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Single Pair Ethernet Nowe sieci samochodowe i przemysłowe



PUBLIC

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Współautorzy

Dziękuję za wkład w niniejszą prezentację

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- Damian Loncierz [Sr. Mechanical Engineer] – grafiki systemu



Agenda

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Ethernet -
standardy,
zastosowania

2

10BASE-T1S
(IEEE802.3.cg)

3

Elektryczna
topologia sieci
10BASE-T1S

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Efektywność PLCA

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Skrętka a płaski
kabel

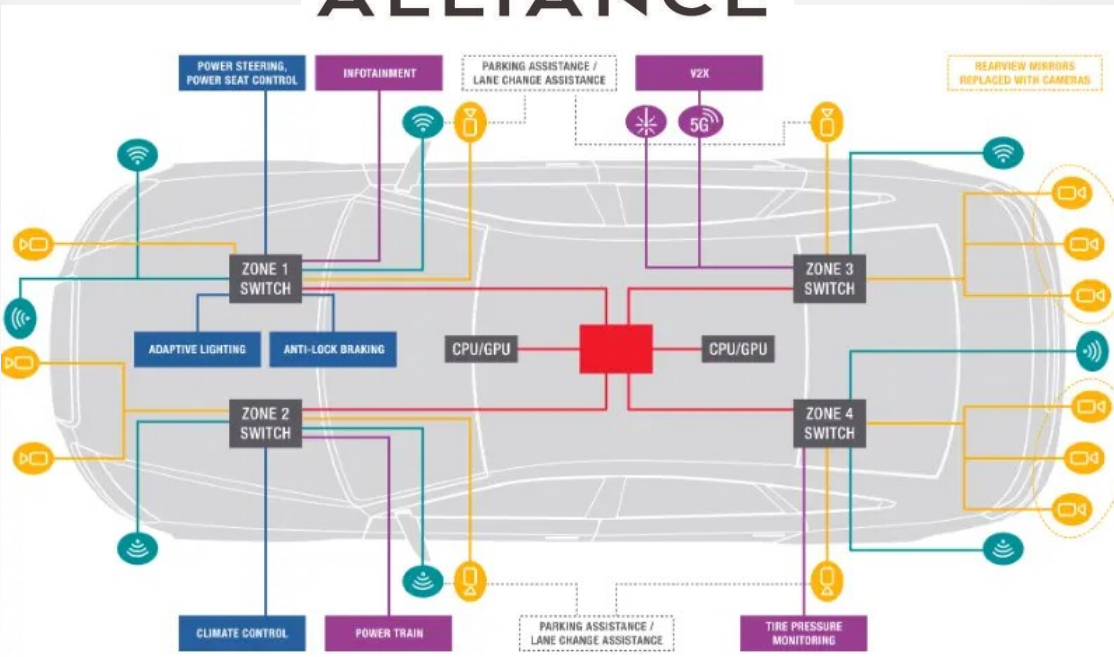
6

Problem gęsto
rozmieszczonych
odbiorników

7

Live demo

Ethernet w samochodach i przemyśle - standardy



• Źródło obrazka: Keysight

LEGEND	
CAN-FD OR 10 MBPS AUTOMOTIVE ETHERNET	100 MBPS AUTOMOTIVE ETHERNET
1 GBPS AUTOMOTIVE ETHERNET	10 GBPS AUTOMOTIVE ETHERNET
> 10 GBPS SERDES	RADAR
	LIDAR
	CAMERA



SMART DEVICES



Actuators

Sensors



Automation Control



Intelligent Motor Control



Components

Terminals

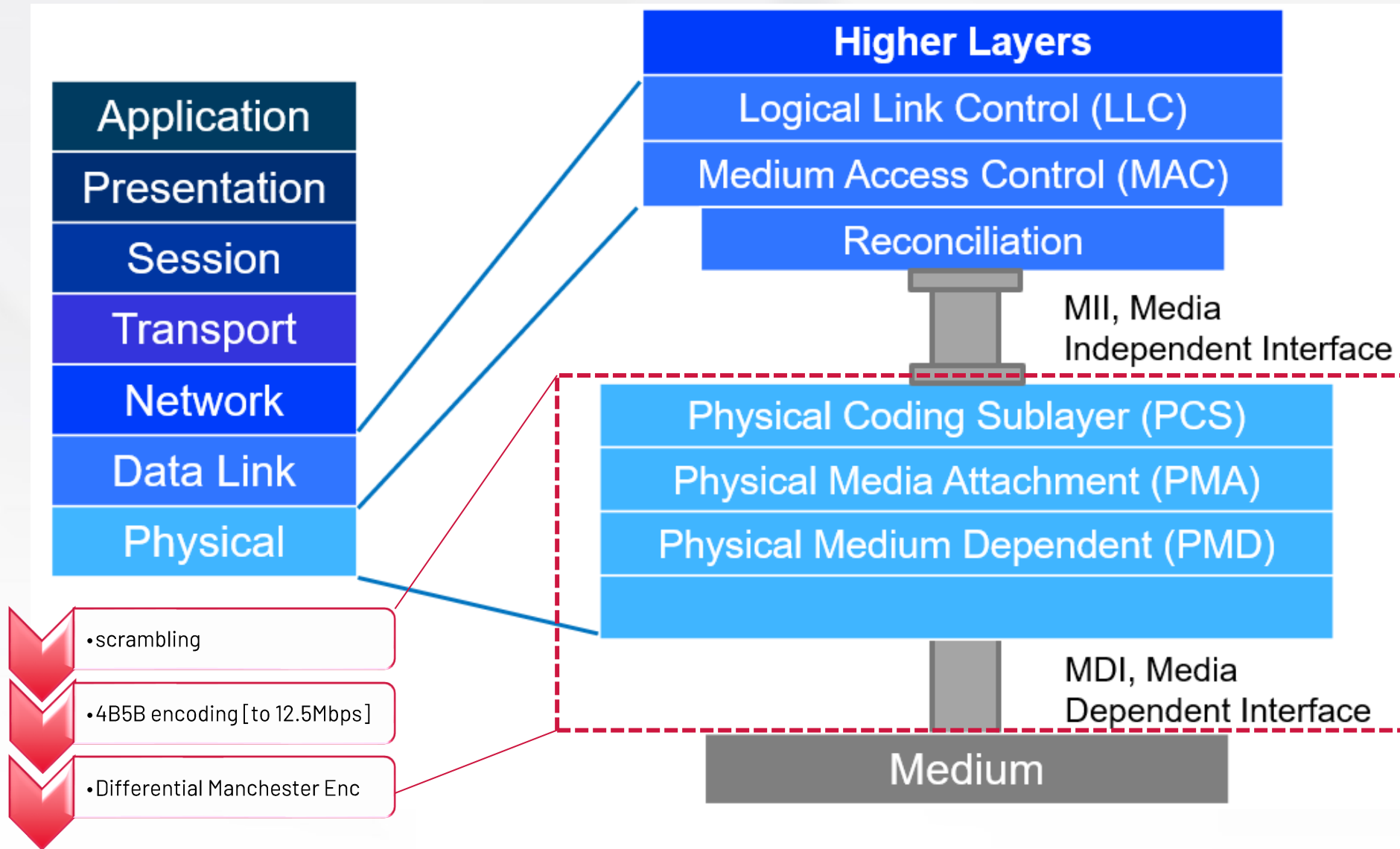


Po co sieć w szafie sterowniczej?

- Redukcja czasu złożenia
- Pełna konfigurowalność
- Zdalna diagnostyka



Ethernet – przewaga dzięki warstwom



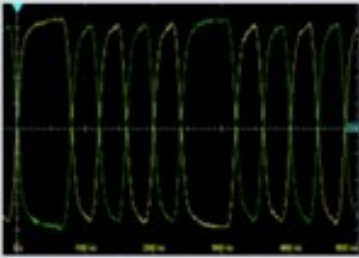
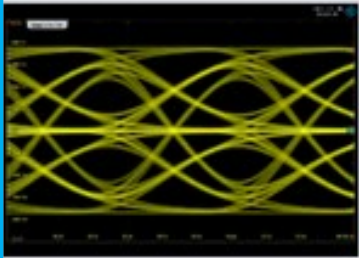
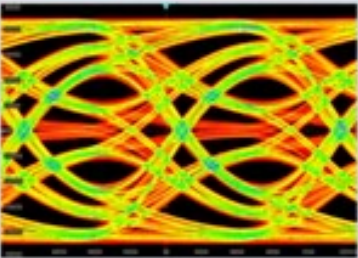
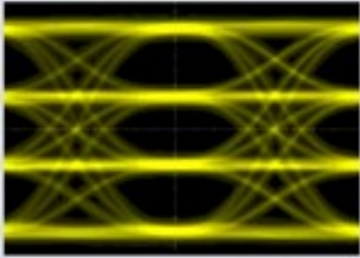
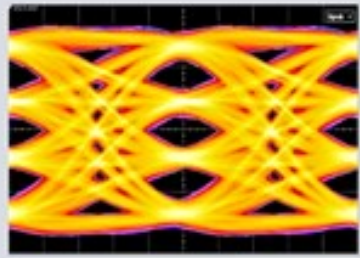
Podmienne warstwy fizyczne o różnych prędkościach np.:

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

- 100BASE-T
- 1000BASE-T

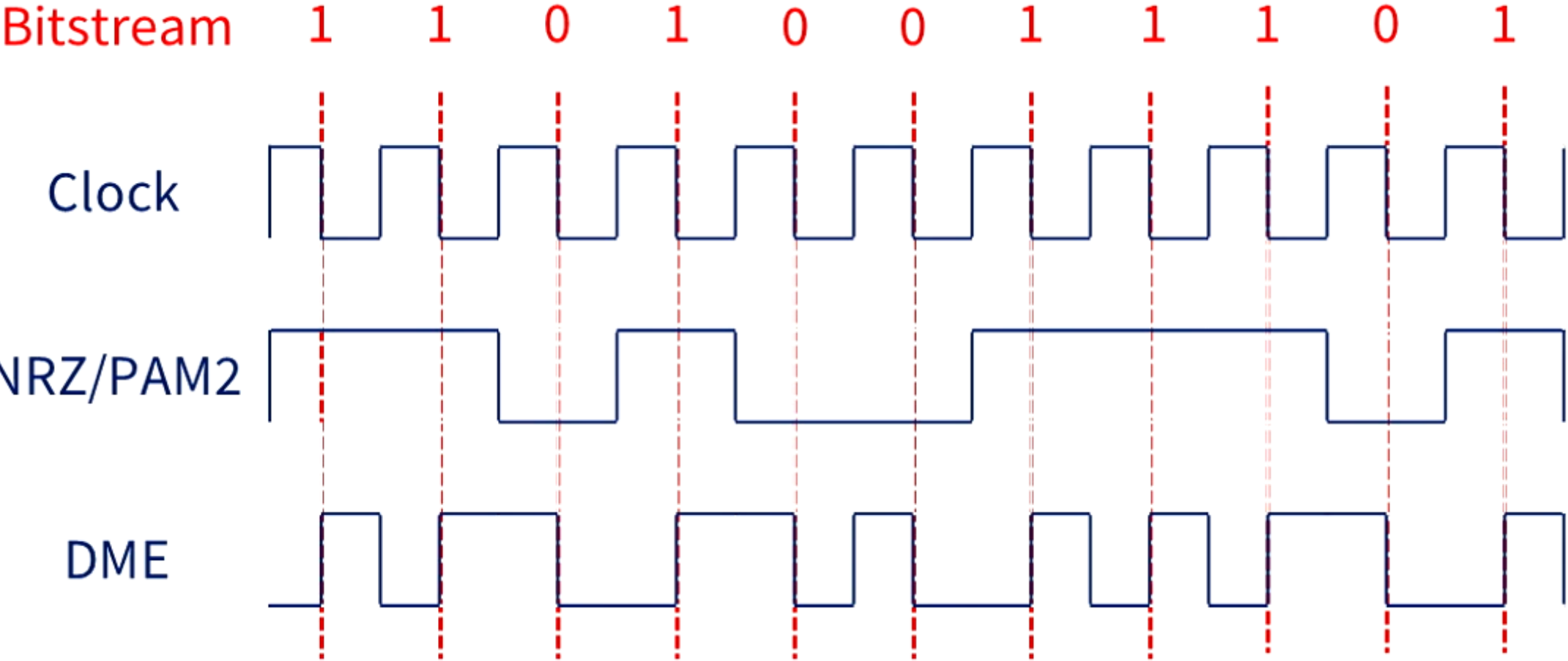
- 200GBASE-DR4 (światłowód)

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)

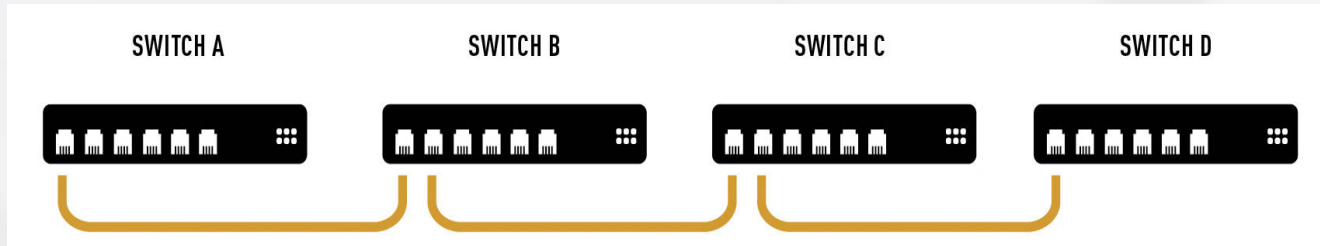
• Źródło obrazka: GRL

Differential Manchester Encoding – prosta synchronizacja odbiornika



• Źródło obrazka: GRL

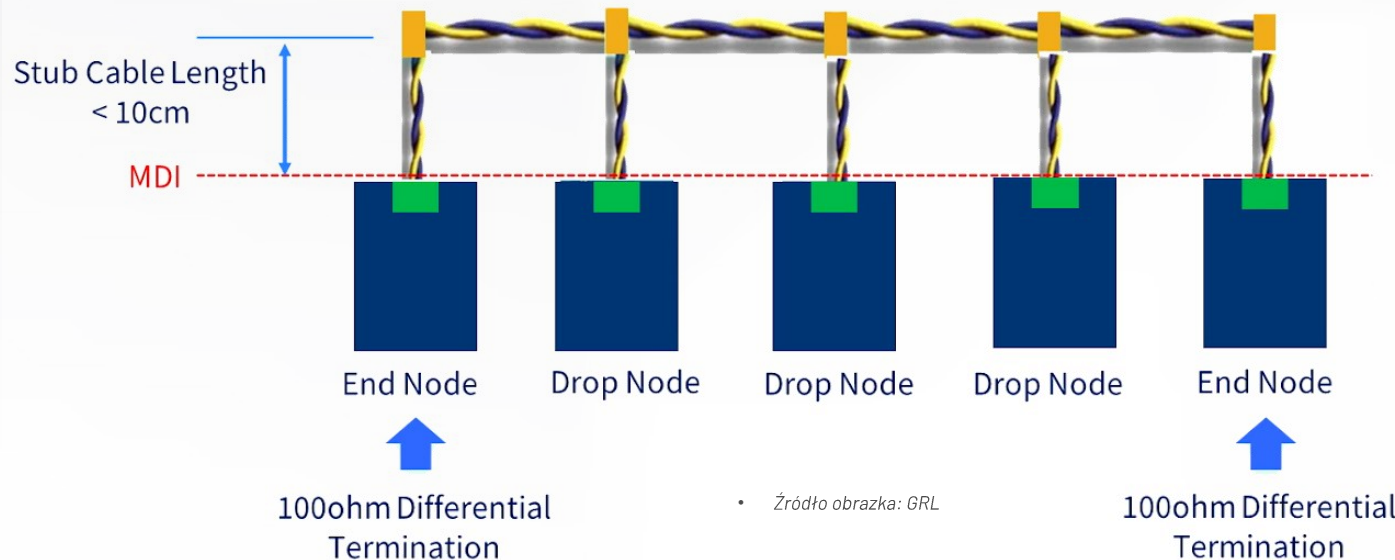
Ethernet dla najprostszycch urządzeń



• Źródło obrazka: Gigamedia

DOTYCHCZAS:

- Switch w każdym urządzeniu
- Wysoki koszt
- Duża moc



10BASE-T1S multi-drop:

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

Topologia sieci 10BASE-T1S, impedancje urządzeń

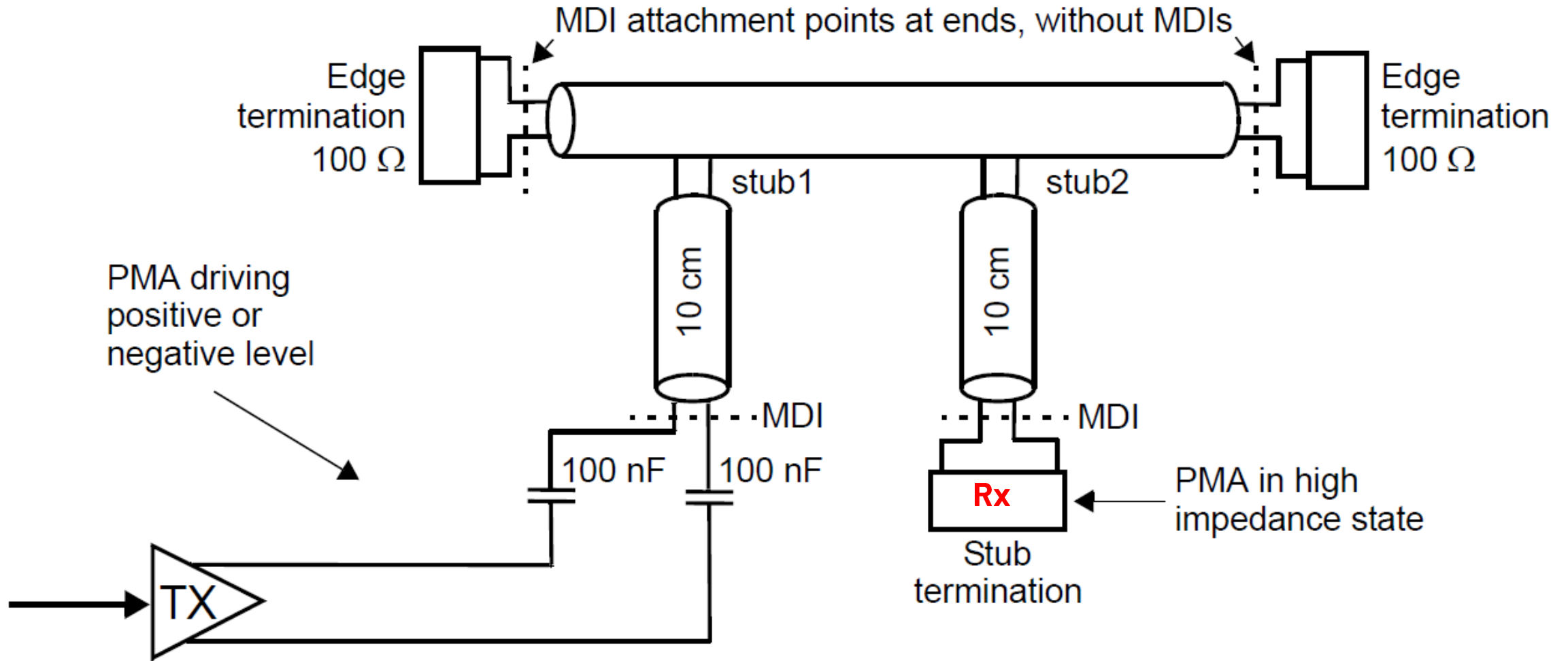
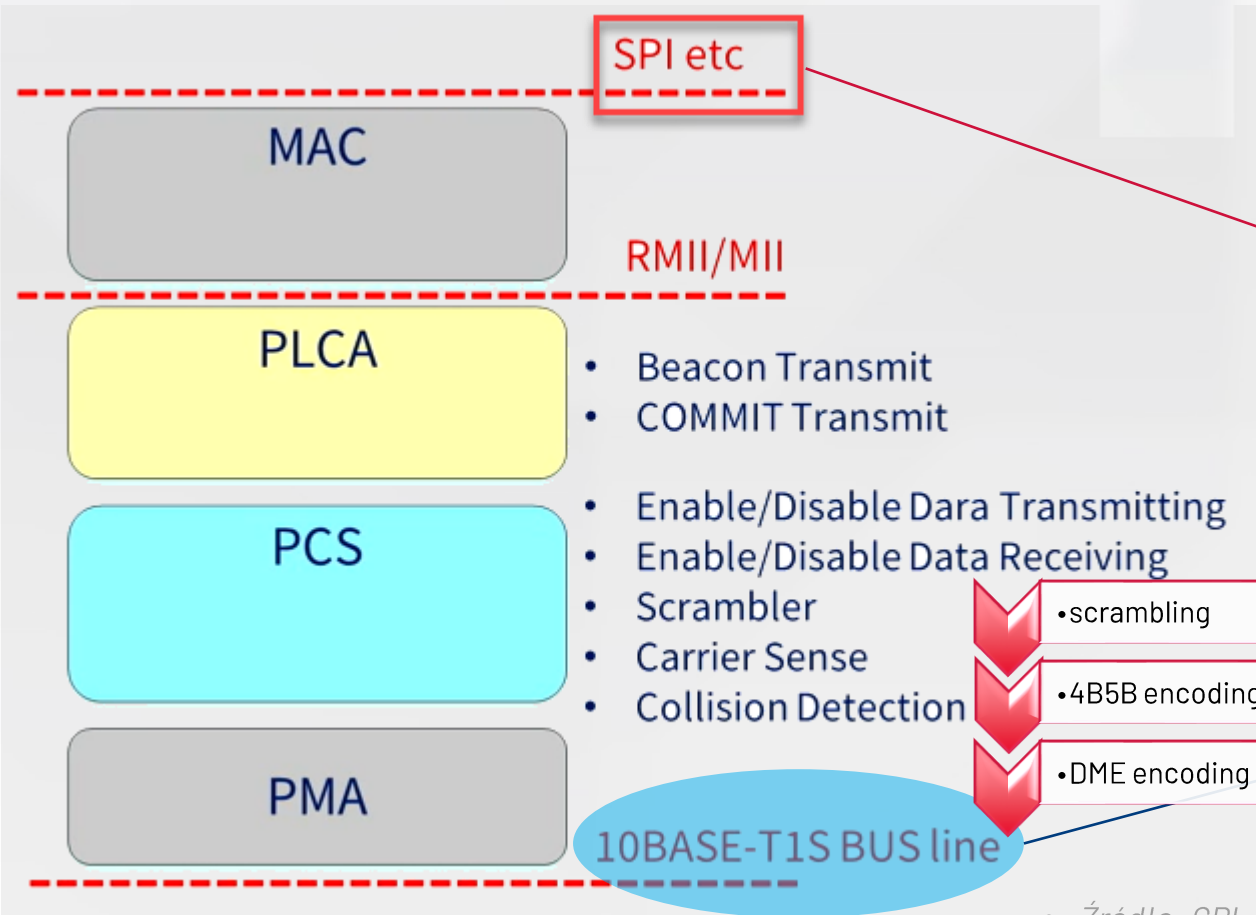
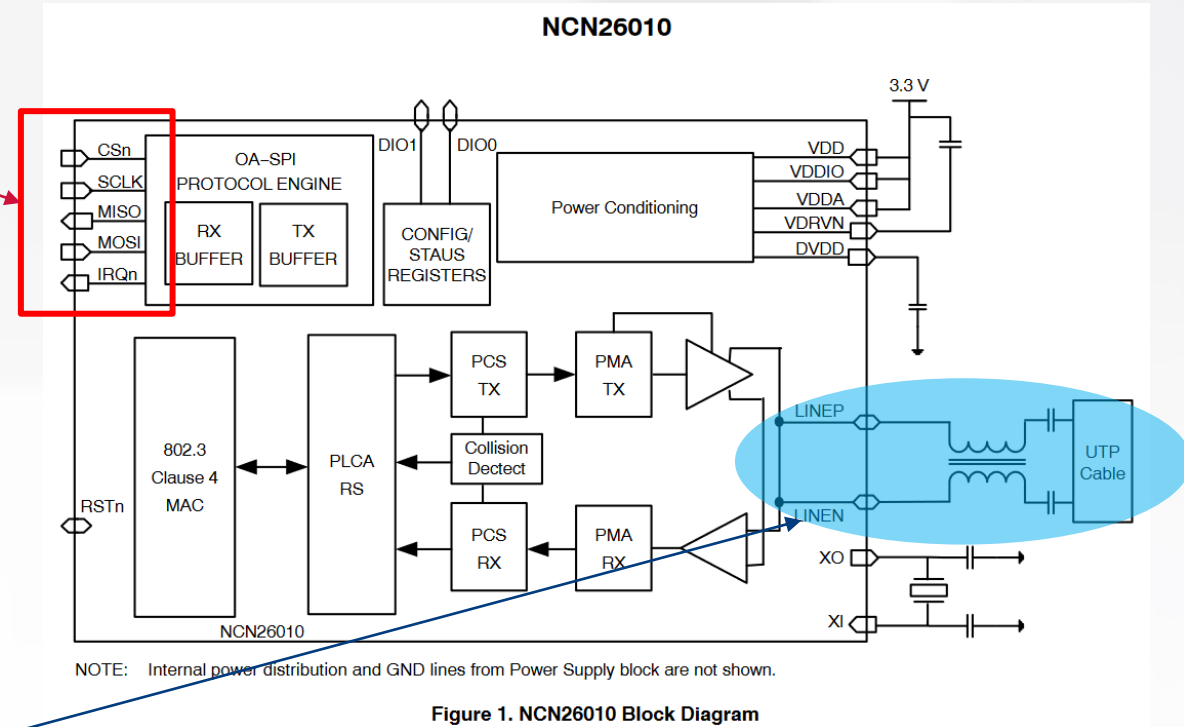


Figure 147-20—Multidrop line termination and PMA

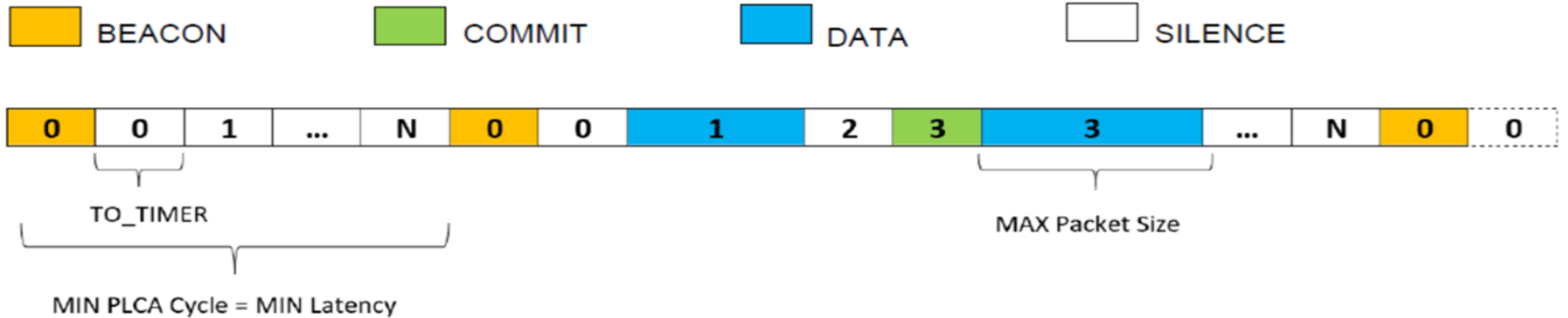
10BASE-T1S z interfejsem SPI?



• Źródło: GRL



PLCA – efektywna transmisja bez kolizji

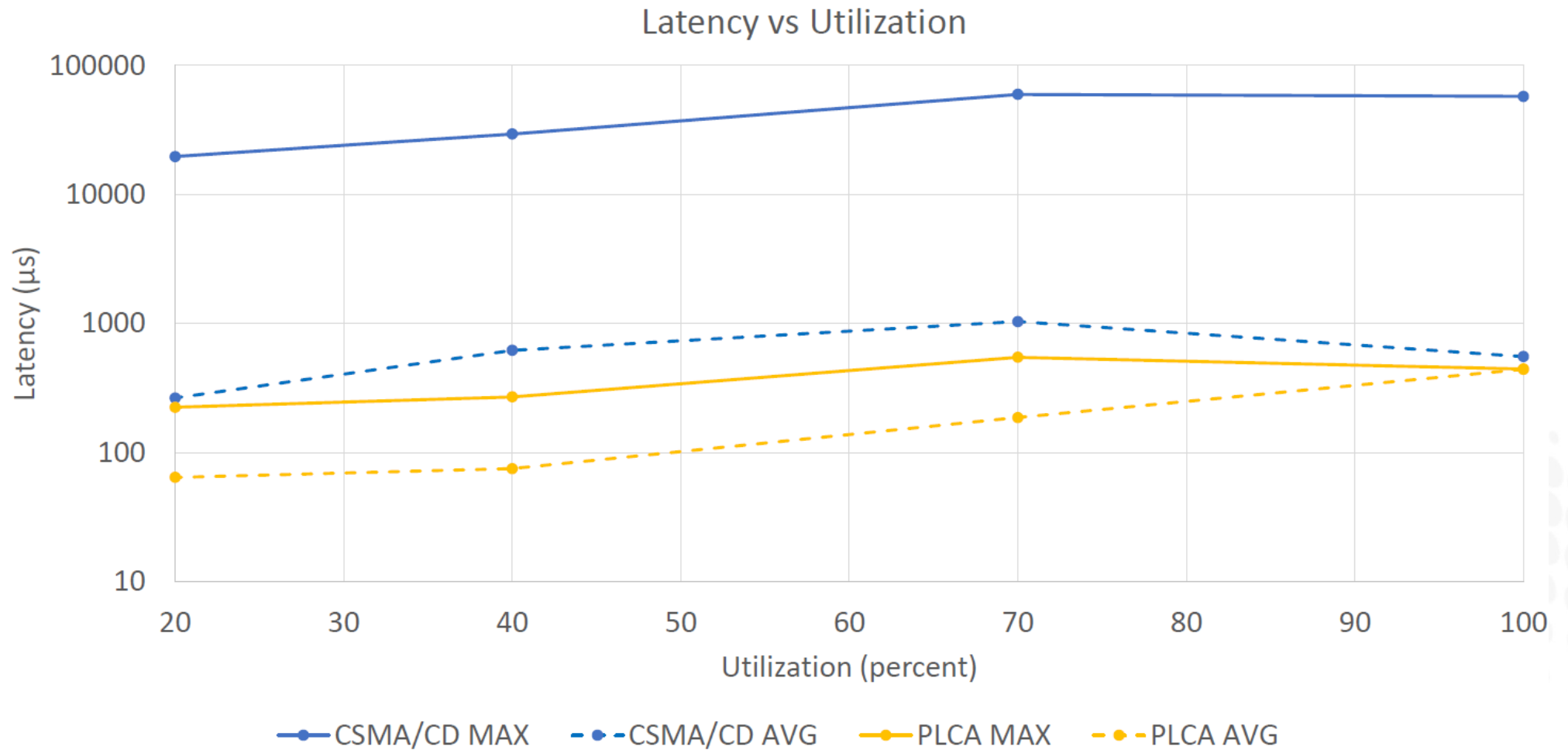


Minimum latency PLCA cycles. No one has anything to transmit in cycle 1, so total latency is equal only to the number of nodes times the TO_TIMER. Only Nodes 1 and 3 have transmissions in cycle 2, so all the other nodes cede their transmit opportunity. Node 1 immediately transmits DATA; Node 3 sends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



• Źródło obrazka:
Teledynelecroy.com

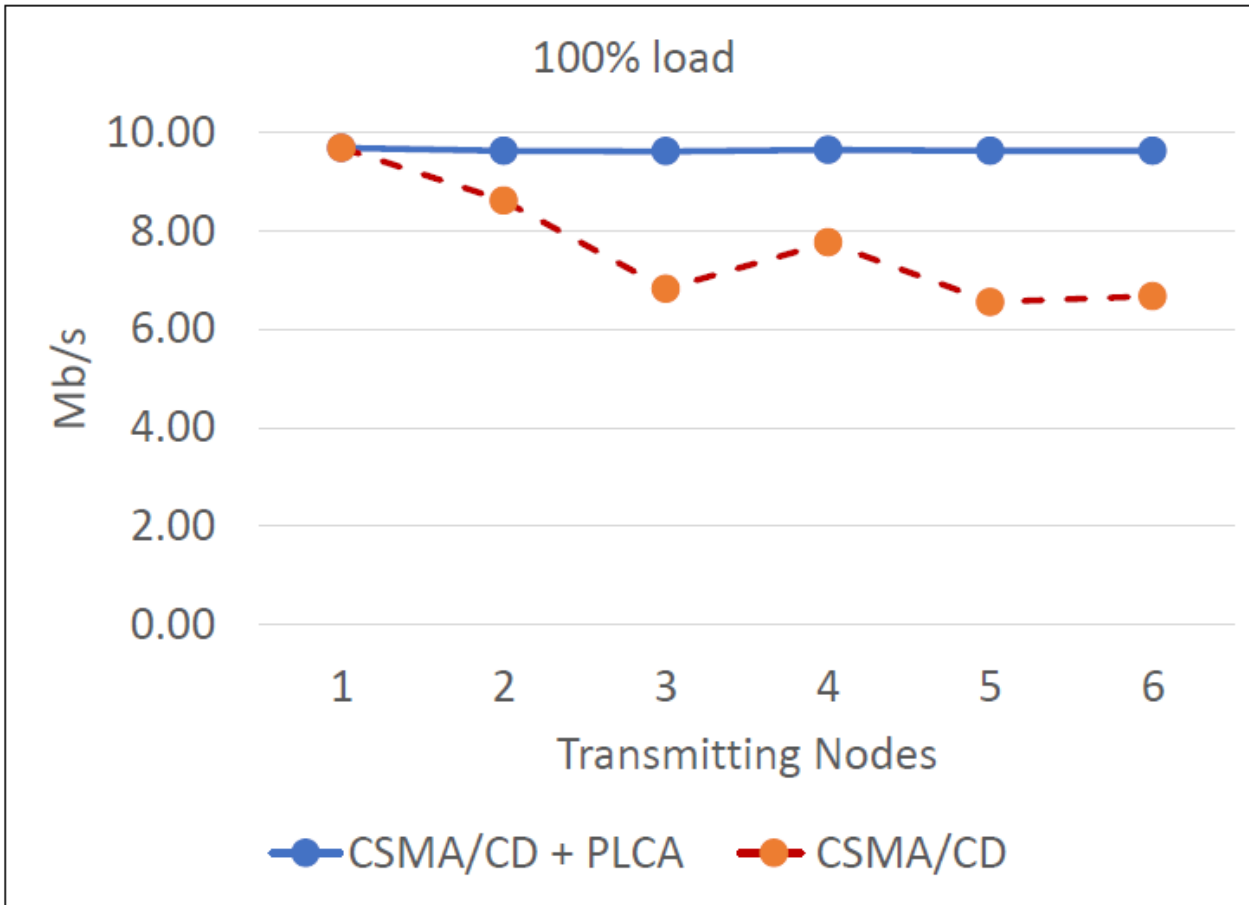
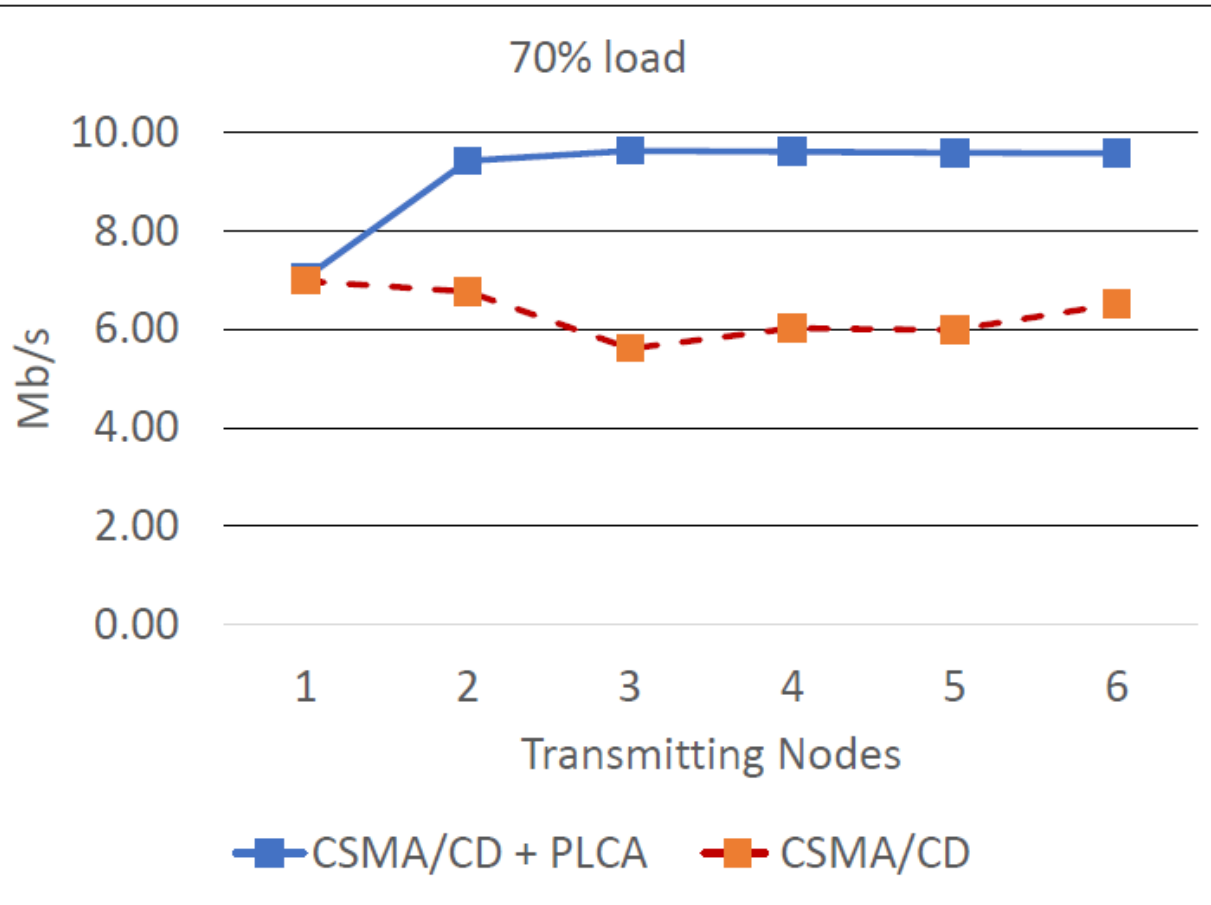
PLCA performance: latency vs utilization



* Simulation example – bandwidth varies

IEEE P802.3cg 10Mb/s Single Pair Ethernet Task Force – Jan 2018 Interim, Long Beach, CA USA

PLCA performance: bandwidth

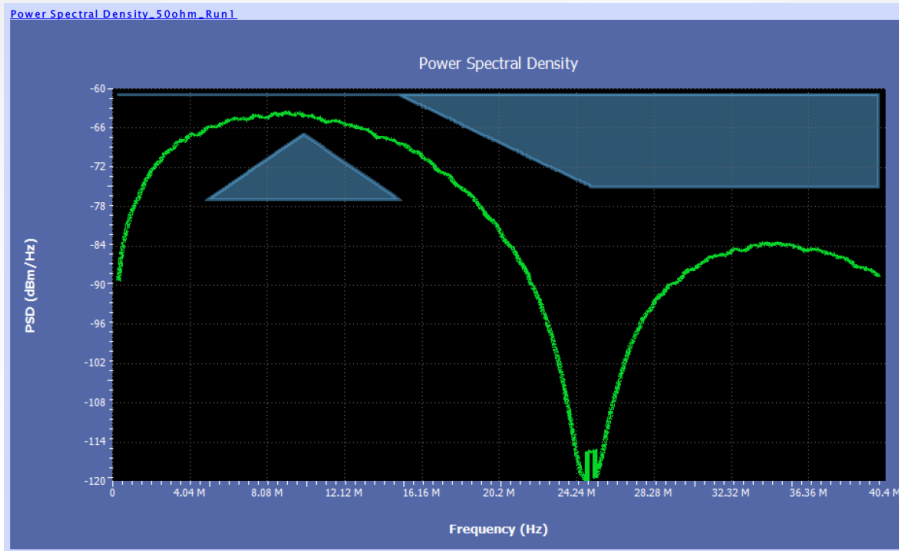


* Simulation example – bandwidth varies

Wymagania elektryczne dotyczące kanału i urządzeń

Table 147-4—MDI impedance limit parameters

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



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

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

where

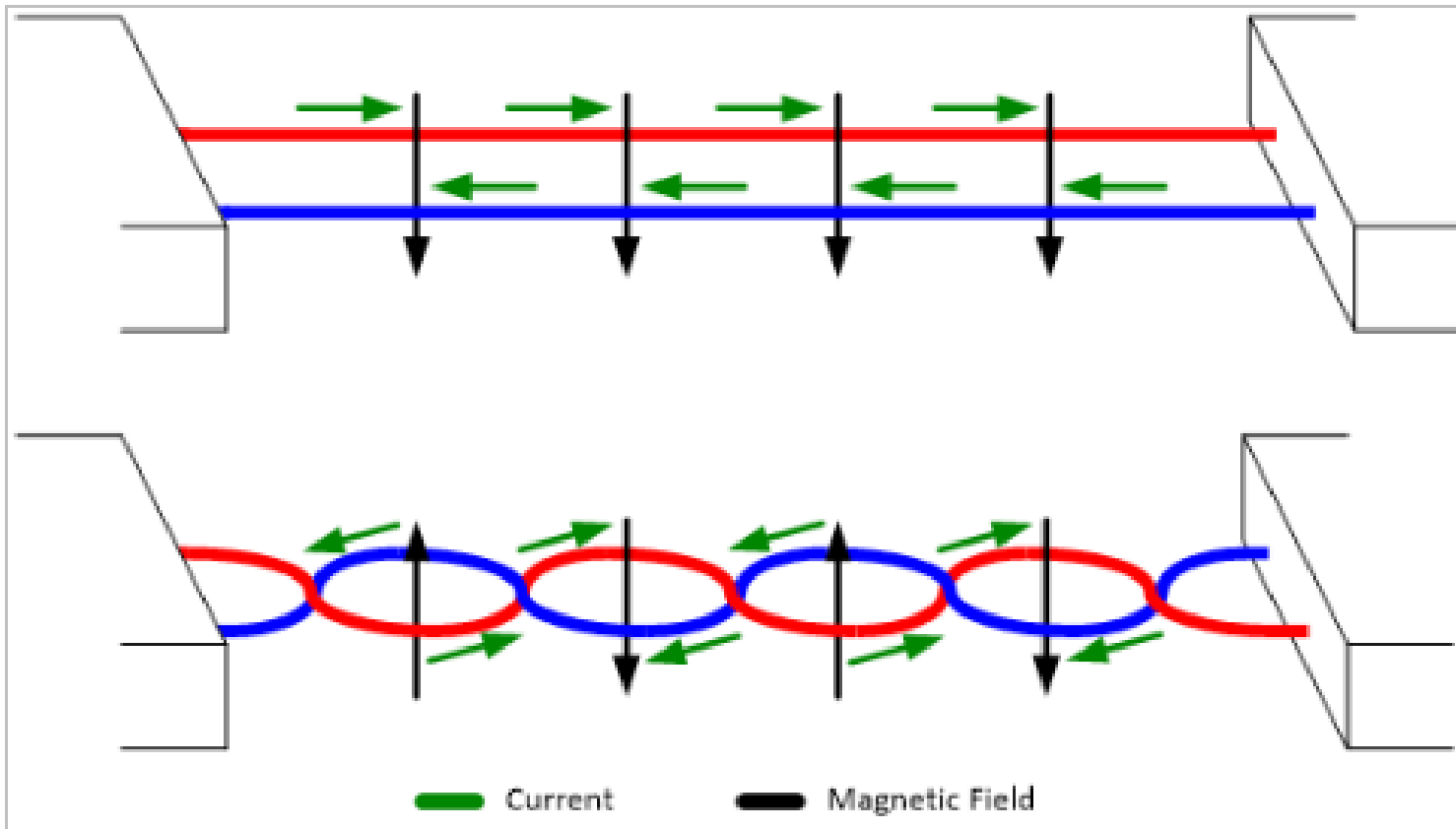
f is the frequency in MHz; $0.3 \leq f \leq 40$

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

where

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

Emisja i odporność - przewaga skrętki UTP/STP



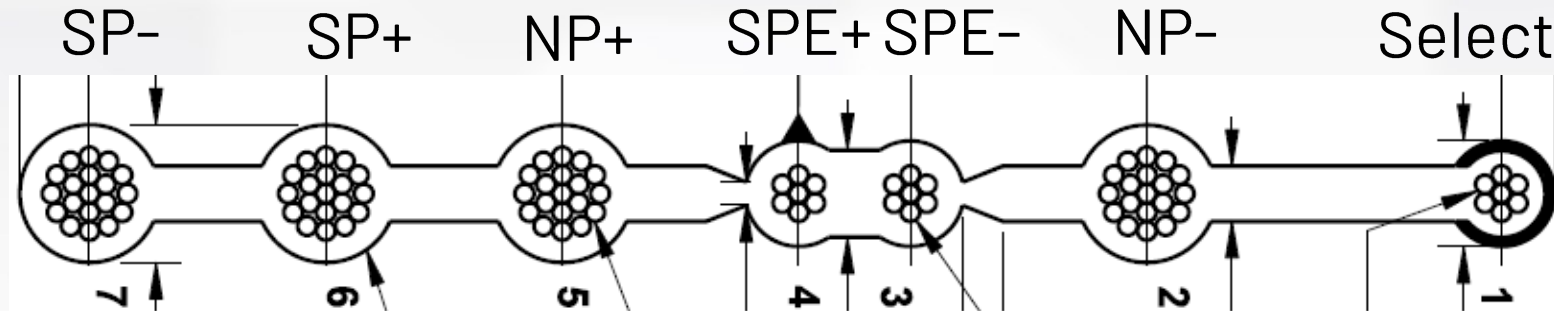
- Redukcja sprzężenia indukcyjnego
- symetryzacja impedancji

• Źródło: emianalyst

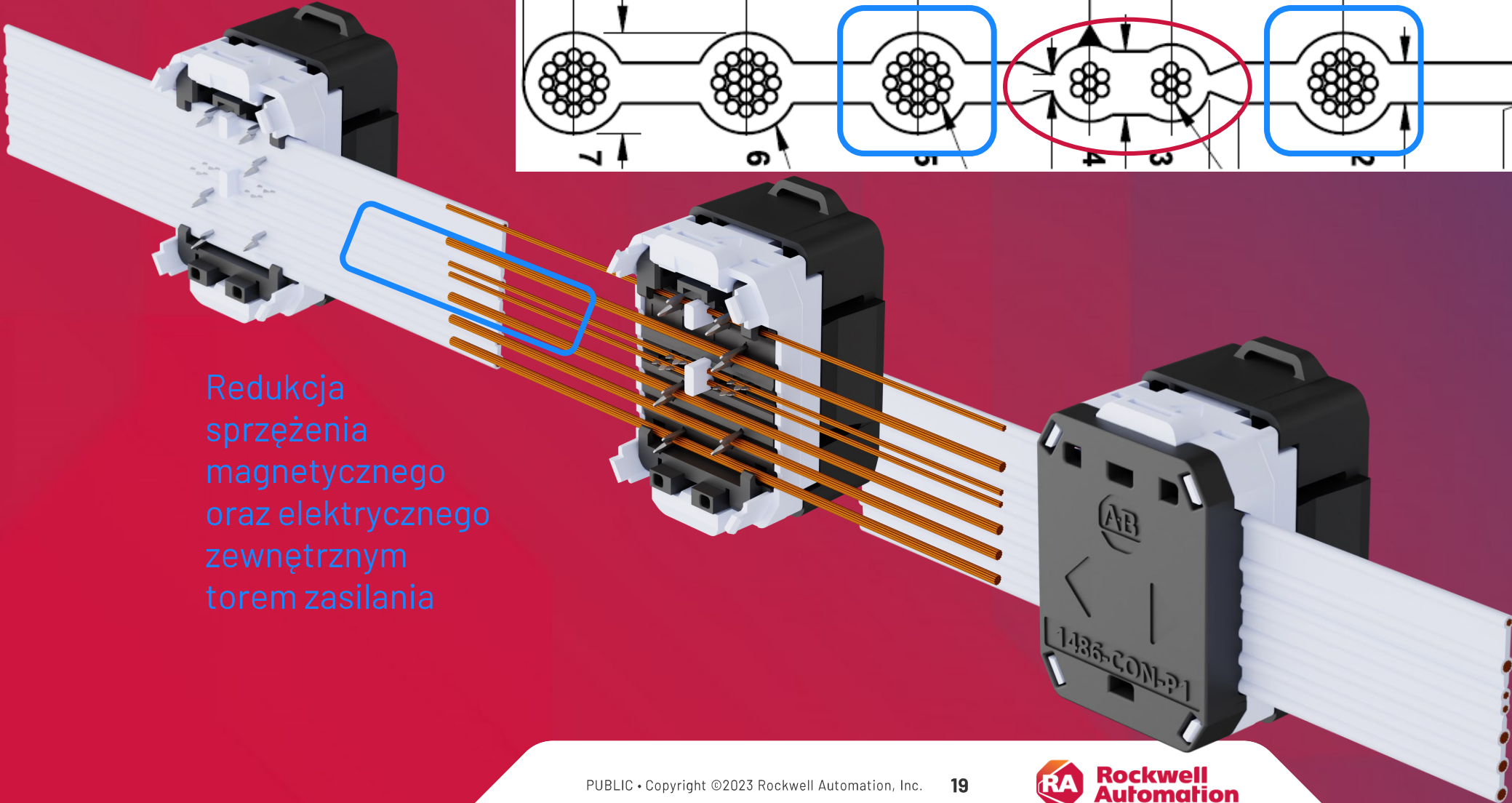
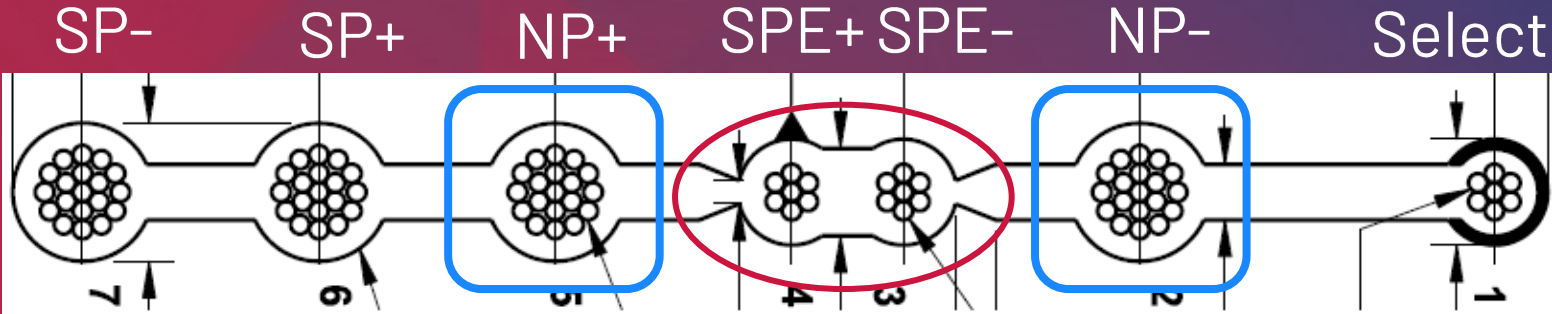
ODVA – płaski kabel dla prostoty montażu

Czy może zastąpić popularną skrętkę?

- SPE+, SPE- dla różnicowej transmisji, $Z_0 = 100 \Omega$
- 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



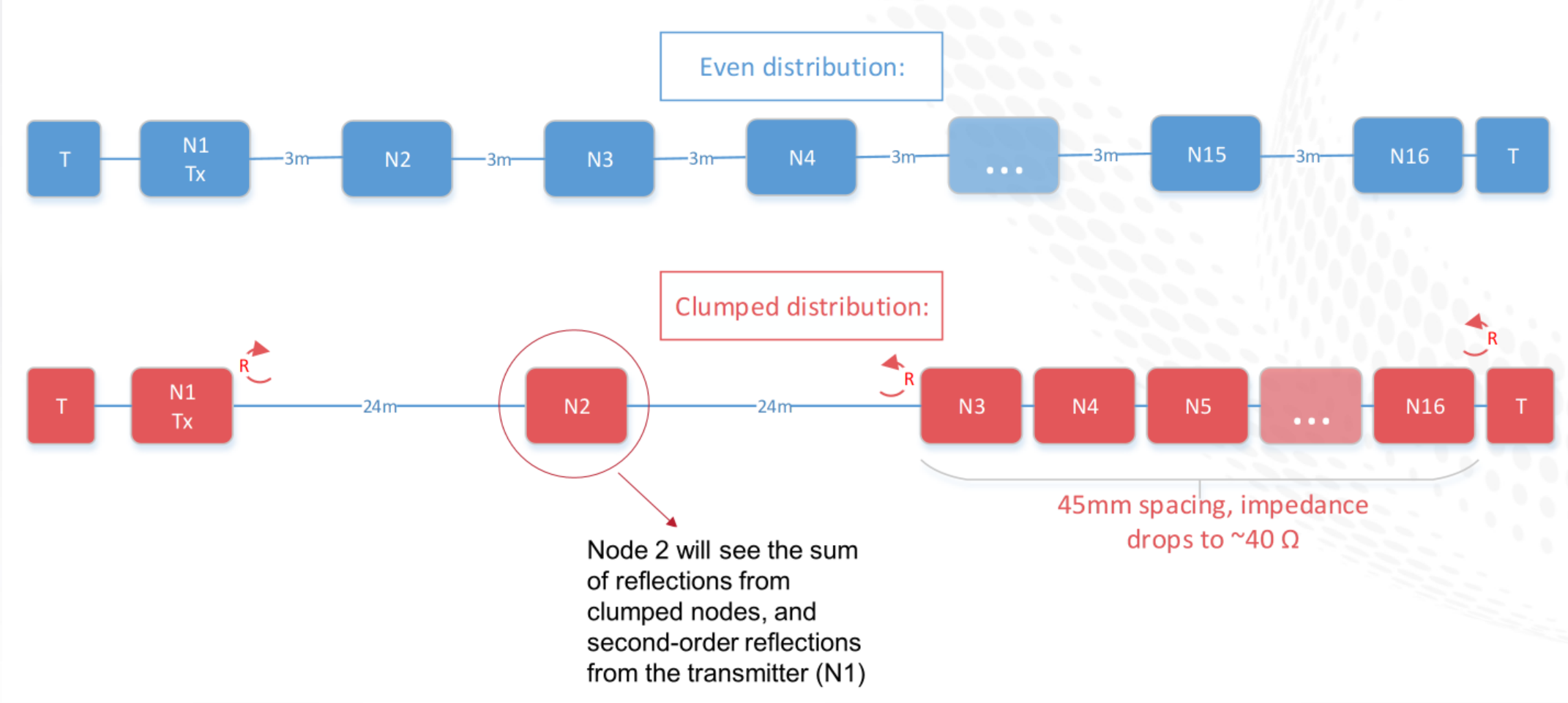
EMC z płaskim kablem?



Redukcja
sprężenia
magnetycznego
oraz elektrycznego
zewnętrznym
torem zasilania

Limit urządzeń w sieci – zależny od topologii

Skupiska urządzeń powodują odbicia sygnału



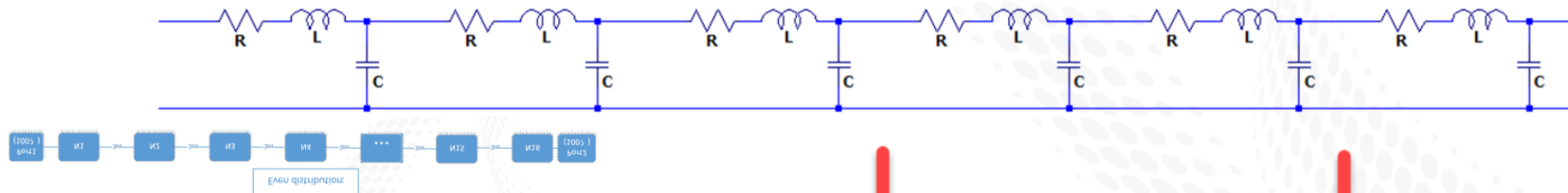
Limit urządzeń w sieci – zależny od topologii

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

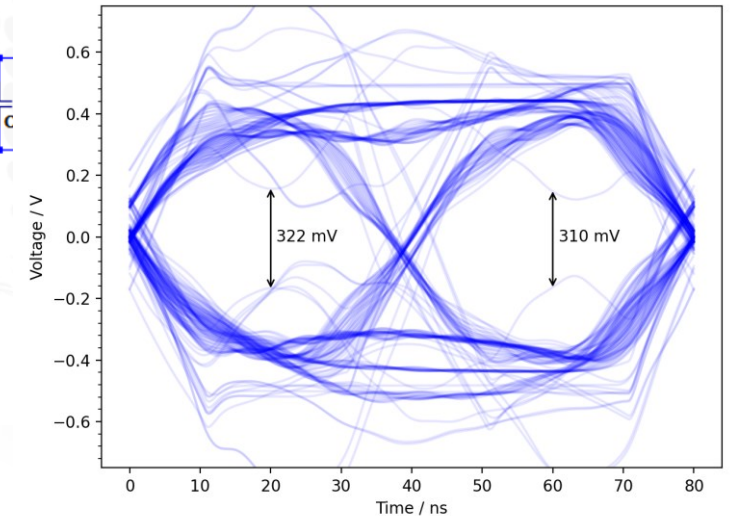
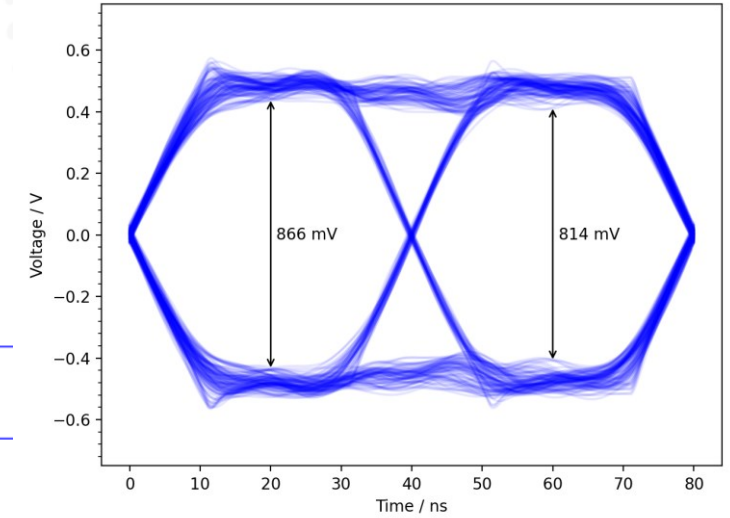
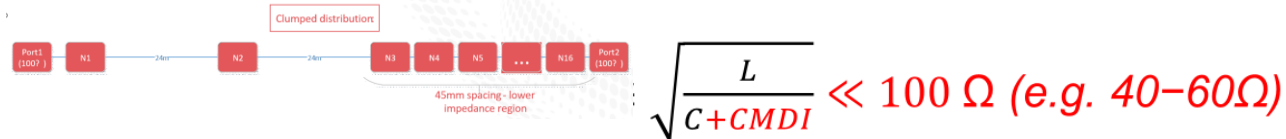
Impedance drop in clumped nodes regions

Cable model

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

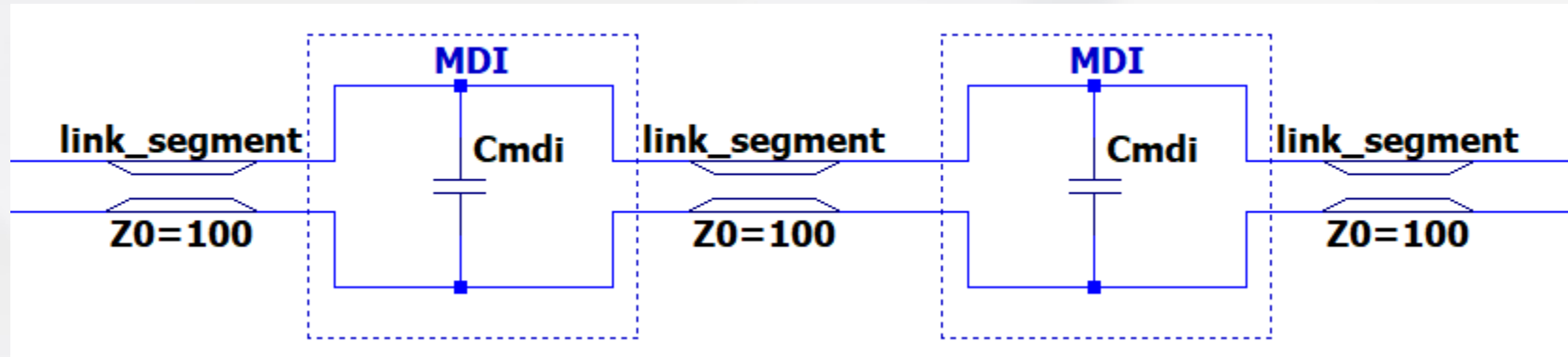


Cable with clumped drop nodes model

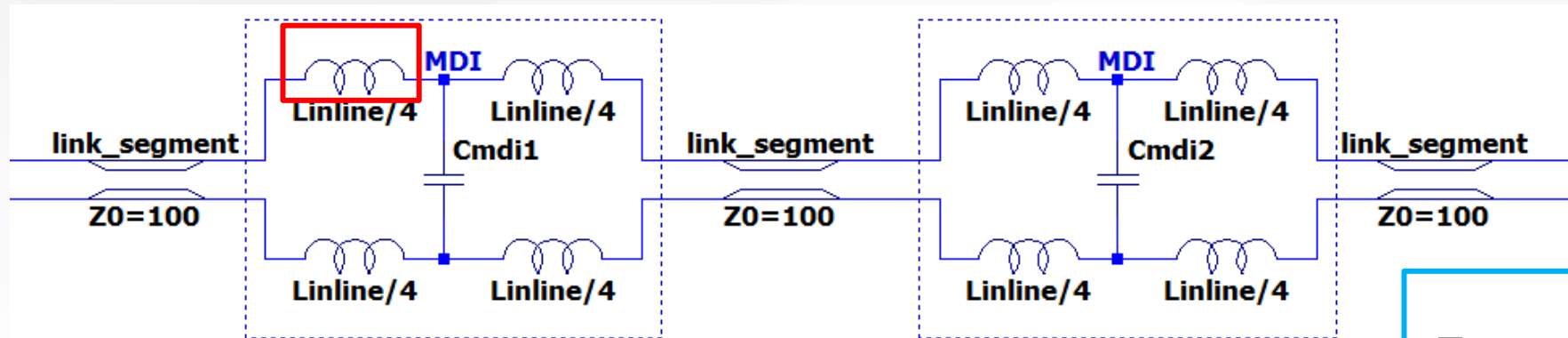


Limit urządzeń w sieci – jak z 8 urządzeń osiągnęliśmy 40?

Skupiska urządzeń powodują odbicia sygnału

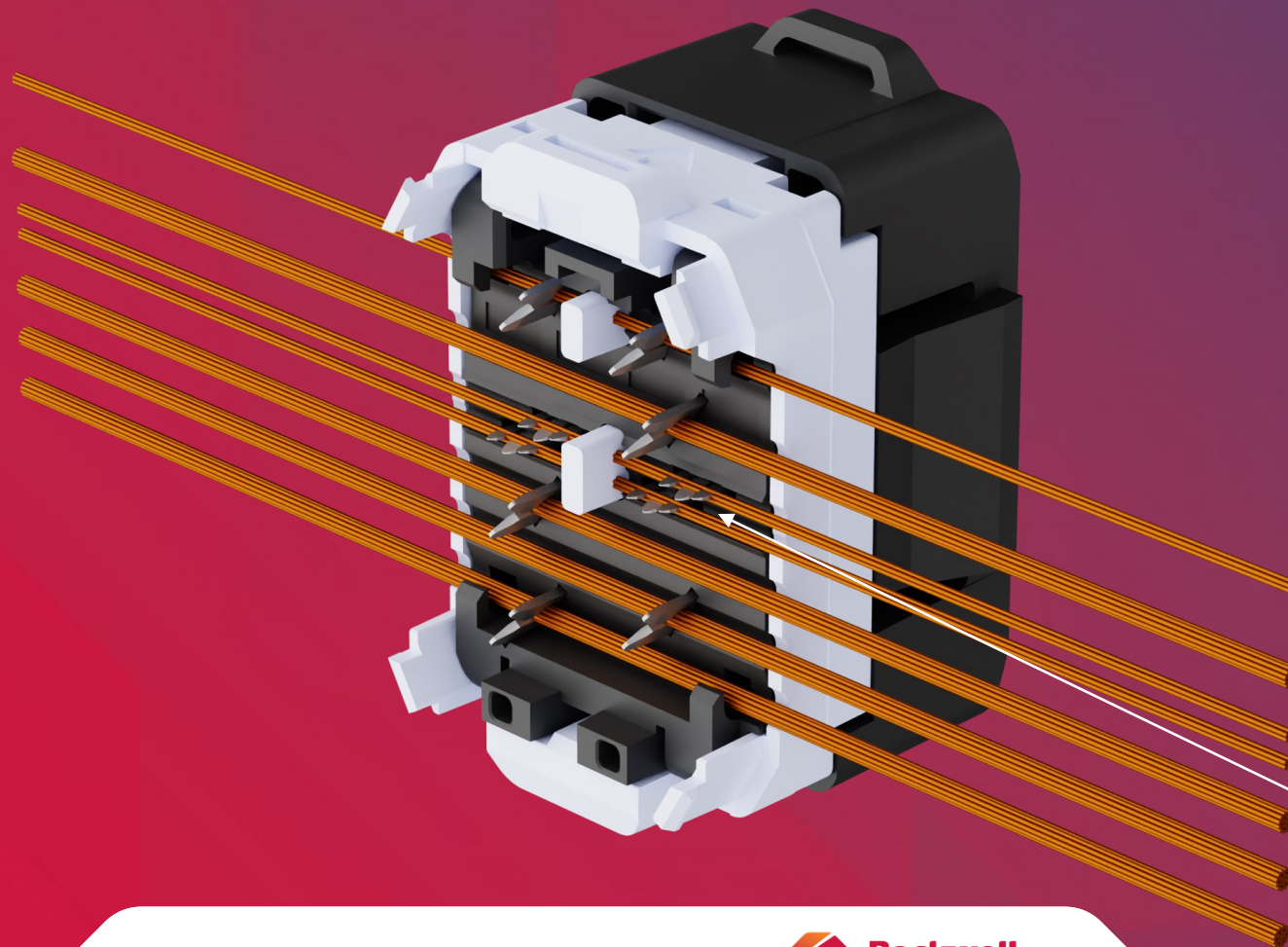


$$Z_0 = \sqrt{\frac{L}{C + C_{MDI}}} < 100 \Omega$$



$$Z_0 = \sqrt{\frac{L + L_{inline}}{C + C_{MDI}}} = 100 \Omega$$

Przykładowy system Ethernet IP in-cabinet



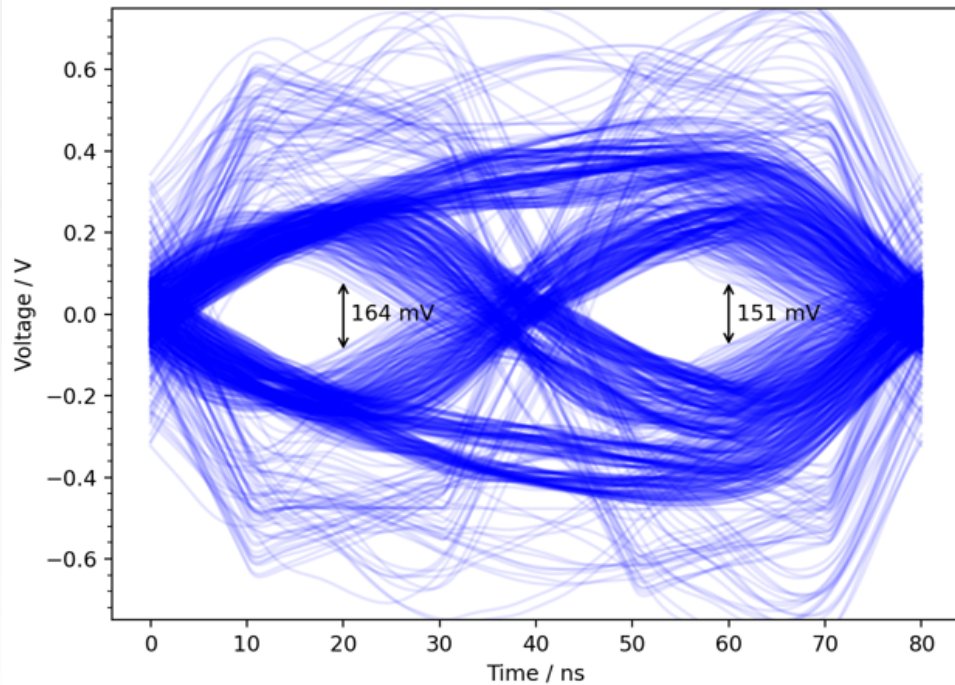
Przecinamy
magistralę SPE,
wstawiamy cewki
kompensujące

Dodanie cewek kompensujących do konektorów

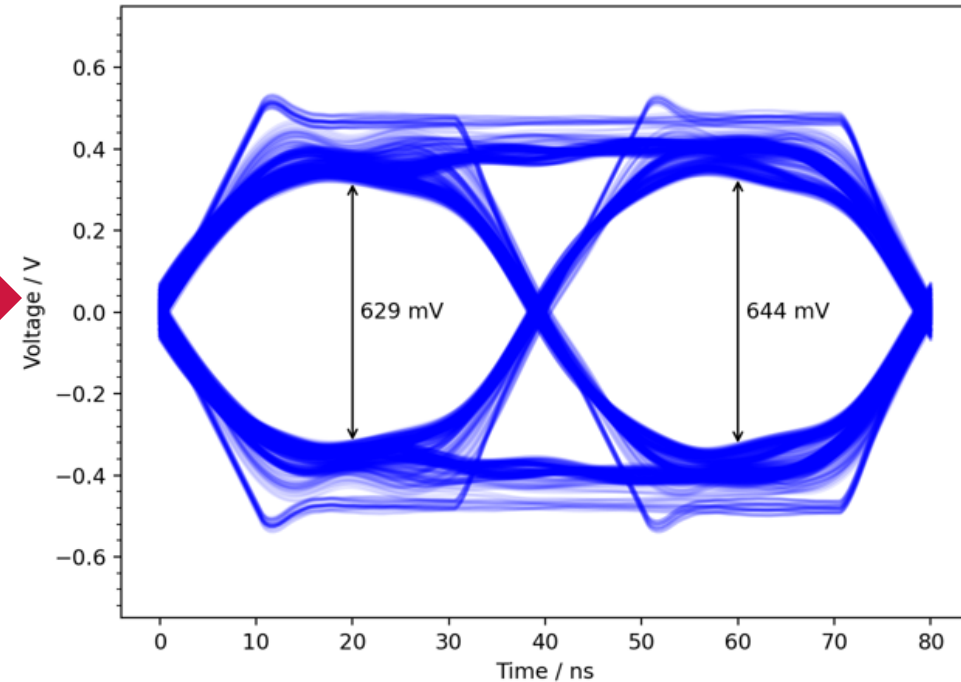
Eye diagrams, clumped distribution

$R=10\text{k}\Omega$, $C=25\text{pF}$ ($L_{\text{ind}}=4*65\text{nH}$), $L=N/A$ (without PoDL)

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



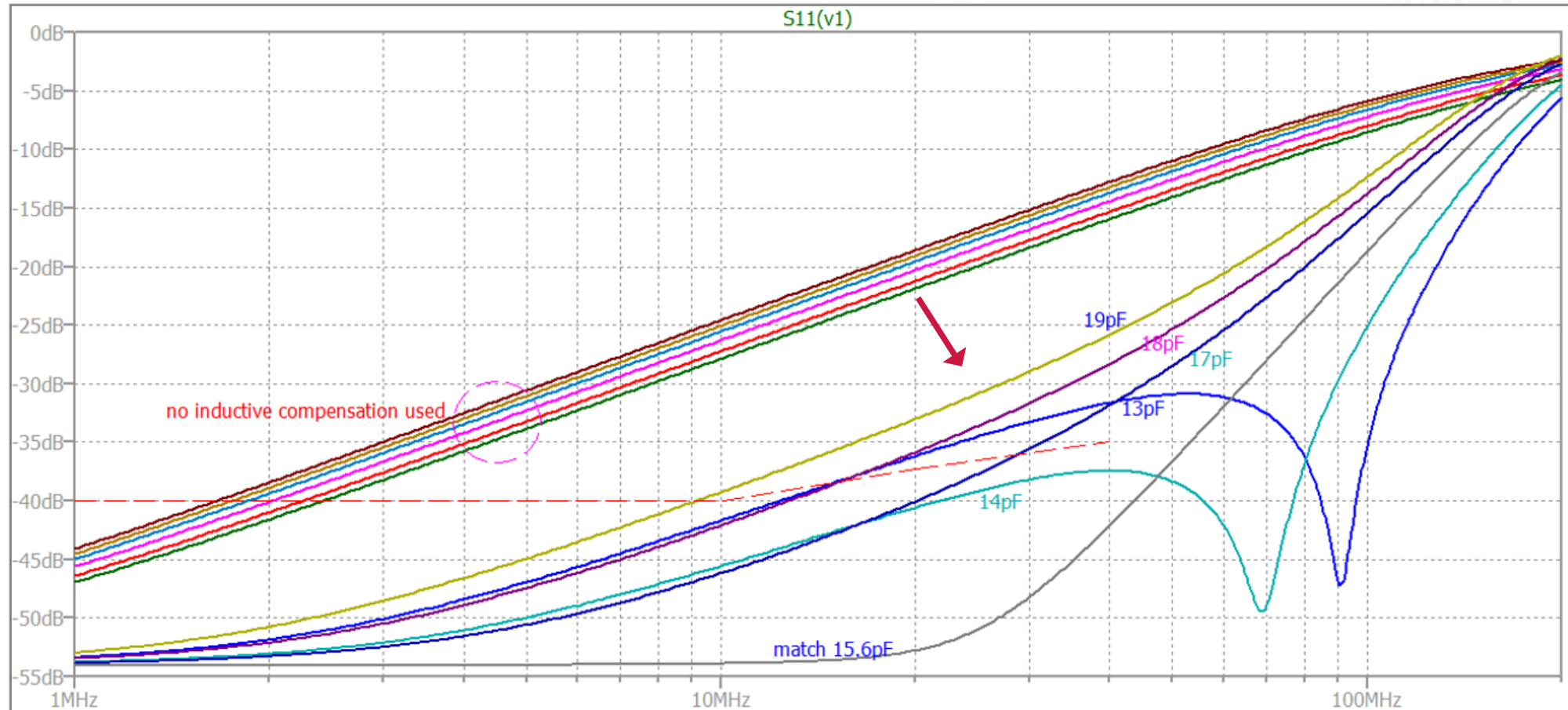
no inline inductors



with inline inductors

Dodanie cewek kompensujących do konektorów – Sdd11 (odbicia)

S11 of MDI, with and without 4*39nH inline inductors
16 nodes, Rphy=10k, Cphy = 13/14/15.6/17/18/19pF. No PoDL.



Live demo

Logix Designer - GW_EMC in GW_2x800F_1x100E.ACD [1756-L85E 35.11]*

File Edit View Search Logic Communications Tools Window Help

Run Mode
 Controller OK
 Energy Storage OK
 I/O OK

Path: AB_ETH-1\192.168.1.139\Backplane

Rem Run No Forces No Edits Redundancy Favorites Add-On PlantPAX Safety Alarms Bit Timer/Counter Input/Output Compare Compute/Math Move/Logical File/Misc. File/Shift Sequencer Equi

Controller Organizer

- Controller GW_EMC
 - Controller Tags
 - Controller Fault Handler
 - Power-Up Handler
- Tasks
 - MainTask
 - MainProgram
 - Unscheduled
 - Motion Groups
 - Alarm Manager
 - Assets
 - Logical Model
 - I/O Configuration
 - 1756 Backplane, 1756-A4
 - [0] 1756-L85E GW_EMC
 - [3] 1756-EN2TR ETH_CARD
 - Ethernet
 - 1756-EN2TR ETH_CARD
 - 1834-AENTR/A Gateway
 - KwikLink/IP
 - 1834-AENTR/A Gatew
 - 800F-INT-L/A Lamp1
 - 800F-INT-L/A Lamp2
 - 104-E-INT-D/A Conta

Module Properties: ETH_CARD:192.168.1.1 (1834-AENTR 1.001)

1834-AENTR, Gateway

Parent: ETH_CARD
 IP address: 192.168.1.120 KwikLink/IP address: 192.168.1.1

Controller connection: Running Device status: OK

INFORMATION

- Overview
- Device Information
- Online Values
- Actual Topology**
- Predictive Maintenance

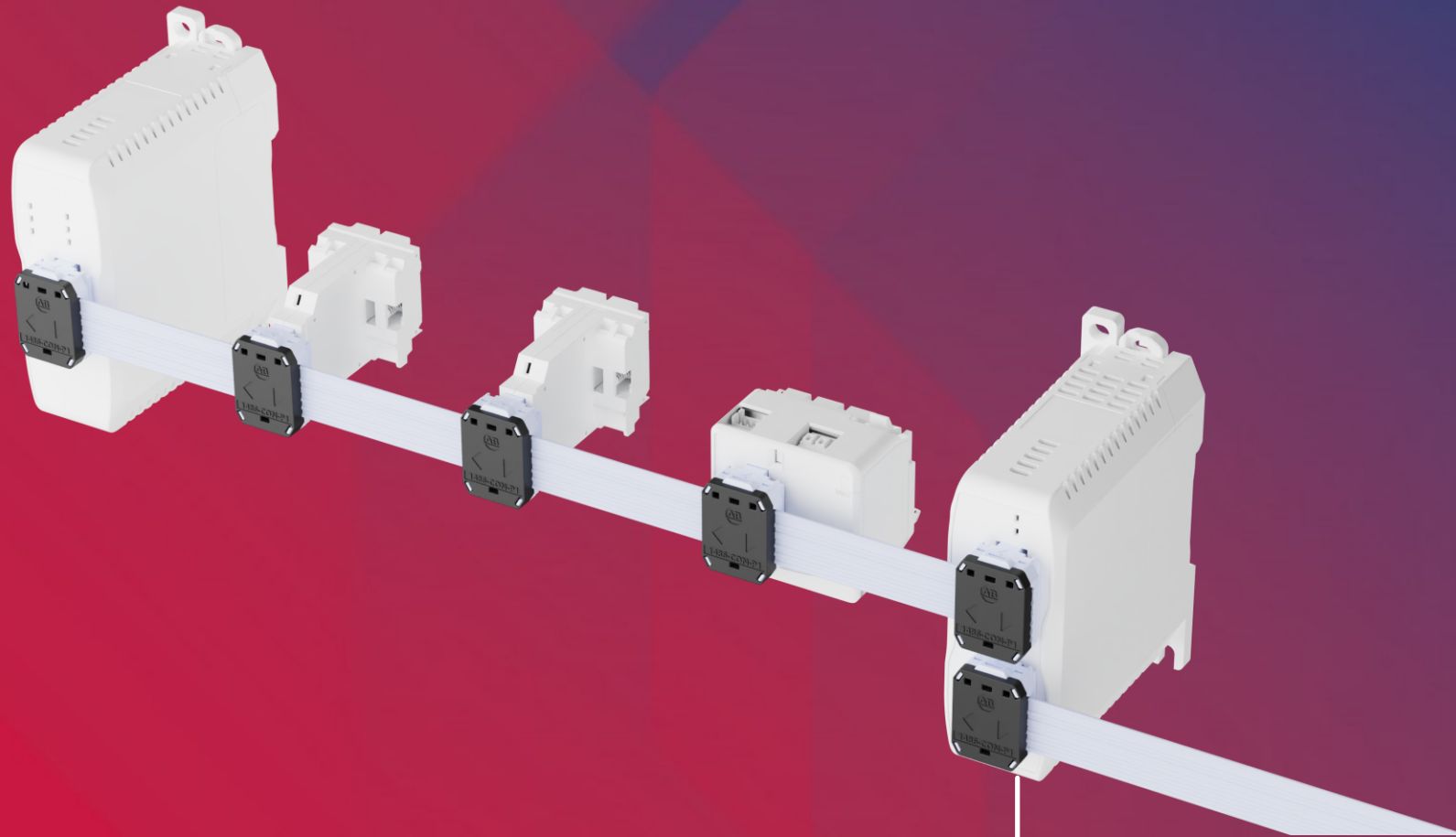
CONFIGURATION

- Connection
- Gateway
- Reference Topology
- Internet Protocol
- Port Configuration
- Network
- Time Sync

Actual Topology

View last updated: 4/11/2024 9:05:06 AM Devices: 4 Status: OK

	Position	Address	Catalog Number	Device Type	Name	Revision	Vendor	Serial Number	MAC Address
	0	192.168.1.1	1834-AENTR	Communication	Gateway	1.001	Rockwell Autom...	5C4220	00:00:BC:02:02:1B
	1	192.168.1.2	800F-INT-L	OperatorInterface...	Lamp1	1.001	Rockwell Autom...	FFFFD9C0	34:C0:F9:E7:0D:32
	2	192.168.1.3	800F-INT-L	OperatorInterface...	Lamp2	1.001	Rockwell Autom...	FFFFD9A3	34:C0:F9:E7:0D:CE
	3	192.168.1.4	104-E-INT-D	MotorStarter	Contacto1	1.001	Rockwell Autom...	FFFFF007	34:C0:F9:E7:20:9F



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