Kickstarting CAN XL evaluation: CAN SIC XL proof-of-concept transceiver

After CAN SIC overcame the limitations of CAN FD, CAN XL will take the next step by introducing data rates up to 20 Mbit/s and 2048-byte payloads. NXP's CAN SIC XL prototype transceivers facilitate the start of CAN XL technology and data path evaluation (on ECU and vehicle level), establishing expertise on the protocol, transceiver, and application.

Figure 1: Architectural trend of automotive vehicle networks; from domain-based to zonal-based networks (Source: NXP)

With major automotive trends like electrification and autonomous driving, in-vehicle networks are expanding rapidly to integrate new functionality and applications. The resulting network complexity and required bandwidth are growing too, redefining the role of CAN in in-vehicle network architectures.

To support these major trends, vehicle networks are moving from domain-based platforms towards zonal network architectures (see Figure 1). The backbone connections between multiple vehicle computers or zonal gateways are generally served with Automotive Ethernet, while CAN communication is pushed toward dedicated domains and edges of the network, interfacing between the edge nodes and the Ethernet backbone, or as backup and wake-up network.

CAN SIC overcomes limitations of CAN FD

The introduction of CAN FD (flexible data-rate) enabled bit rates up to 5 Mbit/s, supporting the industry with more bandwidth beyond Classical CAN networks. In reality however, the achievable bit rate is a trade-off between signal ringing and topology. As a result, CAN FD networks are generally limited to a bit rate of 2 Mbit/s in small and linear networks. To extend the performance potential of CAN FD, NXP developed an implementation of the Signal Improvement Capability (SIC) technology, first introduced in the TJA146x CAN SIC transceiver family compliant with the CiA 601-4 specification. CAN SIC actively improves the CAN signal allowing network designers to implement more complex topologies and extend the achievable data rate up to 8 Mbit/s. Consequently, CAN SIC enables more effective CAN FD networks, allowing more efficient cabling and thus saving weight and cost.

CAN XL: the future of CAN

CAN XL was created to provide additional functionality to CAN, fitting to the changes of the vehicle network architecture, while fixing the limitations of CAN FD. It allows for increased bit rates and larger payloads, while offering all the benefits of CAN, such as large multi-drop networks, (bit rate) scalability, quality of service, and EMC (electro-magnetic compatibility) robustness. Due to its flexibility, CAN XL ▷

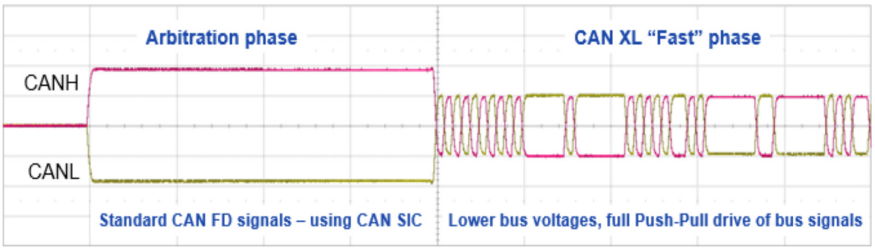

Figure 2: Two physical level schemes of CAN XL – normal CAN FD signal when using CAN SIC (left) and new CAN XL "fast mode" level scheme (right) to enable data rates up to 20 Mbit/s (Source: NXP)

is not bound to zones, but can also create low-latency inter-zonal connections or serve as an efficient implementation of domain networks. In short: CAN XL makes CAN technology ready for seamless integration into the next-generation networks while maintaining the key properties of CAN.

Basics of CAN SIC XL

The benefits of CAN XL are based in both a data link layer protocol extension and an improved physical medium attachment sub-layer implementable in transceivers. The CAN XL protocol itself extends CAN FD with a data payload of up to 2048 byte. CAN XL also enables a transition to a secondary physical level scheme during the data phase, called CAN XL "fast mode". CAN SIC XL transceivers are an extension of CAN SIC, being backwards compatible to CAN FD and utilizing the technology in the non-fast phase of CAN XL. Additionally, it supports a secondary, optimized physical level scheme during the "fast mode", which enables CAN SIC XL transceivers to achieve data rates of up to 20 Mbit/s during that fast phase. This has been first showcased by NXP with its CAN SIC XL proof-of-concept transceiver, called "Albi" during various CiA plugfest events from 2021 to 2023.

Due to the new level scheme and backwards compatibility, the CAN SIC XL transceivers can act in two modes (see Figure 2):

- *SIC mode:* Working according to the original CAN (FD) level scheme in combination with SIC, with a maximum data rate of 8 Mbit/s and the benefits of signal improvement on topology freedom.
- *CAN XL "fast mode":* Enabling the new level scheme and up to 20 Mbit/s data rate capabilities. The different communication styles are initiated by the CAN XL protocol controller.

Use cases for CAN SIC and CAN SIC XL – mixing controllers and transceivers

CAN XL is backwards compatible to CAN FD, meaning controllers and transceivers can be mixed to create ▷

CAN Controller IP Core
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COMPLETE
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SECURE
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RELIABLE
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Transceiver	CAN FD	CAN SIC	CAN SIC	CAN SIC XL
Controller	CAN FD	CAN FD	CAN XL	CAN XL
Data rate (up to)	5 Mbit/s	8 Mbit/s	8 Mbit/s	20 Mbit/s
Payload	64 bytes	64 bytes	2048 bytes	2048 bytes
Topology	Small and linear	Large and complex	Large and complex	Large and complex
Signal Improvement	X	✓	✓	✓
CAN XL "Fast Mode"	X	X	X	✓
Standardization	ISO11898-2:2023			
		CiA601-4		
			CiA610-3	

Figure 3: Use cases for CAN SIC and CAN XL – benefits of mixing transceivers and controllers (Source: NXP)

heterogenous networks and manage adoption of the new technology over time. Four use cases are outlined in Figure 3 and below, each providing their benefits to mix and matching transceivers and controllers.

- *CAN FD controller + CAN FD transceiver:* Enables CAN FD communication up to 5 Mbit/s, but is generally limited to 2 Mbit/s in smaller and more linear networks due to the effects of signal ringing.
- *CAN FD controller + CAN SIC transceivers:* NXP's CAN SIC transceivers are fully backwards compatible to legacy CAN-HS (high-speed) and CAN FD transceivers, enabling an easy and hassle-free upgrade of a CAN FD module by a simple replacement of the transceiver to benefit from the boosted network performances for any CAN FD network. This results in higher achievable data rates in more complex networks.
- *CAN XL controller + CAN SIC transceivers:* This scenario brings two benefits with respect to the previous. By using a CAN XL controller, all benefits of the CAN XL protocol (e.g. 2048 bytes payload) can be utilized up to a bit rate of 8 Mbit/s. This is further extending the capabilities of CAN SIC, while it allows for additional flexibility and a single solution approach for multiple use-cases. Furthermore, NXP is planning to have identical pinning for CAN SIC and CAN SIC XL transceivers, meaning this scenario enables an easy upgrade towards full CAN XL networks.
- *CAN XL controller + CAN SIC XL transceivers:* Getting the maximum performance out of the CAN network by combining the power of both the CAN XL controller as well as the CAN SIC XL transceiver to reach data rates up to 20 Mbit/s. By increasing both the maximum data rate and the payload, CAN XL enables more complex topologies at higher data rates, Ethernet frame tunneling and backwards compatibility with CAN FD. This makes it a very attractive technology for future networks.

System level implementation: why the proof-of-concept silicon is relevant

NXP was the first to launch a CAN SIC XL proof-of-concept silicon ("Albi") capable of demonstrating 20 Mbit/s in CAN XL network, raising the bar for CAN XL and doubling its previous 10 Mbit/s performance target. During the CiA plugfest 2022, C&S has showcased an Ethernet "tunneling" demo over CAN XL using NXP's CAN SIC XL silicon.

Albi has been introduced as a prototype transceiver to proof the extended capabilities of CAN XL up to 20 Mbit/s and allow the market to start early evaluation. Albi is capable of running full 20 Mbit/s communication in real topologies with already proven EMC performance, establishing the starting point for prototype development boards, CAN XL data path and topology evaluation and vehicle-level network tests with CAN XL.

Together with industry partners, C&S and Bosch, a full CAN XL evaluation suite is offered, providing interested adopters access to evaluate the potential of CAN XL as a technology. Multiple parties have started network validation to build up knowledge and expertise in assessing CAN XL for future networks. NXP is also providing CAN SIC XL transceiver simulation models to perform network topology assessments, enabling simple and accessible first-hand experience with CAN XL.

With CAN XL controller IPs available from multiple vendors, the ecosystem around CAN XL is quickly expanding. NXP is currently sampling its first MCUs with integrated CAN XL controllers (S32Z2/E2), enabling easy deployment of CAN XL and supporting customers in building their first CAN XL applications.

Conclusions and product outlook

Besides CAN FD and CAN SIC, there is a clear need to move beyond the available capabilities of CAN both in terms of payload and achievable data rate to support new trends in the vehicle network, while maintaining all the benefits that CAN has to offer.

CAN SIC has been facilitating increased topology and data rate flexibility, optimizing networks for cabling and cost and offering network owners an increased freedom to define their network. CAN SIC XL delivers CAN networks with more performance, enabling network consolidation, simplified domains and a sustainable way towards full zonalization. NXP's CAN SIC XL proof-of-concept silicon "Albi" is allowing OEMs and other industry partners to start capability studies and early evaluation, facilitating a headstart on CAN XL and preparing their networks and applications for future deployment. NXP plans to develop CAN SIC XL transceivers with relevant specifications to serve the networking trends of tomorrow. ◀

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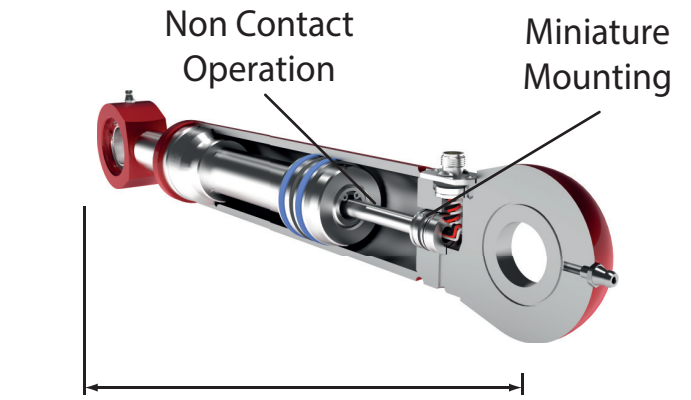

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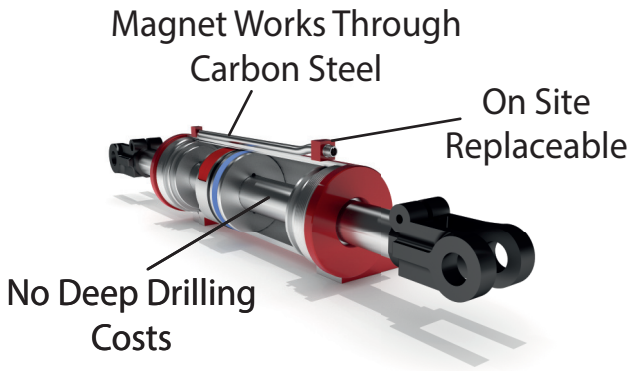

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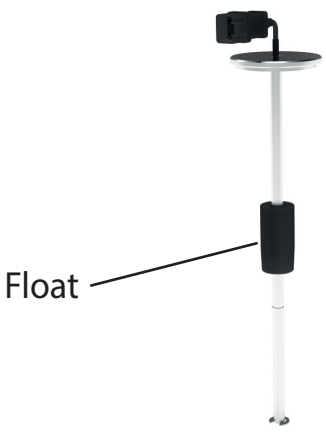

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