Status and future

Reiner Zitzmann

CAN in Automation

Reiner Zitzmann

- Degree in electrical engineering (University Erlangen/Nuremberg)
- General manager of CAN in Automation GmbH
- IEC TC69 WG 10: Project leader CANopen communication (Public charging of light electric vehicles)
- IEC TC9 WG 43: Expert (CANopen Consist Network in rail vehicles)
- CEN TC183 WG 3: Expert (CANopen garbage truck application)
- Expert in mirror groups in Germany or on European level

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CiA 主旨

CiA是开发和支持CANopen和其他基于CAN的更高层协议的国际用户和制造商组织。该非营利组织成立于1992年，旨在提供基于CAN的技术，产品和市场信息。该协会树立了CAN技术的形象，并提供通往未来网络技术的道路。

CiA 服务

系统设计人员

咨询

产品指南

CAN行业会议

技术

研讨会

CiA 规范

技术杂志

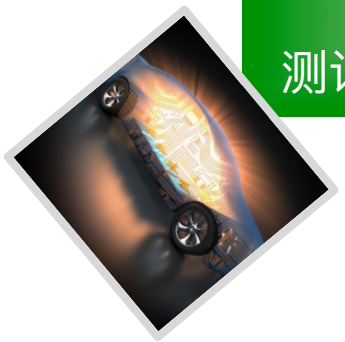
市场

国际CAN会议

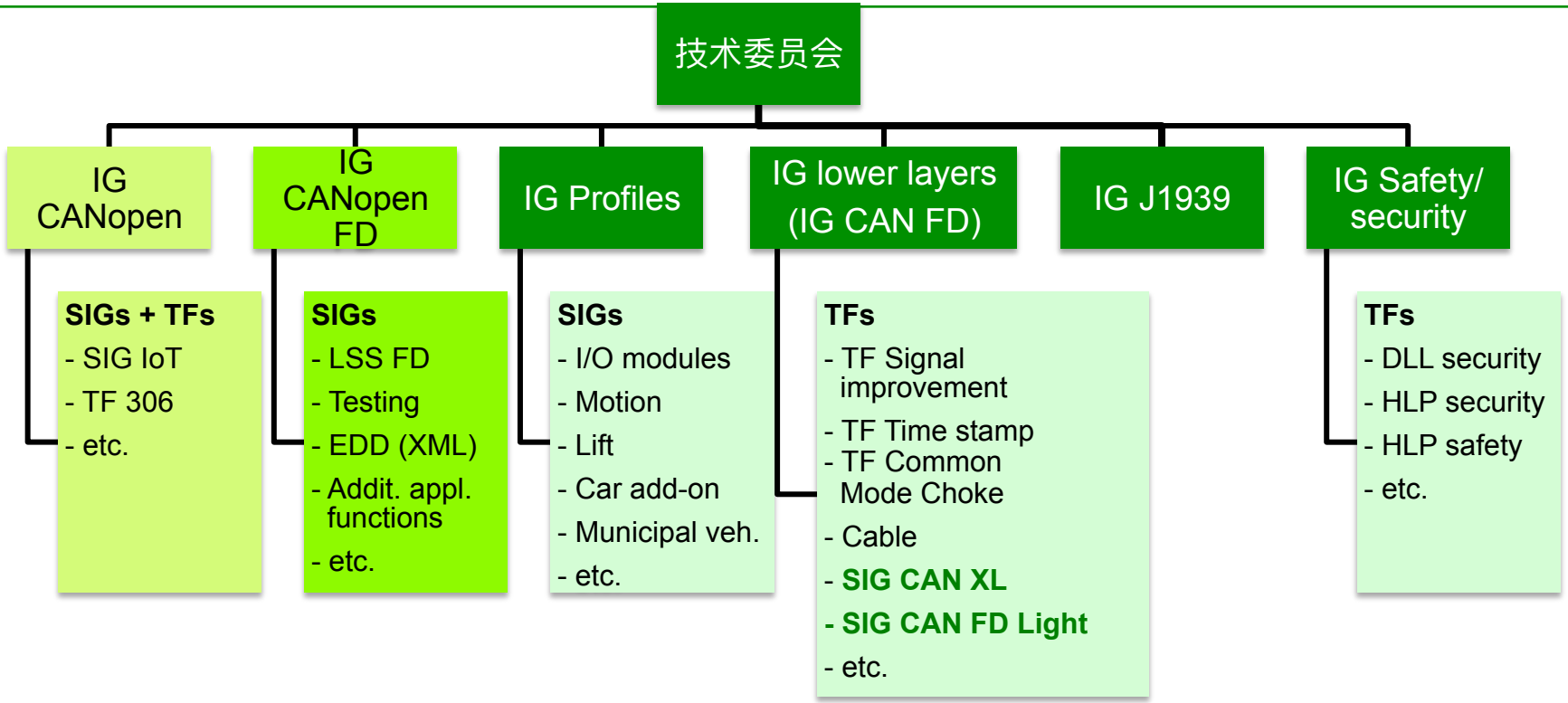
测试

宣传册

设备生产商



CiA 技术组



CiA通过CiA规范（specificaiton）和CiA应用记录（application notes）协助开发人员使用CAN。
这些文件由CiA会员在CiA技术工作组中制定。

First press release

BOSCH AND INTEL JOIN IN DEVELOPMENT OF AUTOMOBILE ELECTRONICS NETWORK

DETROIT, Mich., Feb. 25, 1986 -- Robert Bosch GmbH and Intel Corp. today announced that the companies are jointly developing a high-speed communication link for interconnecting electronic control units within automobiles.

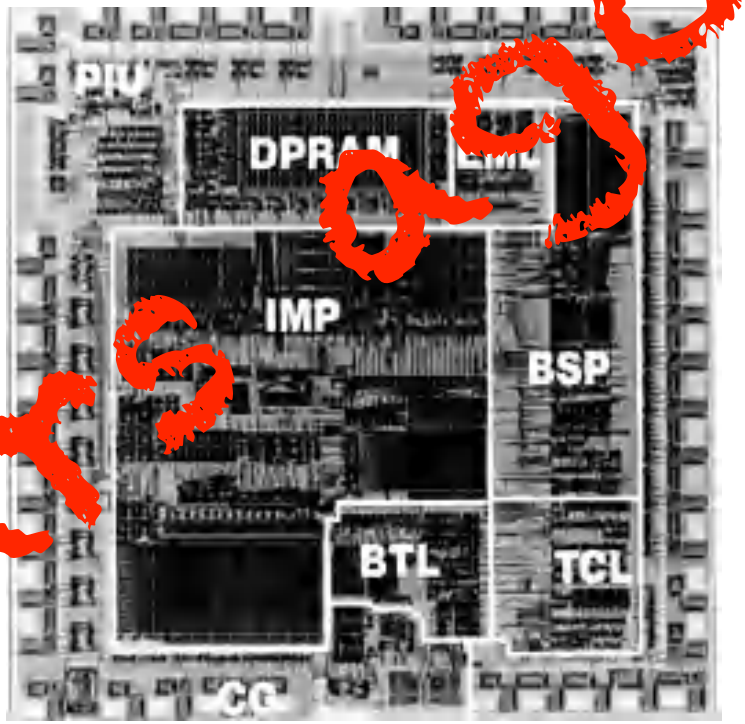
This serial communication system now in development is called the "Controller Area Network" (CAN).

Robert Bosch defined the CAN protocol architecture and is contributing its expertise in automotive system engineering, quality and reliability.

Intel is contributing to the CAN project its knowledge of automotive market requirements and expertise in design of high-reliability, cost-effective very-large-scale integrated (VLSI) products.

The outcome of this cooperation will be a standard line of Intel products: a serial controller which interfaces between various microcontroller architectures and the serial bus; and microcontrollers with the protocol integrated within a single chip.

The Intel products will be offered to the general marketplace as standard products.



Intel's 82526 CAN stand-alone controller chip supported data-rates up to 1 Mbit/s

Take away: CAN is a well-established technology

CAN: 强健的和可靠的

- 经典CAN高速传输（up to 1 Mbit/s ）的鲁棒性已经验证，通过在轿车上已安装的数百万个网络(2016年，安装的CAN节点远远超过15亿个)。
- 经典CAN的数据链路层协议的可靠性保证了在一帧中检测到所有的单一位错误，并且检测到多位错误的概率非常高(错误消息被自动重新传输)。

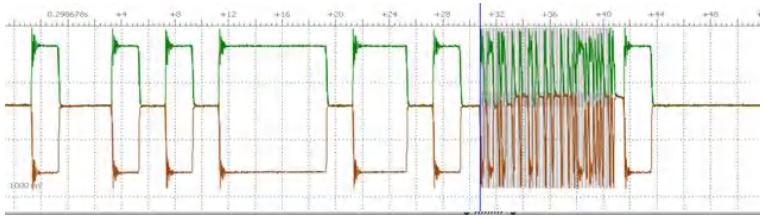
增长的通讯需求

E-class	年	网络	ECUs	消息
W124	1984 - 1995	1	7	<100
W210	1995 - 2002	3	30	200
W211	2002 - 2009	5	52	4100
W212	2009 – 2015	9	67	6000

Source: Mercedes/Daimler

汽车制造商的需求

- 更高的带宽用于软件下载和诊断
- 为新的和额外的功能提供更高的吞吐量
- 数据链路层可靠性(如剩余误码率)无下降
- 低功率消耗
- 不需要进行复杂的员工培训
- 硬件(如控制器和收发器)不涨价
- 不增加重量(如电缆)

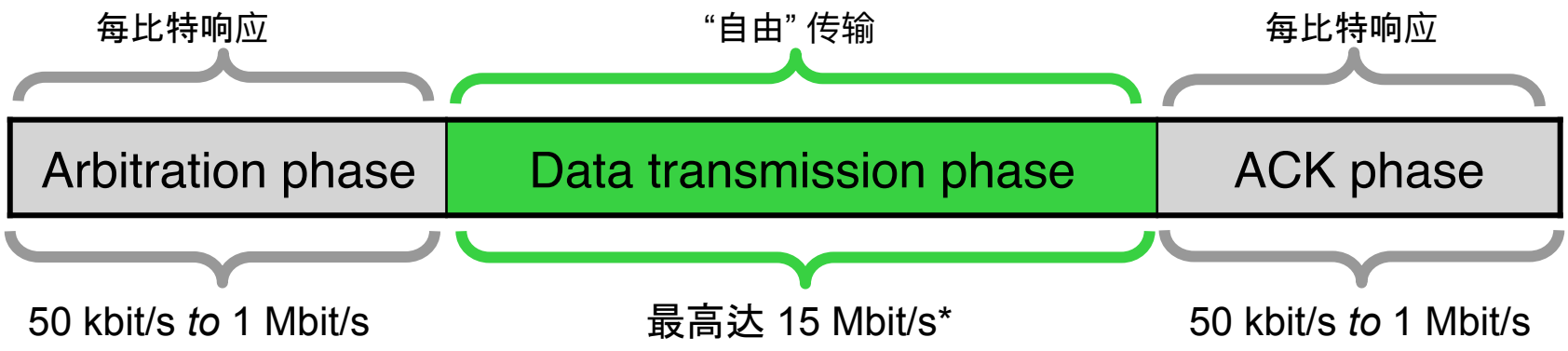


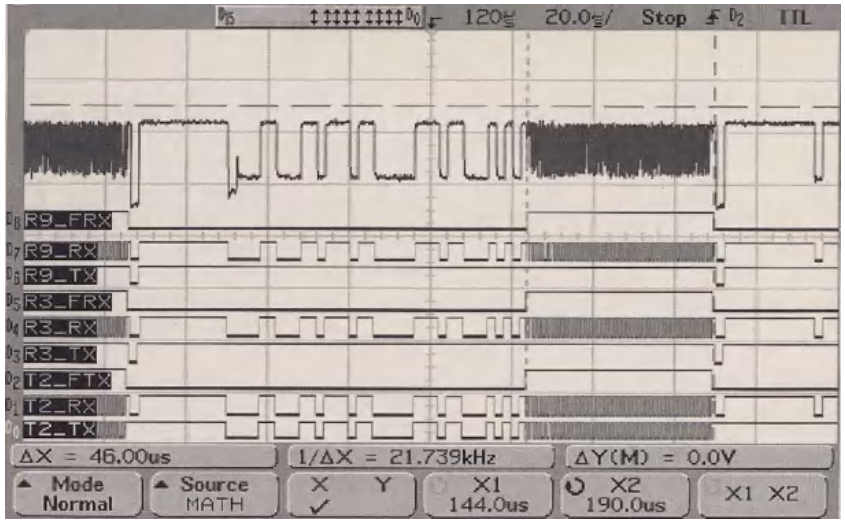
CAN历史

SAE conference **1986** → Bosch CAN 2.0 A/B **1991** → ISO 11898 CAN **1993** → re-organized ISO 11898-1/2 **2003** → ISO 11898-1 with CAN FD **2015**

- 1991: Bosch CAN 2.0 A/B specification
- 1993: ISO 11898 — CAN protocol and high-speed transceiver
- 2003: ISO 11898-1 — CAN data link layer
- 2003: ISO 11898-2 — High-speed physical layer
- 2004: ISO 16845 — CAN conformance test plan
- 2004: ISO 11898-4 — Time-triggered CAN (TTCAN)
- 2007: ISO 11898-5 — High-speed low-power physical layer
- 2013: ISO 11898-6 — High-speed selective wake-up physical layer
- 2014: ISO 16845-2 — ISO 11898-6 conformance test plan
- **2015: ISO 11898-1 — Classical CAN and CAN FD data link layer**
- 2016: ISO 11898-2 — Improved high-speed physical layer
- 2016: ISO 16845-1 — ISO 11898-1:2016 conformance test plan
- 2018: ISO 16845-2 — ISO 11898-2:2018 conformance test plan

CAN 灵活的数据传输速率



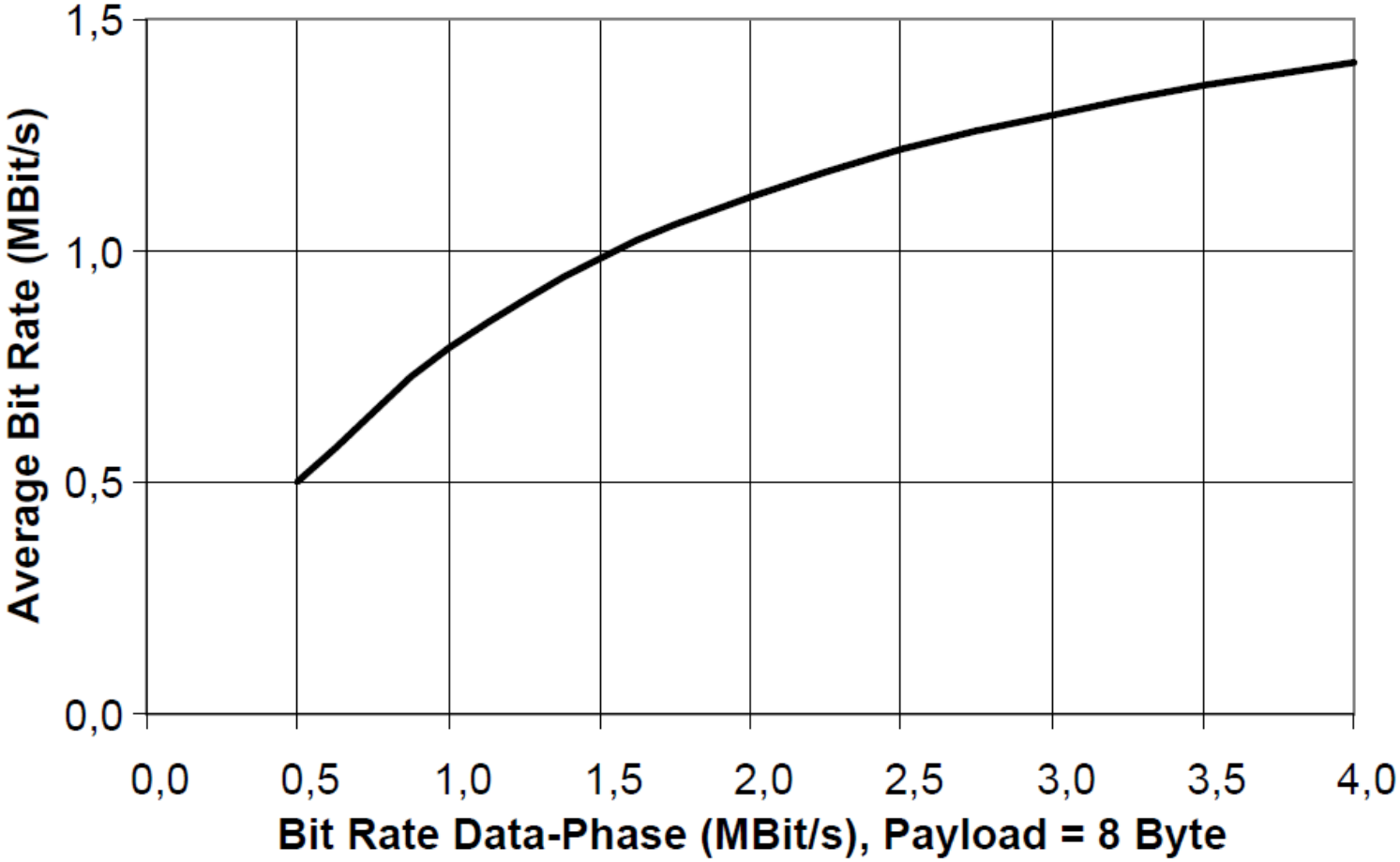


Source: Bosch

*实验室条件下(比如. 22 °C)

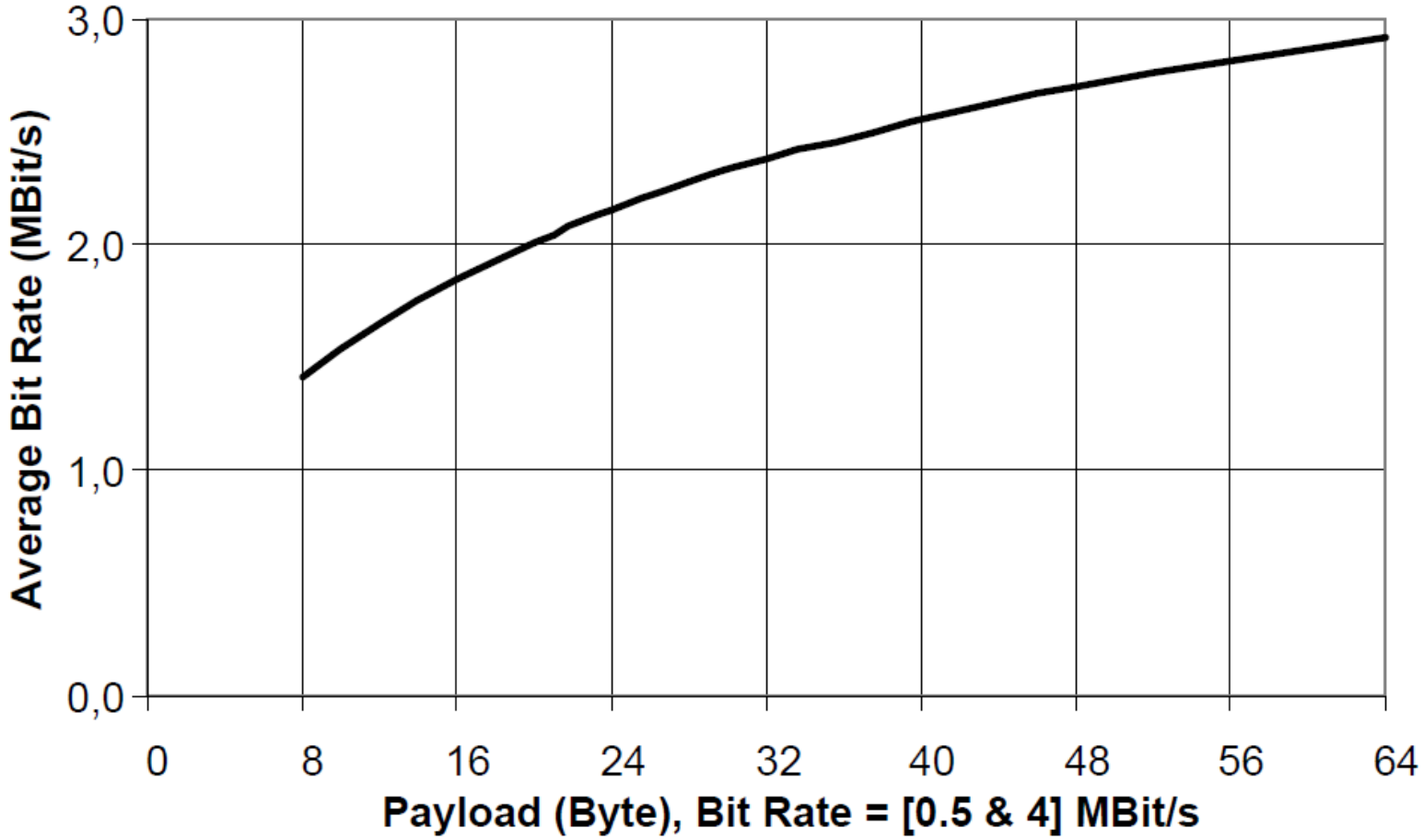
这个截图展示了一个CAN FD数据帧，仲裁速度为500kbit/s，数据传输速度为15 Mbit/s，使用NXP TJA 1040收发机。

CAN FD 从 0,5 到 4 Mbit/s



来源: Florian Hartwich, Robert Bosch GmbH, Paper from the 13. International CAN Conference 2012

CAN FD 从 8 到 64 Byte

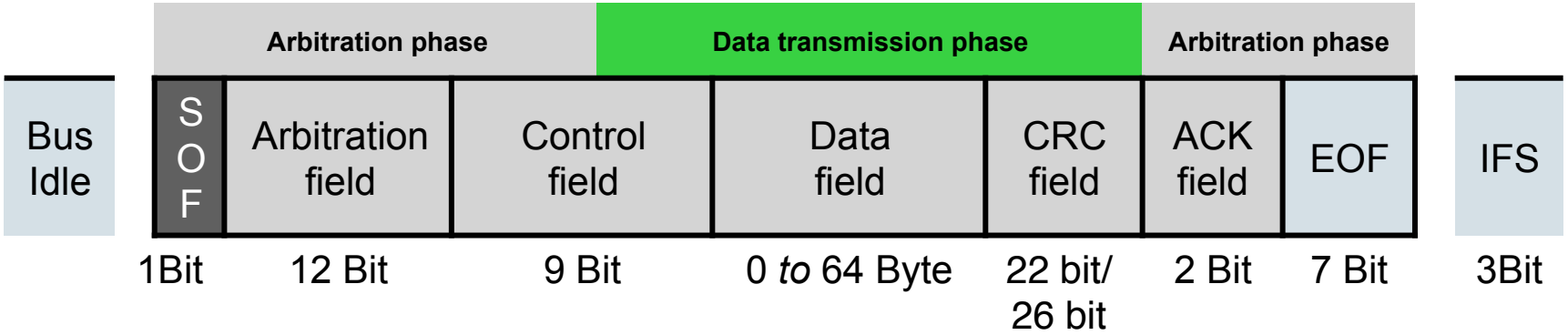


来源: Florian Hartwich, Robert Bosch GmbH, Paper from the 13. International CAN Conference 2012

CAN FD 数据帧格式

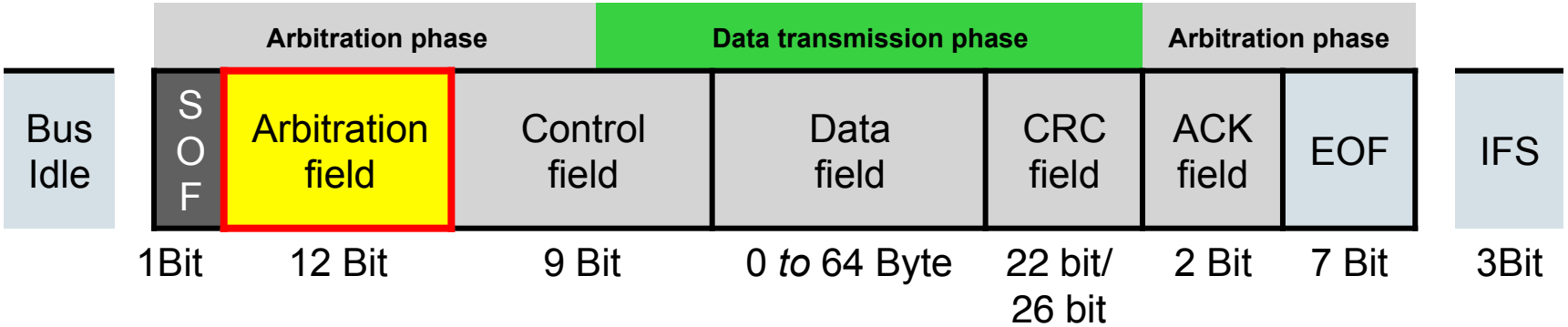
CAN base frame format

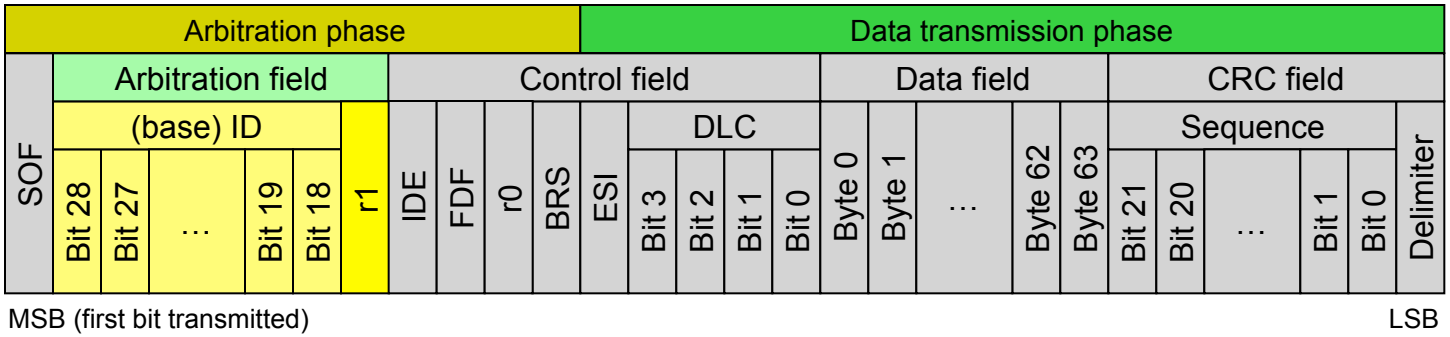
CAN–FD base frame format



ACK = Acknowledge
CRC = Cyclic redundancy check
EOF = End of frame
IFS = Interframe space
SOF = Start of frame

CAN FD仲裁场

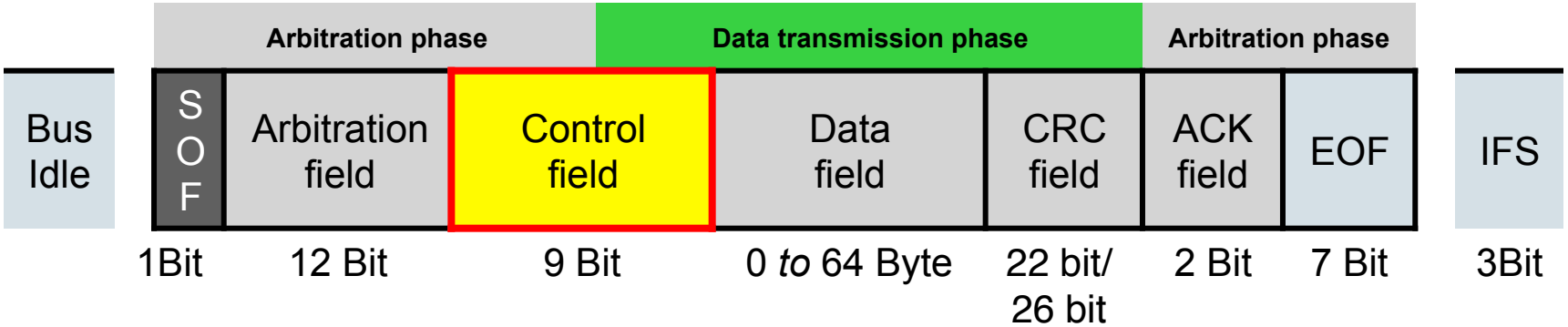


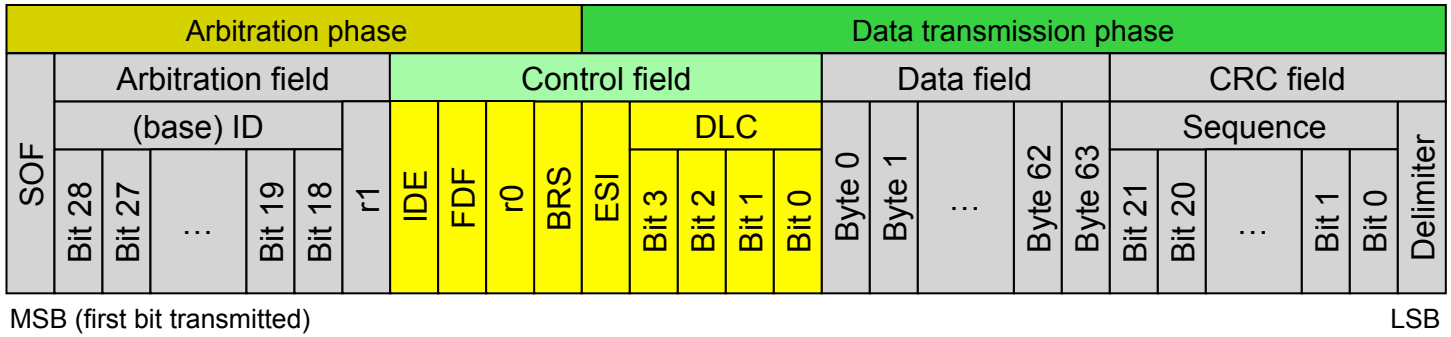


SOF = Start of frame (bit is always of dominant state)
ID = Identifier (frame priority *and* content indication)
RTR = Remote transmission request (dominant, if data frame)
IDE = ID extension (dominant for base frame format)
FDF = FD frame format, (recessive if FD format)
r0/r1 = reserved bit (dominant)
BRS = Bit rate switch (recessive, if switched to alternate bit-rate)

ESI = Error state indicator (recessive, if transmitting node is in error passive state)
DLC = Data length code (indicates the length of the following data field)
CRC = Cyclic redundancy check (15-bit, 17-bit, or 21-bit)
D = Delimiter of CRC/ACK field (bit is always of recessive state)
ACK = Acknowledgment slot (correctly receiving node sends a dominant bit)
EOF = End of frame (all bits are always of recessive state)
IFS = Inter-frame space (the first two bits are always of recessive state)

控制场





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IFS = Inter-frame space (the first two bits are always of recessive state)

控制场 (FD)

	Arbitration phase			Data transmission phase		Arbitration phase		
Bus Idle	SOF	Arbitration field	Control field	Data field	CRC field	ACK field	EOF	IFS
	1Bit	12 Bit	9 Bit	0 *to* 64 Byte	22 bit/ 26 bit	2 Bit	7 Bit	3Bit

Reference	DLC 3	DLC 2	DLC 1	DLC 0	No of bytes
ISO 11898-1	0	0	0	0	0
	0	0	0	1	1
	0	0	1	0	2
	0	0	1	1	3
	0	1	0	0	4
	0	1	0	1	5
	0	1	1	0	6
	0	1	1	1	7
	1	0	0	0	8
CAN-FD	1	0	0	1	12
	1	0	1	0	16
	1	0	1	1	20
	1	1	0	0	24
	1	1	0	1	32
	1	1	1	0	48
	1	1	1	1	64

CAN FD 数据场

Byte 1	Byte 2	Byte 3	...	...	Byte 62	Byte 63	Byte 64

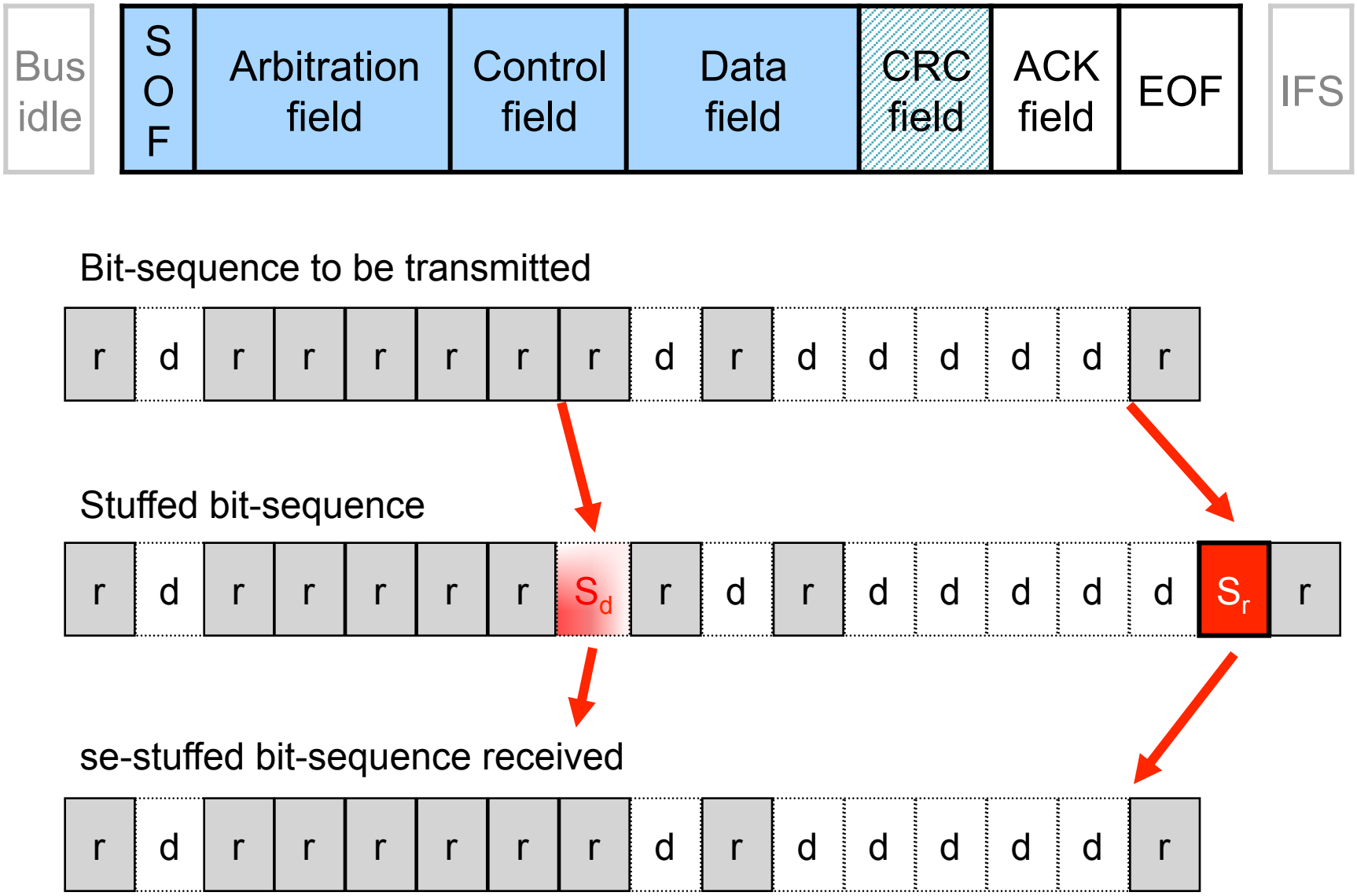
min. length of data field = 0 byte

Byte 1	Byte 2	Byte 3	...	...	Byte 62	Byte 63	Byte 64

MSB LSB

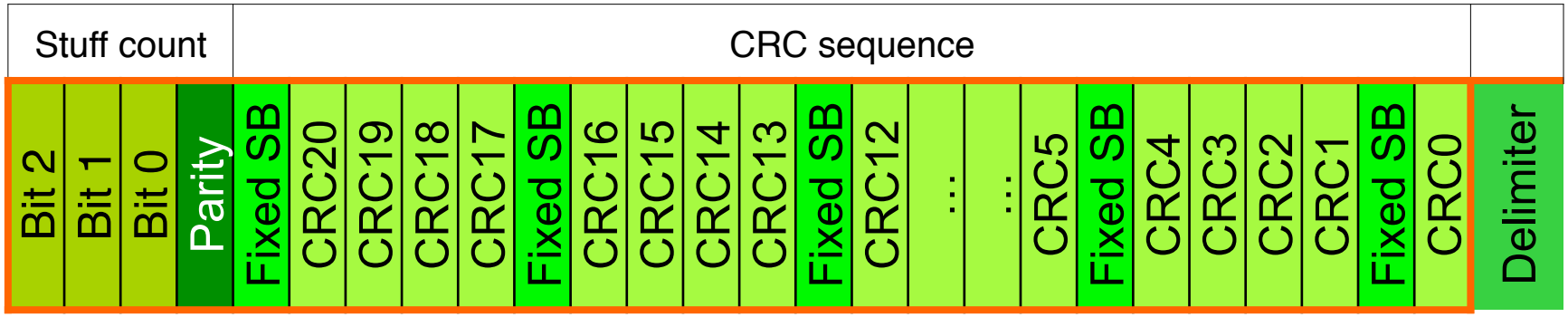
max. length of data field = 64 byte

位填充 (FD)


Bus idle
SOF
Arbitration field
Control field
Data field
CRC field
ACK field
EOF
IFS
Bit-sequence to be transmitted
r d r r r r r r d r d d d d d r
Stuffed bit-sequence
r d r r r r r S_d r d r d d d d d S_r r
se-stuffed bit-sequence received
r d r r r r r r d r d d d d d r

CAN FD 填充计数

CRC field for DLCs > 10 (16 to 64 data bytes)



MSB

LSB

21-bit polynomial:
$x^{21} + x^{20} + x^{13} + x^{11} + x^{7} + x^{4} + x^{3} + 1$

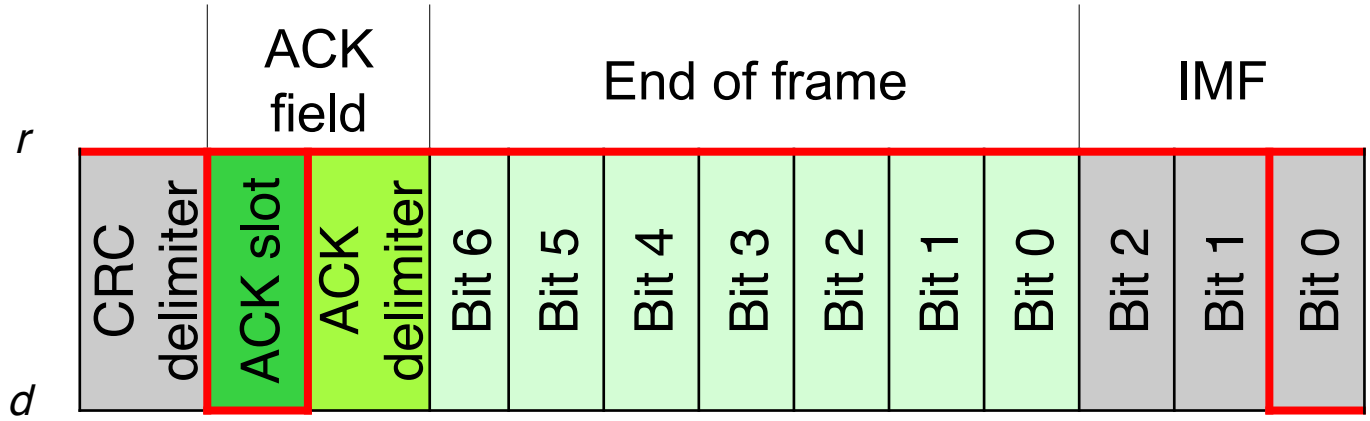
The 3-bit stuff bit counter contains the number of stuff bits in MOD8 followed by a parity bit.

There shall be a fixed stuff bit before the first bit of the stuff count.

Stuff count	Grey code	Parity	Fixed SB
0	0 0 0	0	1
1	0 0 1	1	0
2	0 1 1	0	1
3	0 1 0	1	0
4	1 1 0	0	1
5	1 1 1	1	0
6	1 0 1	0	1
7	1 0 0	1	0

Take away: ISO CAN FD supports Stuff count!

ACK字段, EOF, and IMF



注意 acknowledge字段(ACK) 、帧的结束(EOF)和中场字段(IMF)与经典CAN中的相同。不同的是，在ACK字段的一个显性电平应该被计算为两个标称比特时间。

Take away: These fields are transmitted with nominal bit rate, as arbitration phase.

其他CAN FD协议

- Error frame 错误帧 (使用仲裁比特率)
- Overload frame 超载帧 (使用仲裁比特率)
- *[Classical Remote frame] 经典远程帧*

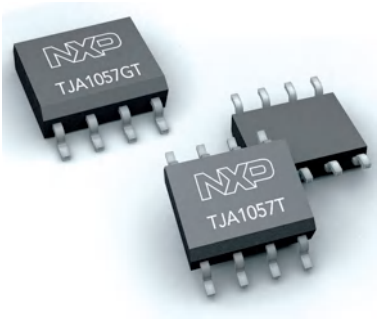
注1: 这些帧使用与经典CAN相同的格式和仲裁比特率。

注2: CiA不推荐使用经典远程帧来请求CAN FD数据帧!

实现选项

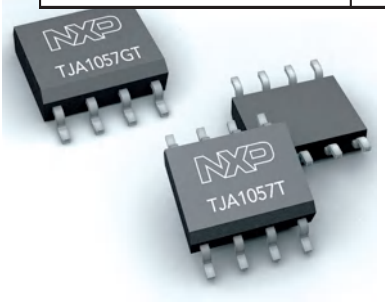
ISO 11898-1:2015 规定的实现选项:

- 只支持经典的CAN帧格式，不支持CAN FD帧格式;
- 支持经典CAN帧格式，容忍CAN FD帧格式;
- 支持经典CAN帧格式和CAN FD帧格式(推荐用于新设计)。



CAN FD 可兼容性

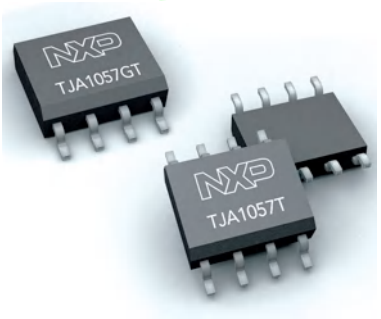
Function	Type of implementation			
	Classical CAN or other when disabling of Flexible Data Rate frame format supported and configured	CAN FD tolerant	CAN FD enabled	CAN FD enabled when disabling of Classical frame format supported and configured (see 10.9.10)
Reception and transmission of Classical Frames	Supported	Supported	Supported	No reception, no transmission. Error Frames will be sent when Classical frames present, unless node in Error Passive state or generally unable to transmit
Reception and transmission of FD Frames	No reception, no transmission. Error Frames will be sent when FD frames present, unless node in Error Passive state or generally unable to transmit	No reception, no transmission, no Error Frames will be sent when FD frames present	Supported	Supported



CAN FD 设备设计

- *CAN FD IP 核:*
  Bosch, esd, Fraunhofer/Cast, Inicore, Kvaser
- *MCUs:* Infineon, Microchip, NXP, Renesas, ST Microelectronics, Texas Instruments (TI)
- *收发器: Analog devices, Infineon, Microchip, NXP, On Semi,* TI, etc.
- *HLP 协议栈:*
  CANopenFD: Emotas, Emsa, esd, MicroControl
  Autosar: Vector
- 很多CiA会员已经提供CAN FD板级产品和工具。

请访问 CAN newsletter 取得最新产品信息
www.can-newsletter.org



高速传输

ISO 11898-2:2003
Physical media attachment (PMA)
- 最高达1 Mbit/s

ISO 11898-5:2007
Low-power mode
- 远程唤醒

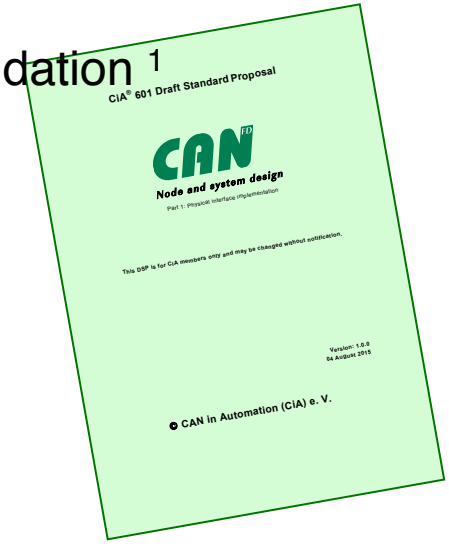
ISO 11898-6:2013
Partial networking
- 可选择唤醒

ISO 11898-2:2016
Physical media attachment (PMA) with optional low-power mode and partial networking
- 最高达 5 Mbit/s
- 远程唤醒
- 可选择唤醒

CiA 601 系列

CAN FD 节点和系统设计

- CiA 601-1 (version 2.0.0): Physical interface implementation [1]
- CiA 601-2 (version 1.0.0): Controller interface recommendation [1]
- CiA 601-3: (version 1.0.0): System design recommendation [1]
- CiA 601-4 (version 2.0.0): Signal improvement [1]
- *CiA 601-5: Reference topology examples* [2]
- CiA 601-6: (version 1.0.0) CAN FD cable recommendation [1]
- *CiA 110: Common-mode choke specification* [2]


CiA® 601 Draft Standard Proposal

CAN FD

Node and system design

Part 1: Physical interface implementation

This DSP is for CiA members only and may be changed without notification.

Version: 1.0.0
04 August 2015

© CAN in Automation (CiA) e. V.

[1] 作为CiA Draft Standard (DS)发表

[2] 开发中

CAN FD 网络类型

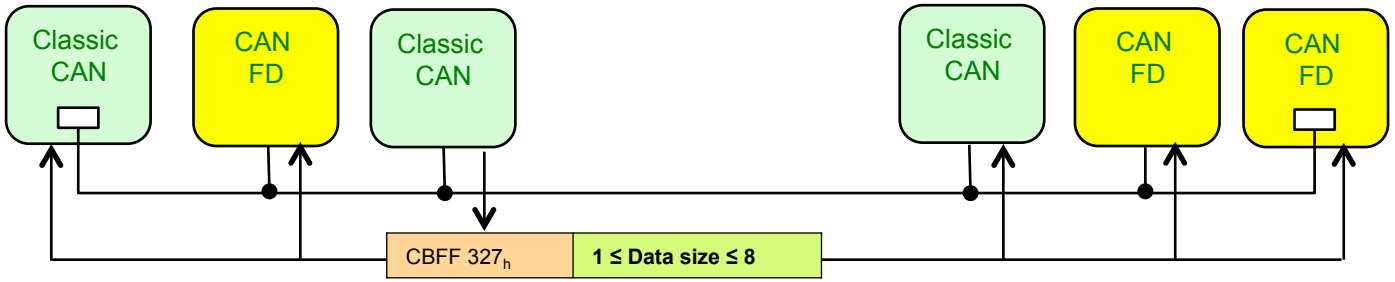
- **类型 A: 同样的仲裁阶段比特率和数据阶段比特率**
  (物理层网络设计不会产生任何影响)

- **类型 B: 不同的仲裁阶段比特率和数据阶段比特率**, 但是低于 1 Mbit/s
  (物理层网络设计需要被优化)

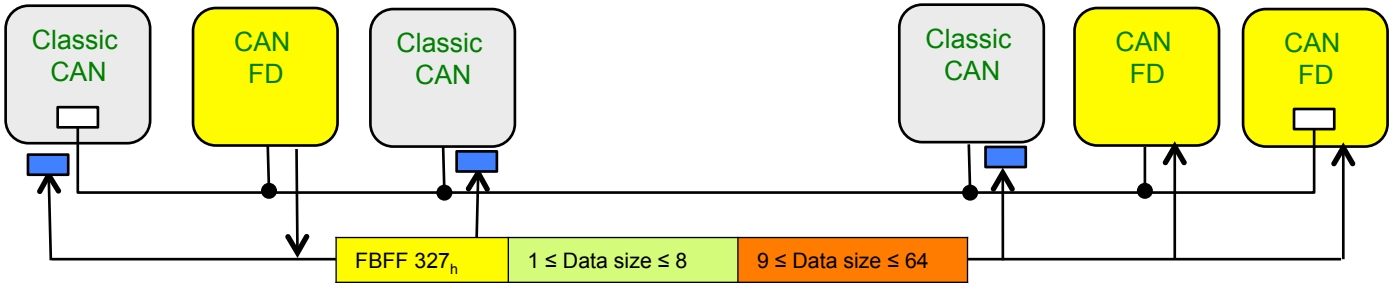
- **类型 C: 数据阶段比特率高于** 1 Mbit/s
  (物理层网络设计需要被优化，需要使用经过验证的收发器)

保护的CAN FD

经典 CAN 通信 ✓

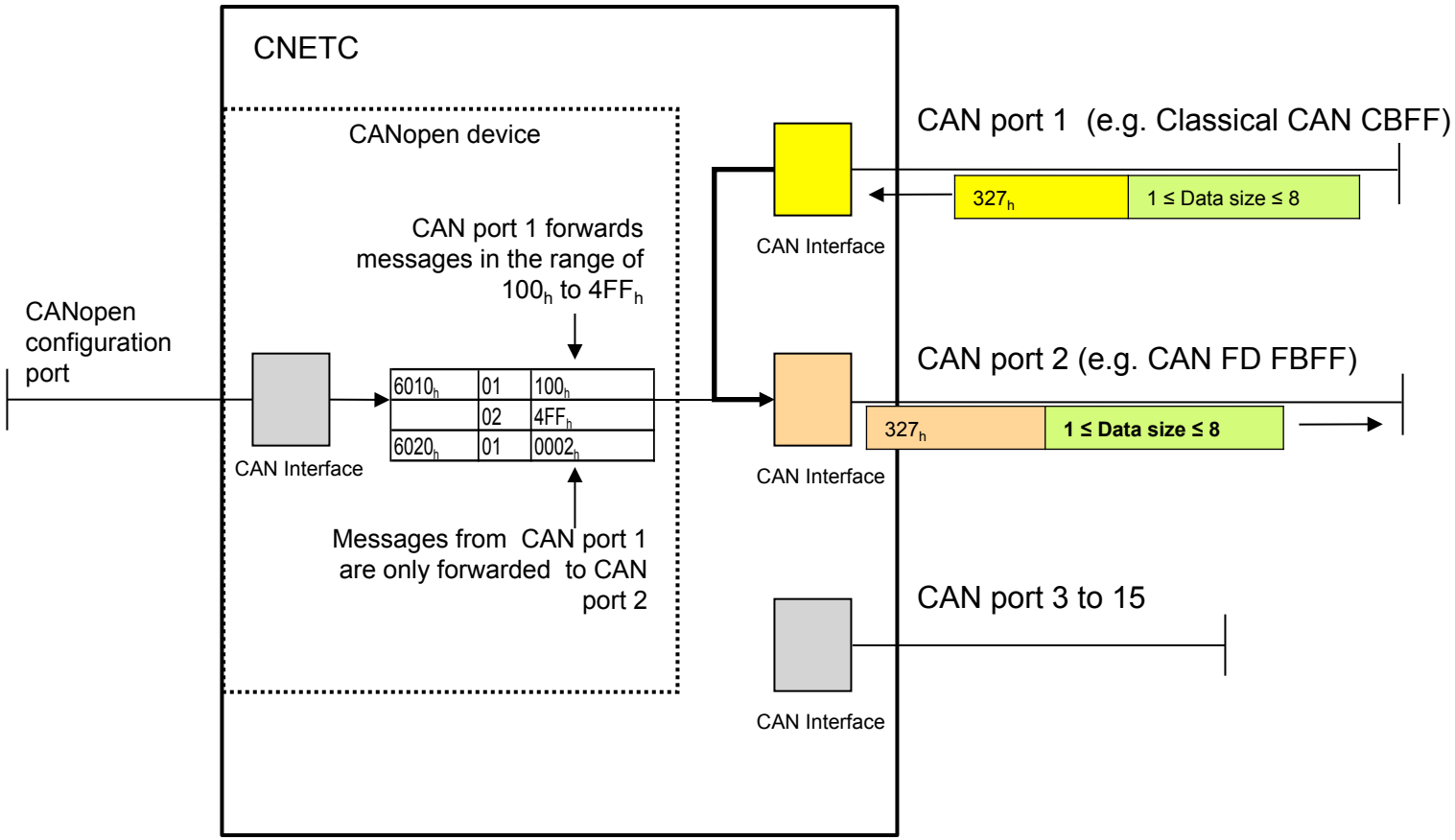


CAN FD 通信 ✓



CAN FD 保护:
避免在传统的CAN控制器上接收CAN FD数据帧的措施
优势: 没有因接收 “未知 ”帧而导致的通信错误
劣势: 没有数据一致性;只有FD控制器接收数据

可配置的网络元件



CiA 456

CBFF Classical CAN base frame format
FBFF CAN FD base frame format

CAN FD 在大众轿车的应用

Golf Neo (2019):
五个 CAN FD 网络

Golf 8 (2019):
三个 CAN FD 网络

CAN FD 在轿车的应用

- 大多数美国和欧洲的汽车制造商将在2022年推出CAN FD，早大众在2019年就已经推出。
- 此外，中国、日本和韩国的汽车制造商也将在未来几年内从CAN迁移到CAN FD。
- 在未来的五到十年内，大部分轿车中的经典CAN网络将被CAN FD网络所取代。

CAN 数据链路层

- 11位或29位消息标识符
- CAN FD帧格式可达64个数据字节
- CAN FD数据帧格式的加速传输的数据段
- 本地错误的全网络化
- 接收和传输消息的错误计数器
- 未检测到错误消息的概率低
- 协议不限制的节点数

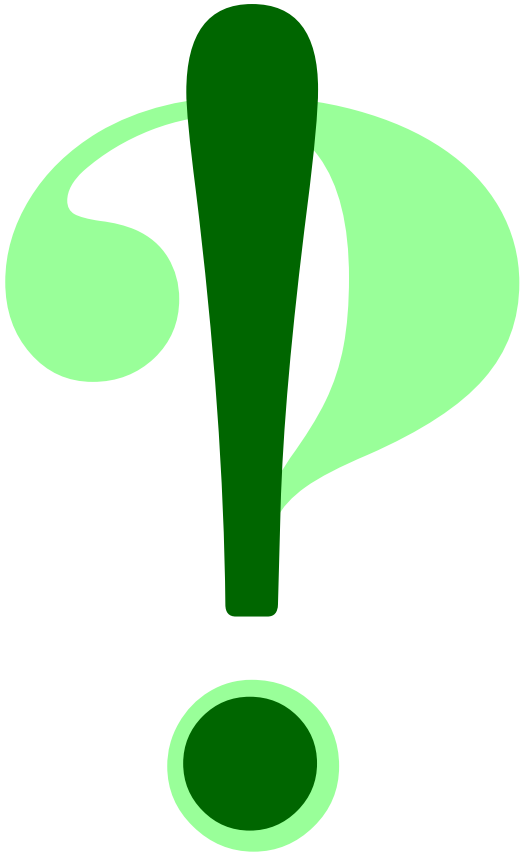
CAN FD 支持的高层协议

- CiA 602-2 (submitted for integration into J1939-22)
- CiA 1301 version 1.0 (CANopen FD application layer and communication profile)
- ISO 15765-2:2016 (ISO transport layer)
- *SAE-IT Arinc 825 CAN FD (application layer)*
- *SAE J1939-22 (application and transport layer for CAN FD)*
- XCP version 1.2 (ASAM universal measurement and calibration protocol)

CAN FD: 不只是更快

- 下一代CAN, CAN FD数据链路层协议，不仅提供更多的吞吐量，而且更大的有效负载
- 这为基于CAN的应用程序提供了更有效的功能安全解决方案。
- CAN FD的较高数据吞吐量协助标准化网关解决方案，使CAN设备和网络成为物联网上的一部分。
- 这些发展支持在遗留应用程序领域的新需求，并通过新的应用程序使CAN在嵌入式和深嵌入式网络中成为主流通信系统。

Questions and answers



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