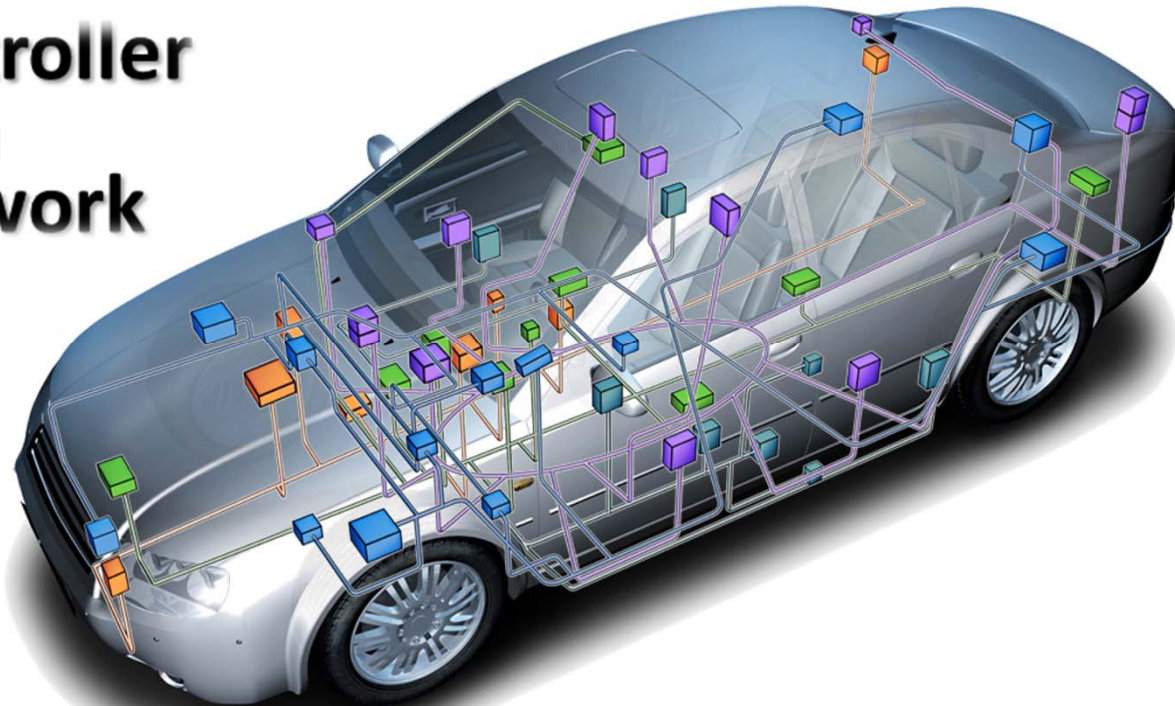# CAN FD – CAN with Flexible Data Rate

Controller
Area
Network

Thomas Lindenkreuz

Robert Bosch GmbH

Automotive Electronics

Vector Kongress 2012

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Agenda

1	What's CAN FD − Benefits ?
2	Use Cases for CAN FD
3	Availability of Components
4	CAN FD Standardization
5	Summary

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History of CAN

84	**Bosch** start development on CAN	
85		
86	CAN **patent** filed	
87	CAN published at **SAE congress Detroit**	
88	First **CAN chips** from Intel and Philips	
89		
90	CAN introduced first in **weaving machines**	
91	First Mercedes-Benz **S-class** with CAN	
92	Foundation of CAN in **Automation**	
93	Standardization of CAN in **ISO 11898**	
94		
	CANopen protocol published by CiA	
95		
96		
97		

Introduction of **TTCAN**

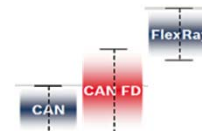**Specification of several ISO 11898-x:**
data link layer
high-speed physical layer
fault-tolerant physical layer
TTCAN
low-power mode
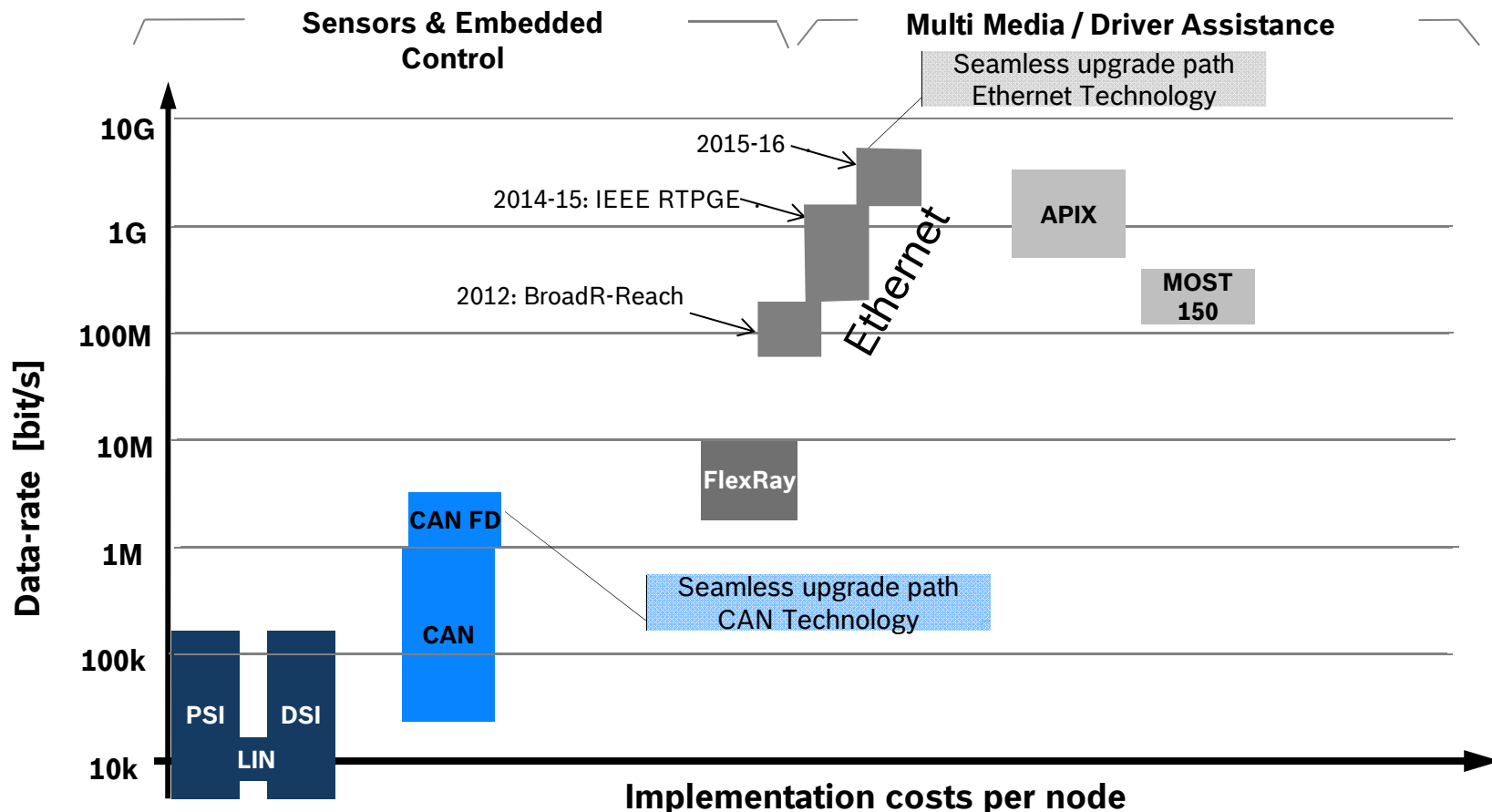selective wake-up

Invention of **CAN FD** (ISO 11898-7)

Source: CiA

99	
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Automotive Future Communication System Landscape

Approaches to increase Data Rate

Standard CAN Frame

| Arbitration Phase | Data Phase | Arbitration Phase |

Payload transmitted at higher bit rate

1. Increase Bit Rate

CAN FD Frame

| Arbitration Phase | | Arbitration Phase |

Implications of higher bit rate
- Changes limited to HW of protocol controller
- Transceivers for higher data rate qualified
- Legacy SW fully compatible

2. Increase Payload

up to 64 Bytes payload in Data Phase (instead of 8 Byte)

CAN FD Frame

| Arbitration Phase | | Arbitration Phase |

Implication of larger payload
- SW update necessary

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CAN FD Base Frame

| Arbitration Field | | Control Field | Data Field | CRC Field | ACK | EOF | Int. | Bus Idle |

| S O F | 11 bit Identifier | r1 | IDE | EDL | r0 | BRS | ESI | 4 bit DLC | 0-64 bytes | 21* bit CRC | 1 | 1 | 1 | 7 | 3 | |

| CAN FD Arbitration | CAN FD Data | CAN FD Arbitration |

* 17 bit CRC for data fields with up to 16 bytes

➔ CAN FD Arbitration Phase
- length: 30 bit times*
- data rate: max. 1 MBit/s

➔ CAN FD Data Phase
- length: 86 bit times* (8 data bytes)
- data rate: > 1 MBit/s

➔ Remote Frames always in CAN Format
- RTR bit replaced by reserved bit r1
- r1 takes part in CAN arbitration
- reserved for protocol expansion

* bit stuffing not considered

EDL – Extended Data Length
Substitutes first reserved bit in standard frames
EDL = recessive indicates CAN FD frame format
        (new DLC-coding and CRC)
EDL = dominant indicates standard CAN frame format

r1, r0 − reserved bits
Transmitted dominant, reserved for future protocol variants

BRS – Bit Rate Switch
BRS = recessive: switch to alternate bit rate
BRS = dominant: do not switch bit rate
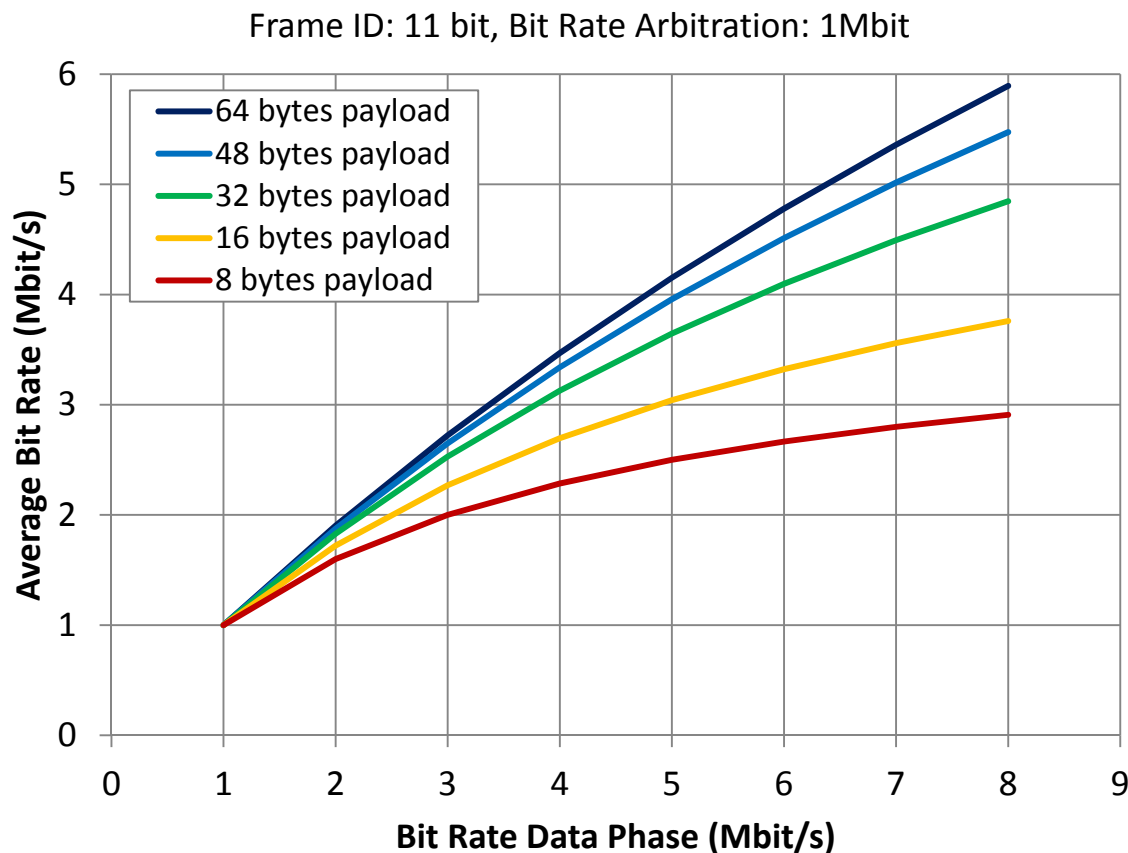
ESI – Error State Indicator
ESI = recessive: transmitting node is error passive
ESI = dominant: transmitting node is error active

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Average CAN FD Bit Rate

Frame ID: 11 bit, Bit Rate Arbitration: 1Mbit

Legend:
- 64 bytes payload
- 48 bytes payload
- 32 bytes payload
- 16 bytes payload
- 8 bytes payload

Y-axis: Average Bit Rate (Mbit/s)
X-axis: Bit Rate Data Phase (Mbit/s)

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Use Case 1: Fast SW Download

Example: Standard data rate − 500 kb/s

FD data rate − 2 Mb/s

➔ Time to transmit 4 standard CAN message with 8 data bytes and 15% stuff bits - 1021 µs

➔ Time to transmit 1 CAN FD message with 32 data bytes and 15% stuff bits   -   229 µs

Source: GM

CAN FD: about 4 times higher bandwidth is realistic

Use Case 2: Avoid Splitting of long messages

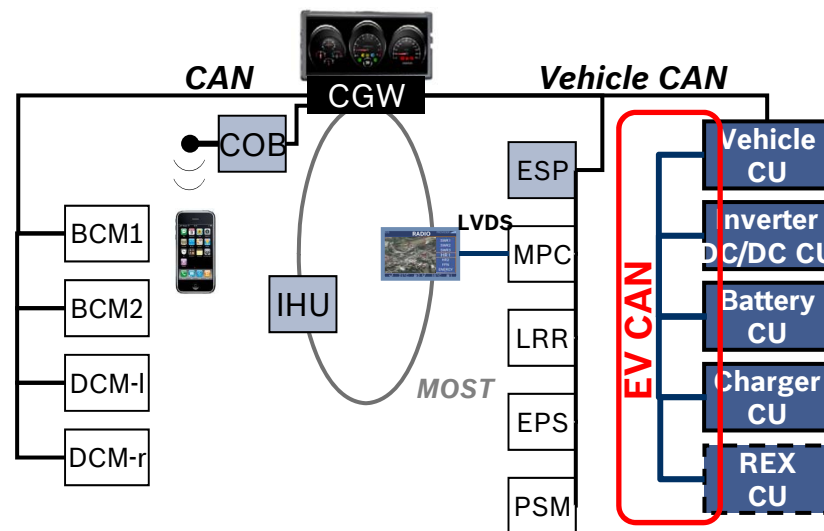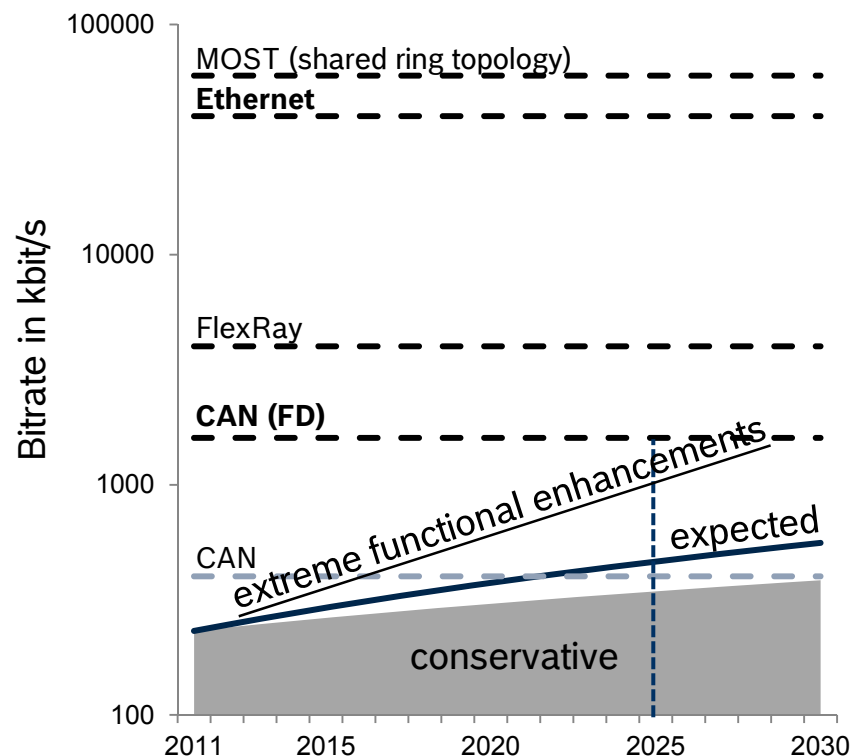**Example (1):** Secure 8 Byte CAN message by additional MAC

(Message Authentication Code)

Example (2): Transmission of acceleration sensor data in x,y,z-direction

CAN FD allows longer messages
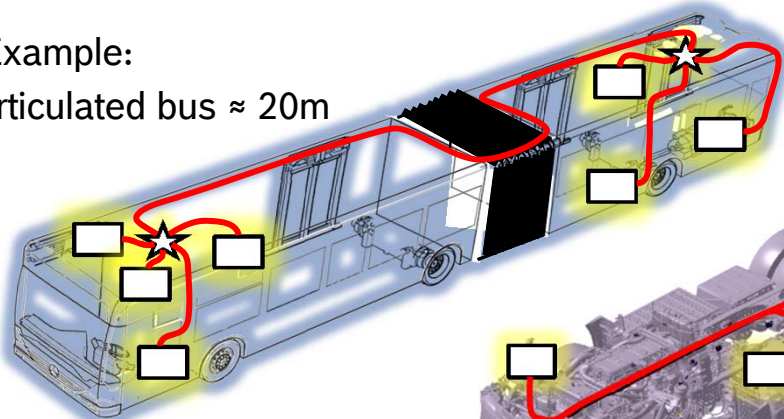## → easier management on the transport layer

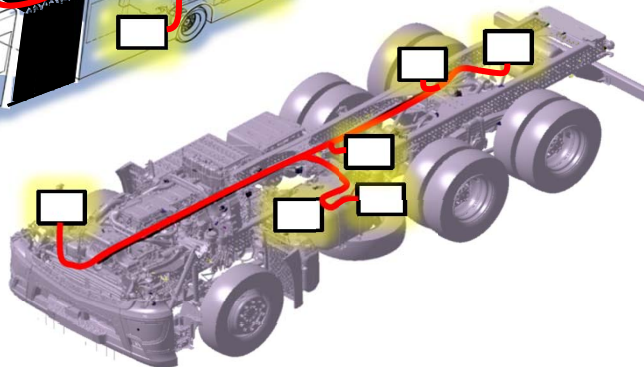**BOSCH**

Use Case 3: Higher Bandwidth − Example EV

CAN FD is fit for next generation of Powertrain requirements.
In case of extreme functional enhancements Ethernet might be necessary.

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Use Case 4: Baud Rate limited by network dimension

Example:
articulated bus ≈ 20m

Example:
truck frame ≈ 9m

SAE J1939-15	
Issued	2008-08
Bit rate	250 kBit/s
Bus length (L)	40 m
Stub length (S)	3 m
Nodes (n)	30

☐ CAN ECU
☆ passive star
— bus line

Source: Daimler

SAE J1939-15 brings CAN technology to its limits

Accelerated Communication on long CAN FD Bus Lines
The data bit rate can be increased independent of cable length
Example: 250 kBit/s + 4 Mbit/s → average bit rate 810 kBit/s

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Bosch CAN FD − Communication Controller IP

IP Module

- CPU IF — 8/16/32
- Memory IF — 32
- Generic Slave IF
- Generic Master IF
- CAN Core → CAN_TX, CAN_RX
- Sync
- Tx Handler — Tx Priorization
- Rx Handler — Acceptance Filtering
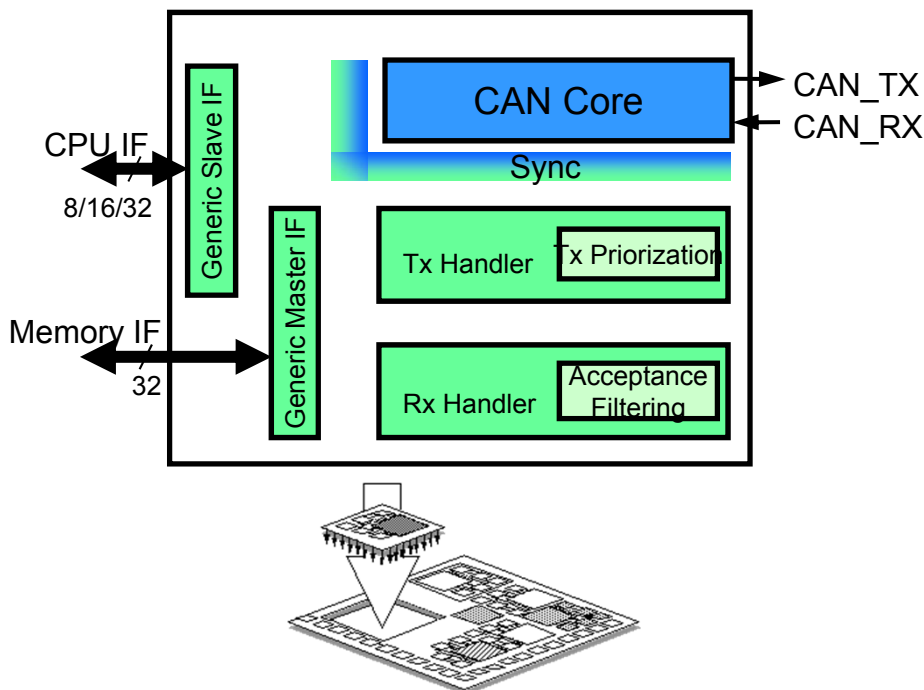
Feature Hierarchy

...	
TTCAN	special features
CAN FD 64	
Calibration on CAN	
Tx FIFO / Queue	
Tx Event FIFO	
Rx FIFO	similar with most implementations
Rx Buffer	
Tx Buffer	
CAN Protocol ISO 11898-1	same with all implementations

M_CAN Module conform with CAN protocol version 2.0 part A, B and ISO 11898-1, -4

NEW: full CAN FD support (higher bit rate, 64 bytes payload) − available now
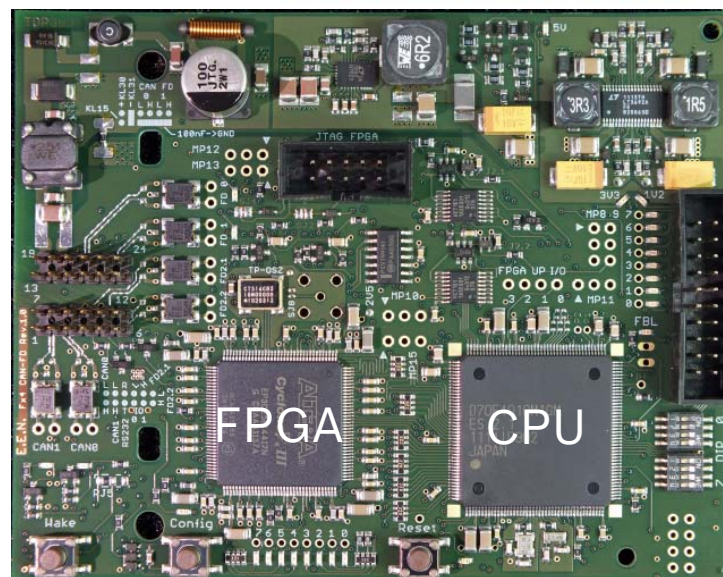
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CAN FD Sample Gateway Device

→ Renesas V850E2/FK4-70F4010 CPU with 2 CAN 2.0 cores

→ 2 CAN FD IP cores running on an Altera EP3C25 FPGA (40MHz) supporting CAN FD @ 10 Mbit/s

→ 3 physical layers for CAN FD selectable

→ Automotive housing and connectors, Truck and passenger car compatible

→ AUTOSAR based test software

World's first gateway supporting CAN FD HW/SW available also to third parties approx. 04/2013

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Tool Support:

CAN FD Bus Analyzer − Measurement − Calibration
CAN FD Diagnostics − Rapid Prototyping HW

CANalyzer
CANoe

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HW Components − MCUs, Transceivers

Fast and firm commitment by semiconductor suppliers

➜ Comprehensive CAN FD qualified Transceiver Roadmap announced

➜ MCU sample silicon with full CAN FD support in Q1/2013 available
  - Roadmaps presented during CAN FD TechDay, Detroit, Oct. 18th 2012

  - Others in preparation

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CAN FD Standardization activities

→ CAN ISO Standardization:
- CAN FD as part 7 → ISO11898-7 → start 10/2012
- Upgrade CAN conformance test: ISO16845 → in parallel

→ CAN FD Upgrade for SAE J1939 → ongoing
(CAN standard for heavy duty vehicles)

→ CAN FD (Mode 1) in Autosar 4.1.1 → committed by Autosar

CAN FD standardization is on the way and committed

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Steps of introduction of CAN FD

Mar 2012	Bosch CAN FD presentation at CAN conference
Apr 2012	CAN FD protocol specification available
Apr 2012	Inaugural meeting of CAN FD Interest Group
Apr 2012	GM CAN FD SAE presentation
Jun 2012	ISO CAN task force supports CAN FD passive for PN transceivers (ISO 11898-6)
Jul 2012	CAN FD preferences spec
Aug 2012	AUTOSAR consortium decides to accommodate CAN FD payload bit rate in release 4.1.1
Oct 2012	CAN FD Tech Day in Michigan
Oct 2012	Submission of CAN FD new work item proposal to ISO
by e/o 2012	Various presentations: electronica 2012, Vector Kongress, CAN Info Day Warwickshire UK, ...
Q1/2013	First microcontroller with CAN FD64 available

Partly Source: GM

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Summary

→ CAN FD provides a seamless upgrade of the classic CAN technology
- Similar costs as for classic CAN
- Higher bandwidth
- Small impact on current SW and applications
- Physical layer and structure of topologies can be maintained

→ Life time cycle of existing E/E-Architectures can be extended

→ CAN FDEco-System needs to be slightly upgraded and is already growing

→ High interest in the car industry, particularly truck applications, volume passenger car manufactures

→ Bosch's next generations ECUs will support CAN FD

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Thank you for your attention !

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