CAN in Future Networks Understanding The Different Trends and Solutions

Ingo Kissel

FAE/Marketing In-Vehicle Networking

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NXP SECURE CONNECTIONS FOR A SMARTER WORLD

Agenda

- Main Applications & CAN Portfolio Overview

- Functional Modes

- Mainstream CAN Portfolio

- CAN FD

- Advanced Functions

Mercedes-Benz W-140

Volkswagen Golf Mk5

Volkswagen Golf 2019

1993 - 2000

PCA82C250 – First Philips transceiver (>20Mpcs in 2017)

SJA1000 – Standalone CAN controller (>3Mpcs in 2018)

2000 - 2010

Gen-2 and Gen-3 launched

TJA1042, TJA1051 became standard in the market

HS-CAN becomes dominant automotive networking technology

2010 - 2020

CAN FD defined and rolling out

Mantis launched with benchmark EMC

Partial Networking defined and rolls out

Node explosion, increased competition

NXP acknowledged market leader

NXP leads on innovation, support, reliability and expertise

NXP leads on No Hassle Quality and Supply

Mercedes-Benz W-140

Volkswagen Golf 2019

1993 - 2000

2010 - 2020

High Speed CAN

Fault Tolerant CAN

Single Wire CAN

Increase of types

High Speed CAN
Fault Tolerant CAN
Single Wire CAN
VeLIO
Partial Networking
CAN FD 2 Mbps
CAN FD 5 Mbps
CAN FD Passive
CAN FD Shield
CAN FD Protect
Isolated HS-CAN

Secure Transceiver
CAN FD Signal Improvement
48 V Isolated CAN

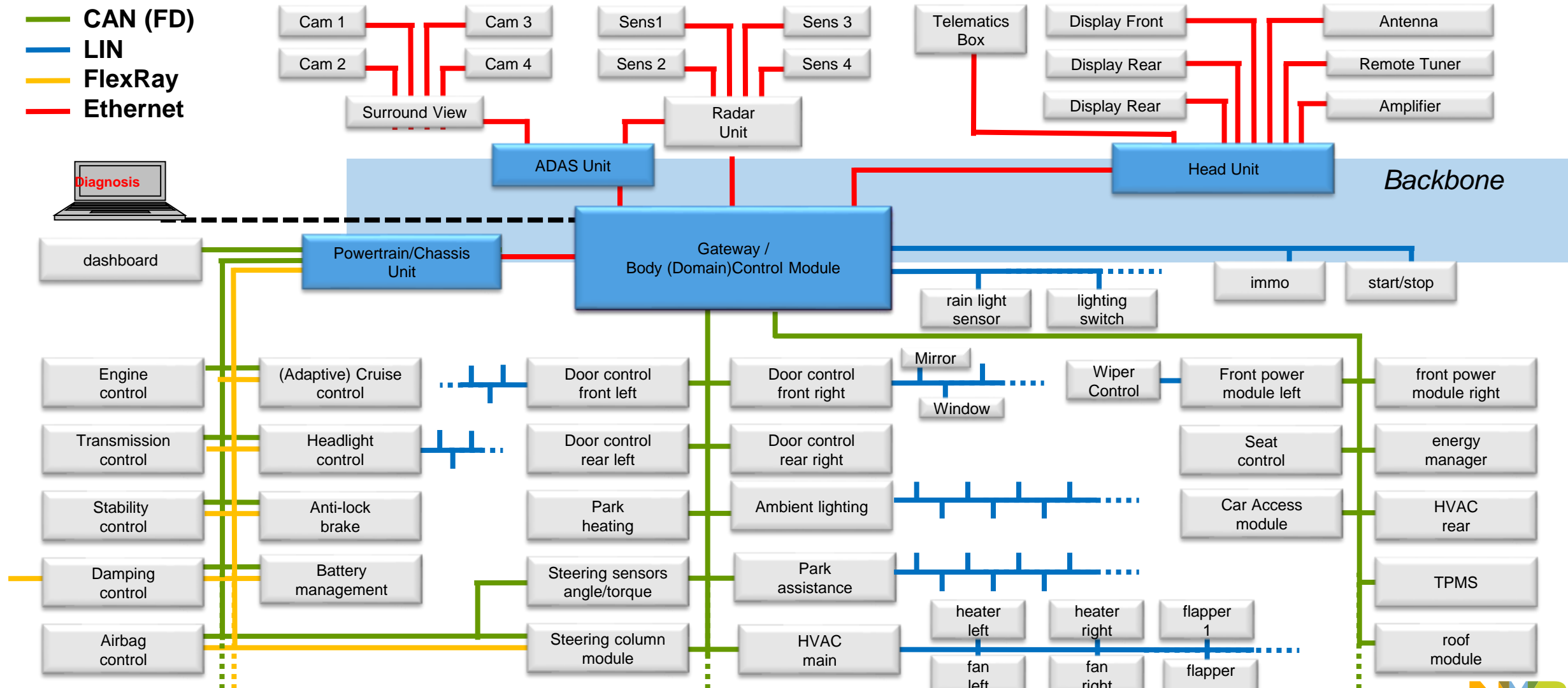# Towards Autonomous Drive: A Car Network Today

2B NODES IN 2014
4B NODES IN 2020

OVERGROWING AUTOMOTIVE MARKET

COMMUNICATION, ENERGY MANAGEMENT, SAFETY, SECURITY

KEY ENABLER FOR ALL CAR INNOVATION

— CAN (FD)
— LIN
— FlexRay
— Ethernet

Cam 1 Cam 3
Cam 2 Cam 4
Surround View

Sens1 Sens 3
Sens 2 Sens 4
Radar Unit

Telematics Box
Display Front
Display Rear
Display Rear

Antenna
Remote Tuner
Amplifier

Diagnosis

ADAS Unit

Head Unit

Backbone

dashboard

Powertrain/Chassis Unit

Gateway /
Body (Domain)Control Module

immo   start/stop

rain light sensor   lighting switch

Engine control   (Adaptive) Cruise control   Door control front left   Door control front right   Mirror   Window   Wiper Control   Front power module left   front power module right

Transmission control   Headlight control   Door control rear left   Door control rear right   Seat control   energy manager

Stability control   Anti-lock brake   Park heating   Ambient lighting   Car Access module   HVAC rear

Damping control   Battery management   Steering sensors angle/torque   Park assistance   TPMS

Airbag control   Steering column module   HVAC main   heater left   heater right   flapper 1   roof module

fan left   fan right   flapper ...

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STANDARD APPLICATIONS

Classical CAN (sub-1Mbps)

12 V Systems	Mainstream CAN applications for passenger vehicles
12 V VeLIO Certified	Specific wave-shape, required by Toyota
24 V Systems	Higher bus robustness requirements for commercial vehicles

CAN FD (Beyond 1Mbps)

CAN FD

Transceiver Performance Requirements:
- 5 Mbps operation guaranteed
- 2 Mbps EMC IBEE Compliant
- C&S CAN FD Interoperability Compliant

CAN FD Option: 1.8µs WUP
- 2023+
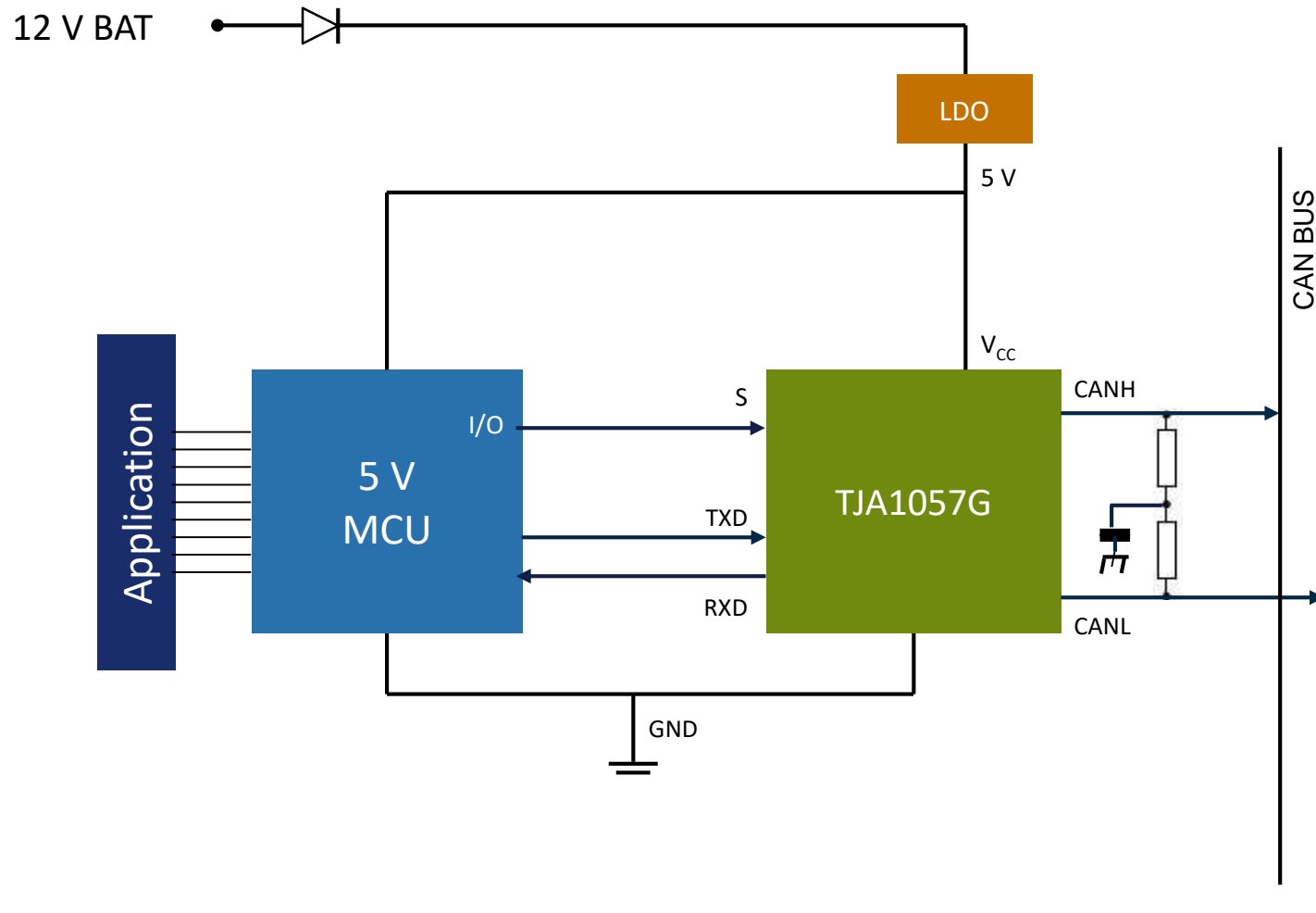
Filtering CAN FD frames — 2 Mbps / 5 Mbps

CAN with Flexible data rate
For higher bitrates at 2- and 5 Mbps, transceivers must guarantee:
- tighter timing tolerances
- improved EMC at higher bit rates
- interoperability tests

Smart bridging functions to use "Classical CAN" MCUs in CAN FD networks

NEW NXP FUNCTIONS

Active Signal Improvement	Boosting potential topology size & speed limit (5 Mbps+) for CAN FD
Secure Transceiver	Basic security functions embedded in the transceiver
Isolated HS-CAN Transceiver	Required for 48 V Mild Hybrids, Full Hybrids and Electric Vehicles

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		

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12 V VeLIO Certified

24 V Systems

CAN FD Beyond 1Mbps

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NEW NXP FUNCTIONS

Active Signal Improvement

Secure Transceiver

Isolated HS-CAN Transceiver

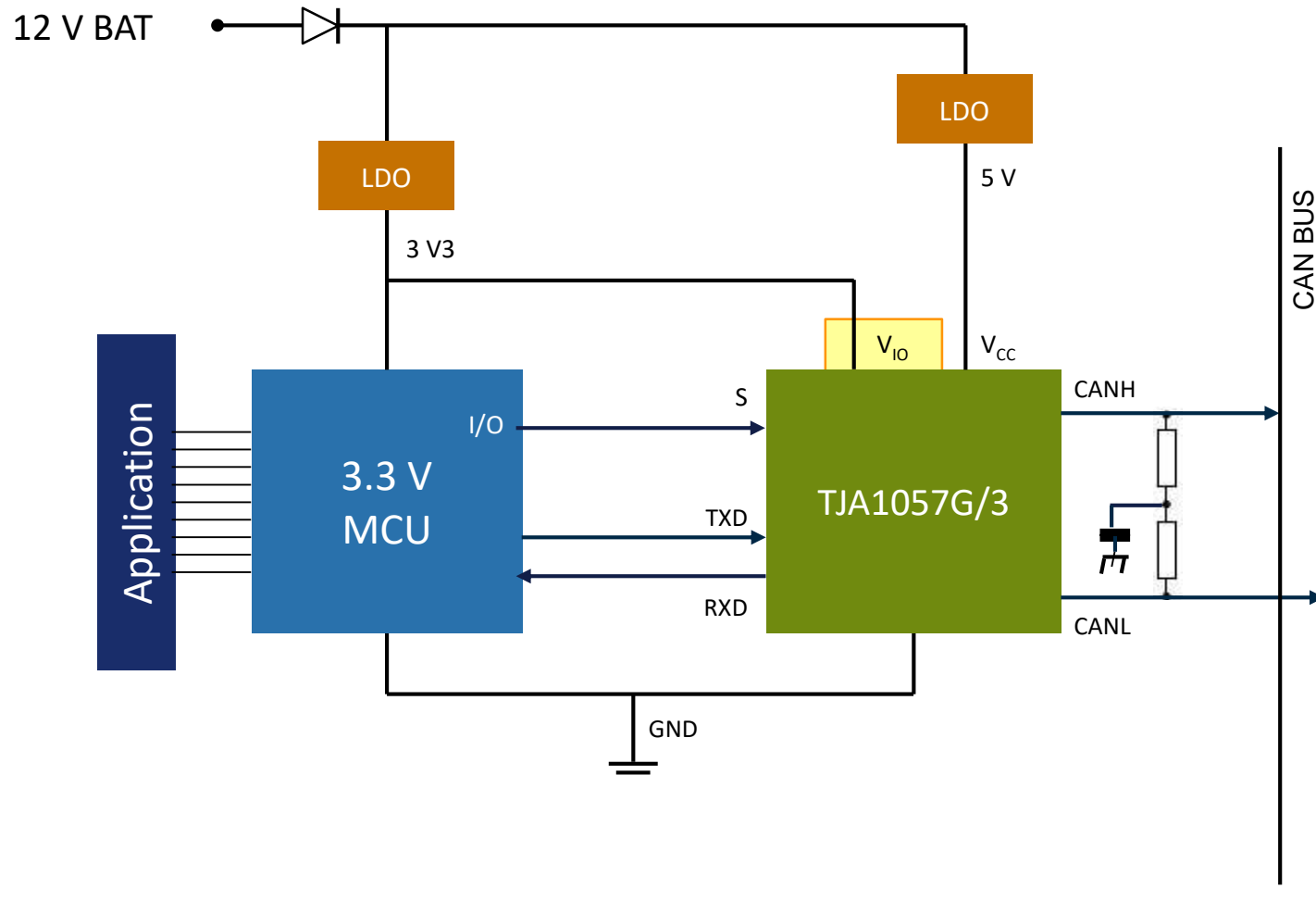NXP

Functional Mode: BASIC HS-CAN

Simplest CAN application

No low power modes
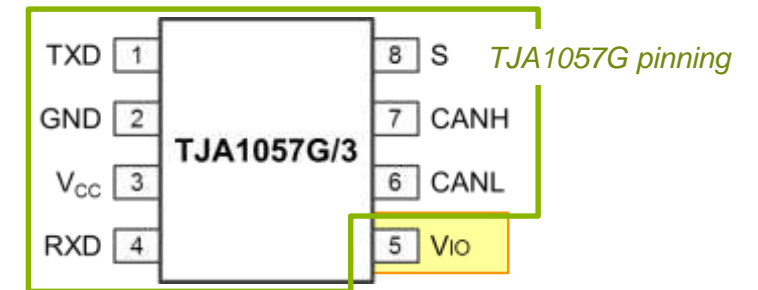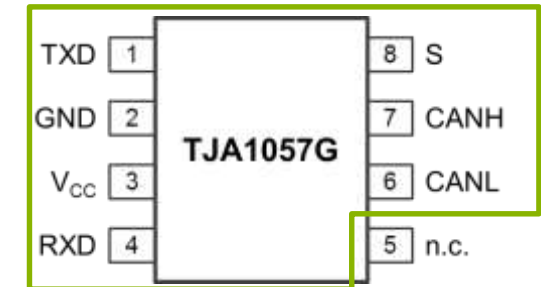
Silent / Listen-only mode

Functional Mode: BASIC HS-CAN

- Simplest CAN application
- No low power modes
- Silent / Listen-only mode
- V_{IO} option for 3.3 V MCU

TJA1057G pinning

Basic		Standby		Dual Standby		Sleep	Partial Networking
5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		
TJA1057G	TJA1057G/3						

STANDARD APPLICATIONS

Classical CAN (sub-1Mbps)

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- 12 V VeLIO Certified
- 24 V Systems

CAN FD (Beyond 1Mbps)

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NEW NXP FUNCTIONS

- Active Signal Improvement
- Secure Transceiver
- Isolated HS-CAN Transceiver

NXP

Functional Mode: HS-CAN with STANDBY MODE

Silent pin replaced by Standby (STB) pin

Used by Host MCU to reduce power consumption

Host MCU typically goes to "stop" for fast start

Transceiver wakes up:
- Detects bus activity → wakes up MCU
- Host MCU wants to send a message

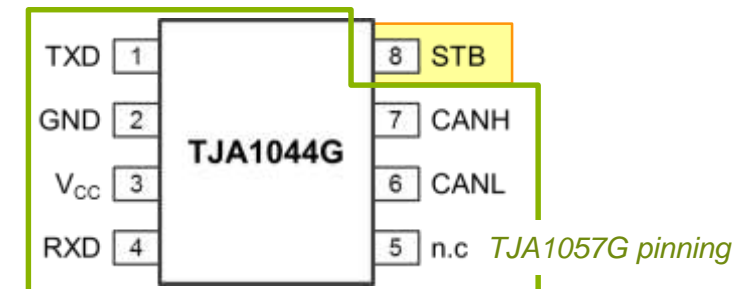# Functional Mode: HS-CAN with STANDBY MODE

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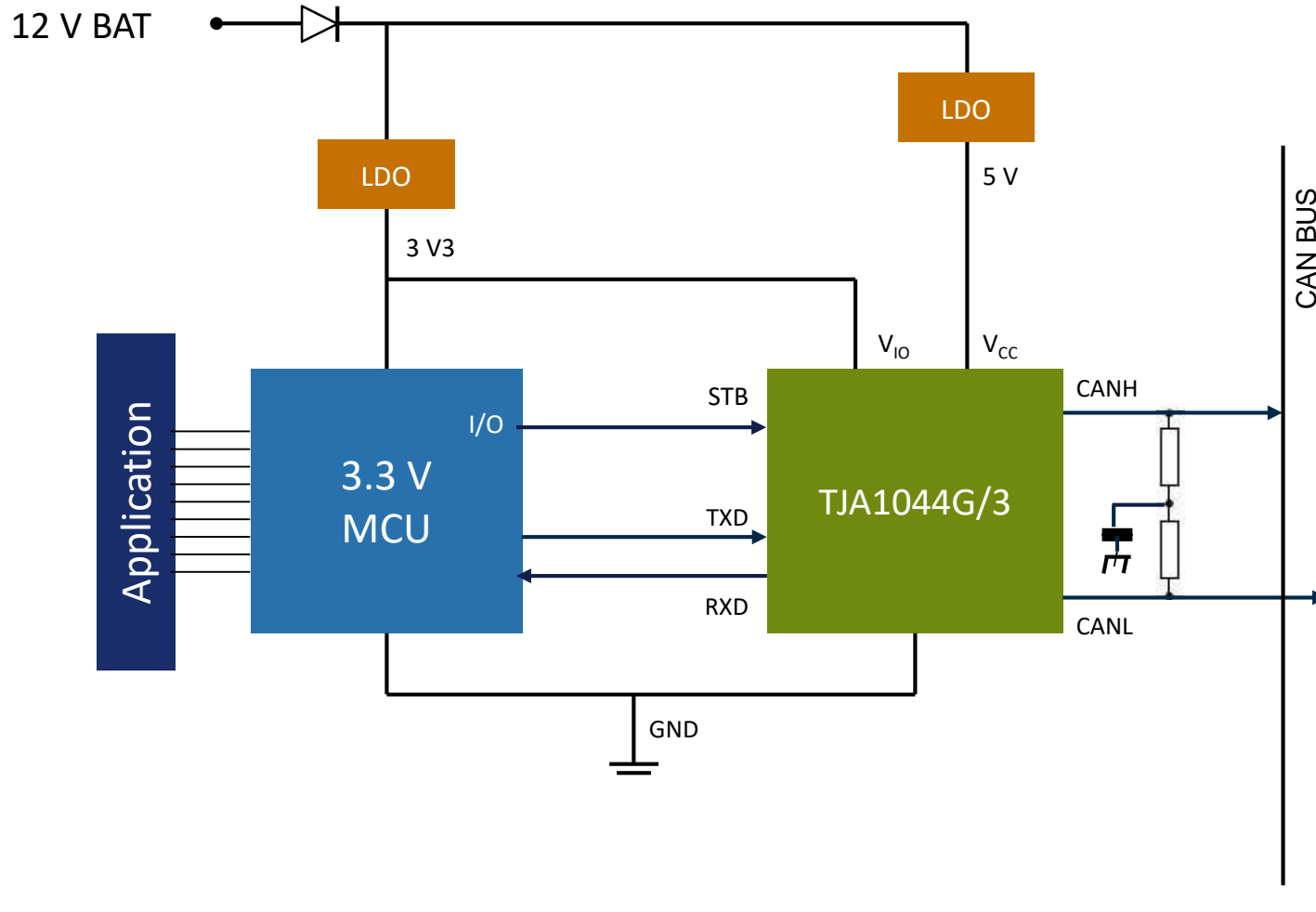
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V_{IO} option for 3.3 V MCU

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		
	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3				

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| Filtering CAN FD frames | 2 Mbps |
| | 5 Mbps |

NEW NXP FUNCTIONS

- Active Signal Improvement
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	Basic		Standby		Dual Standby		Sleep	Partial Networking
	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		

STANDARD APPLICATIONS

Classical CAN (sub-1Mbps)

12 V Systems
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24 V Systems

	Basic		Standby	
	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3

CAN FD (Beyond 1Mbps)

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NEW NXP FUNCTIONS

Active Signal Improvement
Secure Transceiver
Isolated HS-CAN Transceiver

Dual Channel HS-CAN With STANDBY MODE

Two independent CAN interfaces available

Independent standby modes available per channel

Offers smaller board space in multi-channel CAN applications

HVSON14 package offers 77% smaller board-space vs. 2 individual SO8 packages

Scales from TJA1044G pinning

TXD1	1	14	STB1
GND1	2	13	CANH1
V$_{CC1}$	3	12	CANL1
RXD1	4 TJA1046	11	STB2
TXD1	5	10	CANH2
GND2	6	9	CANL2
Vcc2	7	8	RXD2

Dual Channel HS-CAN with STANDBY MODE
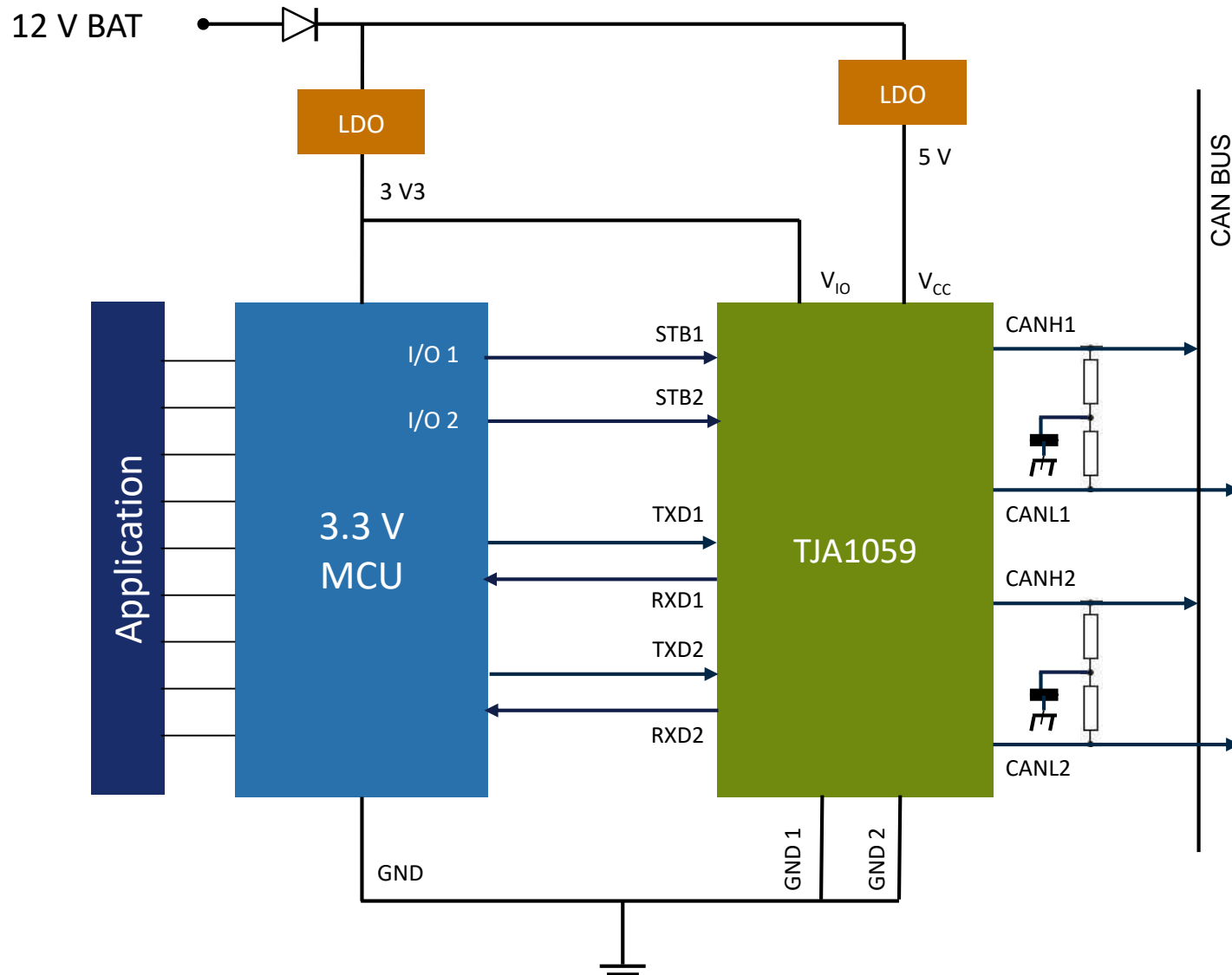
Two independent CAN interfaces available

Independent standby modes available per channel

Offers smaller board space in multi-channel CAN applications

HVSON14 package offers 77% smaller board-space vs. 2 individual SO8 packages

VIO pin enables use with MCUs with 3.3 V or 5 V supply

Scales from TJA1044G/3 pinning

Functional Mode: HS-CAN with SLEEP MODE

Offers both Standby and Sleep modes

Battery connection powers low-power receiver to enable complete ECU shutdown

Transceiver wakes up:
- Receives bus activity → wakes up MCU
- Local wake-up event on WAKE pin
- Host MCU wants to send a message

V_{IO} standard for 3.3 V MCU

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		
	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	

STANDARD APPLICATIONS

Classical CAN (sub-1Mbps)

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CAN FD (Beyond 1Mbps)

CAN FD

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CAN FD Option: 1.8µs WUP
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| Filtering CAN FD frames | 2 Mbps |
| | 5 Mbps |

NEW NXP FUNCTIONS

- Active Signal Improvement
- Secure Transceiver
- Isolated HS-CAN Transceiver

Velio: Special Requirement for Toyota

- **Functionally** – 100% same operation as regular transceivers

- **Differences:**
  - Toyota has tighter requirements on CAN signal slopes to limit signal ringing within the network
  - Requires different CAN transmitter, with performance trade-offs for non-VeLIO markets
  - VeLIO testing house certification required which measures these parameters

- **Products, specifically tuned to meet requirements**
  - Standby: TJA1044V and TJA1044V/3
  - Dual Standby: TJA1046V and TJA1059
  - *Applicable to Standby mode only (other modes not used at Toyota)*

Waveform of CAN_H-CMC
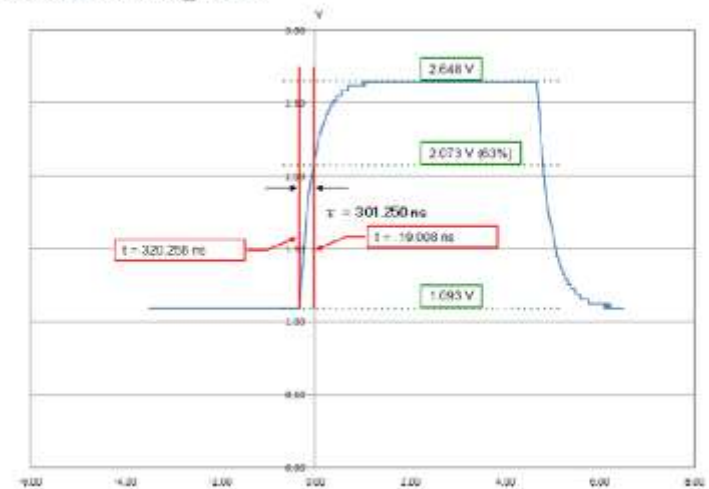
Waveform of Vdiff

STANDARD APPLICATIONS

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	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		
Classical CAN (sub-1Mbps) — 12 V Systems	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	
	N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A	

Classical CAN (sub-1Mbps)
- 12 V Systems
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CAN FD (Beyond 1Mbps)

CAN FD
Transceiver Performance Requirements:
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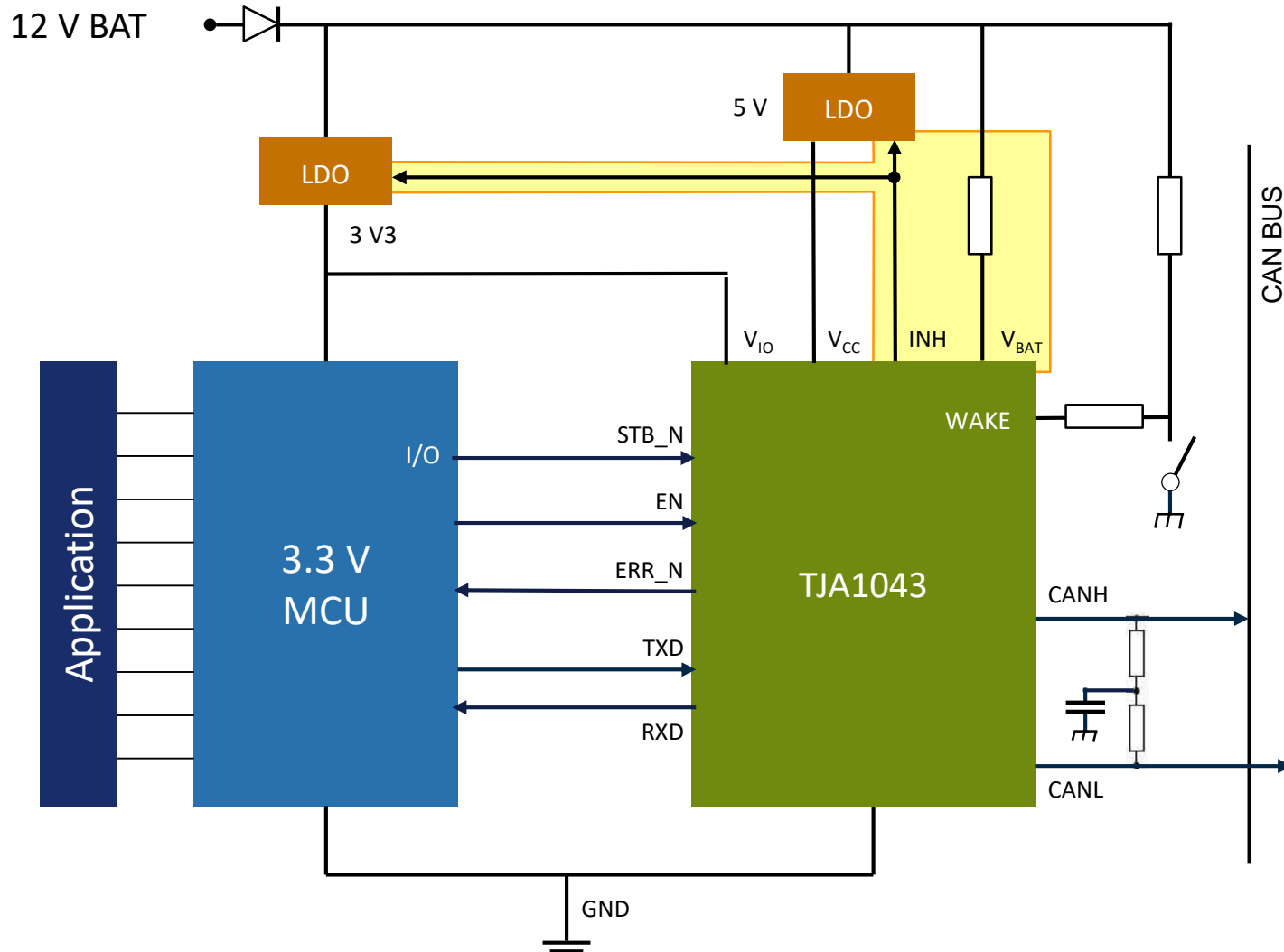- 2023+

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NEW NXP FUNCTIONS

- Active Signal Improvement
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STANDARD APPLICATIONS

	Basic		Standby		Dual Standby		Sleep	Partial Networking
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	N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A	

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NEW NXP FUNCTIONS

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24 V Systems

- Commercial vehicles: trucks and buses

- Requires protection against bus failures
  - e.g. short to battery, short to ground

- 24 V ready transceivers offer an extended voltage robustness of ±58 V

- Required on all transceivers types
  - Basic: TJA1051 family
  - Standby: TJA1042 family, TJA1059 (dual)
  - Sleep: TJA1043

STANDARD APPLICATIONS		Basic		Standby		Dual Standby		Sleep	Partial Networking
		5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		
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CAN FD
Beyond 1Mbps

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NEW NXP FUNCTIONS

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STANDARD APPLICATIONS

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CAN FD Beyond 1Mbps

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NEW NXP FUNCTIONS

Active Signal Improvement

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CAN with Flexible Data Rate: Boosting CAN's Potential
10 times faster, minimum effort

- Accelerated bandwidth to support new and complex functions
  - Enables faster data communication up to 5 Mbps

- Accelerate ECU Flashing in production

- Larger payloads to support security introduction
  - Allows for larger payload up to 64-bytes

- Low cost, low power and low disruption vs. switching to alternate technologies

CAN FD: Tighter Performance Requirements

Advanced Timing Parameters

- Beyond 1 Mbps: bit times need to be guaranteed to ensure reliable communication, defined for 2- and 5 Mbps.
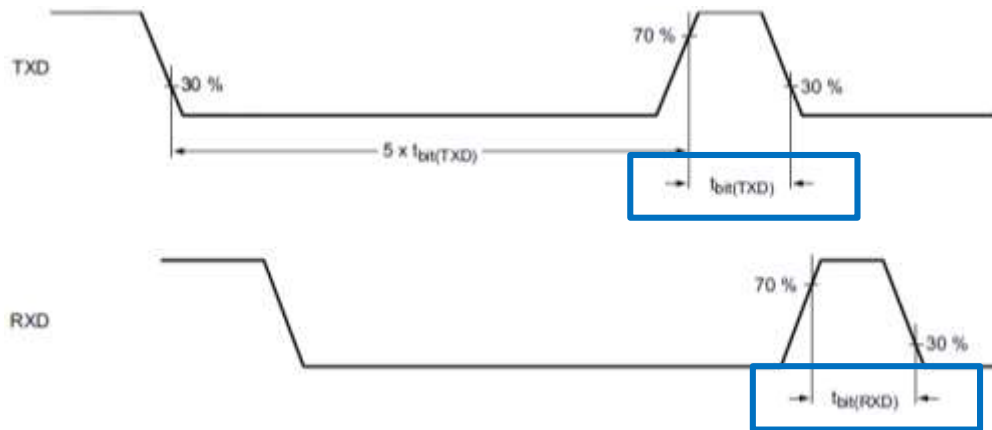
- Other parameters are also introduced or tightened – defined in ISO11898-2:2016 and SAE J2284-4 / -5.

- KEY POINT: 5 Mbps performance is required by OEMs for 2 Mbps applications
  OEMs require more timing margin in network

CAN FD EMC Testing

- **Emission:** Increasing speed means higher emission.

- **Immunity:** Higher speeds means tighter jitter tolerances

- Tests at 2- and 5 Mbps

- KEY POINT: OEMs require 2 Mbps EMC PASS for 2 Mbps operation*

Emission example

Jitter limit
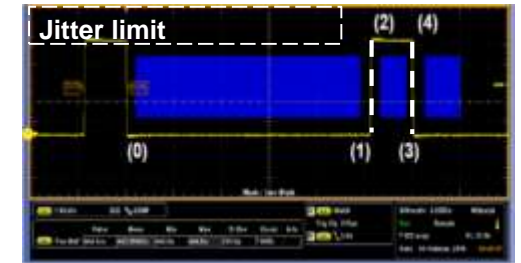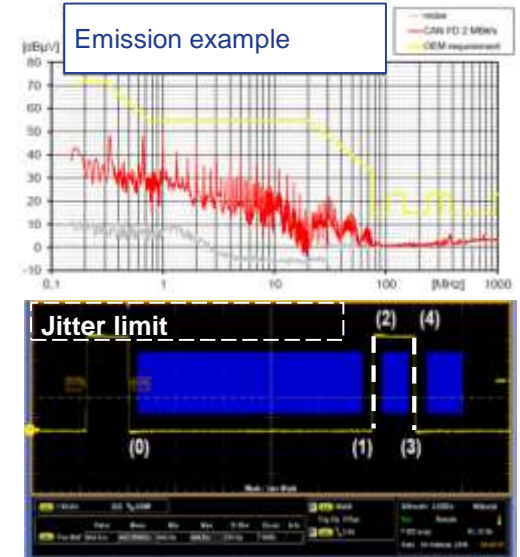
CAN FD Interoperability (IOPT) Testing

- CAN FD interoperability tests required to ensure different transceivers communicate without issues.

- Compliance to ISO standard is certified.

- KEY POINT: MUST HAVE for OEM approval

C&S CAN

STANDARD APPLICATIONS

Classical CAN (sub-1Mbps)

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		
12 V Systems	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	
12 V VeLIO Certified	N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A	
24 V Systems	TJA1051	TJA1051/3	TJA1042	TJA1042/3	TJA1059	TJA1059	TJA1043	

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2 Mbps
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	Basic		Standby		Dual Standby		Sleep
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	TJA1441B	TJA1441A					

NEW NXP FUNCTIONS

Active Signal Improvement
Secure Transceiver
Isolated HS-CAN Transceiver

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STANDARD APPLICATIONS

Classical CAN sub-1Mbps

		Basic 5 V MCU	Basic 3 V3 MCU	Standby 5 V MCU	Standby 3 V3 MCU	Dual Standby 5 V MCU	Dual Standby 3 V3 MCU	Sleep
12 V Systems		TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043
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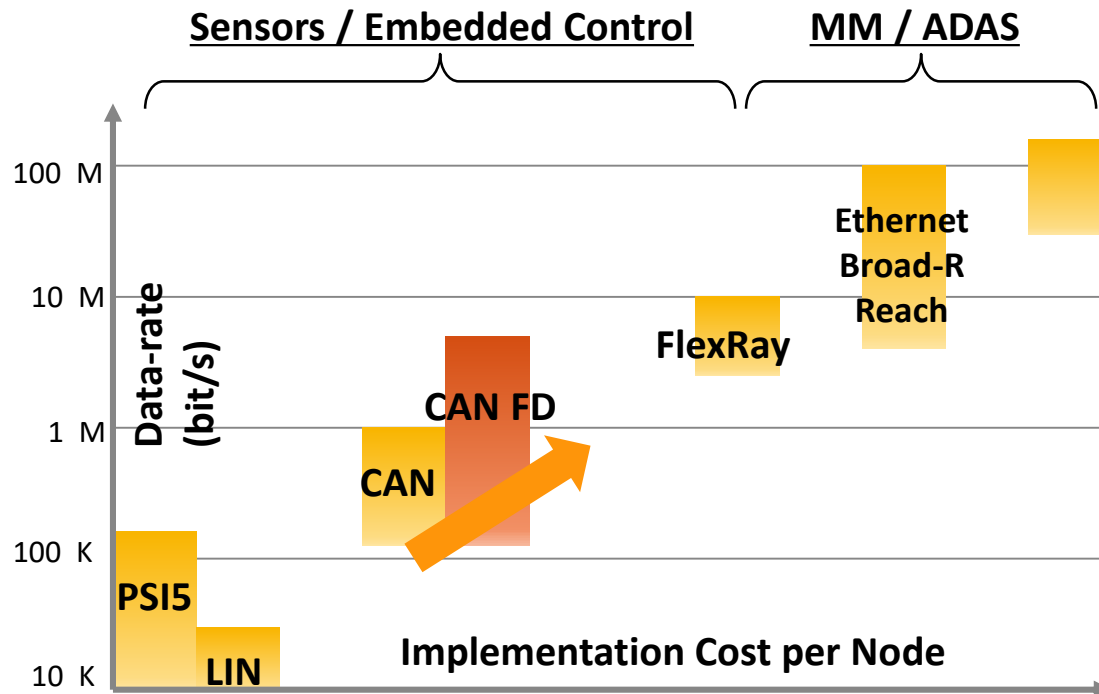- 2023+

Filtering CAN FD frames

	2 Mbps
	5 Mbps

Basic 5 V MCU	Basic 3 V3 MCU	Standby 5 V MCU	Standby 3 V3 MCU	Dual Standby 5 V MCU	Dual Standby 3 V3 MCU	Sleep
TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043
TJA1441B	TJA1441A					

NEW NXP FUNCTIONS

Active Signal Improvement

Secure Transceiver

Isolated HS-CAN Transceiver

Fast WUP (1.8μs) Requirement

Wake Up Filter Time (μs)   0,15   0,5   1,8   3.0 3,9   5,0

SOPs until 2023

Classic CAN &
SAE CAN FD

G5 CAN FD

NXP Legacy Products

SOPs 2023+

VW, BMW

NXP New Products

TJA1044GT/3 released
TJA144x-Aviary in development

True WW compliance requires to meet tightest range

Waking-up CAN traffic must work at faster data rates.
Requires faster detection due to shorter bits.

TRADE OFF: risk to wake-up on noise / glitches.

RESULT: Different OEMs have different requirements!
– SAE (US Big-3, RSA, others): keep current filter!
– G5, Toyota and others: require to faster filter by 2023.
– VW: requests 3.9 μs for 2020 platform.

To meet ALL requirements with one device:
must support the tightest range of all specs:

That is: 0.5μs – 1.8μs

NXP current devices: 0.5μs – 3.0μs (OK for today)

All new products will meet 0.5μs – 1.8μs

Already released products:
– TJA1044GT(K)/3 - standby mode HS-CAN

In development - AVIARY family:
– TJA1442x – Standby mode HS-CAN
– TJA1443x – Sleep mode HS-CAN
– TJA1448 – Dual-channel standby mode HS-CAN

STANDARD APPLICATIONS

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	TJA1441B	TJA1441A					
	N/A	N/A	TJA1442B	TJA1044G/3 / TJA1442A	TJA1448B	TJA1448A	TJA1443A

NEW NXP FUNCTIONS

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Isolated HS-CAN Transceiver

STANDARD APPLICATIONS

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		

Classical CAN (sub-1Mbps)

	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	Sleep	
12 V Systems	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	
	TJA1441B	TJA1441A	TJA1442B	TJA1442A	TJA1448B	TJA1448A	TJA1443A	
12 V VeLIO Certified	N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A	
			TJA1442B	TJA1442A	TJA1448B	TJA1448A		
24 V Systems	TJA1051	TJA1051/3	TJA1042	TJA1042/3	TJA1059	TJA1059	TJA1043	

CAN FD (Beyond 1Mbps)

CAN FD

Transceiver Performance Requirements:
- 5 Mbps operation guaranteed
- 2 Mbps EMC IBEE Compliant
- C&S CAN FD Interoperability Compliant

CAN FD Option: 1.8µs WUP
- 2023+

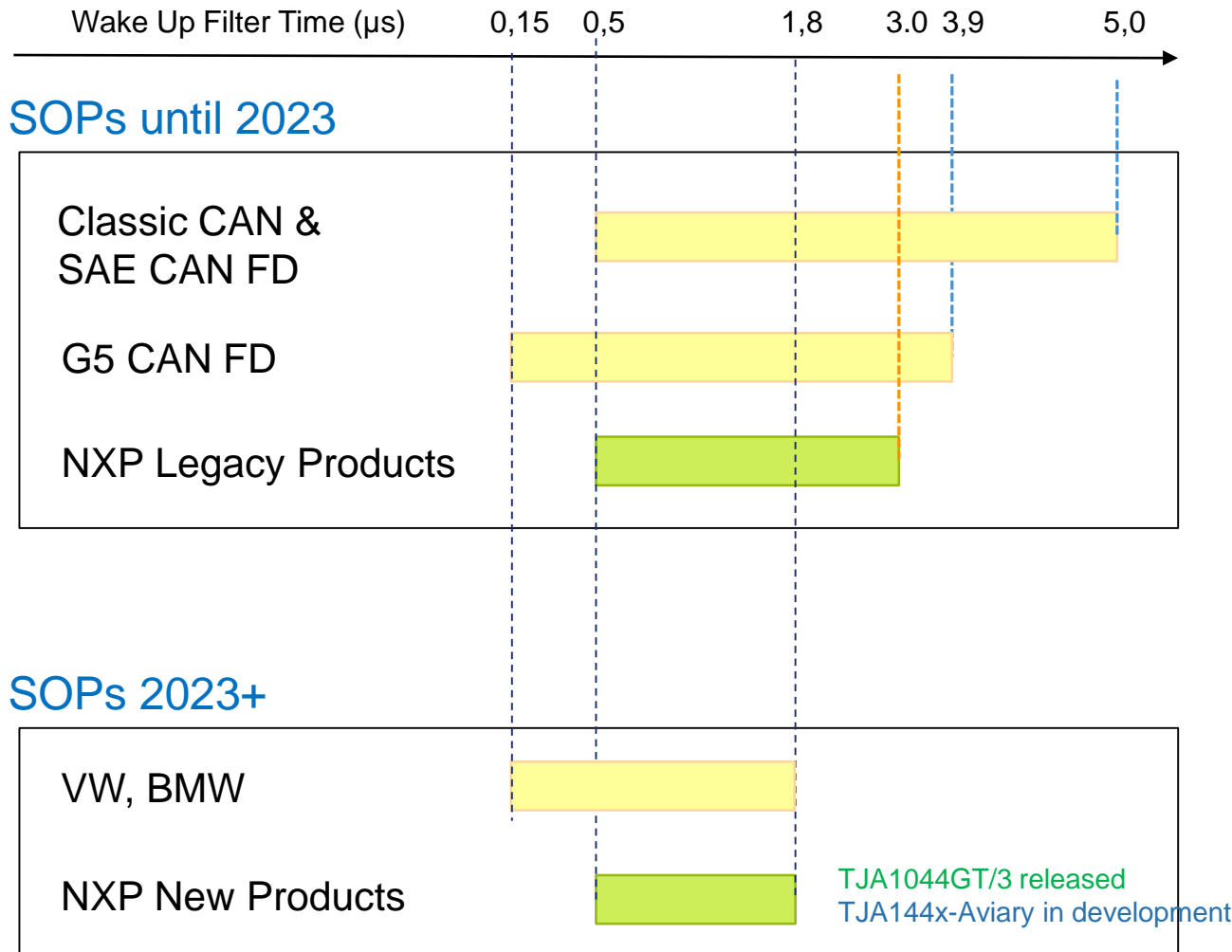Filtering CAN FD frames — 2 Mbps / 5 Mbps

	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	Sleep	
	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	
	TJA1441B	TJA1441A						
	N/A	N/A	TJA1442B	TJA1044G/3	TJA1448B	TJA1448A	TJA1443A	
				TJA1442A				

NEW NXP FUNCTIONS

- Active Signal Improvement
- Secure Transceiver
- Isolated HS-CAN Transceiver

Recommended replacement option!

NXP

STANDARD APPLICATIONS

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		

Classical CAN — sub-1Mbps

	Basic 5 V MCU	Basic 3 V3 MCU	Standby 5 V MCU	Standby 3 V3 MCU	Dual Standby 5 V MCU	Dual Standby 3 V3 MCU	Sleep
12 V Systems	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043
	TJA1441B	TJA1441A	TJA1442B	TJA1442A	TJA1448B	TJA1448A	TJA1443A
12 V VeLIO Certified	N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A
			TJA1442B	TJA1442A	TJA1448B	TJA1448A	
24 V Systems	TJA1051	TJA1051/3	TJA1042	TJA1042/3	TJA1059	TJA1059	TJA1043

CAN FD — Beyond 1Mbps

CAN FD

Transceiver Performance Requirements:
- 5 Mbps operation guaranteed
- 2 Mbps EMC IBEE Compliant
- C&S CAN FD Interoperability Compliant

CAN FD Option: 1.8µs WUP
- 2023+

Filtering CAN FD frames
- 2 Mbps
- 5 Mbps

	Basic 5 V MCU	Basic 3 V3 MCU	Standby 5 V MCU	Standby 3 V3 MCU	Dual Standby 5 V MCU	Dual Standby 3 V3 MCU	Sleep
CAN FD	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043
	TJA1441B	TJA1441A					
	N/A	N/A	TJA1442B	TJA1044G/3	TJA1448B	TJA1448A	TJA1443A
				TJA1442A			

NEW NXP FUNCTIONS

- Active Signal Improvement
- Secure Transceiver
- Isolated HS-CAN Transceiver

Smart CAN Nodes: More Intelligence for CAN

Ultra-low emission, ultra-low power, CAN FD cell

CAN TRANSCEIVER

CAN DECODER

CAN BUS MONITOR　→　**PARTIAL NETWORKING**

ENERGY SAVING, FAST ECU FLASHING

Functional Mode: HS-CAN with PARTIAL NETWORKING

The drawback of standard CAN bus wake-up behavior:

All ECUs are woken-up by <u>any</u> activity ✉ on the bus

| ECU X | ECU active |
| ECU X | ECU in sleep mode |
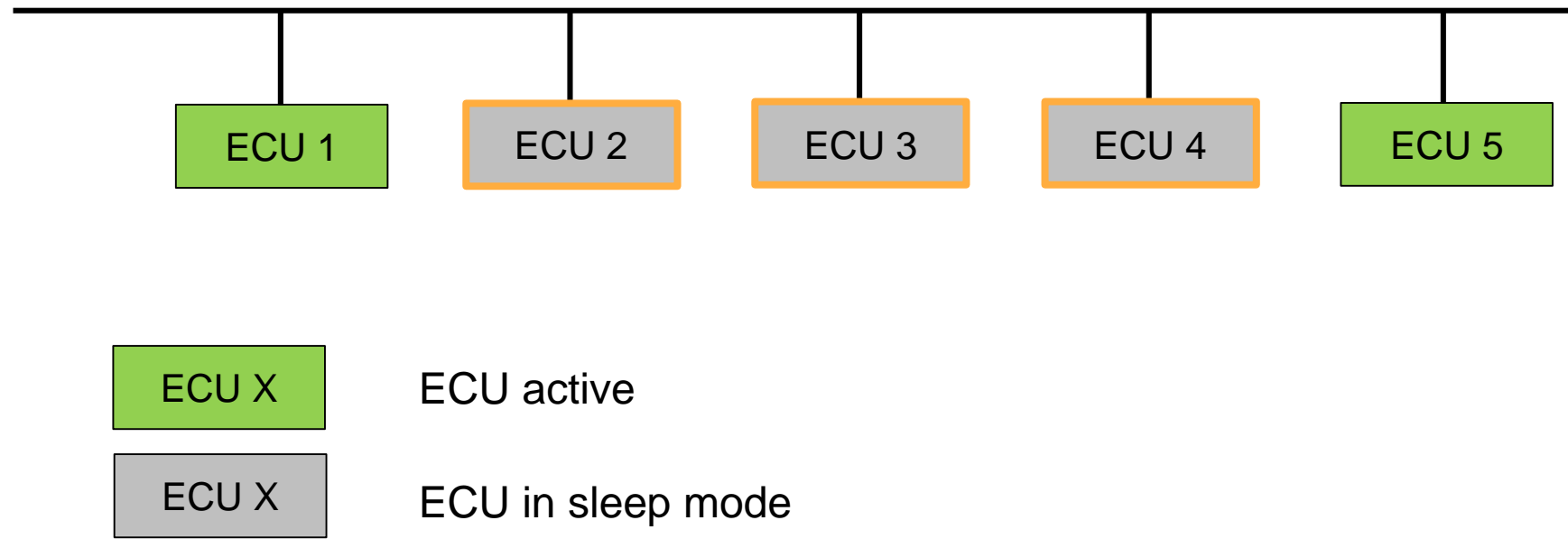
Functional Mode: HS-CAN with PARTIAL NETWORKING

Partial Networking allows specific parts of a network to operate, while others remain inactive

- Normal Bus traffic ✉ does not wake-up an ECU in Partial Networking (PN) mode

- In Partial Networking mode, ECUs wake-up only on specific wake-up messages ✉
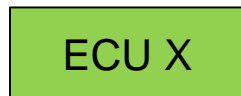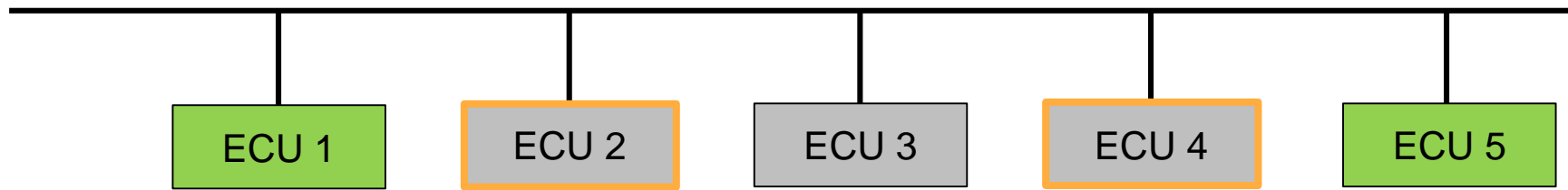
| ECU 1 | ECU 2 | ECU 3 | ECU 4 | ECU 5 |

| ECU X | ECU active |
| ECU X | ECU in sleep mode |
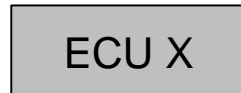
Functional Mode: HS-CAN with PARTIAL NETWORKING
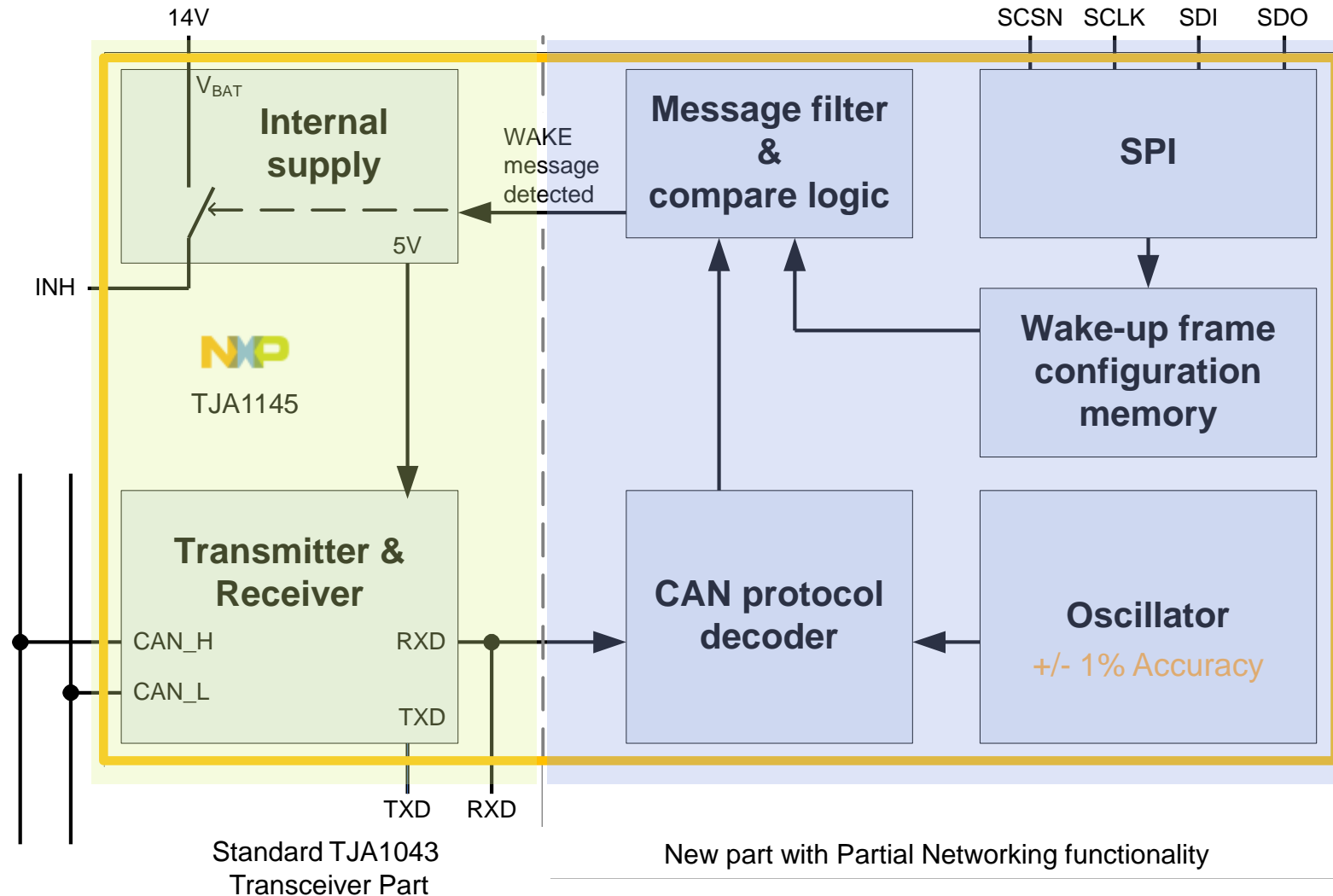
Functional Mode: HS-CAN with PARTIAL NETWORKING
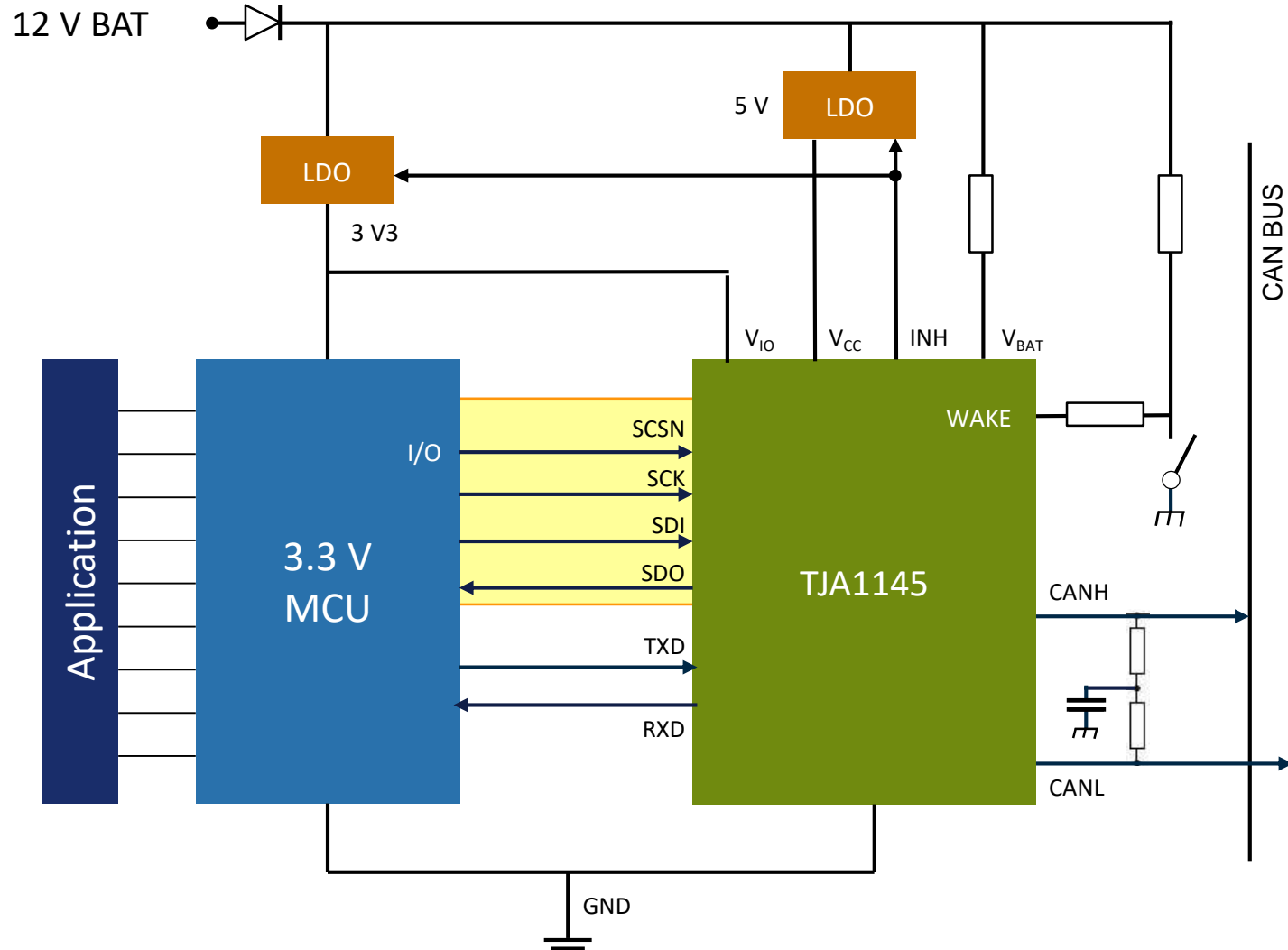
Control pins mapped to SPI interface

Transceiver has MTP memory storing wake-up configuration, programmed via Host MCU

V_{IO} standard for 3.3 V MCU

STANDARD APPLICATIONS

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		

Classical CAN (sub-1Mbps)

12 V Systems

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1145
	TJA1441B	TJA1441A	TJA1442B	TJA1442A	TJA1448B	TJA1448A	TJA1443A	

12 V VeLIO Certified

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A	N/A
			TJA1442B	TJA1442A	TJA1448B	TJA1448A		

24 V Systems

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	TJA1051	TJA1051/3	TJA1042	TJA1042/3	TJA1059	TJA1059	TJA1043	TJA1145

CAN FD (Beyond 1Mbps)

CAN FD

Transceiver Performance Requirements:
- 5 Mbps operation guaranteed
- 2 Mbps EMC IBEE Compliant
- C&S CAN FD Interoperability Compliant

CAN FD Option: 1.8µs WUP
- 2023+

Filtering CAN FD frames
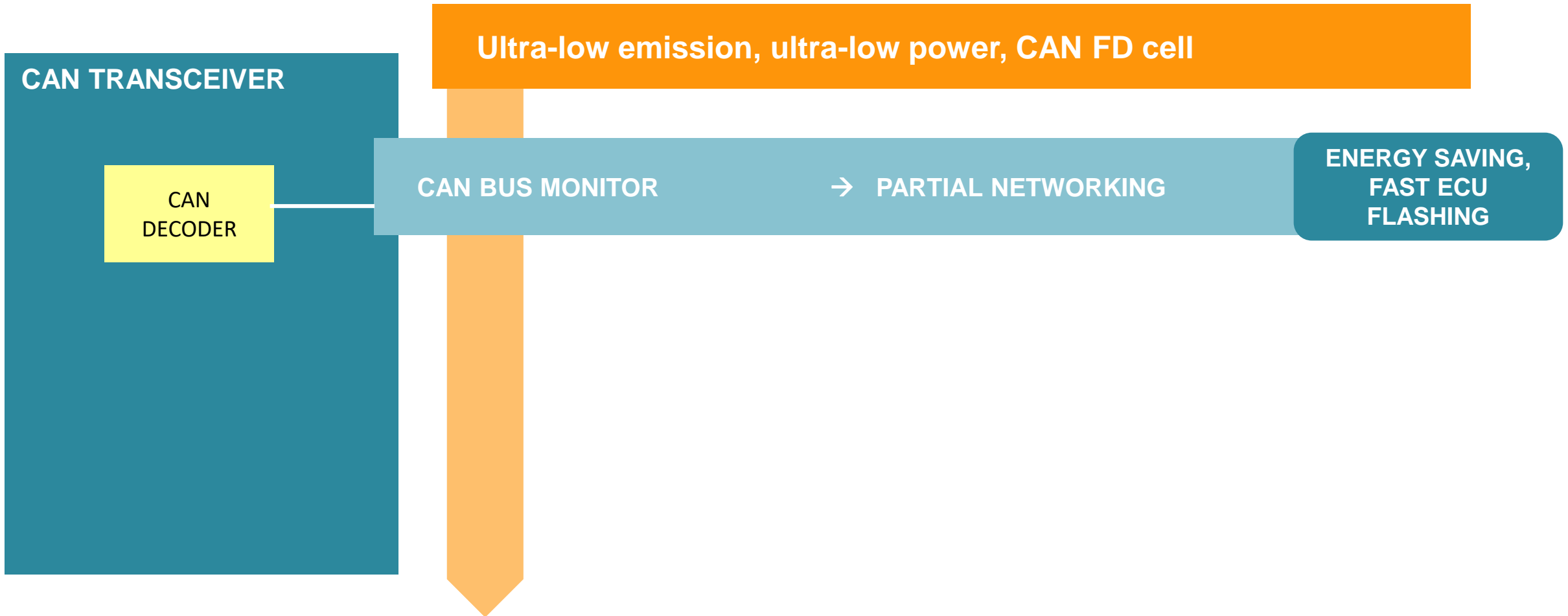- 2 Mbps
- 5 Mbps

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1445
	TJA1441B	TJA1441A						
	N/A	N/A	TJA1442B	TJA1044G/3	TJA1448B	TJA1448A	TJA1443A	TJA1445
				TJA1442A				

NEW NXP FUNCTIONS

- Active Signal Improvement
- Secure Transceiver
- Isolated HS-CAN Transceiver

STANDARD APPLICATIONS

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		

Classical CAN (sub-1Mbps)

12 V Systems	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1145
	TJA1441B	TJA1441A	TJA1442B	TJA1442A	TJA1448B	TJA1448A	TJA1443A	
12 V VeLIO Certified	N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A	N/A
			TJA1442B	TJA1442A	TJA1448B	TJA1448A		
24 V Systems	TJA1051	TJA1051/3	TJA1042	TJA1042/3	TJA1059	TJA1059	TJA1043	TJA1145

CAN FD (Beyond 1Mbps)

CAN FD

Transceiver Performance Requirements:
- 5 Mbps operation guaranteed
- 2 Mbps EMC IBEE Compliant
- C&S CAN FD Interoperability Compliant

CAN FD Option: 1.8µs WUP
- 2023+

Filtering CAN FD frames
- 2 Mbps
- 5 Mbps

	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	Sleep	Partial Networking
	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1445
	TJA1441B	TJA1441A						
	N/A	N/A	TJA1442B	TJA1044G/3	TJA1448B	TJA1448A	TJA1443A	TJA1445
				TJA1442A				

NEW NXP FUNCTIONS

Active Signal Improvement

Secure Transceiver

Isolated HS-CAN Transceiver

Smart CAN Nodes: More Intelligence for CAN

Ultra-low Emission, Ultra-low Power, CAN FD cell

CAN TRANSCEIVER

CAN DECODER

CAN FD CONTROLLER

CAN BUS MONITOR → PARTIAL NETWORKING

ENERGY SAVING, FAST ECU FLASHING

CAN FD BUS MONITOR → FD SHIELD FD PROTECT

RE-USE CAN ECUs IN CAN FD NETWORKS

FILTERING CAN FD FRAMES

- **CORE PROBLEM:** "Classic" CAN controllers cannot understand CAN FD → ERROR

- **All legacy ECUs require update:**
  - Additional cost and effort
  - Limited CAN FD support on simple MCUs

- **NXP's solution:** use transceiver to filter CAN FD

- **FD PASSIVE:** Classical CAN ECUs placed in partial networking mode during CAN FD communication

- **FD SHIELD:** Classical CAN ECUs to arbitrate against CAN FD ECUs in normal operation

- **FD PROTECT:** Targets filtering of high speed CAN FD traffic during ECU flashing periods
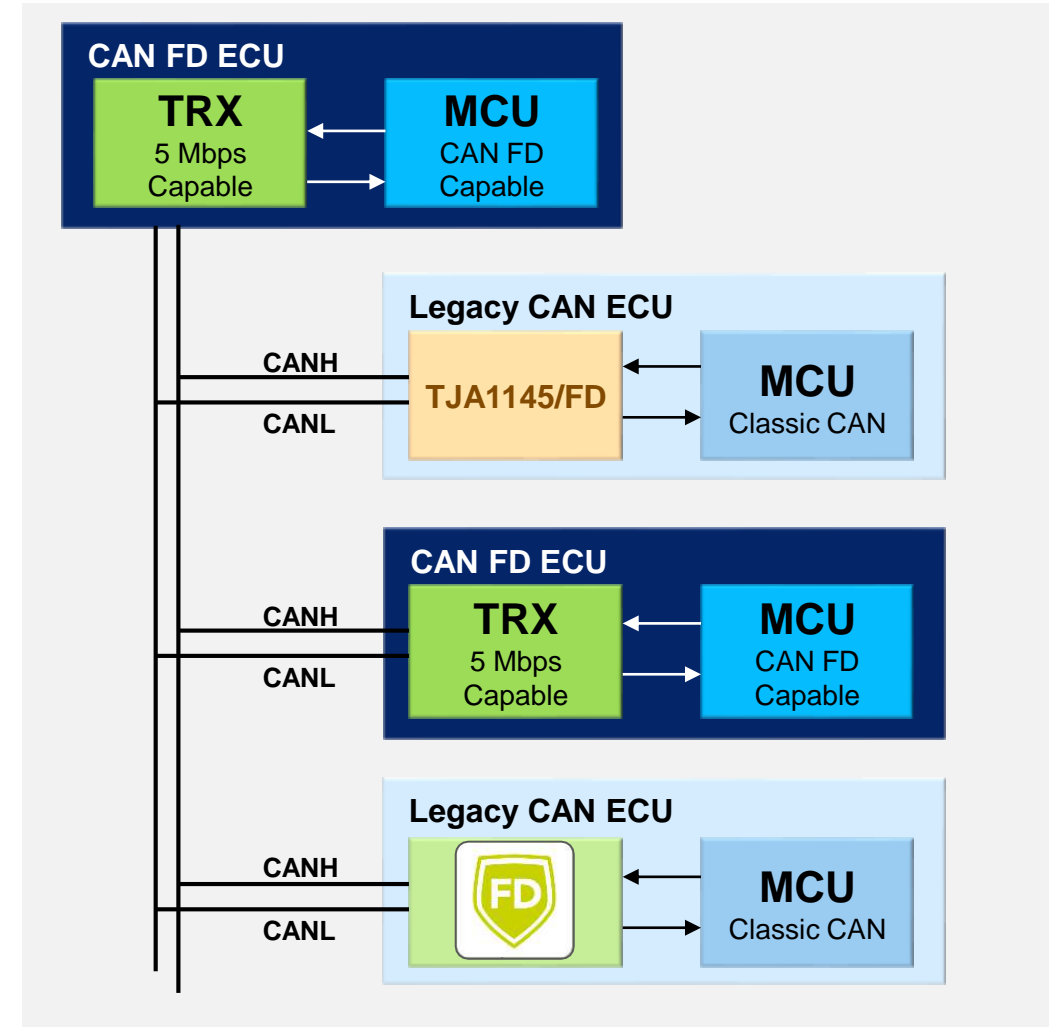
FD PASSIVE: TJA1145/FD

- ## FD PASSIVE "shields" CAN FD frames using Partial Networking function

Bus signal		GO TO SLEEP FRAME		CAN FD frame		CAN FD frame		WAKE UP FRAME		Classical CAN frame	

Wake Up	ACTIVE	SLEEP MODE	ACTIVE

RxD signal	GO TO SLEEP FRAME		Classical CAN frame
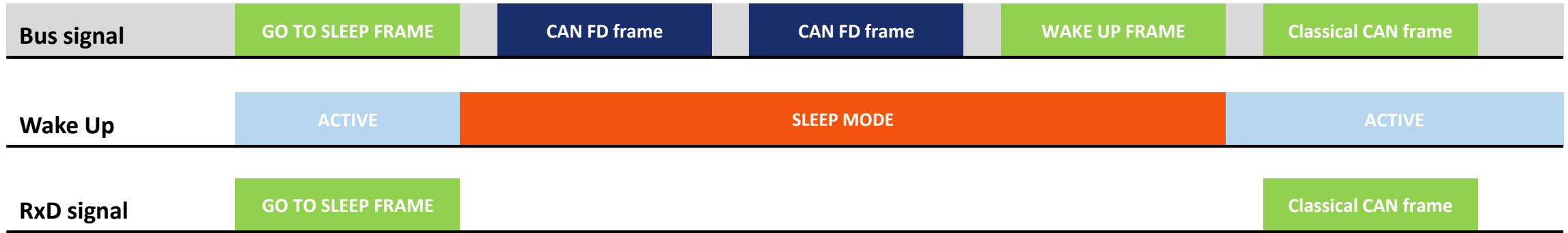
  – With Partial Networking enabled – CAN FD frames are ignored. ECU remains in low power.

  – With standard TJA1145, CAN FD frames would be read as errors – destroying communication.

  – Only TJA1145/FD version is able to filter frames during Partial Networking mode.

- ## Use Case: ECU flashing, where normal communication is Classical CAN.

FD SHIELD: TJA1141 – 43 Family

- **FD SHIELD** "shields" CAN FD frames on an _individual basis_ at max. 2 Mbps

Bus signal	Classical CAN frame	CAN FD frame	CAN FD frame	Classical CAN frame	CAN FD frame

RxD signal	Classical CAN frame	Frame ID	RXD=low	Frame ID	RXD=low	Classical CAN frame	Frame ID	RXD=low
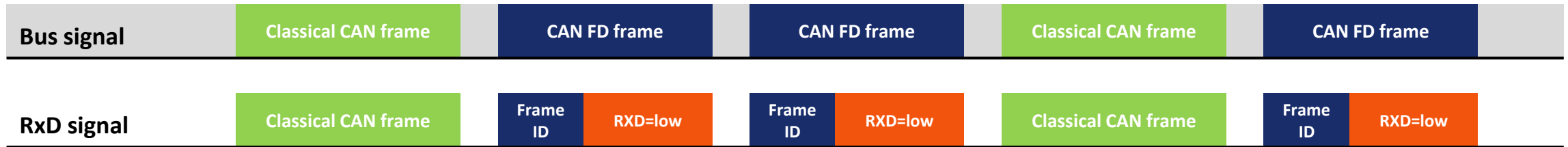
- – Classical CAN controllers and CAN FD controllers arbitrate as per normal rules of CAN.
- – All nodes say continually in sync – no messages are lost.
- – Fully ISO and AUTOSAR compliant.
- – Limited to 2 Mbps bit rate.

- **Use Case:** bridging function for legacy Classical CAN ECUs in CAN FD networks

FD PROTECT: TJA1147 – TJA1149

- FD PROTECT "shields" _stream of_ CAN FD frames at _max. 5 Mbps_

Bus signal	Classical CAN frame	CAN FD frame	Classical CAN frame	CAN FD frame

RxD signal	Classical CAN frame	Frame ID	RXD=low	Frame ID	RXD=low

Protect phase ends after Classical CAN frame

$t_0 = 0s$ $t_{END} = 1s$

Protect phase ends after timeout (no CAN FD frame)
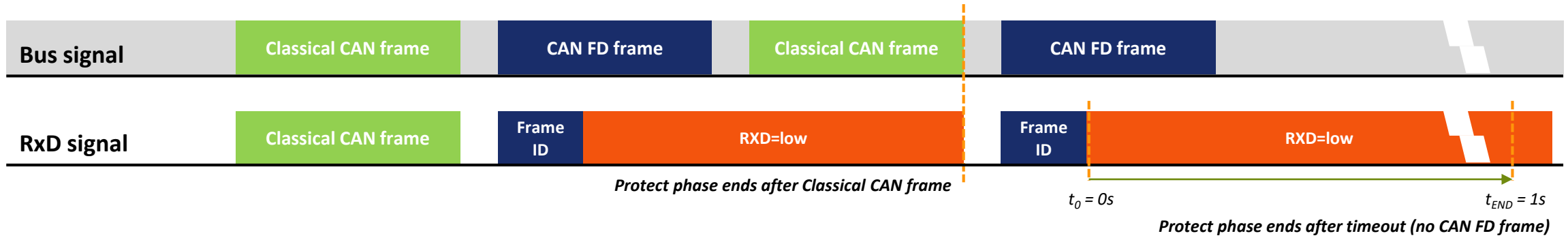
- Returns to normal transceiver operation when:
  - A Classical CAN frame has been received
  - No CAN FD frame observed for longer than 1s
- Classical CAN cannot transmit during stream of CAN FD communication.

- Use Case: ECU flashing, where normal communication is Classical CAN.

STANDARD APPLICATIONS

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		

Classical CAN (sub-1Mbps)

12 V Systems	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1145
	TJA1441B	TJA1441A	TJA1442B	TJA1442A	TJA1448B	TJA1448A	TJA1443A	
12 V VeLIO Certified	N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A	N/A
			TJA1442B	TJA1442A	TJA1448B	TJA1448A		
24 V Systems	TJA1051	TJA1051/3	TJA1042	TJA1042/3	TJA1059	TJA1059	TJA1043	TJA1145

CAN FD (Beyond 1Mbps)

CAN FD

Transceiver Performance Requirements:
- 5 Mbps operation guaranteed
- 2 Mbps EMC IBEE Compliant
- C&S CAN FD Interoperability Compliant

CAN FD Option: 1.8µs WUP
- 2023+

Filtering CAN FD frames — 2 Mbps, 5 Mbps

	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	Sleep	Partial Networking
	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1445
	TJA1441B	TJA1441A						
	N/A	N/A	TJA1442B	TJA1044G/3	TJA1448B	TJA1448A	TJA1443A	TJA1445
				TJA1442A				
	TJA1141B	TJA1141A	TJA1142B	TJA1142A			TJA1143A	TJA1145/FD
	TJA1147B	TJA1147A	TJA1148B	TJA1148A			TJA1149A	

NEW NXP FUNCTIONS

Active Signal Improvement ("FALCON")
Secure Transceiver ("STINGER")
Isolated HS-CAN Transceiver

STANDARD APPLICATIONS

Classical CAN (sub-1Mbps)
- 12 V Systems
- 12 V VeLIO Certified
- 24 V Systems

CAN FD (Beyond 1Mbps)
- CAN FD
  Transceiver Performance Requirements:
  - 5 Mbps operation guaranteed
  - 2 Mbps EMC IBEE Compliant
  - C&S CAN FD Interoperability Compliant
- CAN FD Option: 1.8µs WUP
  - 2023+
- Filtering CAN FD frames
  - 2 Mbps
  - 5 Mbps

NEW NXP FUNCTIONS
- Active Signal Improvement ("FALCON")
- Secure Transceiver ("STINGER")
- Isolated HS-CAN Transceiver

	Basic 5 V MCU	Basic 3 V3 MCU	Standby 5 V MCU	Standby 3 V3 MCU	Dual Standby 5 V MCU	Dual Standby 3 V3 MCU	Sleep	Partial Networking
	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1145
	TJA1441B	TJA1441A	TJA1442B	TJA1442A	TJA1448B	TJA1448A	TJA1443A	
	N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A	N/A
			TJA1442B	TJA1442A	TJA1448B	TJA1448A		
	TJA1051	TJA1051/3	TJA1042	TJA1042	TJA1046	TJA1059	TJA1043	TJA1145
STANDARD FUNCTIONS								
	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1445
	TJA1441B	TJA1441A						
	N/A	N/A	TJA1442B	TJA1044G/3 / TJA1442A	TJA1448B	TJA1448A	TJA1443A	TJA1445
DIFFERENTIATING FUNCTIONS	TJA1141B	TJA1141A	TJA1142B	TJA1142A			TJA1143A	TJA1145/FD
	TJA1147B	TJA1147A	TJA1148B	TJA1148A			TJA1149A	

UNIQUE INNOVATION FOR CONTINUED LEADERSHIP

Three Key Areas Of Innovation In CAN

Faster networks

Accelerate potential of CAN FD

Leverage wide CAN install base

CAN FD challenging 10Mbps

Secure transceivers

Security functions inside transceiver

Drop-in feature introduction

Complementing Secure MCUs

Bridging voltage domains

New isolated CAN for EVs, Hybrids and 48 V Networks

Unique wake-up function for ultimate efficiency

Standard CAN Transceiver

Future-proofing CAN modules of today where CAN remains dominant bus

STANDARD APPLICATIONS

Classical CAN (sub-1Mbps)

		Basic 5 V MCU	Basic 3 V3 MCU	Standby 5 V MCU	Standby 3 V3 MCU	Dual Standby 5 V MCU	Dual Standby 3 V3 MCU	Sleep	Partial Networking
12 V Systems		TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1145
12 V Systems		TJA1441B	TJA1441A	TJA1442B	TJA1442A	TJA1448B	TJA1448A	TJA1443A	TJA1145
12 V VeLIO Certified		N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A	N/A
12 V VeLIO Certified		N/A	N/A	TJA1442B	TJA1442A	TJA1448B	TJA1448A	N/A	N/A
24 V Systems		TJA1051	TJA1051/3	TJA1042	TJA1042/3	TJA1059	TJA1059	TJA1043	TJA1145

CAN FD (Beyond 1Mbps)

CAN FD
Transceiver Performance Requirements:
- 5 Mbps operation guaranteed
- 2 Mbps EMC IBEE Compliant
- C&S CAN FD Interoperability Compliant

CAN FD Option: 1.8µs WUP
- 2023+

Filtering CAN FD frames

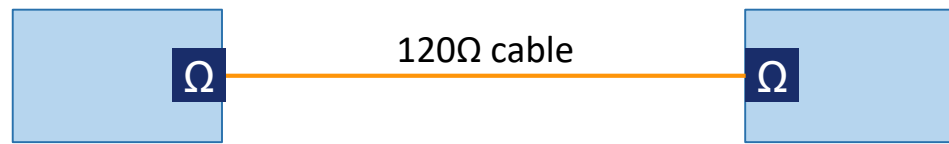|		Basic 5 V MCU	Basic 3 V3 MCU	Standby 5 V MCU	Standby 3 V3 MCU	Dual Standby 5 V MCU	Dual Standby 3 V3 MCU	Sleep	Partial Networking
CAN FD		TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1445
CAN FD		TJA1441B	TJA1441A						
CAN FD Option: 1.8µs WUP		N/A	N/A	TJA1442B	TJA1044G/3	TJA1448B	TJA1448A	TJA1443A	TJA1445
CAN FD Option: 1.8µs WUP		N/A	N/A	TJA1442B	TJA1442A	TJA1448B	TJA1448A	TJA1443A	TJA1445
Filtering CAN FD frames	2 Mbps	TJA1141B	TJA1141A	TJA1142B	TJA1142A			TJA1143A	TJA1145/FD
Filtering CAN FD frames	5 Mbps	TJA1147B	TJA1147A	TJA1148B	TJA1148A			TJA1149A	

NEW NXP FUNCTIONS

- Active Signal Improvement ("FALCON")
- Secure Transceiver ("STINGER")
- Isolated HS-CAN Transceiver

NXP

Cable Tension: Perfect Signal vs. Perfect Network

120Ω cable

Perfect Point to Point connections
= THE PERFECT SIGNAL

But completely unrealistic for REAL WORLD!

50-120Ω cable
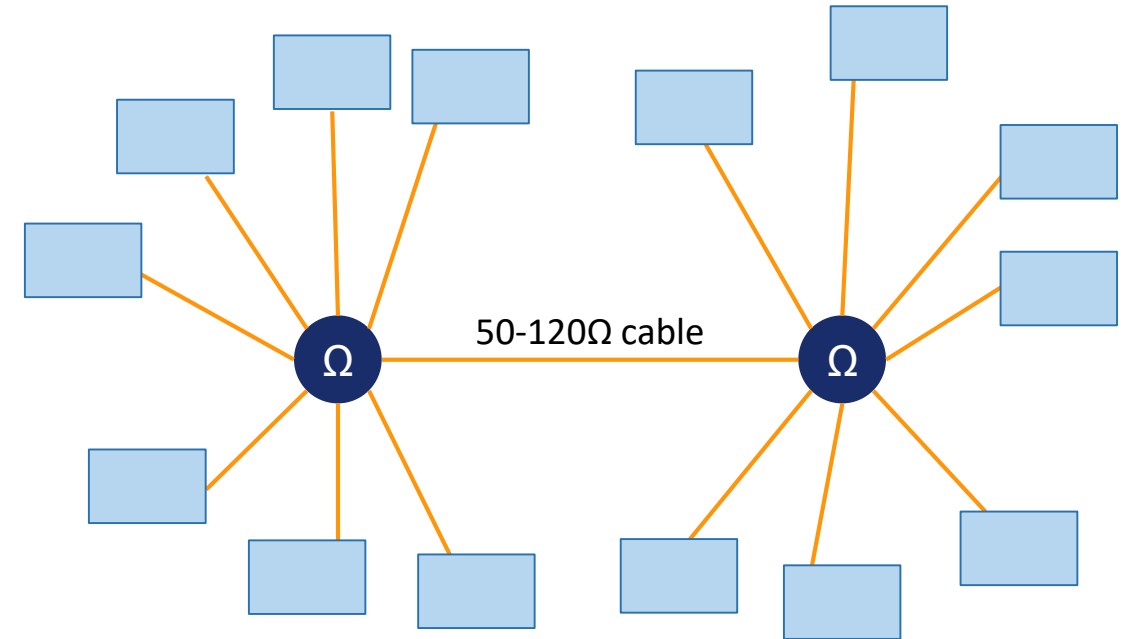
= THE PERFECT TOPOLOGY

But completely destroying SIGNALS!

Signal Improvement – Core Problem

- Reflections are created in complex network topologies.

500kbps bit time = 2000ns

0.5 V

80% sample point = 1600ns

Differential Signal

500kbps bit time = 2000ns

80% sample point = 1600ns

RxD Signal
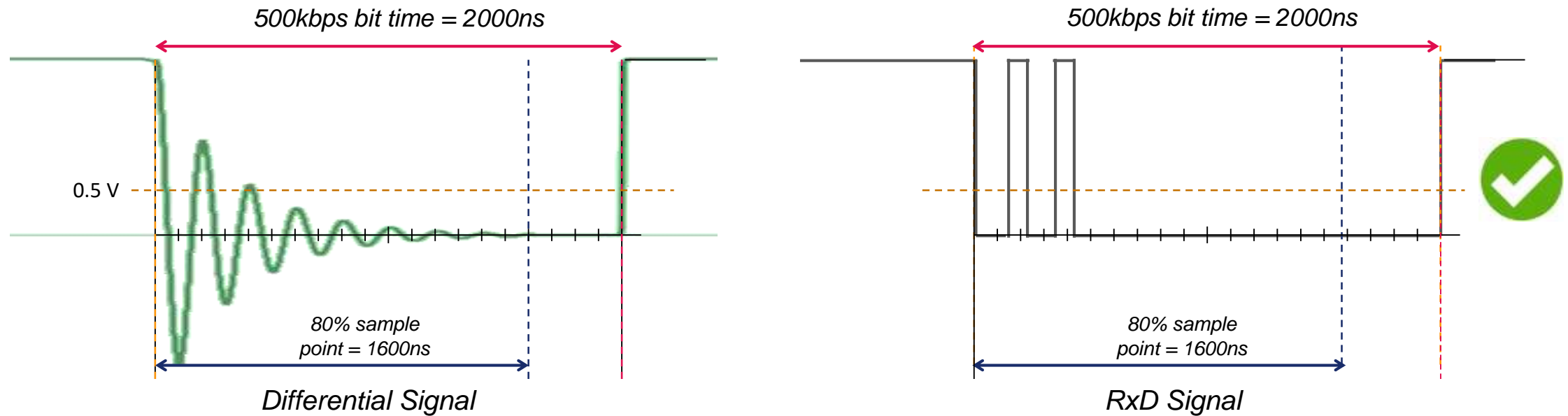
Signal Improvement – Core Problem

- Reflections are created in complex network topologies.
- At faster bitrates, there is no time to dissipate reflections → communication errors!

2 Mbps bit time = 500ns

0.5 V

80% sample point = 400ns

Differential Signal

2 Mbps bit time = 500ns

0.5 V

80% sample point = 400ns

RxD Signal
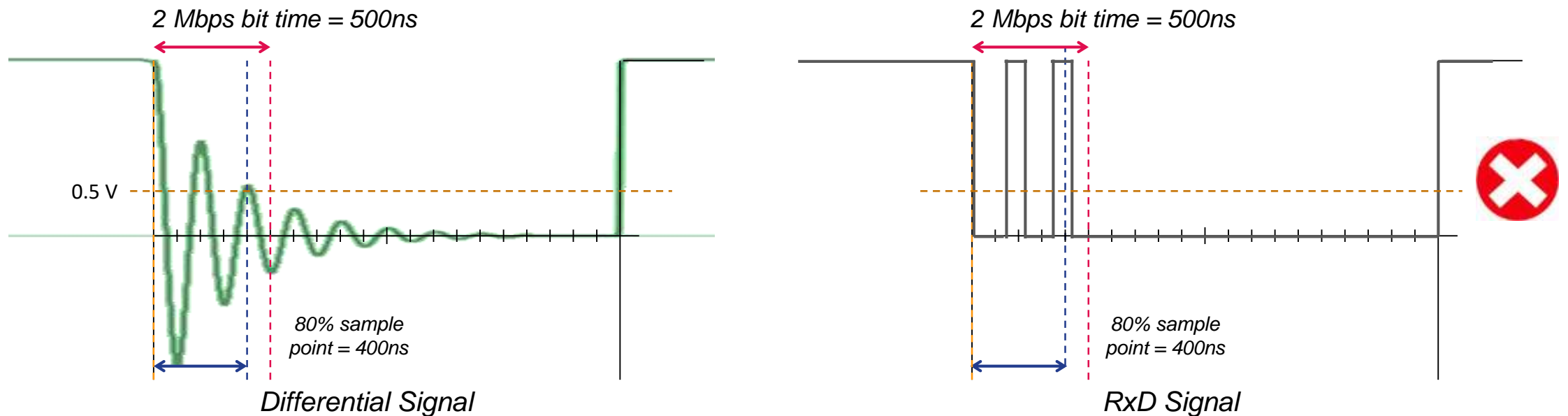
FALCON

The CAN transceiver. Re-invented.

Now sampling to all car makers

NXP SECURE CONNECTIONS FOR A SMARTER WORLD
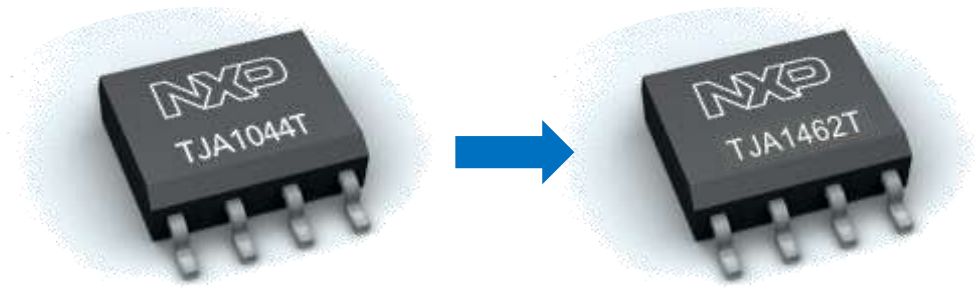
A pin-compatible replacement transceiver

Actively improves bus signals by eliminating ringing and plateau effects due to topology

→ **Large, flexible, low-cost networks at 2+Mbps**
   reduced system cost and easier design

→ **Accelerated networks running 5-8Mbps**
   targeting ADAS applications, e.g. RADAR

Extends CAN FD as low-cost technology for secure, low-end ADAS applications

STANDARD APPLICATIONS

	Basic		Standby		Dual Standby		Sleep	Partial Networking
	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU	5 V MCU	3 V3 MCU		

Classical CAN (sub-1Mbps)

	Basic		Standby		Dual Standby		Sleep	Partial Networking
12 V Systems	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1145
	TJA1441B	TJA1441A	TJA1442B	TJA1442A	TJA1448B	TJA1448A	TJA1443A	
12 V VeLIO Certified	N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A	N/A
			TJA1442B	TJA1442A	TJA1448B	TJA1448A		
24 V Systems	TJA1051	TJA1051/3	TJA1042	TJA1042/3	TJA1059	TJA1059	TJA1043	TJA1145

CAN FD (Beyond 1Mbps)

CAN FD
Transceiver Performance Requirements:
- 5 Mbps operation guaranteed
- 2 Mbps EMC IBEE Compliant
- C&S CAN FD Interoperability Compliant

CAN FD Option: 1.8µs WUP
- 2023+

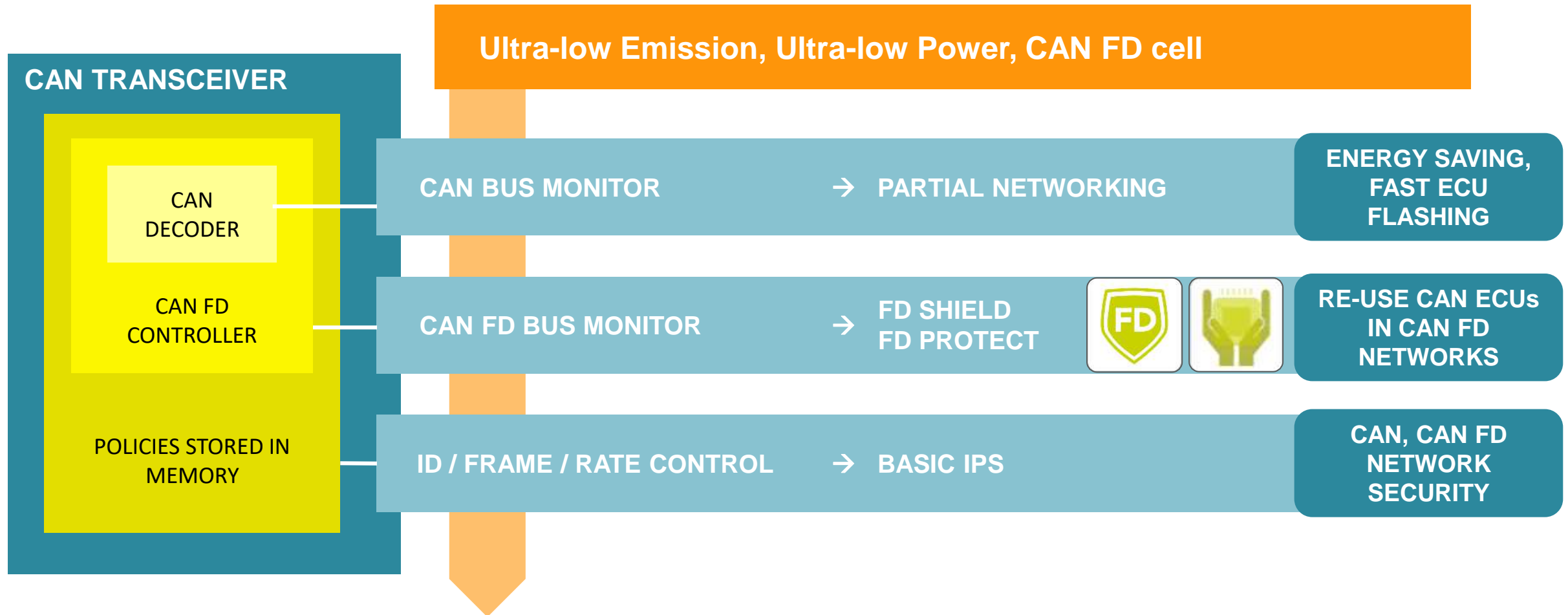**Filtering CAN FD frames**

	Basic		Standby		Dual Standby		Sleep	Partial Networking
CAN FD	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1445
	TJA1441B	TJA1441A						
CAN FD Option 1.8µs WUP	N/A	N/A	TJA1442B	TJA1044G/3	TJA1448B	TJA1448A	TJA1443A	TJA1445
				TJA1442A				
2 Mbps	TJA1141B	TJA1141A	TJA1142B	TJA1142A			TJA1143A	TJA1145/FD
5 Mbps	TJA1147B	TJA1147A	TJA1148B	TJA1148A			TJA1149A	

NEW NXP FUNCTIONS

Active Signal Improvement
Secure Transceiver
Isolated HS-CAN Transceiver

Smart CAN Nodes: More Intelligence for CAN

Ultra-low Emission, Ultra-low Power, CAN FD cell

CAN TRANSCEIVER

CAN DECODER

CAN FD CONTROLLER

POLICIES STORED IN MEMORY

CAN BUS MONITOR → PARTIAL NETWORKING

ENERGY SAVING, FAST ECU FLASHING

CAN FD BUS MONITOR → FD SHIELD FD PROTECT

RE-USE CAN ECUs IN CAN FD NETWORKS

ID / FRAME / RATE CONTROL → BASIC IPS
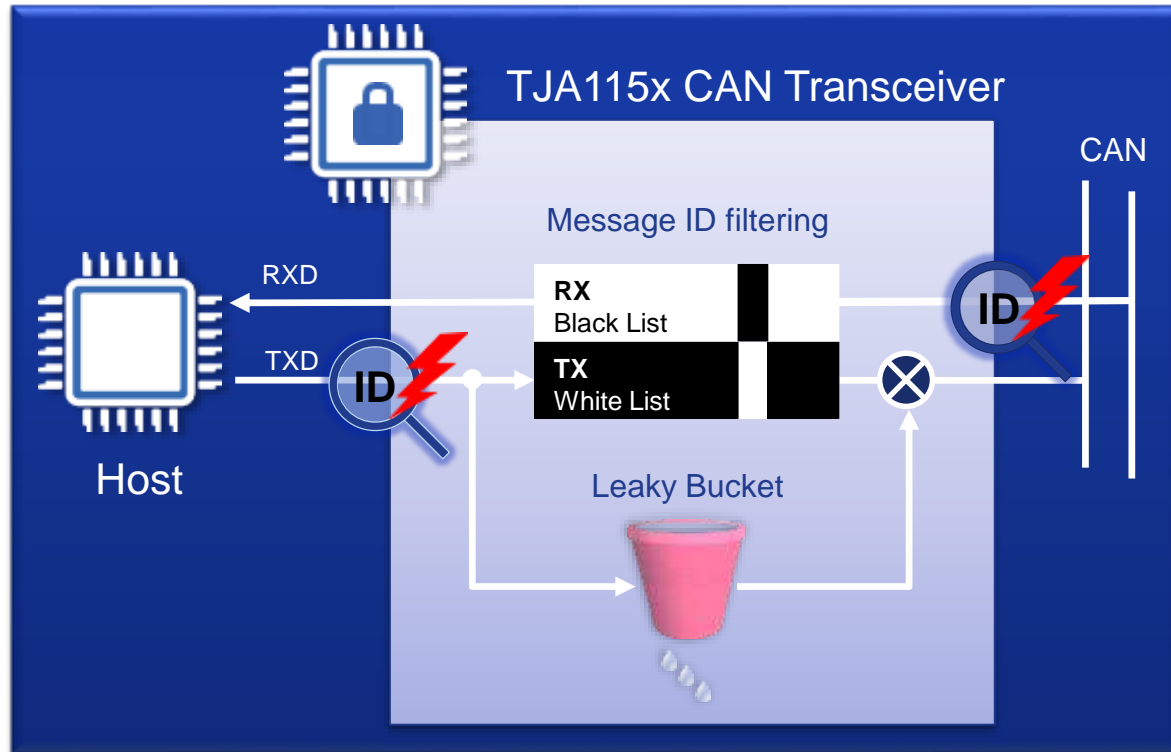
CAN, CAN FD NETWORK SECURITY

NXP Secure CAN Transceiver "Intrusion Containment System"

CAN supervisor protecting

- *own* messages and
- *own* bus behavior

Guarantees legitimate senders without cryptography

Protecting & helping the target of a hack

TJA115x CAN Transceiver

Message ID filtering

RXD

RX Black List

TXD

ID

TX White List

ID

CAN

Host

Leaky Bucket

- **Intrusion detection & prevention (IDS / IPS)**
  - On-the-fly CAN ID filtering (TX) and bus-guarding (RX) based on user configurable white & black list, preventing Spoofing & Tampering

- **Flooding prevention (DoS)**
  - Threshold on message transmission: leaky bucket strategy weighted on frame size

- **Simple CAN transceiver replacement**
  - No Software - purely hardware based solution.

STANDARD APPLICATIONS

Classical CAN (sub-1Mbps)

	Basic 5 V MCU	Basic 3 V3 MCU	Standby 5 V MCU	Standby 3 V3 MCU	Dual Standby 5 V MCU	Dual Standby 3 V3 MCU	Sleep	Partial Networking
12 V Systems	TJA1057G	TJA1057G/3	TJA1044G	TJA1044G/3	TJA1046	TJA1059	TJA1043	TJA1145
	TJA1441B	TJA1441A	TJA1442B	TJA1442A	TJA1448B	TJA1448A	TJA1443A	
12 V VeLIO Certified	N/A	N/A	TJA1044V	TJA1044V/3	TJA1046V	TJA1059	N/A	N/A
			TJA1442B	TJA1442A	TJA1448B	TJA1448A		
24 V Systems	TJA1051	TJA1051/3	TJA1042	TJA1042/3	TJA1059	TJA1059	TJA1043	TJA1145

CAN FD (Beyond 1Mbps)

CAN FD — Transceiver Performance Requirements:
- 5 Mbps operation guaranteed
- 2 Mbps EMC IBEE Compliant
- C&S CAN FD Interoperability Compliant

CAN FD Option: 1.8µs WUP
- 2023+

Filtering CAN FD frames: 2 Mbps / 5 Mbps

|	Basic 5 V MCU	Basic 3 V3 MCU	Standby 5 V MCU	Standby 3 V3 MCU	Dual Standby 5 V MCU	Dual Standby 3 V3 MCU	Sleep	Partial Networking
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	TJA1441B	TJA1441A						
CAN FD Option: 1.8µs WUP	N/A	N/A	TJA1442B	TJA1044G/3	TJA1448B	TJA1448A	TJA1443A	TJA1445
				TJA1442A				
Filtering CAN FD frames 2 Mbps	TJA1141B	TJA1141A	TJA1142B	TJA1142A			TJA1143A	TJA1145/FD
Filtering CAN FD frames 5 Mbps	TJA1147B	TJA1147A	TJA1148B	TJA1148A			TJA1149A	

NEW NXP FUNCTIONS

- Active Signal Improvement
- Secure Transceiver
- Isolated HS-CAN Transceiver

NXP

The Problem with Multi-Voltage Domains

- Most automotive CAN transceivers are designed for 12/24 V systems and may be destroyed with higher voltages.
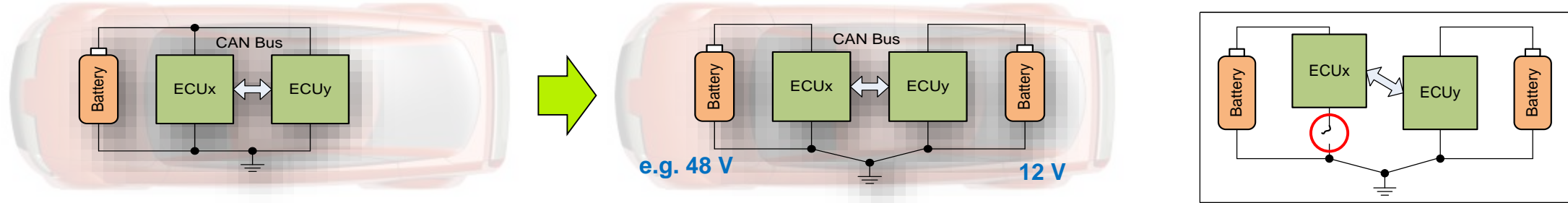
- Loss of ground in 48 V network will elevate voltage on the rest of the network!
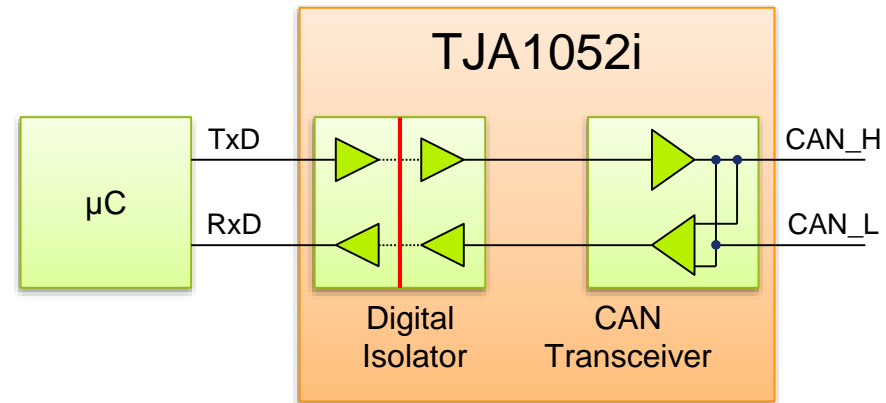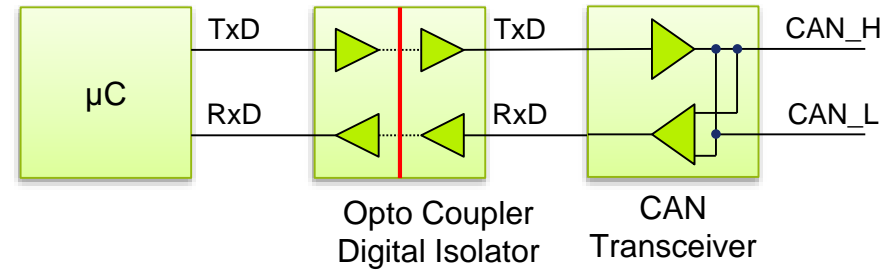
- OEMs now conclude:

  - Upgrading every node, ASIC, ASSP to be 70V tolerant is not the direction to pursue.

  - Every ECU on 48 V network will instead be connected to 12 V CAN bus. Galvanic isolation will separate the domains.

  - REASON: there always exists a failure mode where 48 V ends up on the 12 V CAN bus – need to protect every node, ASIC, ASSP, etc...
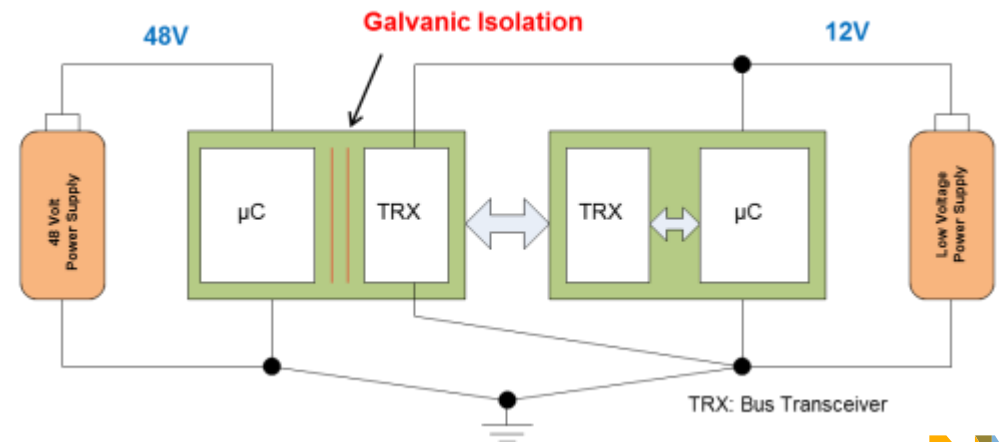
NXP TJA1052i Isolated CAN Transceiver

- **Integrated CAN Transceiver and high speed Digital Isolator**

  - Replacing CAN Transceiver and separate Opto Coupler or Digital Isolator

- **Advantages:**

  - Flawless co-operation of isolator/transceiver

  - Up to 5kV isolation

  - Small Board Space (one chip solution)

  - System cost down (less IC count and test)

  - Guaranteed CAN FD operation up to 2 Mbps

- **Target Applications:**

  - High voltage battery systems

  - 48 V Mild Hybrids

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NEW NXP FUNCTIONS

- Active Signal Improvement
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- Isolated HS-CAN Transceiver — TJA1052i

Final Message

- CAN is everywhere – across highly diverse applications

- NXP leads on Innovation, Quality and "No hassle"

- Moving forward, it will continue to be our innovation that differentiates NXP and secure our market leadership

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FOR A SMARTER WORLD