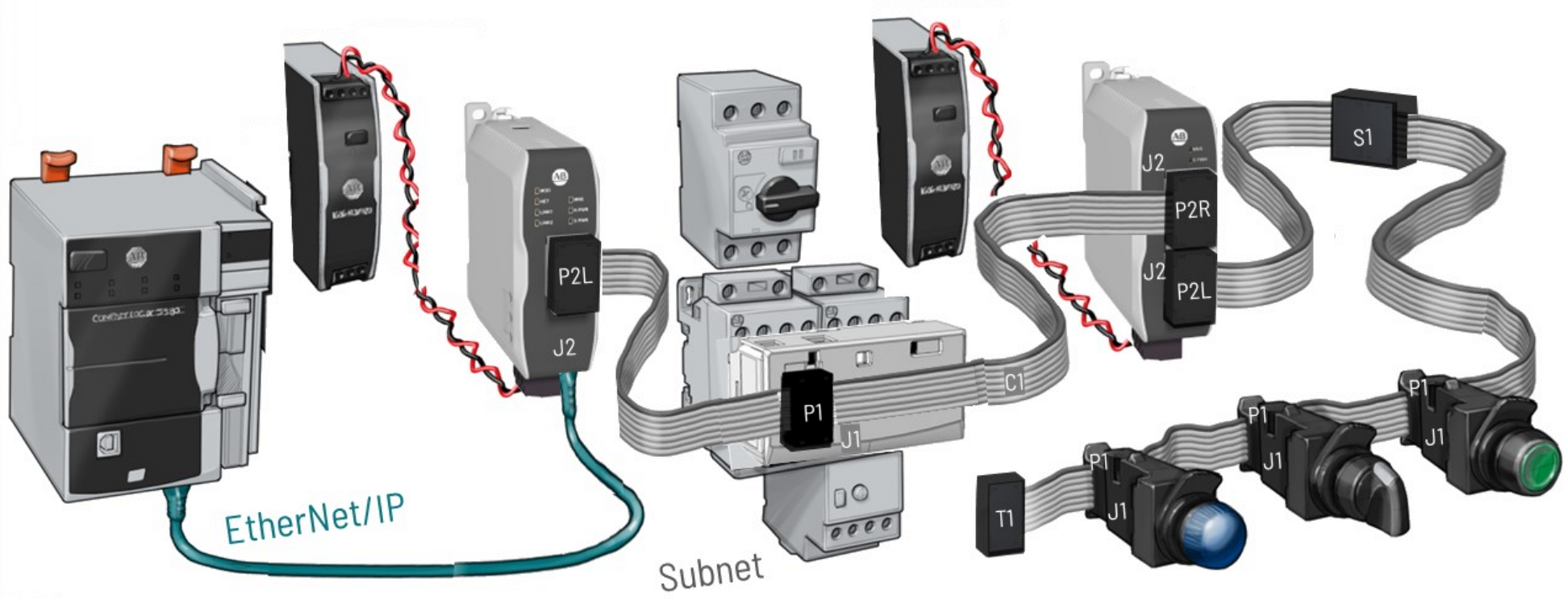

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Single Pair Ethernet
Nowe sieci samochodowe i przemysłowe

PUBLIC

WOJCIECH KOCZWARA • 15•04•2024

Współautorzy

Dziękuję za wkład w niniejszą prezentację

- Grzegorz Smołka [Project Engineer, Hardware Test] – autor instalacji LIVE DEMO
- Damian Loncierz [Sr. Mechanical Engineer] – grafiki systemu

Agenda

1 Ethernet – standardy, zastosowania

2 10BASE-T1S (IEEE802.3.cg)

3 Elektryczna topologia sieci 10BASE-T1S

4 Efektywność PLCA

5 Skrętka a płaski kabel

6 Problem gęsto rozmieszczonych odbiorników

7 Live demo

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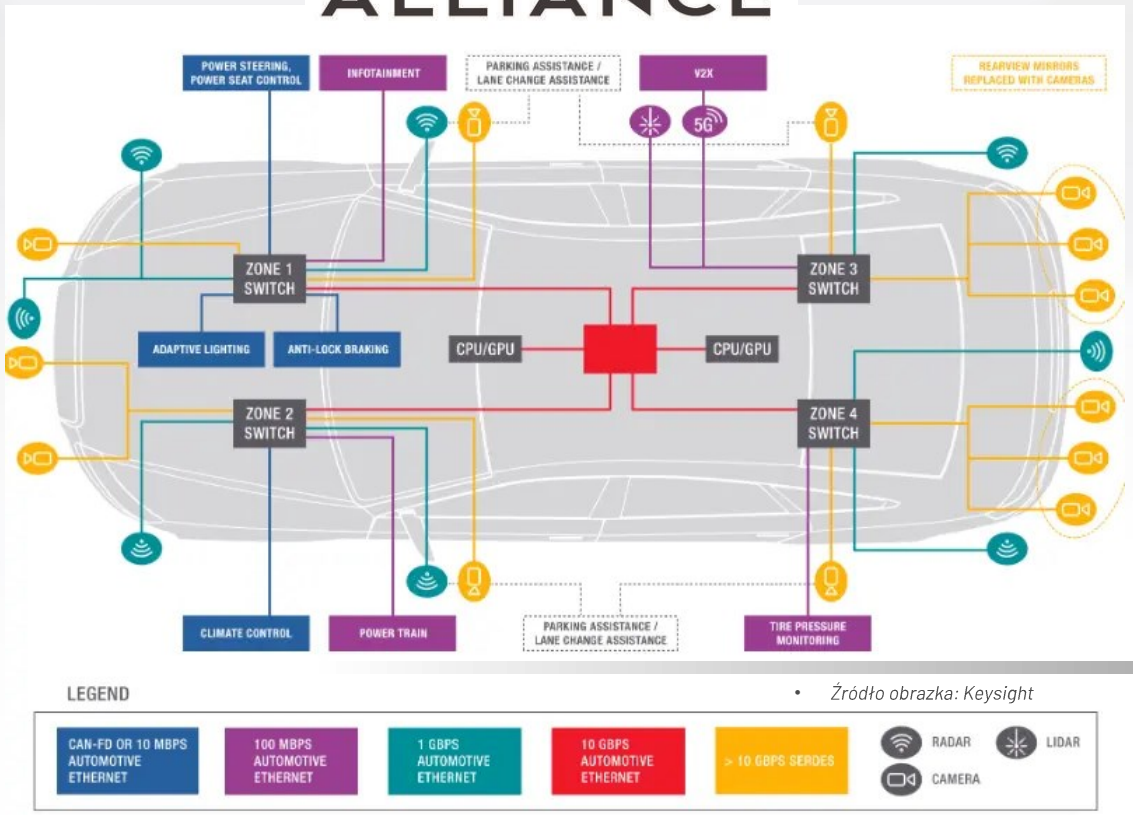
Ethernet w samochodach i przemyśle - standardy

IEEE 802

OPEN ALLIANCE

ODVA



- *Źródło obrazka: Keysight*

SMART DEVICES

Actuators

Sensors

Automation Control

Intelligent Motor Control

Components

?

Terminals

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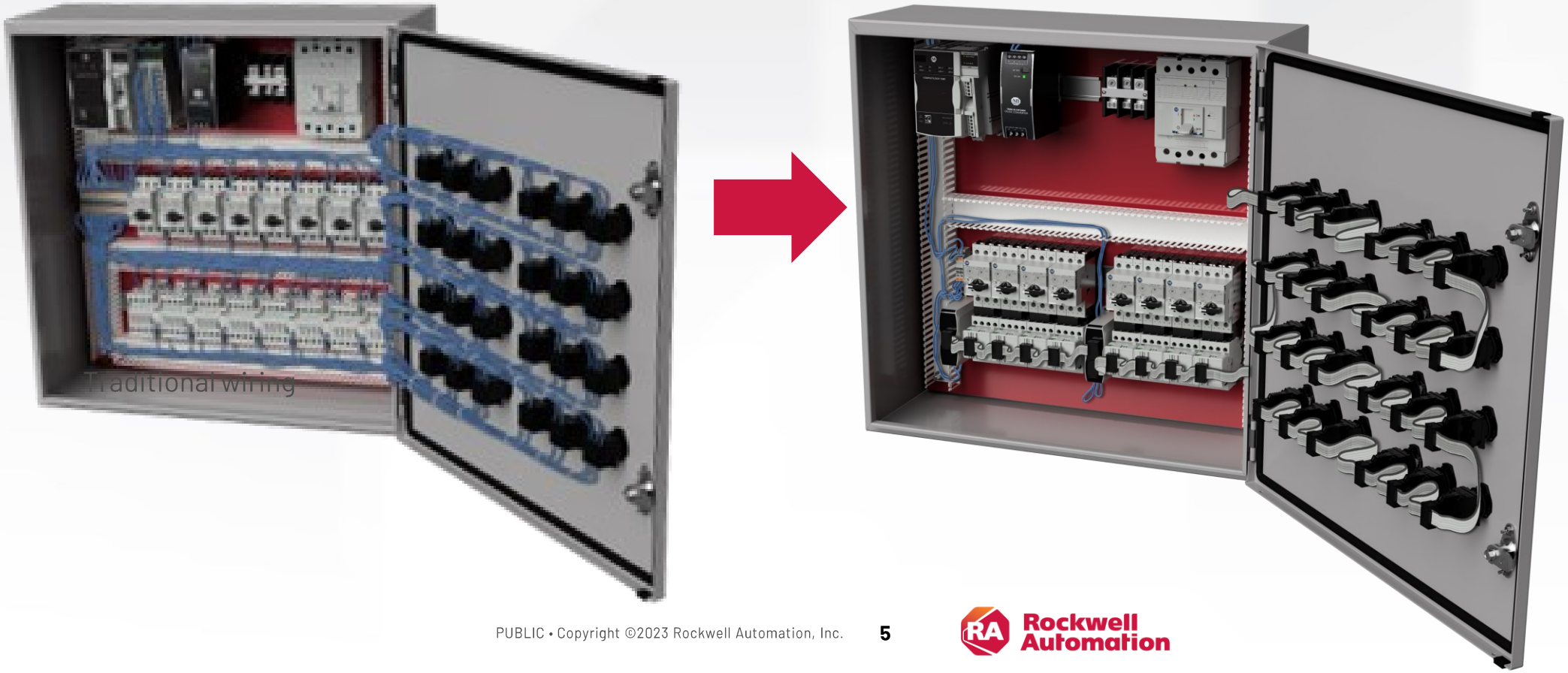
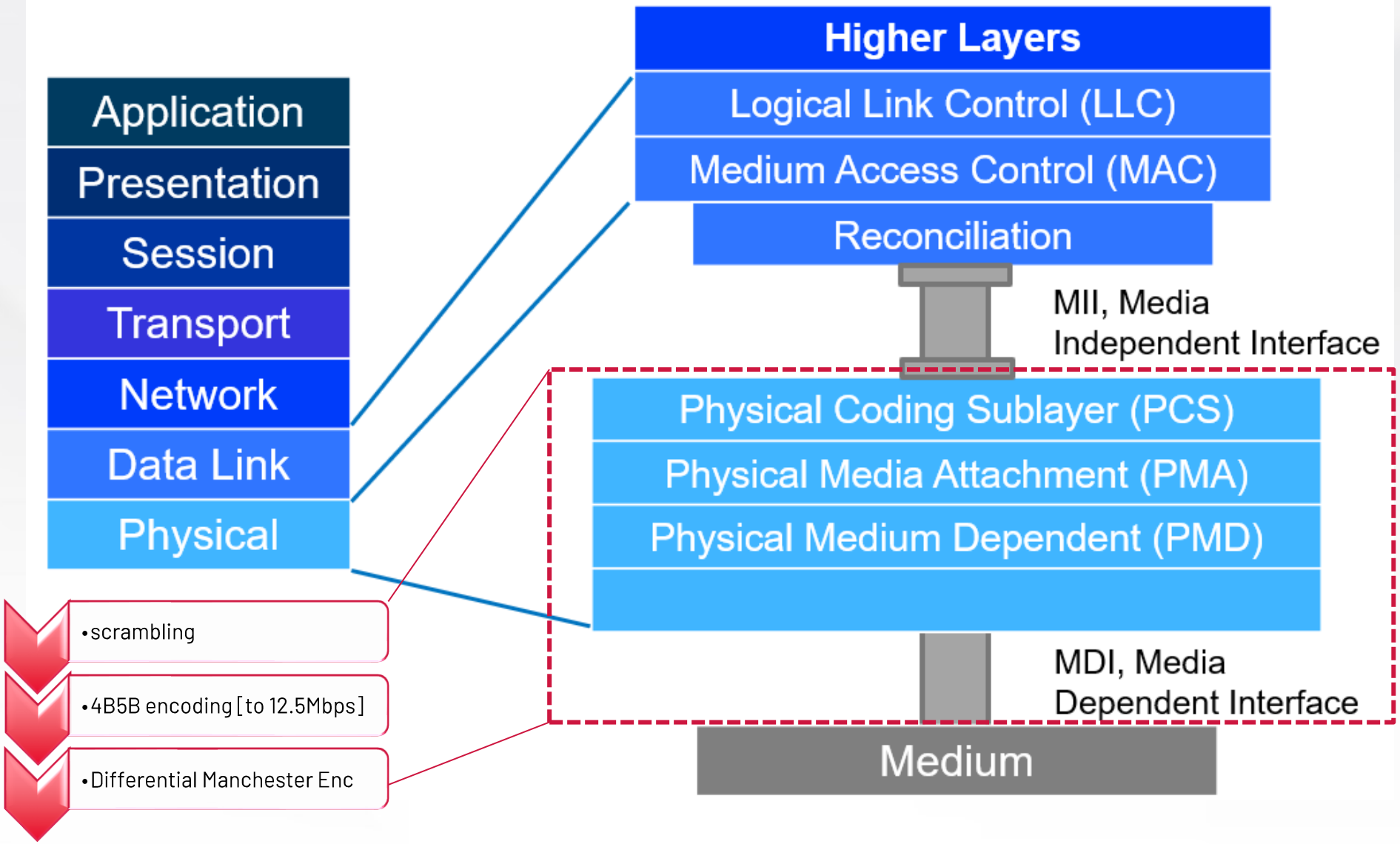
Po co sieć w szafie sterowniczej?

- Redukcja czasu złożenia
- Pełna konfigurowalność
- Zdalna diagnostyka



Ethernet – przewaga dzięki warstwom



IEEE 802

Podmienialne warstwy fizyczne o różnych prędkościach np.:

- **10BASE-T1S**
- 100BASE-T1
- 1000BASE-T1
- 2.5/5/10GBASE-T1
- 25GBASE-T1

- 100BASE-T
- 1000BASE-T

- 200GBASE-DR4 (światłowód)

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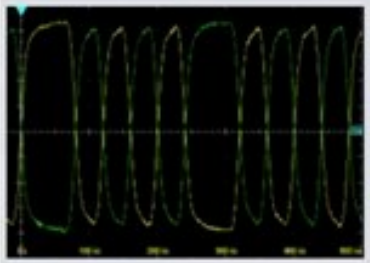
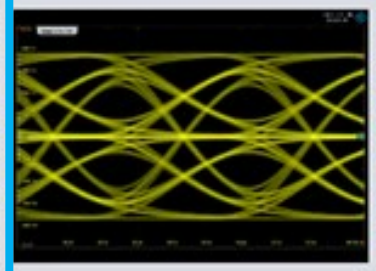
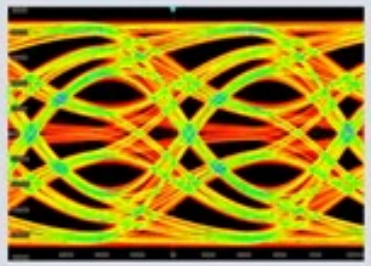
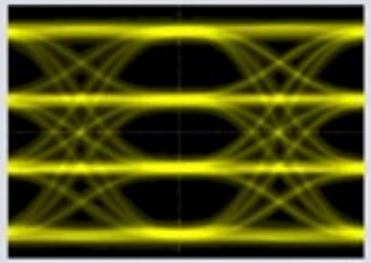
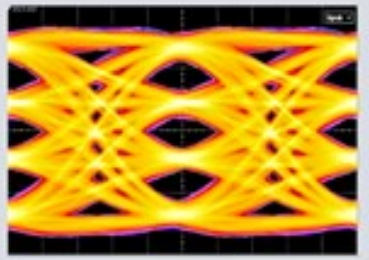
Single Pair Ethernet – popularne standardy

	10BASE-T1S	100BASE-T1	1000BASE-T1	2.5/5/10GBASE-T1	25GBASE-T1
IEEE 802.3 Reference	802.3cg-2019 Clause 147	802.3bw-2015 Clause 96	802.3bp-2016 Clause 97	802.3ch-2020 Clause 149	IEEE P802.3cy Clause 165
OPEN Alliance	TC14	TC1 (Closed)	TC12	TC15	N/A
Bit Rate (Gbps)	0.010	0.100	1.0	2.5 / 5.0 / 10.0	25.0
Baud Rate (MBd)	12.5	66.66	750	1406.25 / 2812.5 / 5625	14062.5
Encoding	2-Level DME	PAM3		PAM4	
Cabling	UTP (Unshielded Twisted Pair)	UTP (STP optional)		STP (Shielded Twisted Pair)	

• *Źródło obrazka: GRL*

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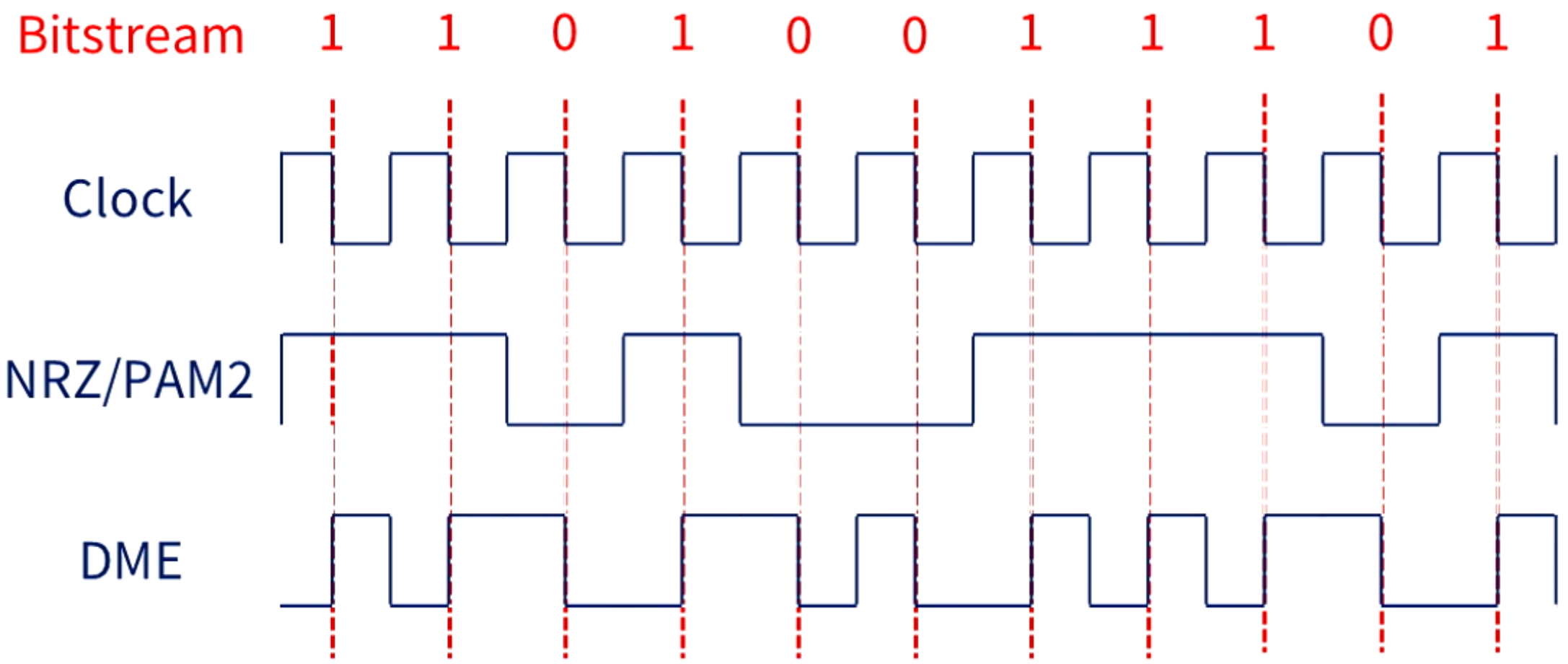
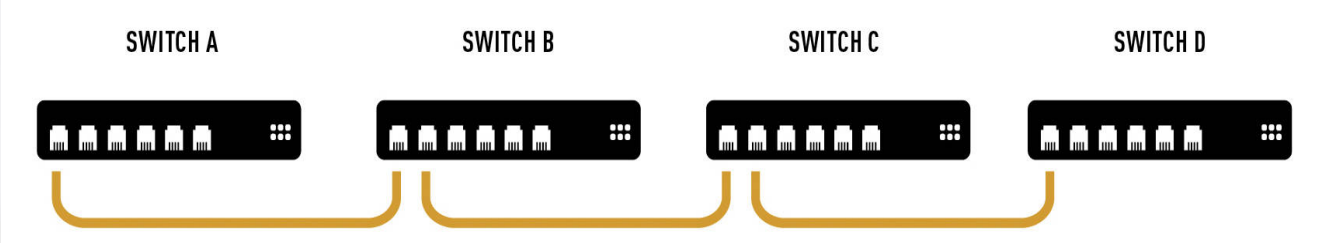
Differential Manchester Encoding – prosta synchronizacja odbiornika



- *Źródło obrazka: GRL*

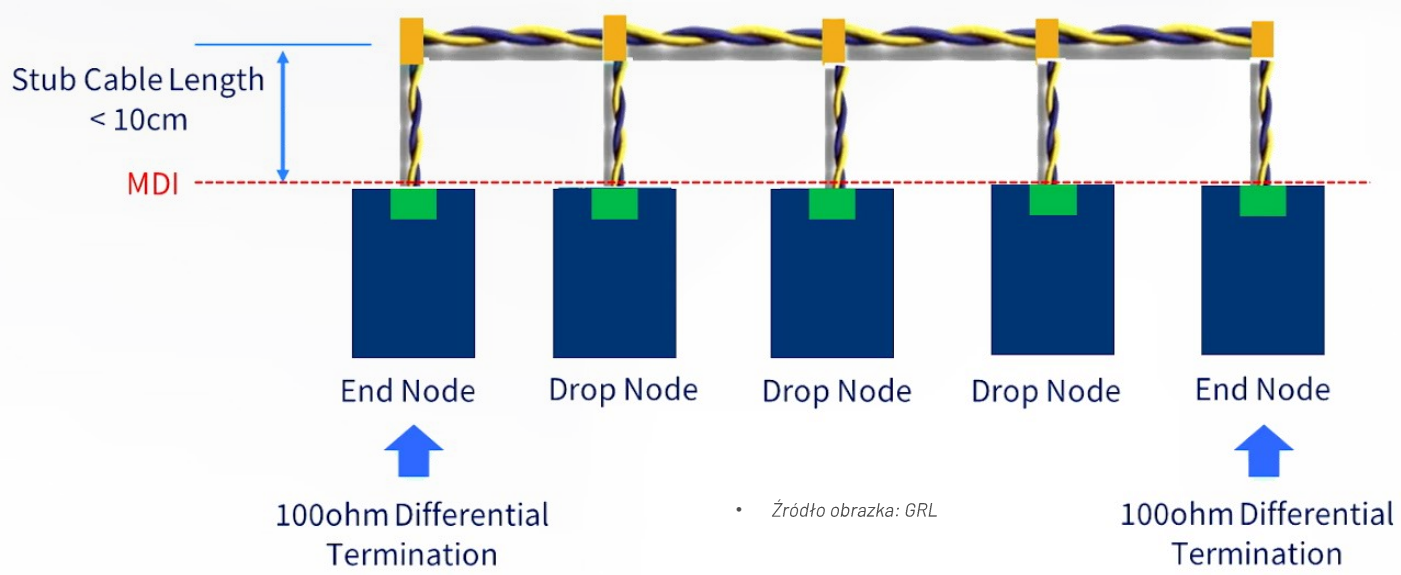
Ethernet dla najprostszych urządzeń



- *Źródło obrazka: Gigamedia*

DOTYCHCZAS:

- Switch w każdym urządzeniu
- Wysoki koszt
- Duża moc



- *Źródło obrazka: GRL*

10BASE-T1S multi-drop:

- **Brak switchy**
- **Niski koszt**
- **Oszczędność mocy**
- **8-40 urządzeń**

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Topologia sieci 10BASE-T1S, impedancje urządzeń

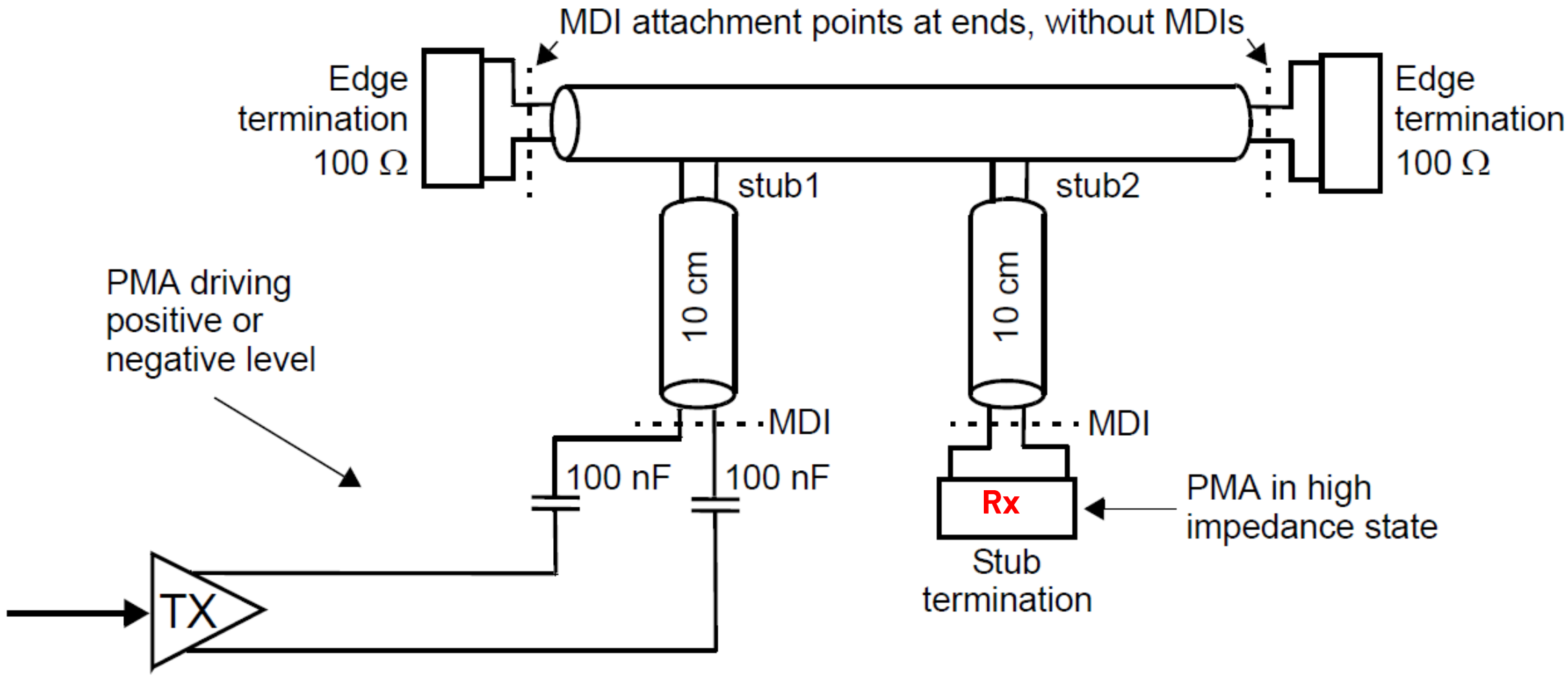
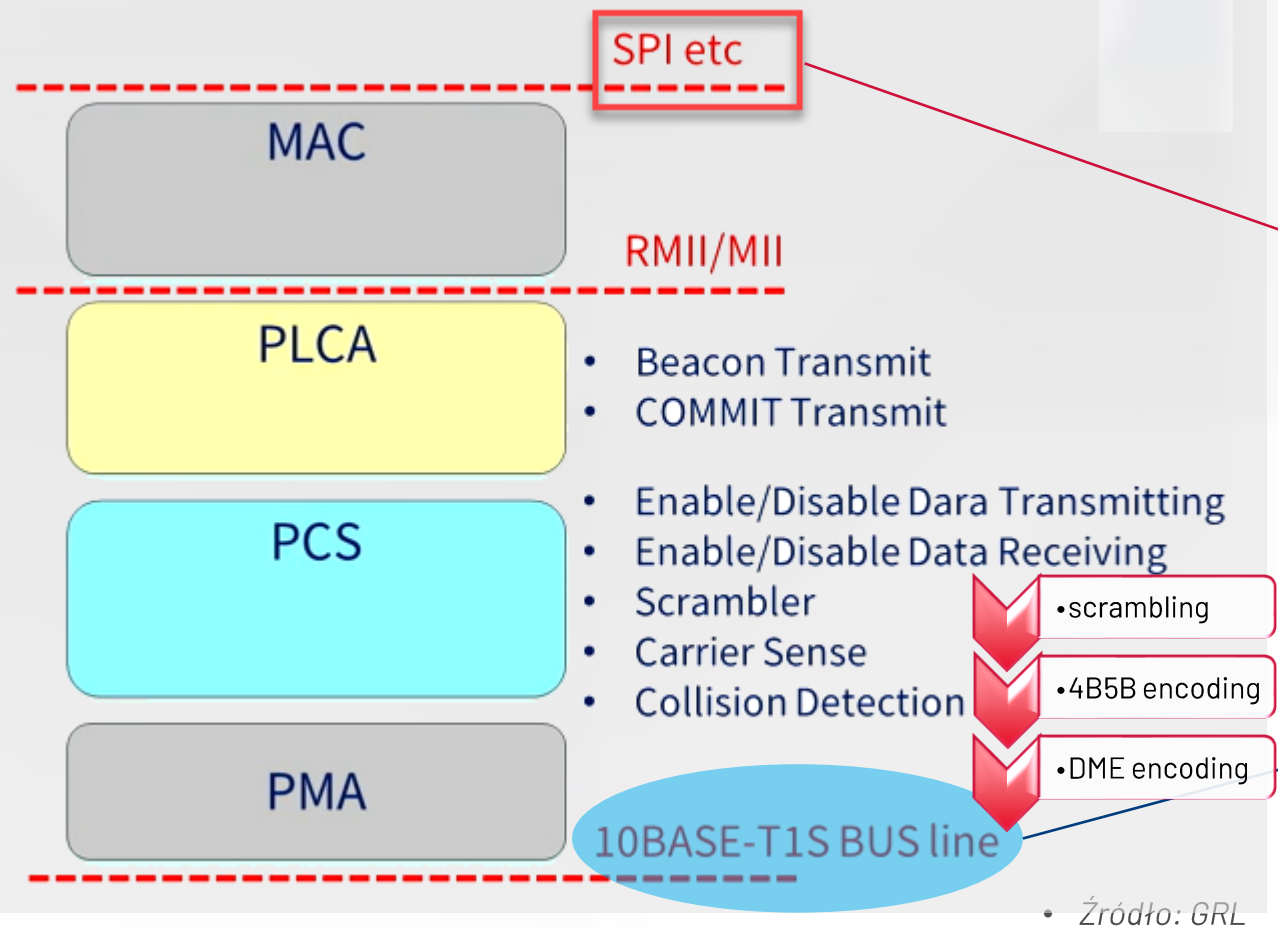


Figure 147–20—Multidrop line termination and PMA

10BASE-T1S z interfejsem SPI?



- *Źródło: GRL*

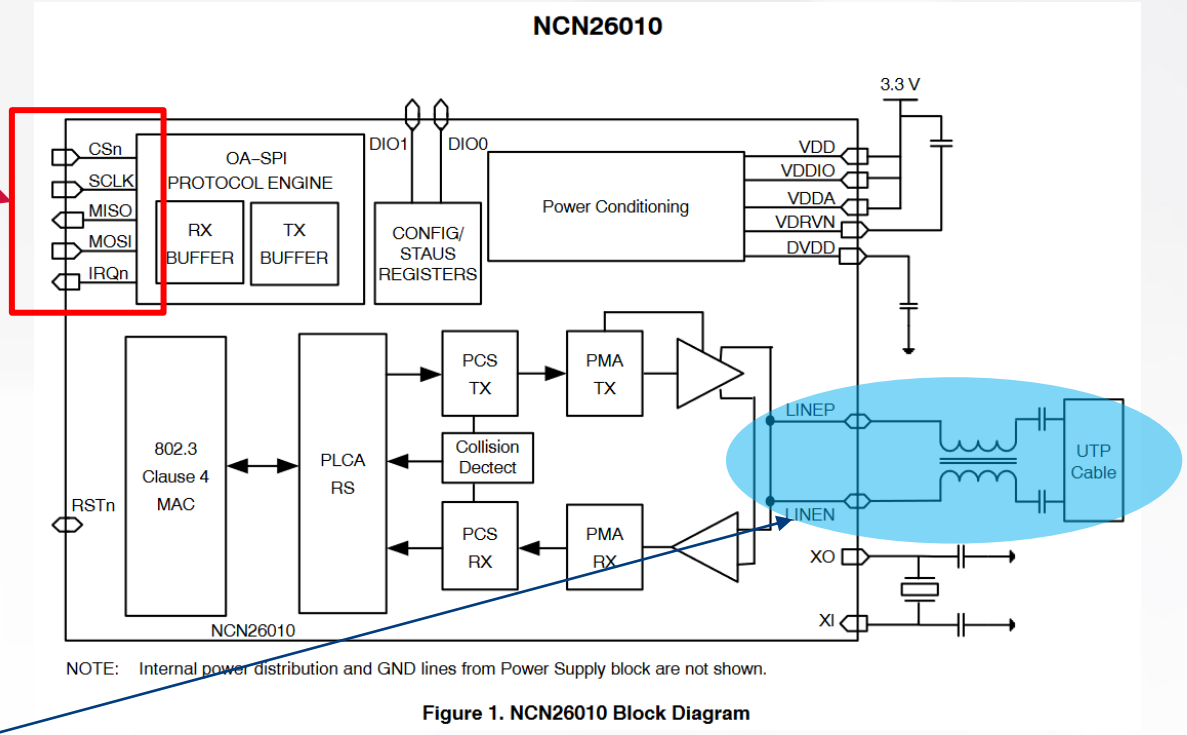


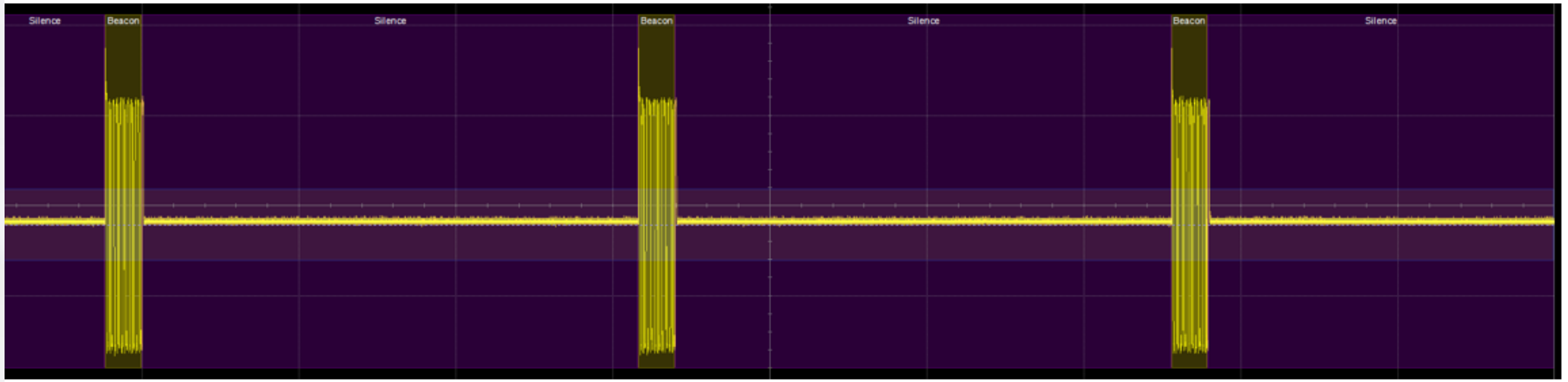
Figure 1. NCN26010 Block Diagram

PLCA – efektywna transmisja bez kolizji

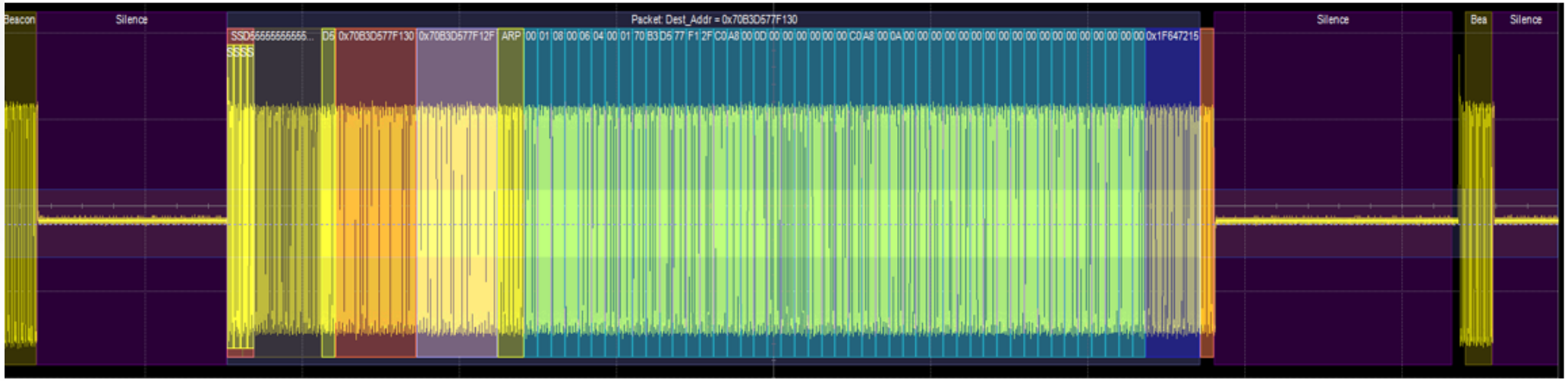
Minimum latency PLCA cycles. No one has anything to transmit in cycle 1, so total latency is equal only to the number of nodes times the TO_TIMER. Only Nodes 1 and 3 have transmissions in cycle 2, so all the other nodes cede their transmit opportunity. Node 1 immediately transmits DATA; Node 3 sends a COMMIT followed by DATA.

- *Źródło obrazka: Teledynelecroy.com*

PLCA – efektywna transmisja bez kolizji



If there is no traffic, only BEACON are sent on the bus



Data from a node will expand the time between two BEACON

Źródło obrazka: Teledynelecroy.com

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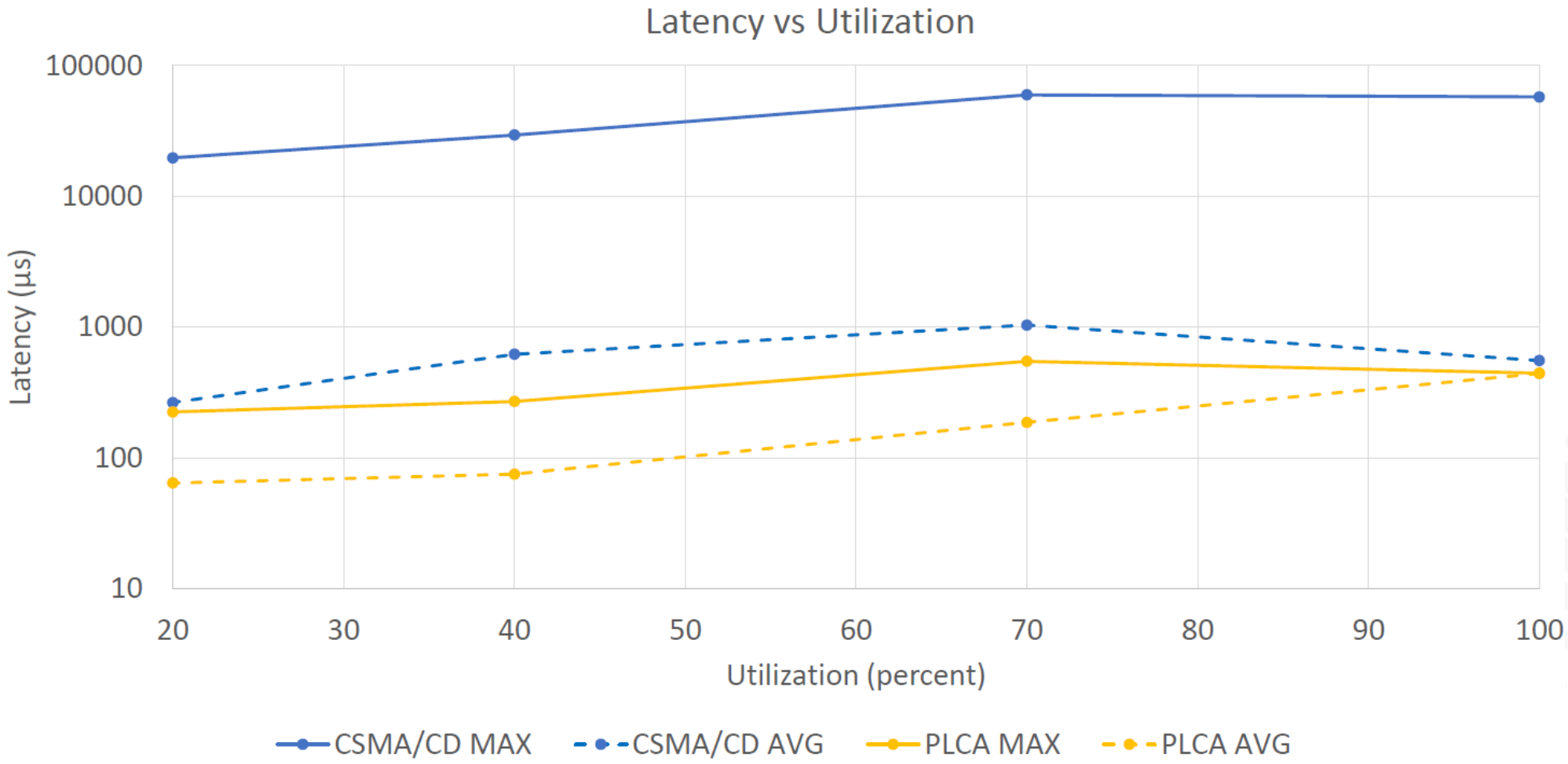
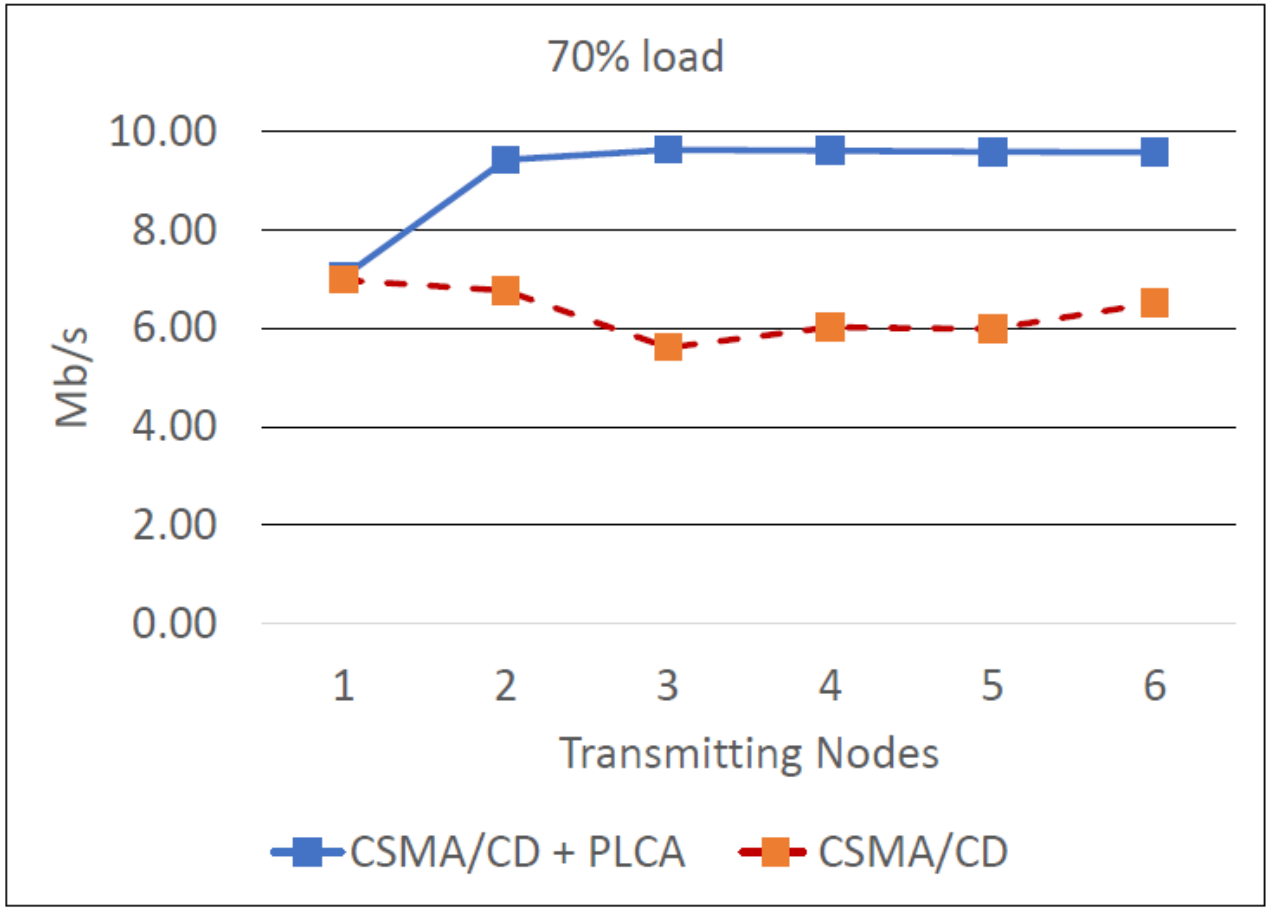
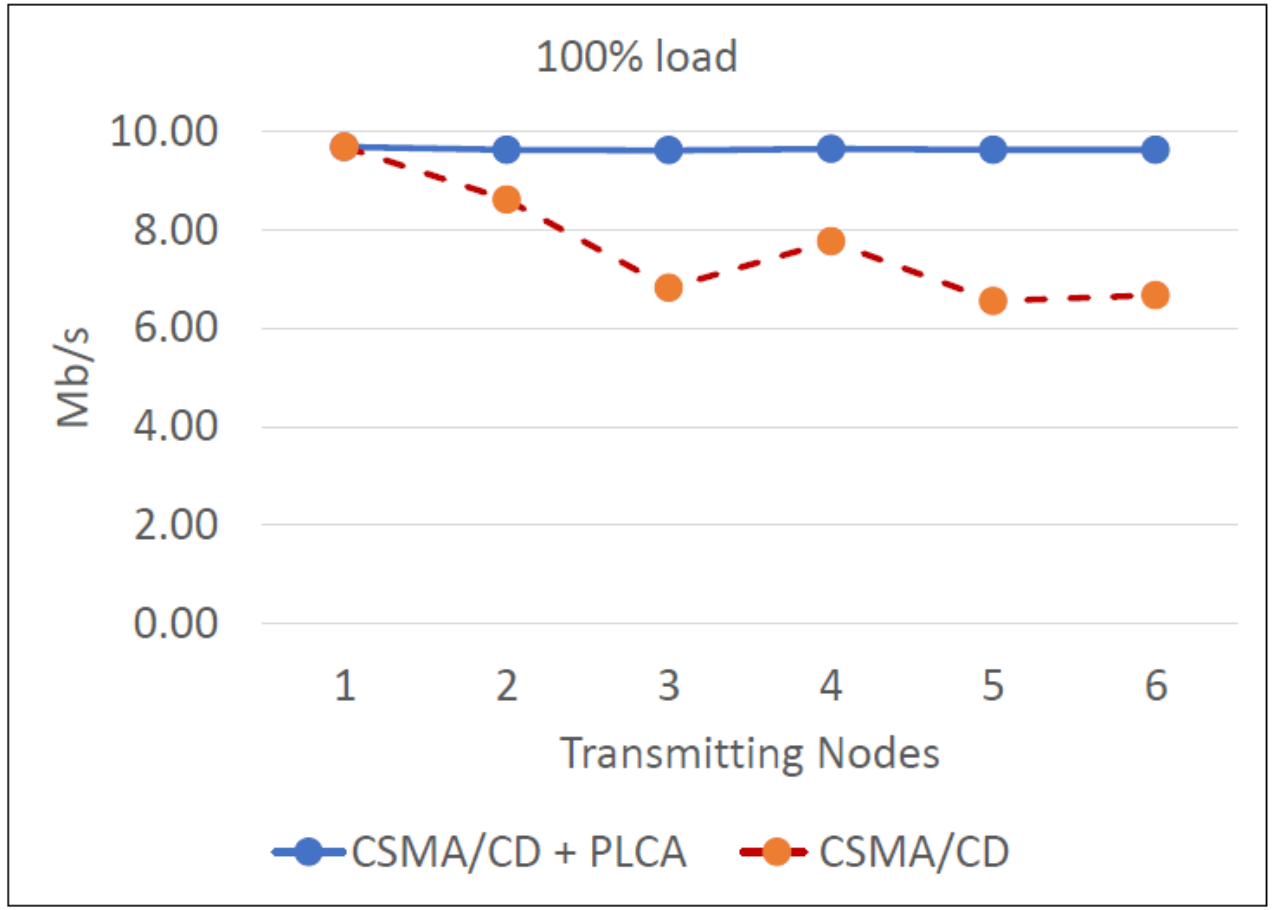
PLCA performance: latency vs utilization



* Simulation example – bandwidth varies

PLCA performance: bandwidth



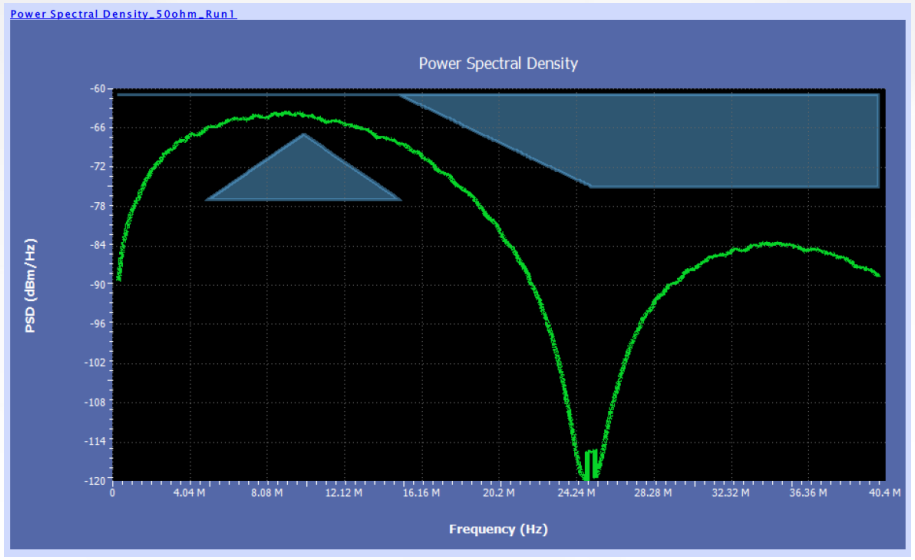


* Simulation example – bandwidth varies

Wymagania elektryczne dotyczące kanału i urządzeń

Table 147–4—MDI impedance limit parameters

Parameter name	Unit of measure	Minimum value	Maximum value
R	kΩ	10	—
L	μH	80	—
C_{tot}	pF	—	180
C_{node}	pF	—	15



$$\text{Insertion loss}(f) < \begin{cases} 1.0 + \frac{1.6(f-1)}{9} & 0.3 \le f < 10 \\ 2.6 + \frac{2.3(f-10)}{23} & 10 \le f < 33 \\ 4.9 + \frac{2.3(f-33)}{33} & 33 \le f \le 40 \end{cases} \text{ dB}$$

$$\text{Return loss}(f) > \begin{cases} 14 & 0.3 \le f < 10 \\ 14 - 10\log_{10}\left(\frac{f}{10}\right) & 10 \le f \le 40 \end{cases} \text{ dB}$$

where

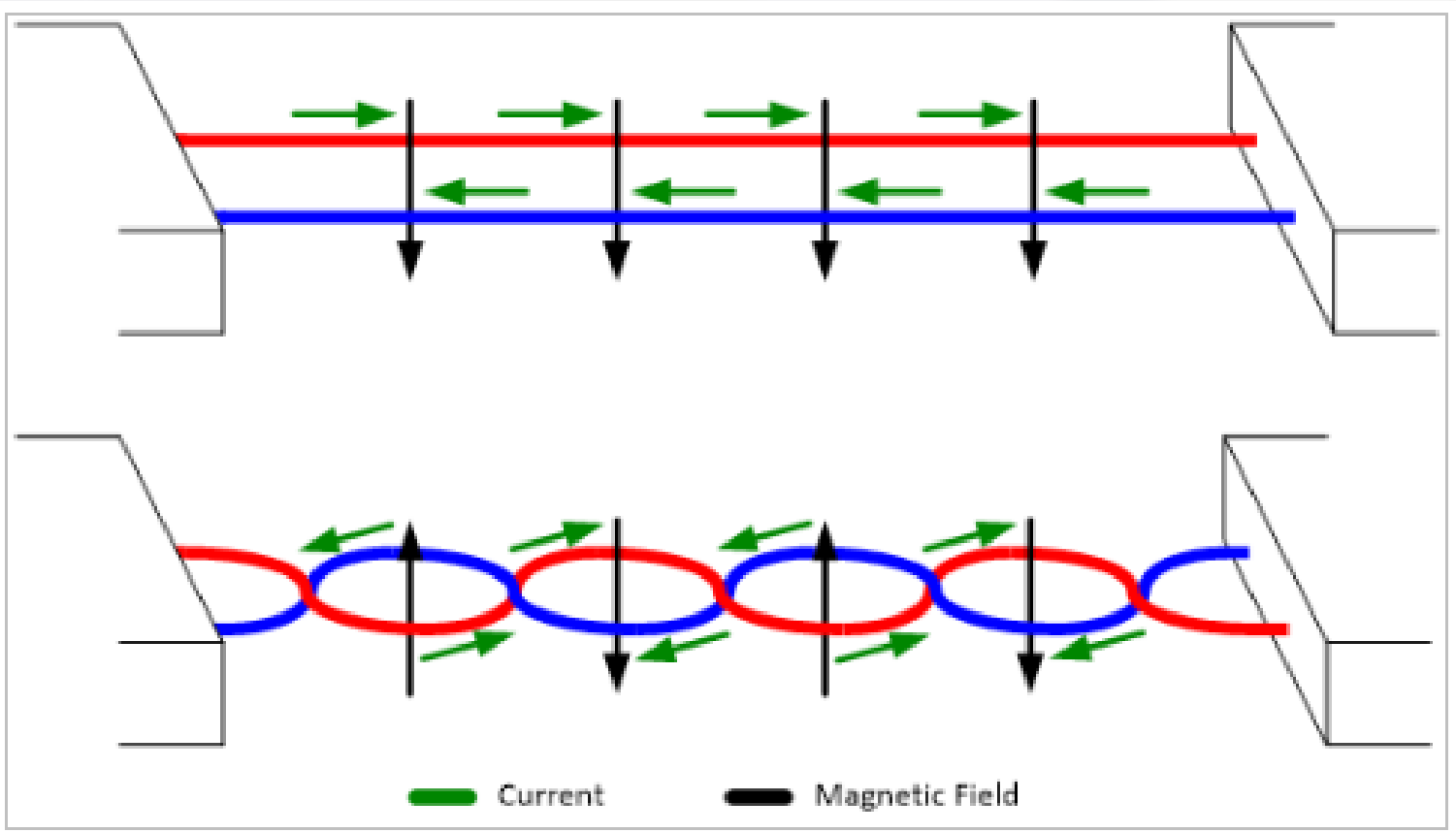
f is the frequency in MHz; $0.3 \le f \le 40$

$$\text{Mode conversion loss}(f) > \begin{cases} 43 & 0.3 \le f < 20 \\ 43 - 20\log_{10}\left(\frac{f}{20}\right) & 20 \le f \le 200 \end{cases} \text{ dB}$$

where

f is the frequency in MHz; $0.3 \le f \le 200$

Emisja i odporność – przewaga skrętki UTP/STP



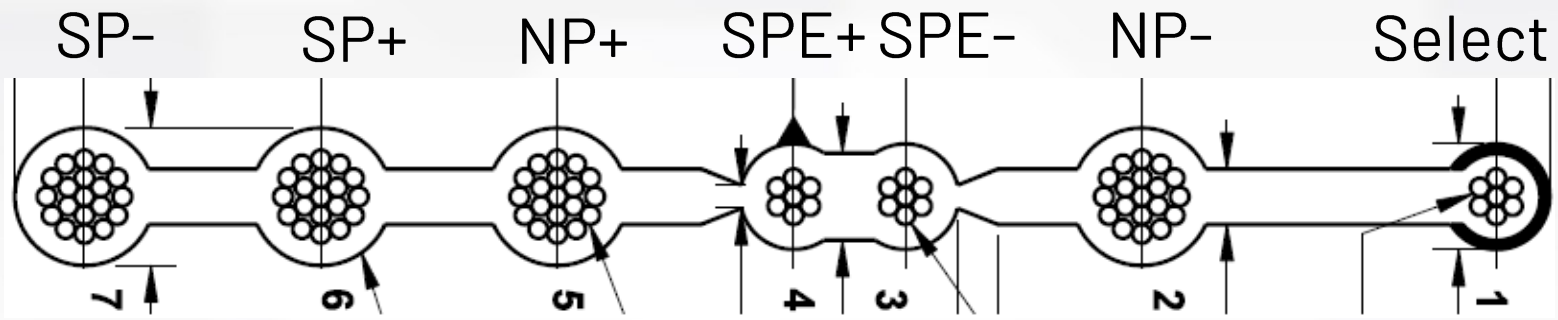
- Redukcja sprzężenia indukcyjnego
- symetryzacja impedancji

- *Źródło: emianalyst*

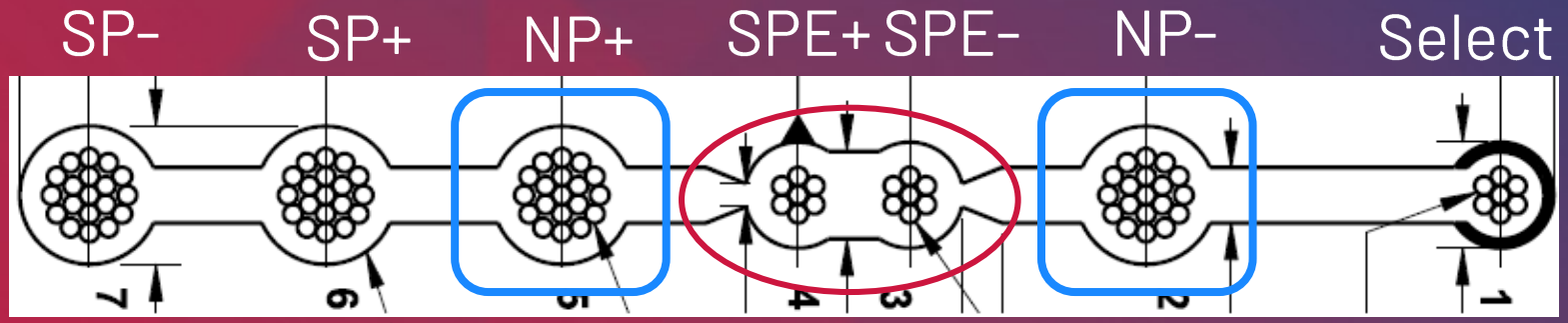
ODVA – płaski kabel dla prostoty montażu

Czy może zastąpić popularną skrętkę?

- SPE+, SPE- dla różnicowej transmisji, Z0 = 100 Ω
- NP+/- (Network Power) dla zasilania wszystkich urządzeń w sieci
- SP+/- (Switching Power) to zasilanie do zadań specjalnych
- Select Line – linia dla odkrywania topologii sieci, łączy tylko z najbliższymi sąsiadami



EMC z płaskim kablem?



Redukcja sprzężenia magnetycznego oraz elektrycznego zewnętrznym torem zasilania

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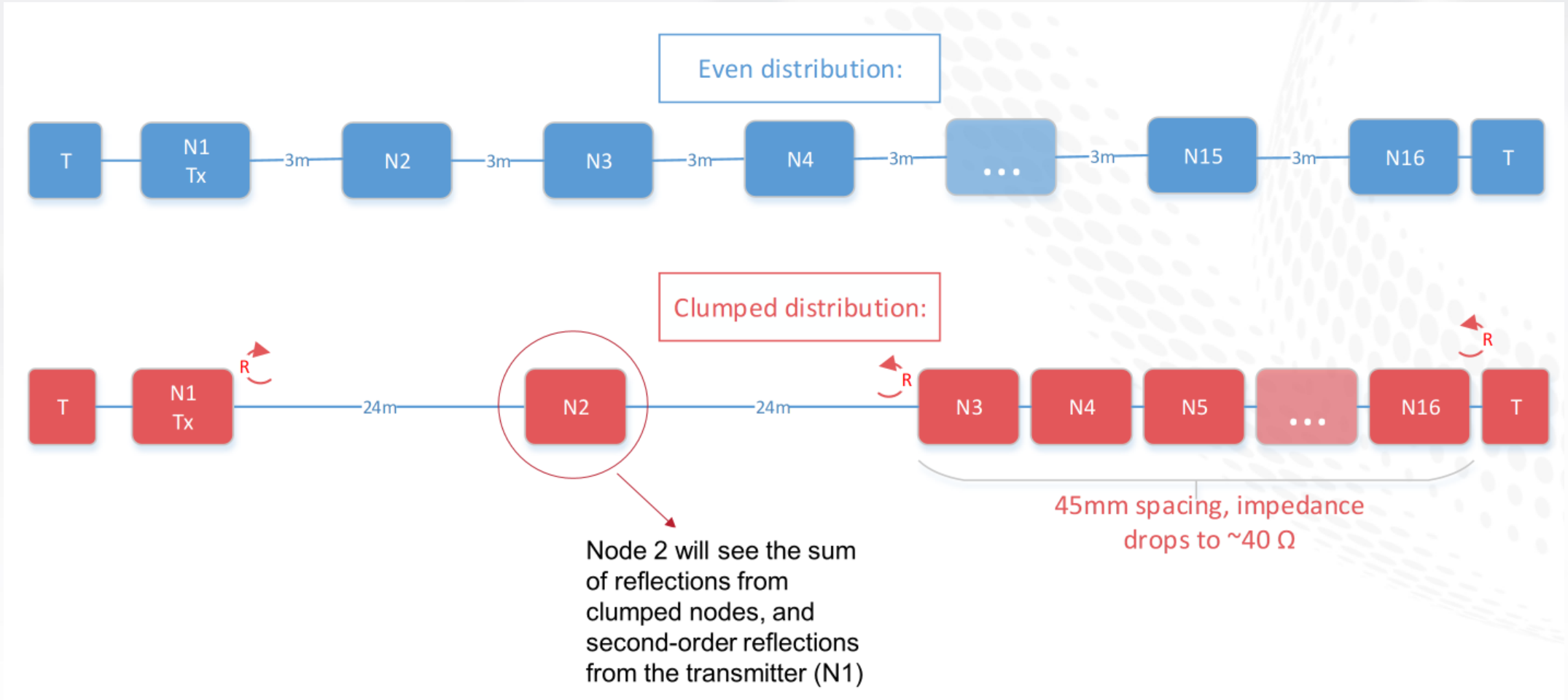
Limit urządzeń w sieci – zależny od topologii

Skupiska urządzeń powodują odbicia sygnału



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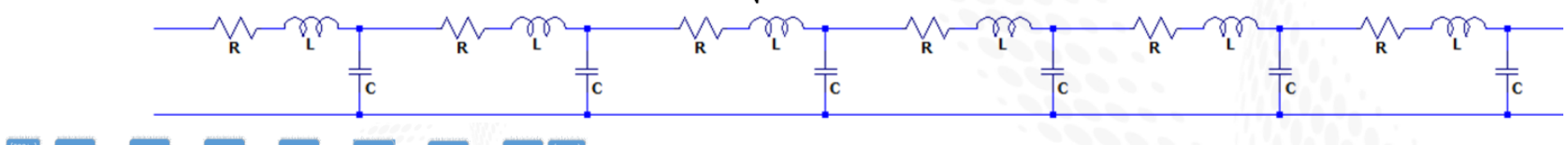
Limit urządzeń w sieci – zależny od topologii

Przyczyna lokalnego obniżenia impedancji – lokalny wzrost pojemności łącza po dołączeniu urządzeń

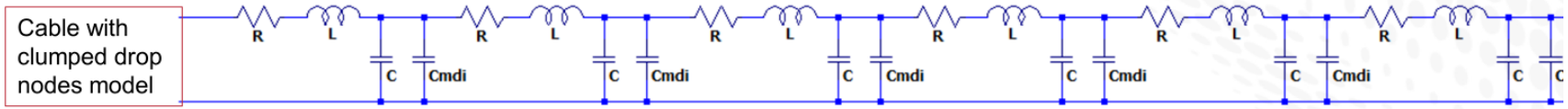
Impedance drop in clumped nodes regions

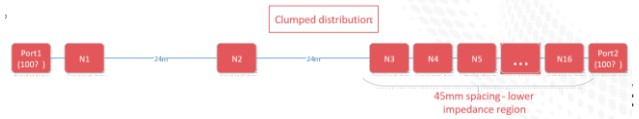
Cable model

$$Z_0 \cong \sqrt{\frac{L}{C}} = 100\ \Omega$$

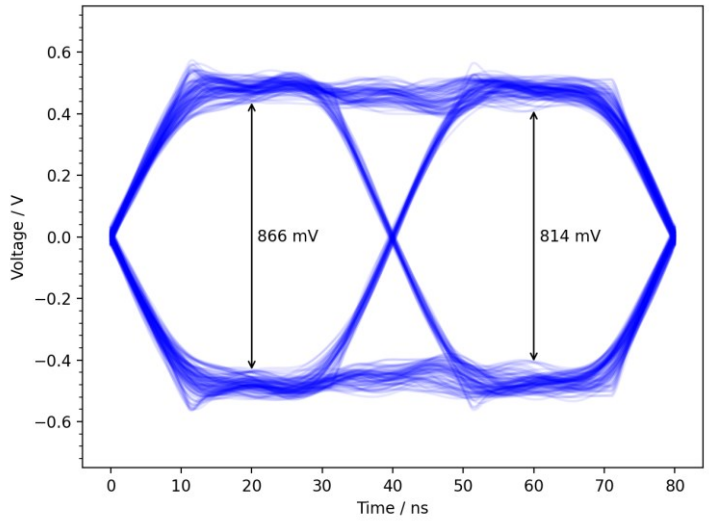


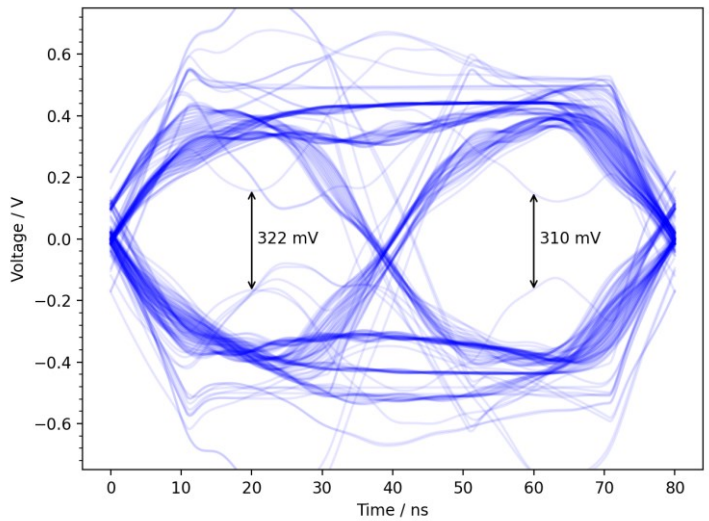
Cable with clumped drop nodes model





$$\sqrt{\frac{L}{C+CMDI}} \ll 100\ \Omega\ (e.g.\ 40\text{–}60\Omega)$$





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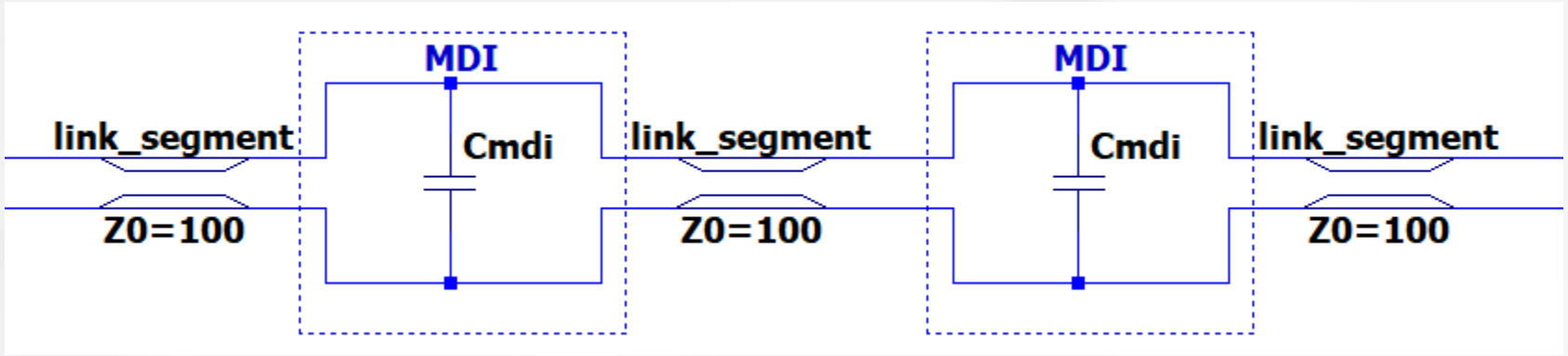
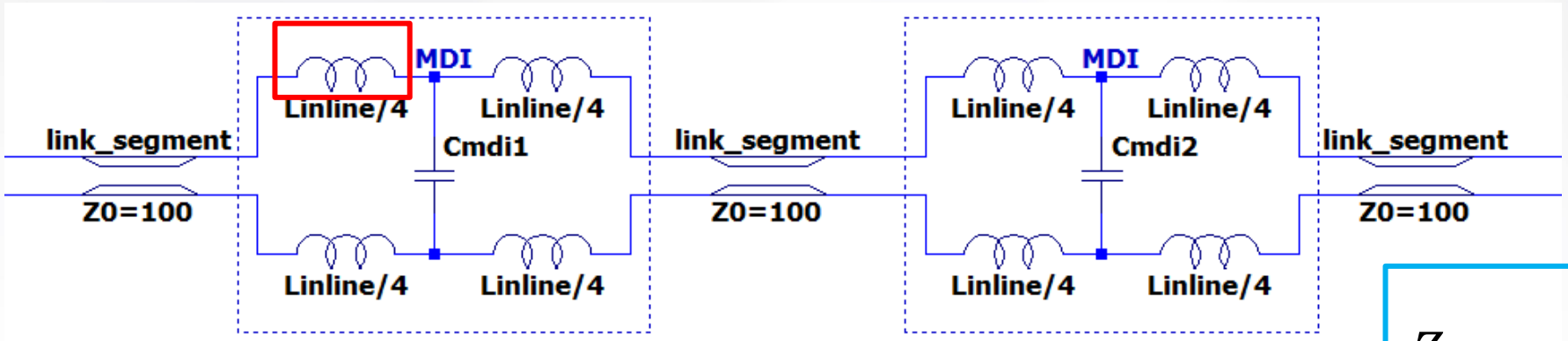
Limit urządzeń w sieci – jak z 8 urządzeń osiągnęliśmy 40?

Skupiska urządzeń powodują odbicia sygnału



$$Z_0 = \sqrt{\frac{L}{C+CMDI}} < 100\ \Omega$$



$$Z_0 = \sqrt{\frac{L+Linlin_e}{C+CMDI}} =$$

100 Ω

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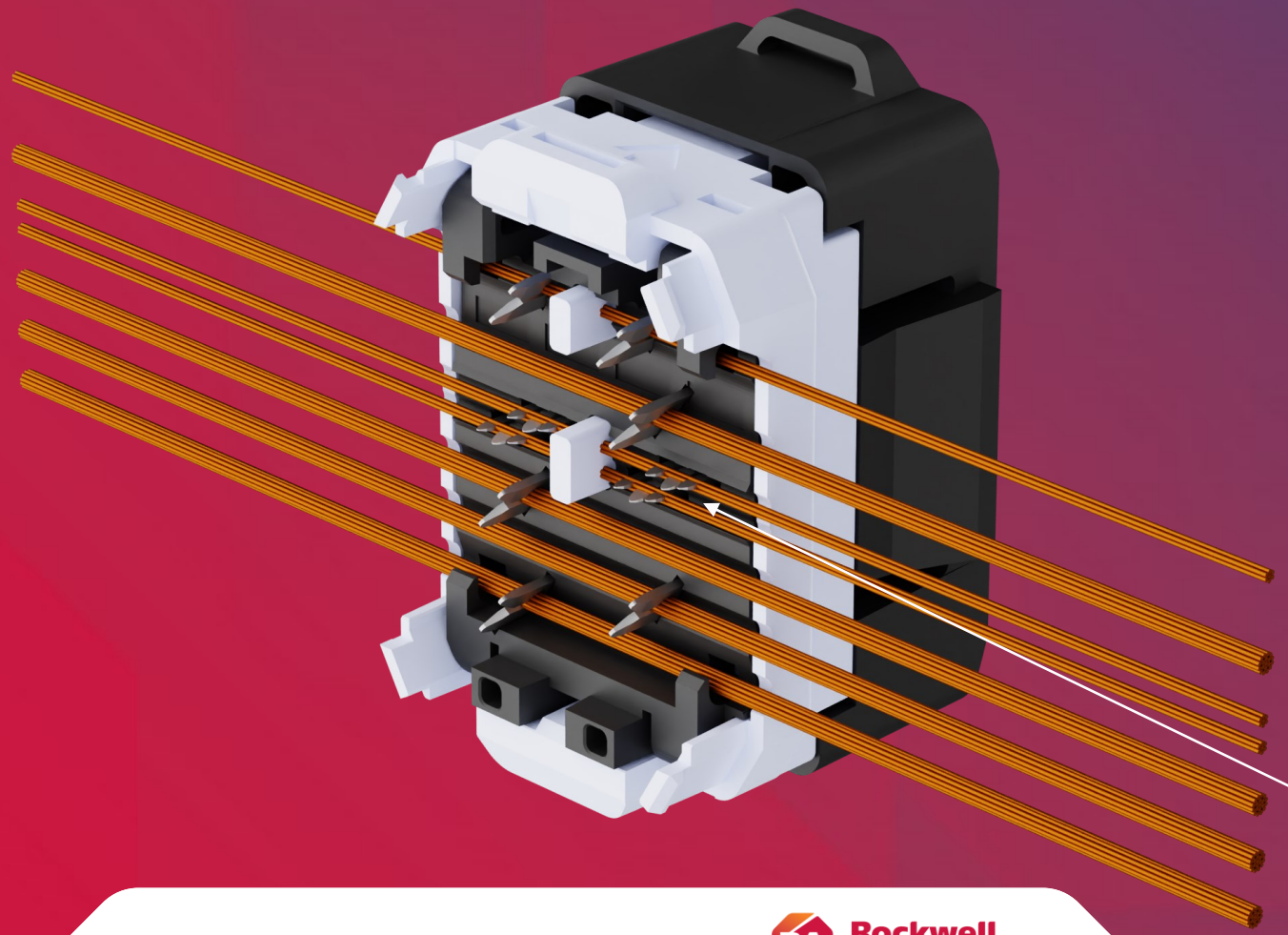
Przykładowy system Ethernet IP in-cabinet



Przecinamy magistralę SPE, wstawiamy cewki kompensujące

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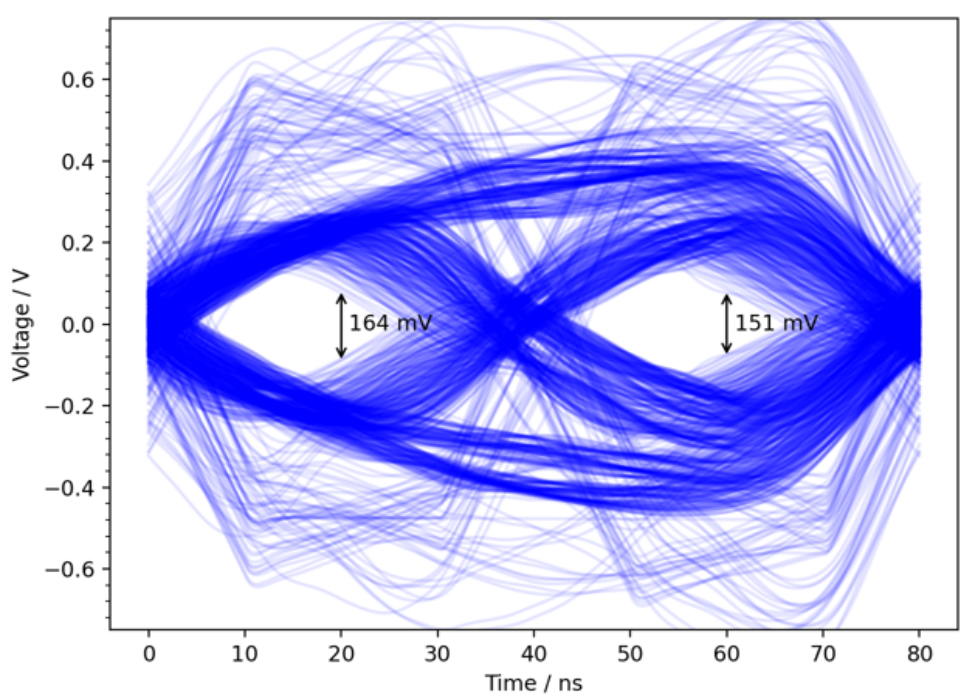
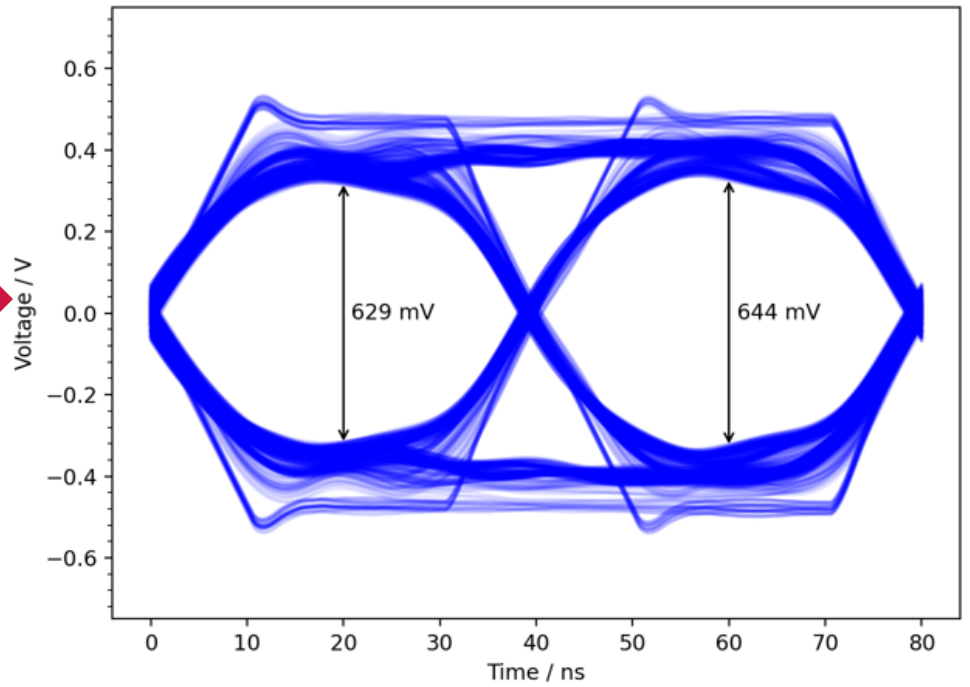
Dodanie cewek kompensujących do konektorów

Eye diagrams, clumped distribution

R=10kΩ, C=25pF (Lind=4*65nH), L=N/A (without PoDL)

16 nodes, 50m cable, 45mm clumped section spacing, 10cm stubs





no inline inductors

with inline inductors

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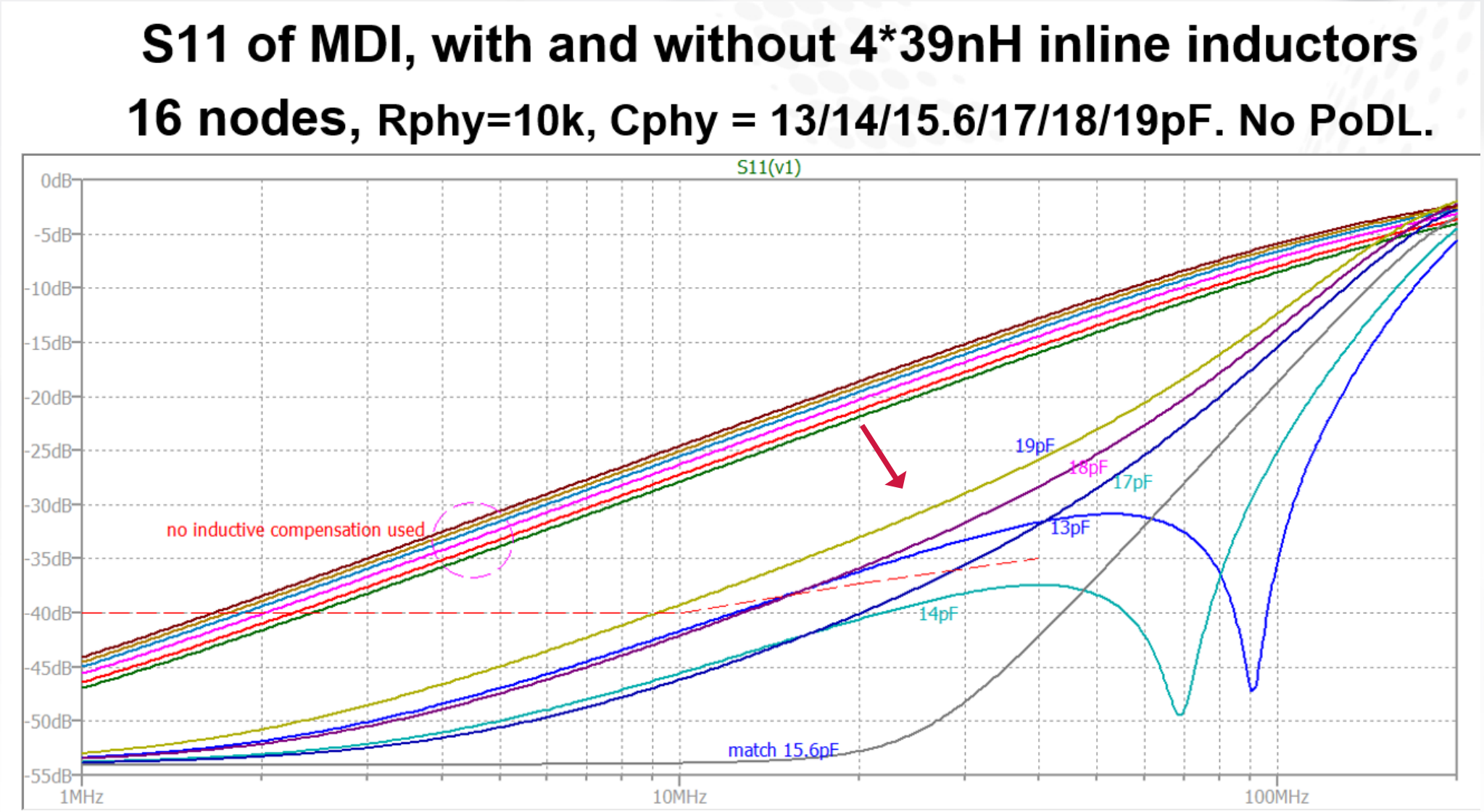
Dodanie cewek kompensujących do konektorów – Sdd11 (odbicia)



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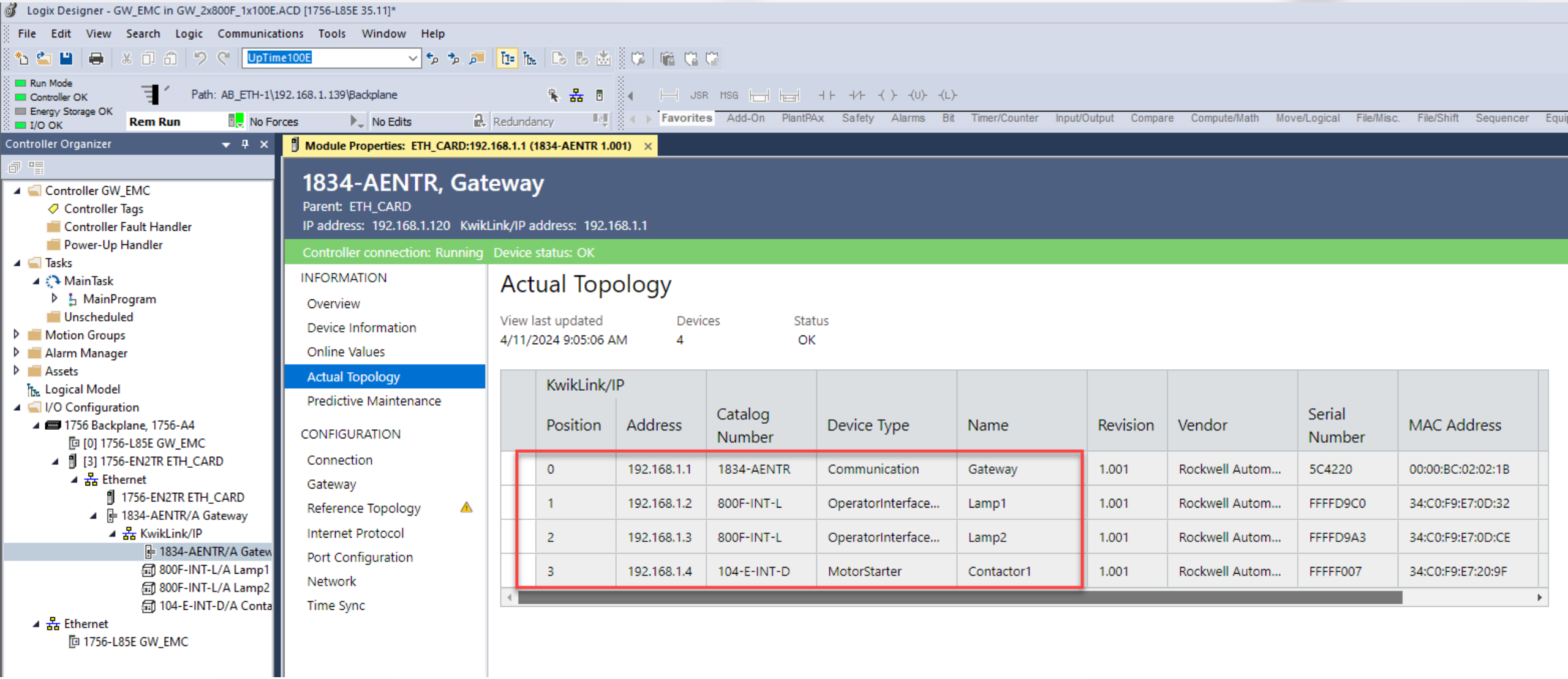
Live demo



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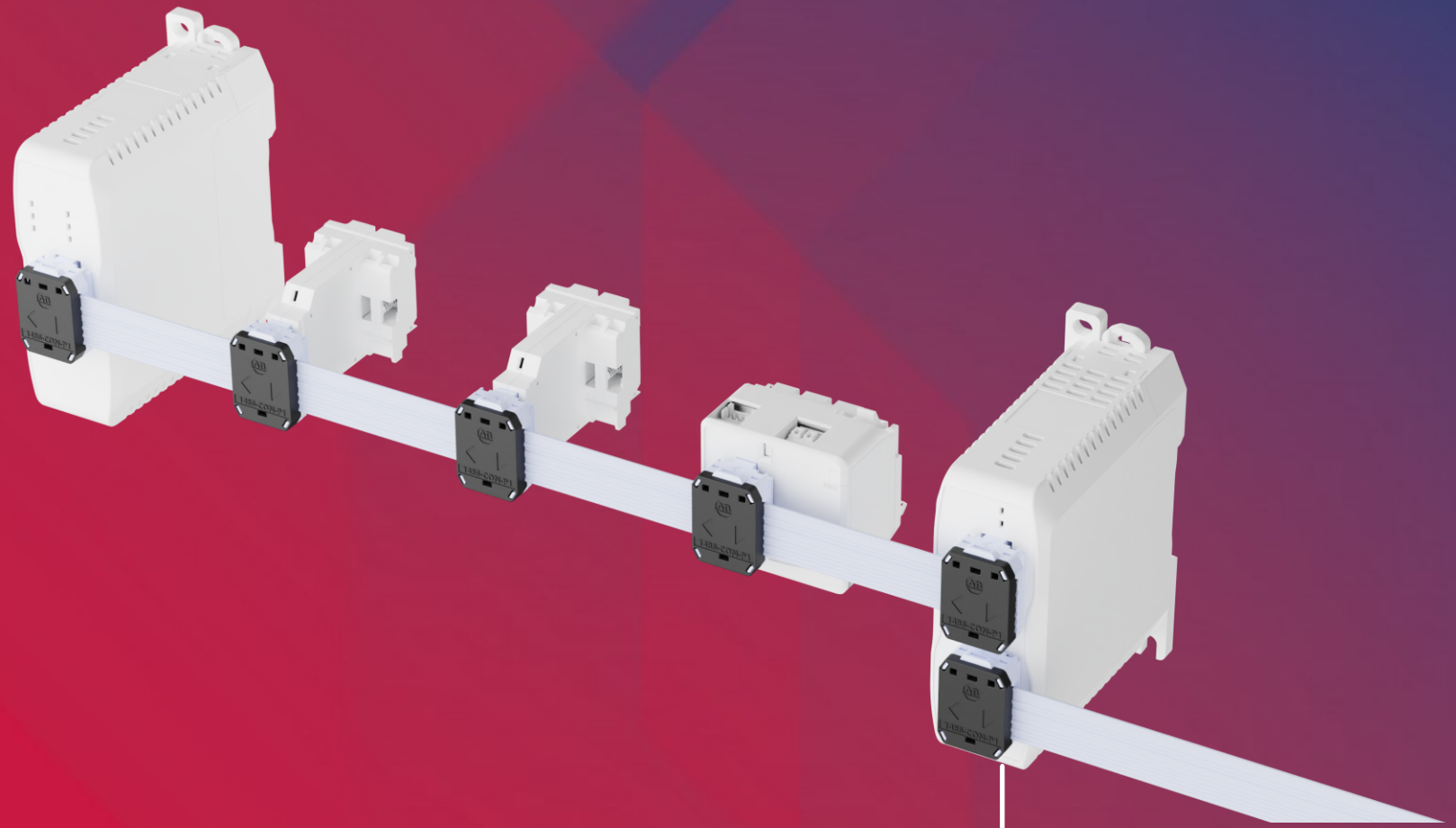

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