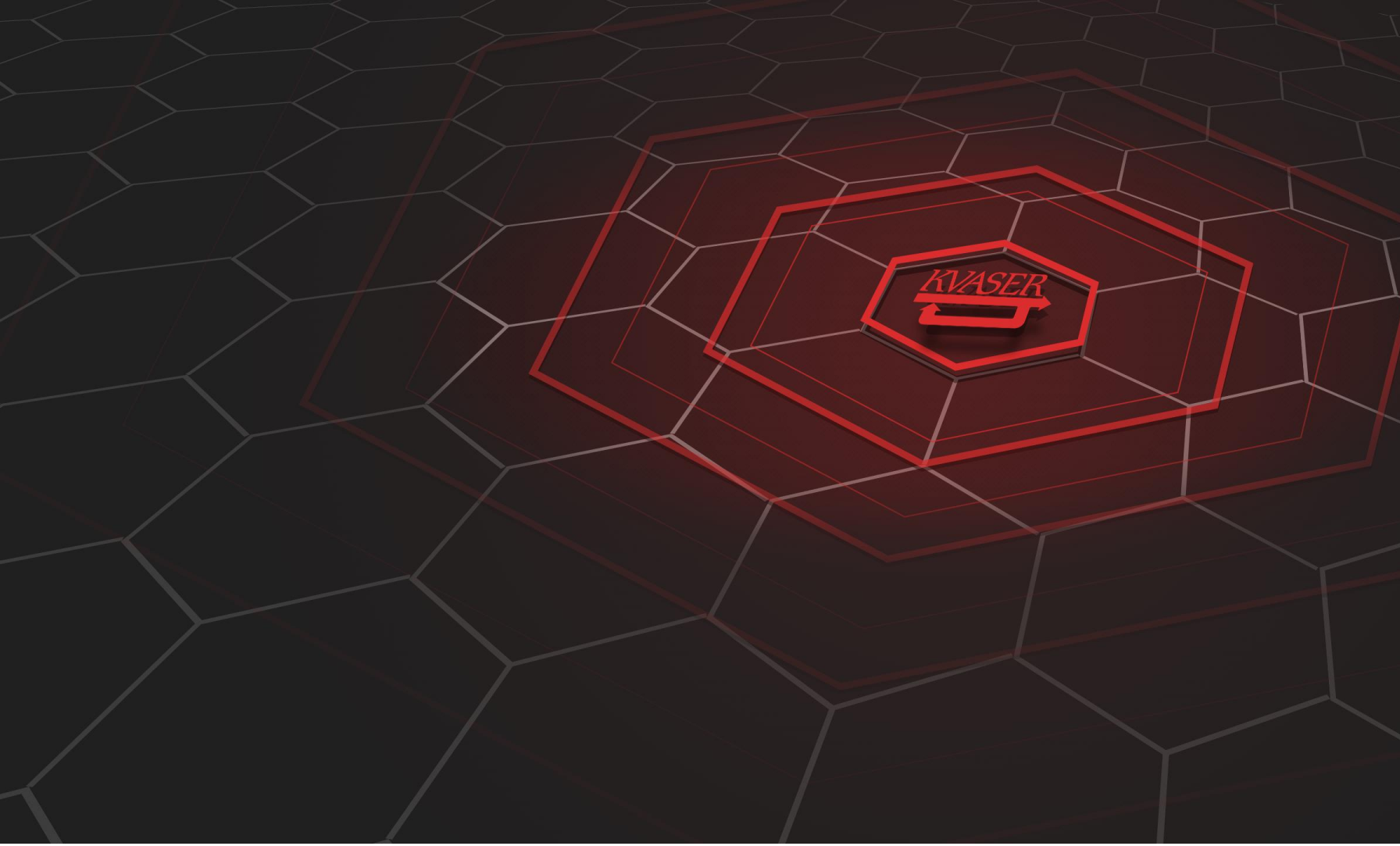

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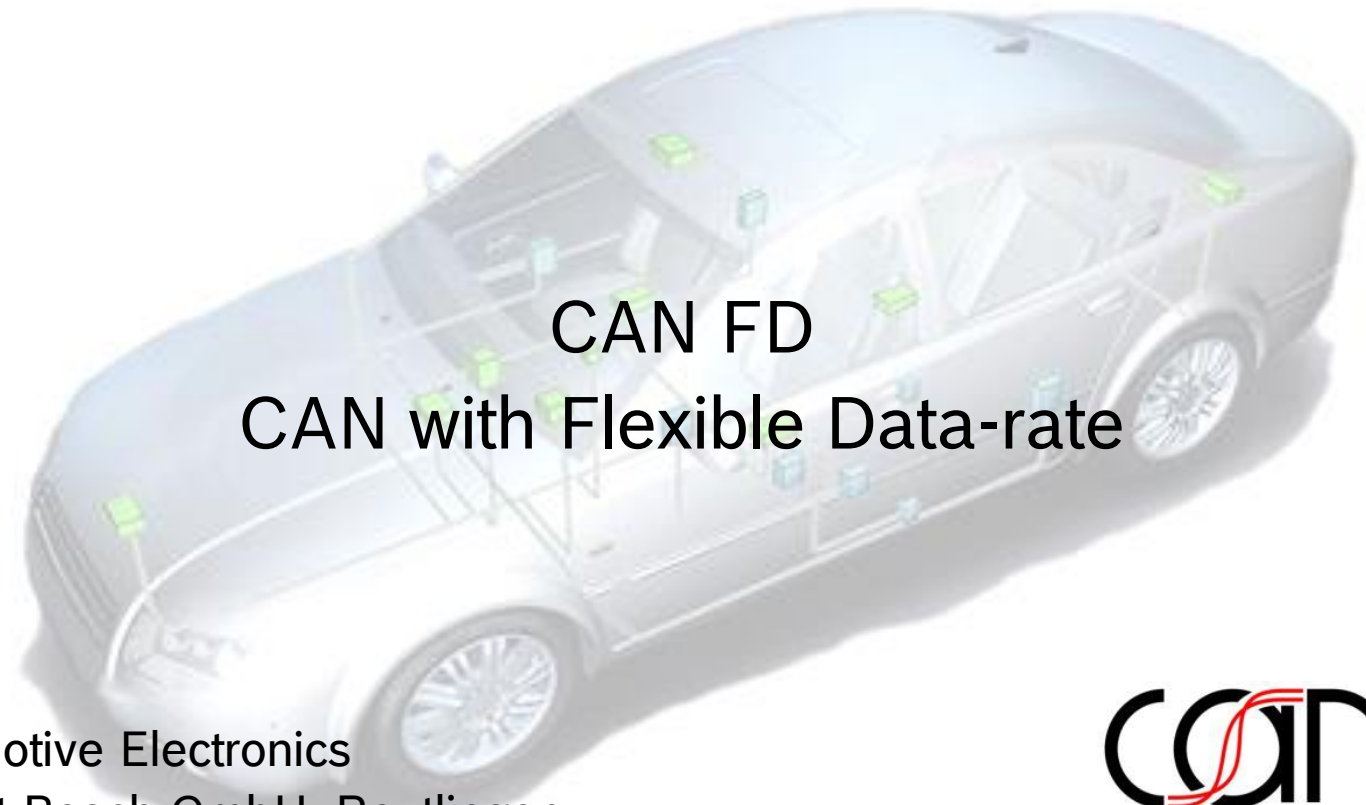

CAN FD
CAN with Flexible Data-rate

Automotive Electronics
Robert Bosch GmbH, Reutlingen

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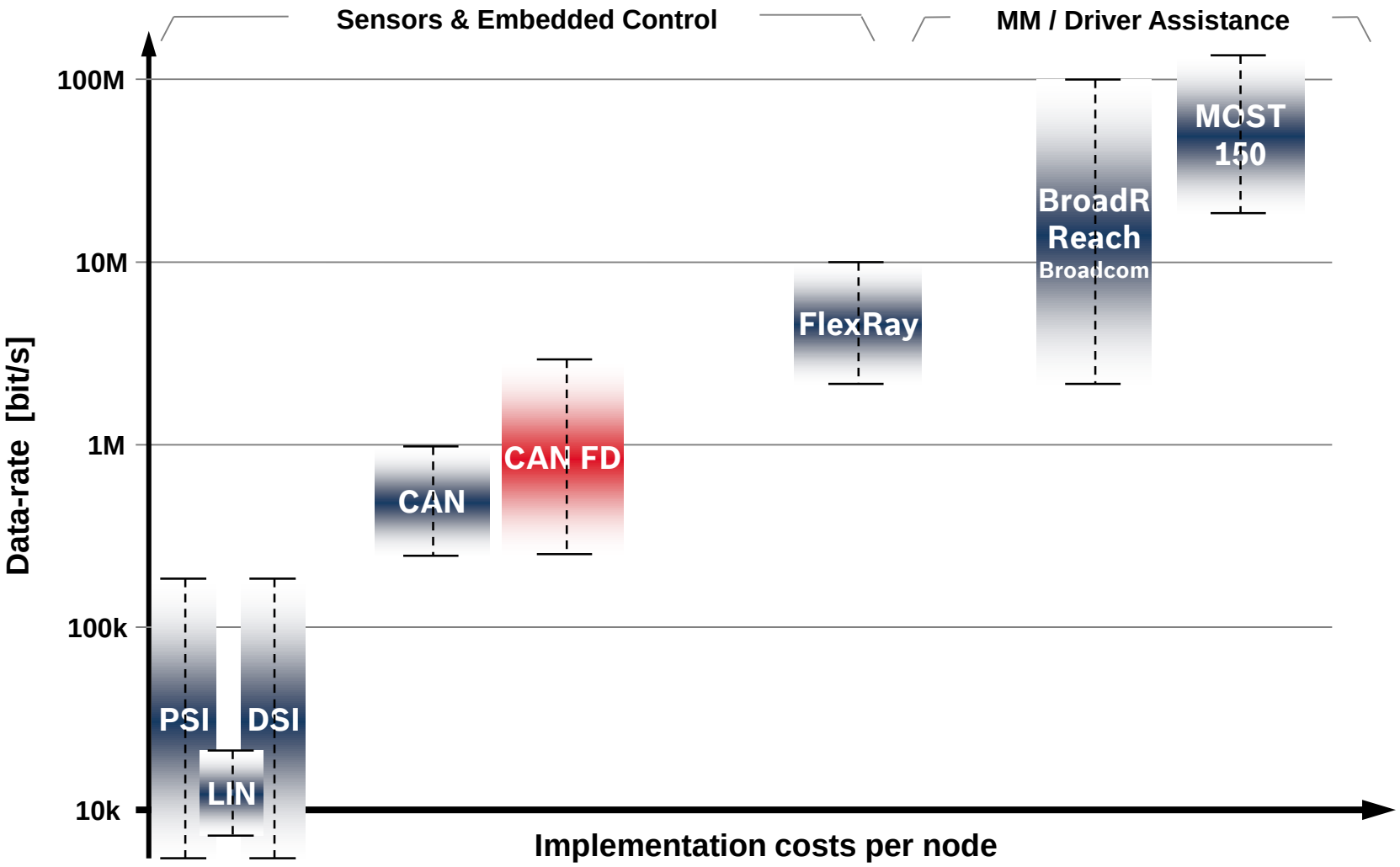
CAN FD - CAN with Flexible Data-rate



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Motivation

- Increasing demand for bandwidth in automotive communication
- Close gap between CAN (max. 1 MBit/s) and FlexRay (10 MBit/s)
- Time-triggered communication not flexible enough
- High effort for migration to FlexRay / Ethernet
  - Hardware costs
  - Software changes

→ Make CAN faster !

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Approach

- Unchanged
  - CAN arbitration
  - CAN acknowledge mechanism
- New
  - switch to higher bit rate for transmission of
    - Data Length Code
    - Data Field
    - Frame CRC
  - data fields with more than eight bytes possible
    - configured by unused DLC codes “1001” to “1111”
    - e.g. 12, 16, 20, 24, 32, 48, 64 bytes (t.b.d.)
  - new CRC polynomials for longer data fields, HD=6

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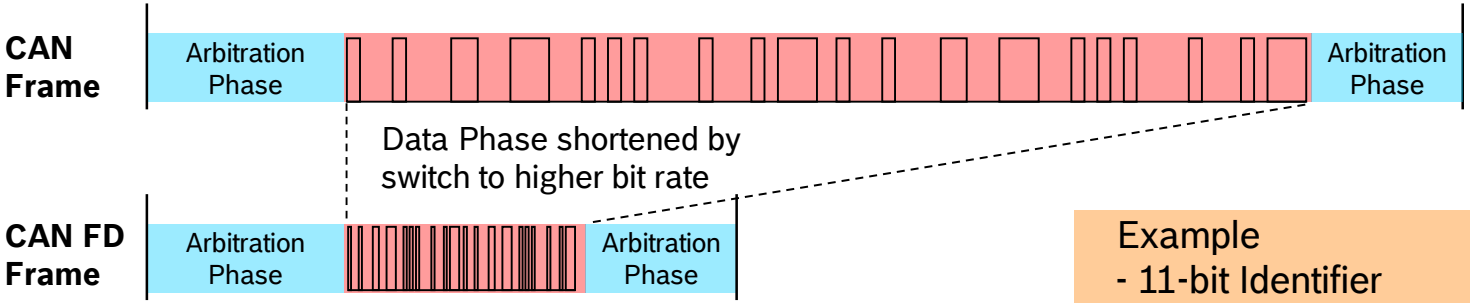
Approach



Example
- 11-bit Identifier
- Arbitration Phase 1 Mbit/s
- Data Phase 4 Mbit/s
→ average bit rate 2.3 Mbit/s

- → Based on existing CAN
  - well known technology, minimized risk
  - **changes limited to HW:** protocol controller
    - for bit rates up 1 MBit/s standard CAN transceivers usable
  - **no changes to SW:** with 8 bytes data field (legacy SW fully compatible)
    - even higher data rate possible by data fields >8 bytes and SW change
- → Costs similar to CAN
- → Closing gap between CAN (max. 1 MBit/s) and FlexRay (10 MBit/s)
- → **1st Demonstrator available**

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CAN FD Frame Format

CAN FD makes use of the reserved bits of CAN and introduces new control bits:

- EDL – Extended Data Length
  - substitutes first reserved bit in standard frames
  - EDL = recessive indicates CAN FD frame format (new DLC-coding/CRC)
  - EDL = dominant indicates standard CAN frame format
- r0 – reserved bit
  - 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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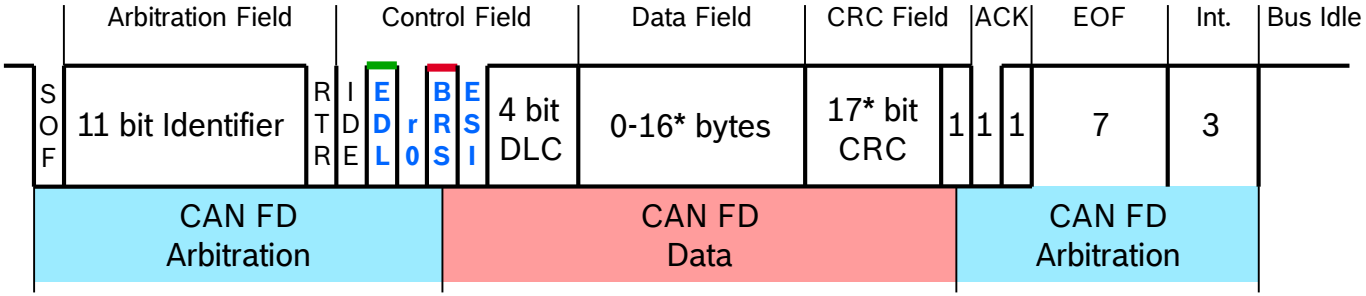
CAN FD Standard Frame



*data fields with more than 16 bytes also supported (longer CRC)

EDL – Extended Data Length
r0 – dominant
BRS – Bit Rate Switch
ESI – Error State Indicator

- CAN FD Arbitration Phase
  - length: 30 bit times*
  - data rate: max. 1 MBit/s
- CAN FD Data Phase
  - length: 86 bit times* with 8 data bytes
  - data rate: > 1 MBit/s

* bit stuffing not considered

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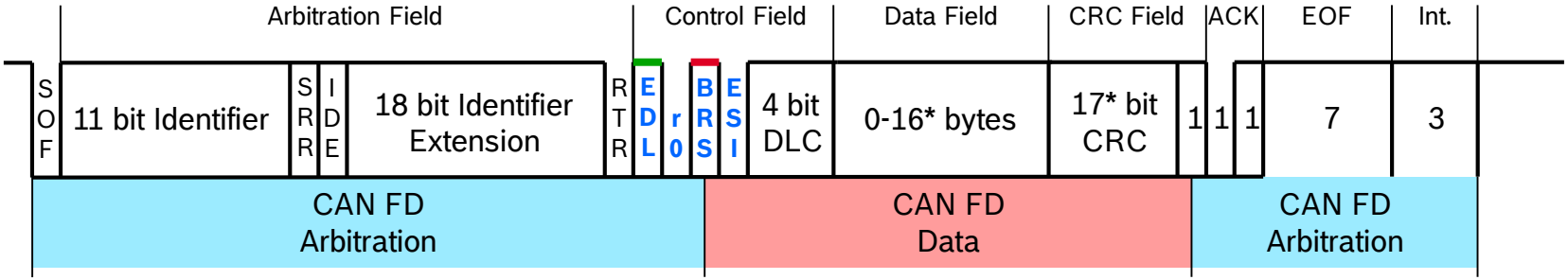
CAN FD Extended Frame



*data fields with more than 16 bytes also supported (longer CRC)

EDL – Extended Data Length
r0 – dominant
BRS – Bit Rate Switch
ESI – Error State Indicator

- CAN FD Arbitration Phase
  - length: 49 bit times*
  - data rate: max. 1 MBit/s
- CAN FD Data Phase
  - length: 86 bit times* with 8 data bytes
  - data rate: > 1 MBit/s

* bit stuffing not considered

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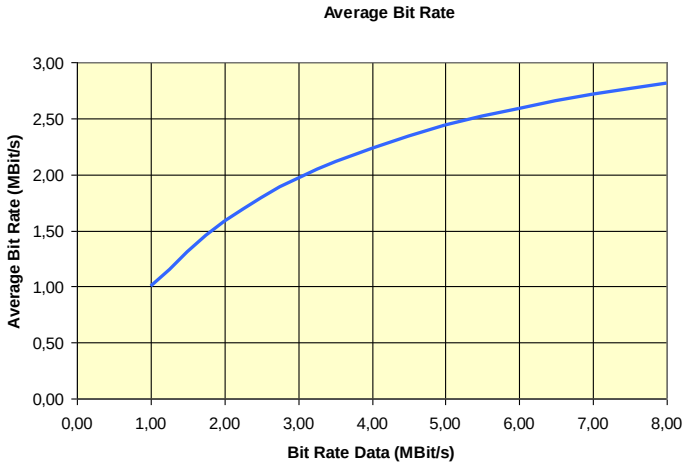
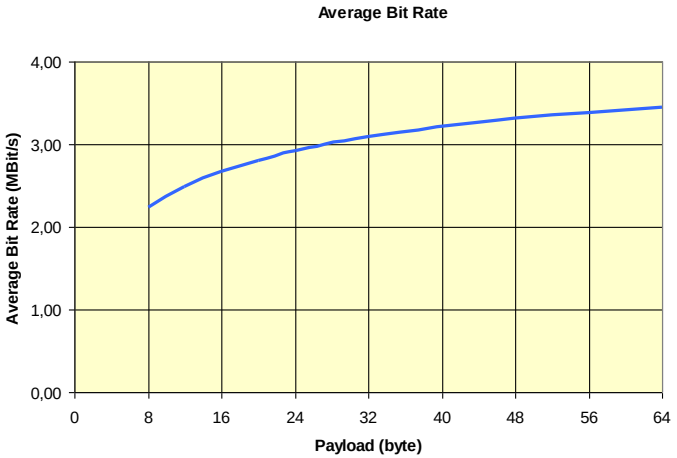
Average Bit Rate



Identifier 11 Bit
Data Field 8 Byte
Bit Rate Arb. 1 MBit/s



Identifier 11 Bit
Bit Rate Arb. 1 MBit/s
Bit Rate Data 4 MBits

bit stuffing not considered

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Application of CAN FD Features

- CAN FD with Bit Rate Switching
  - increase net data rate
  - data length may be limited to 8 bytes for legacy SW
  - fast bit rate above 1 MBit/s
    - increase number of frames on CAN bus
    - fill gap between FlexRay and CAN
  - fast bit rate below 1MBit/s
    - long bus line may limit bit rate in arbitration to e.g. 50KBit/s, transmission of data field with e.g. 500KBit/s possible
    - no requalification or redesign of transceivers necessary
- CAN FD w/o Bit Rate Switching
  - increase of payload to header ratio
  - no requalification or redesign of transceivers necessary
  - fall back in case of bus errors during fast bit rate

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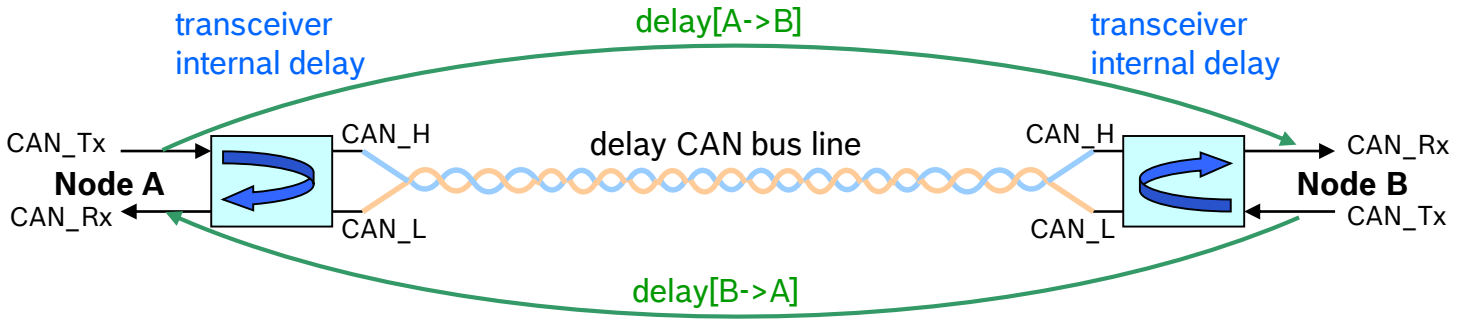
Physical Layer



- CAN Physical Layer
  - Transceiver internal delay CAN_Tx → CAN_Rx: up to 240ns
  - delay on CAN bus line: ~5ns/m
- CAN FD Arbitration Phase: arbitrate with remote nodes
  - Limitation: delay[A→B] + delay[B→A] <TSEG1*
- CAN FD Data Phase: monitor own transmissions
  - Limitation: transceiver internal delay <TSEG1*
  - independent of length of CAN bus line

*TSEG1 = Time Segment before Sample Point

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Introduction Scenario

- Step 1: Single ECUs equipped with CAN FD
  - use CAN FD for SW download , other nodes in silent mode
  - network still operated as standard CAN network
- Step 2: First CAN FD application
  - network completely operated as CAN FD network

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Next Steps

- Validate CAN FD functionality in FPGA environment
  - check function of bit rate switching
  - check impact on physical layer
- Complete Bosch CAN FD specification
- Contact OEMs, find first application
- Contact semiconductor companies
  - integrate CAN FD on µCs
  - develop CAN FD transceivers
- Contact CAN tool suppliers, integrate CAN FD support
- Upgrade Bosch CAN IP-modules to CAN FD
- Initiate ISO standardization
- Assure AUTOSAR support

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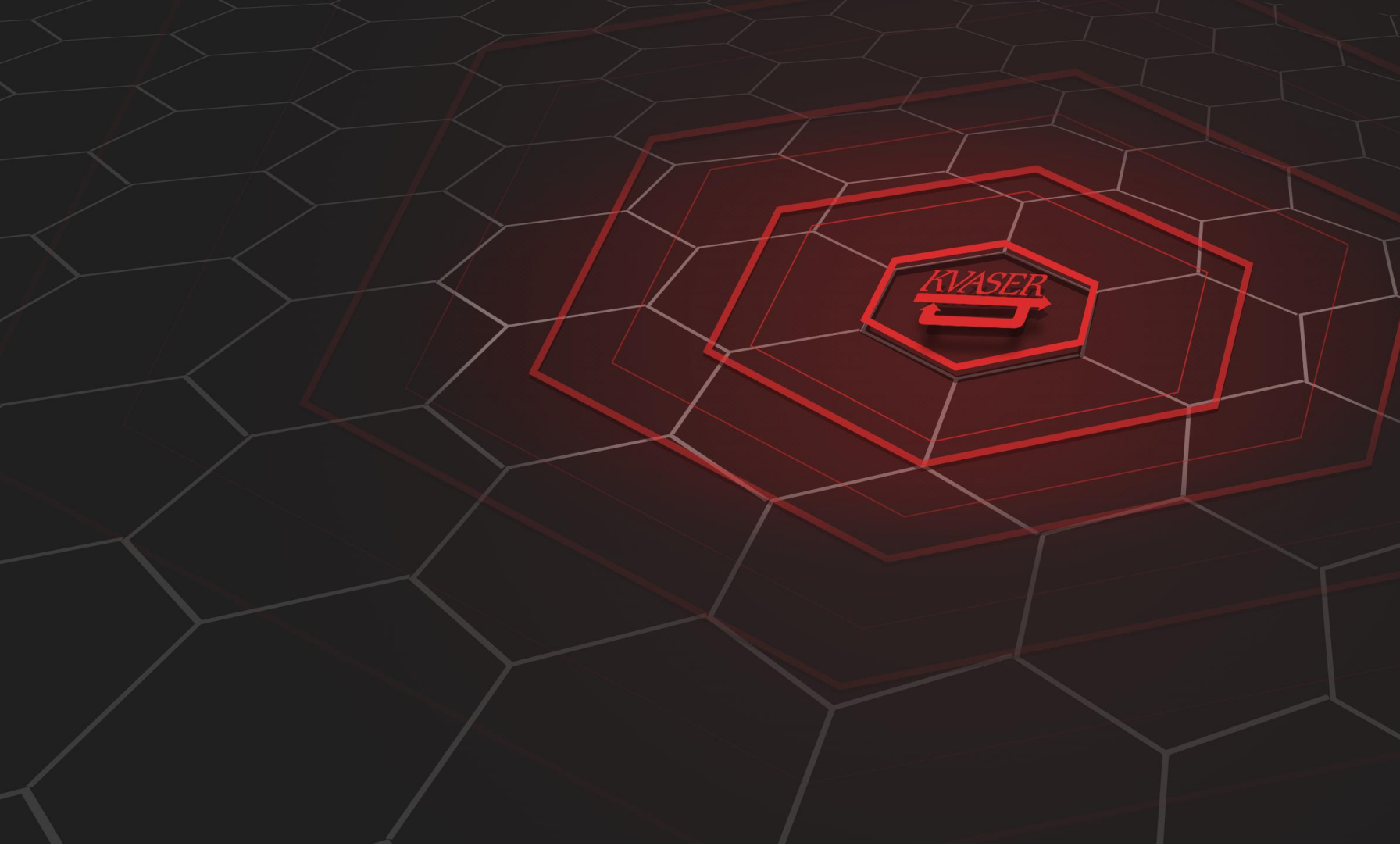

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