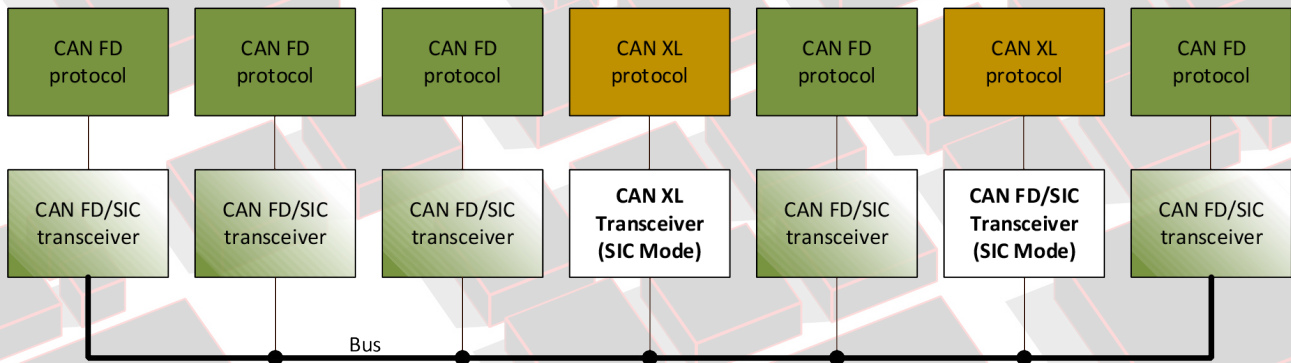


SIC or SIC XL – this is not the question



In the beginning, there was the high-speed (HS) CAN transceiver supporting bit rates up to 1 Mbit/s. In 2016, it has been improved for higher speeds (2 Mbit/s and 5 Mbit/s). With the introduction of SIC (signal improvement capability) technology, CAN FD networks are able to go to 8 Mbit/s. CAN SIC XL transceiver can achieve in FAST mode up to 20 Mbit/s. This article describes the differences and the possible combinations of CAN protocol generations and CAN transceiver technologies.

(Source: Infineon/Adobe Stock)

At the moment three variants of the CAN protocol are available: Classical CAN with 11-bit and 29-bit identifier fields, an 8-byte data field, and one bit rate; CAN FD with 11-bit and 29-bit identifier fields, a 64-byte data field, and two bit rates (arbitration phase and data phase); CAN XL with an 11-bit priority identifier and a separate 32-bit acceptance field, and two bit rates (similar to CAN FD).

As more bytes in the data field are given as longer the time to transmit a data frame is. Additional types of transceivers are needed to increase the bit rate and to reduce the time to transmit a data frame. In the last years, three new CAN transceiver types have been developed.

CAN FD transceiver

The first step to improve bit rate was an improvement of the performance of the CAN HS transceivers. For higher bit rates the specification of the symmetry parameter for the transmitter and the receiver were added and tailored compared to the established CAN transceivers. Transceivers do not care about the protocol. They are only acting as a level shifter and a more precise driver performance allows to increase the bit rate in a network. The basic concept of the transceiver was not changed. With this new concept up to 5 Mbit/s in linear topologies are possible. In star topologies the transmitter concept generates ringing after the dominant-to-recessive transition and this ringing reduces the possible maximum bit rate.

CAN SIC transceiver

The second improvement step of CAN transceiver is the adding of signal improvement capability (SIC). There are two SIC transceiver concepts:

- ◆ the transmitter-based approach;
- ◆ the receiver-based approach.

In the transmitter-based approach, the transmitter controls the dominant-to-recessive transition and drives the network lines actively to a 0-V differential signal for a certain time (called SIC time). The impedance of the transmitter during the SIC time is 100 Ohm like a typical CAN wire impedance. This reduces the ringing to a minimum and allows higher bit rates. The advantage of this concept is that the recessive bit time can be shorter than the SIC time. The transmitter directly switches from SIC mode to dominant if a dominant signal is transmitted. Bit rates up to 8 Mbit/s are possible with this approach.

The disadvantage is that the ringing is reduced on the transmitting node only. But the transmitting node is the source of the ringing and reduces this ringing very effectively.

The receiver-based approach activates an additional transceiver-internal termination resistor after the dominant-to-recessive transition is detected by the receiver. The advantage is that this additional resistor is activated on all nodes in a network. The disadvantage is that for each bit rate own transceiver implementations are needed. In addition, a shorter bit time leads to a shorter SIC time. For high bit rates the impact is low and 8 Mbit/s cannot be supported.

With CAN SIC transceivers, a 64-byte CAN FD data frame running at 5 Mbit/s in the data phase becomes shorter than an 8-byte Classical CAN frame transmitted with 500 kbit/s. But for CAN XL data frames with payloads up to 2048 byte, a data-phase bit rate of 5 Mbit/s is too slow. A calculation example:

- ◆ 8-byte Classical CAN data frame at 500 kbit/s: $\sim 260 \mu\text{s}$
- ◆ 64-byte CAN FD data frame at 500 kbit/5 Mbit/s: $\sim 200 \mu\text{s}$
- ◆ 2048-byte CAN XL data frame at 500 kbit/5 Mbit/s: $\sim 3,7 \text{ ms}$



CAN SIC XL transceiver

To increase the bit rate further, the CAN SIC XL transceiver supports two transmitter modes:

- ◆ The *SIC mode* is used in the arbitration phase of the CAN XL protocol. It is also possible to use this mode in the data phase. In this mode, the CAN SIC XL transceiver acts as an CAN SIC transceiver. With this mode up to 8 Mbit/s in the data phase are possible.
- ◆ In the *FAST mode*, the transceiver controls both levels on the network lines like a Flexray transceiver. The symmetric alternating differential bus signal and the transmitter impedance of 100 Ohm (like a typical CAN wire impedance) allow higher bit rates in the data phase of the CAN XL protocol.

The mode change from SIC mode to FAST mode is controlled by the CAN XL controller (often embedded in a host controller) via the TxD pin. During arbitration phase, the TxD signals are the same as for all other kind of transceivers. TxD high controls recessive level on the network lines and TxD low controls the dominant level. During the FAST mode phase, the CAN XL controller transmits PWM symbols to the transceiver. The length of the PWM symbols can vary between 50 ns and 200 ns. If a transceiver detects this PWM symbol, it changes the mode from SIC to FAST and if no symbols are detected anymore the transceiver switches back to SIC mode. The duty cycle of the PWM symbol represents the level, which is transmitted. If the duty cycle is less than 50 %, this represents a logical 0 and level 0 (positive differential signal). If the duty cycle is above 50 %, this ▶

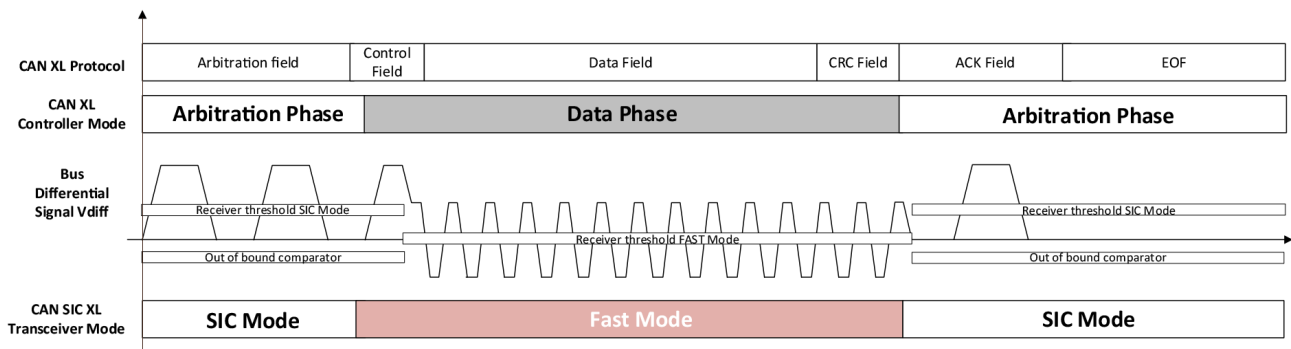


Figure 1: Differential bus signal and receiver thresholds in CAN SIC XL transceiver communication (Source: Infineon)

CANopen Miniature Pressure Transmitter CMP 8270

- Different accuracy classes i. e. 0.1 % FS typ
- Measurement of pressure and temperature
- CANopen DS301/DS404, supports CAN 2.0A/B



Table 1: Combination options for CAN SIC XL transceivers and CAN protocol controllers

CAN protocol	Supported CAN SIC XL transceiver mode		Max. possible bit rate
	SIC mode	SIC and FAST mode	
Classical CAN	X	-	1 Mbit/s
CAN FD	X	-	up to 8 Mbit/s
CAN XL SIC mode only used	X	-	up to 8 Mbit/s
CAN XL SIC and FAST mode used	-	X	up to 20 Mbit/s

Table 2: Combination options for all CAN transceiver types

CAN protocol type	CAN transceiver type			Max possible bit rate
	HS transceiver	CAN FD transceiver	SIC (XL) transceiver	
Classical CAN	X	X	X	1 Mbit/s
CAN FD	X	-	-	1 Mbit/s
	-	X	-	up to 5 Mbit/s (point to point)
	-	-	X	up to 8 Mbit/s

represents a logical 1 and level 1 (negative differential signal).

Not only transmitting transceivers are controlled during the data phase with PWM signals. Also receiving transceivers evaluate the PWM signal to switch the receiver into FAST mode. In FAST mode, the receiver thresholds are set to 0 V instead of 700 mV in SIC mode. For more details, you should consult the CiA 612-2 document.

The CAN SIC XL concept guarantees that the CAN protocol controllers and the transceivers are always in the same mode. There is no mismatch due to errors possible.

CAN SIC XL transceiver and CAN protocol variants

The CAN SIC XL transceivers can be used with all CAN protocol generations: Classical CAN, CAN FD, and CAN XL. The CAN XL protocol handler according to CiA 610-1 (in the near future ISO 11898-1) supports all variants of CAN protocols:

- ◆ Classical CAN with 11-bit and 29-bit identifier
- ◆ CAN FD protocol with 11-bit and 29-bit identifier
- ◆ CAN FD light with 11-bit identifier
- ◆ CAN XL with 11-bit priority identifier.

CAN Newsletter Online



CAN Newsletter magazine *The new dynamic parameters of CAN SIC*

The CiA 601-4 specification for CAN SIC transceivers is released and will be hand over to the updated ISO 11898-2 soon; the CiA 601-1 specification helps to understand the CAN FD high-speed transmission.

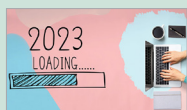
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CiA marketing group *Promoting CAN XL*

CAN in Automation (CiA) has established the Marketing Group (MG) CAN XL. It organizes joint marketing activities in order to promote the CAN XL protocol as well as related specifications and recommendations.

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CAN technology trends *Back to the roots and closer to the front end*

In 2023, the CAN XL ecosystem is going to be completed, CAN FD is increasingly adapted in non-automotive applications, and Classical CAN is applied in deeply embedded networks substituting traditional serial communication links.

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CAN Newsletter magazine *Interviews with providers: CAN SIC transceivers*

CAN SIC (signal improvement capability) transceivers can be used in Classical CAN, CAN FD, and CAN XL networks, reduce signal ringing, improve achievable bit rates, and provide more design flexibility regarding topology.

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MCUs with CAN XL *Ready for automotive cybersecurity management certification*

Infineon announced that Aurix TC4xx is the first microcontroller unit (MCU) family to be certified according to ISO/SAE 21434 standard for automotive cybersecurity management systems.

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CAN Newsletter magazine *30 years of CiA: Celebration and feedback*

On June 1 and 2, CiA and its members celebrated the 30th birthday of CAN in Automation in a nice location in Nuremberg in the midst of the city park. The CAN Newsletter magazine reported about the celebration and CiA members answered some questions in an interview.

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The new CAN SIC XL transceiver supports

- ◆ SIC mode (like SIC transceivers according to CiA 601-4 and ISO 11898-2:2023)
- ◆ FAST mode (for high bit rates in the CAN XL data phase)

This flexibility allows the combinations of CAN SIC XL transceivers and CAN protocol controllers shown in the Table 1.

The maximum bit rate, given in these tables, depends on the network topology and can be lower. The maximal possible bit rate can be achieved in a point-to-point network (just two nodes) with termination resistors on both ends.

The CAN FD protocol and the CAN XL protocol allows a mixed communication in one network. If a CAN FD protocol handler detects a CAN XL data frame, the protocol handler stops frame detection after FDF bit and changes into the reintegration mode and is waiting to the end of the CAN XL data frame. The CAN XL controller is able to support both data frame types. But for both protocols configuration is needed.

On the physical layer side, it is possible that in FAST mode the differential bus levels can be below the receiver thresholds of CAN FD and CAN SIC transceiver. This has the consequence that from the physical layer point of view a reliable mixed protocol communication is only possible, if all nodes are using CAN FD or SIC mode only. The transceiver with the lowest possible bit rate determines the bit rate.

An example: Some nodes in the network using CAN FD controller and CAN FD or CAN SIC transceiver and other nodes using CAN XL controller and CAN SIC XL

transceiver. The communication is working, if the CAN SIC XL transceiver is working in SIC mode only (in arbitration and data phase). This can be configured in the CAN XL controller. In such a network, CAN SIC transceivers allow up to 8 Mbit/s and the maximum possible bit rate in this network can be maximum 8 Mbit/s for CAN FD and CAN XL communication. The maximum bit rate can be reduces depending on the network topology. Have in mind that reflection and ringing on the network lines can reduce the bit rate dramatically. The maximum possible bit rate for each network should be verified via simulation.

The CAN XL protocol handler combined with a CAN SIC XL transceiver allows to support Classical CAN, CAN FD, and CAN XL communication without hardware modification. Only different configurations are needed. Also mixed CAN FD and CAN XL communication in one network is possible. ◀



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