CAN XL

COMPARISONS
1. CAN XL ⇔ CAN FD ⇔ CAN
2. CAN XL ⇔ 10BASE-T1S

AUGUST 2022

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COMPARISON

CAN XL ⇔ FD ⇔ CC

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CAN XL – Next Step in CAN Evolution

Comparison of CAN Protocols (Layer 2)

many improvements

Property	Classical CAN	CAN FD	CAN XL
Data Field	[0 ... 8 byte]	[0 ... 64 byte]	[1 ... 2048 byte]
Identifier	11 bit & 29 bit	11 bit & 29 bit	11 bit
Bus Access	CSMA/CR (Arbitration)	CSMA/CR (Arbitration)	CSMA/CR (Arbitration)
Acceptance Field	–	–	32 bit (Message ID)
VCAN ID	–	–	8 bit
SDU Type	–	–	8 bit
Bit Stuffing	dynamic	dynamic fixed in CRC	dynamic (in arbitration field) fixed (in data phase)
CRC	15 bit	17 or 21 bit	PCRC: 13 bit FCRC: 32 bit (outperforms Flexray & Ethernet)
Error Signaling	ON	ON	Software Configurable: ON/OFF
Transceiver Mode Switching	Not supported	Not supported	Software Configurable: ON/OFF
Bit rate ratio: data/arb	–	Up to approx. 16.	Up to 40 (e.g. 500 kbit/s & 20 Mbit/s)
Arbitration phase bit rate **Data phase bit rate**	[0 ... 1 Mbit/s] –	[0 ... 1 Mbit/s] [<arb. bit rate> ... 8 Mbit/s]	[0 ... 1 Mbit/s] [2x <arb. bit rate> ... 20 Mbit/s]

CAN XL – Next Step in CAN Evolution
New Frame Format

Classical CAN & CAN FD MAC Frame

Arbitration Field	Control Field	Data Field	CRC Field	ACK Field	EOF Field
Identifier	...	Data Bytes	...	ACK	EOF

- Frame's arbitration priority
- Indicates type of Data in Data Field
- Addressing:
  a) Message ID or
  b) src/dest address

CAN XL MAC Frame

New Functions

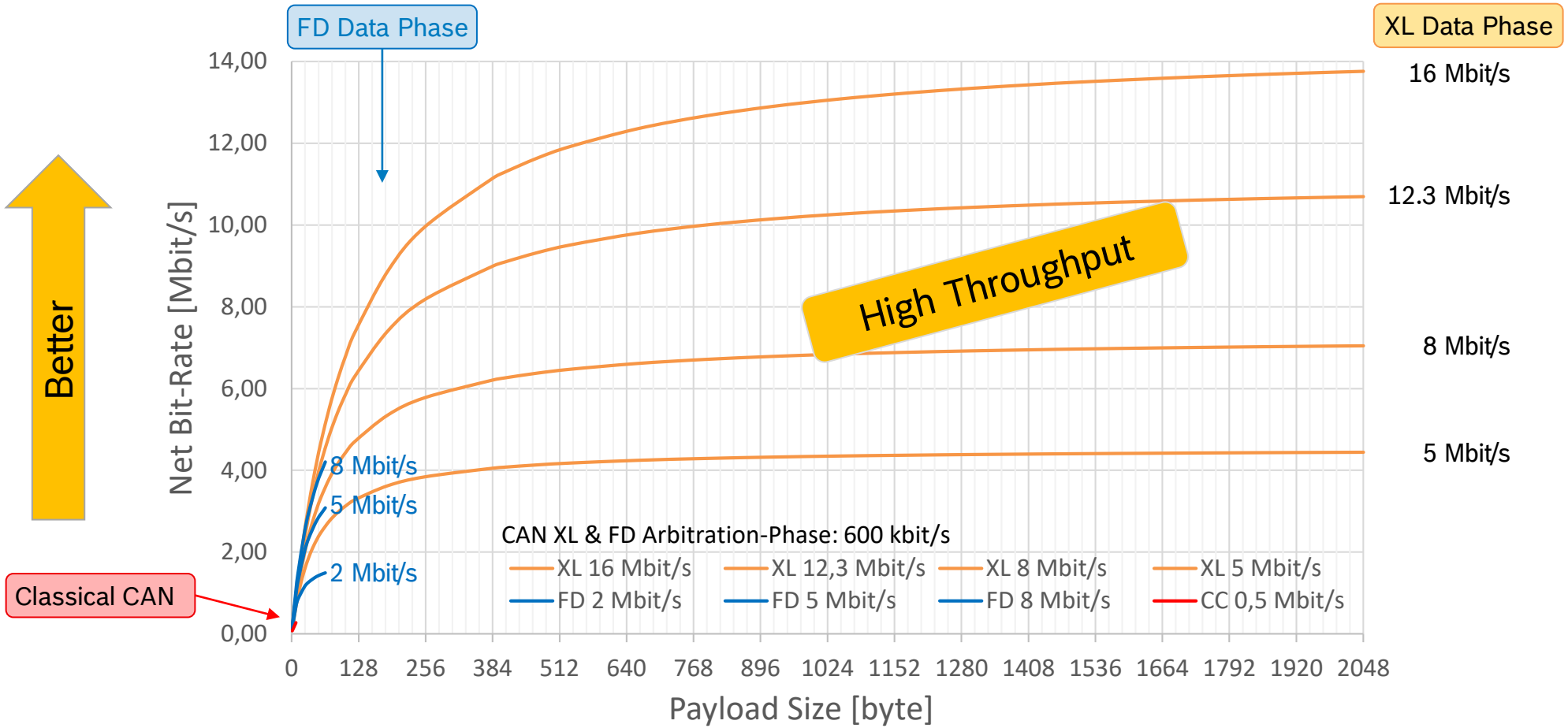
Arbitration Field		Control Field								Data Field	CRC Field		ACK Field		EOF Field
Priority ID	XL	ADS	SDT	SEC	DLC	SBC	PCRC	VCID	AF	Data Bytes	FCRC	FCP	DAS	ACK	EOF

- Frame's arbitration priority
- Indicates type of Data in Data Field
- Indicates use of add-on function
- Identifies Virtual CAN Network
- Addressing:
  a) Message ID or
  b) src/dest address

→ One dedicated field for each type of information

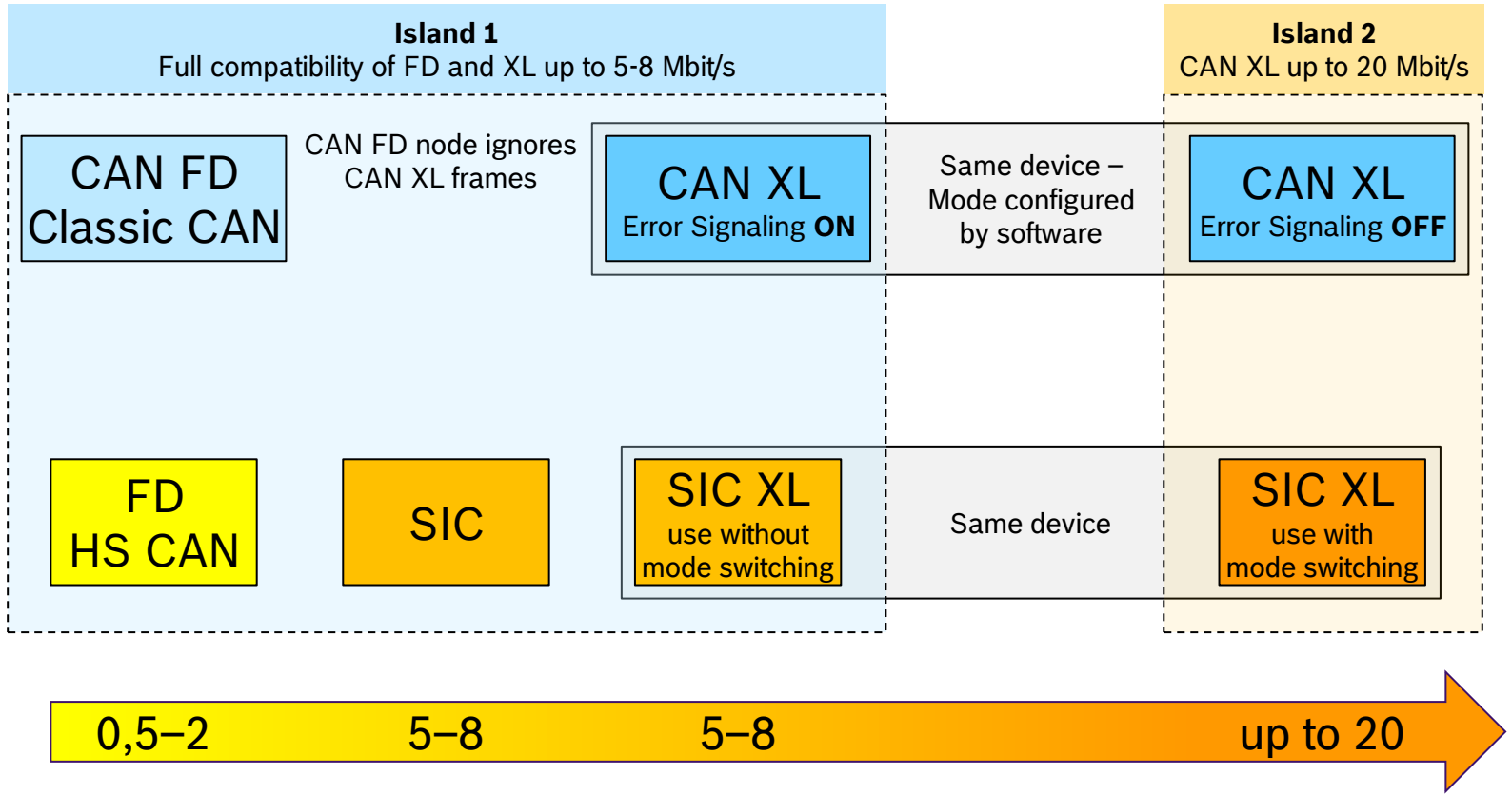
CAN XL – Next Step in CAN Evolution

Comparison – Net Bit Rate over Payload Size



CAN XL – Next Step in CAN Evolution
Compatibility

Extreme Flexibility and Compatibility



*depending on used Transceiver and topology

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COMPARISON

CAN XL ⇔ 10BASE-T1S

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Comparison of CAN XL & 10BASE-T1S
Functionality on Layer 1 and Layer 2

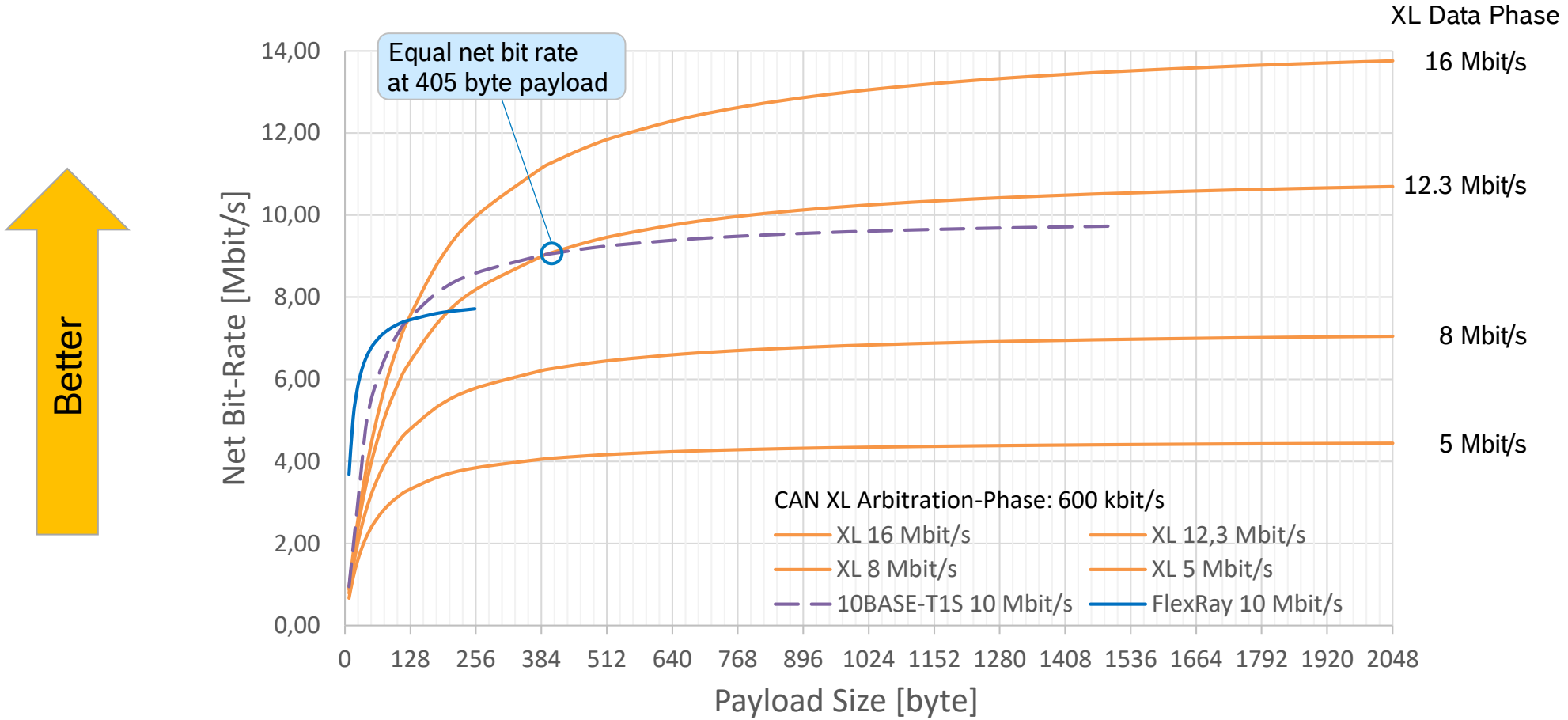
Property	CAN XL	10BASE-T1S
Data Field	[1 ... 2048 byte] (byte granularity)	[46 ... 1500 byte] (byte granularity)
Frame Priority	11 bit (Priority Identifier)	3 bit (802.1Q Header PCP [Priority Code Point])
Bus Access	CSMA/CR (Arbitration)	PLCA (Round Robin) **or** CSMA/CD (Collision Detection)
Addressing	32 bit (Acceptance Field), e.g. holds Message ID	2x48 bit (Source/Destination MAC Address)
Virtual Network Support	8 bit (VCAN ID)	12 bit (VLAN ID)
Payload Content Indication	8 bit (SDU Type)	16 bit (EtherType)
CRC	PCRC: 13 bit (HD=6) FCRC: 32 bit (HD=6, outperforms Flexray & Ethernet)	Frame Check Sequence (FCS): 32 bit CRC polynomial with limited performance [link] (HD=4 from 351 byte to 1518 byte frame length)
Line Coding on Bus	NRZ (non-return-to-zero) + Stuff Bits - dynamic bit stuffing (arbitration field) - fixed bit stuffing (data phase, 1 stuff bit after 10 bit)	4B/5B coding DME (Differential Manchester Encoding)
Line Coding Overhead	1 out of 11 bit = 1/11 = 9 %	1 out of 5 bit = 1/5 = 20 %
Frequency (shortest Pulse) on wire	6,1 MHz (**81.25 ns**) @ 12.3 Mbit/s in Data Phase 8,0 MHz (62.50 ns) @ 16.0 Mbit/s in Data Phase	12.5 MHz (**40 ns**) due to DME
Gross Bit Rate on wire	Arbitration phase bit rate: [0 ... 1 Mbit/s] Data phase bit rate: [2x arb. bit rate ... 20 Mbit/s]	12.5 MHz Symbol Rate (1 symbol = DME encoded bit)

Comparison of CAN XL & 10BASE-T1S
Application Related Properties

Property	CAN XL	10BASE-T1S
Data Field	[1 … 2048 byte] (byte granularity)	[46 … 1500 byte] (byte granularity)
Time Synchronization	- 64 bit time stamping - Time sync as specified in CiA603-1 possible - Time sync according IEEE 802.1AS likely possible	Time sync according IEEE 802.1AS possible with some limitation: PDelay not measurable
Tunneling	- Legacy CAN & CAN FD - Ethernet Tunneling	IEEE1722 provides Classical CAN & CAN FD tunneling IEEE1722 under rework to support CAN XL tunneling
Software Scalability	New microcontrollers with CAN XL: support software based enabling of features from (500 kbit/s) CC to FD to XL to XL with Transceiver-Mode-Switching (up to 20 Mbit/s)	- (supports only hardware scalability: use a different PHY, e.g. 100BASE-T1)
Add-on feature Security	CANsec according CiA613-2 (under development)	MACsec
Add-on feature Fragmentation [QoS]	Fragmentation according CiA613-3 (under development) ➔ Target: increase QoS by shorter frames on the bus	Frame preemption **not applicable** in Multi-Drop
Fault Injection [Safety] (only in Bosch IP “X_CAN”)	Allows to intentionally transmit an erroneous frame ➔ Target: validate error detection capability of other nodes during life time; e.g. perform before power off	-

Comparison of CAN XL & 10BASE-T1S

Net Bit Rate over Payload Size



CAN XL – Next Step in CAN Evolution

Technical Comparison: CAN XL vs. 10BASE T1S

Feature	CAN XL	10BASE-T1S
Number of nodes (per bus)	2 … ≥ 20	2 … 8
Bit Rate	1 … up to 20* Mbit/s	10 Mbit/s
Network: Stubs	Supports long stubs (e.g. up to 1-3m)	Max. 10 cm
Network: Topology	Complex topologies possible at high bit rates (e.g. double-star)	Daisy-chain (needs 2 connectors due to short stub length)
Transceivers	4 transceiver speed grades (High Speed, FD, SIC, SIC XL) => interoperable, when mode switch not used	One transceiver speed
Transceiver Pins	2 pins (RxD, TxD), same for all transceivers	MII (>10 Pins), or OA 3-pin interface (3 Pins), or MAC-PHY (5 Pins)
Scalability	Scalable: bit rate / network topology / transceiver / # nodes	Scalable: Only # nodes
µC Hardware	New CAN controllers (according CiA610-1) support all 3 flavors of CAN: Classical, FD, XL.	With MII => any transceiver supported (CRS signal often not present!) With Open Alliance 3-pin interface => only 10BASE-T1S transceiver
Migration	Layer 1+2: XL and FD are interoperable up to 5-8 Mbit/s.	Migration done with switches
PoDL	Not supported	Supported, but cost intense due to e.g. required high quality cabling + potential need for common ground line
Safety	All nodes are independent	Master node required: single point of failure

* depending on used Transceiver and topology

CAN XL – Next Step in CAN Evolution

Price advantage of CAN XL over 10BASE-T1S

		CAN XL	10BASE-T1S
01	**Lower price per bit on the cable**	Efficient line coding: only 10% overhead => 11 Mbit/s required for 10 Mbit/s	Inefficient line coding: 250% overhead => 25 Mbit/s required for 10 Mbit/s
02	**Cheaper network topology/cabling**	complex topologies possible (verification by sim.) need only 1 connector for the node	max. 10 cm Stubs, daisy-chain required, need 2 connectors for the node
03	**Cost optimal bit rate configurable**	Any data bit rate configurable in range [1 ... 20 Mbit/s]	only 10 Mbit/s
04	**Cost optimal transceivers usable**	4 Transceivers (High Speed, FD, SIC, SIC XL) => trade off between bit rate and price	one transceiver
05	**Only 2 ECU Pins required**	2 pins (CAN_H, CAN_L)	4 pins due to daisy chain; 2 pins in, 2 pins out
06	**Only 2 Transceiver Pins required**	2 pins (RX, TX)	3-10 Pins, depending on used interface

CAN XL

KEY PERFORMANCE INDICATORS

CAN XL – Next Step in CAN Evolution

CAN XL Node (CiA610-1) Usability Matrix

Software Configurable Node behavior (CAN Variant)

Protocol (Data Link Layer)	**CAN** node	**CAN FD** node		**CAN XL** node				
Max. payload	8 bytes	64 bytes		2048 bytes				
Transceiver (Physical Layer)	CAN	CAN FD	CAN SIC	CAN	CAN FD	CAN SIC	CAN SIC XL FAST*	CAN SIC XL FAST*
Max. bit rate in real OEM applications	500 kbit/s	2 Mbit/s	5 Mbit/s	500 kbit/s	2 Mbit/s	5 Mbit/s	5 Mbit/s	up to 20 Mbit/s
Error Signalling	Error Flag	Error Flag	Error Flag	Error Flag	Error Flag	Error Flag	not available	not available
Topology Dimension	large	normal	large	large	normal	large	extra large	large

XL & FD compatible
➔ mixed FD/XL network possible

XL and FD **NOT** compatible
➔ pure CAN XL network

* **CAN SIC XL Transceiver** operated in FAST Mode
Hint: CAN XL Transceiver operated in SLOW Mode = CAN SIC Transceiver

CAN XL – Next Step in CAN Evolution

Key Success Factors

01

Bit rate up to 20 Mbit/s

just limited by selected PHY technology

CAN XL protocol targeted for high-speed CAN XL transceivers (up to 20Mbit/s), but also works with CAN FD or CAN SIC transceivers

02

Large payload size + New Functions (SDT, VCID, ...)

allows tunneling of e.g. Ethernet traffic (transparent for higher layer protocols)

All kind of payload types supported – including largest possible Ethernet frame, IPv6, ...

03

Incremental upgrade

& mixed networks (CAN FD & CAN XL)

Co-existence of “cheap” CAN FD and fast CAN XL nodes in same network

04

Extreme scalability

- wide range of bit rates configurable [up to 20 Mbit/s]
- any transceiver (Classic, FD, SIC, SIC XL) usable
- Use Cases: (1) Signal based communication
  (2) Service oriented communication (via ETH tunnelling)

05

Supports complex network topologies

Flexible trade-off between speed and complex networks (e.g. long stubs supported)

06

AUTOSAR support

Concept proposal since early 2020
– will be available by end of 2022

07

Price

expected to be cheaper than 10BASE-T1S

08

Availability

– CiA610-1 specification released in November 2021 as DSP (ISO Standardization ongoing: adopt CiA610-1 content)
– Samples of automotive micro controllers with CAN XL will be available in 2022