X_CAN IP-Module Overview

Sunderdiek, ME-IC/PRM-IP, October 2025

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IP business @ Bosch Mobility Electronics
IP Portfolio

I/O Processing IP | **Communication IPs** | **Accelerator IP**

GTM IP Gen 4

... realtime oriented I/O co-processor *(aka "Timer")*

- A scalable timer solution for ...
  - digital input data processing (e.g. sensor data)
  - digital output data generation (e.g PWMs for actor control)
- Integrated multi-threaded RISC cores for real-time oriented control loops
- Generic architecture to address multiple domains
  - Powertrain (combustion & electric)
  - Chassis and Body applications
  - Inverter, PFC,
  - ...

CAN IPs

... Controller Area Network IPs

- **X_CAN IP**
  - Triple-protocol support: *1
    - Classical CAN, CAN FD and **CAN XL (new)** and CAN FD light commander
  - Active DMA support
  - Bitrates up to 20 Mbit/s
  - Payload up to 2048 byte
- **M_CAN IP**
  - Dual-protocol support: *1
    - Classical CAN and CAN FD and CAN FD light commander
  - Bitrate up to 8 Mbit/s
  - Payload up to 64 bytes
- **XS_CAN IP**
  - Small gate count
  - Triple-protocol support:
    - Classical CAN, CAN FD and **CAN XL (new)**
  - Bitrates up to 20 Mbit/s
  - Payload up to 2048 byte
  - CAN FD light Commander up to 8Mbit/s **(new)**
- **FDLR_CAN IP**
  - CAN FD light responder IP
  - For Responder Nodes, MCU less
  - Bitrate up to 8 Mbit/s
  - Payload up to 64 bytes

CAN protocol licensing

- CAN FD (light) protocol license
- CAN XL protocol license

*1, CAN FD light Commander up to 1 Mbit/s

DFA IP Data Flow Architecture

... HW based accelerator for advanced mathematical algorithms

- Ready for AI & ML (**A**rtificial **I**ntelligence, **M**achine **L**earning)
- Data-based modeling, signal processing, control theory, physical equations
- Enabler for new compute-intensive functions e.g. novel features + legal regulations like EU7, OBM

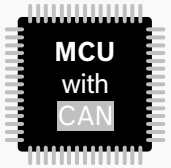
Computer Vision IP Gen 2

... comprehensive set of computer vision processing elements

- Optical Flow
  - Optical flow field estimation
  - Native 12MPix input image resolution support
  - Nearly one flow vector per pixel
  - Camera's ego-motion estimation
- Stereo Disparity module
- Classifier Engine
- Structure from Motion Detection

CAN XL – Next Step in CAN Evolution

ISO: Standardization Published



ISO11898-1:2024

Contains all CAN Protocols

- CAN CC (unchanged)
- CAN FD (unchanged)
- CAN XL
- CAN FD light responder

Status

Published on
May 24th, 2024

Source: ISO web site https://www.iso.org/standard/86384.html

ISO11898-2:2024

Contains all CAN Transceivers

- HS-CAN (unchanged)
- CAN FD (unchanged)
- CAN SIC
- CAN SIC XL

Status

Published on
March 22nd, 2024

Source: ISO web site https://www.iso.org/standard/85120.html

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CAN XL – Next Step in CAN Evolution

Superior up to 20 Mbit/s network solution

IP available

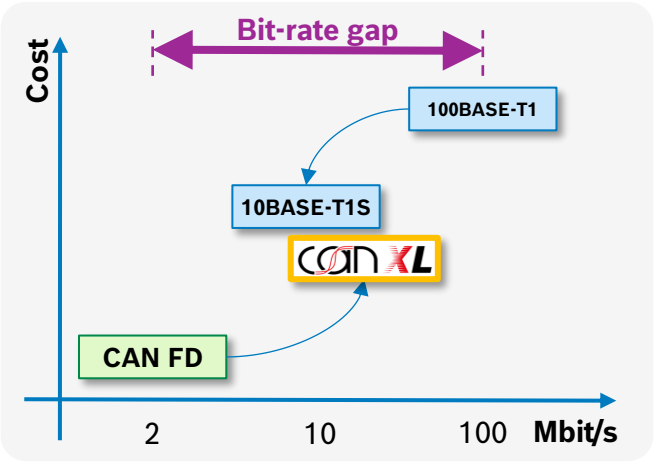
Broad availability in nextGen µCs

Target / Motivation

Provide a superior ≤20Mbit/s CAN solution with respect to

- Price (Transceiver, Pins, Cabling, ...)
- Safety and Security
- Enables SOA (Service Oriented Architecture)
- Quality of Service

Preserve CAN properties: Arbitration, robustness, long stubs, ...



Compatibility of CAN FD and XL enables ...

- Incremental upgrade path
  ➔ larger acceptance (re-use of CAN / CAN FD knowhow and equipment)
- E/E Architecture design freedom: "mixed FD/XL" or "XL only" networks:
  - "XL only" networks up to 20 Mbit/s
  - "mixed" networks limited to 8 Mbit/s (e.g. XL 8 Mbit/s, FD 2 Mbit/s)

Key Success Factors

1) **Cost Optimal E/E Architectures**
   Single bus for 3 types of traffic
   (CAN FD, CAN XL and Ethernet)
2) **Bit rate up to 20 Mbit/s**
   Compatible with wide range of transc.
   (HS-CAN, FD, SIC, SIC XL)
3) **Large payload size (1 .. 2048 bytes)**
   enough space for any application
4) **Ethernet Tunneling**
   allows use of TCP/IP, SOME/IP, etc.
5) **Incremental upgrade**
   Allows CAN FD and CAN XL on the same network (up to 8 Mbit/s)
6) **Scalable**
   flexible tradeoff between cost, speed and network complexity
7) **Broad availability**
   majority of nextGen automotive µCs

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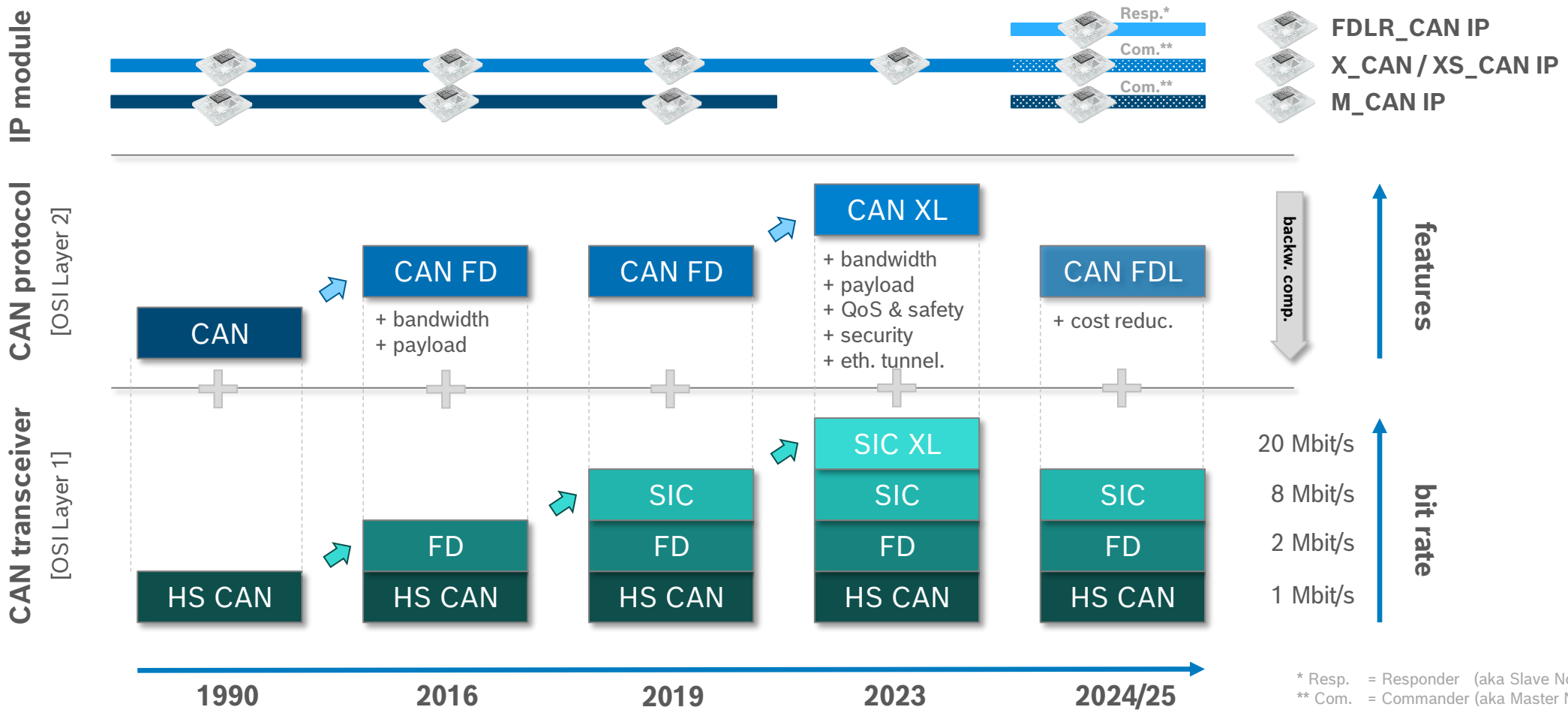
CAN roadmap



* Resp. = Responder (aka Slave Node)
** Com. = Commander (aka Master Node)

X_CAN Overview

FEATURES

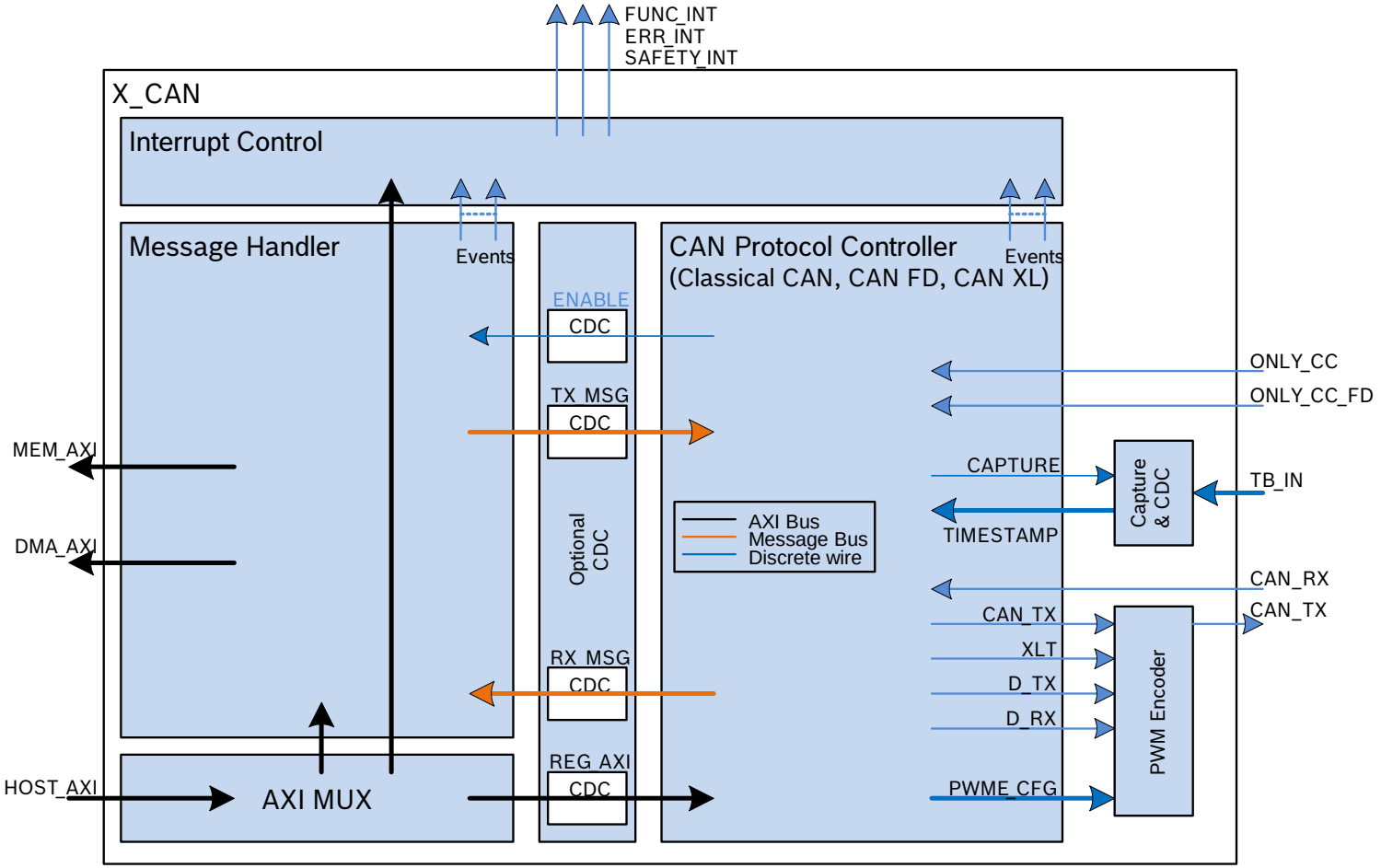
- Support of CAN CC, CAN FD, and CAN XL
  - Conform with ISO11898-1:2024
- Full support of CAN XL protocol
  - Up to 20Mbit/s and up to 2048 bytes
- Small local memory
  - approx. 4 Kbytes for up to 255 filter elements
- Internal DMA engine, XCAN acts as DMA master for message handling
  - Message storage in system memory
  - Low CPU impact, any accesses to/from the system memory are done using the internal DMA engine (less interrupts)
- 8 RX FIFO queues, each with up to 1024 messages
- 8 TX FIFO queues, each with up to 1024 messages
- 1 TX priority queue, up to 32 slots, configurable by SW
- 255 RX filters on the first 8 byte of a frame (e.g., CAN XL header and AF)
- TX filtering capabilities to support security
- Privileged accesses to protect configuration and RX/TX filtering (optional)
- 64-bit Timestamps from external Timebase
- ASIL D capable with external measures

X_CAN Overview

FEATURES

- AXI interface compliant to AMBA 4 ARM Ltd protocol
  - AXI4-Lite slave interface (HOST_AXI)
  - AXI4 master DMA interface (DMA_AXI)
  - AXI4 master Local Memory interface (MEM_AXI)
- CAN Error Logging
- Fault Injection Module
- Programmable loop-back test mode
- Multiple X_CAN can share the same Local Memory
- Maskable module interrupts with three categories: Functional, Functional Error and Safety
- Three clock domains (HOST, CAN, TIMEBASE)
- Power-down support

X_CAN Overview
Block diagram (simplified)



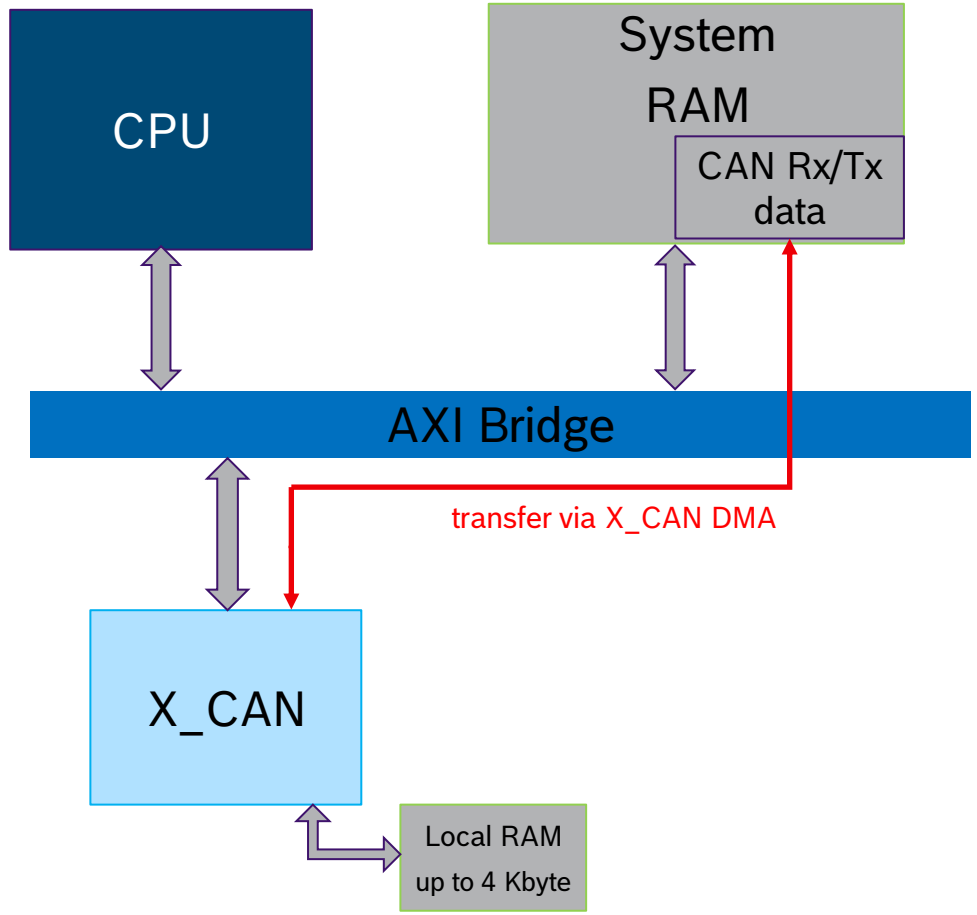
Signal	Dir	Function
HOST_AXI	I/O	RD/WR access to config/control/status registers
DMA_AXI	I/O	DMA Interface for message transfer between XCAN and System RAM
MEM_AXI	I/O	Interface to local Message RAM
FUNC_INT	O	Functional Interrupt
ERR_INT	O	Error Interrupt
SAFETY_INT	O	Safety Interrupt
CAN_RX	I	CAN receive input from transceiver
CAN_TX	O	CAN transmit output to transceiver
TB_IN	I	Time Base Input from external counter for 64-bit time stamping
ONLY_CC_FD	I	If fixed to '1' only Classical CAN and CAN FD operation enabled
ONLY_CC	I	If fixed to '1' only Classical CAN operation enabled

Glossary:

- CDC - Clock Domain Crossing

X_CAN Overview
X_CAN is DMA Master

- Advantages
  - RX/TX data stored in system memory
    - All data handled in system memory
    - No extra transfers from/to local RAM to be initiated by CPU
    - Reduced interrupt load for processor core
  - Only small local RAM required (up to 4 Kbyte)
    - Local RAM holds acceptance filter elements
    - Local RAM holds active descriptors for DMA transfer to system memory



X_CAN Overview
Timeline & Deliverables

Revision 1.1.0
Available

Deliverables include:

- VHDL Source Code
- User Manual (programmer's view)
- Module Integration Guide (designer's view)
- FMEDA
- Safety Manual
- Functional Safety assessment certificate
- Conformance Test Report for CAN and CAN FD
  - Passed in June 2022

Licensing conditions available at Bosch AE
Please see: https://www.bosch-semiconductors.com/ip-modules/can-protocol-license/

Revision 1.1.0
CAN XL Conformance tested
depending on availability of CAN XL CT

Planned for Q1/2026

Conformance Tested for Classical CAN, CAN FD, and CAN XL

X_CAN Overview
IP Delivery content and Service

- The X_CAN package include:
  - xcan_readme.txt, User manual, Integration guide, both as pdf and as word document
  - Excel Sheet for calculation memory latency and min. Host clock,
  - Safety Case documents:
    - Safety Manual, Safety Certificate, DFA (Dependent Failure Analysis), DIA (Development Interface Agreement), FMEDA (Failure modes, effects, and diagnostic analysis)
  - Verification report, Verification Plan Summary, Spyglass configuration files, constraint file for synthesis and IP-XACT XML file, synchronizer list.
- Service include:
  - Free updates for the X_CAN IP, Errata, Testbench
  - AppNote: Transmission **Transmission and Reception Handling with FIFO Queue + SW examples**
  - Free Technical support during integration
  - Free Technical support during usage of the X_CAN IP, e.g., bring up / debugging for CAN CC/FD/XL messaging