

The purpose of this presentation is to

- Provide pros and cons for DME & NRZ
- Provide information for power spectral density
- Provide channel information for PHY analysis
- Provide supporting data for 10BASE-T1 line coding, and line data rate for multipoint channels

Pros & Cons

DME

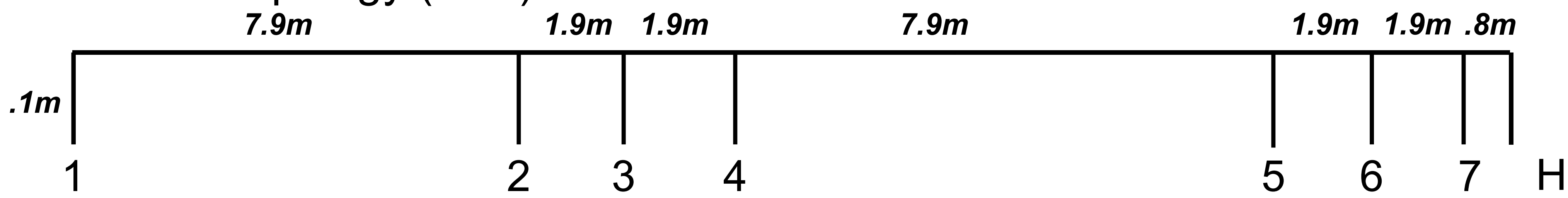
- Manchester Encoded
- inherently DC balanced
- Scrambler would help emissions
- Does not require equalizer for 10BASE-T1S channels (no DC)
- Requires ~2x bandwidth of NRZ

NRZ

- PAM-2
- Not DC Balanced
- Scrambler required
- Requires Equalizer for 10BASE-T1S channels due to PoDL and low frequency noise
- Requires1 bit per baud

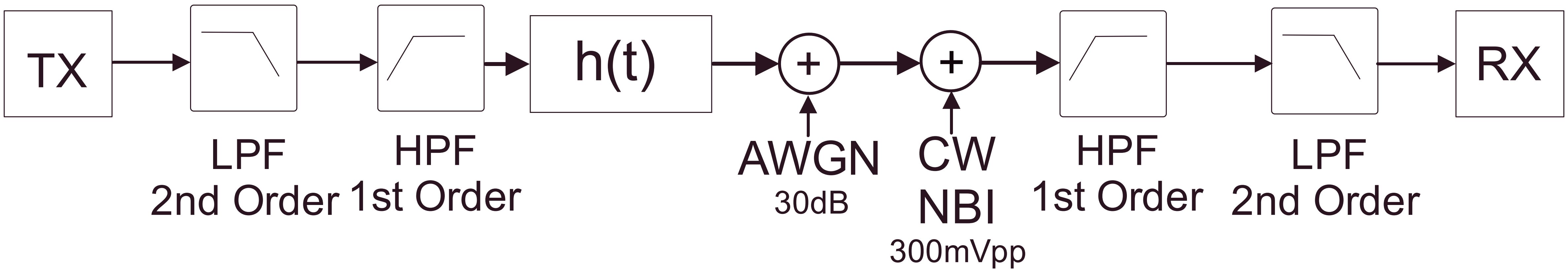
Configuration for Channel Measurements

- Multipoint configuration (8 nodes) per buntz_10SPE_05b_0329.pdf (Buntz) presentation on 29 March 2017.
- Passive linear topology (max) as follows:



- Cable segments using 100BASE-T1 cable with 100mm stubs.
- Evaluate frequency response under the following conditions:
  - Nodes 1 and H terminated at 100 Ω
  - Nodes 2-7 terminated at 1KΩ when silent and receiving
  - Nodes 2-7 terminated at 10Ω while transmitting
  - Investigate frequency response
    - With inner nodes TX/RX including adjacent nodes
    - Worst-case attenuation

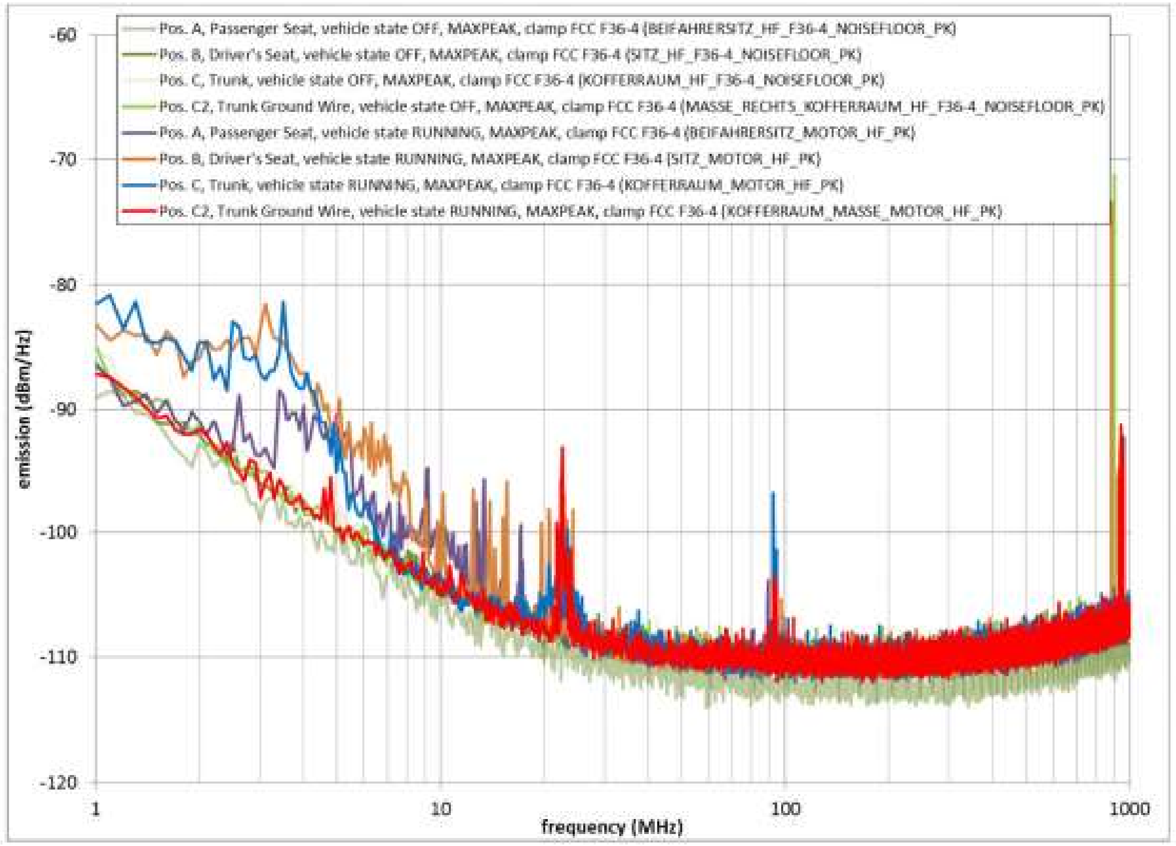
Simulation Setup for Eye Diagrams



- TX: 64 byte, 25Mbps random data frames
  - DME with 40ns data pulse width
  - NRZ with 40ns data pulse width
- TX Voltage: 1Vpk-pk at transmitter (matched load?)
- TX LPF: 2nd order Butterworth
  - 3dB cutoff of 27MHz for DME
  - 3dB cutoff of 20MHz for NRZ
- TX HPF: 1st order, 3dB cutoff of 100kHz (for PoDL)
- White noise 30dB SNR
- h(t) “Max” channels
- CW of 300mV pk-pk 1-30MHz at RX input
- RX HPF: 1st order
  - 1MHz for DME
  - 4 MHz for NRZ
- RX LPF: 2nd order
- No equalization for simulation
  - Matched Filter for DME receiver
  - Matched Filter for NRZ receiver

Automotive Noise

- Recall from buntz_3bp_01_0313.pdf[1]:



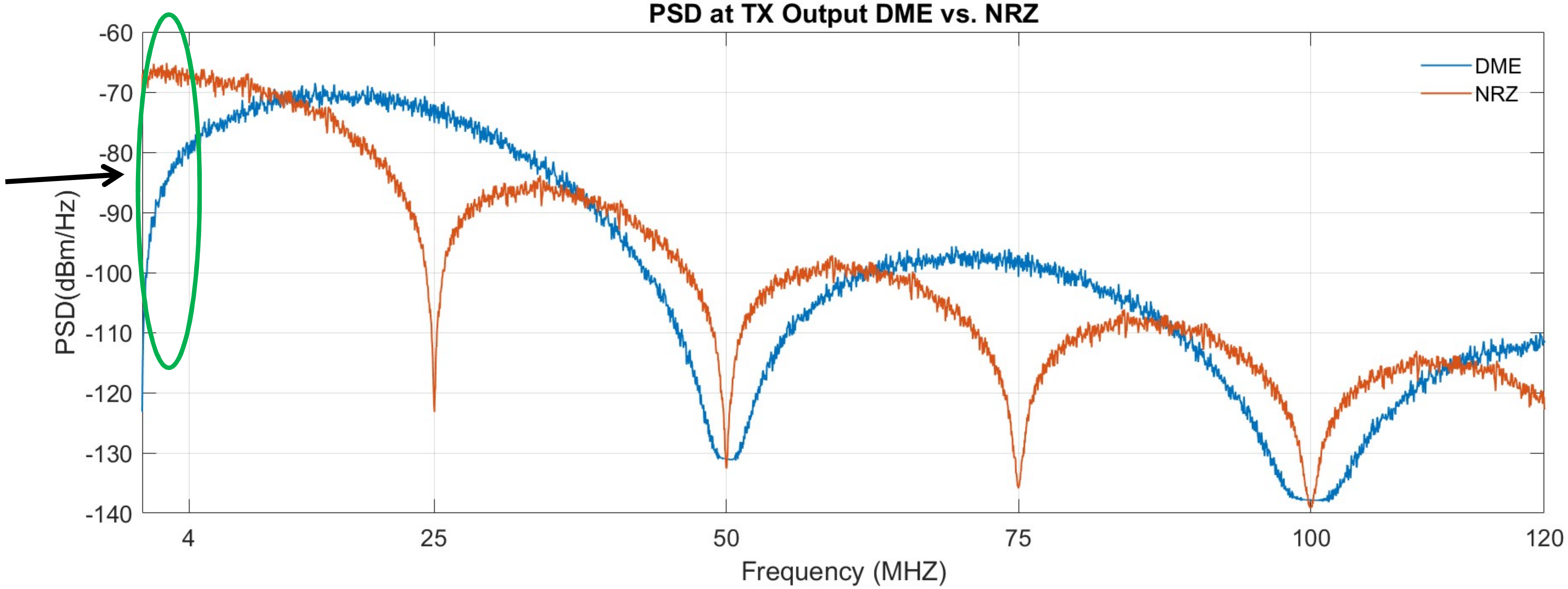
- In-car noise has a large low-frequency component.

[1] “Common Mode Noise on an automotive dataline” from buntz_3bp_01_0313.pdf on 13 Mar 2013

Transmit Power Spectral Comparison

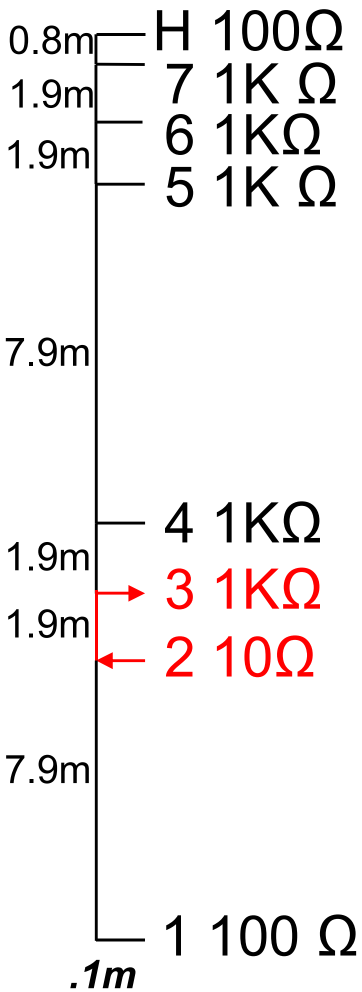
- 1 Volt pk-pk measured on 100Ω

Low-frequency vehicle [1] and PoDL noise



- DME more spectrally compatible to automotive noise and PoDL than NRZ for 10BASE-T1S

Channel Frequency Response Node 2->Node 3



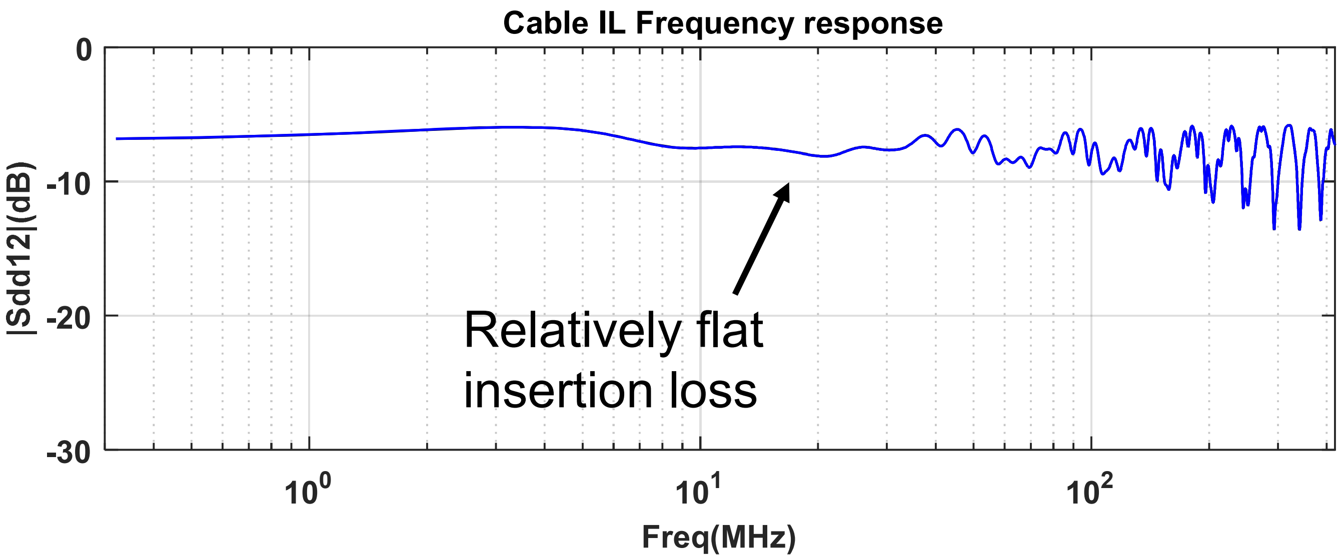
Node 2: Tx(10Ω)

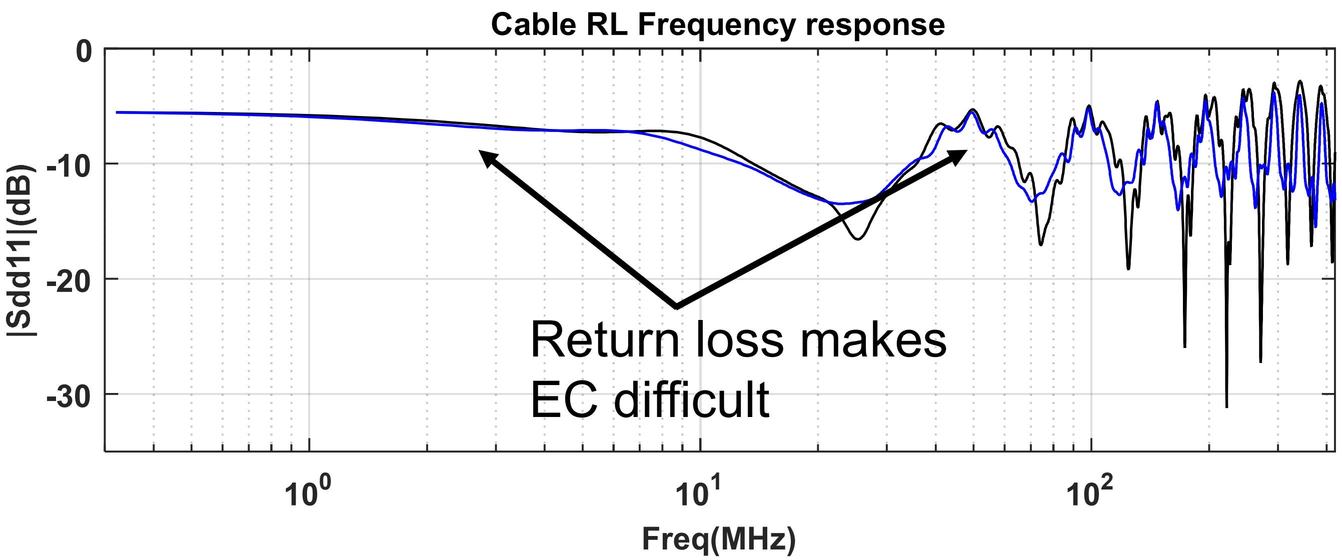
Node 3: Rx(1KΩ)

Node 1: Terminated(100Ω)

Node H: Terminated(100Ω)

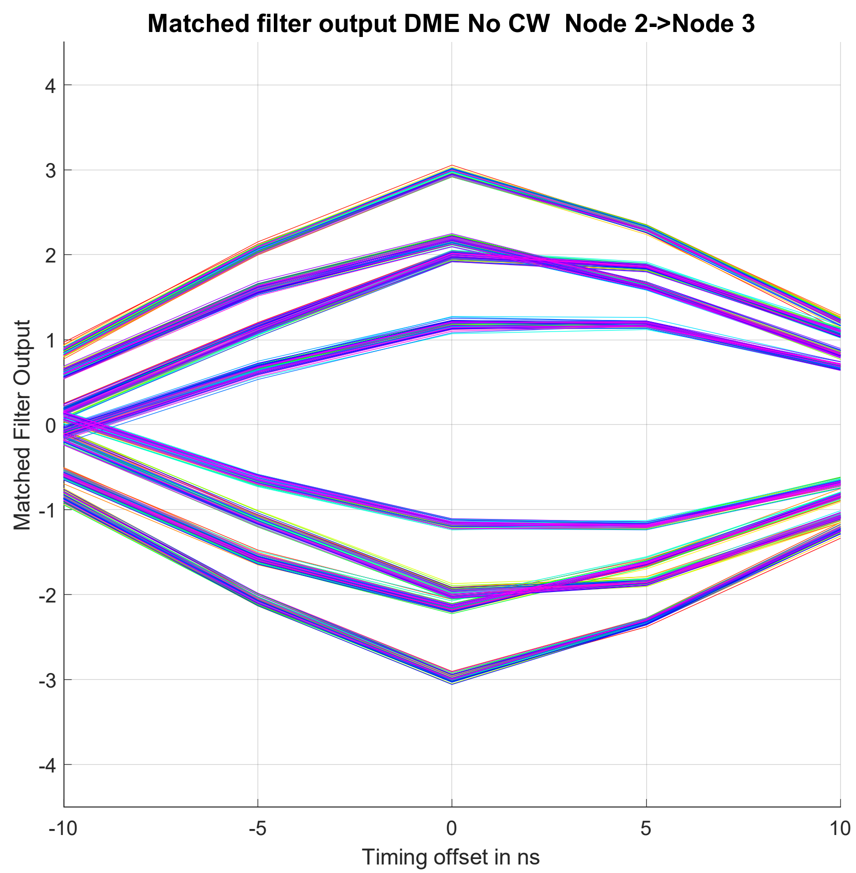
All other nodes: 1KΩ

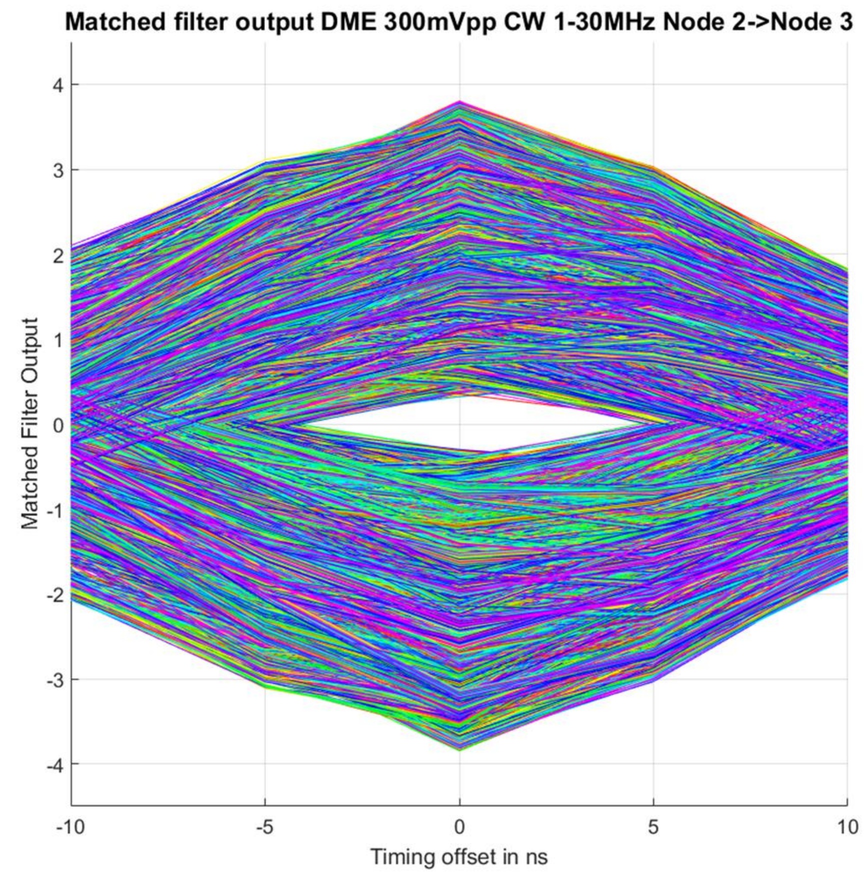




Eye Diagram for DME Node 2->Node 3

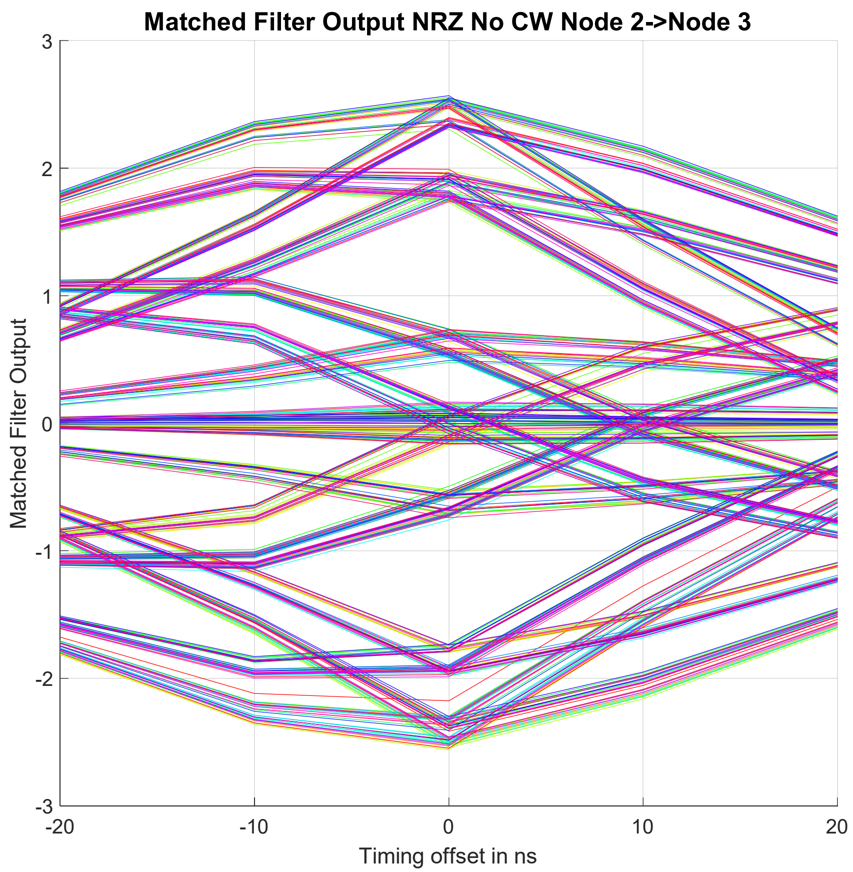
- **Channel:** Node 2->3 (buntz.. “Max”)

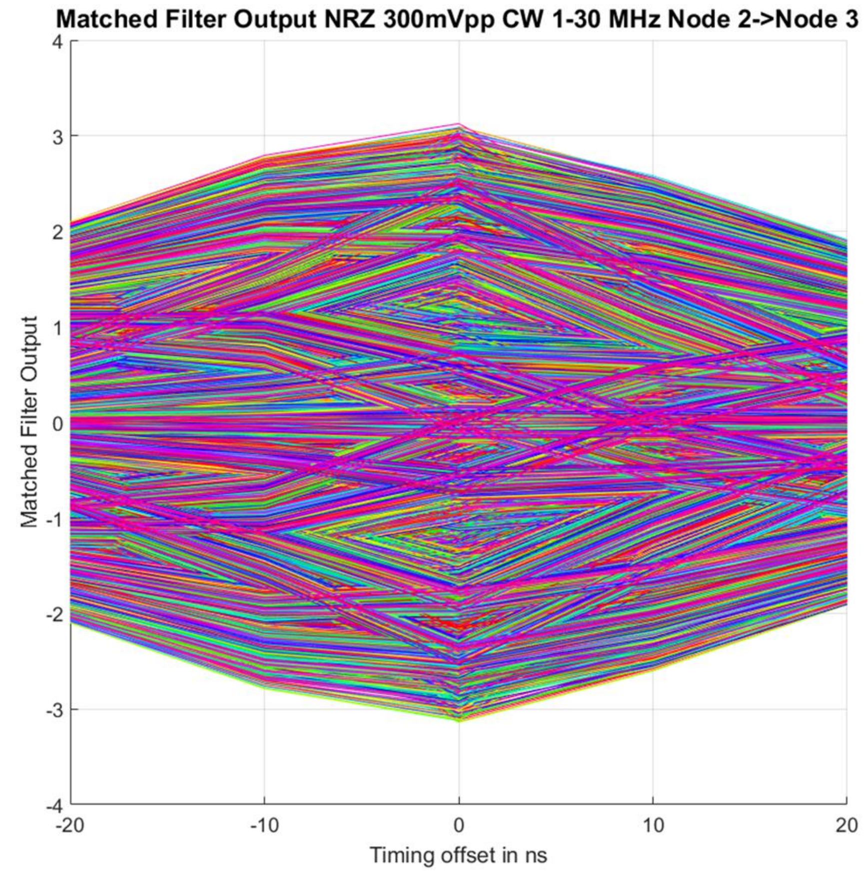




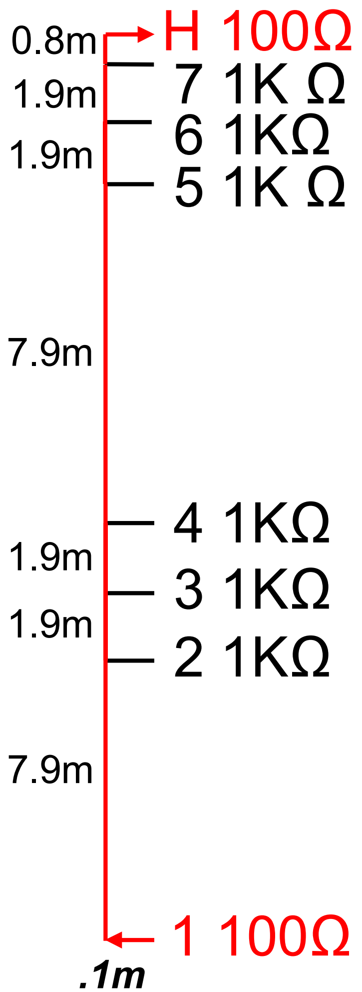
Eye Diagram for NRZ 2->Node 3

- **Channel:** Node 2->3 (buntz.. “Max”)

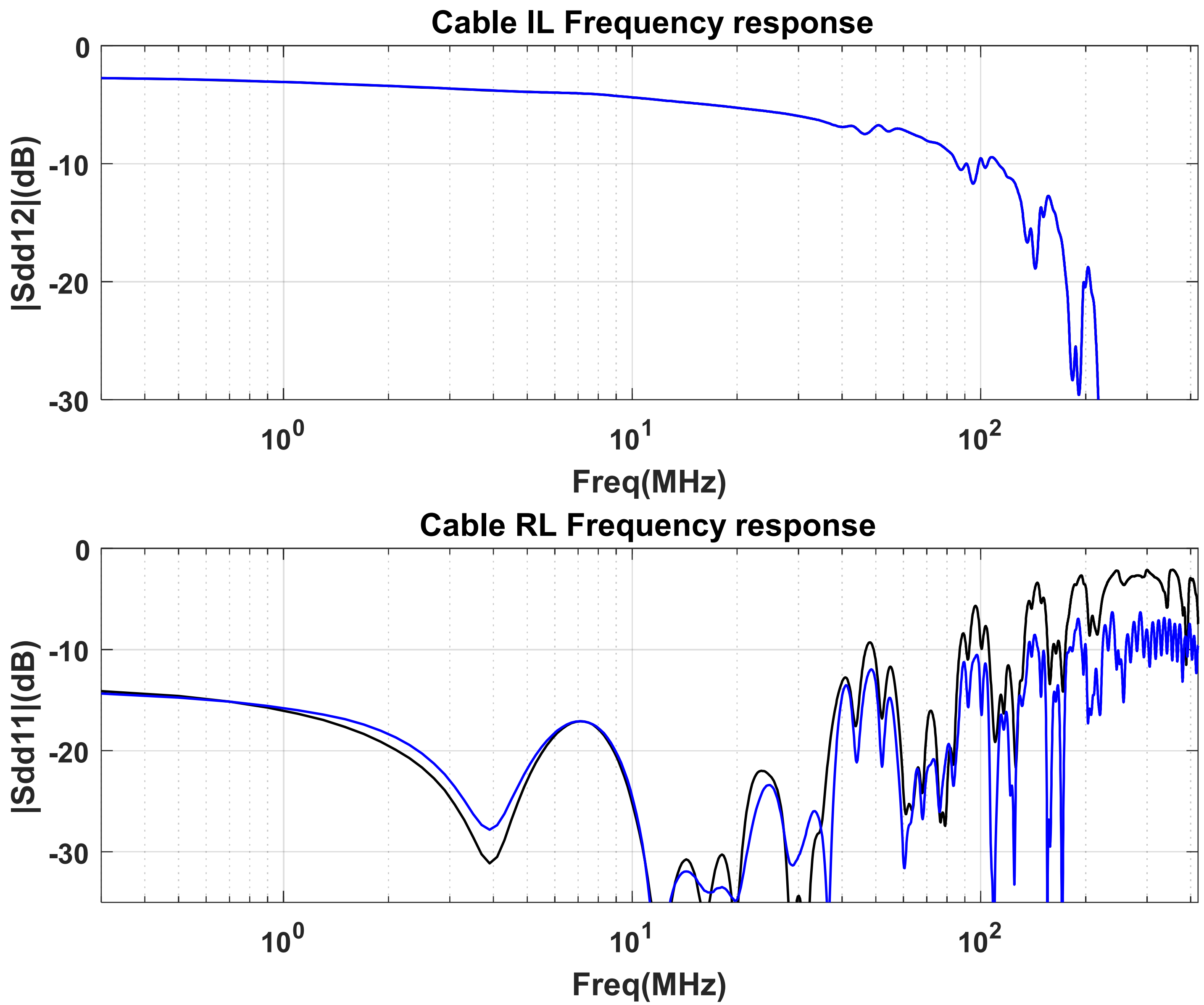




Channel Frequency Response Node 1->Node H

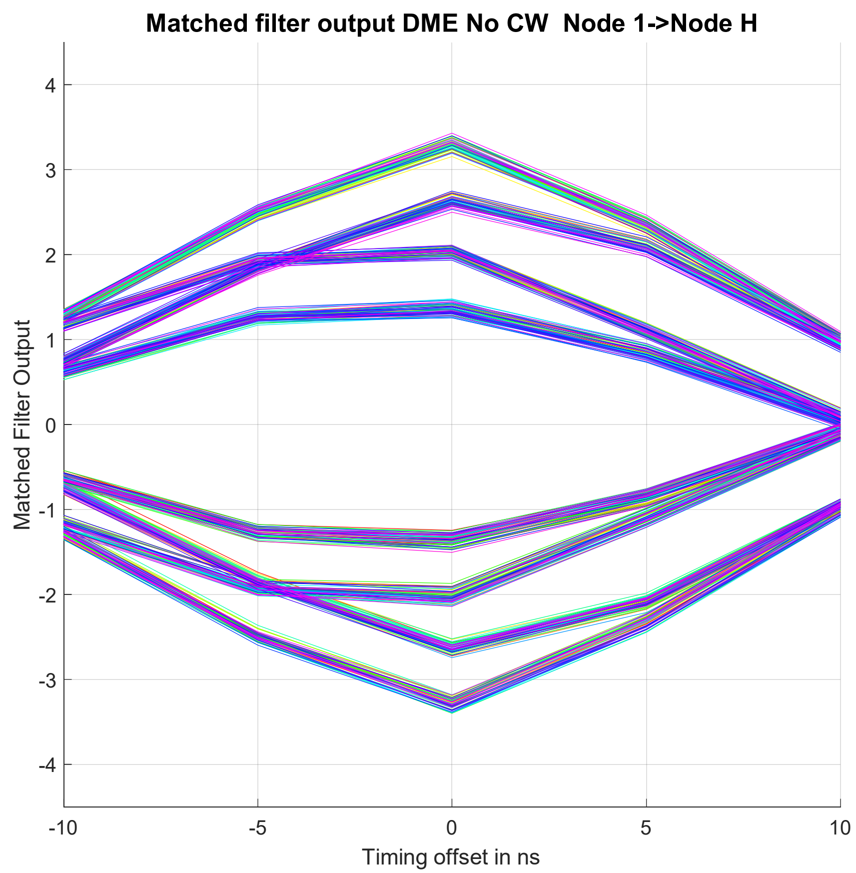


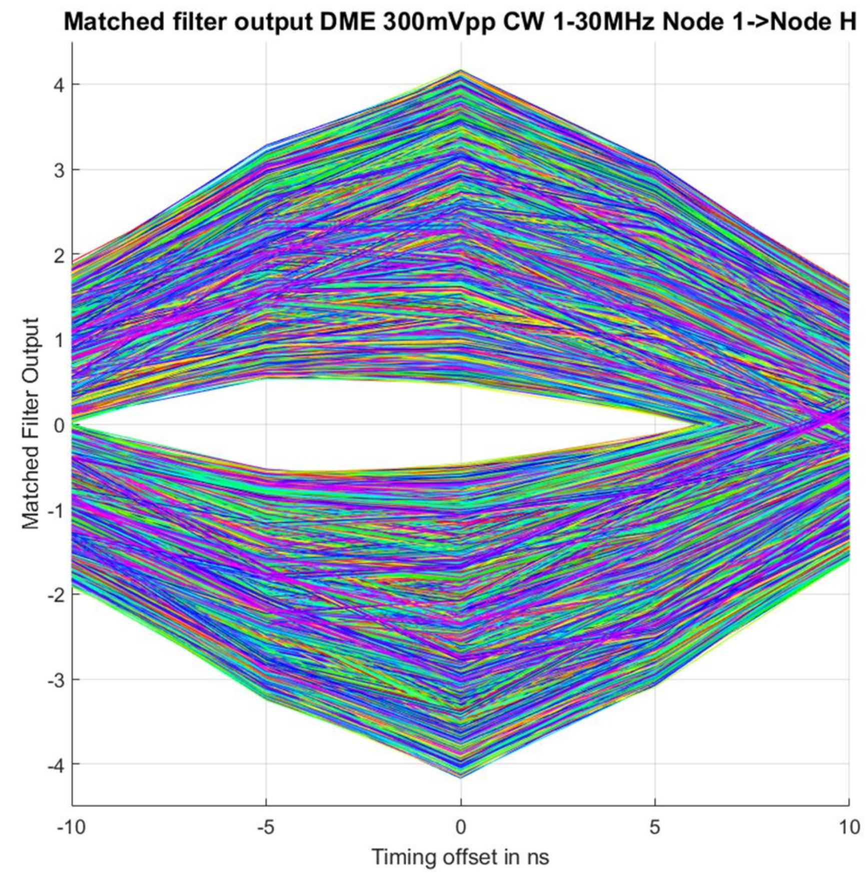
Node 1: Tx(100Ω)
Node H: Rx(100Ω)
All Others: 1KΩ



Eye Diagram for DME Node 1->Node H

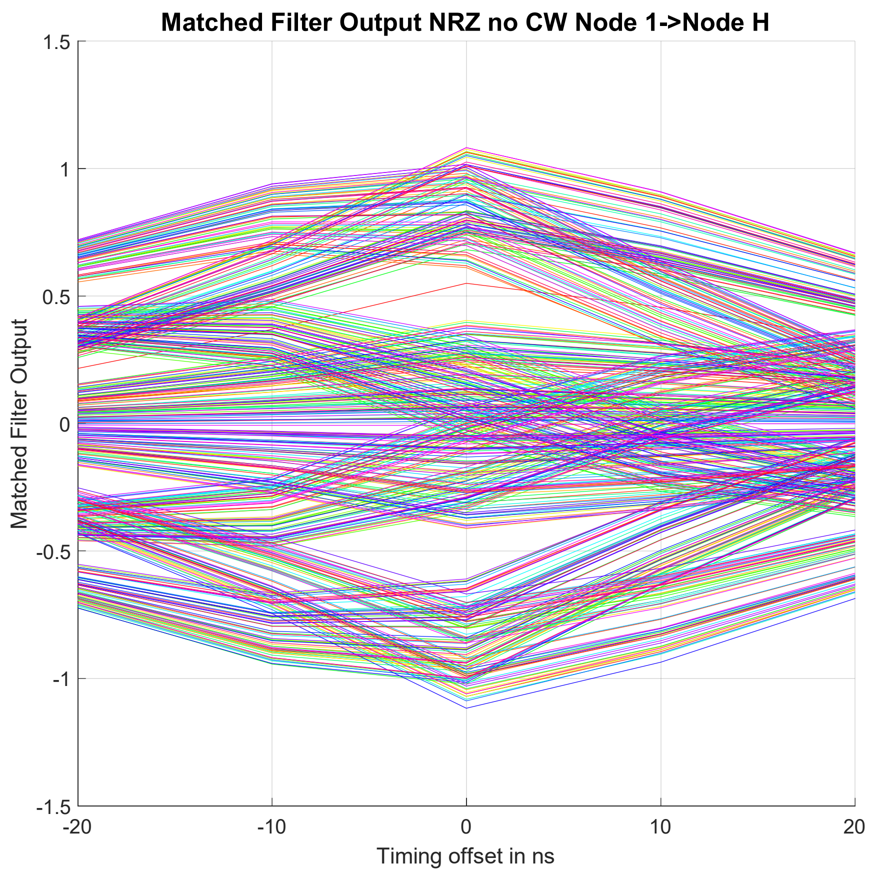
- **Channel:** Node 1->H (buntz.. “Max”)

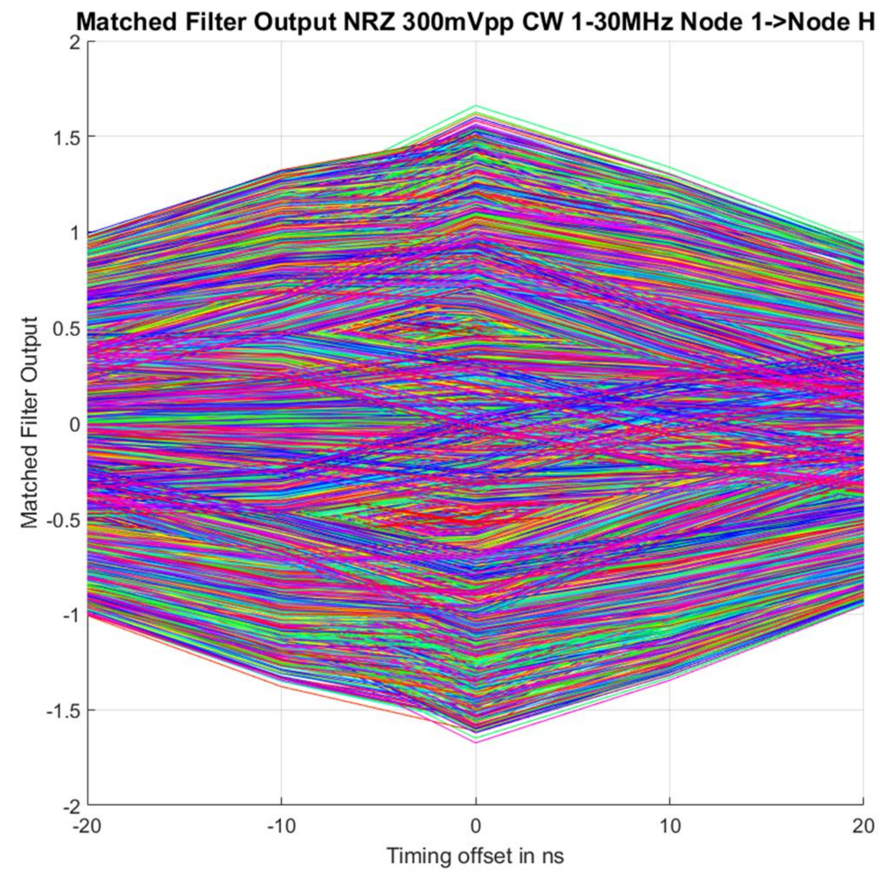




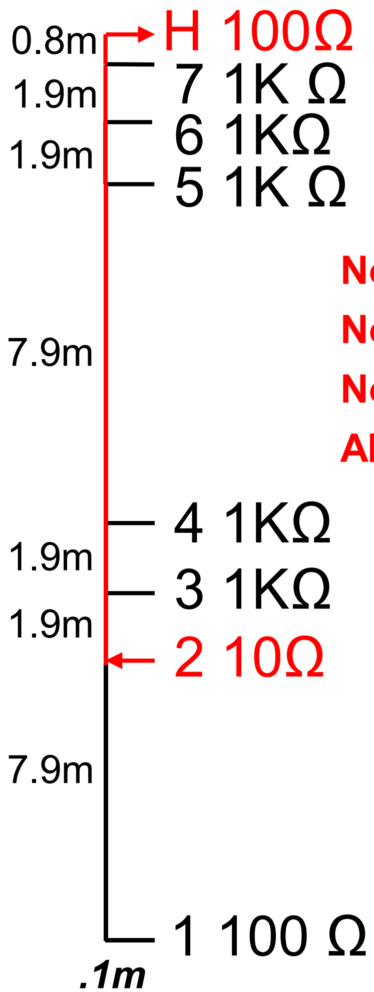
Eye Diagram for NRZ Node 1 -> Node H

- **Channel:** Node 1->H (buntz.. “Max”)





Channel Frequency Response Node 2->Node H

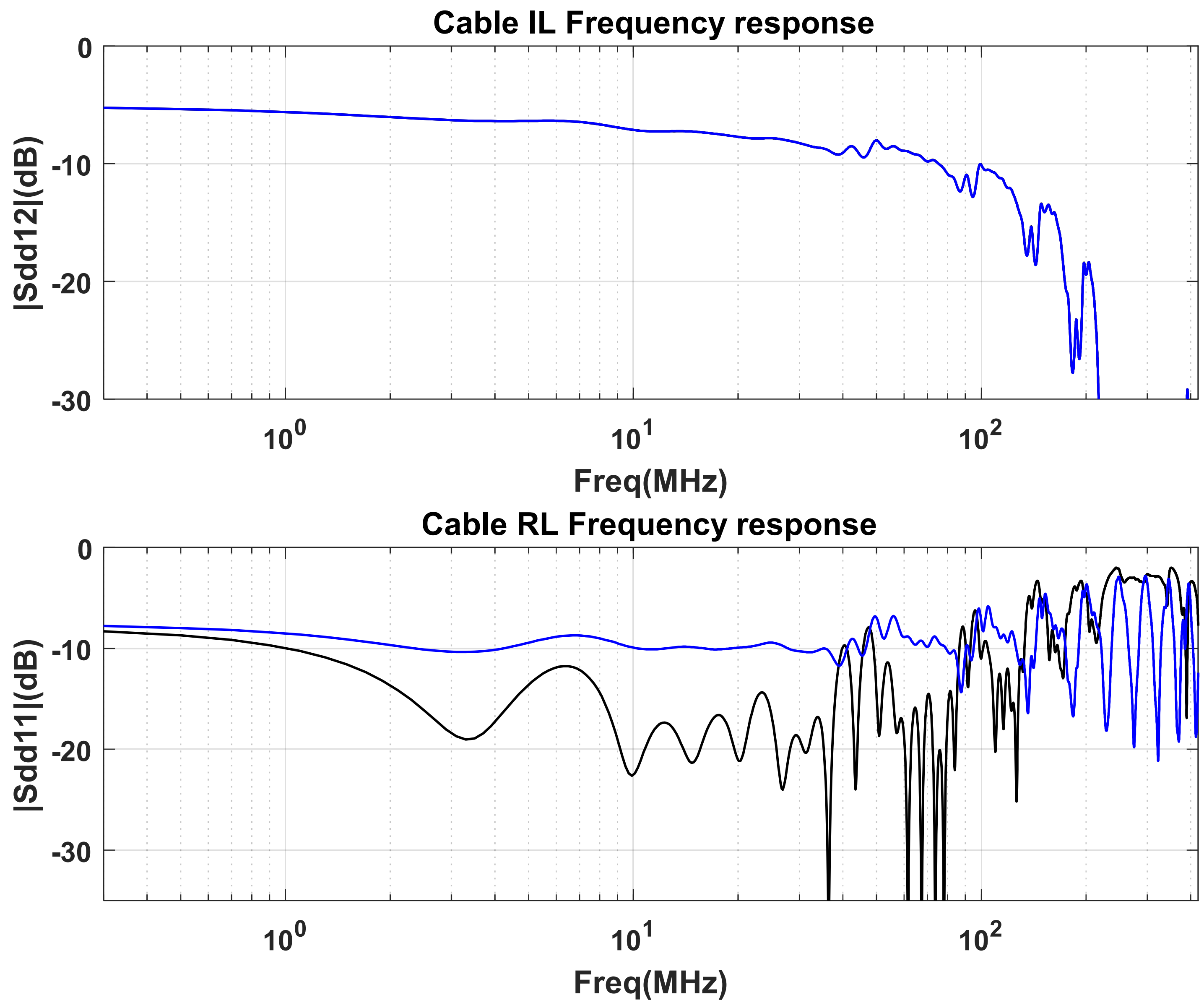


Node 1: Terminated (100Ω)

Node H: Rx(100Ω)

Node 2: TX (10Ω)

All Others 1kΩ



Eye Diagram for DME Node 2->Node H

- **Channel:** Node 2->H (buntz.. "Max")
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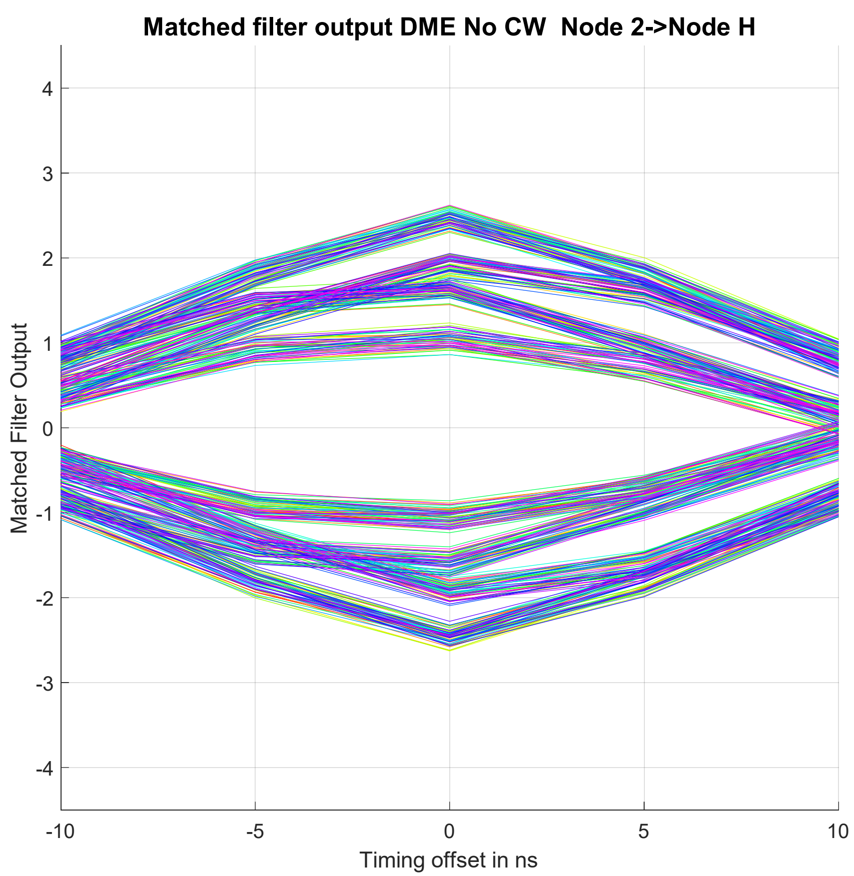
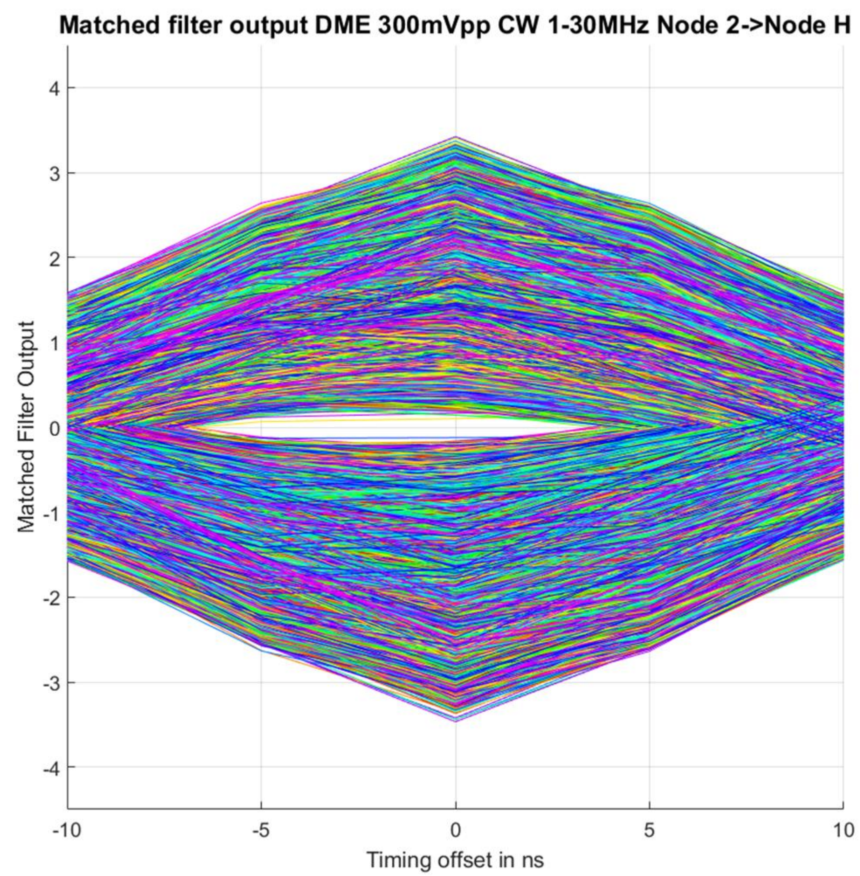
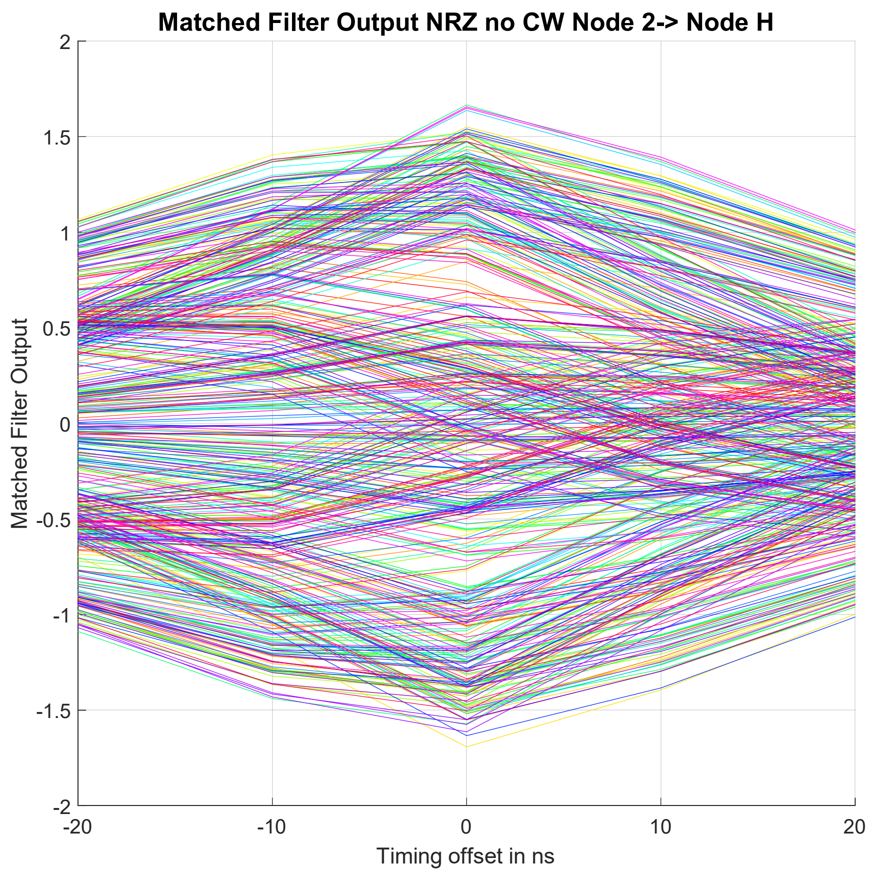


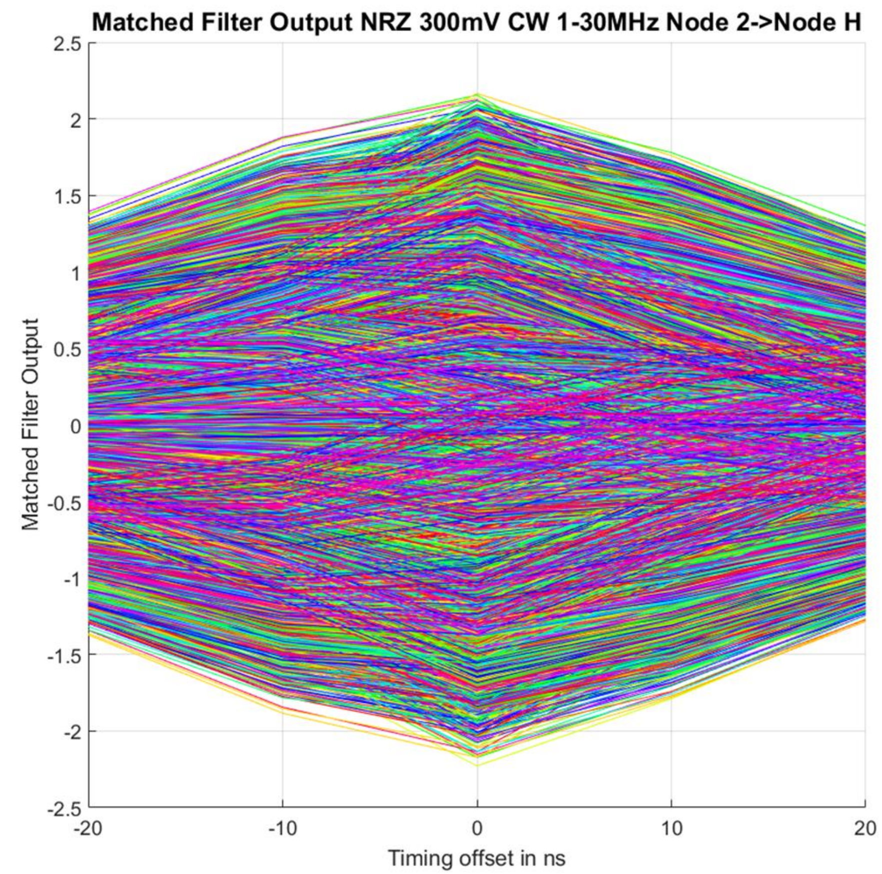


- Eye is open

Eye Diagram for NRZ Node 2->Node H

- **Channel:** Node 2->H (buntz.. "Max")





Conclusions

- Link segments with end termination of 100Ω have low attenuation and don't have deep spectral nulls for frequencies of interest in 10BASE-T1S.
- DME is spectrally compatible with PoDL and the noise environment of 10BASE-T1S.
- DME does not require equalization for 10BASE-T1S while NRZ requires an equalizer because of PoDL and low frequency noise.
- 20Mbps aggregated data rate plus 5Mbps for OAM/control will work fine for 10BASE-T1S, allowing full- duplex point-to-point operation at full 10Mbps line rate without echo cancellation.

Thank You!