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# 802.3da Verification of Consensus Model Simulation

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# Purpose and Outline

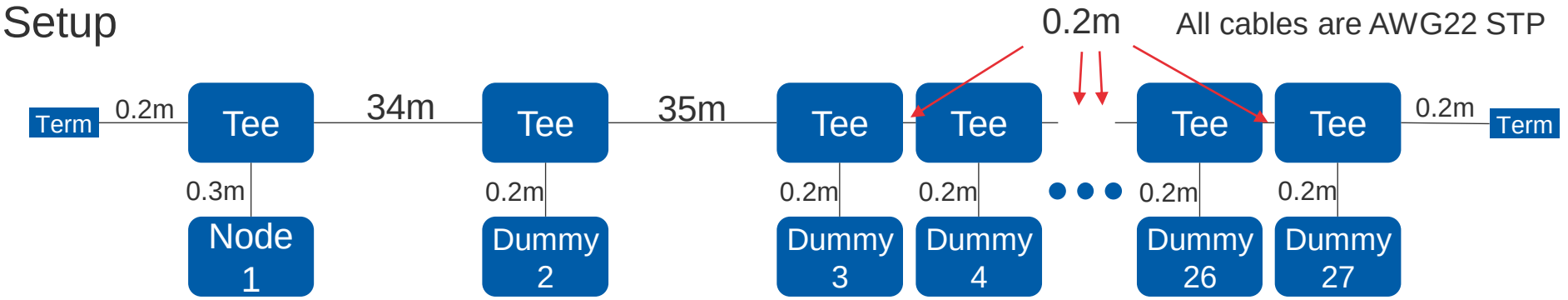
- Purpose
  - Verification of consensus model simulation
  - Comparison of measured eye diagrams and simulated eye diagrams
  - Evaluation of exemplary link
  - Provide additional evidence in order not to preclude inductive compensation within the link segment

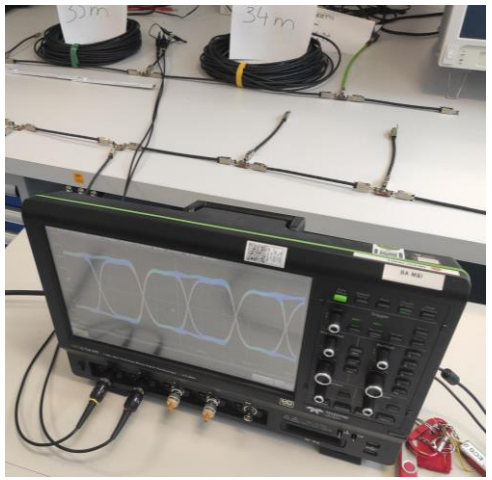
- Outline
  - Introduction of measurement setup
  - Details on used prototypes
  - Eye diagram measurements and simulations results
  - VNA Results
  - Conclusion

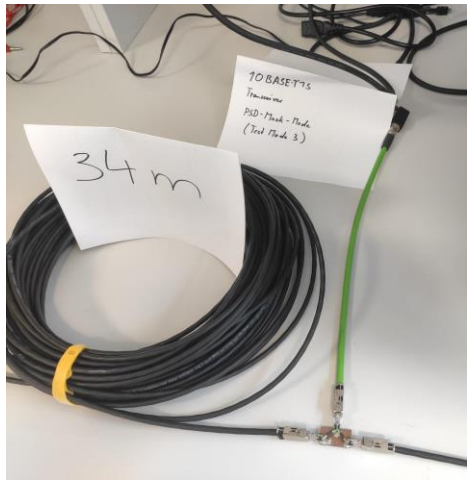
öffentlich | public

# Measurement Setup

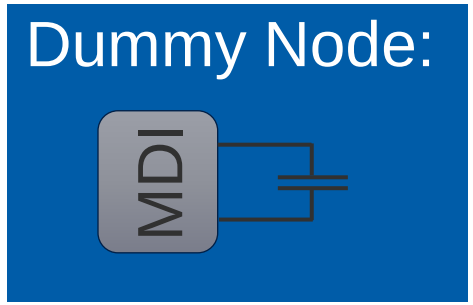
## Setup



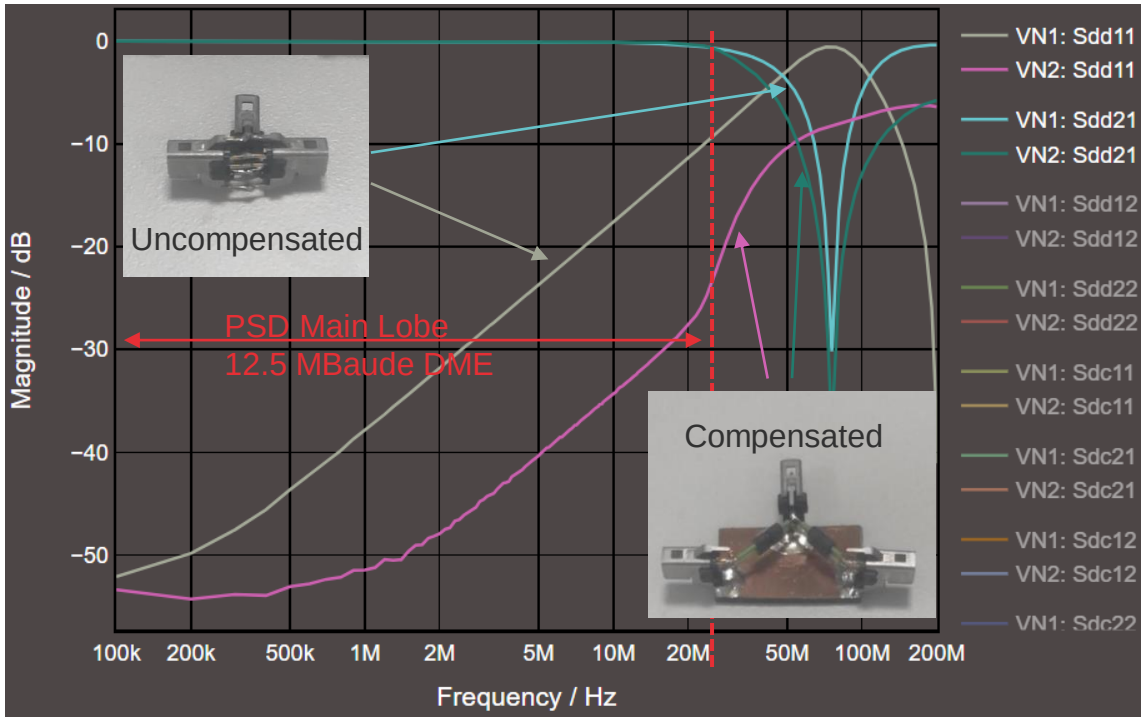



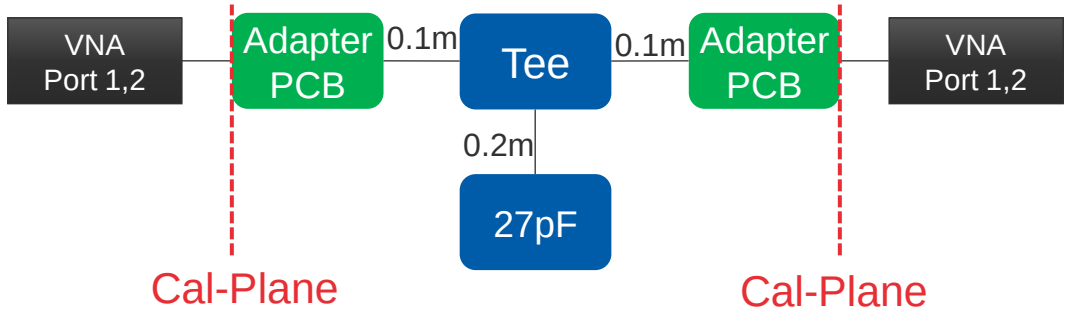





- Eye Diagram measurements and simulation comparisons:
  - Measurement 1: Uncompensated Tee, all Dummy Nodes 27pF
  - Measurement 2: Compensated Tee, all Dummy Nodes 27pF
  - Measurement 3: Compensated Tee, all Dummy Nodes disconnected (corner case)
  - Measurement 4: Compensated Tee, scattered capacitance of Dummy Nodes

# Tee Connectors with optional compensation




- Uncompensated Tee
  - Simple assembly of 3 connectors
  - Return loss within the PSD Main Lobe with 27pF Node connected on a stub

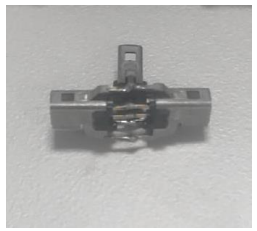
$$S_{dd11} < -9.3\ \mathrm{dB}$$

- Compensated Tee
  - Assembly of 3 connectors, with a binocular ferrite within the trunk portion to increase inductance on the node connection
  - Return loss within the PSD Main Lobe with 27pF Node connected on a stub

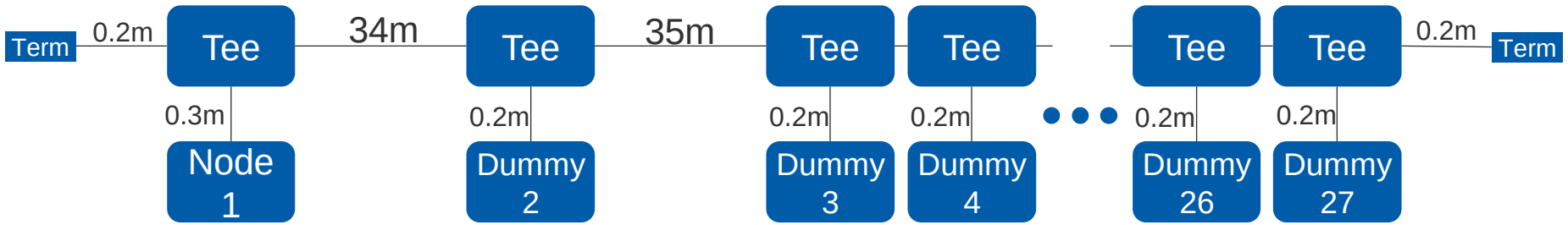
$$S_{dd11} < -23.3\ \mathrm{dB}$$

# Measurement Setup

## Measurement 1



All Tees **without** compensation

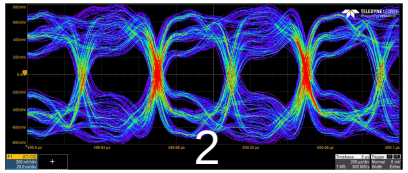


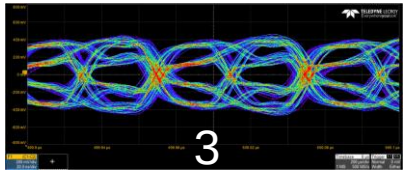

Node 1 – TX Node:
10BASE-T1S Phy
Transformer Coupled
MDI Capacitance approx. 24 pF
Test Mode 3 – PSD according to 802.3cg

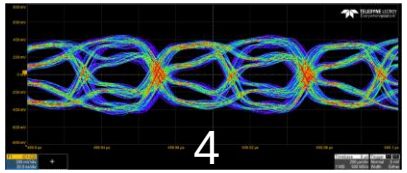
All Dummy Nodes 27pF, No PoDL, No Resistor

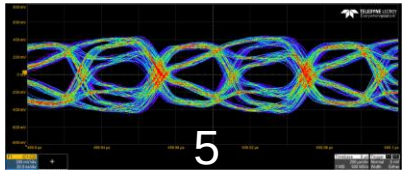
# Measurements Results

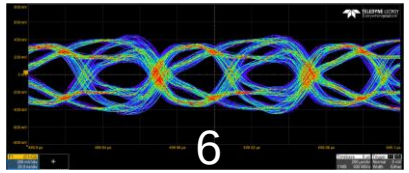
## Measurement 1 – Uncompensated Tee, all Dummy Nodes 27pF

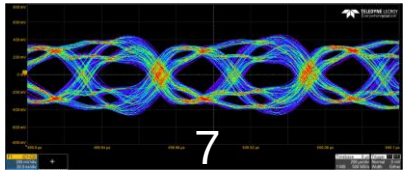


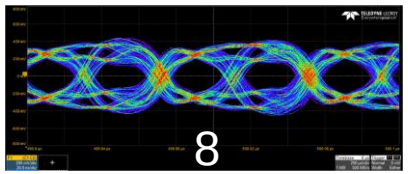


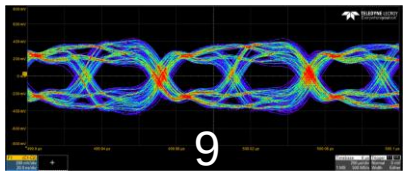


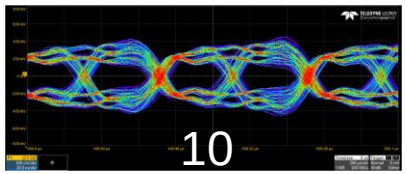


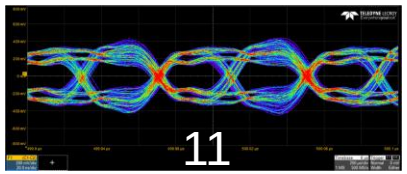


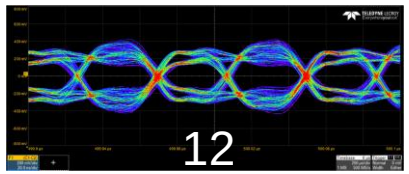


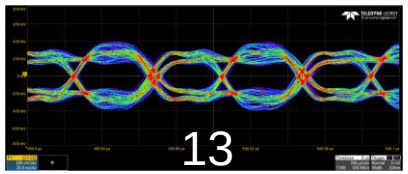


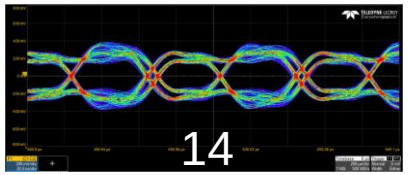


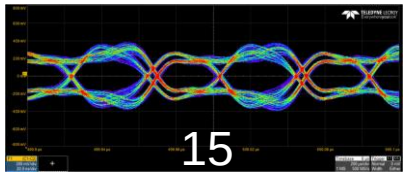


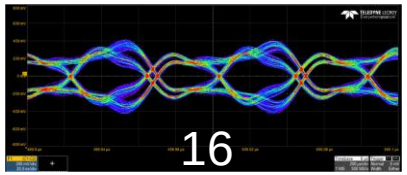


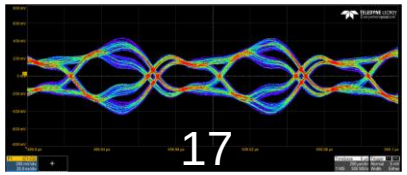


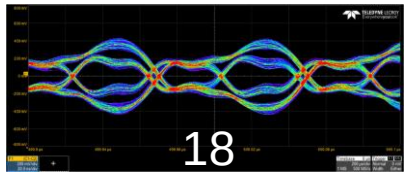


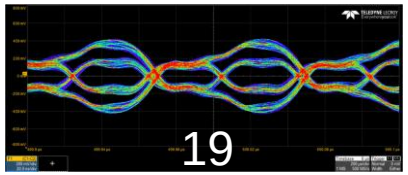


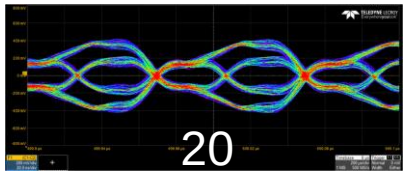


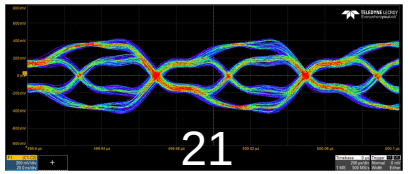


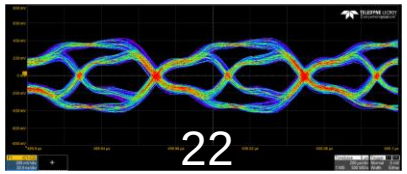


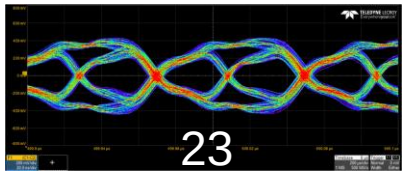


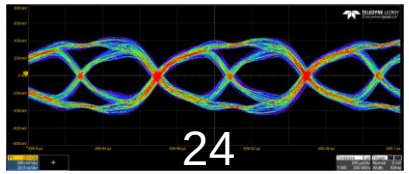


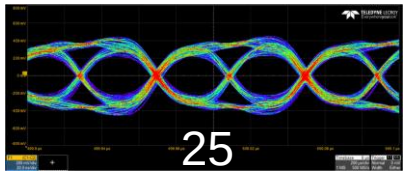


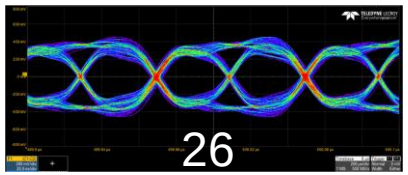


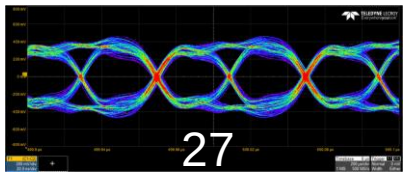








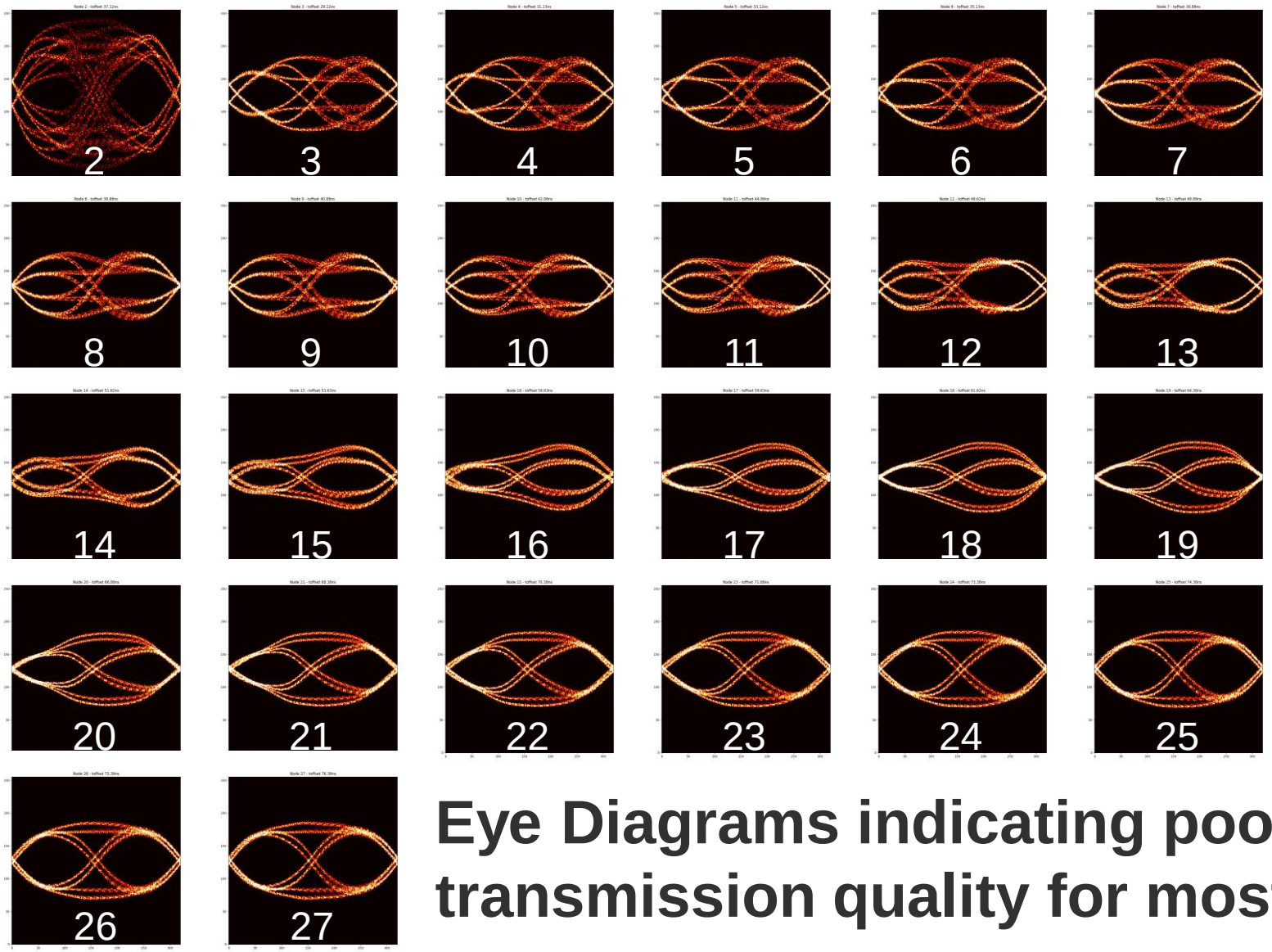


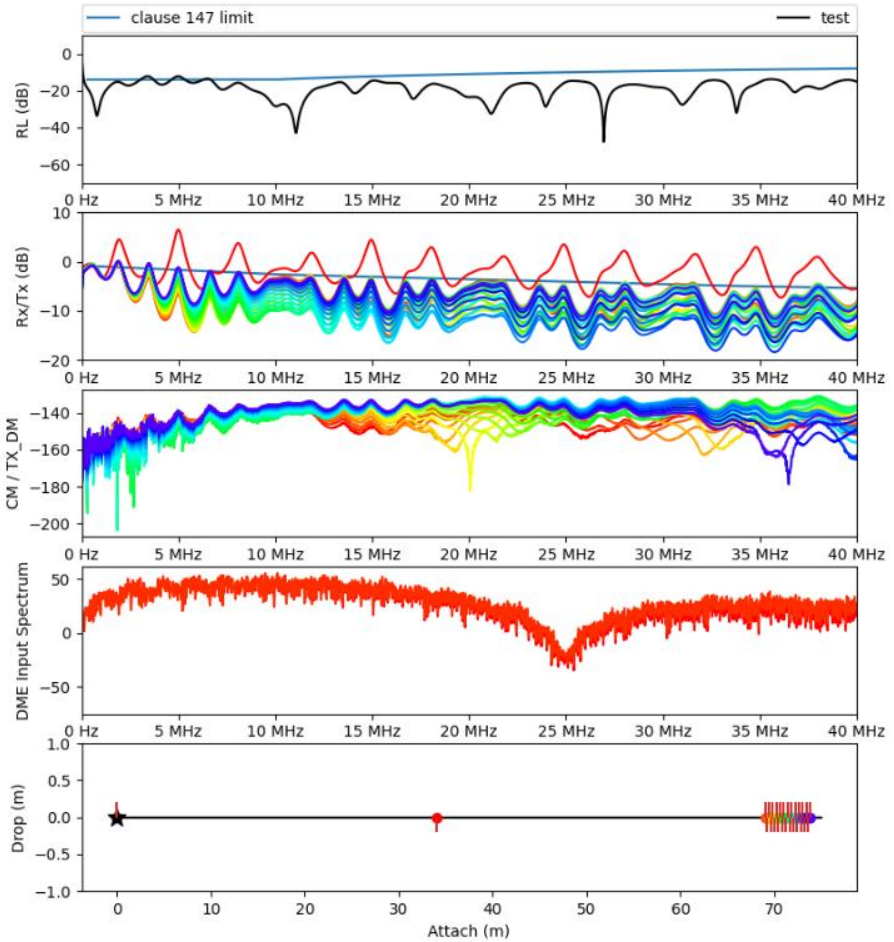



**Eye Diagrams indicating poor transmission quality for most nodes**

# Simulation Results

## Simulation 1 - Github Model, Uncompensated Tee (ideal model), all Nodes 27pF

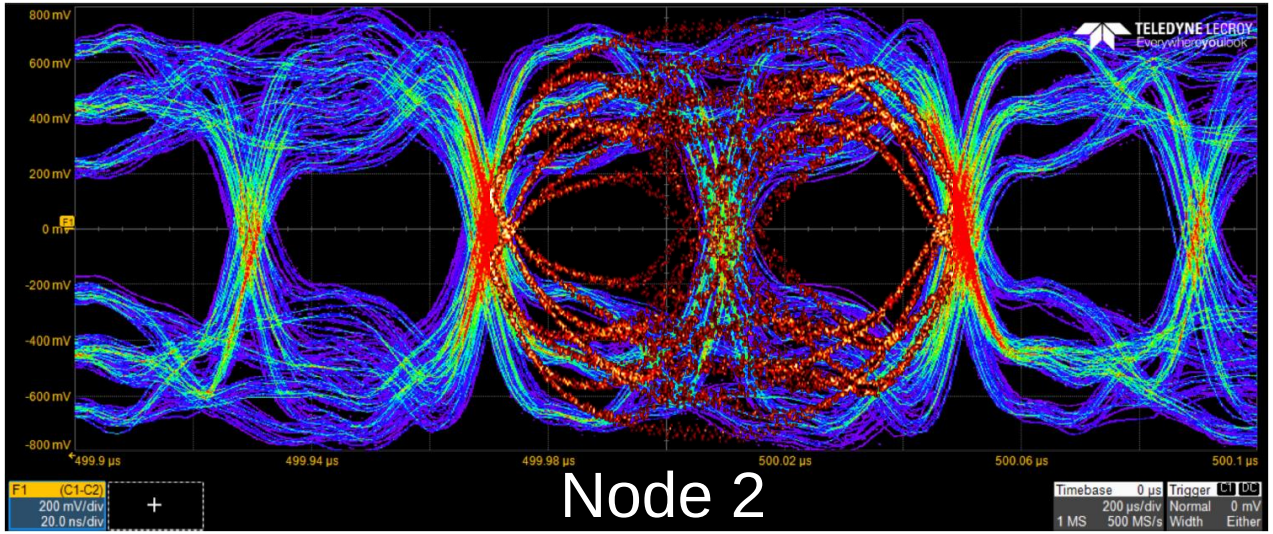


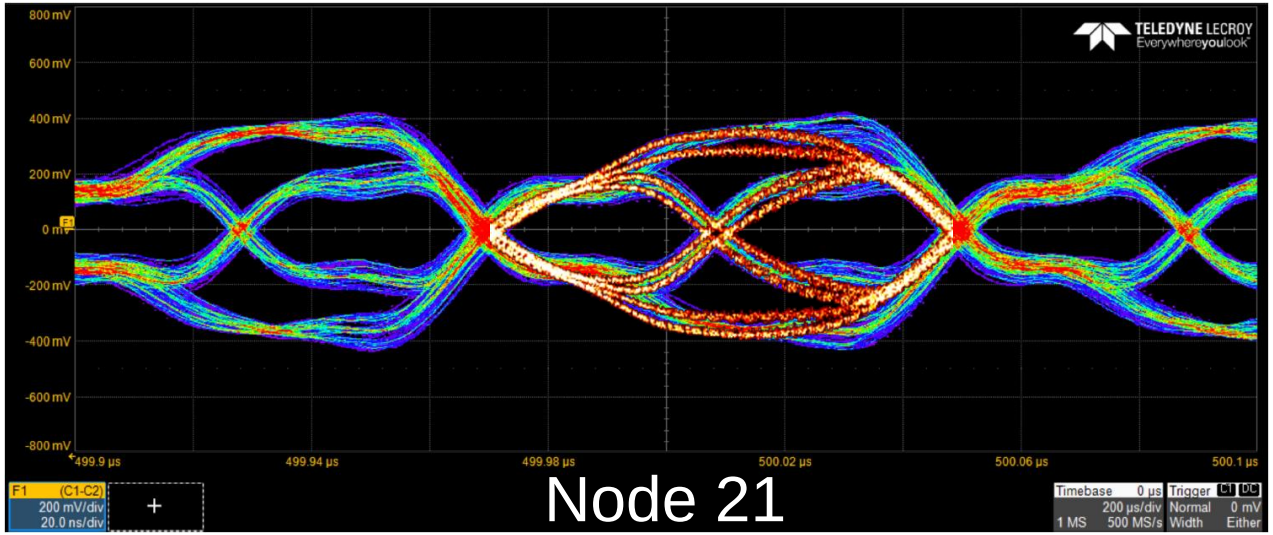




**Eye Diagrams indicating poor transmission quality for most nodes**

# Detail Comparison Node 2 and Node 21

## Unompensated Tee, all Nodes 27pF

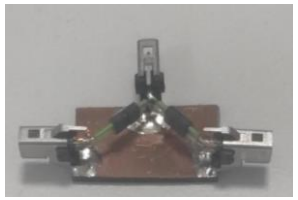


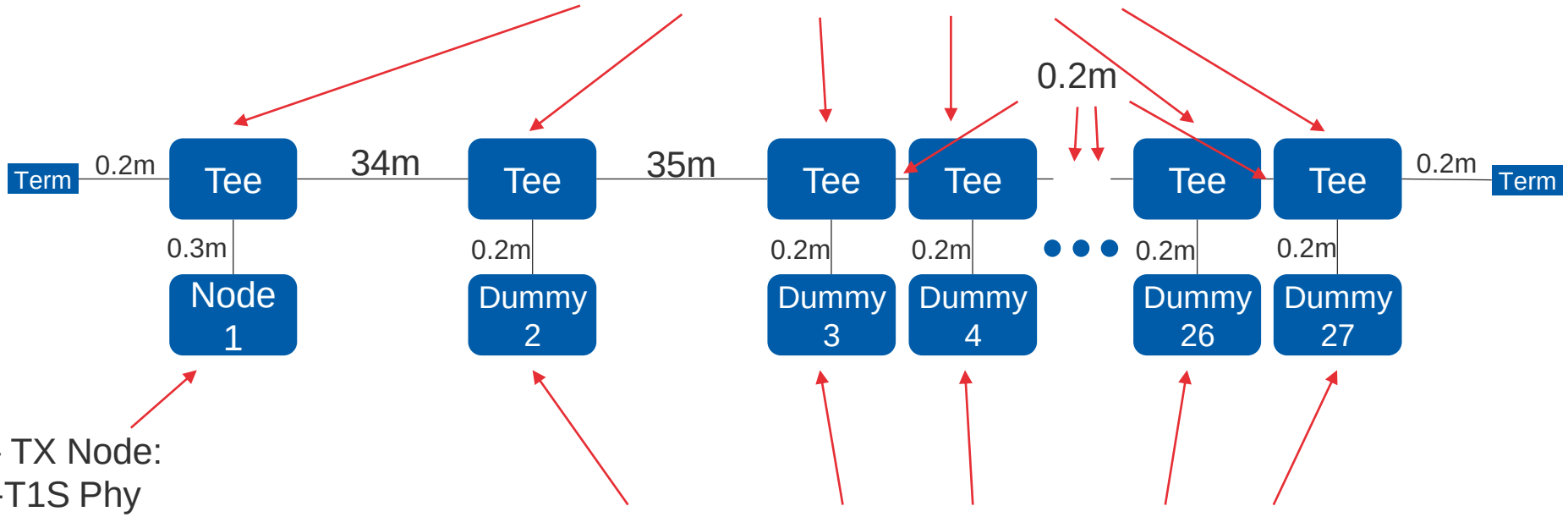

- Differences between measurements and simulations, however both are showing same direction
- Measurement and simulation indicating signal integrity issues
- Some nodes might have signal integrity problems

# Measurement Setup

## Measurement 2 – Compensated Tee, all Dummy Nodes 27pF



All Tees **with** compensation

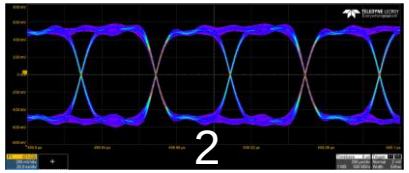


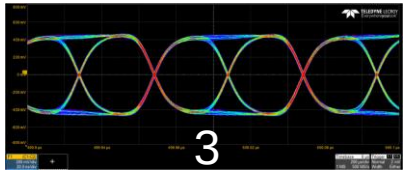

Node 1 – TX Node:
10BASE-T1S Phy
Transformer Coupled
MDI Capacitance approx. 24 pF
Test Mode 3 – PSD according to 802.3cg

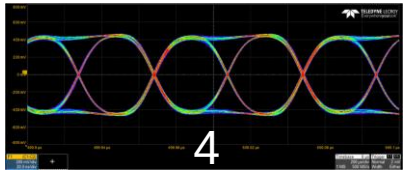
All Dummy Nodes 27pF, No PoDL, No Resistor

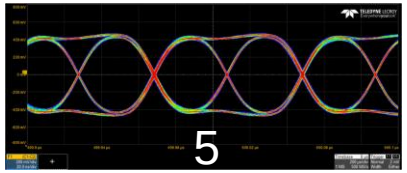
# Measurement Results

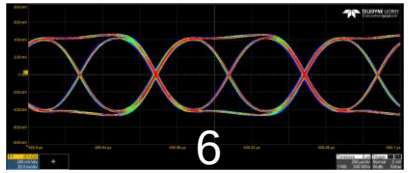
## Measurement 2 – Compensated Tee, all Dummy Nodes 27pF

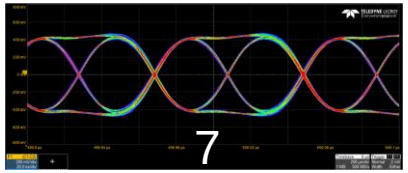


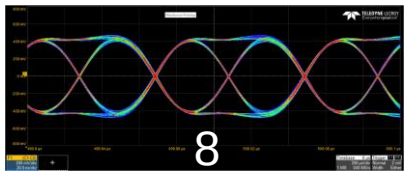


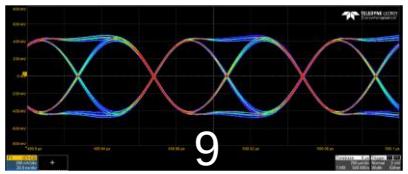


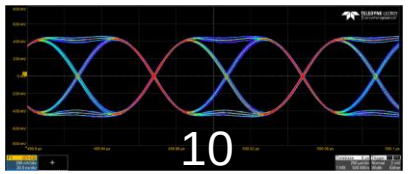


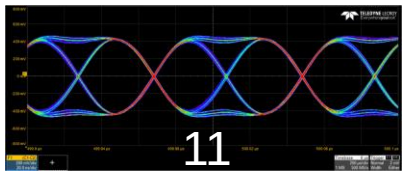


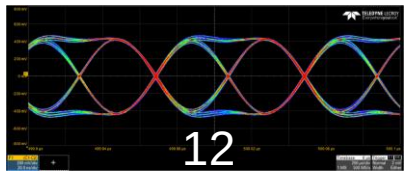


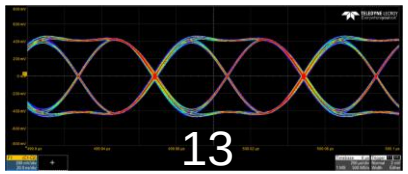


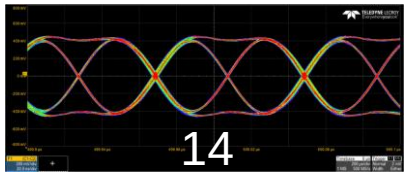


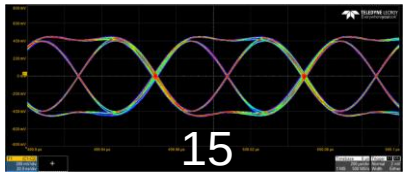


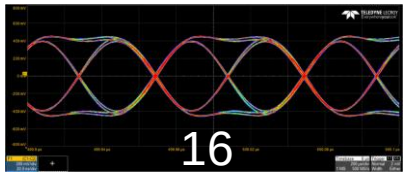


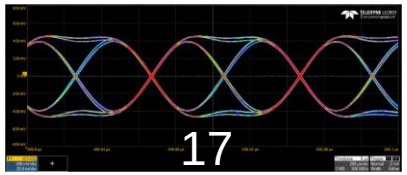


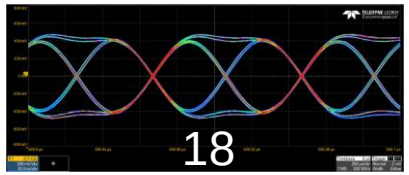


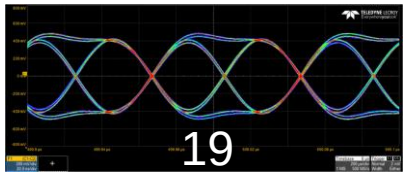


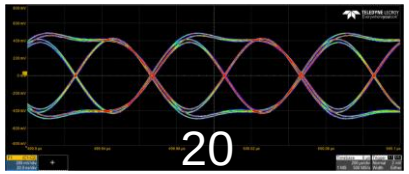


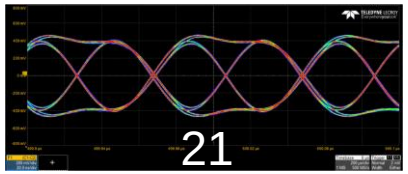


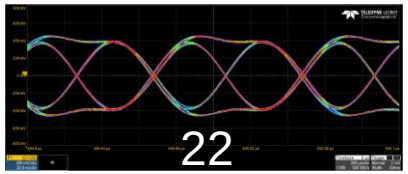


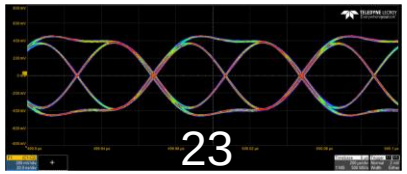


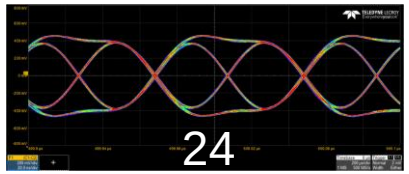


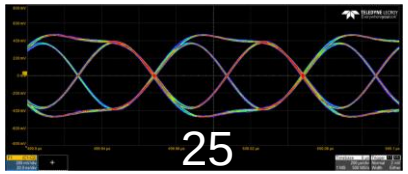


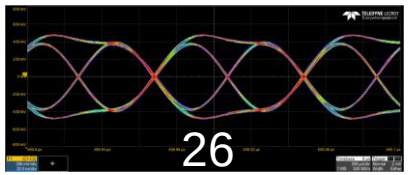


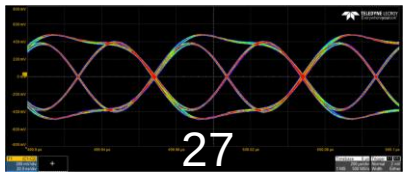








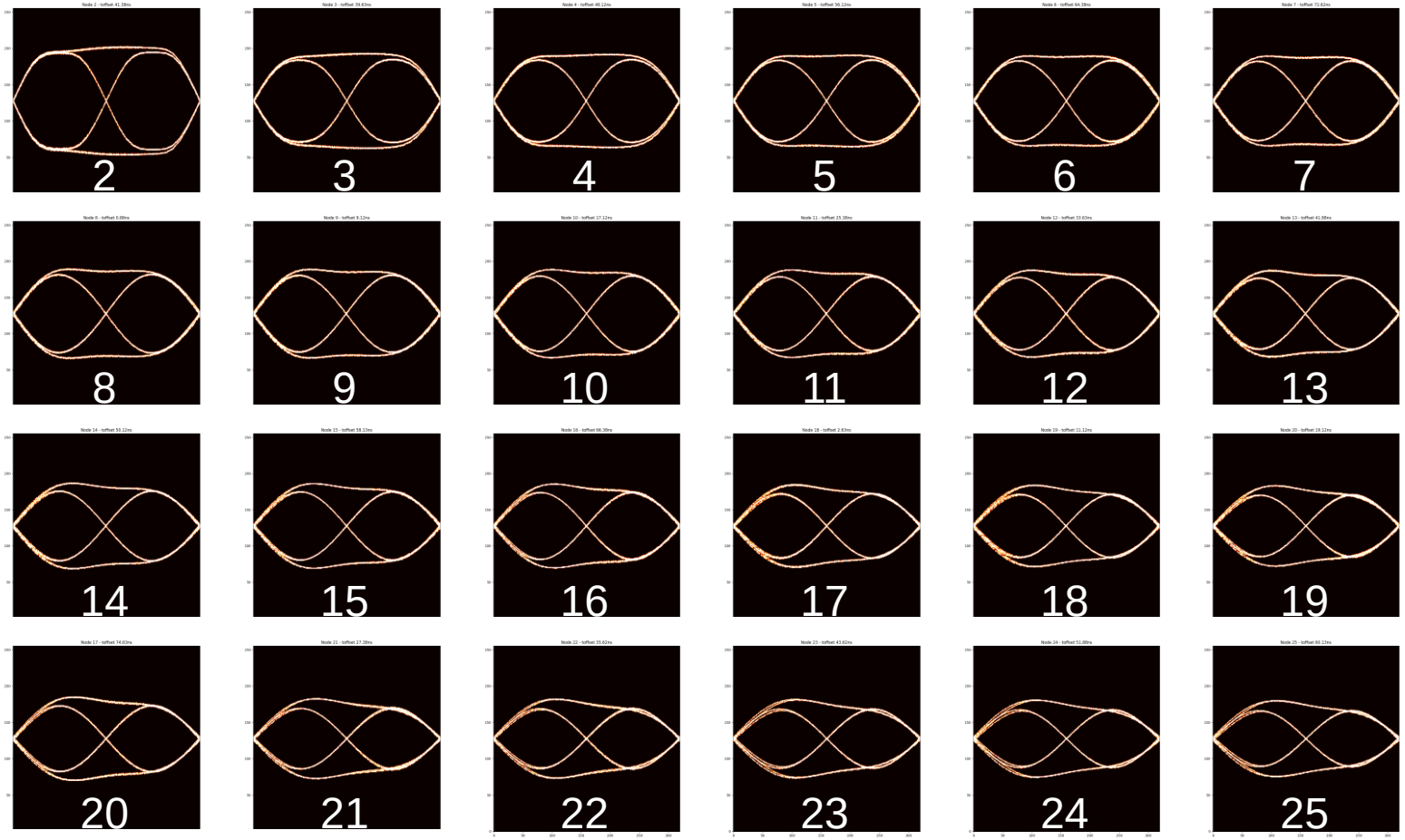


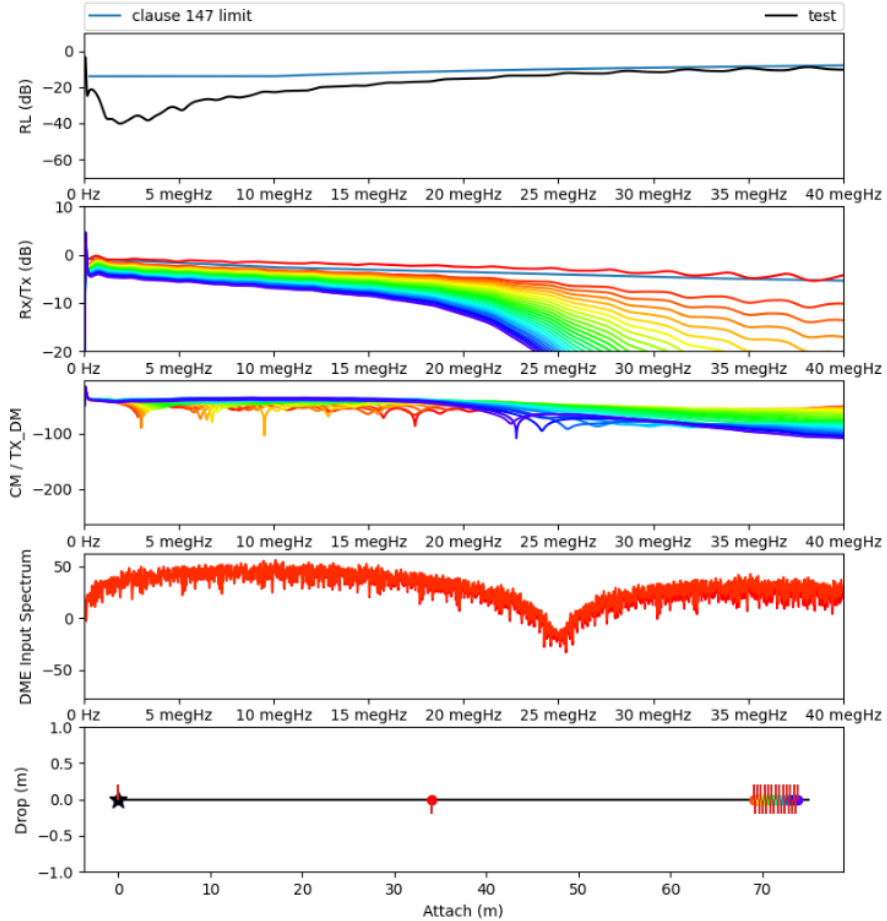



**Eye Diagrams indicating good transmission quality for all nodes**

# Simulation Results

## Simulation 2 – Github Model, Compensated Tee, all Dummy Nodes 27pF

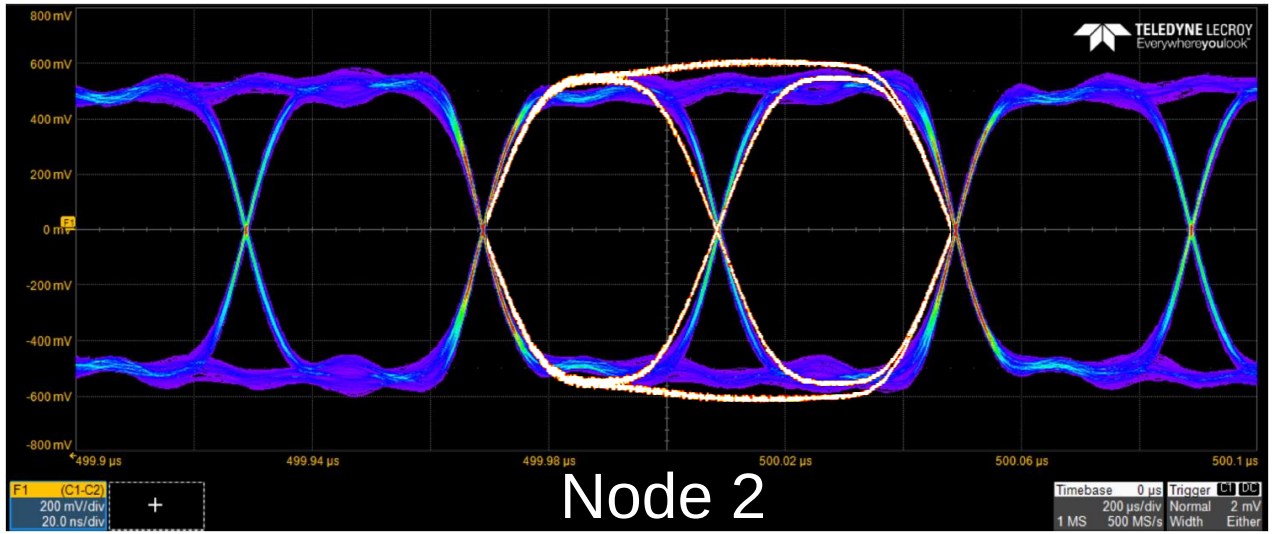


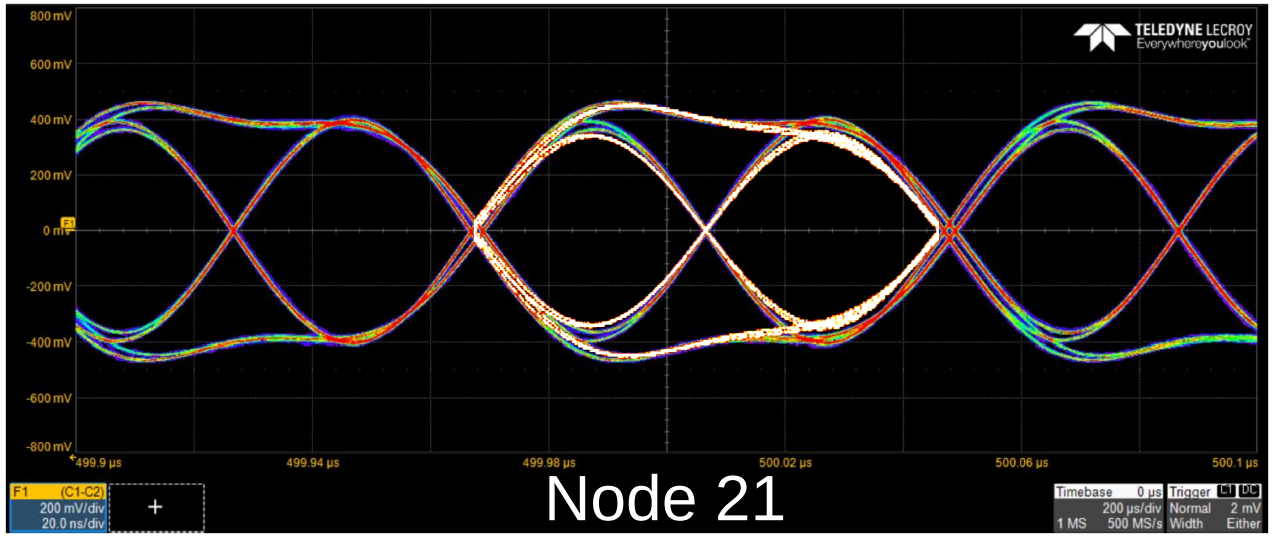




**Eye Diagrams indicating good transmission quality for all nodes**

# Detail Comparison

## Compensated Tee, all Dummy Nodes 27pF

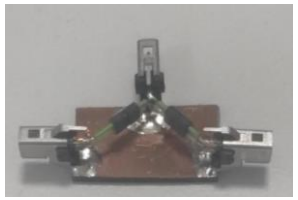


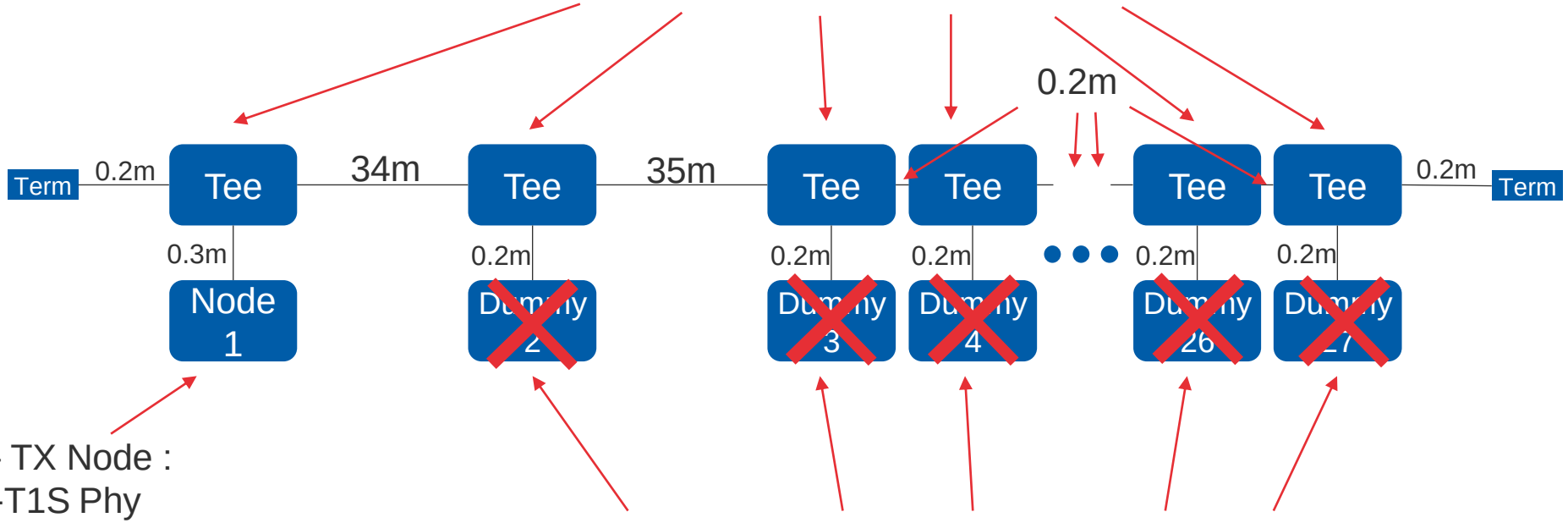

- Very good match of simulated and measured eye diagrams
- All receiving nodes showing quite good eye diagrams
- Exemplary channel should be functional as intended

# Measurement Setup

## Measurement 3 – Compensated Tee, all Dummy Nodes disconnected



All Tees **with** compensation

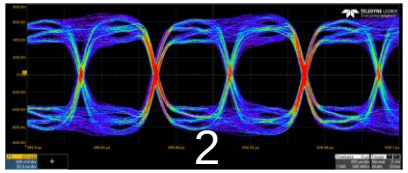


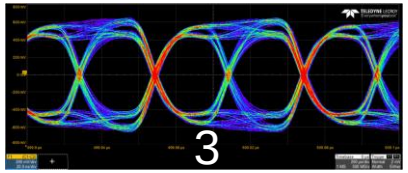

Node 1 – TX Node :
10BASE-T1S Phy
Transformer Coupled
MDI Capacitance approx. 24 pF
Test Mode 3 – PSD according to 802.3cg

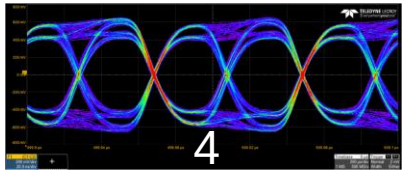
All Dummy Nodes disconnected
→ Worst case for overcompensation

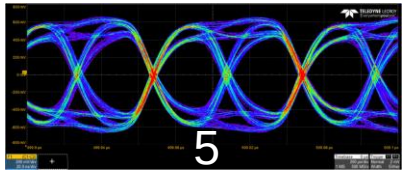
# Measurement Results

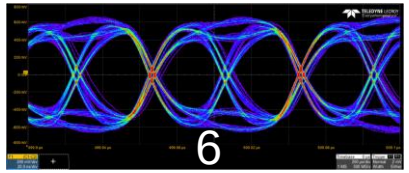
## Measurement 3 – Compensated Tee, all Dummy Nodes disconnected

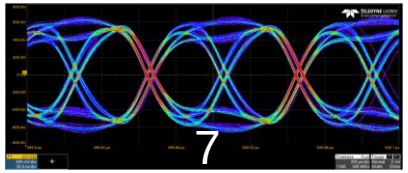


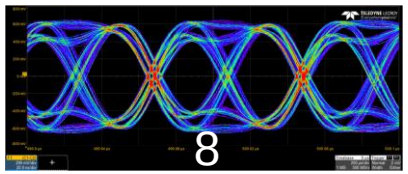


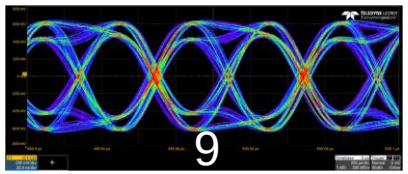


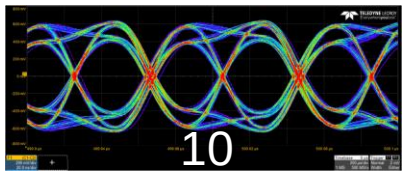


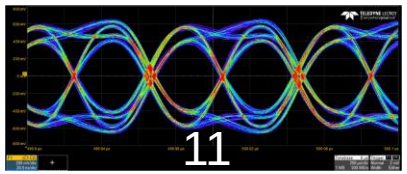


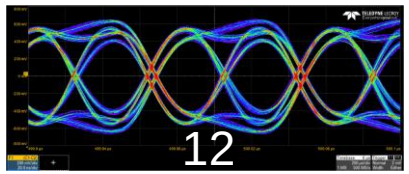


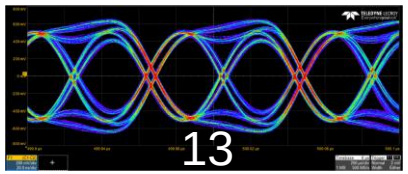


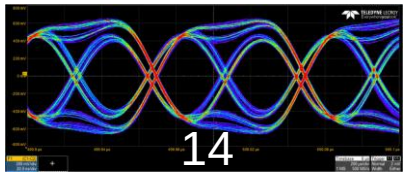


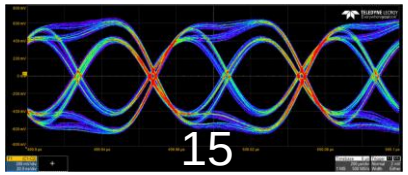


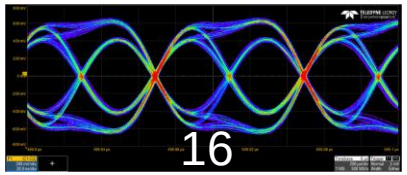


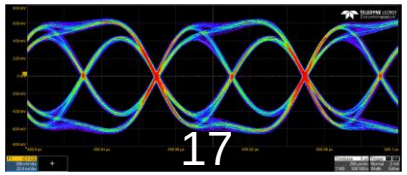


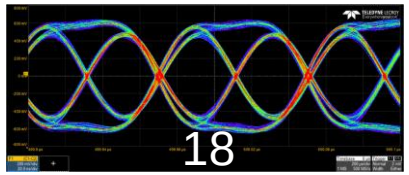


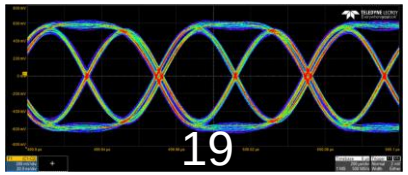


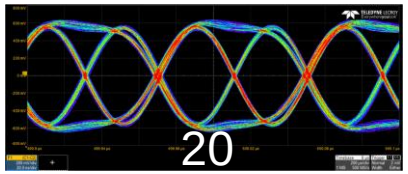


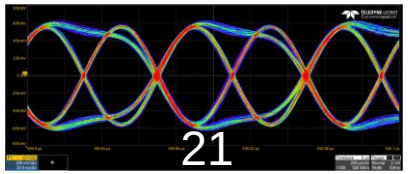


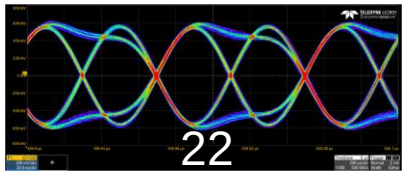


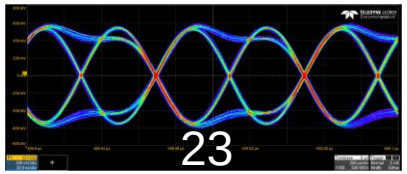


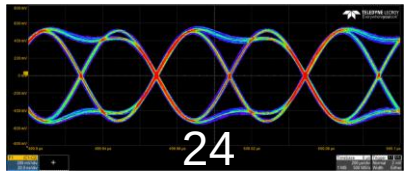


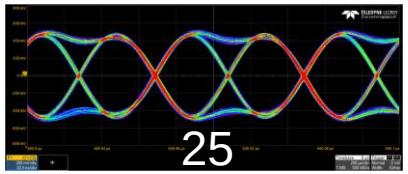


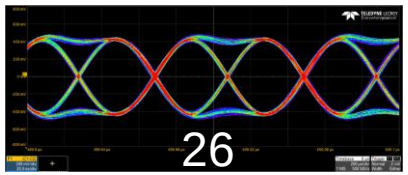


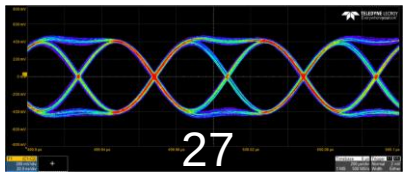








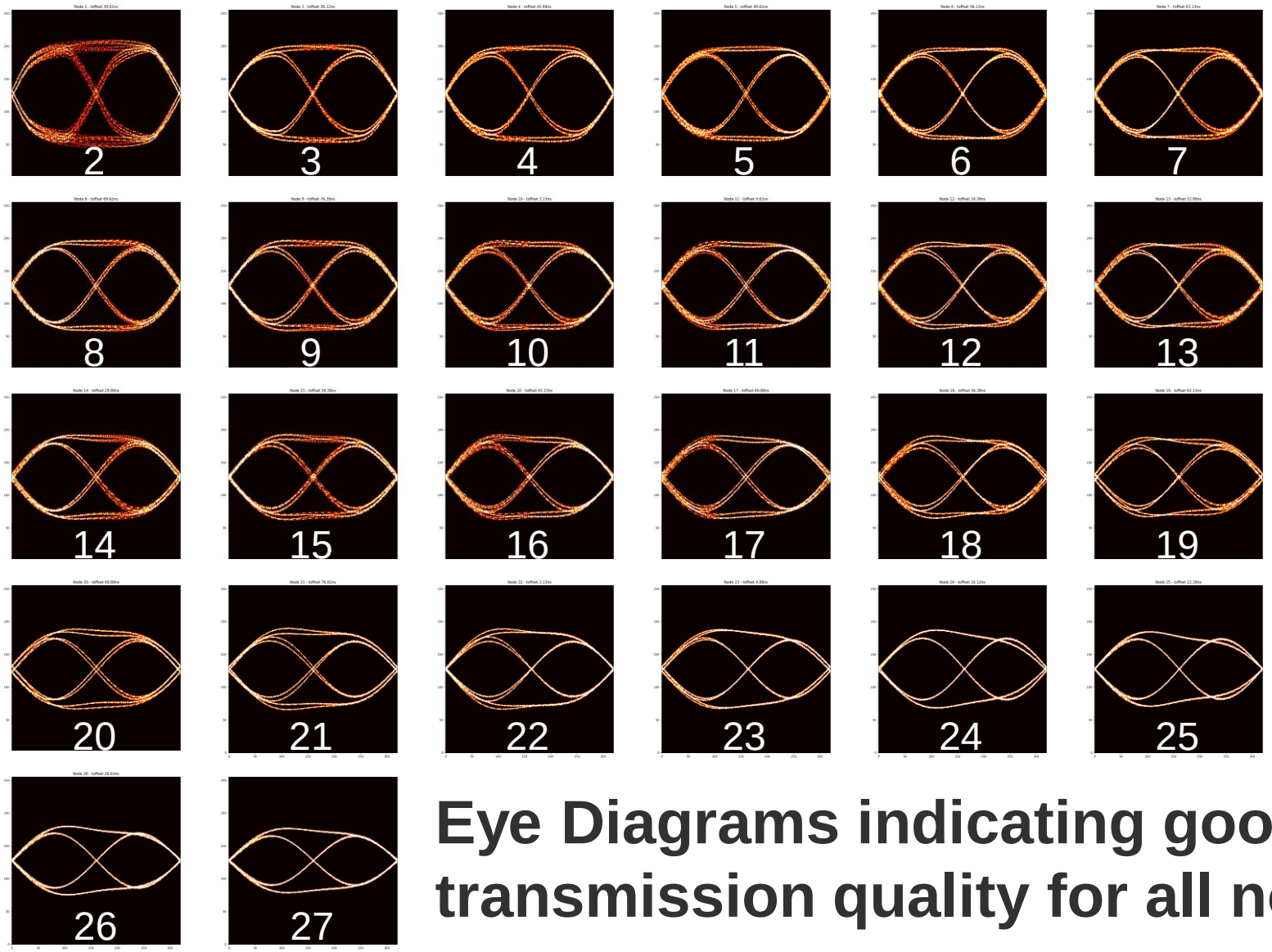


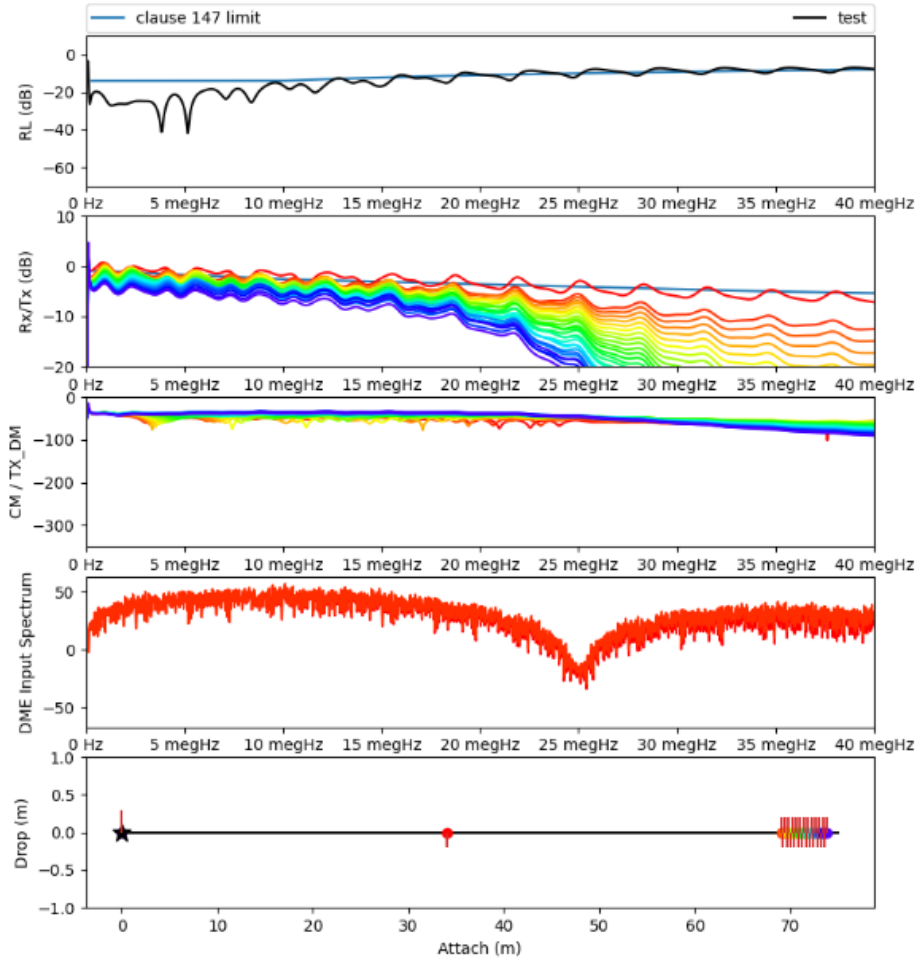



**Eye Diagrams indicating decreased transmission quality for some nodes due to massive overcompensation**

# Simulation Results

## Results 3 – Github Model, Compensated Tee, Nodes 0.1pF

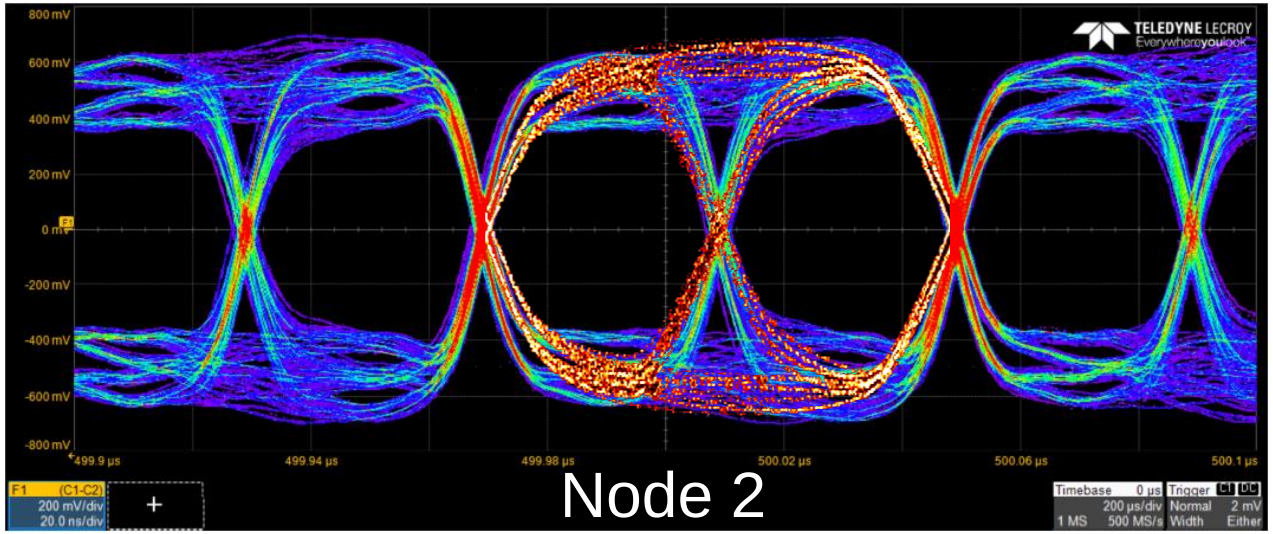


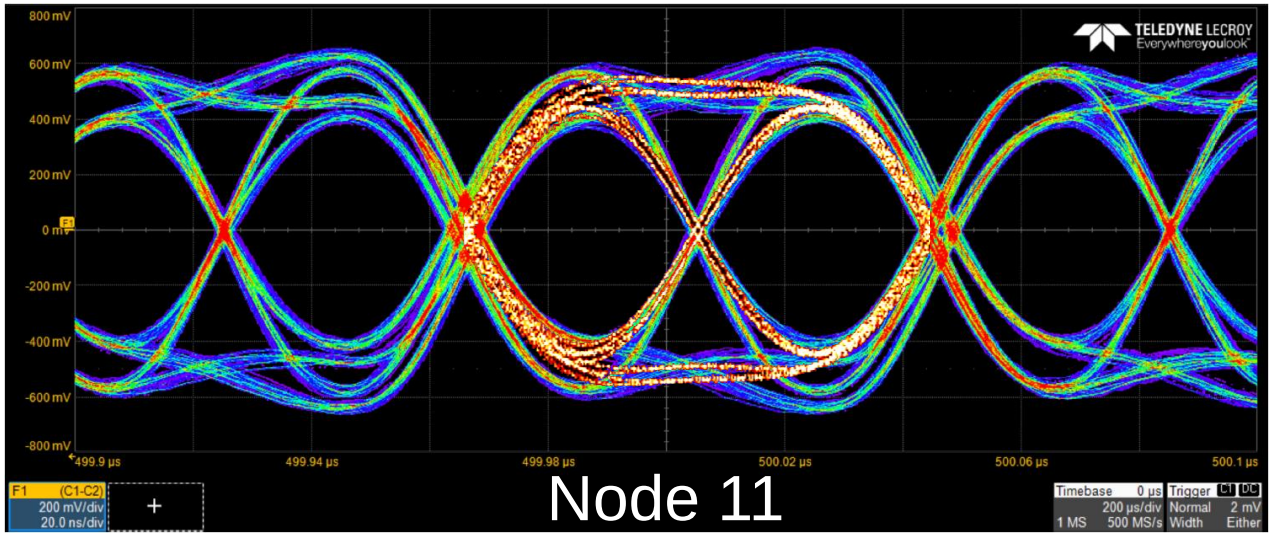




**Eye Diagrams indicating good transmission quality for all nodes**

# Detail Comparison Node 2 and Node 11

## Compensated Tee, all Dummy Nodes disconnected

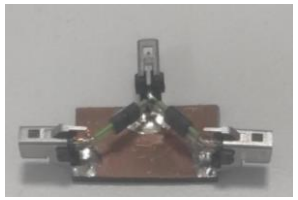


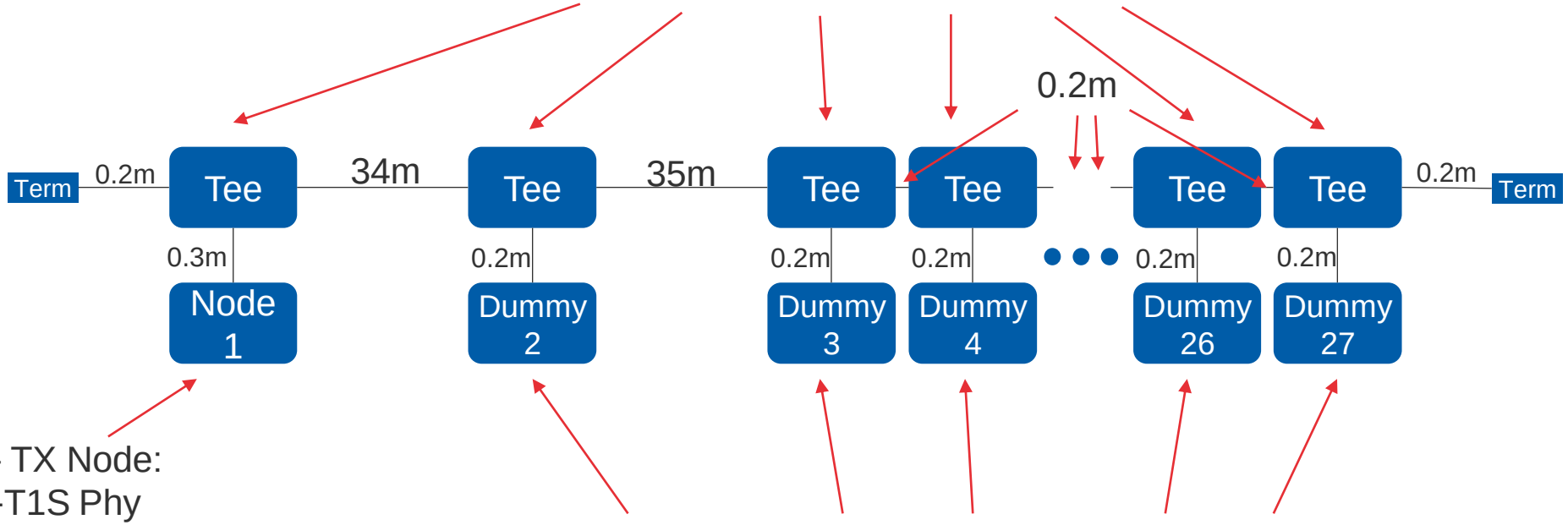

- Differences between measurements and simulations
  - Simulated eye diagrams showing better signal integrity than measured eye diagrams
  - Guess to verify: Vector-fit of S-Parameter might be problematic at corner cases (open)

# Measurement Setup

## Measurement 4 – Compensated Tee, Dummy Node capacity scattered between 15pF and 33pF



All Tees **with** compensation



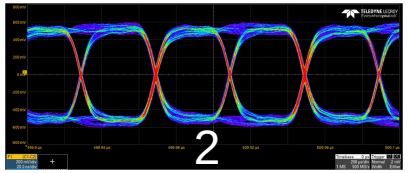

Node 1 – TX Node:
10BASE-T1S Phy
Transformer Coupled
MDI Capacitance approx. 24 pF
Test Mode 3 – PSD according to 802.3cg

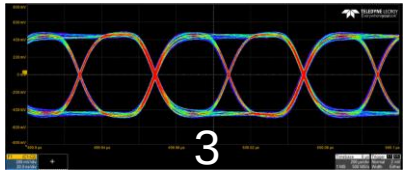
Dummy Nodes Capacitance according to Table , No PoDL, No Resistor

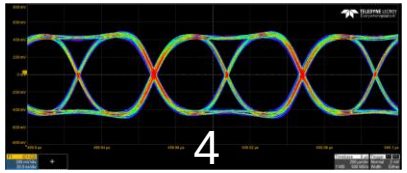
| Node | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Capacitance [pF] | | 22 | 18 | 15 | 27 | 22 | 15 | 33 | 27 | 27 | 27 | 15 | 33 | 22 | 27 | 18 | 27 | 27 | 15 | 27 | 33 | 33 | 22 | 27 | 33 | 22 | 15 |

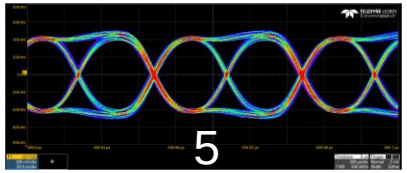
# Measurements Results

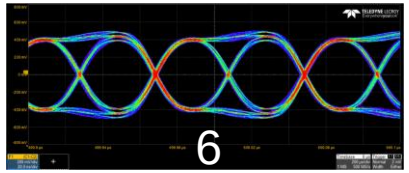
## Measurement 4 – Compensated Tee, Dummy Node capacity scattered between 15pF and 33pF

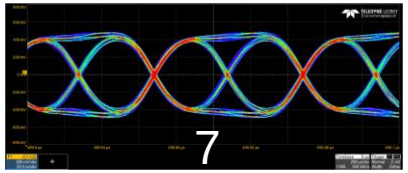


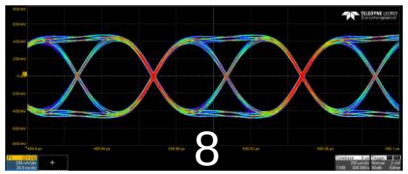


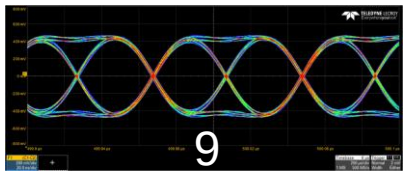


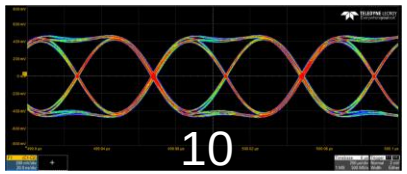


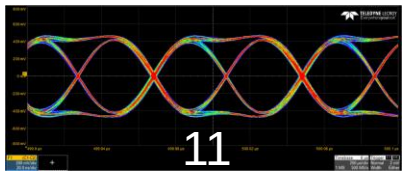


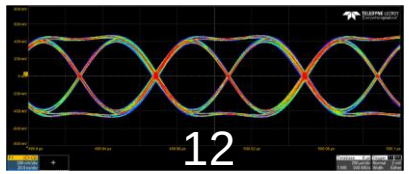


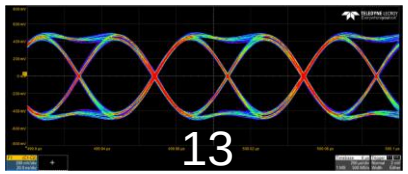


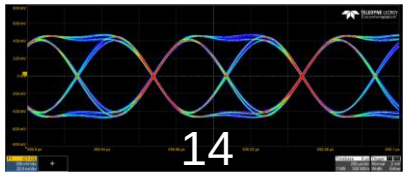


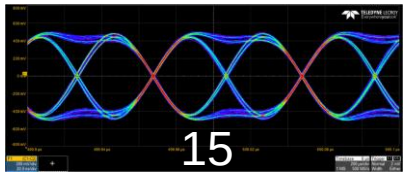


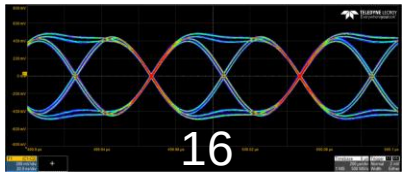


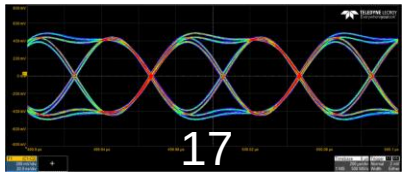


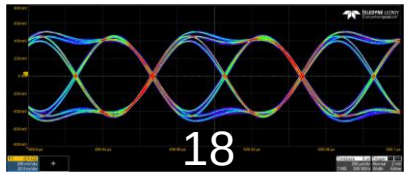


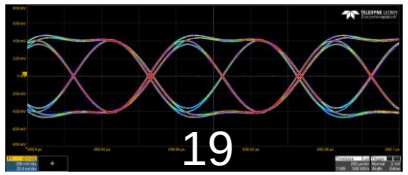


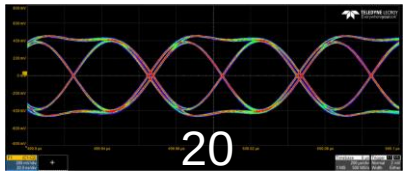


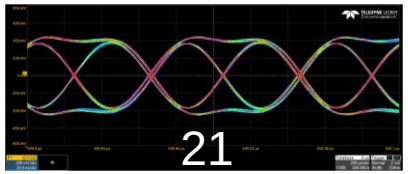


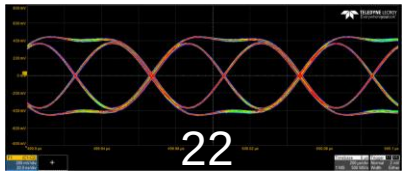


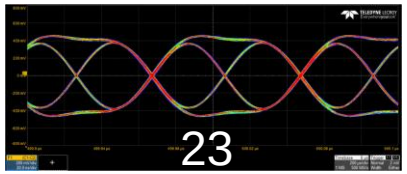


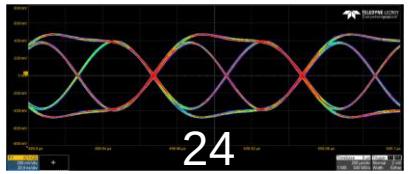


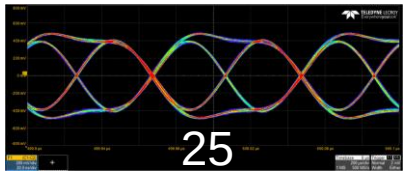


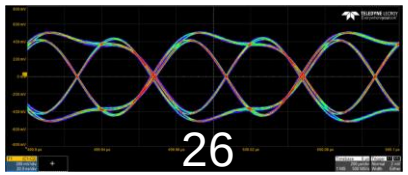


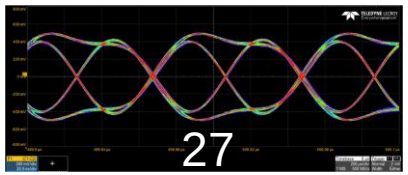










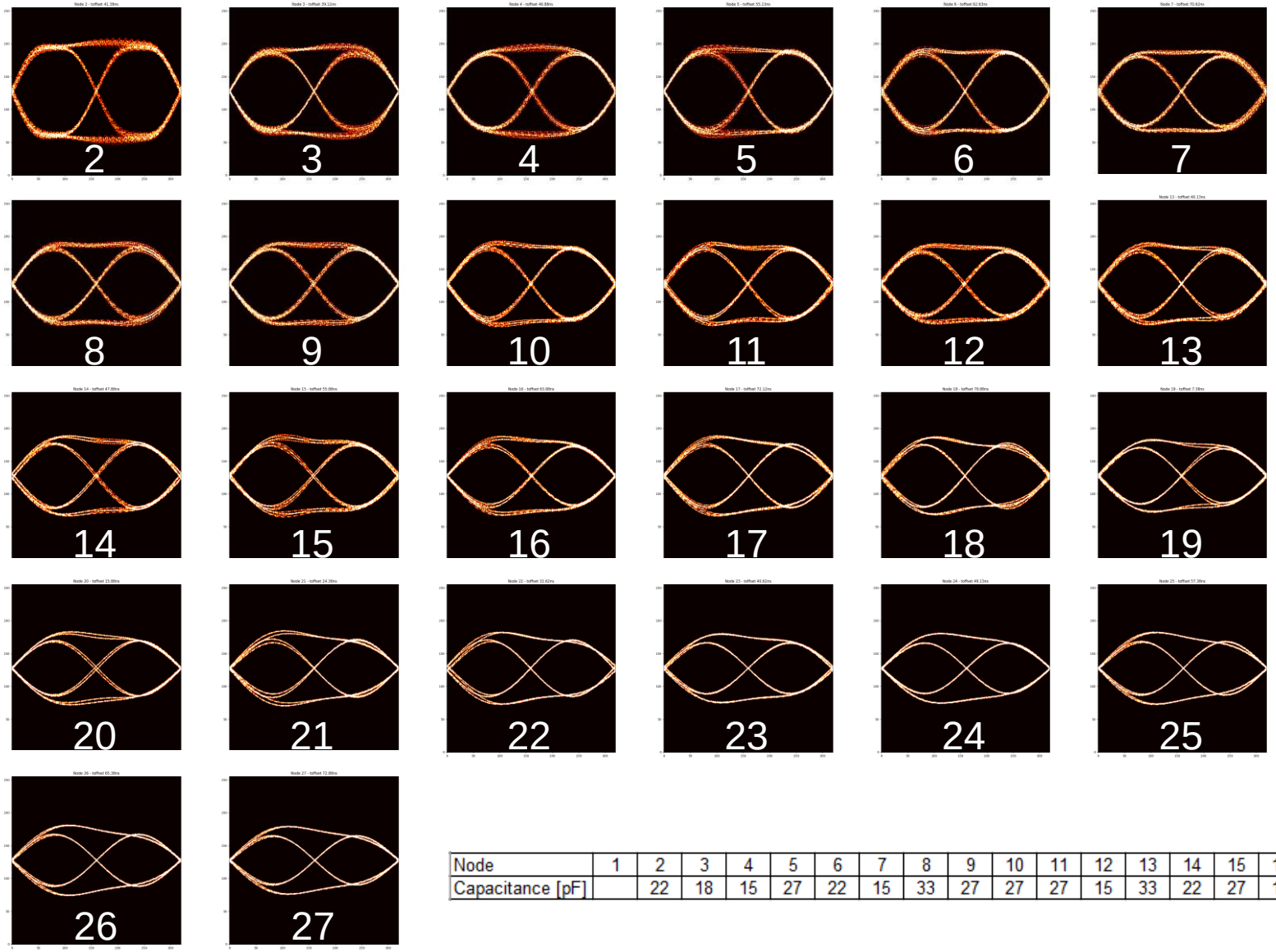


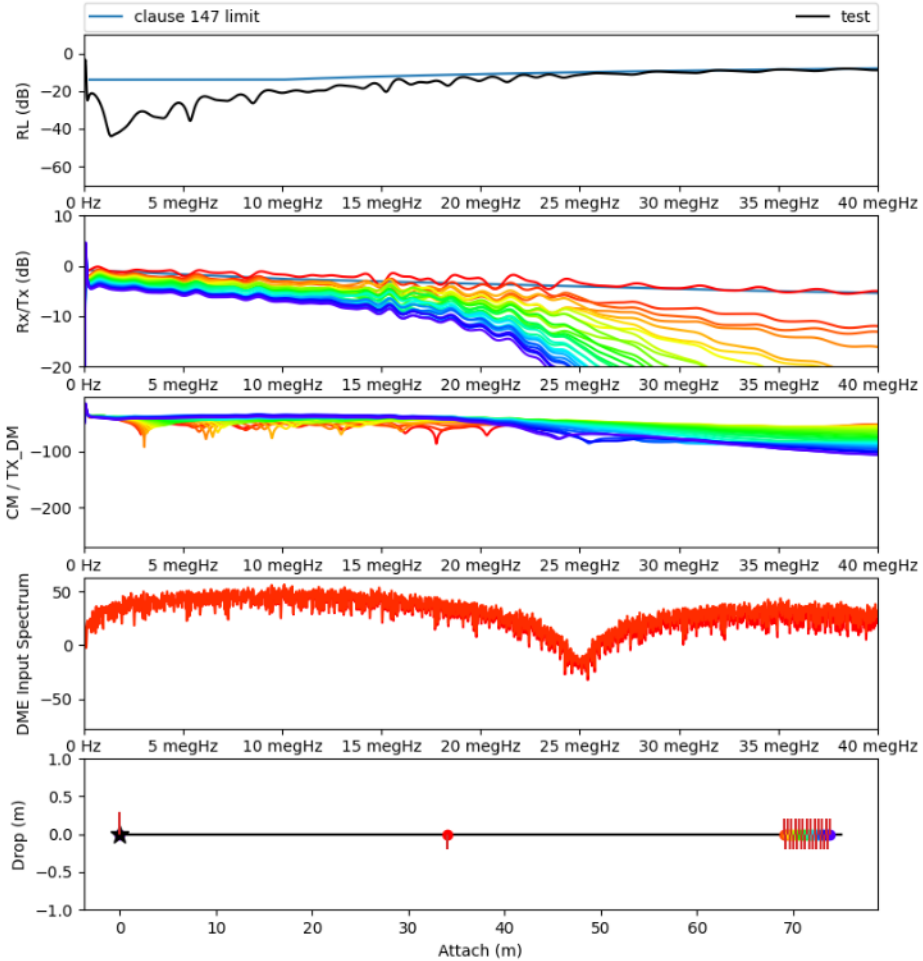

**Eyediagrams indicating good transmission quality for all nodes**

| Node | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Capacitance [pF] | | 22 | 18 | 15 | 27 | 22 | 15 | 33 | 27 | 27 | 27 | 15 | 33 | 22 | 27 | 18 | 27 | 27 | 15 | 27 | 33 | 33 | 22 | 27 | 33 | 22 | 15 |

# Simulation Results

## Simulation 4 – Github Model, Compensated Tee, Node capacity scattered between 15pF and 33pF

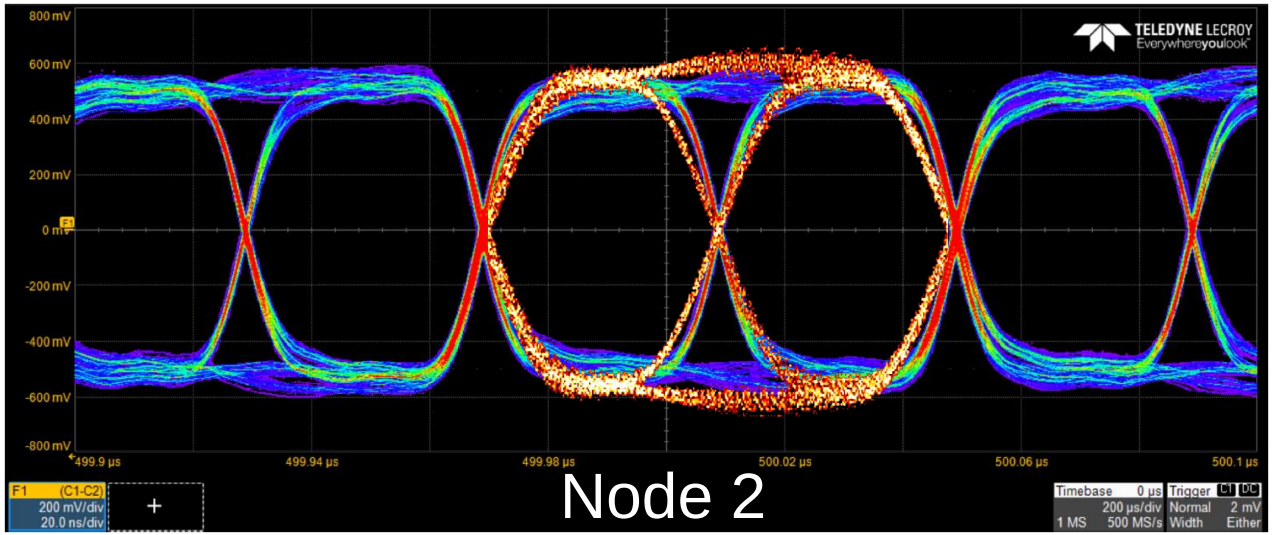


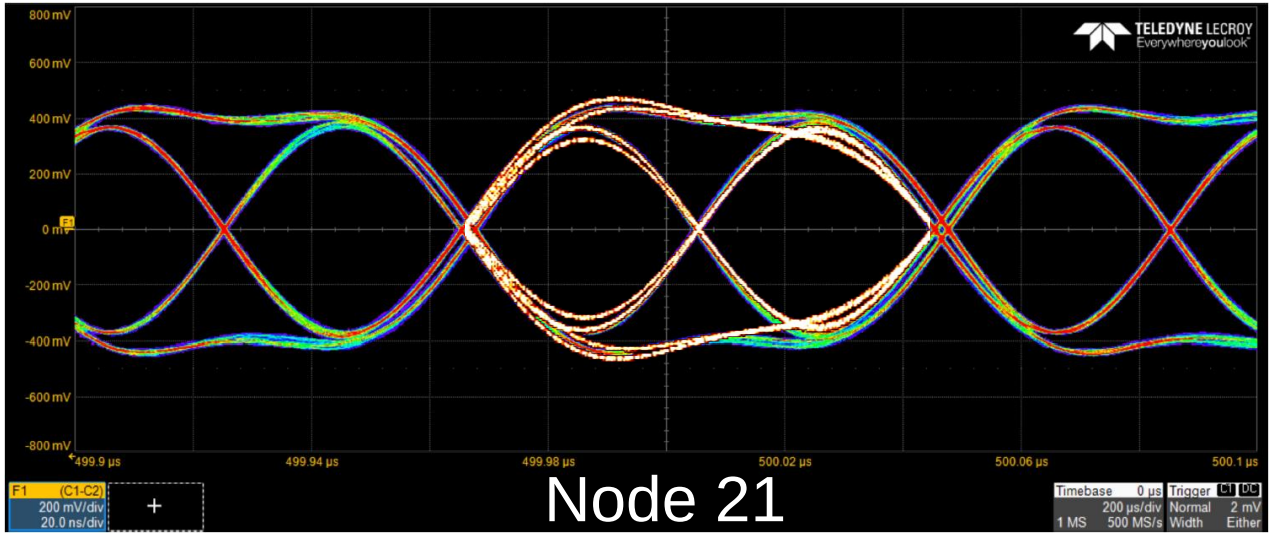




| Node | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Capacitance [pF] | | 22 | 18 | 15 | 27 | 22 | 15 | 33 | 27 | 27 | 27 | 15 | 33 | 22 | 27 | 18 | 27 | 27 | 15 | 27 | 33 | 33 | 22 | 27 | 33 | 22 | 15 |

# Detail Comparison Node 2 and Node 21

Compensated Tee, all Dummy Nodes scattered between 15pF and 33pF

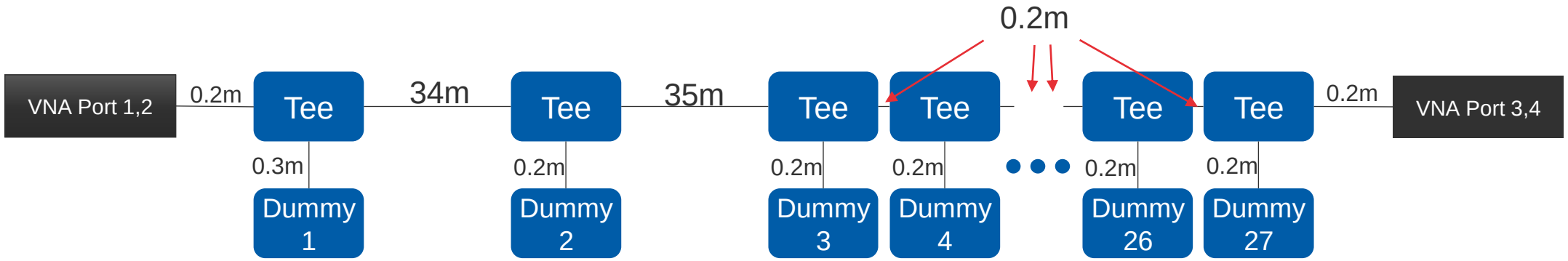


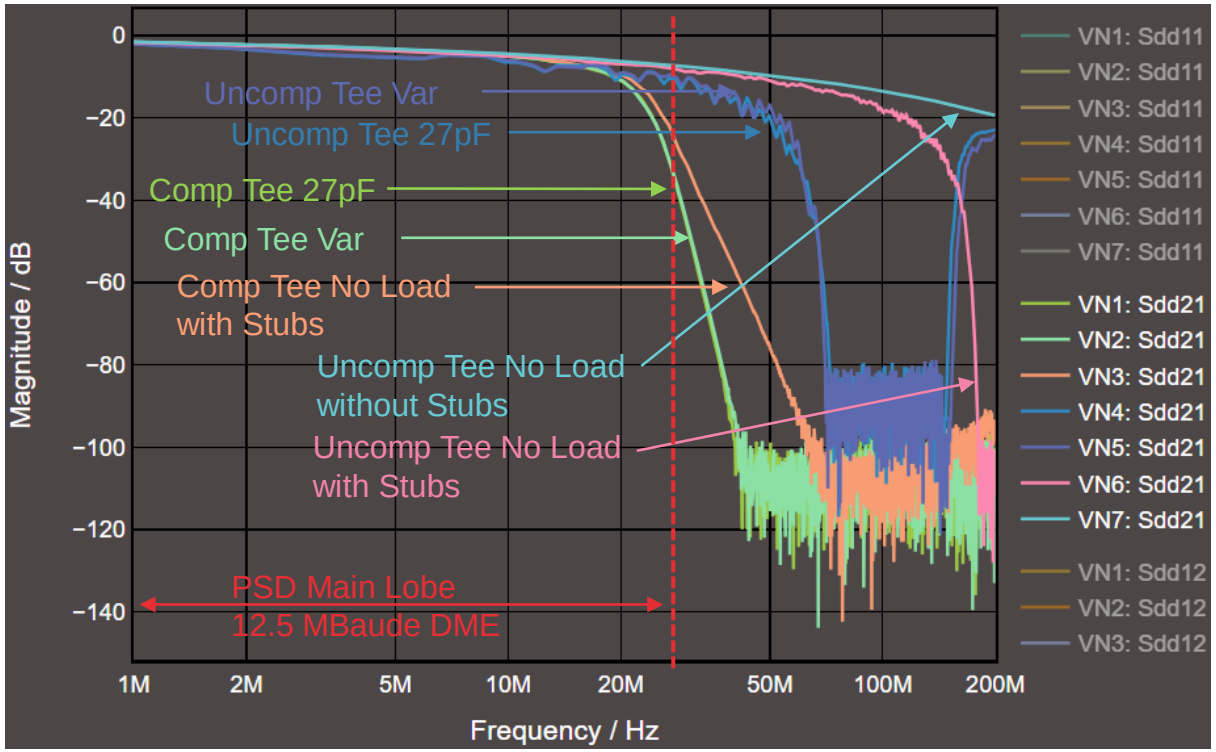



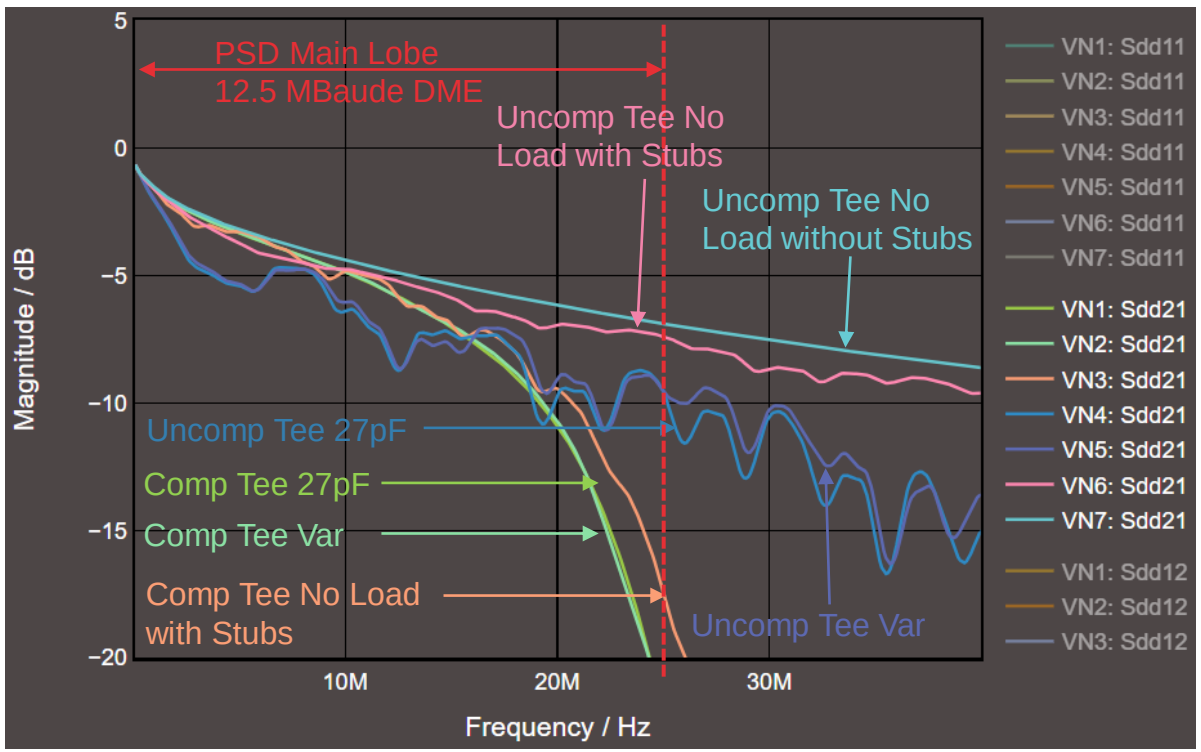

- Only minor differences
- Simulated eye diagrams are close to measured eye diagrams
- All receiving nodes showing quite good eye diagrams
- Exemplary channel should be functional as intended

# Measurement Result

## Measurement 5 - VNA Channel



# Summary

- VNA Measurements
  - Uncompensated Tee
    - Without nodes and stubs attached, the electrical properties of the link segment are similar to a cable alone
    - Adding open stubs without nodes attached results in a low pass behavior at higher frequencies and a small ripple within the signal band
    - Adding nodes to the stubs resulting in additional capacitance and widens the notch and increases the ripple in the signal band
  - Compensated Tee
    - Shows a low pass characteristic at the end of the signal band, which is slightly shifted towards lower frequencies through capacitive loading
    - Without the node capacities attached, there is a ripple in the signal band
    - The ripple is removed by the node capacities

# Summary

- Comparison measurements and github simulation model
  - Generally good match for uncompensated links with minor deviations at some nodes
  - Very good match of eye diagrams for compensated links simulated with the vector fit Tee approach and typical node capacitance.
  - Without node capacitance, the simulation shows better signal integrity than observed in the measurements.
- Link Evaluation
  - With added node capacities, using compensated Tees results in better eye diagrams than uncompensated Tees
  - The influence of variation in node capacitance is minor
  - Disconnecting all node capacities in the compensated link reduces the signal quality due to overcompensation. Nevertheless, the eye diagrams of the compensated link without the node capacities look better than the uncompensated link with all node capacities attached
- Compensated Tees can substantially improve the electrical properties of the link segment
  - Inductive compensation within the link segment should not be precluded to allow flexible implementation

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# Questions

Thank you for your attention!

Questions?