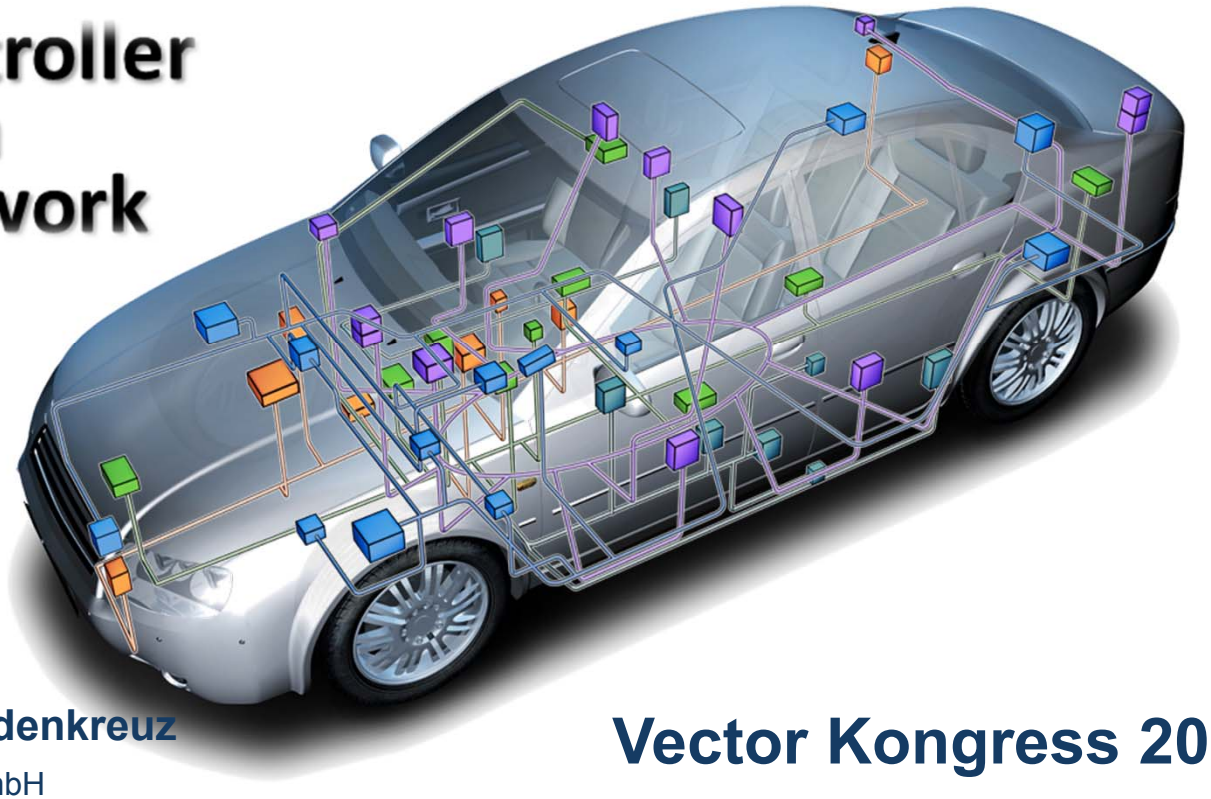
CAN FD – CAN with Flexible Data Rate

Controller
Area
Network



Thomas Lindenkreuz
Robert Bosch GmbH
Automotive Electronics

Vector Kongress 2012

BOSCH

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**

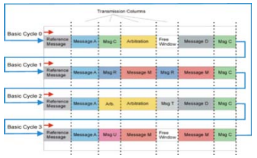
93 Standardization of CAN in **ISO 11898**

94

95 **CANopen** protocol published by CiA

96

97



99 Introduction of **TTCAN**

00

01

02

03 **Specification of several ISO 11898-x:**

04 data link layer

05 high-speed physical layer

06 fault-tolerant physical layer

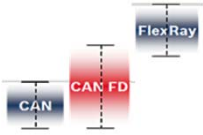
07 TTCAN

08 low-power mode

09 selective wake-up

10

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

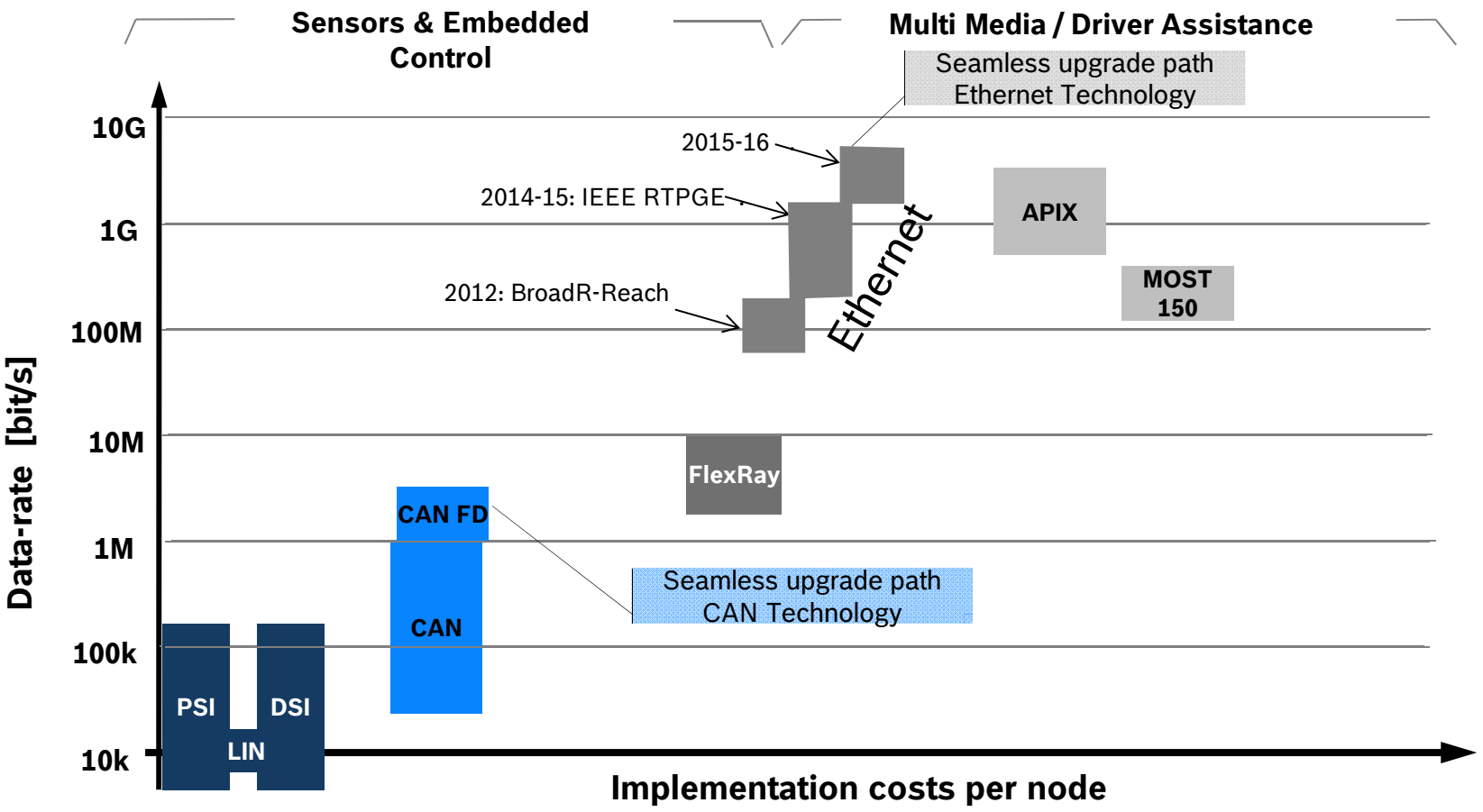


12 Source: CiA

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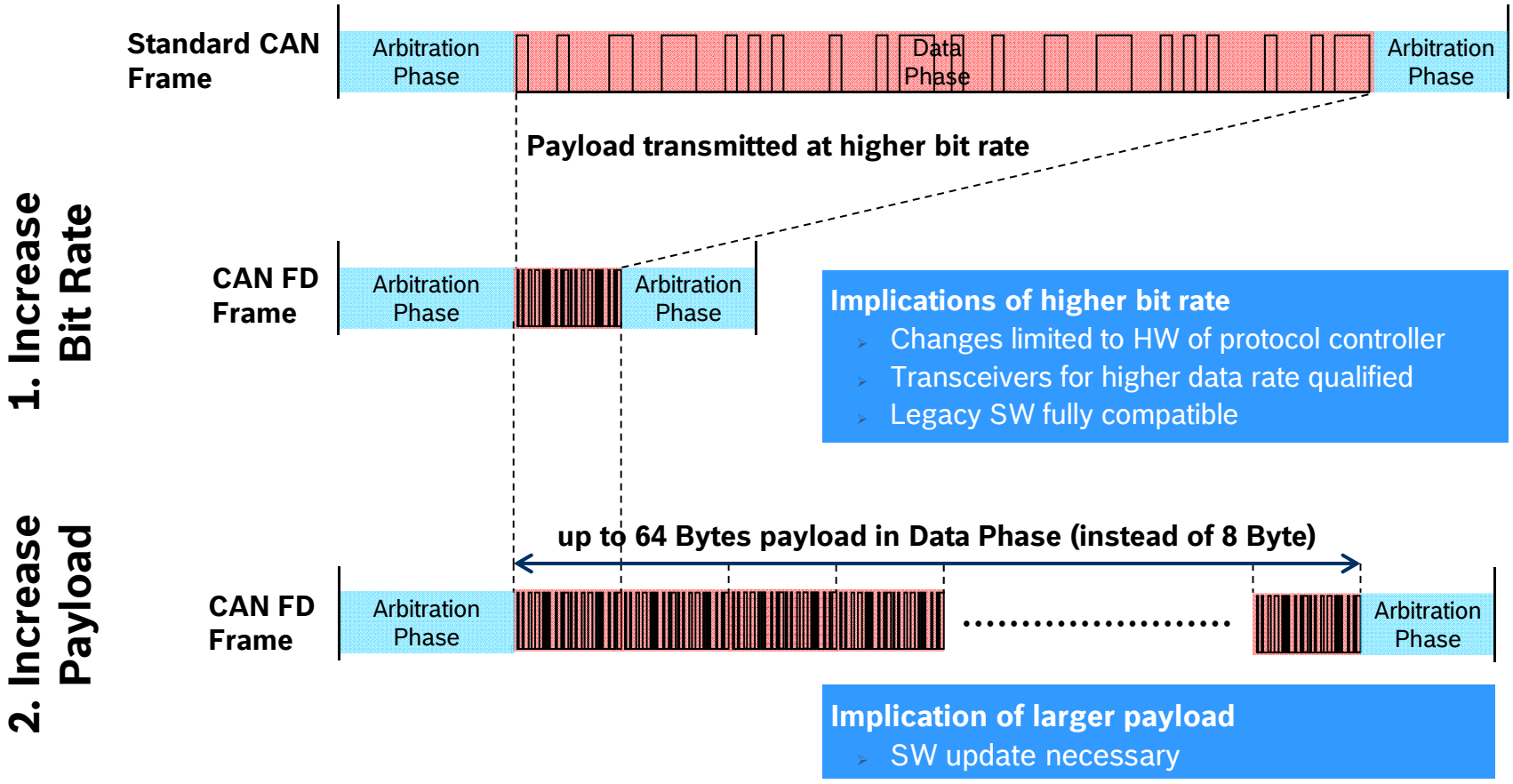
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Automotive Future Communication System Landscape



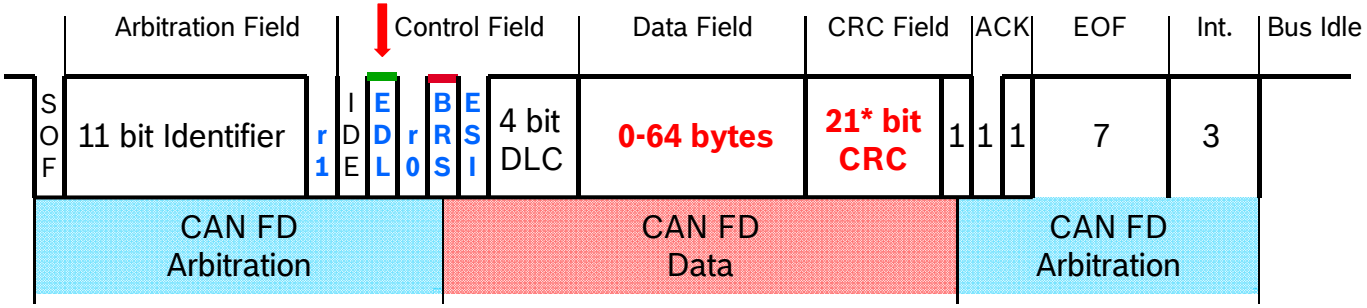
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Approaches to increase Data Rate



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CAN FD Base Frame



* 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

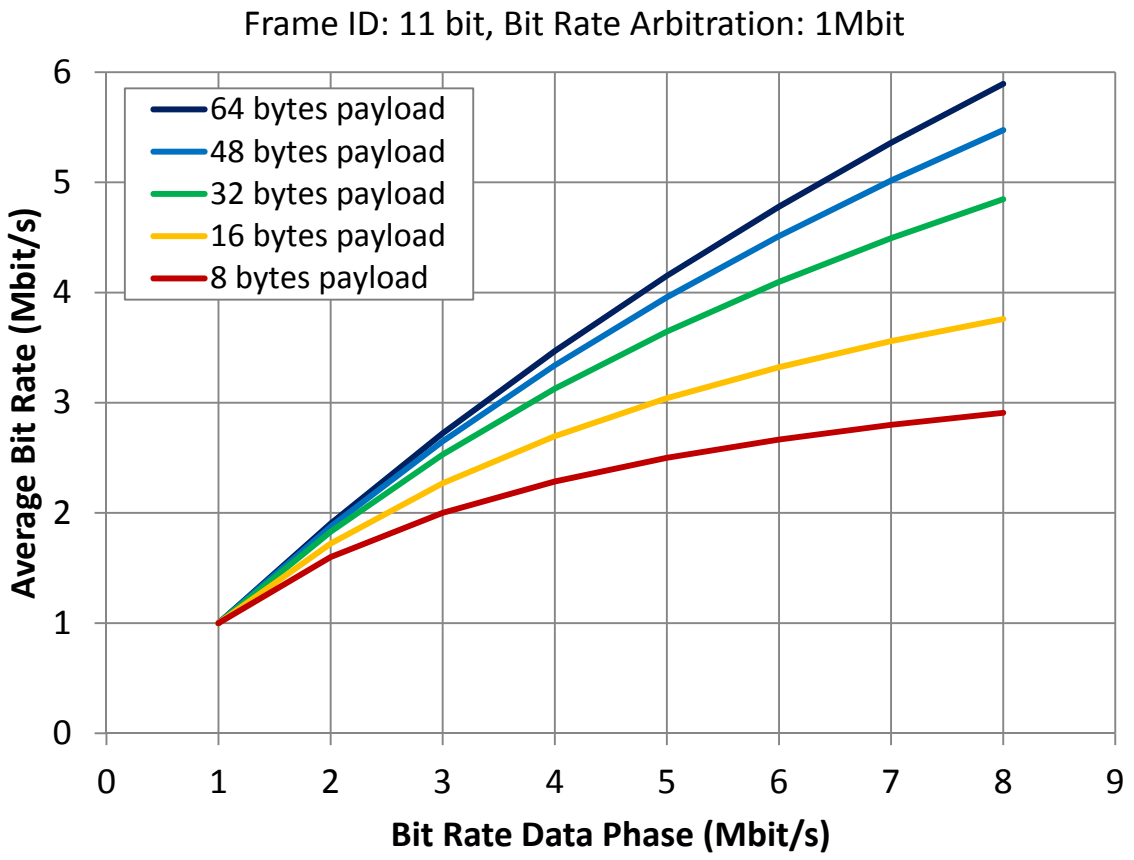
r1, r0 – reserved bits
Transmitted dominant, reserved for future protocol variants

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



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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

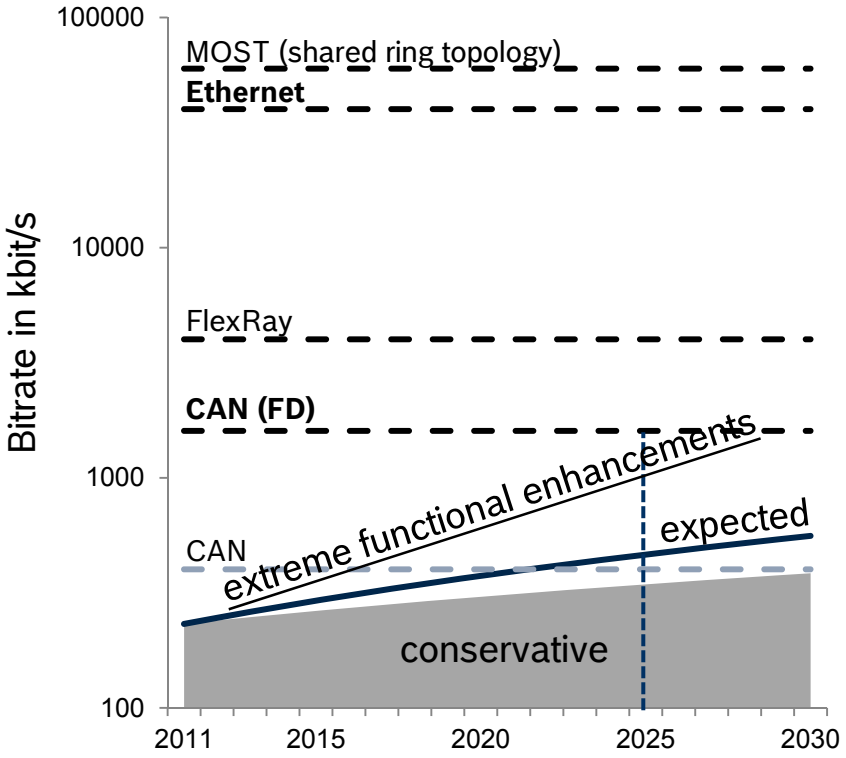
Example (1): Secure 8 Byte CAN message by additional MAC (Message Authentication Code)

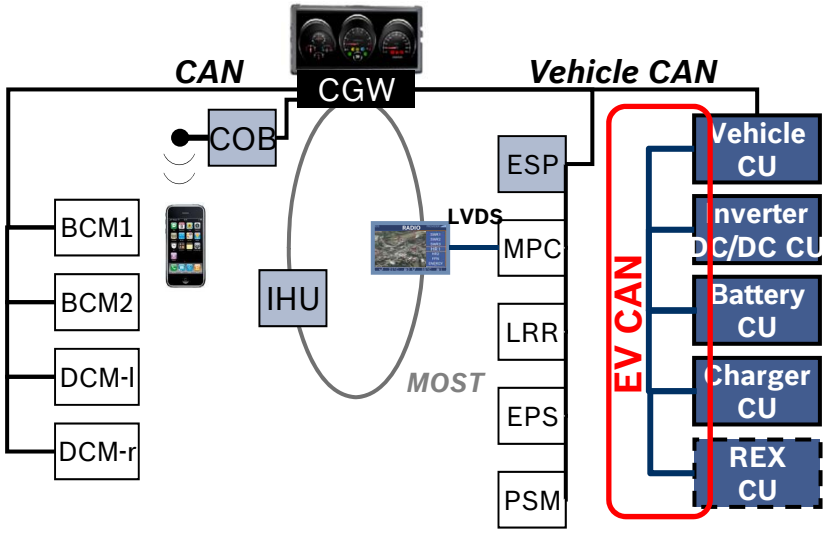
Example (2): Transmission of acceleration sensor data in x,y,z-direction

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

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Use Case 3: Higher Bandwidth – Example EV



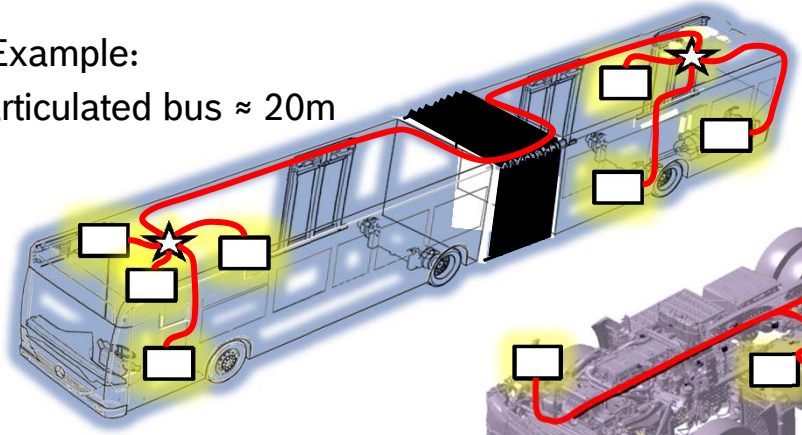


CAN FD is fit for next generation of Powertrain requirements.
In case of extreme functional enhancements Ethernet might be necessary.

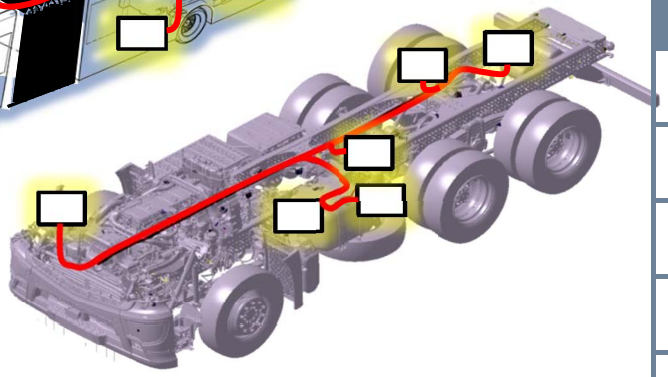
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Use Case 4: Baud Rate limited by network dimension

Example:
articulated bus ≈ 20m



Example:
truck frame ≈ 9m



CAN ECU
passive star
bus line

Source: Daimler

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

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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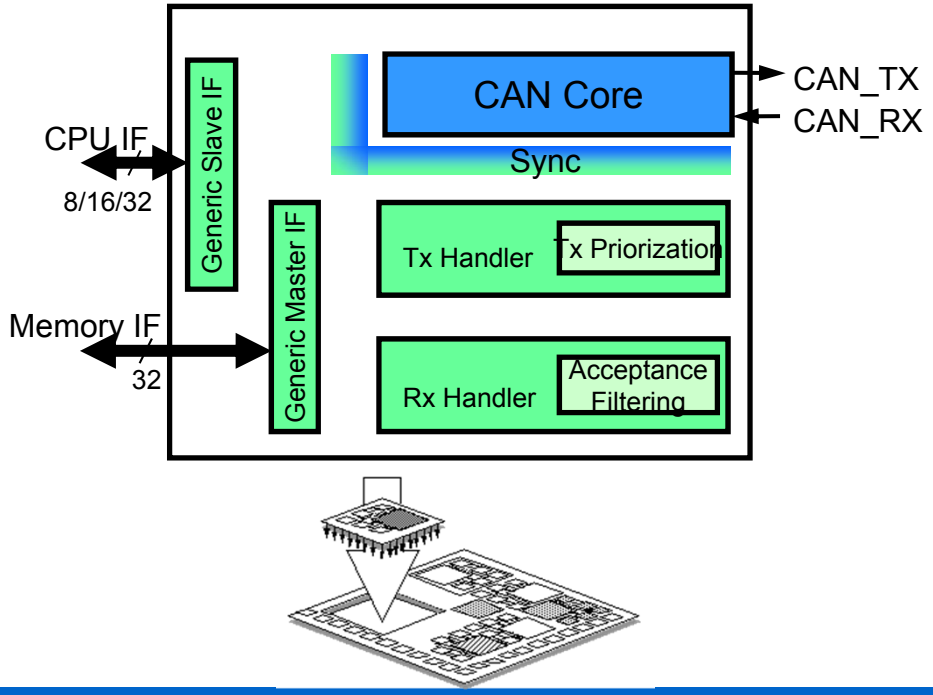
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Bosch CAN FD – Communication Controller IP

IP Module



Feature Hierarchy

...	special features
TTCAN	
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

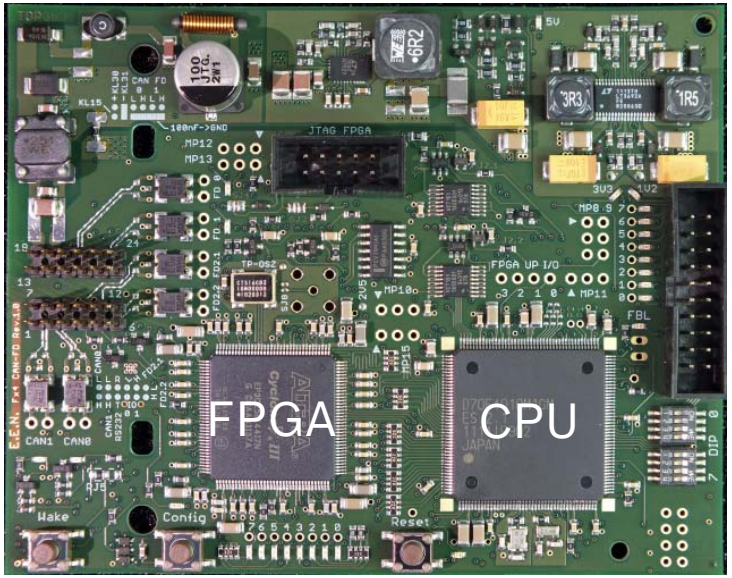
M_CAN Module conform with CAN protocol version 2.0 part A, B and ISO 11898-1, -4

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

vector

CANalyzer
CANoe





ETAS

BUSMASTER



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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 (CAN standard for heavy duty vehicles) → ongoing
- 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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