DIGITAL WE DAYS 2024

10 MBIT SINGLE PAIR ETHERNET OVER SHORT RANGE – MDI & PODL DESIGN

Simon Mark

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

AGENDA

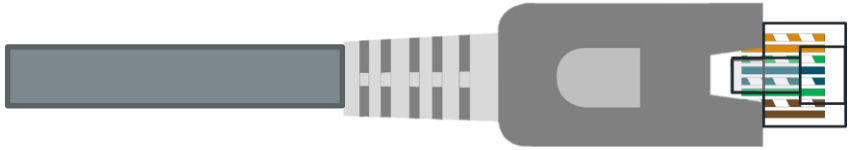
1. From Ethernet to SPE
2. Technical data
3. From automotive to industrial
4. 10BASE-T1s – in detail

1. FROM ETHERNET TO SPE

Multi Pair Ethernet

2- Pairs: 100BASE-TX *(IEEE802.3 Clause 25)*

4- Pairs: 1000BASE-T *(IEEE802.3 Clause 40)*

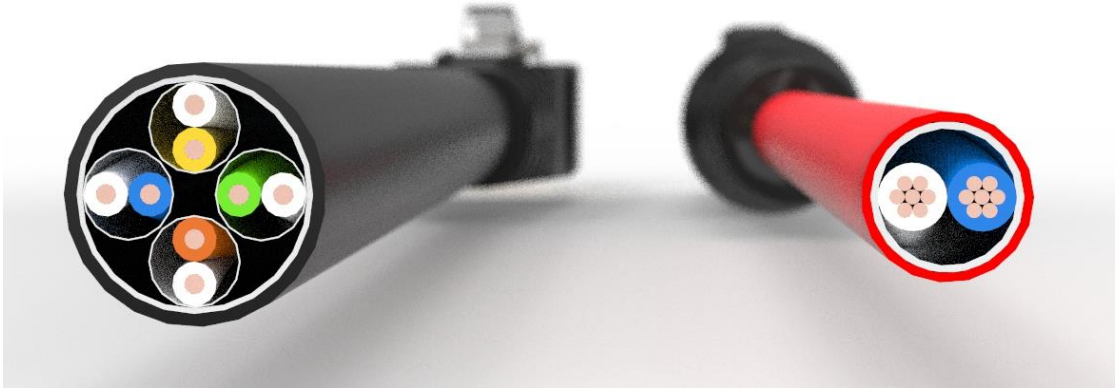


Cost reduction

Automotive Ethernet

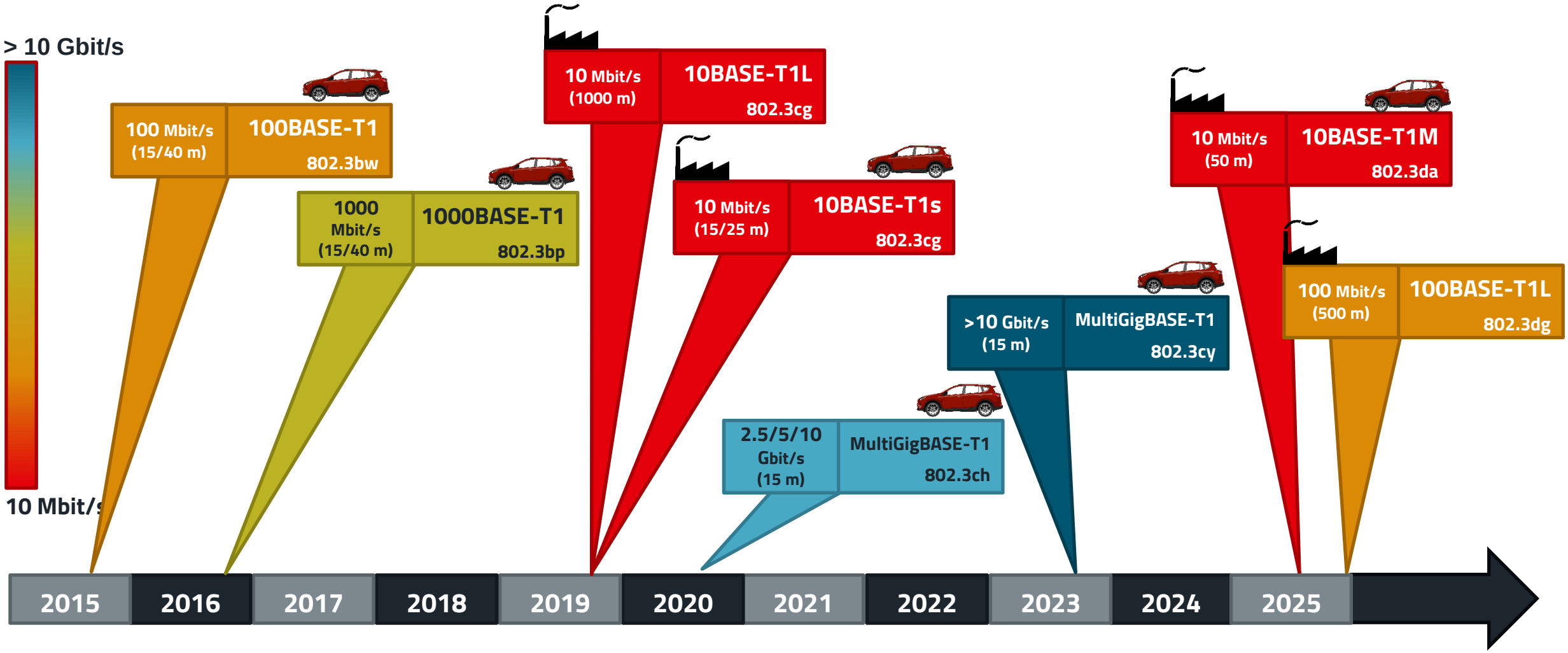
1- Pair: 100BASE-T1 *(IEEE 802.3bw)*

1- Pair: 1000BASE-T1 *(IEEE802.3bp)*



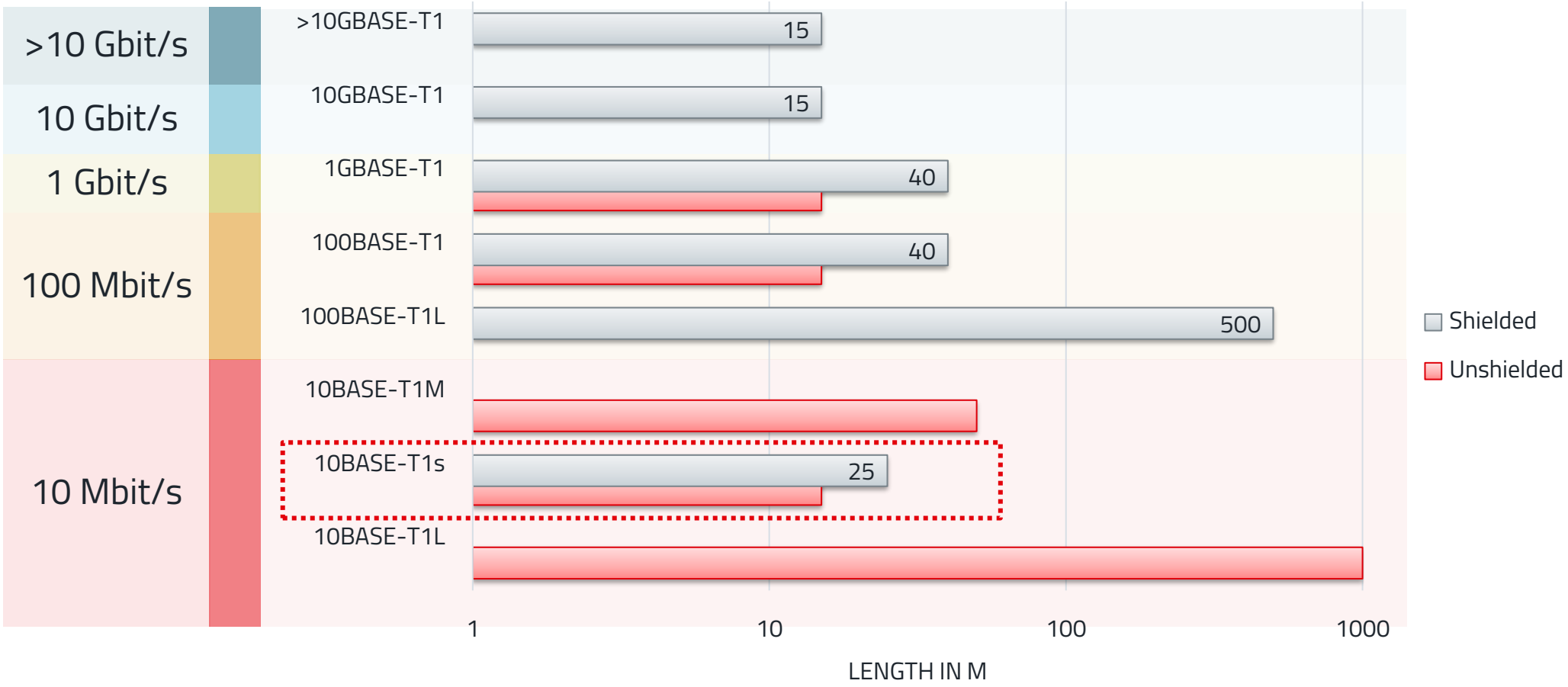
1. FROM ETHERNET TO SPE

1.1 Single Pair Ethernet History



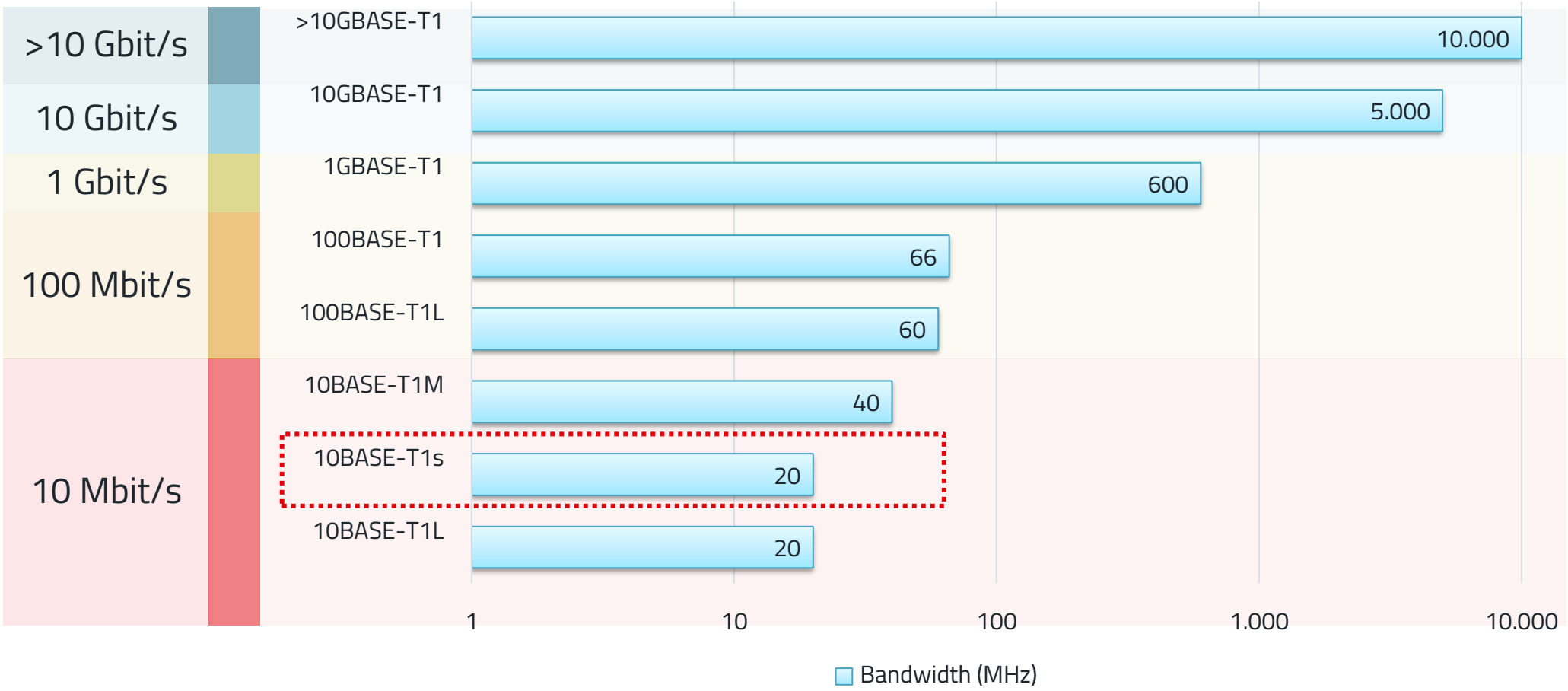
2. SPE – TECHNICAL DATA

2.1 Wiring length



2. SPE – TECHNICAL DATA

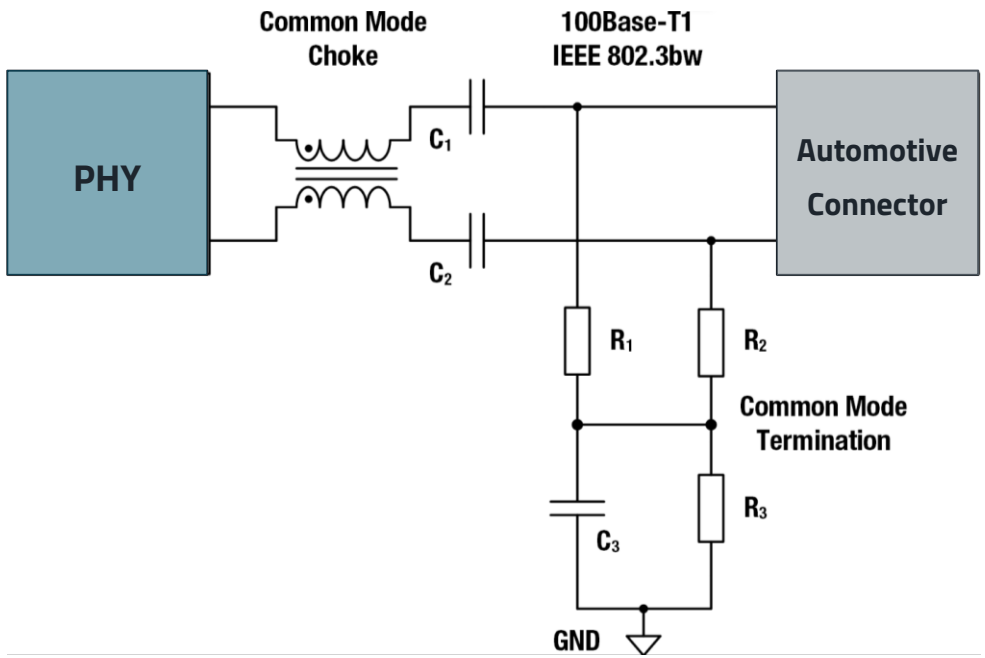
2.2 Bandwidth



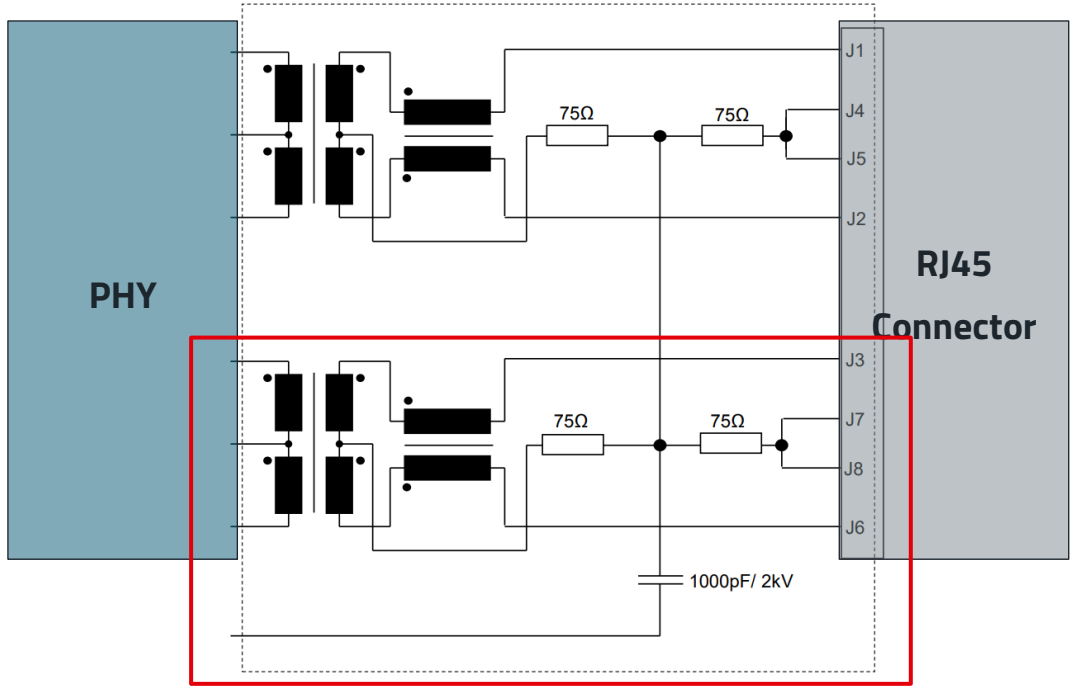
3. FROM AUTOMOTIVE TO INDUSTRIAL

3.1 MDI circuits in comparison

Automotive 10/100/1000BASE-T1



Industrial Multi Pair Ethernet 100BASE-TX



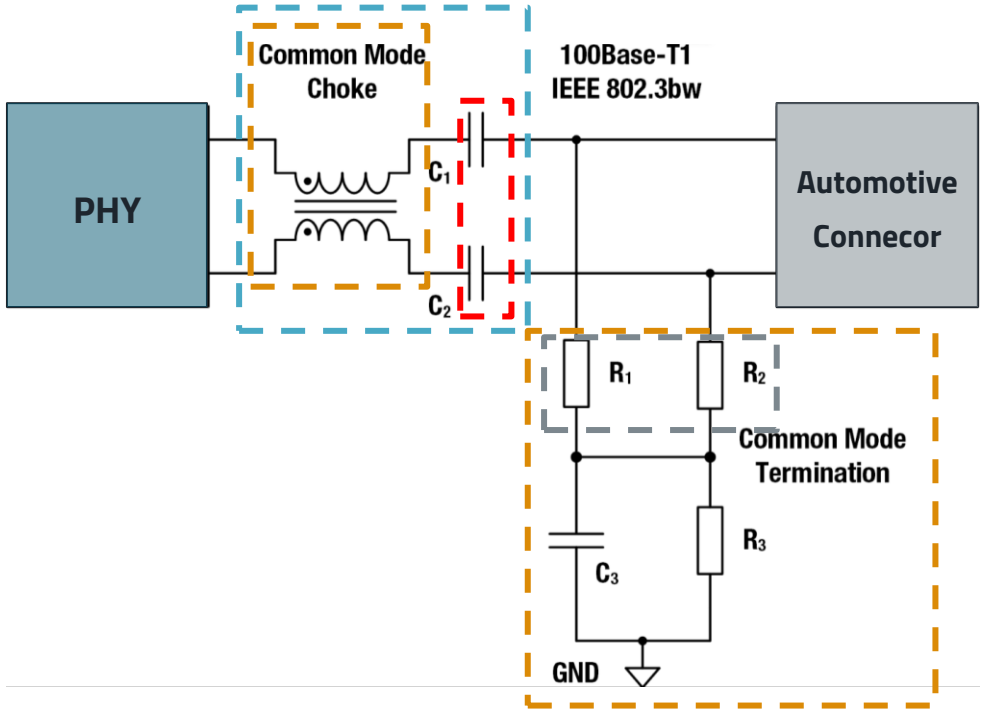
3. FROM AUTOMOTIVE TO INDUSTRIAL

3.2 Design requirements - Automotive

Automotive Requirements

Isolation	60 V
CM Attenuation	✓
Return Loss	✓
Mode Conversion	✓
Cheap & small	✓

Circuit



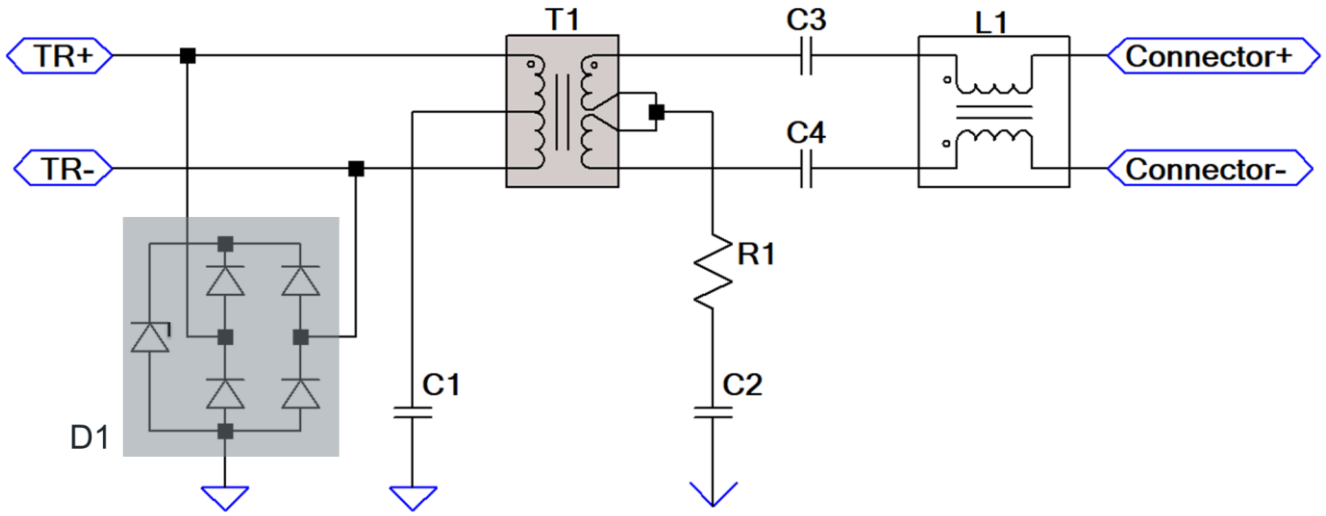
3. FROM AUTOMOTIVE TO INDUSTRIAL

3.3 Design requirements - Industry

Industry Requirements

- Isolation
- Isolation DC
- CM Attenuation
- Return Loss
- Mode Conversion
- ESD Protection

Circuit



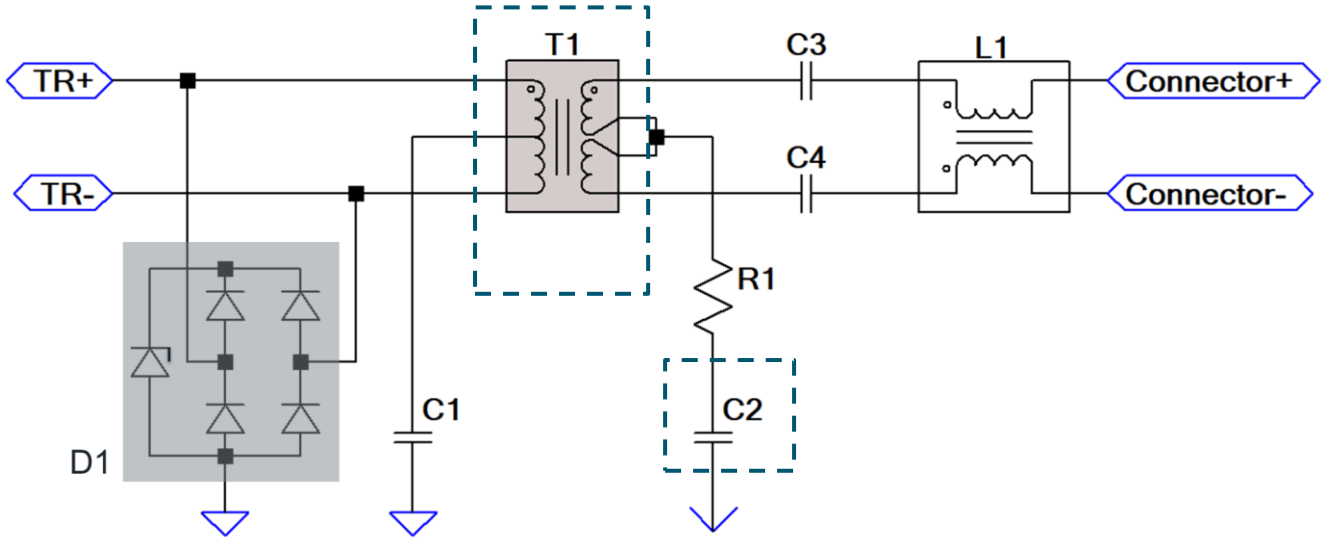
3. FROM AUTOMOTIVE TO INDUSTRIAL

3.3 Design requirements - Industry

Industry Requirements

Isolation	1500 V
Isolation DC	
CM Dämpfung	
Return Loss	
Moden Umwandlung	
ESD Schutz	

Circuit



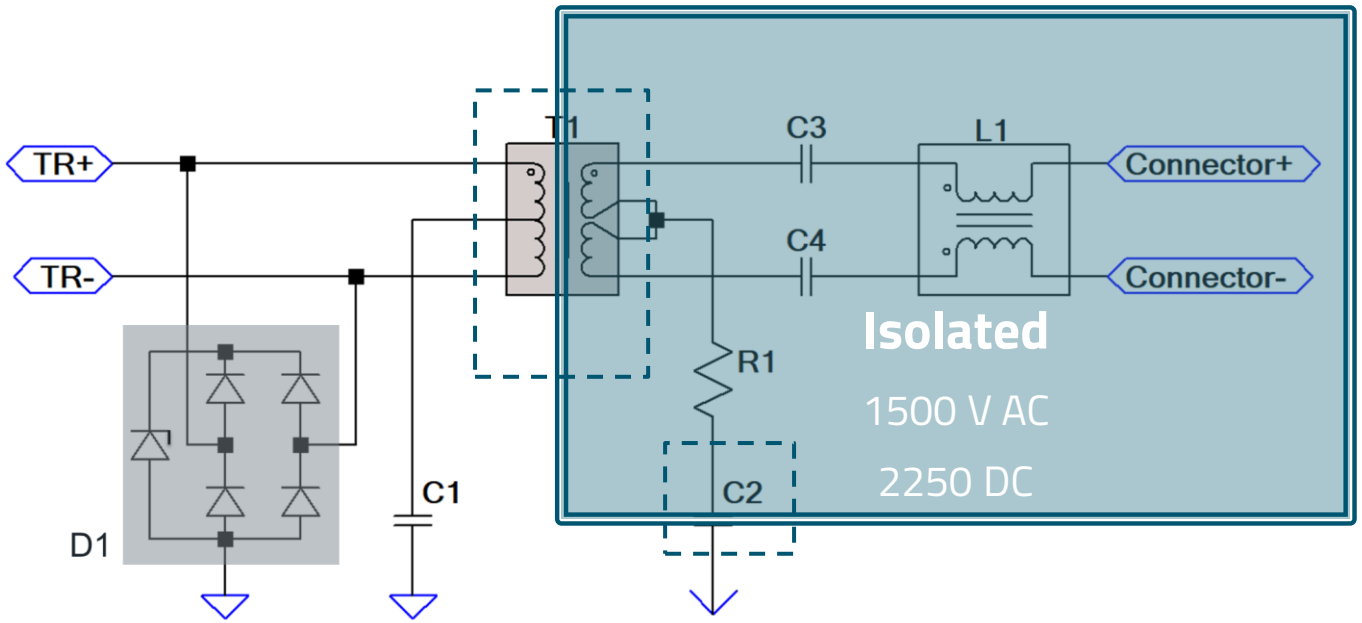
3. FROM AUTOMOTIVE TO INDUSTRIAL

3.3 Design requirements - Industry

Industry Requirements

Isolation	1500 V
Isolation DC	
CM Attenuation	
Return Loss	
Mode Conversion	
ESD Protection	

Circuit



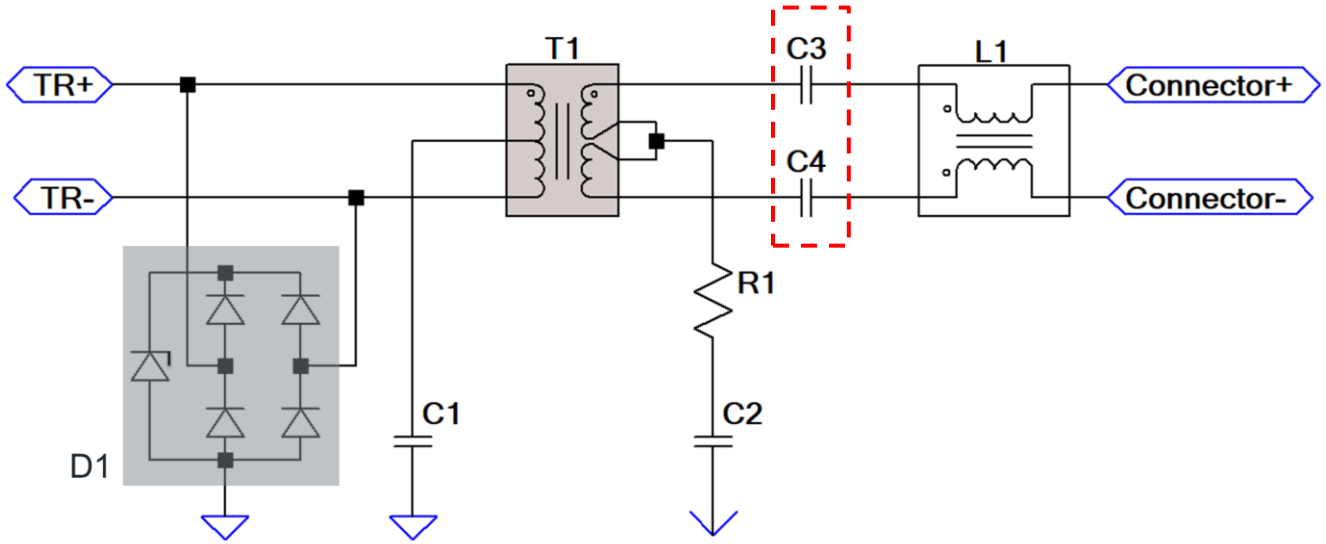
3. FROM AUTOMOTIVE TO INDUSTRIAL

3.3 Design requirements - Industry

Industry Requirements

Isolation	1500 V
Isolation DC	**60 V**
CM Attenuation	
Return Loss	
Mode Conversion	
ESD Protection	

Circuit



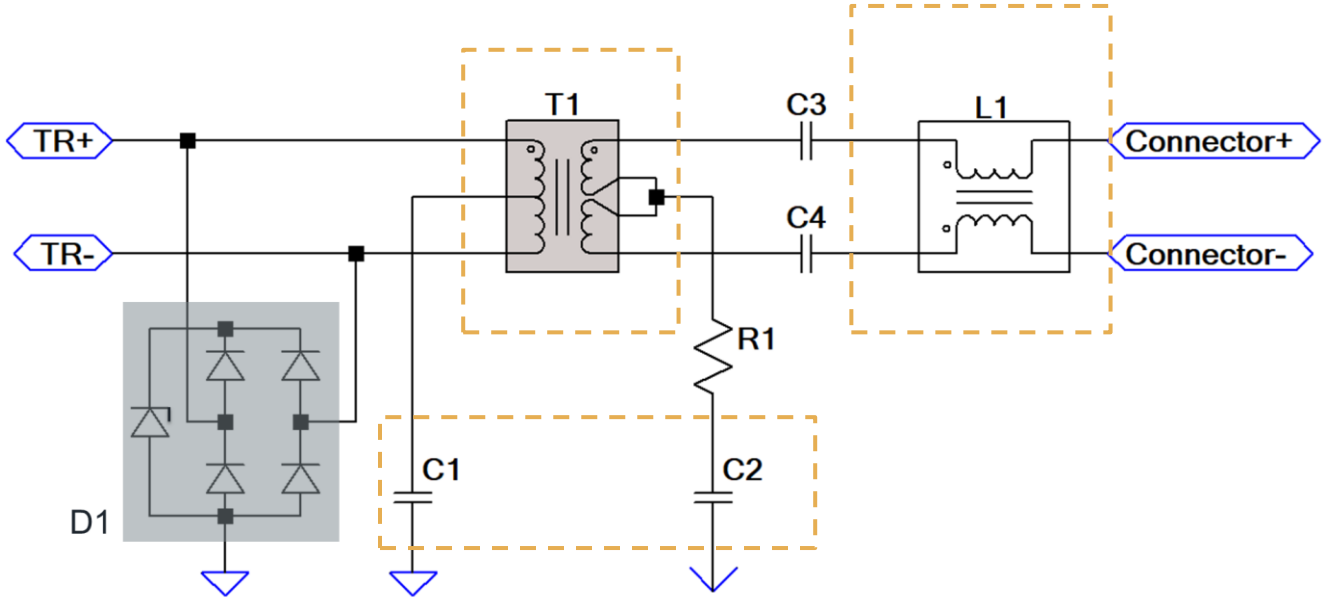
3. FROM AUTOMOTIVE TO INDUSTRIAL

3.3 Design requirements - Industry

Industry Requirements

Isolation	1500 V
Isolation DC	60 V
CM Attenuation	✓
Return Loss	
Mode Conversion	
ESD Protection	

Circuit



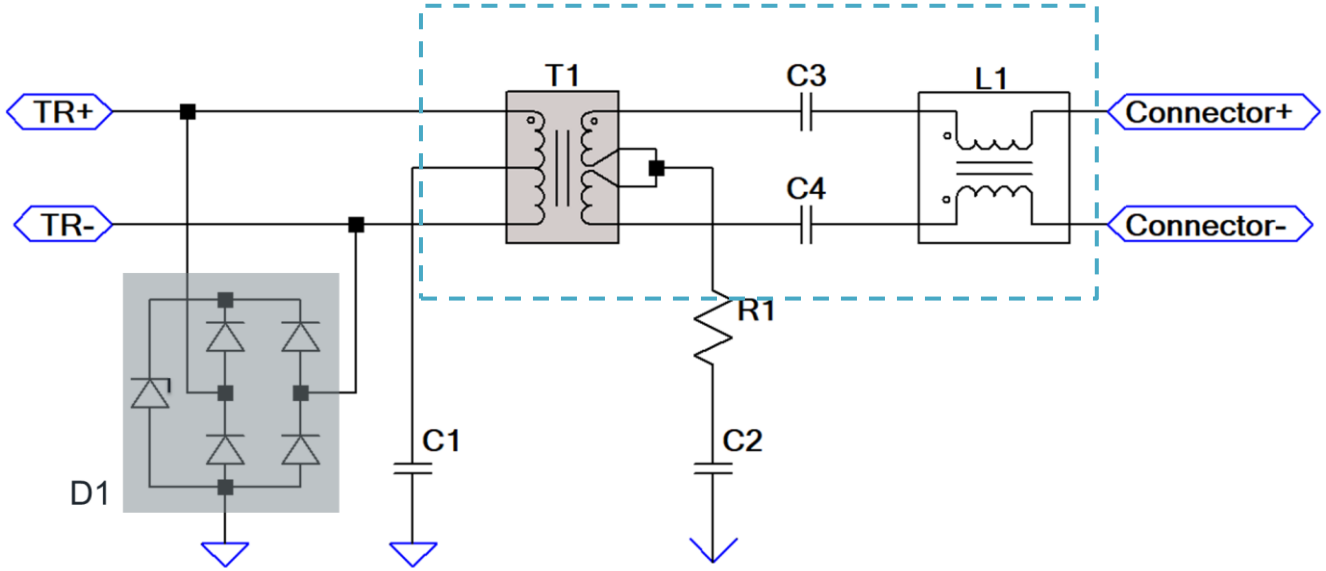
3. FROM AUTOMOTIVE TO INDUSTRIAL

3.3 Design requirements - Industry

Industry Requirements

Isolation	1500 V
Isolation DC	60 V
CM Attenuation	✓
Return Loss	✓
Mode Conversion	
ESD Protection	

Circuit



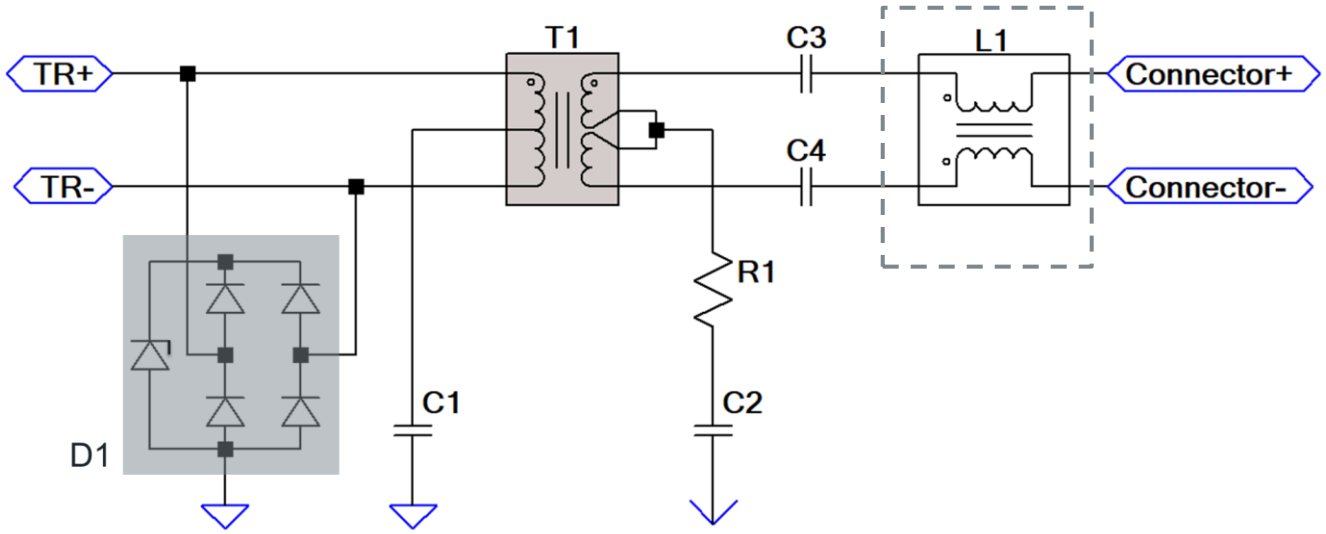
3. FROM AUTOMOTIVE TO INDUSTRIAL

3.3 Design requirements - Industry

Industry Requirements

Isolation	1500 V
Isolation DC	60 V
CM Attenuation	✓
Return Loss	✓
Mode Conversion	✓
ESD Protection	

Circuit



3. FROM AUTOMOTIVE TO INDUSTRIAL

3.3 Design requirements - Industry

Industry Requirements

Isolation	1500 V
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CM Dämpfung	✓
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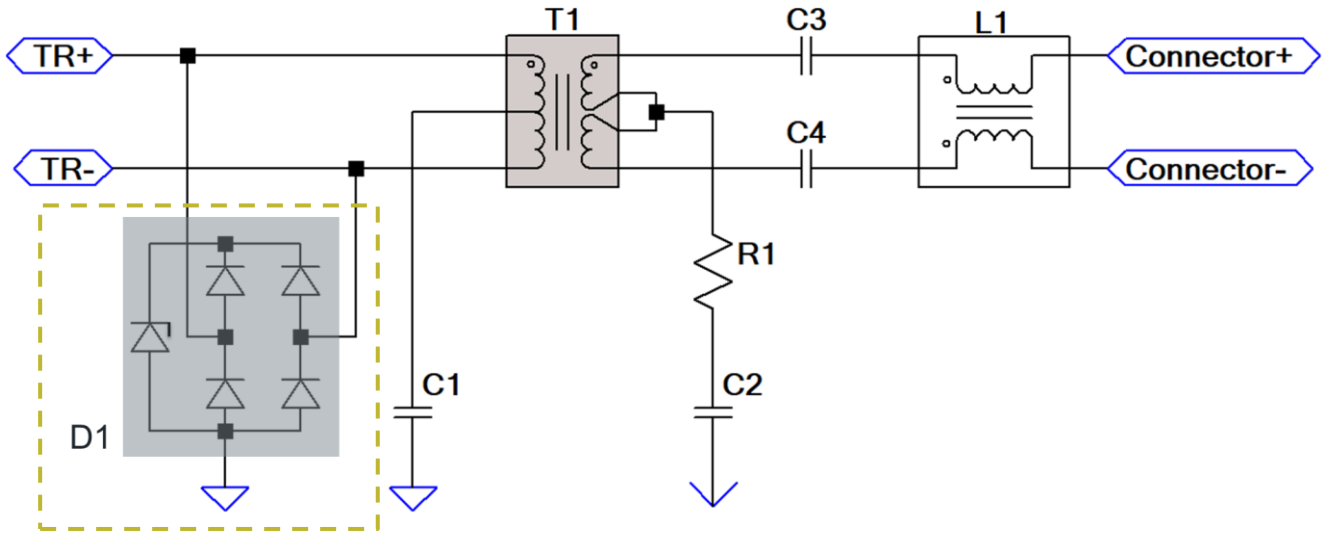
Circuit



4. 10BASE-T1S IN DETAIL

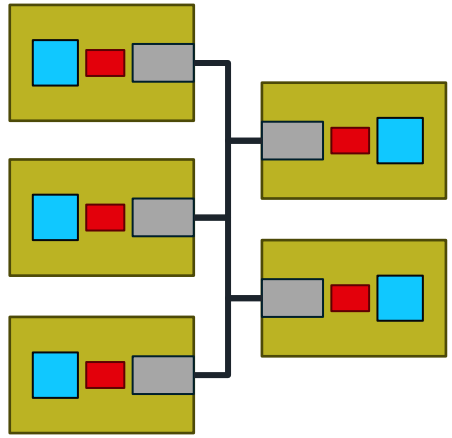
10BASE-T1s and 10BASE-T1L - Summary and comparison

10BASE-T1L

- Data transmission: Full duplex
- System: Point to point
- Number of nodes: 2
- Length: up to over 1000 m

10BASE-T1s

- Data transmission : **Half duplex**
- System: Bus
- Number of nodes : 8-40
- Length : up to. 25 m

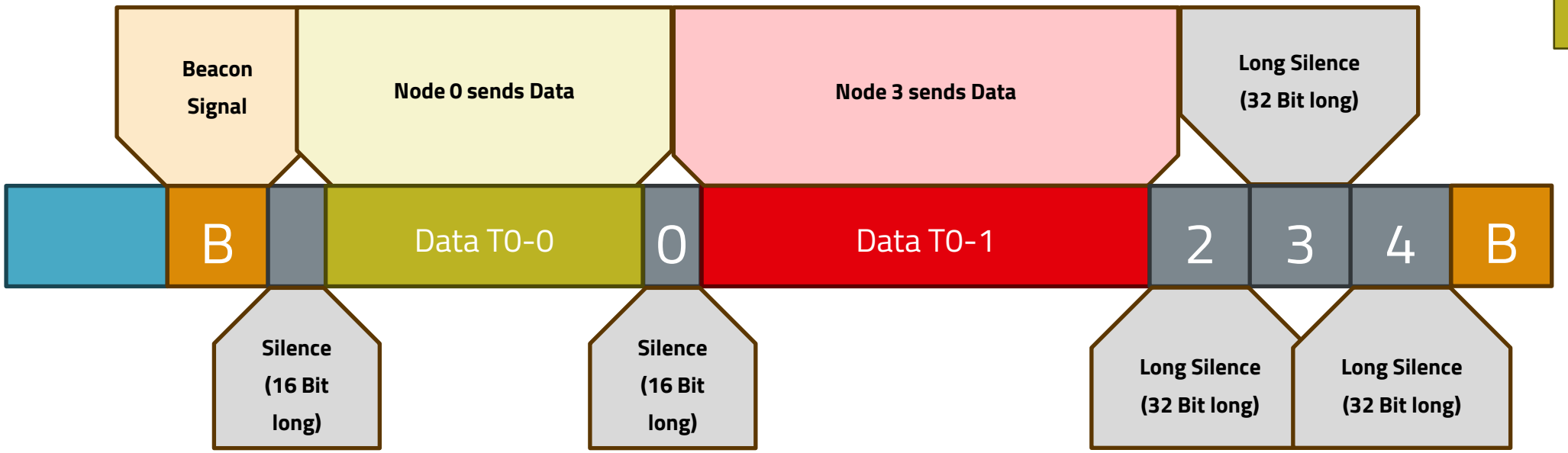


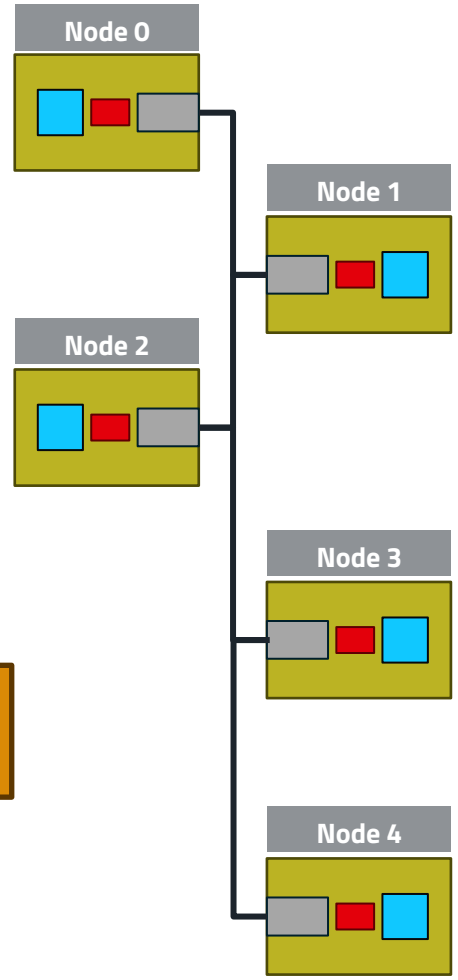
- Data transmission : **Half duplex / Full duplex**
- System: Point to Point
- Number of nodes : 2
- Length: 15 m

4. 10BASE-T1S IN DETAIL

How it Works – PLCA (Physical Layer Collision Avoidance)

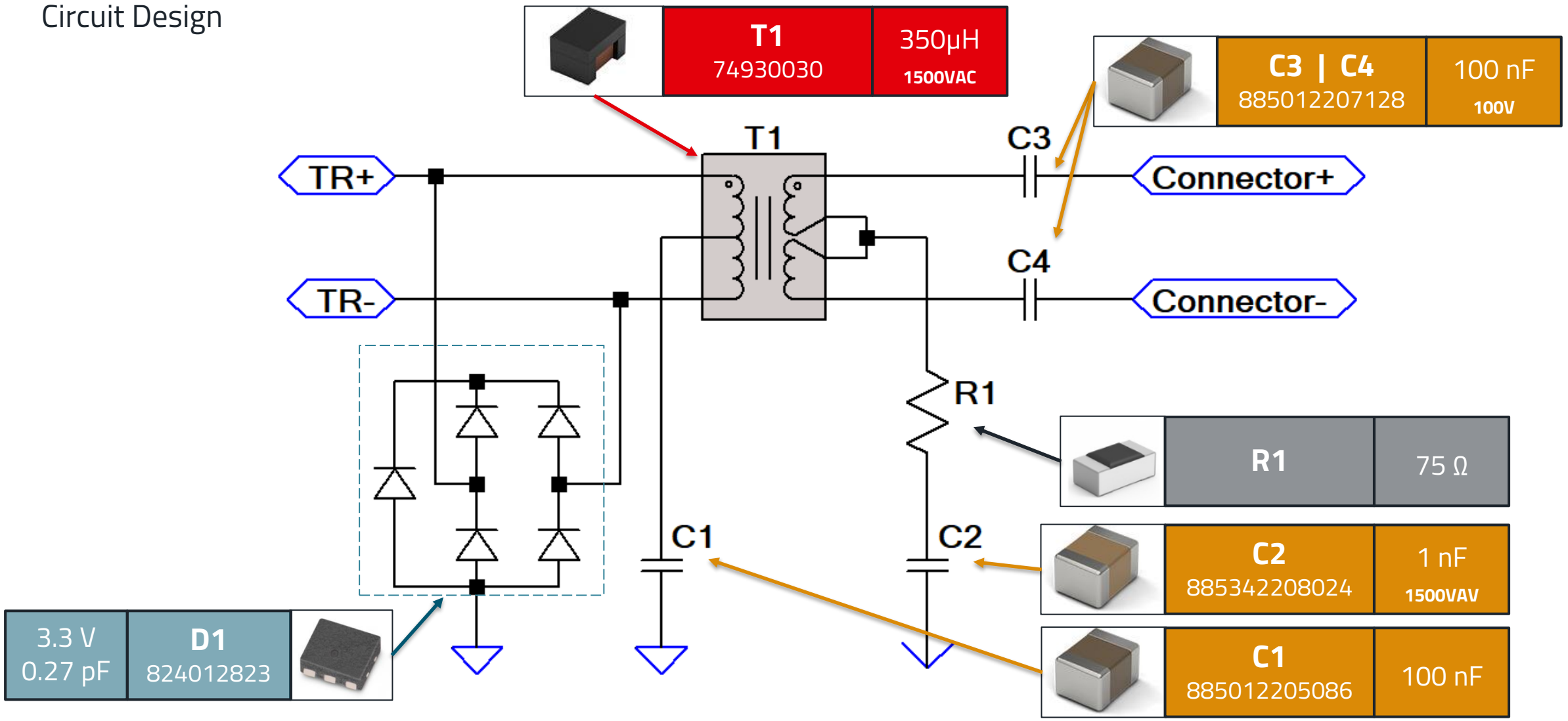
- Every Node has a specific Number
- Every Node has a specific Time so send Data
- In the Time a node is sending Data, all other Nodes are high impendant at the PHY





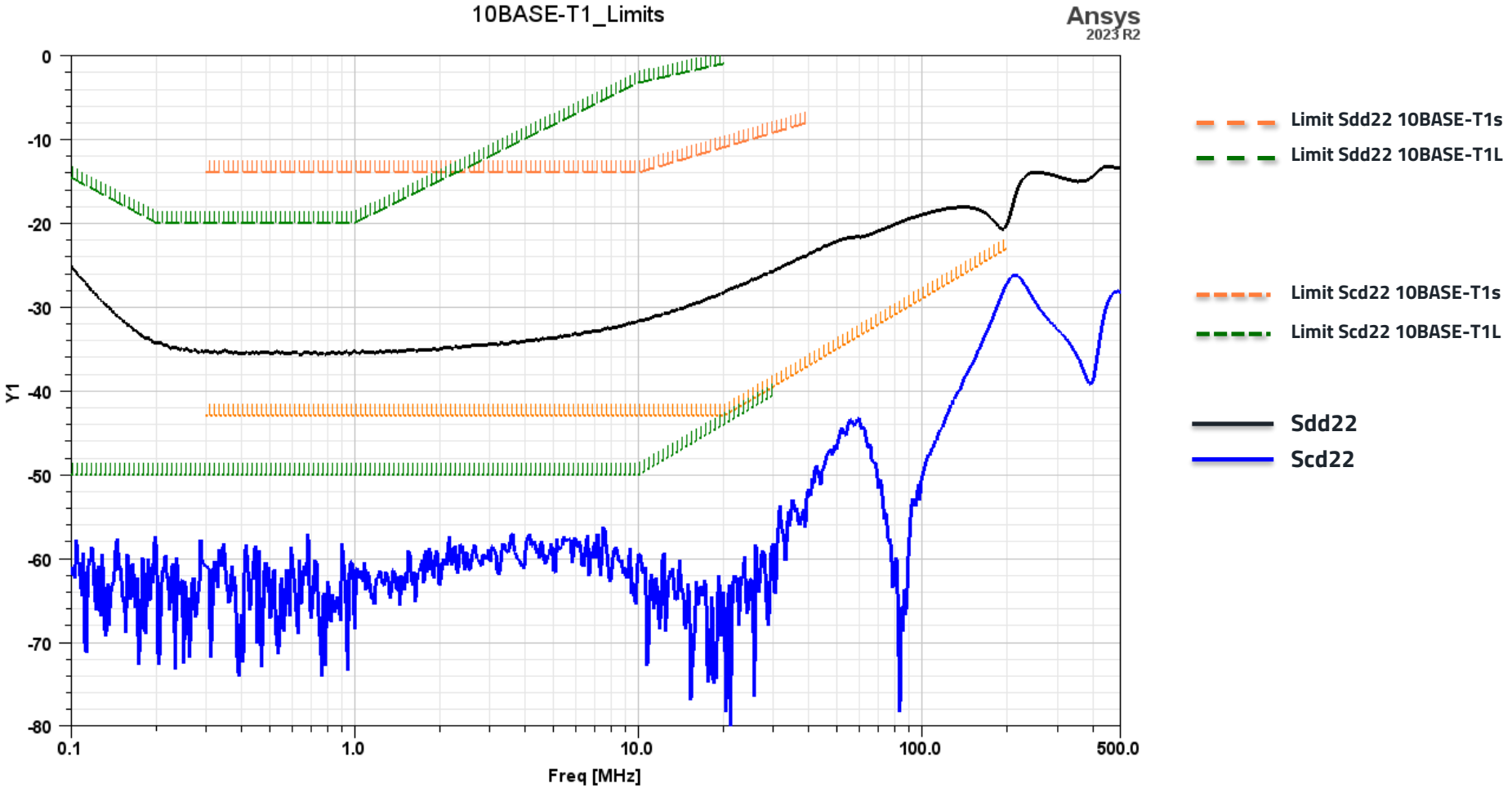
4. 10BASE-T1S IN DETAIL

Circuit Design



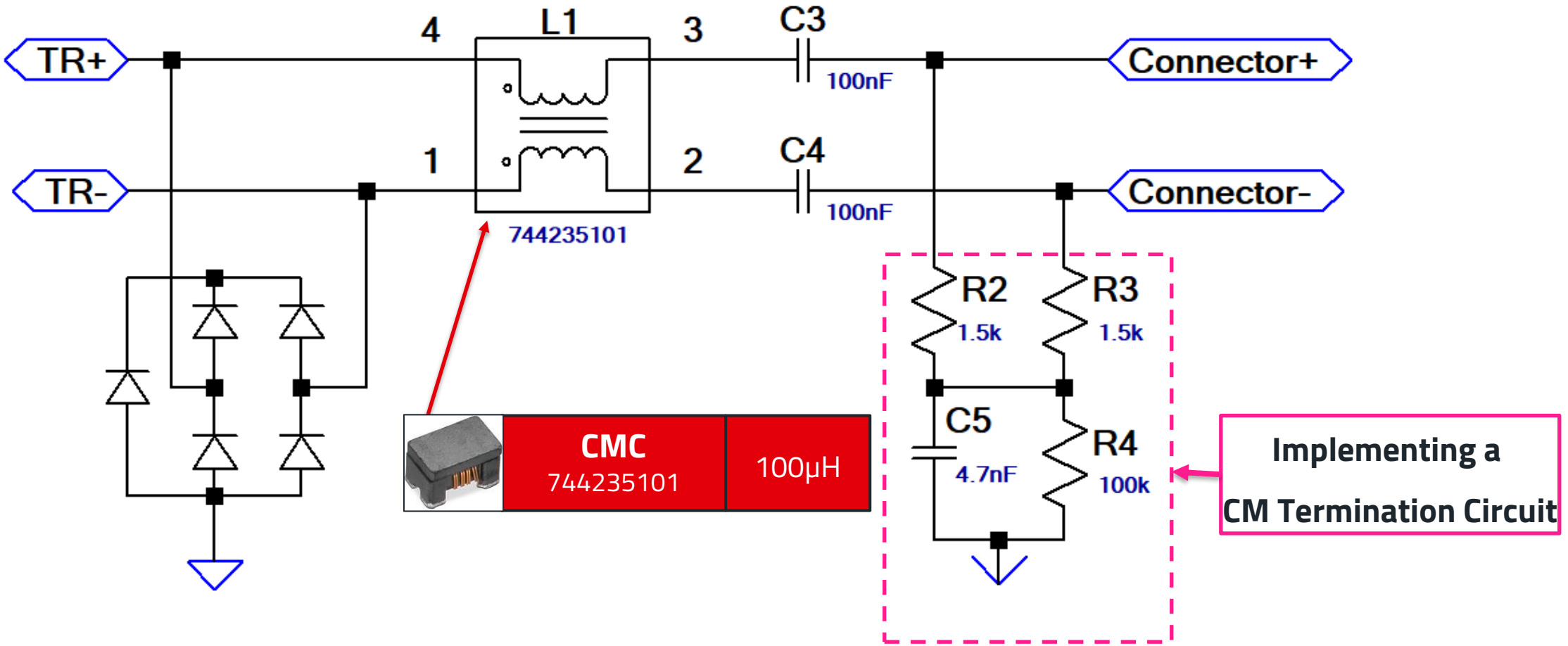
4. 10BASE-T1S IN DETAIL

Limits according IEEE 802.3cg



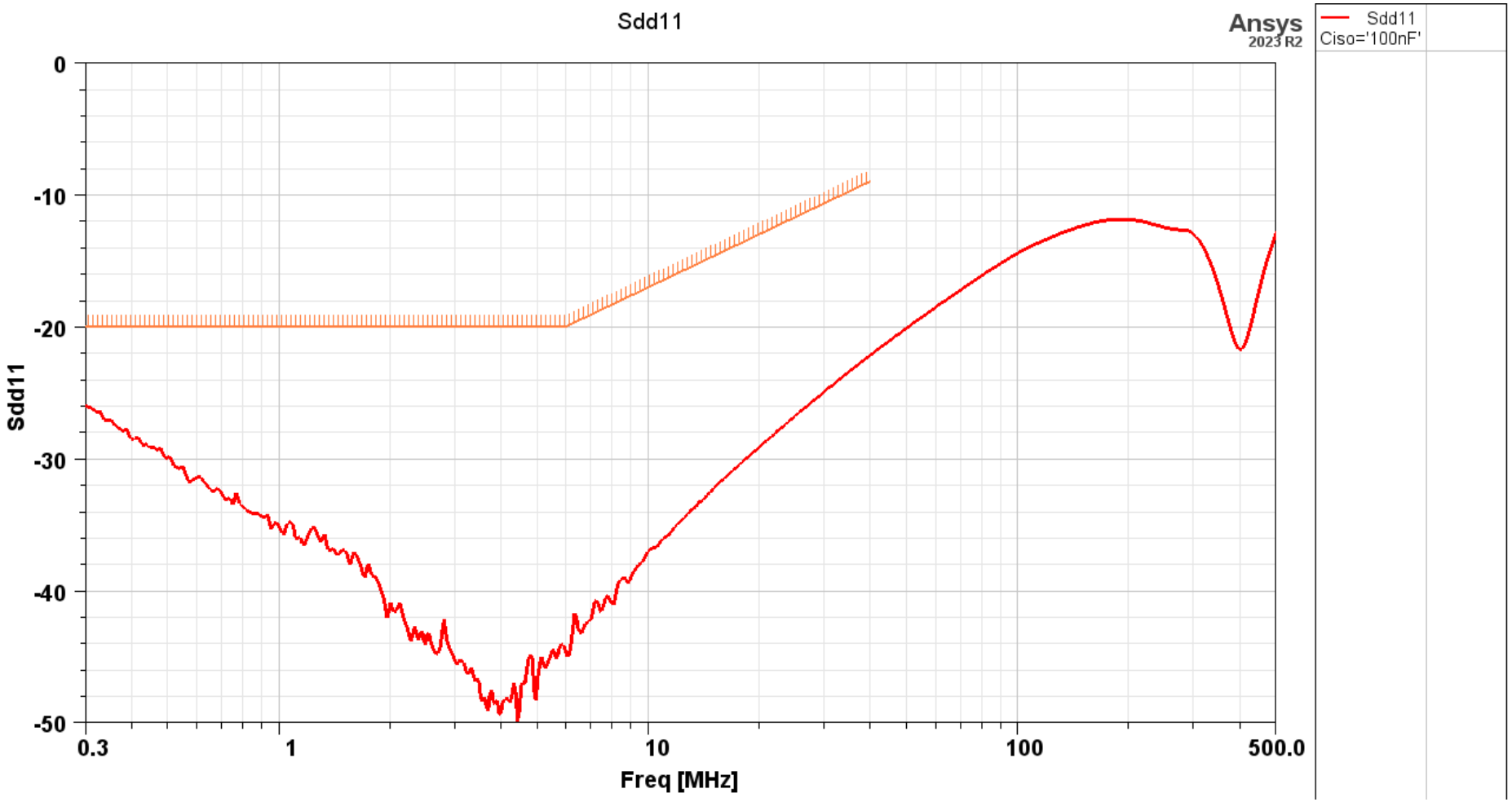
4. 10BASE-T1S IN DETAIL

Circuit Design with CMC to archive OPEN Alliance limts



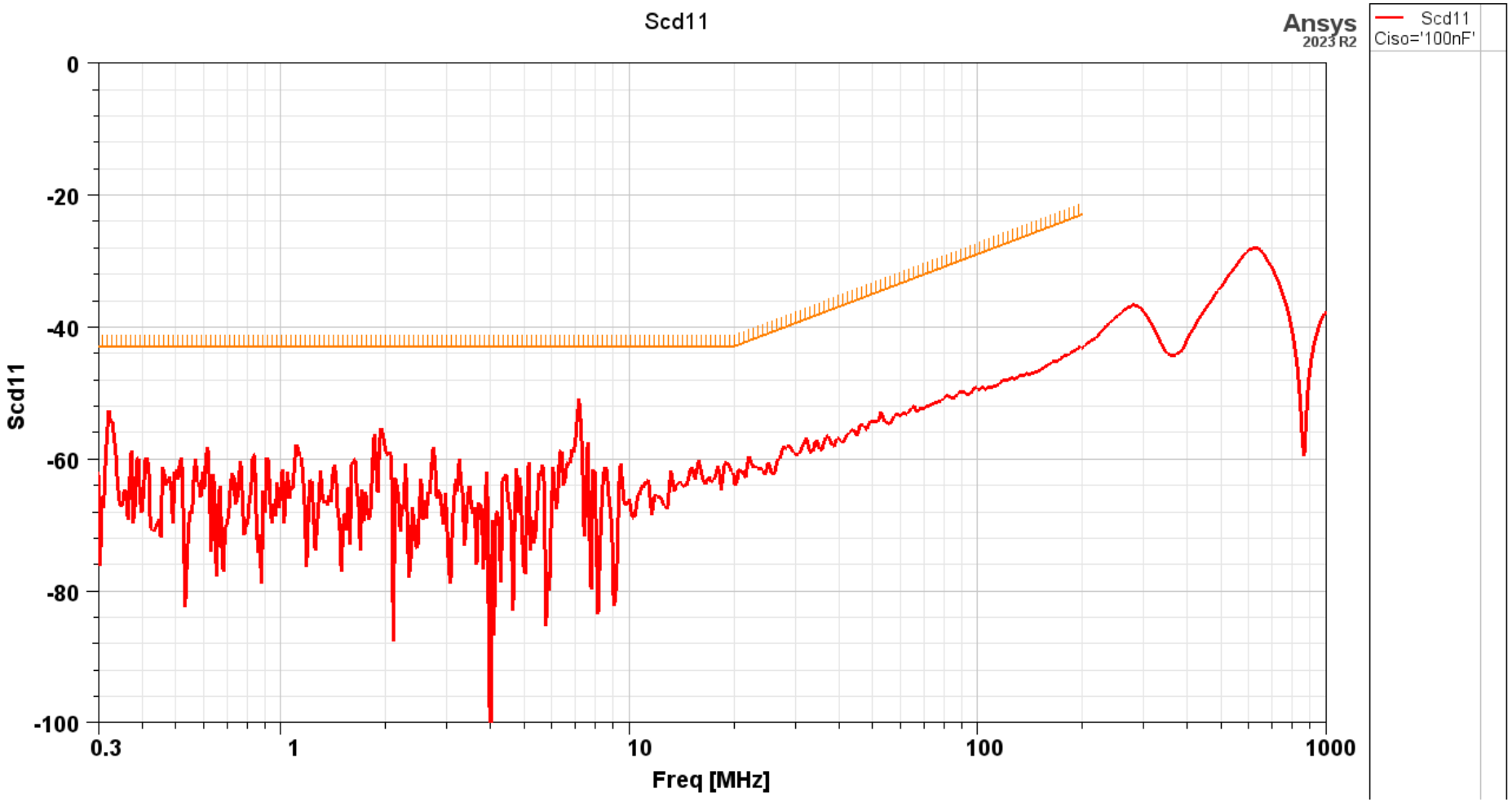
4. 10BASE-T1S IN DETAIL

Return Loss



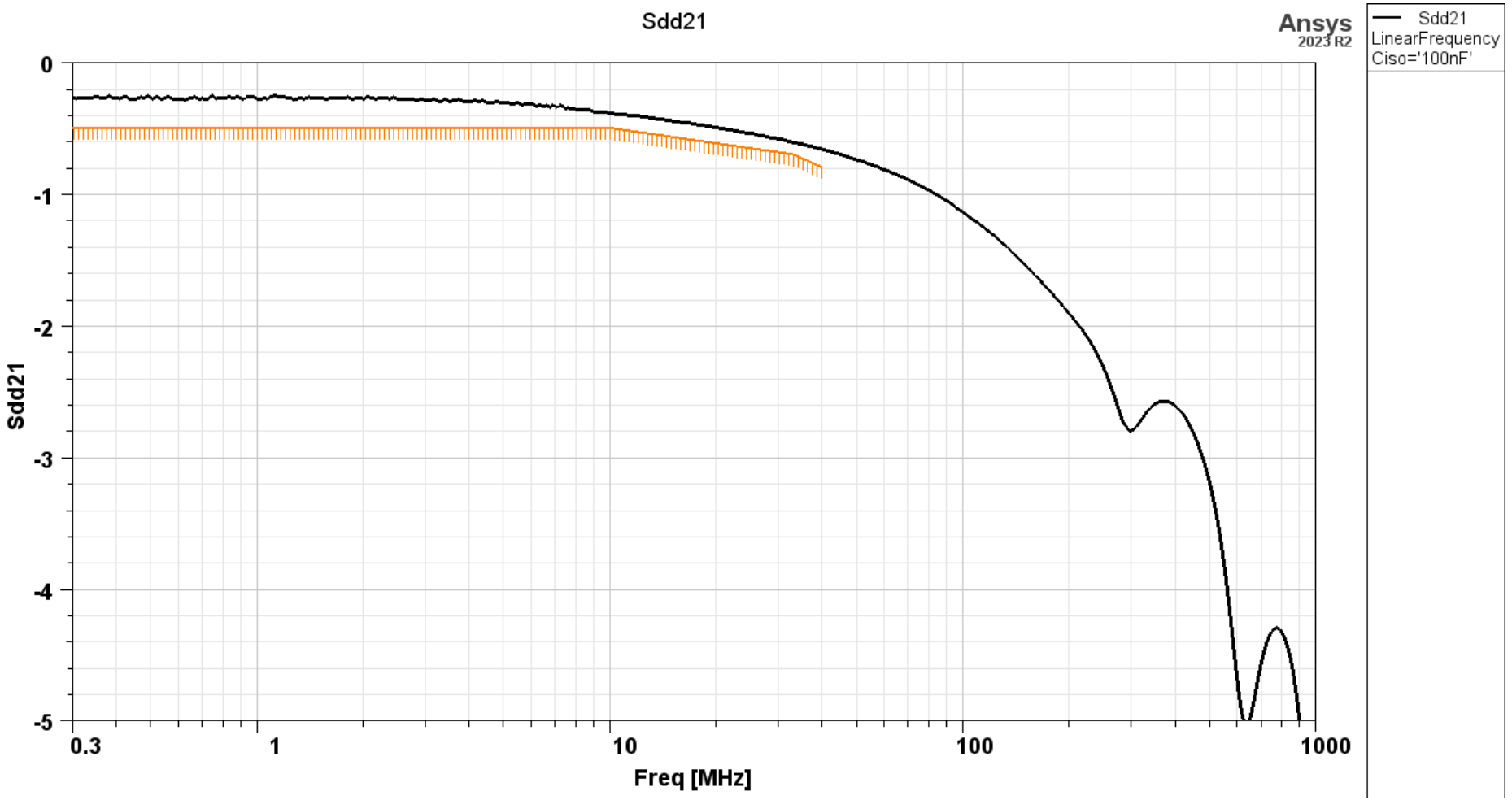
4. 10BASE-T1S IN DETAIL

Return Loss



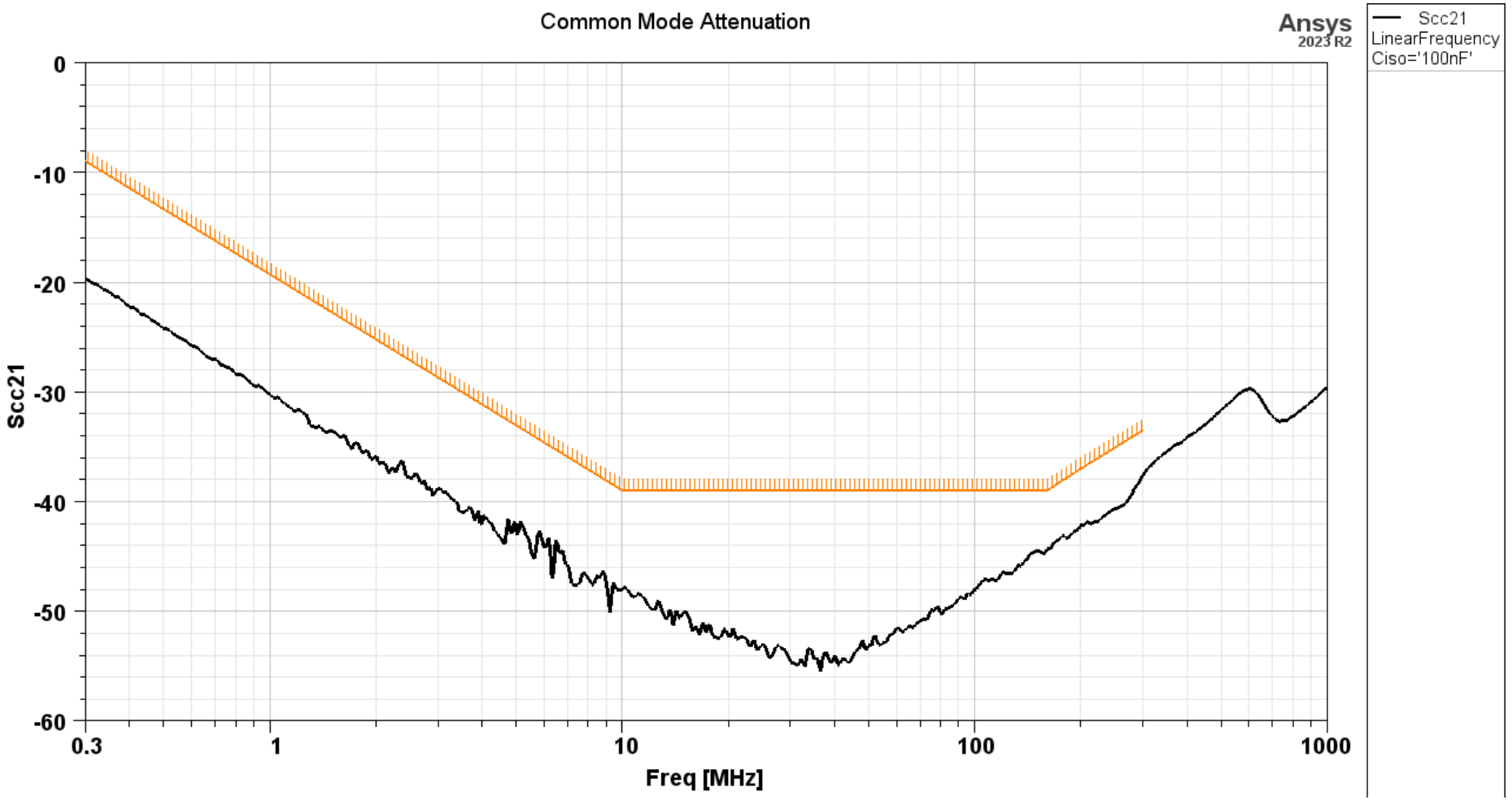
4. 10BASE-T1S IN DETAIL

Return Loss



4. 10BASE-T1S IN DETAIL

Return Loss



4. 10BASE-T1S IN DETAIL

Droop

Clause 146.5.4.2 (10BASE-T1L)

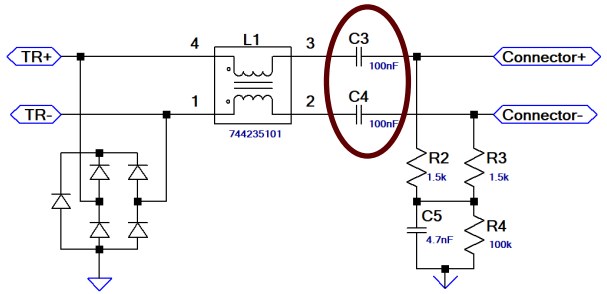
- While in test mode 2, the positive and negative droop of the transmitter should measure **below 10%.**
- This measurement is referenced to an **initial value** taken at **133.3 ns after the zero crossing** and a final value measured at **800 ns** after the zero crossing.

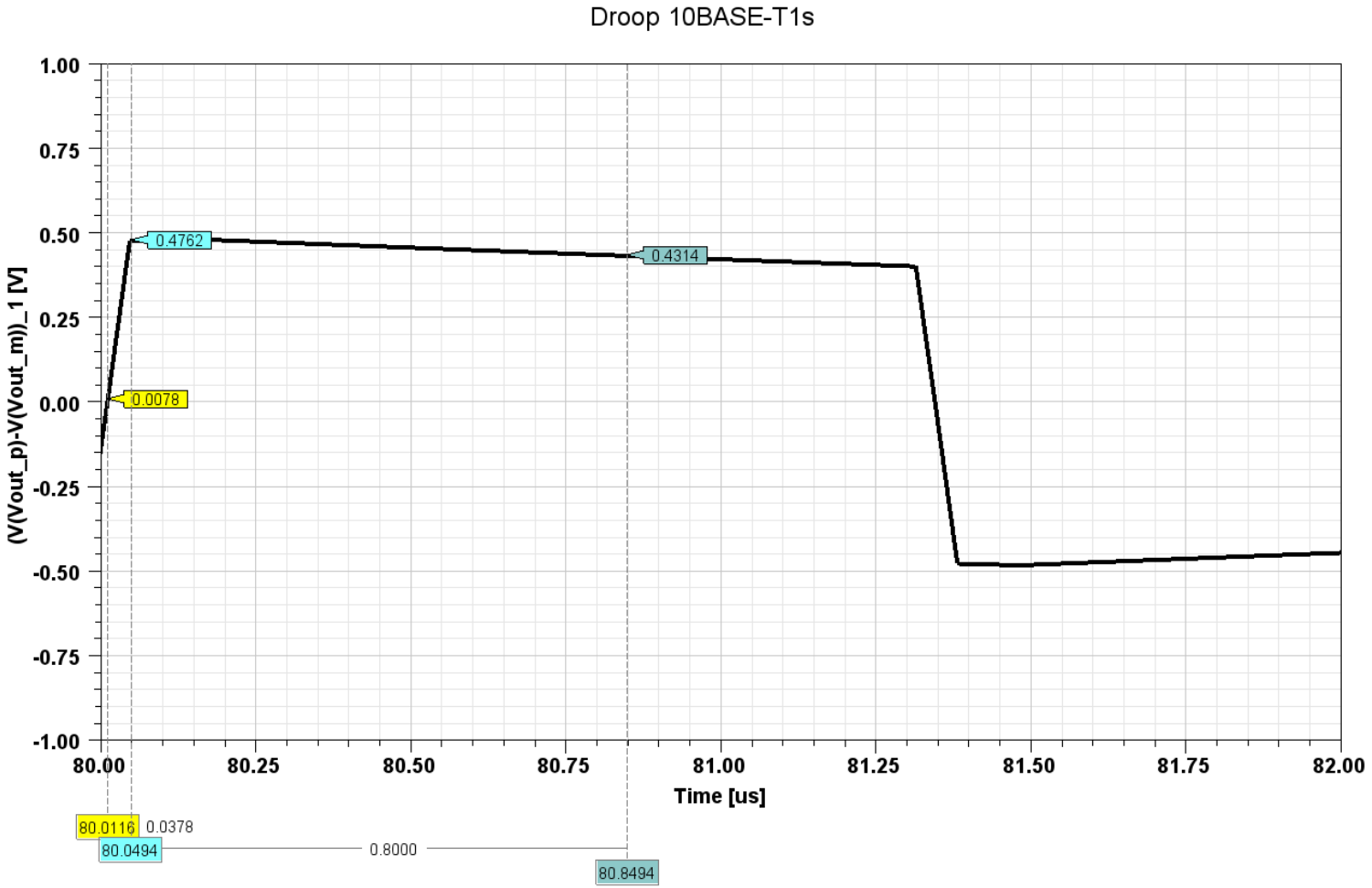
Clause 147.5.4.2 (10BASE-T1s)

- While in test mode 2, the positive and negative droop of the transmitter should measure **below 30%.**
- This measurement is referenced to an **initial peak value** taken **after the zero crossing** and the value **800 ns** after the initial peak value.

4. 10BASE-T1S IN DETAIL

Drooptest with different capacitors





@ 100nF: Droop = 13 %

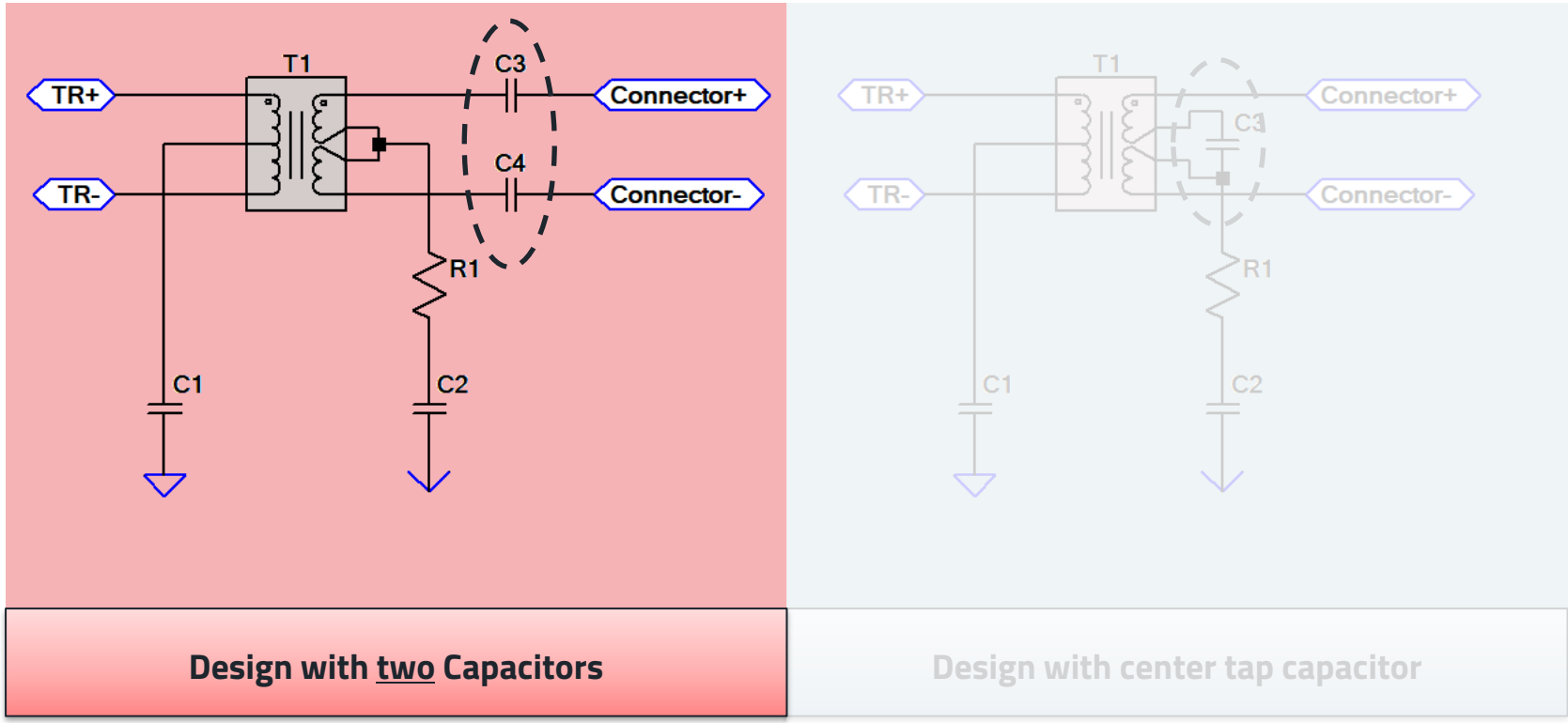
@ 220nF: Droop = 9,4 %

@ 470nF: Droop = 7,8 %

10BASE-T1s	10BASE-T1L
Capacitor:	**Capacitor:**
100 nF	470 nF
220 nF	
470 nF	

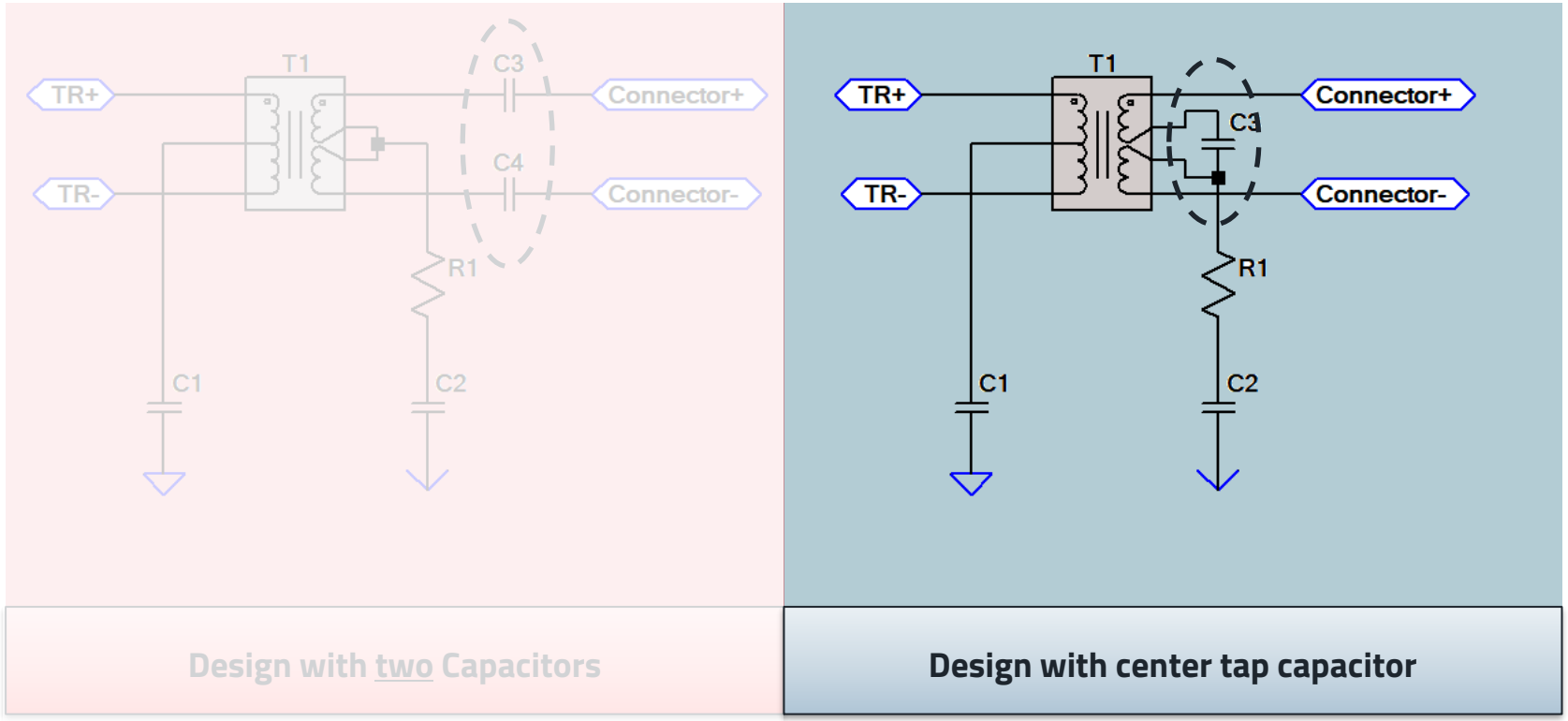
4. 10BASE-T1S IN DETAIL

SPE Circuit – DC isolation capacitor



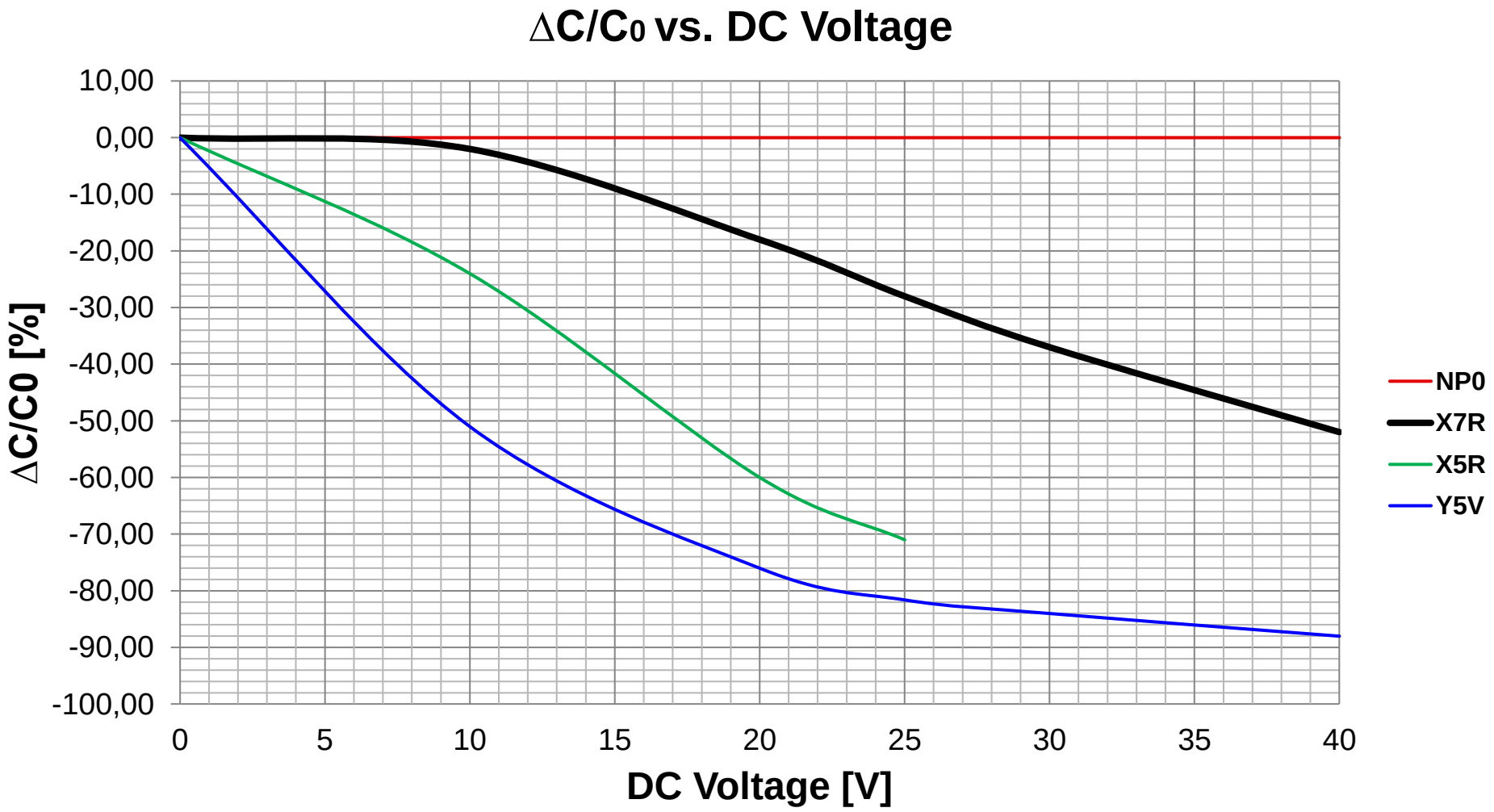
4. 10BASE-T1S IN DETAIL

SPE Circuit – DC isolation capacitor



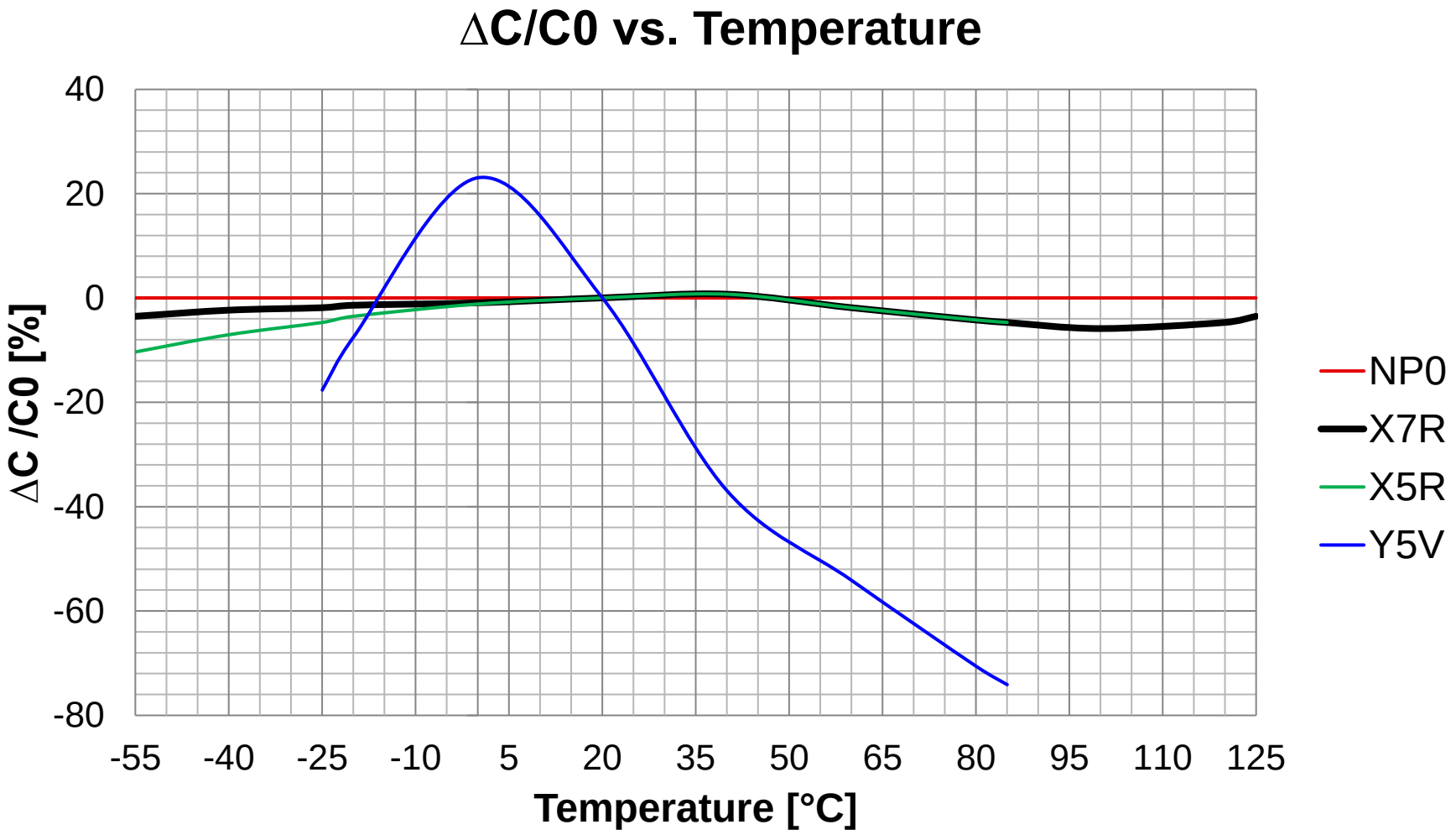
4. 10BASE-T1S IN DETAIL

DC Isolation Capacitors – Satturation



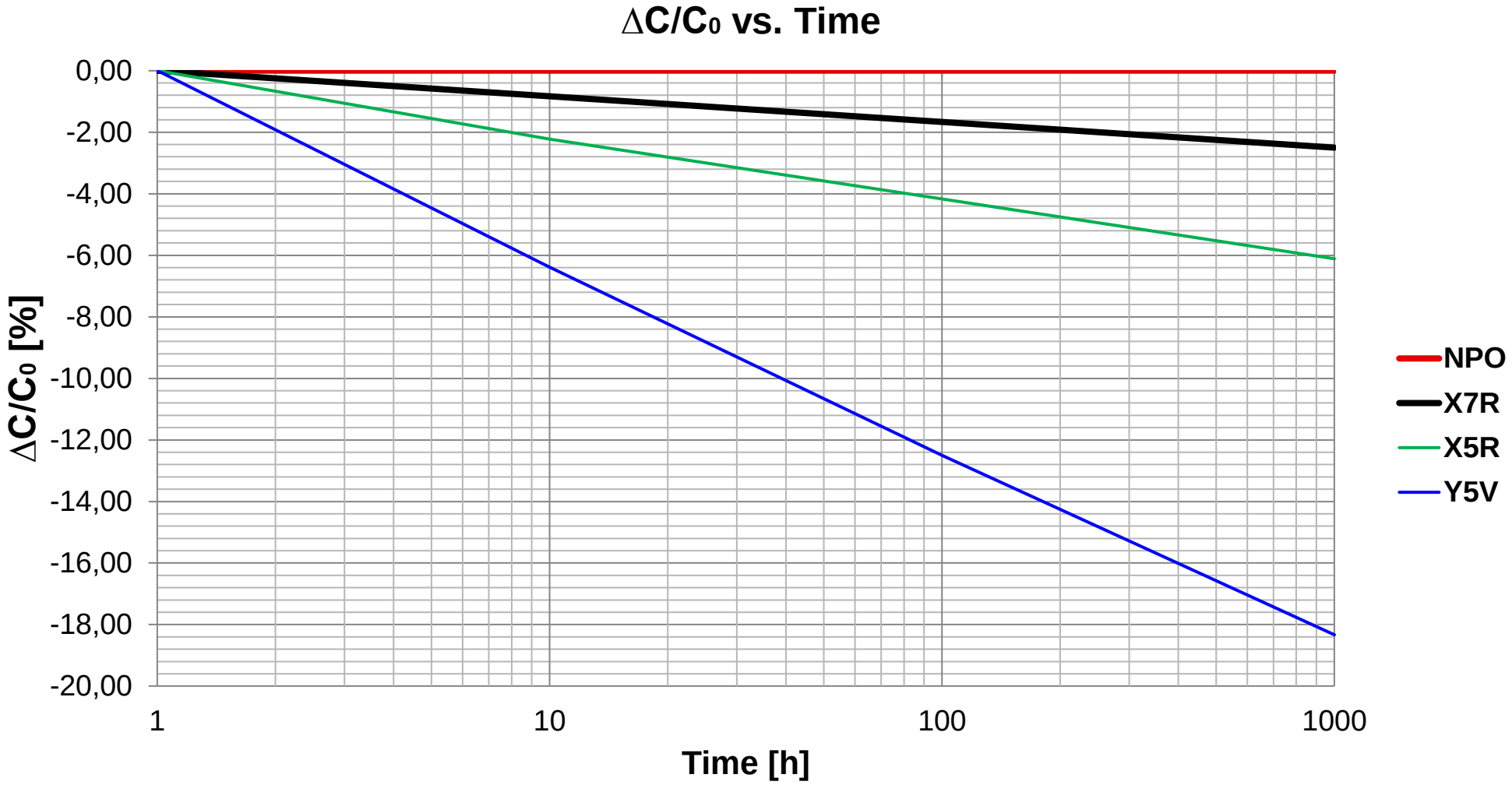
4. 10BASE-T1S IN DETAIL

DC Isolation Capacitors – Temperature behaviour



4. 10BASE-T1S IN DETAIL

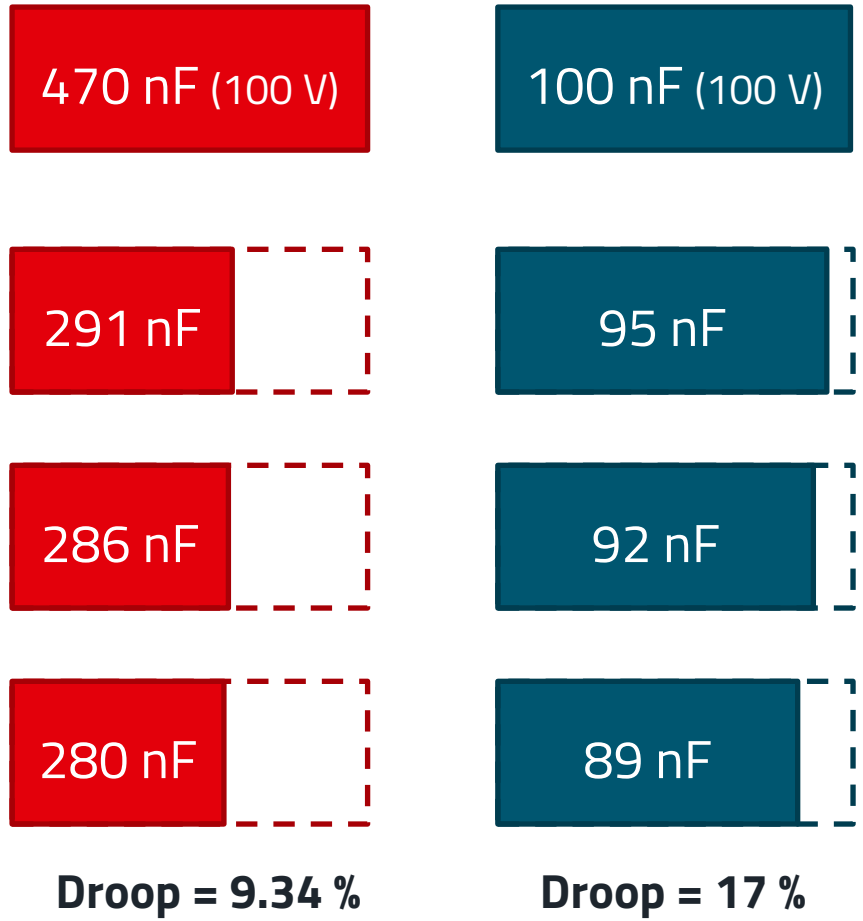
DC Isolation Capacitors – Aging



4. 10BASE-T1S IN DETAIL

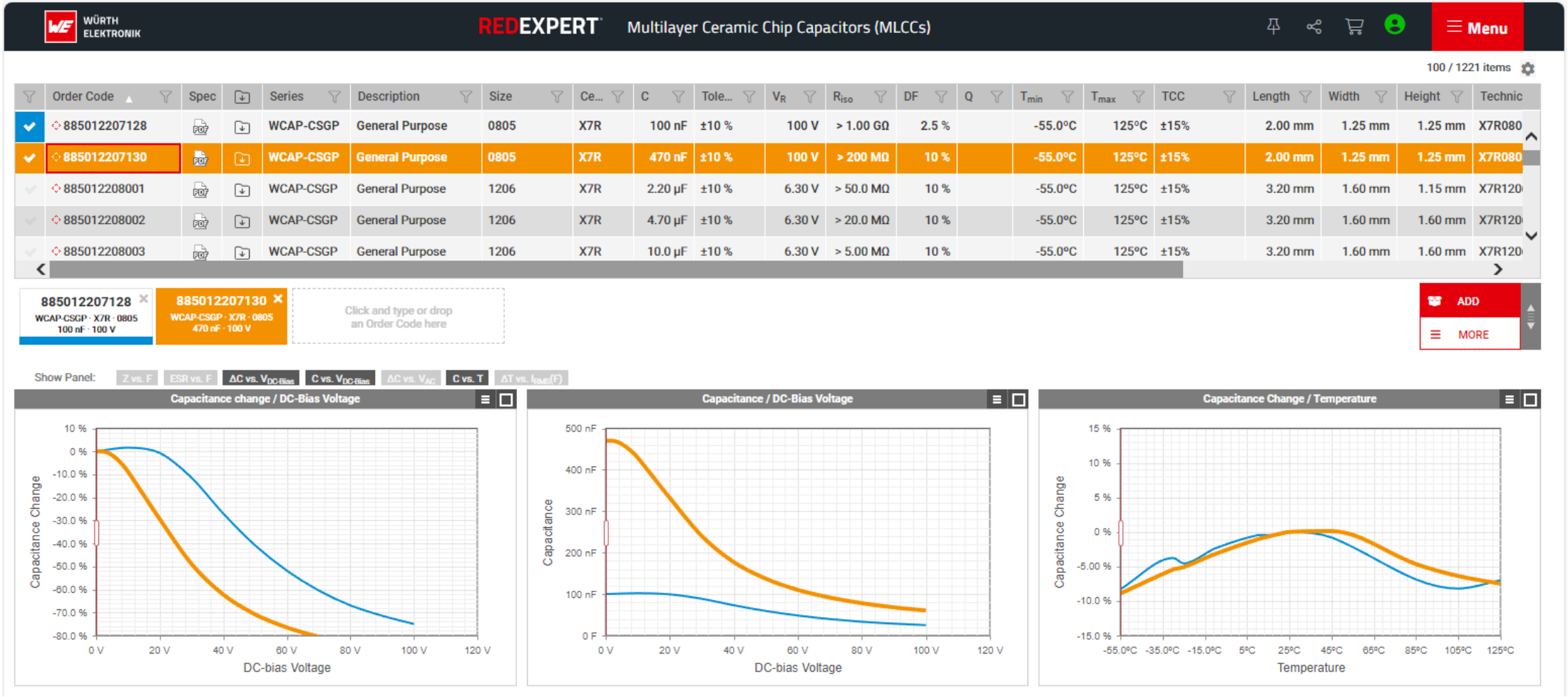
DC Isolation Capacitor – Calculation Example

- Capacitor for 10BASE-T1L (885012207130 | 885012207128) :
  - C: **470 nF** ±10% | **100 nF** ±10%
  - Nennspannung: 100 V | 100 V
  - Typ: X7R | X7R
- DC Saturation: 58 V both → 24 V per Capacitor
  - C_{470nF} → **-38 %**
  - C_{100nF} → **-5 %**
- Environment Temperature ca. **65 °C**
  - C_{470nF} → **-1.84 %**
  - C_{100nF} → **-3.8 %**
- Aging after 1000 h → **-2 %**
  - C_{470nF} → **-2 %**
  - C_{100nF} → **-2 %**



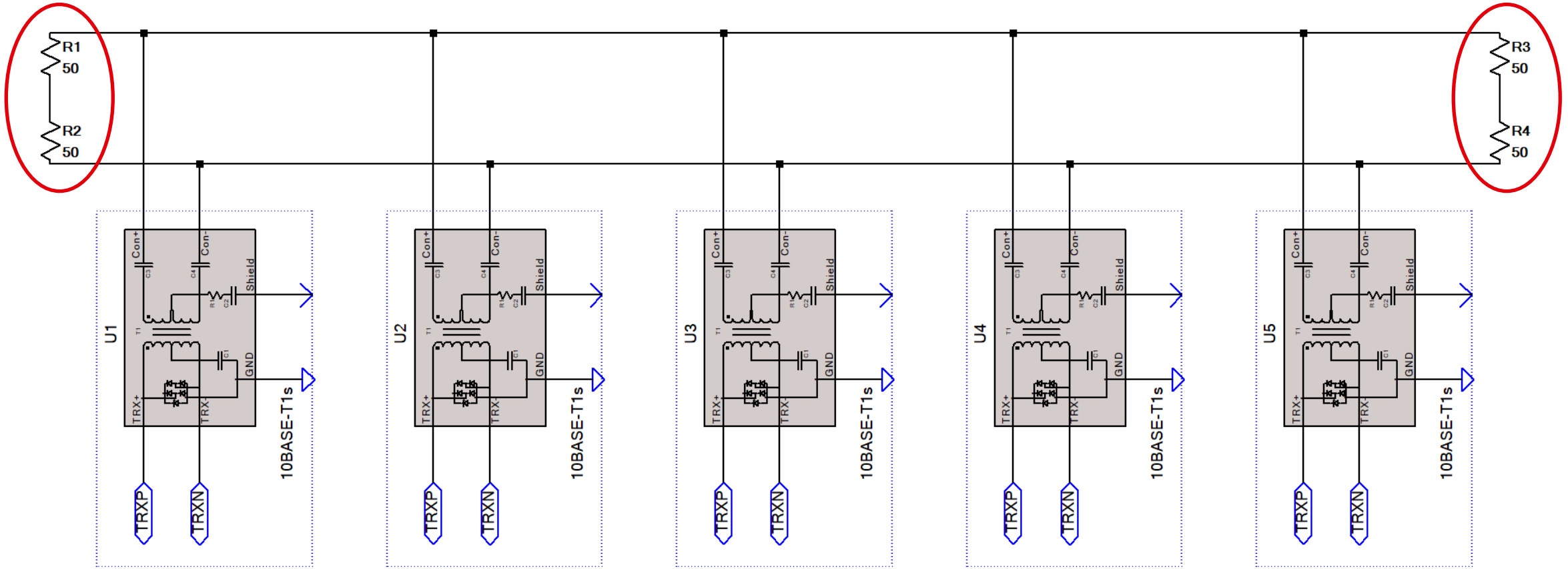
4. 10BASE-T1S IN DETAIL

DC Isolation Capacitor – Redexpert Tool



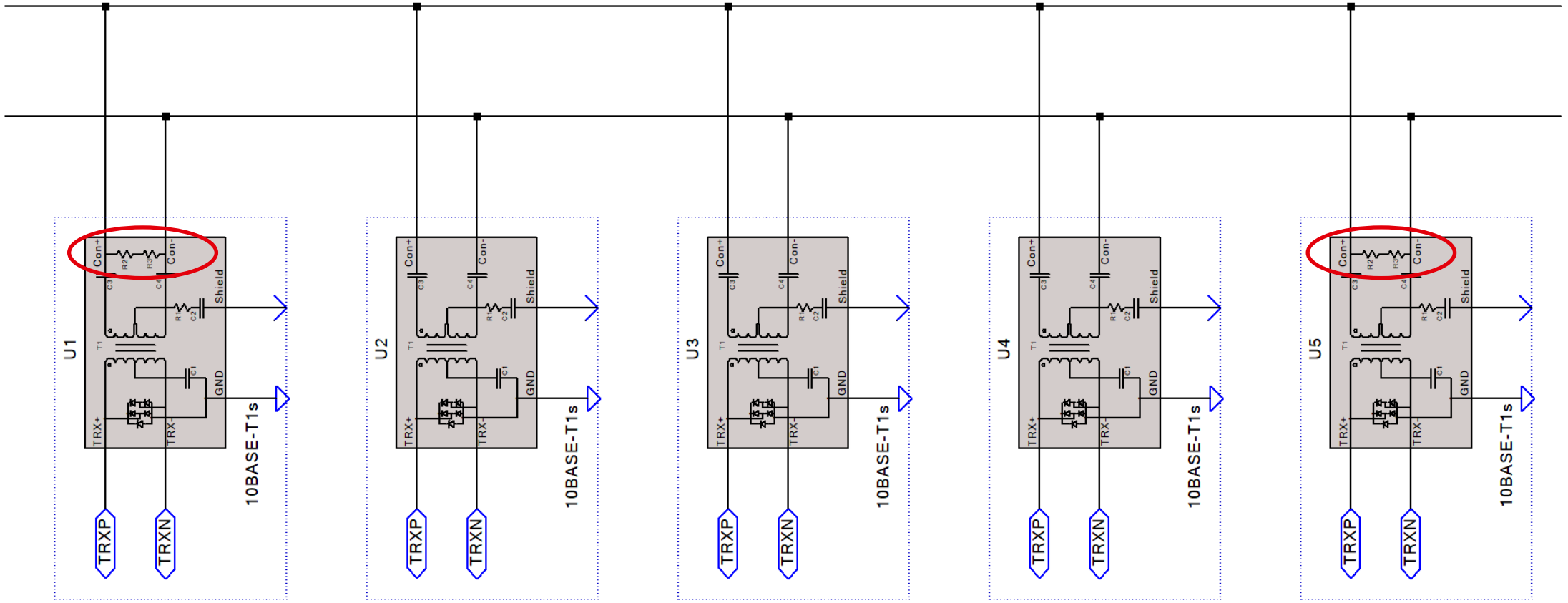
4. 10BASE-T1S IN DETAIL

Termination on Bus Line for 10BASE-T1s



4. 10BASE-T1S IN DETAIL

Termination at MDI for 10BASE-T1s



4. 10BASE-T1S IN DETAIL

4.2 PHY ICs for SPE

10BASE-T1L

- **Analog Devices**
  - PHY
    - *ADIN1100*
    - *ADIN1110 (MAC-PHY)*
  - 2-Port Switch
    - *ADIN2111 (MAC-PHY)*
- **Texas Instruments**
  - *DP83TD510E*

10BASE-T1s

- **ONSEMI**
  - *NCN26010 (MAC-PHY)*
- **Microchip**
  - *LAN8650 (MAC-PHY)*
  - *LAN8651 (MAC-PHY)*
  - *LAN8670*
  - *LAN8671*
  - *LAN8672*

Questions

& Answers

We are here for you now!
Ask us directly via our chat or via E-Mail.

digital-we-days@we-online.com
Simon.Mark@we-online.com