

Ethernet Technology & Generic Cabling

From the Inside Out

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European & National Activities



Member

TC215 WG1: Cabling Design
TC215 WG2: Cabling Installation – QA and Installation Practices
TC215 WG3: Facilities and Infrastructures for Data Centres



Delegate of TC93

TC215: Electrotechnical Aspects of Telecommunications Equipment



Member

TC93: Internal Networks of Electronic Communications for
Houses and Buildings



Country Chair



Member

Standard Committee for Cabling Design & Installation



Member

Professional Engineer



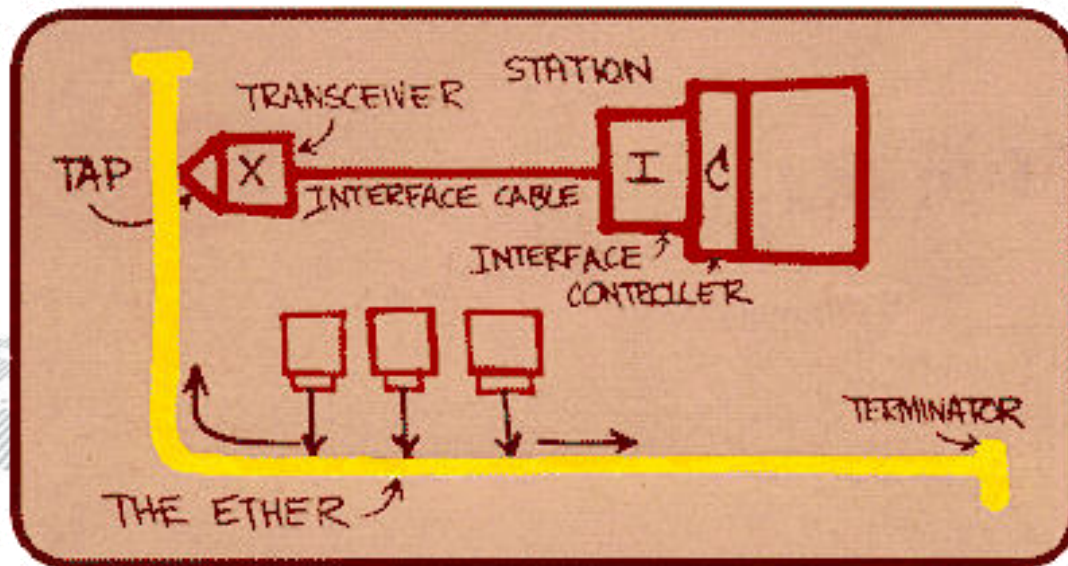
Consulting Member



Ethernet

“Dominant” LAN technology:

- cheap \$20 for 100Mbps!
- first widely used LAN technology
- Simpler, cheaper than token LANs and ATM
- Kept up with speed race: 10, 100, 1000 Mbps



Metcalfe's Ethernet sketch

Ethernet uses CSMA/CD

- No slots.
- Adapter doesn't transmit if it senses that some other adapter is transmitting, that is, *carrier sense*.
- Transmitting adapter aborts when it senses that another adapter is transmitting, that is, *collision detection*.
- Before attempting a retransmission, adapter waits a random time, that is, *multiple access*.

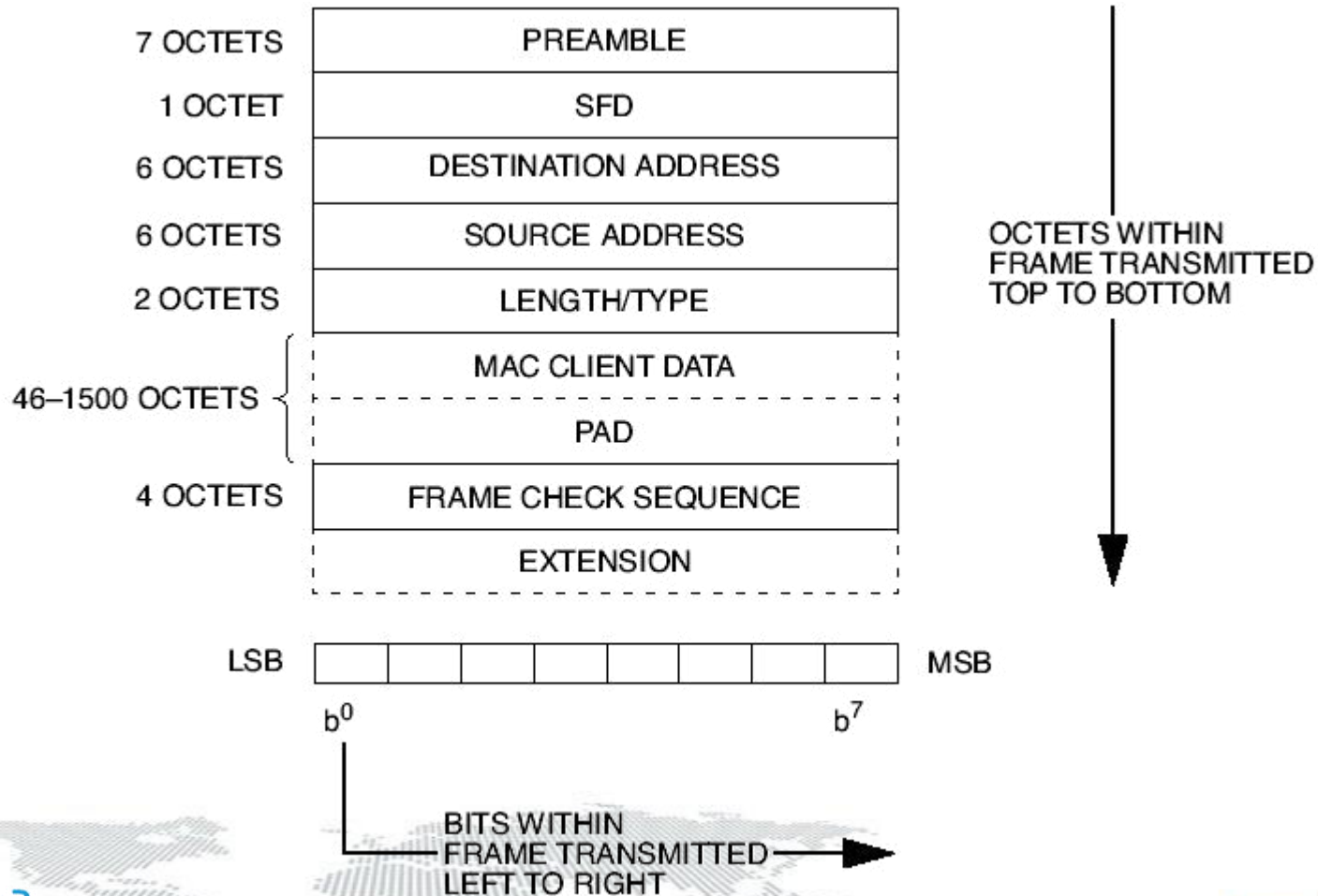
CSMA/CD Efficiency

- t_{prop} = max propagation time between 2 nodes in LAN
- t_{trans} = time to transmit max-size ethernet frame

$$\text{efficiency} = \frac{1}{1 + 5t_{\text{prop}} / t_{\text{trans}}}$$

- Efficiency goes to 1 as t_{prop} goes to 0
- Goes to 1 as t_{trans} goes to infinity
- Much better than ALOHA, but still decentralized, simple, and cheap

Ethernet Frame (MAC)



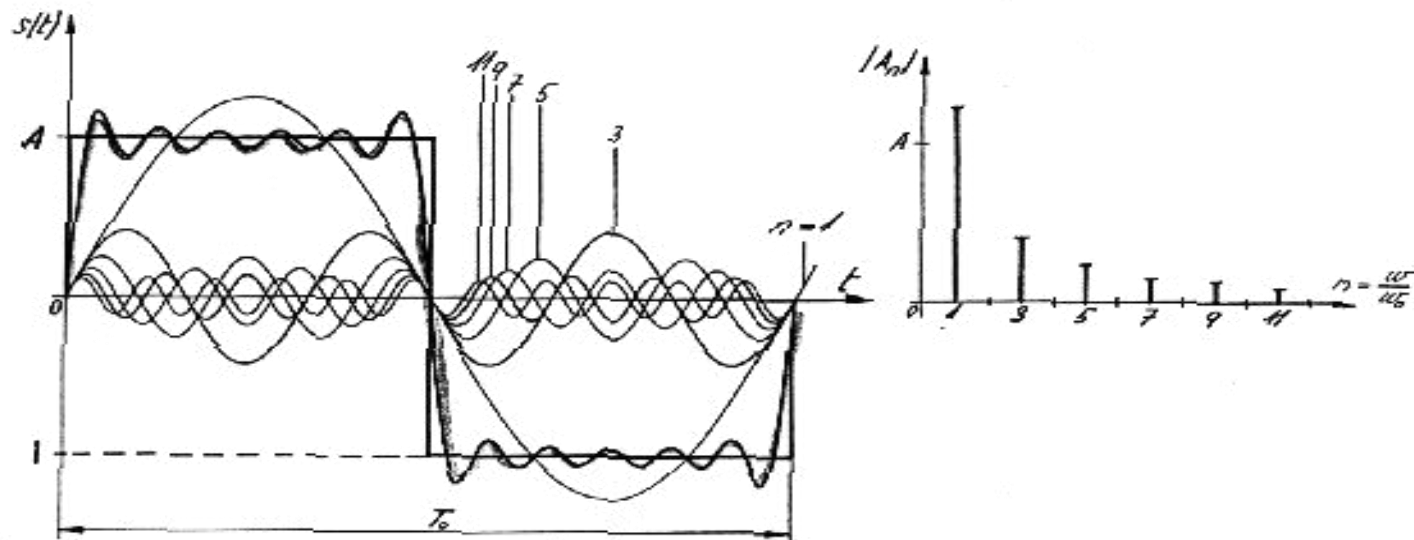
Digital Signal – Fourier Transformation

Nachrichtentechnik

Signale

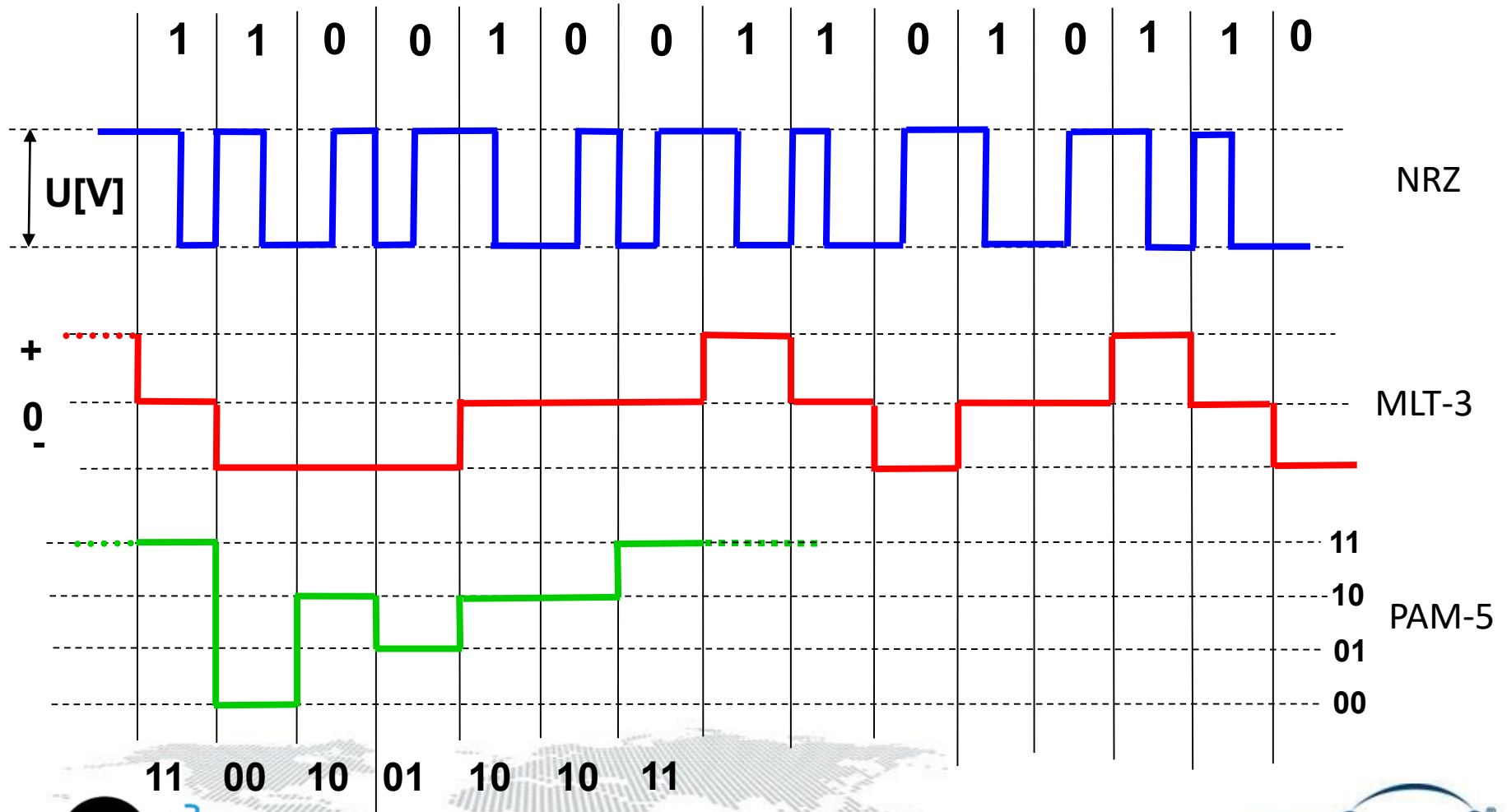
2.4.1-2

c) "Polares" periodisches Rechtecksignal

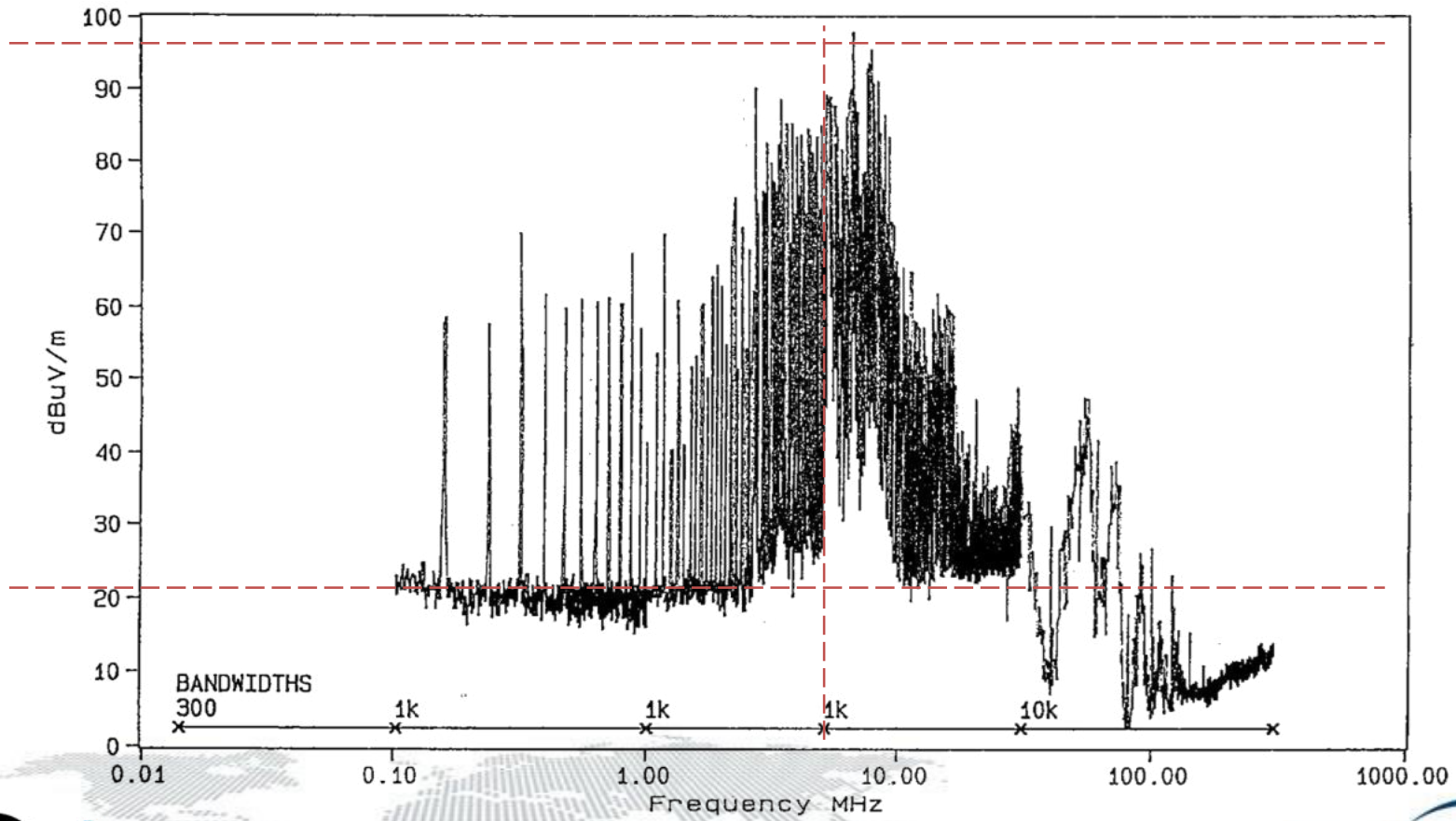


$$s(t) = \frac{4A}{\pi} \left(\sin \omega_0 t + \frac{1}{3} \sin 3\omega_0 t + \frac{1}{5} \sin 5\omega_0 t + \dots \right)$$

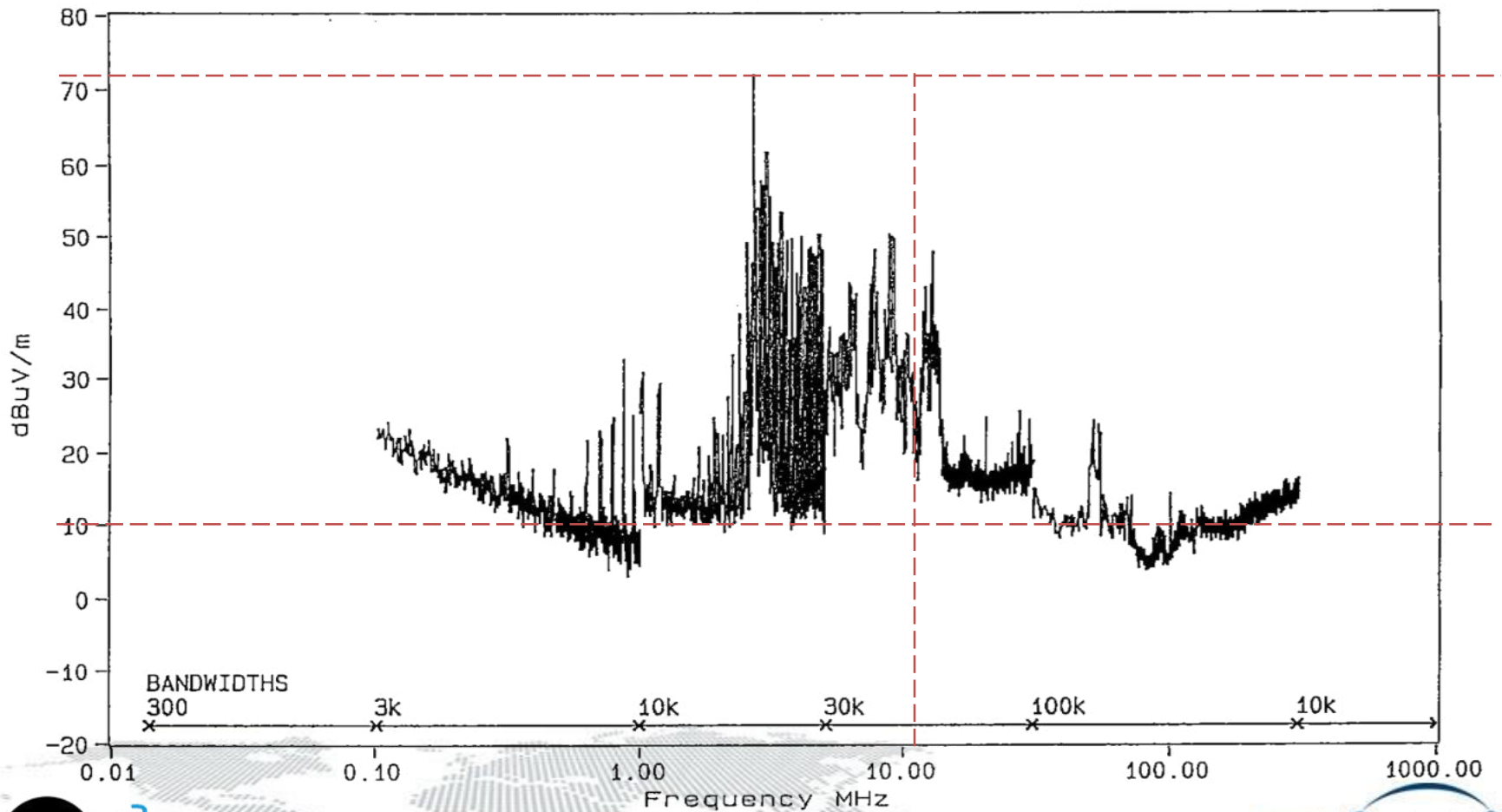
Frequency vs Data Rate



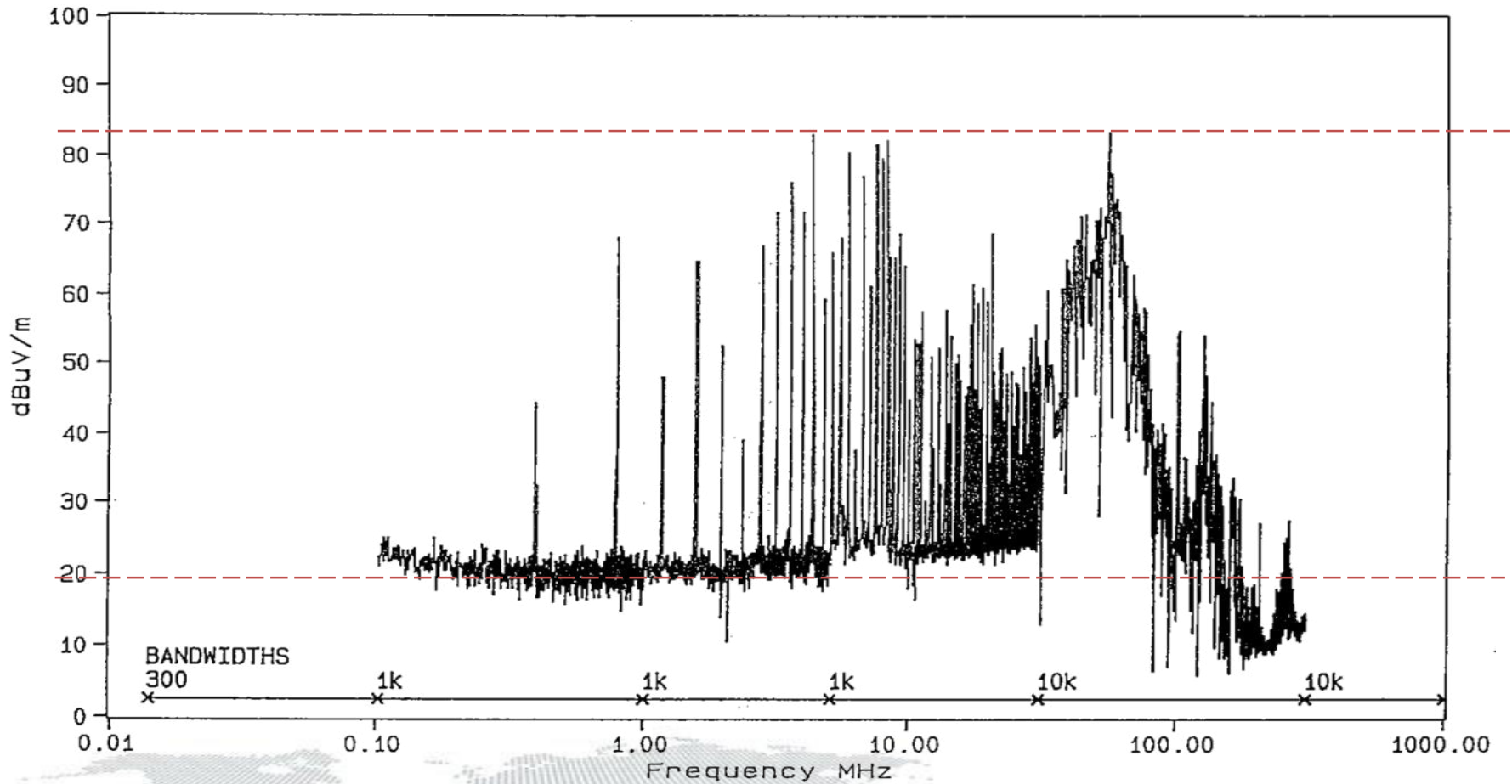
U/UTP – 10BaseT, Manchester



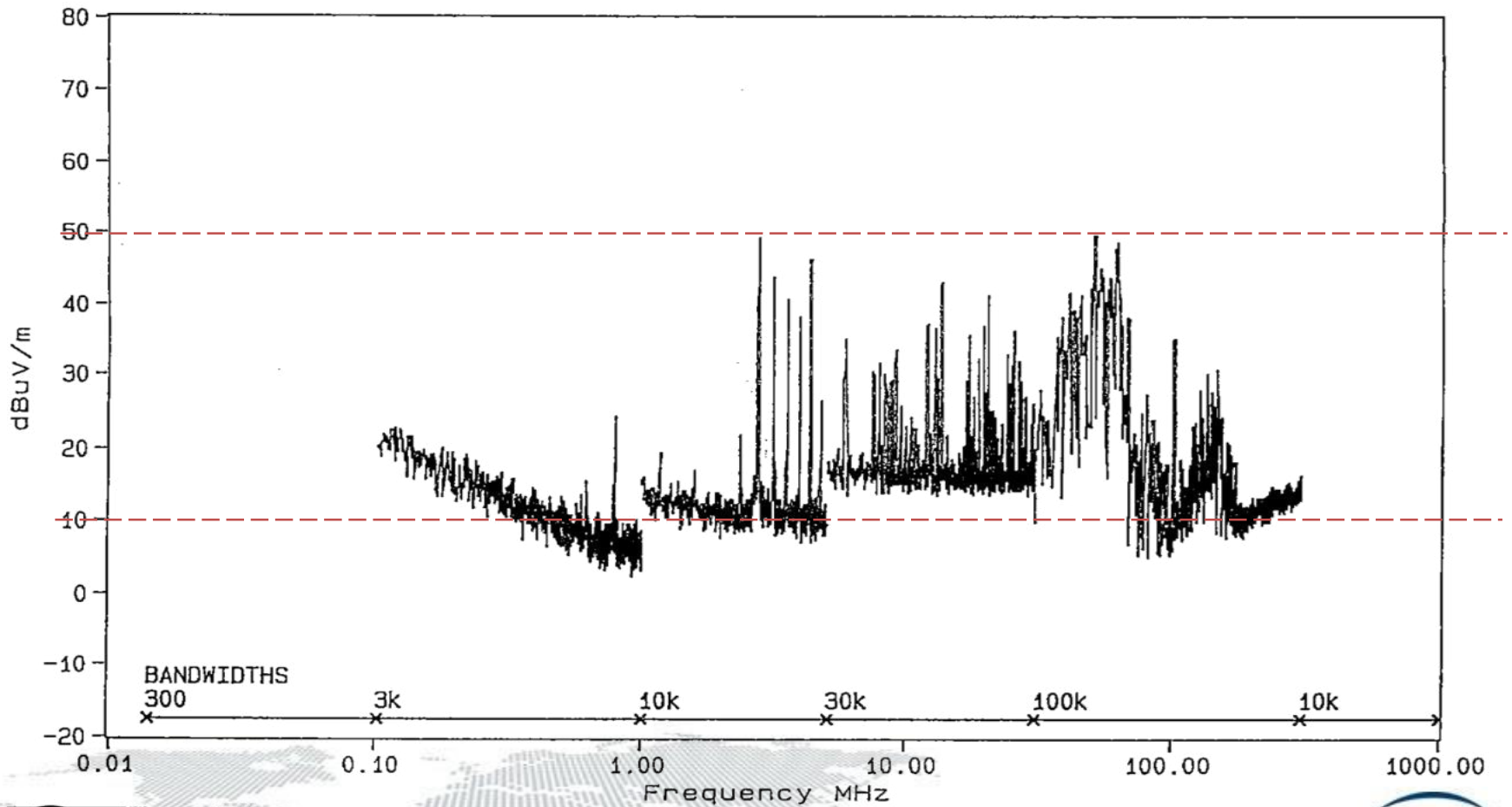
F/UTP – 10BaseT, Manchester



U/UTP – 100Mbps, NRZI



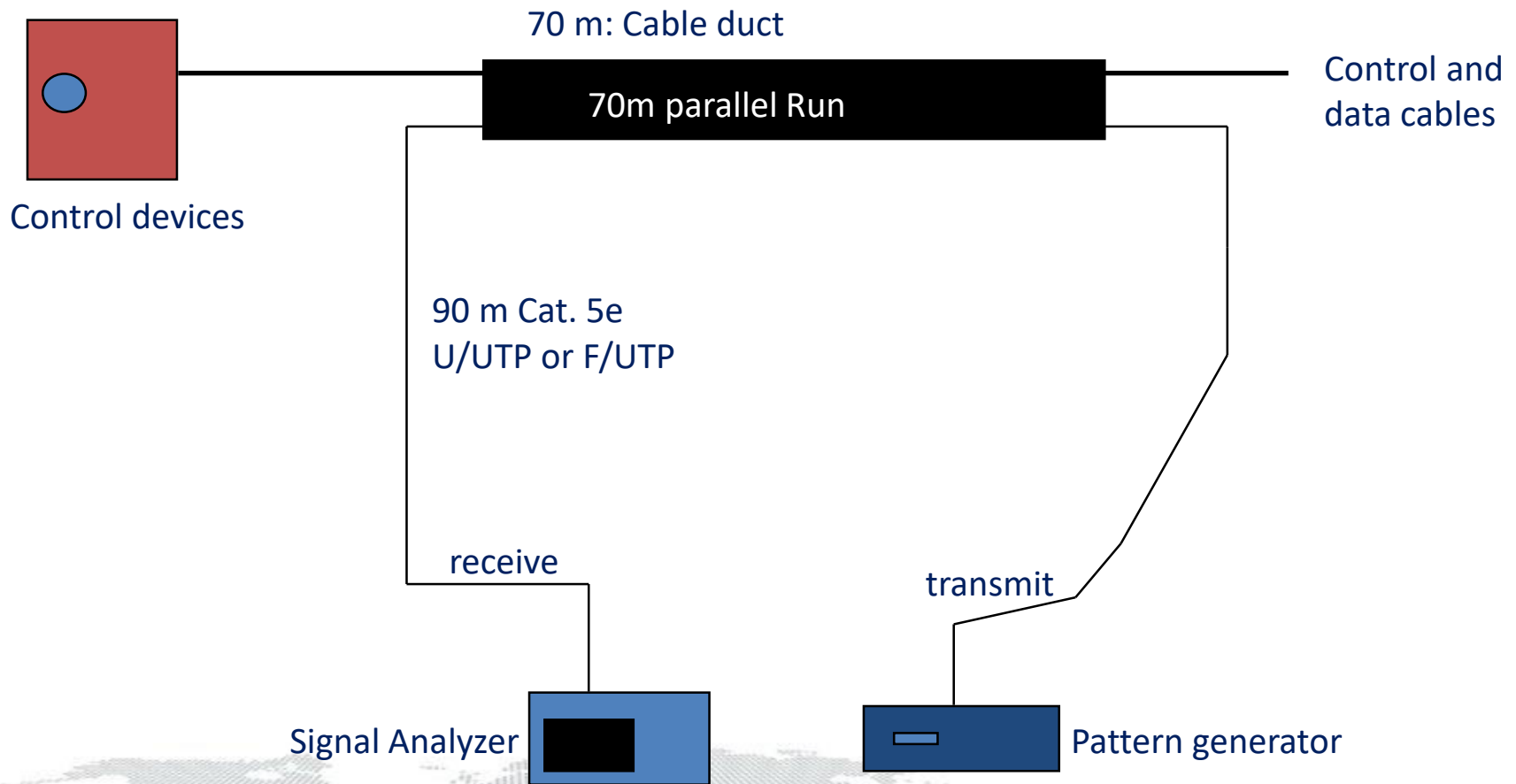
F/UTP – 100Mbps, NRZI



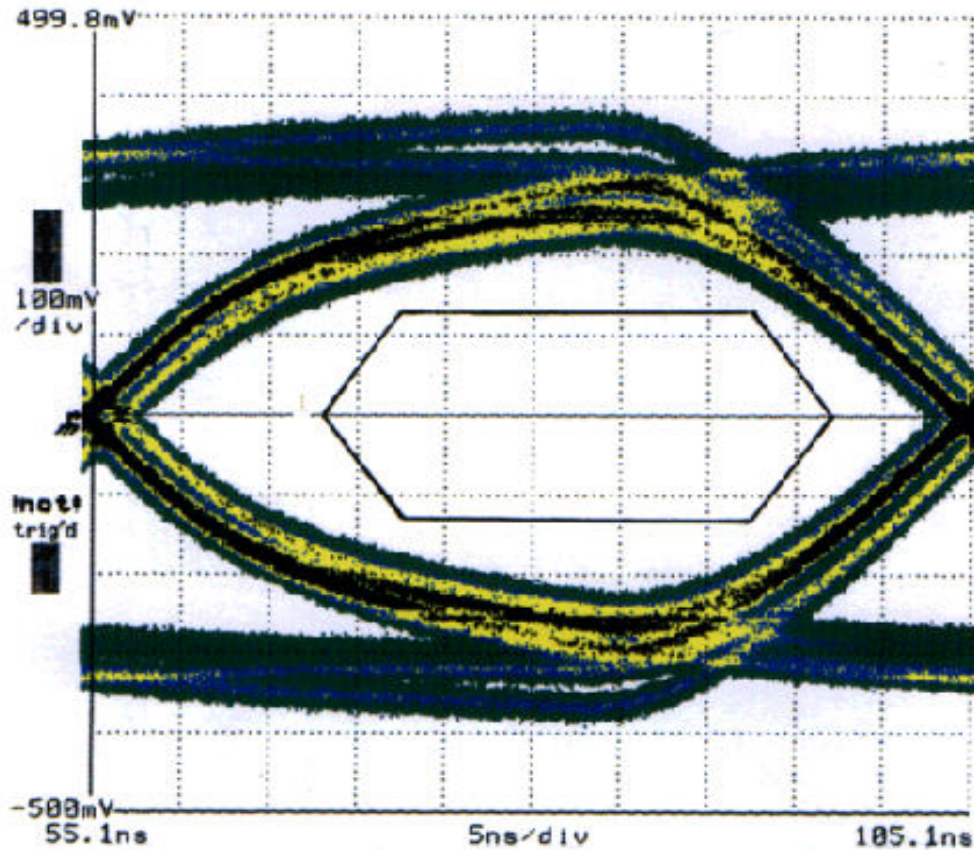
Eye Pattern Test

- Eye Pattern are used to monitor "health" or quality of digital signals.
- Eye Pattern mask tests allow to compare received digital signals.
- Eye Pattern test cannot substitute for a Bit Error Rate (BER) test, but there is a correlation between the two.

Setup: Eye Pattern Test 1



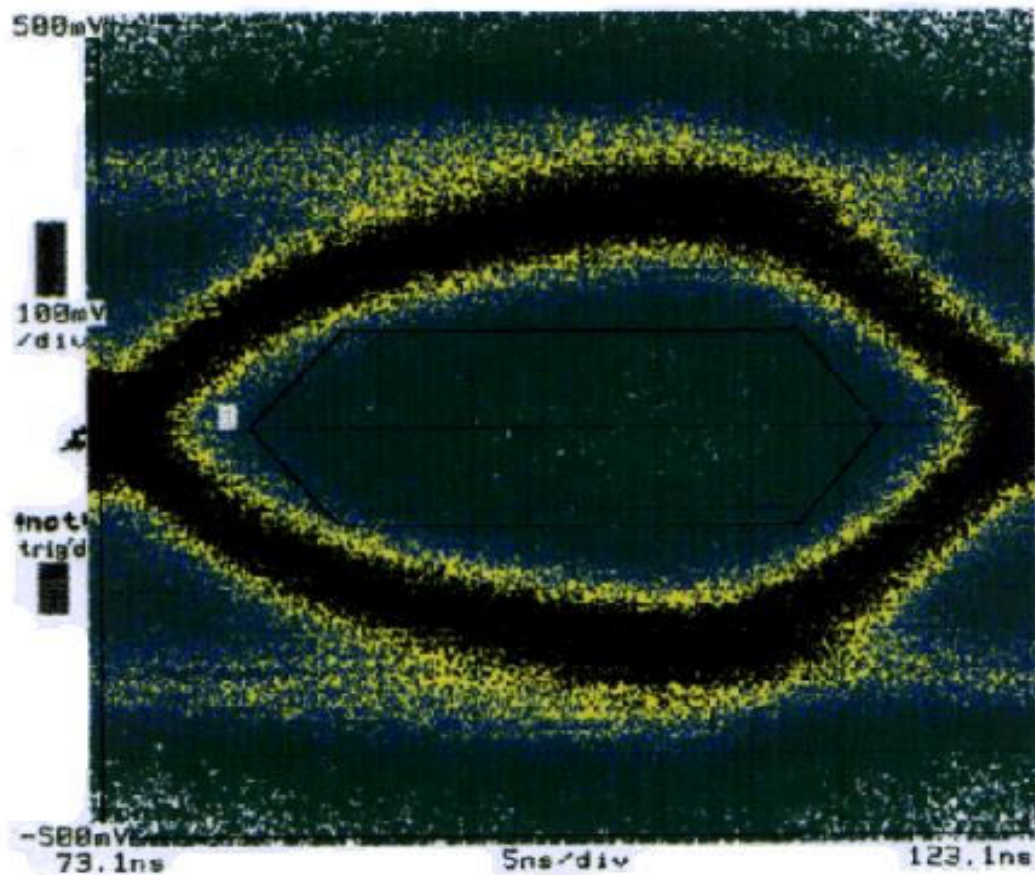
Eye Diagram 1



U/UTP

- 10-BaseT, Manchester code
 - Reference - no induced noise
-
- Total number of scans: 1000
 - Test time: 400sec
 - No of mask intrusions: 0

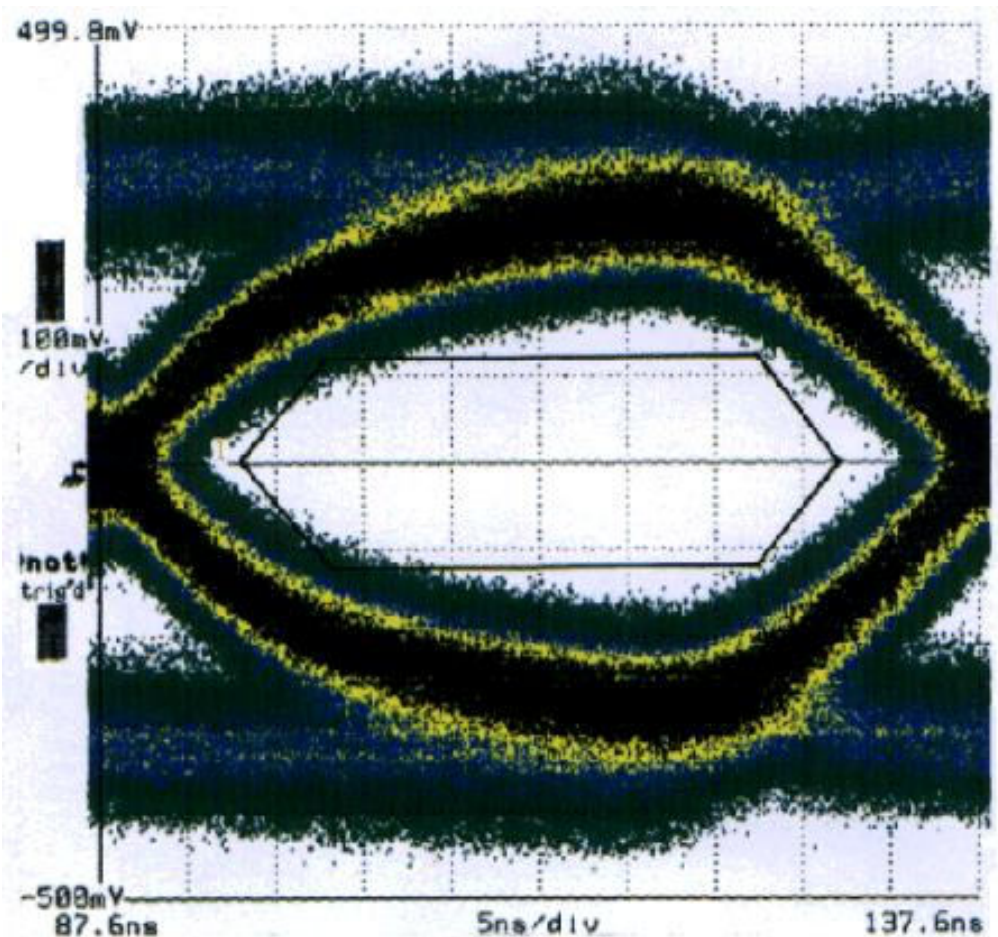
Eye Diagram 2



U/UTP

- 10-BaseT, Manchester code
 - With induced noise
-
- Total number of scans: 1000
 - Test time: 400sec
 - No of mask intrusions: 21,936

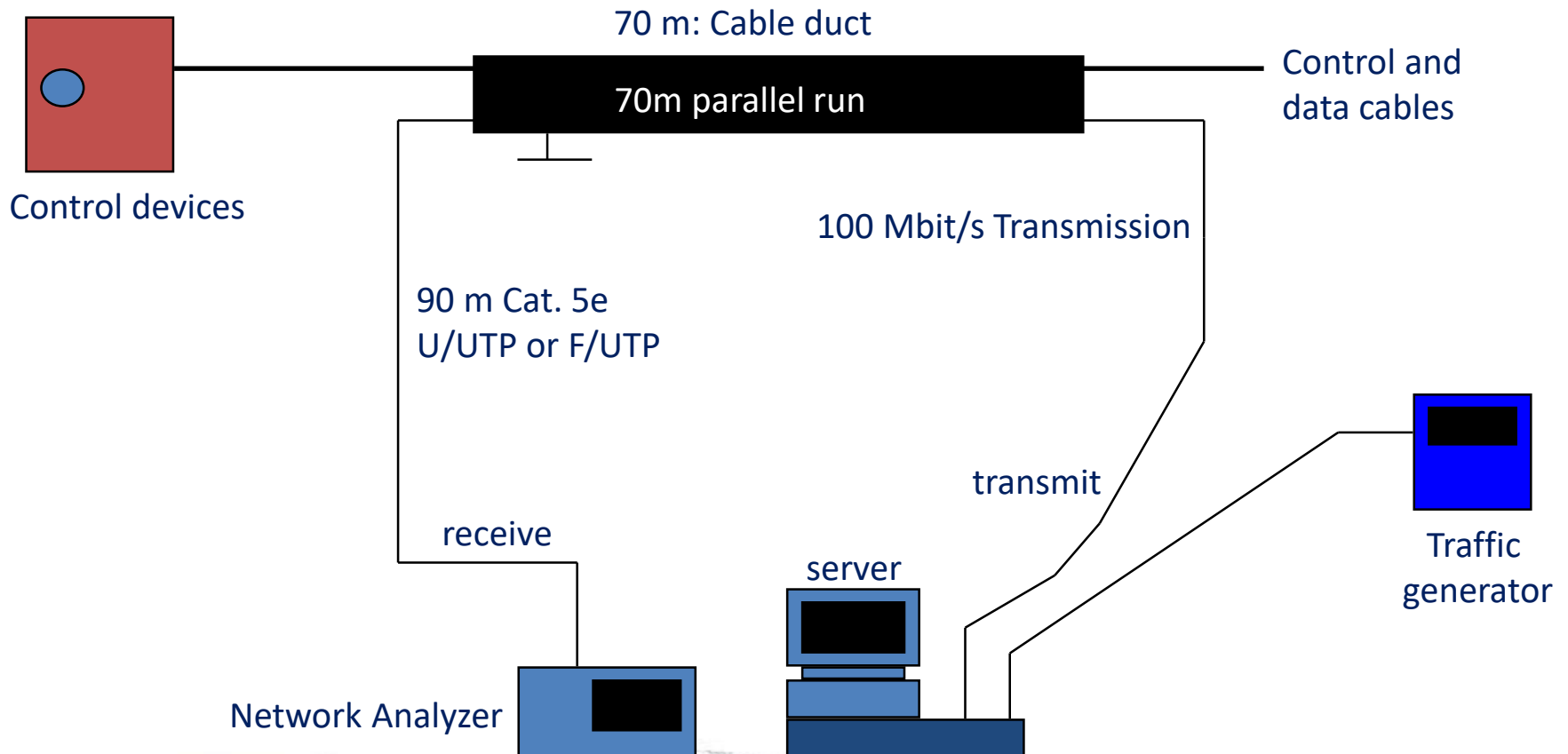
Eye Diagram 3



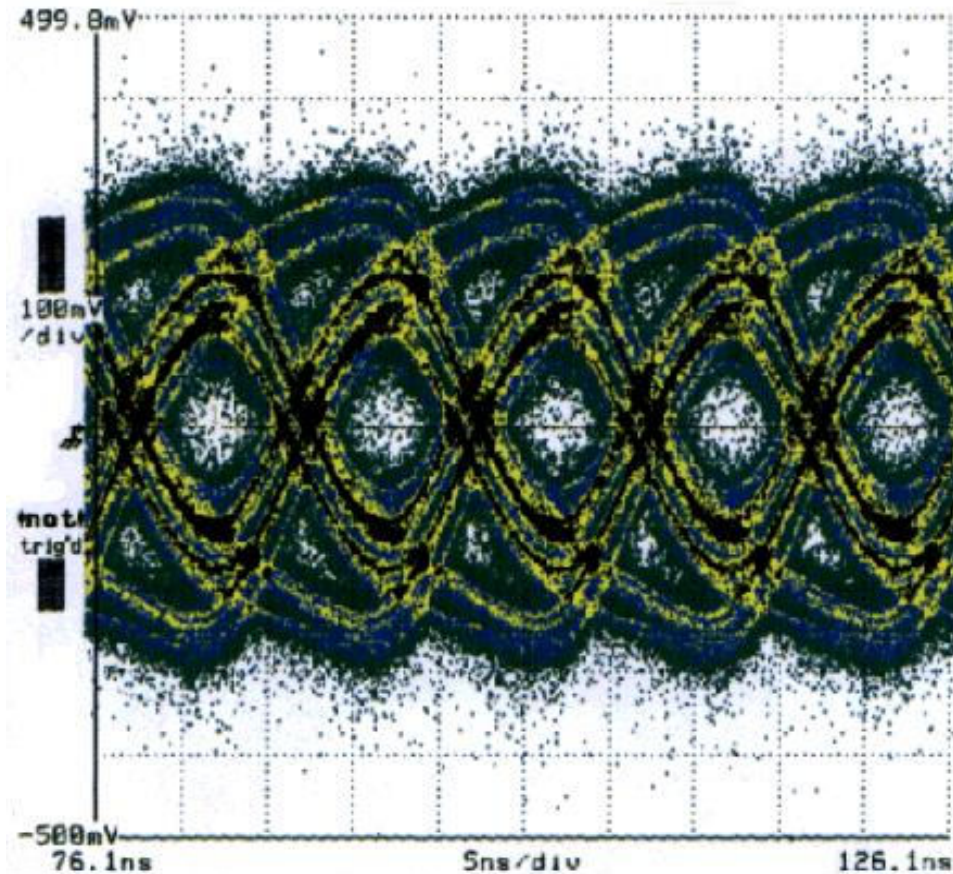
F/UTP

- 10-BaseT, Manchester Code
 - Grounded at both ends
 - With induced noise
-
- Total number of scans: 1000
 - Test time: 400sec
 - No of mask intrusions: 256

Setup: Eye Pattern Test 2

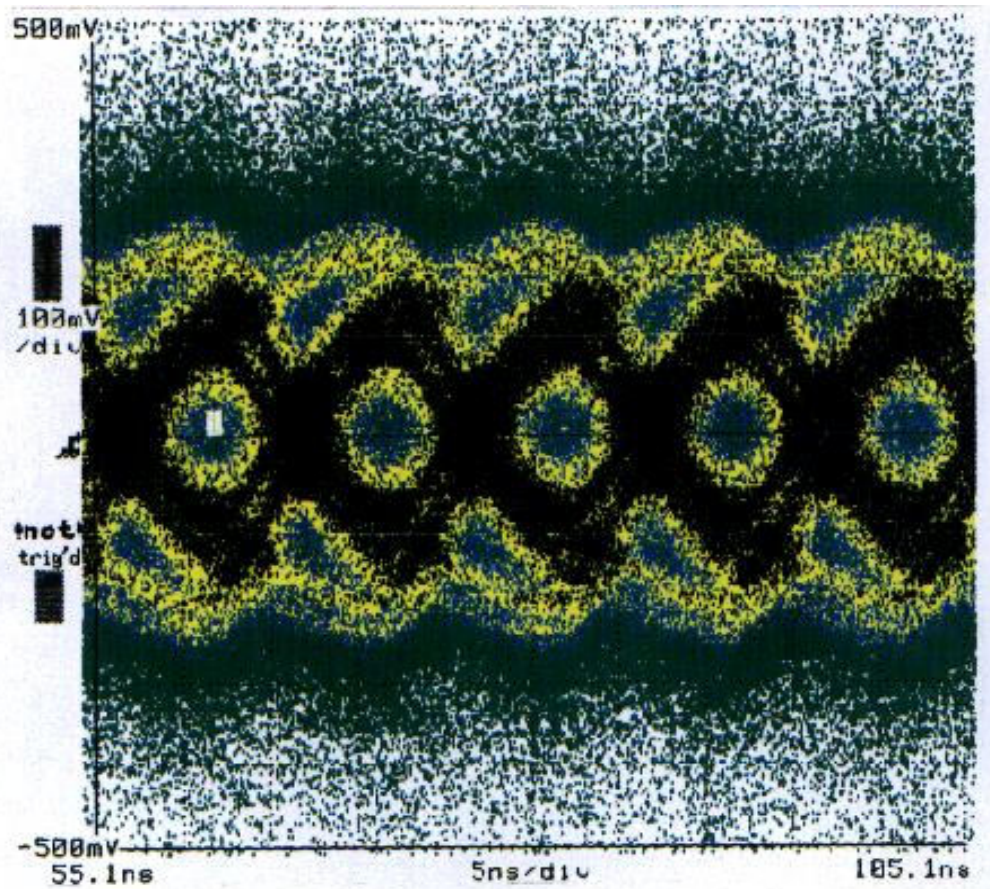


U/UTP Reference Cable



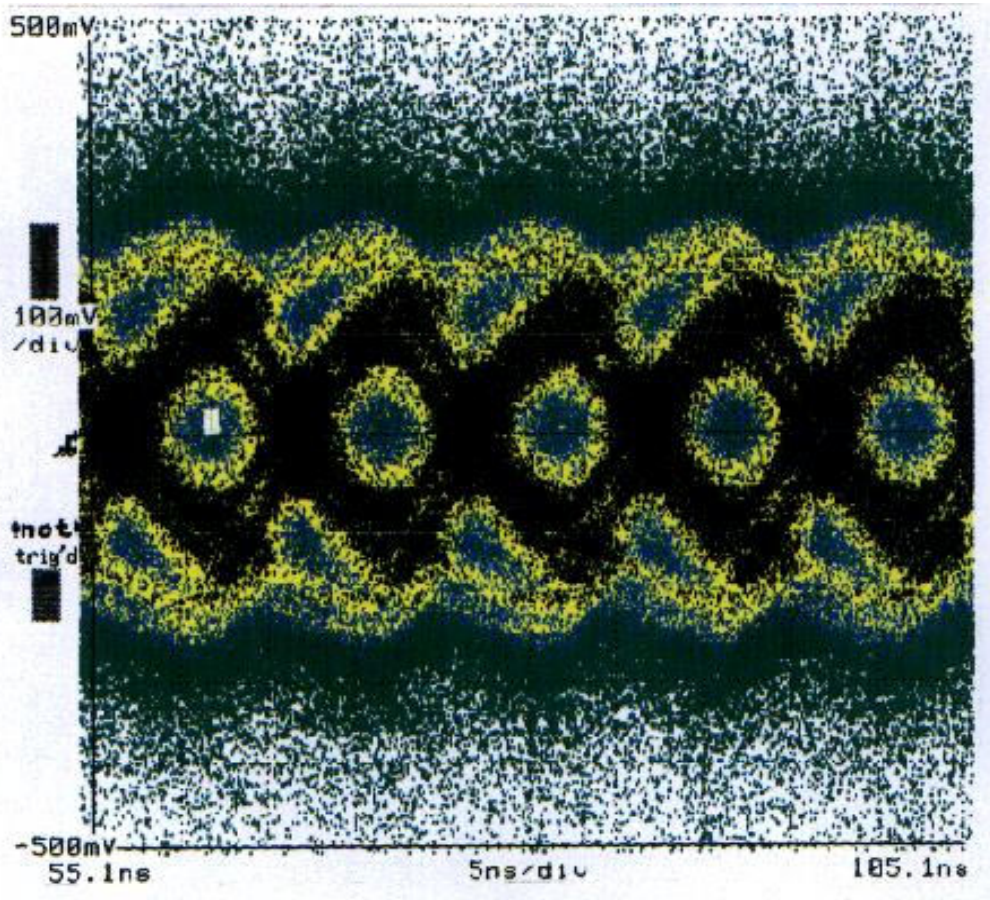
- Eye pattern test
 - Network test 100-BaseT, NRZI
 - Reference - no induced noise
-
- Frame size: 450 bytes
 - Transmission time: 405 sec
 - Transmitted frames: 970,962
 - Bad CRC/retries: 0
 - Short/runt: 0
 - Lost frames: 0
-
- Frame error rate: $< 10^{-10}$
 - Best case BER: $< 10^{-10}$

U/UTP with Noise



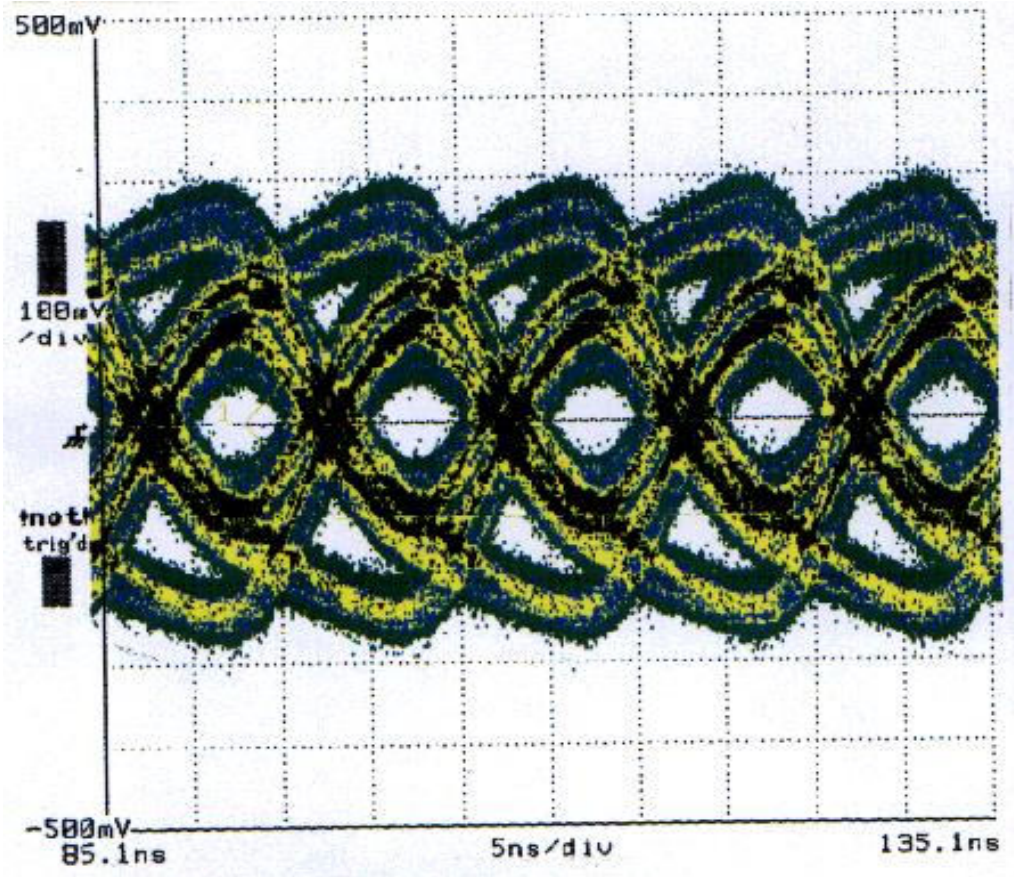
- Eye pattern test
 - Network test 100-BaseT, NRZI
 - Small frame size (450 Bytes)
-
- Frame size: 450 bytes
 - Transmission time: 405 sec
 - Transmitted frames: 975,825
 - Bad CRC/retries: 656
 - Short/runt: 199
 - Lost frames: 0
-
- Frame error rate: $< 6.7 \cdot 10^{-4}$
 - Best case BER: $< 1.9 \cdot 10^{-7}$

U/UTP with Noise



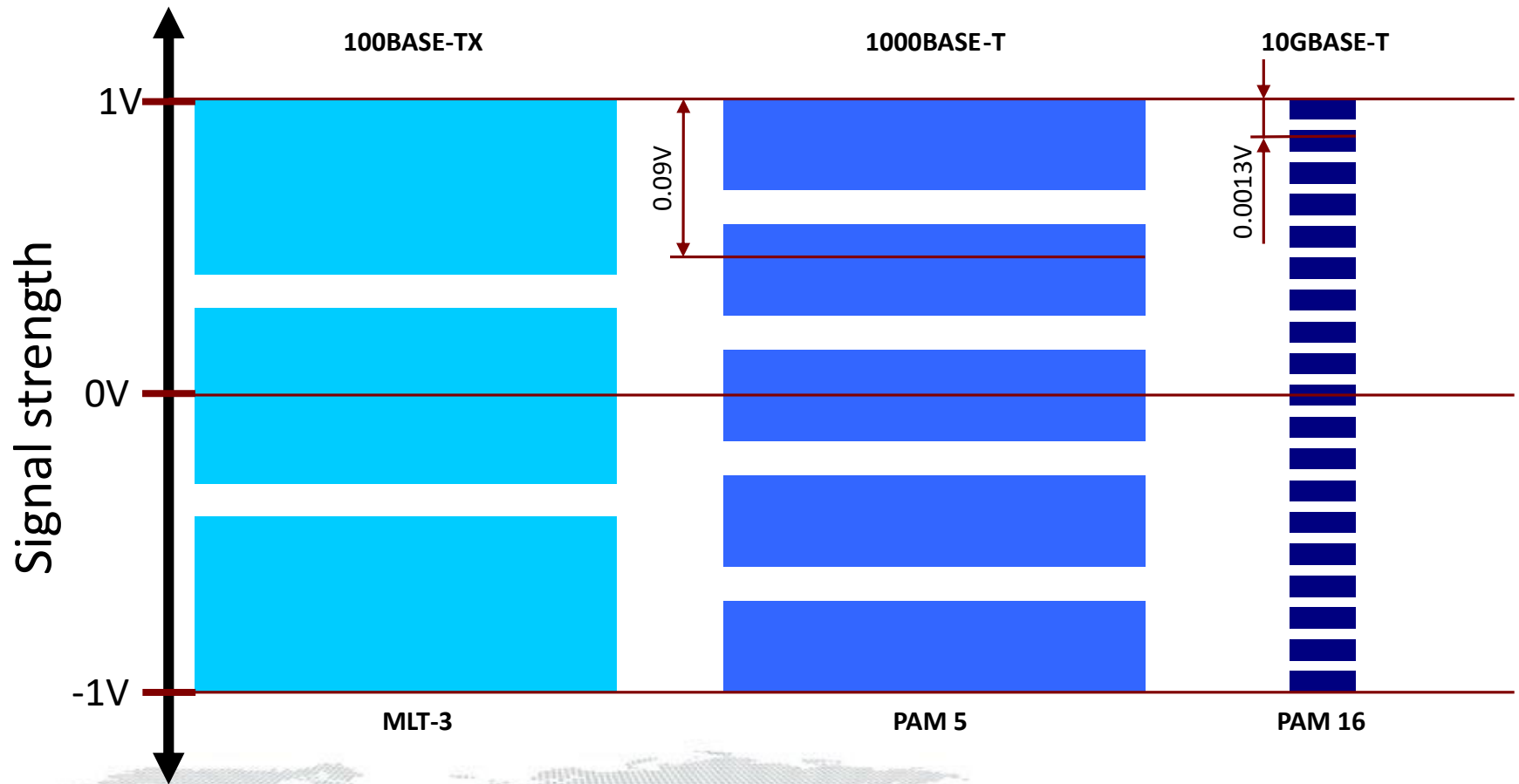
- Eye pattern test
 - Network test 100-BaseT, NRZI
 - Large frame size (1000 Bytes)
-
- | | |
|-----------------------|------------|
| • Frame size: | 1000 bytes |
| • Transmission time: | 405 sec |
| • Transmitted frames: | 484598 |
| • Bad CRC/retries: | 6623 |
| • Short/runt: | 1618 |
| • Lost frames: | 28 |
-
- | | |
|---------------------|-----------------------|
| • Frame error rate: | $< 1.4 \cdot 10^{-2}$ |
| • Best case BER: | $< 1.7 \cdot 10^{-6}$ |

F/UTP with Noise

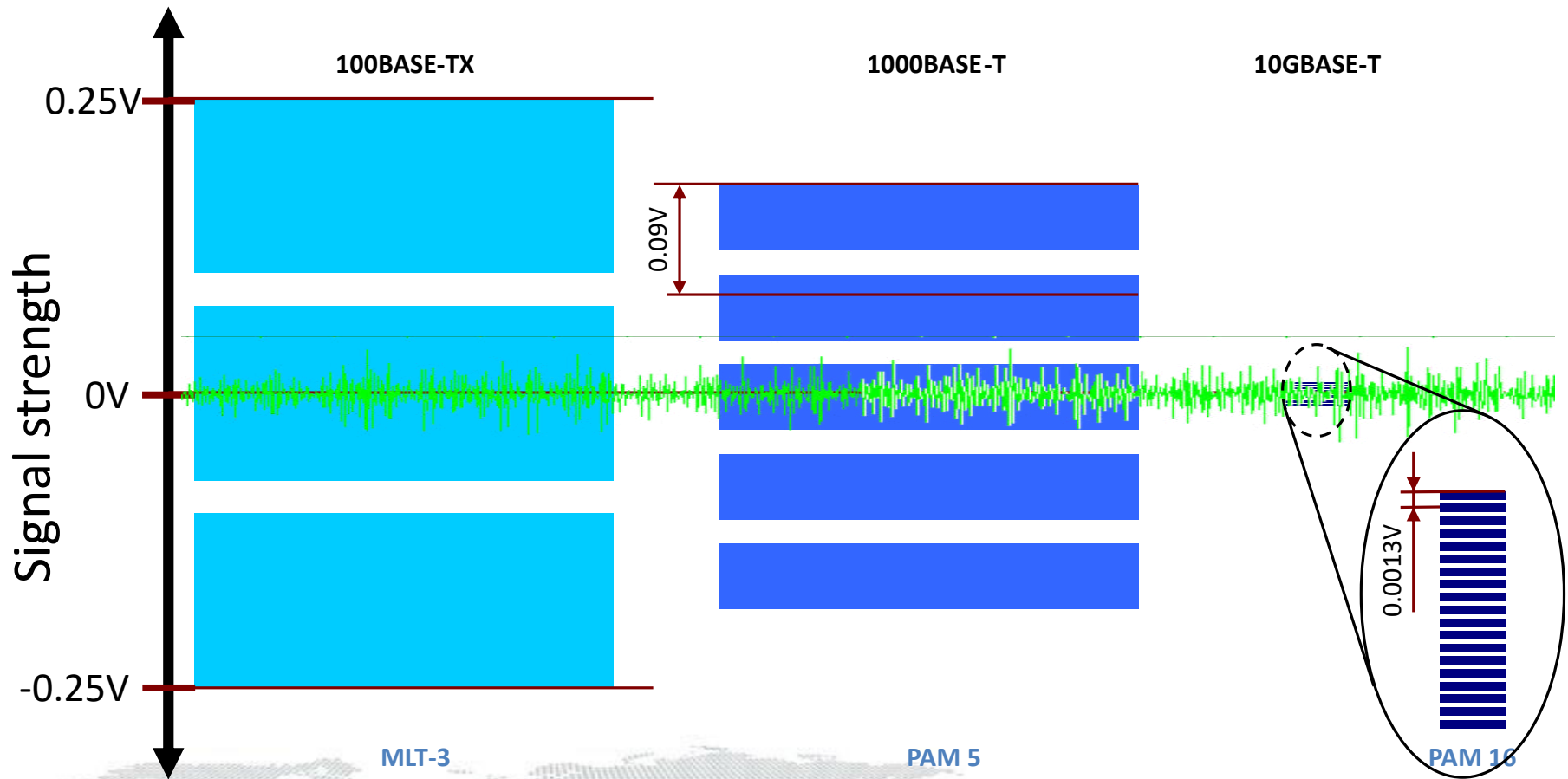


- Eye pattern test
 - Network test 100-BaseT, NRZI
 - perfectly grounded
-
- Frame size: 1000 bytes
 - Transmission time: 405 sec
 - Transmitted frames: 481006
 - Bad CRC/retries: 0
 - Short/run: 0
 - Lost frame: 0
-
- Frame error rate: $< 10^{-10}$
 - Best case BER: $< 10^{-10}$

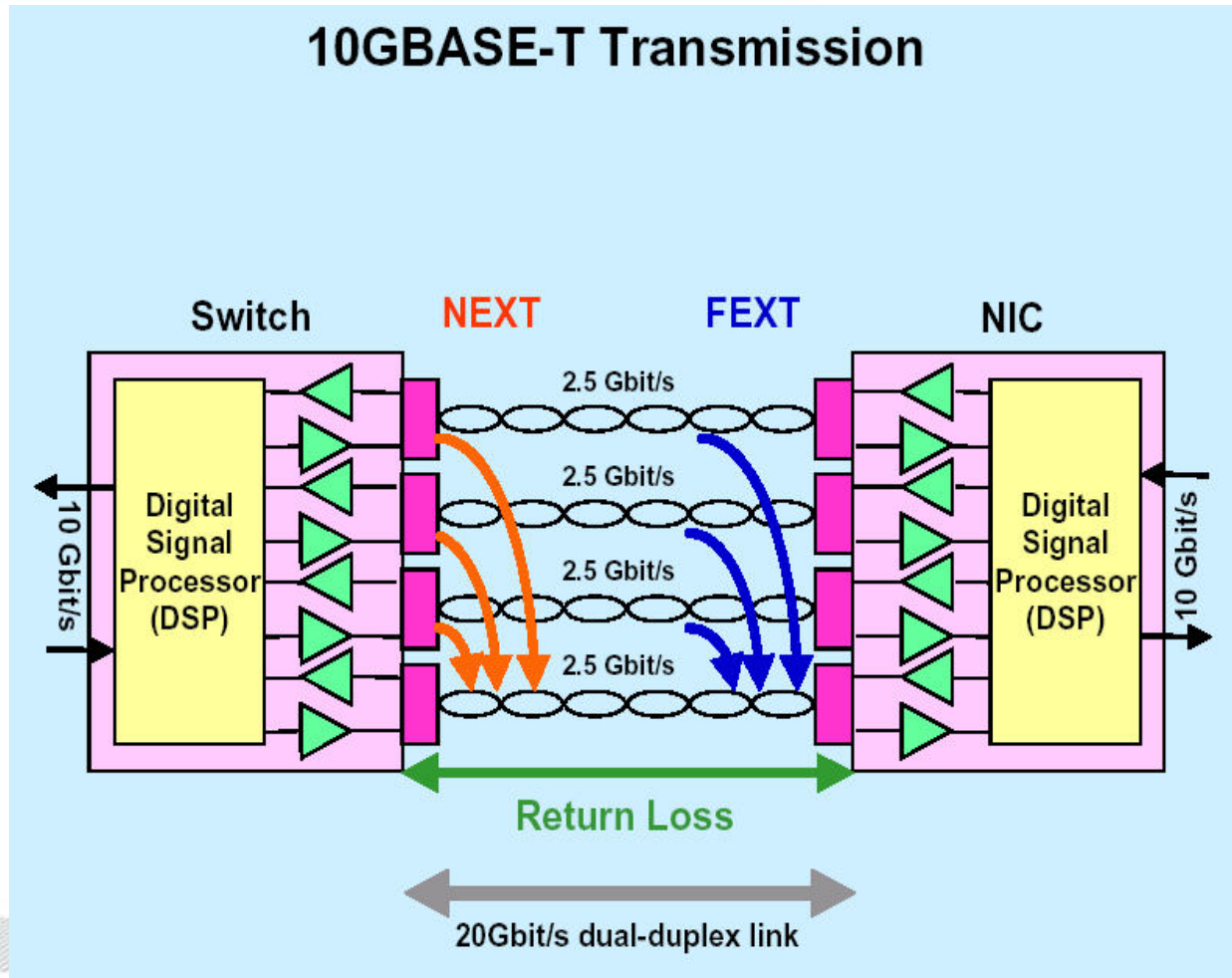
Coding Transmitted Signal



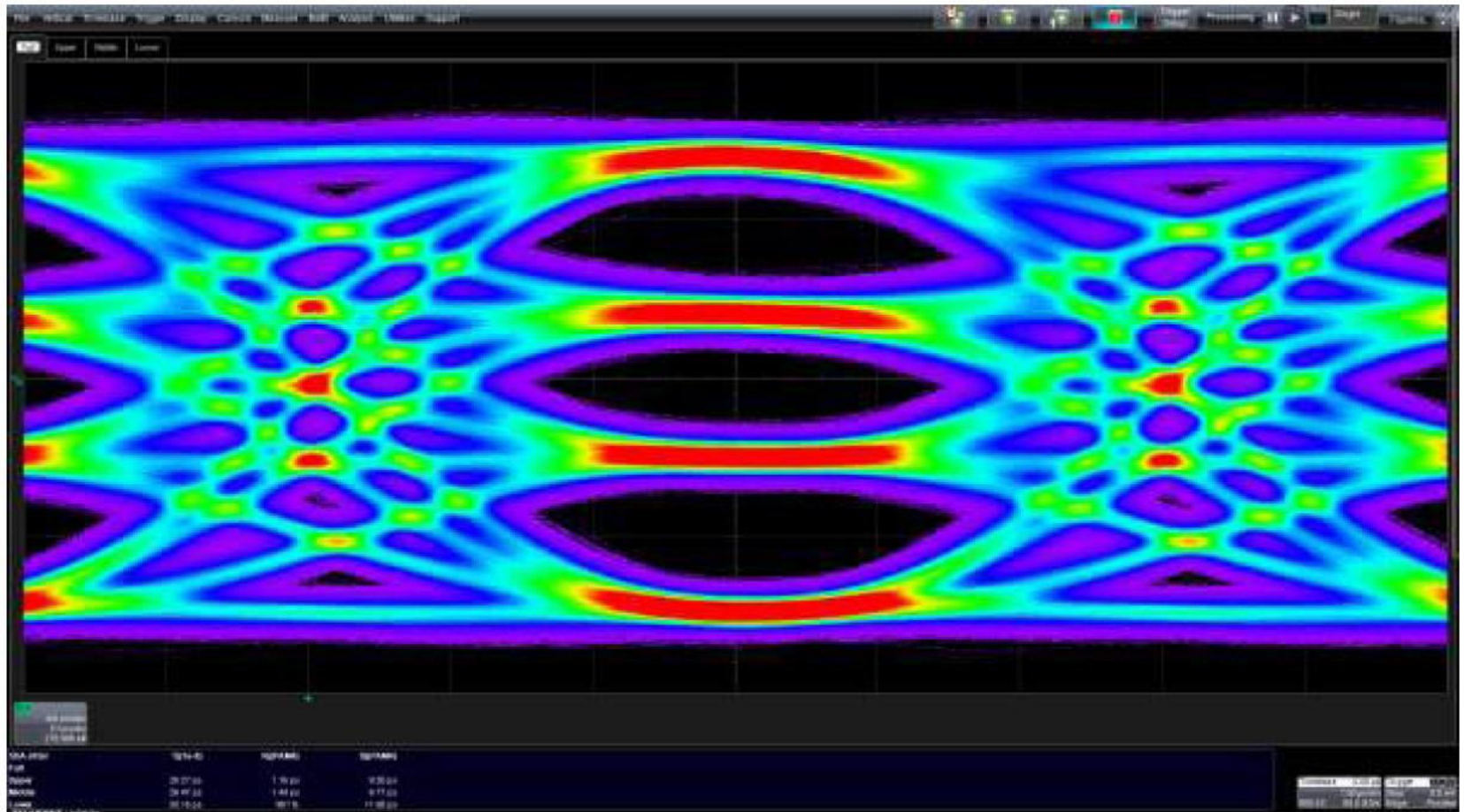
Coding Received Signal



Active Compensation with 10Gbps Ethernet



NRZ-PAM2 – 100Gbps



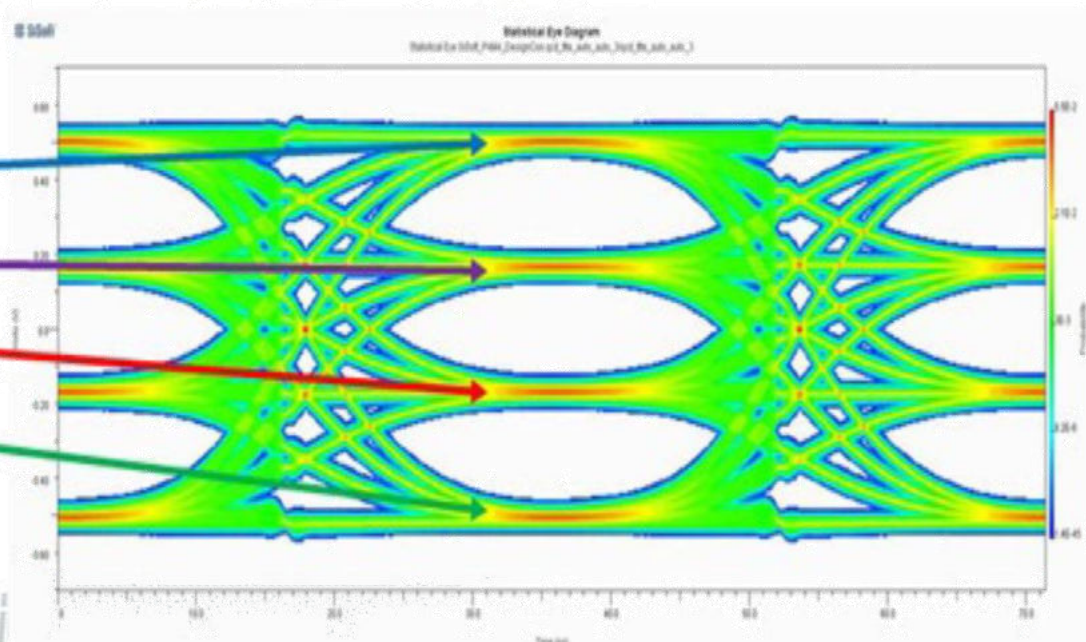
PAM4 – 400Gbps, Transceiver

Grey Code And/Or Mapping

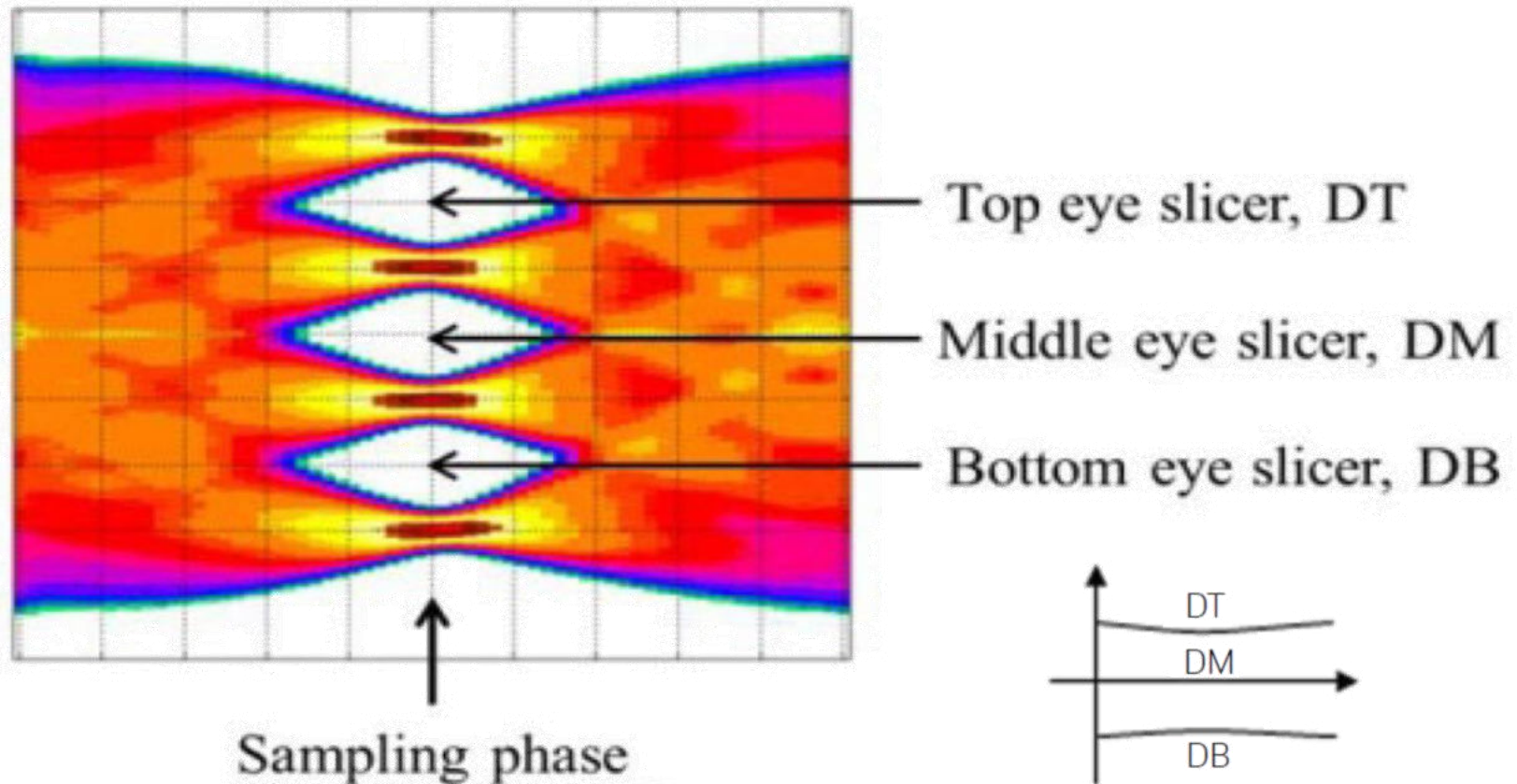
- Four digits (0, 1, 2, 3) mapping between serial bits and PAM4 symbols/levels
- Listed from lowest to highest symbol
- These digits correspond to binary bit patterns 00, 01, 10, 11

Grey Code: 3201

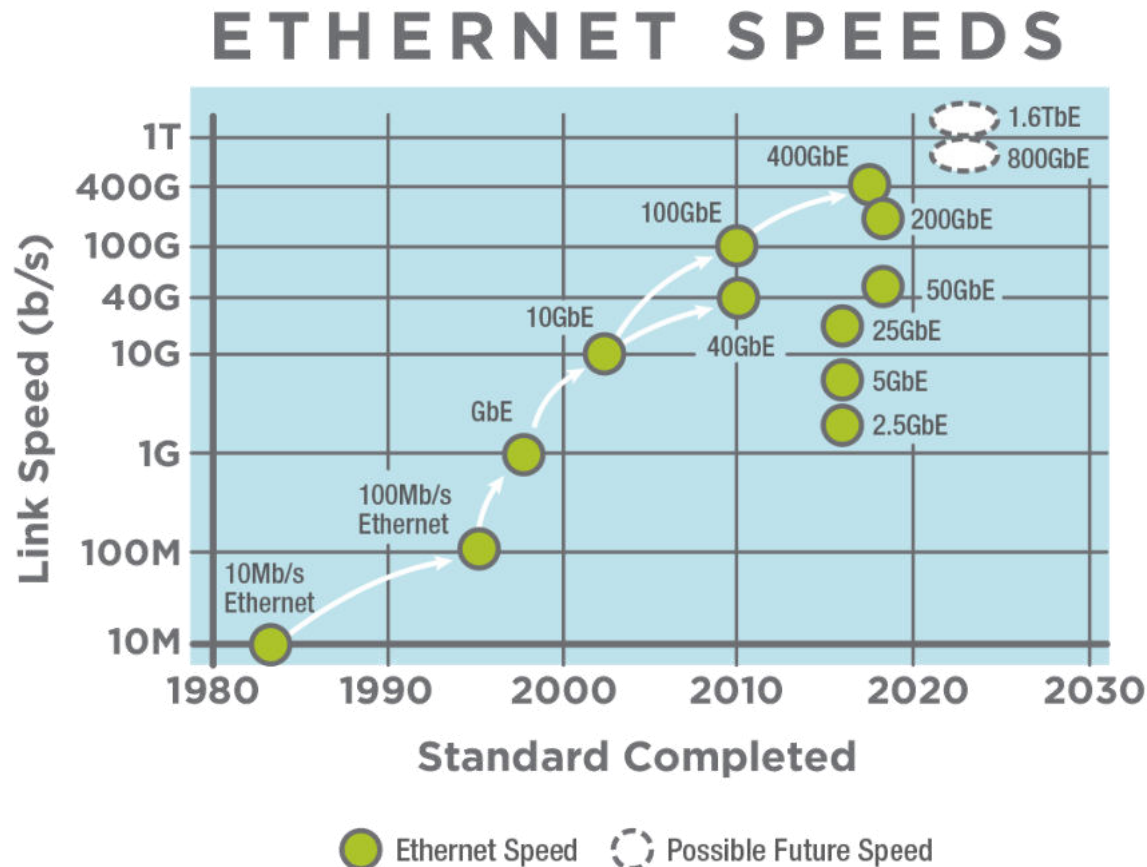
- 01
- 00
- 10
- 11



PAM4 – 400Gbps, Receiver

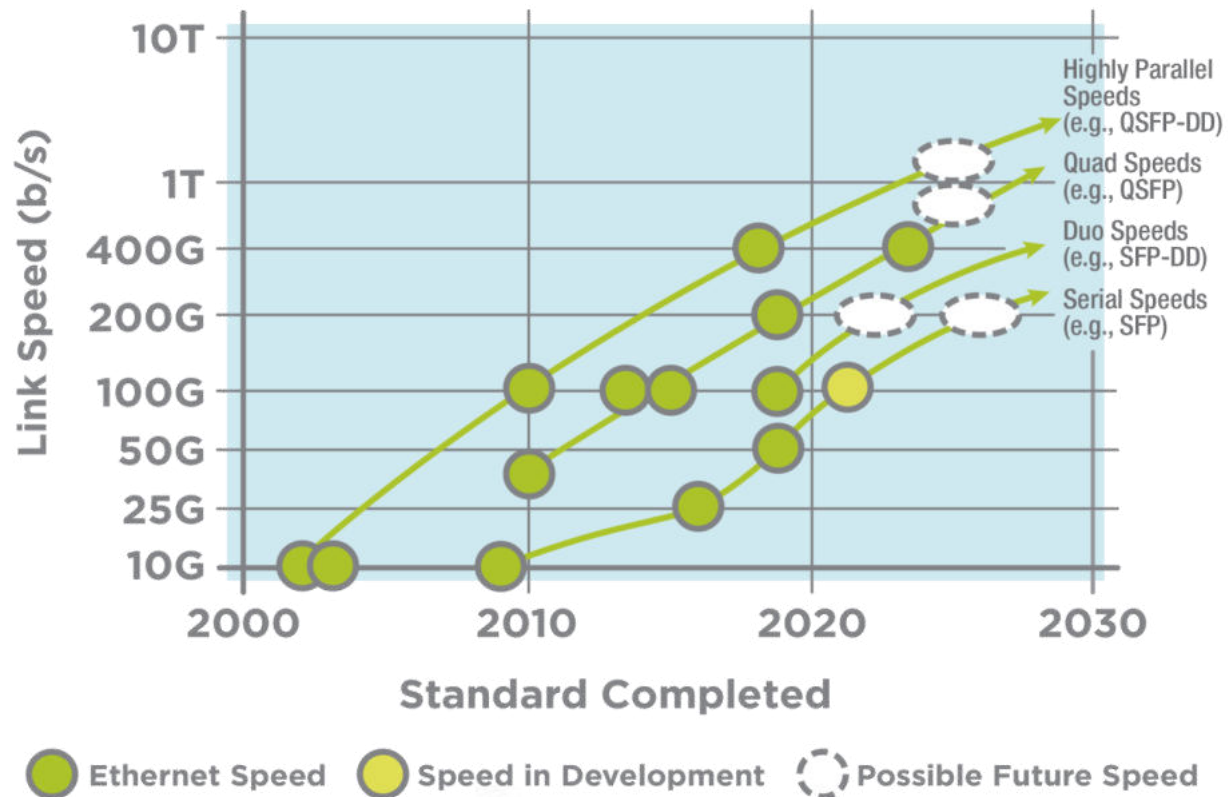


Link Speeds Evolution

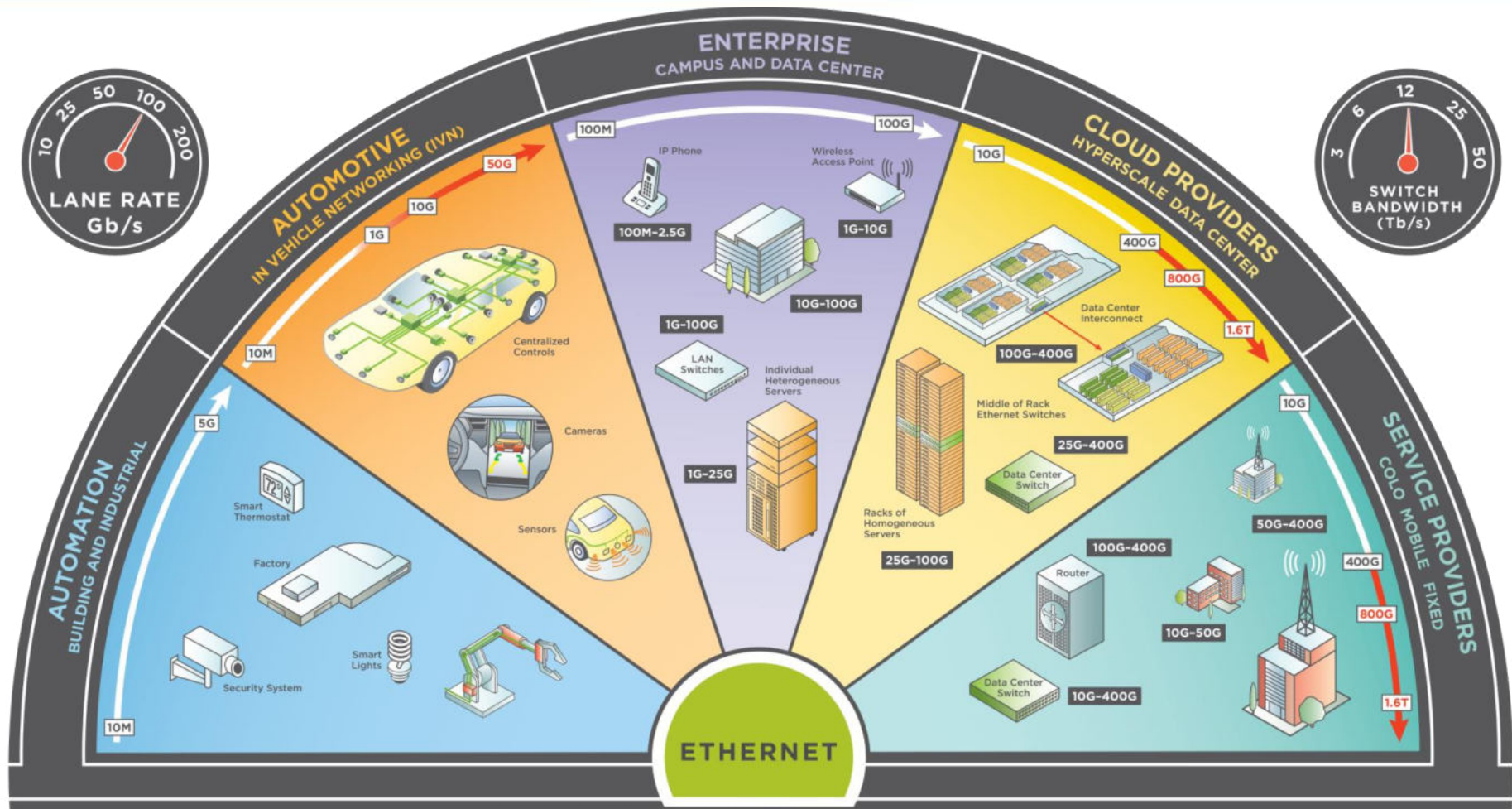


Speeds

TO TERABIT SPEEDS



Ethernet Graphic Road 2016



Questions



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