Inventor presented the improved CAN data link layer

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Introduction
This article provides detailed information of the presentation about CAN FD, which was given on 29th November by Thomas Lindenkreuz from Robert Bosch. It reports about the CAN FD benefits and the use cases for the improved CAN protocol. The article also informs about the already available components.

Thomas Lindenkreuz, the Director for the development of digital ASICs and IP modules at Robert Bosch, Automotive Electronics, Development Division Semiconductors gave a presentation about CAN with flexible data rate. He has been working for Bosch since 1990 in various functions and is one of the CAN FD inventors. According to Mr. Lindenkreuz, CAN FD has already achieved a degree of maturity, which shows that the improved CAN technology has a successful future. Interest in the improved CAN technology and company's CAN FD demonstrator at the tabletop exhibition accompanying the congress, resulted in a full hall of listeners.

After a historical overview of CAN development, the performance comparison of diverse automotive network technologies was presented. Figure 1 indicates the network's possible bandwidth relationship to the implementation costs per node. The evaluation shows that CAN FD would de facto not cause additional costs regarding the hardware at the same time offering the traditional CAN technology benefits. The bit-rate achievable by CAN FD rises into the area, which is currently covered by Flexray. According to company's discussions with the Asian carmakers, Flexray with bit-rates of 2,5 Mbit/s and 5 Mbit/s is rather used for emulation of CAN on the Flexray networks as for the time-controlled communication. Introduction of CAN FD would make these practices obsolete. In his presentation on the congress, Mr. Röder from Continental has even predicted that Flexray will disappear from the future car electronic architectures, so that only CAN, LIN and Ethernet will be used.

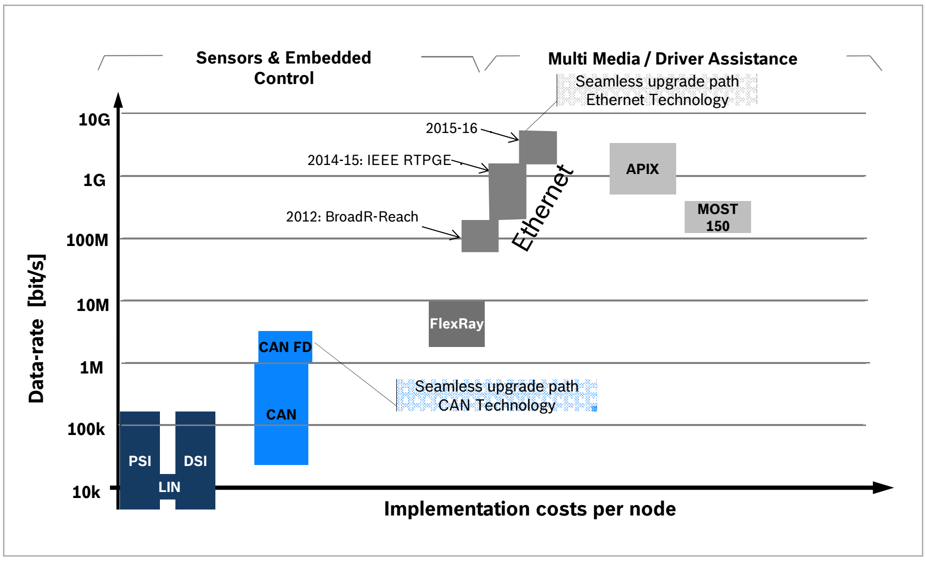

Figure 1: Possible bandwidth relationship to the implementation costs per node for automotive networks

CAN FD basics

The CAN FD idea is to transmit the bits within the data phase of a CAN frame with a higher bit-rate as in the arbitration and the acknowledge parts. If the length of a CAN FD frame's data field stays at 8 bytes, no changes in the software have to be made. Of course, the whole network should be configured as a CAN FD network, but from the software side it looks, as it would be the classic CAN communication. The difference is the faster data transmission. This led the developers of CAN FD to the idea to increase the amount of bits transmitted while the data phase. The 64-byte length was chosen, because it seemed to be a value comfortably realizable in the practice. The data field could be clocked eight times faster. This would result in a CAN FD message with 64 data bytes, which lasts approximately as long as the classic CAN message (with 8 data bytes) transmission. Thus, the whole network design would be de facto not disturbed.

A CAN FD frame (Figure 2) makes use from the EDL (extended data length) bit in the control field, which was reserved for future use by the "prime fathers" of CAN. The recessive EDL-bit state indicates a CAN FD frame while the dominant EDL state (as it was hitherto) indicates the traditional CAN frame. In the first case, the control field additionally indicates whether the ▷

6th Vector Congress
End of November 2012, Vector Informatik organized the 6th two-day Vector Congress in Stuttgart (Germany). Up to 300 people came to the event and met engineers mostly coming from the automotive electronics branch. Several CAN-relevant topics were presented in the area of diagnostics (Vector, Müller), heavy-duty vehicles (Volvo, Niemczyk; Caterpillar, Weck; Vector, Fellmeth), ECU testing (Bosch, Kempe), Autosar safety (Peiker, Müller) and the new bus systems (Continental, Röder; Bosch, Lindenkreuz). The released presentations are available from company's website at https://www.vector.com/vi_congress12_en.html.

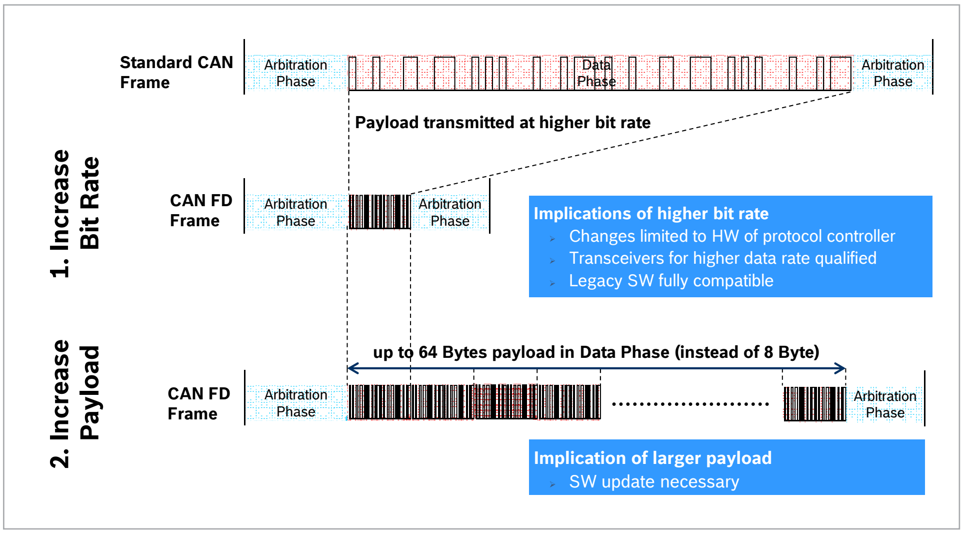

Figure 2: CAN FD frame

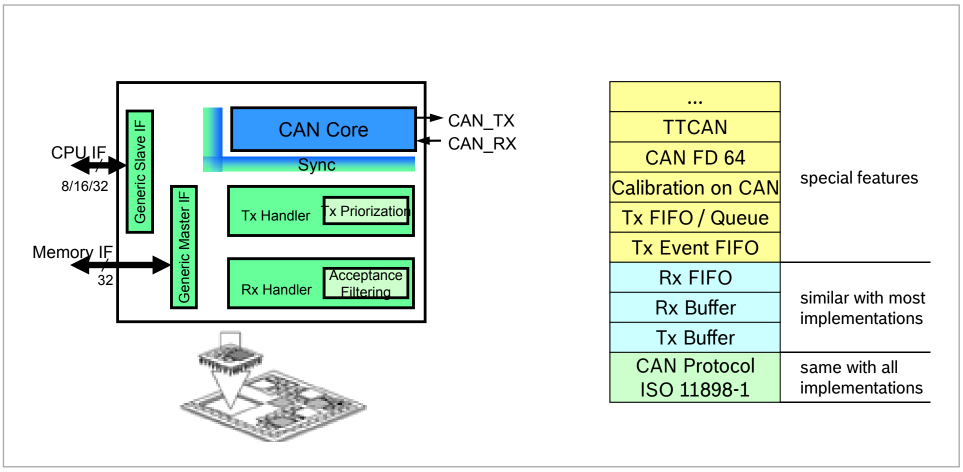

Figure 3: Architecture of the M_CAN communication controller

bit-rate in the data field will be switched and in which error state (passive or active) the transmitting node is currently. Additionally, the coding of the DLC (data length code) and the CRC (cyclic redundancy check) is changed with regard to a longer data field.

Mr. Lindenkreuz also shown, how the average message bit-rate varies depending on the length of the data field (payload). Using the arbitration bit-rate of 1 Mbit/s and the data-field bit-rate of e.g. 6 Mbit/s results in average bit-rates of ca. 2,5 Mbit/s (8-byte payload) up to ca. 5 Mbit/s (64-byte payload).

Possible use cases

Common use cases include a fast software download. An example calculation comparing classic CAN (500 kbit/s, 8 data bytes) transmission of 32 payload-bytes with CAN FD (2 Mbit/s, 32 data bytes) shows that with CAN FD a four-times faster transmission of the intended payload is possible. Bosch's internal usage interest is the fast flashing of the ECUs (band end programming). Alone for this purpose, it was reasonable for the company to invent the enhanced CAN technology.

CAN FD transmission also allows to avoid splitting of long messages. For example, data sent from a three-axis acceleration sensor could contain three 8-byte values respectively related to X, Y and Z axes. Using a CAN FD frame, transmission of the three values within one message is possible. This simplifies the handling of data, as it is received for all three axes without a time offset. This also eases the management on the transport layer. Additionally, longer CAN FD messages allow a secure 8-byte data transmission fulfilled by adding of a MAC (message authentication code) to the data field.

As a data exchange growth in electric vehicles is expected for the next years, CAN FD would fit for the next generation of power train requirements of such vehicles. In case of extreme functional enhancements, use of Ethernet might be necessary.

A further use case allows for faster communication on long bus lines typically found in trucks and omnibuses. These vehicles commonly use the bit-rate of 250 kbit/s and communicate according to the J1939 protocol. As the bit-rate in the data field is in- ▷

creased independent of cable length, average bit-rates of up to 810 kbit/s are estimated to be possible.

Availability of components

Figure 3 shows the architecture of the M_CAN communication controller from Bosch. This is available with full CAN FD support (higher bit-rate and 64-byte payload). M stands for modular and means that diverse CAN features may be flexibly combined and passed to company's semiconductor-manufacturers to be integrated on silicon. Interested parties may contact Bosch in order to get a license for the CAN FD-capable M_CAN modules.

Through cooperation by Bosch, Daimler Truck and NXP, a CAN FD gateway board was created, which could be seen on Bosch's demonstrator at the accompanying exhibition. The board includes a classic CAN controller and an FPGA with two implemented and instantiated CAN FD IP cores. The cores are able to run with up to 10 Mbit/s. Up to three selectable physical layers for CAN FD can be implemented on the board. Regarding the form factor, it was designed to fit into the useful automotive housings. The board also features truck and passenger car compatible connectors. Autosar-based test software for the board is on development. The companies agreed to provide the board (hardware and software) to the third parties beginning with April 2013.

Tools for CAN FD are available from Vector (CANalyzer, CANoe) and from the Bosch's daughter company Etas (e.g. Busmaster). The CAN FD-capable CANoe version was presented by Vector on the accompanying exhibition.

Regarding the hardware, Bosch met a commitment with NXP (at the CAN FD Tech Day in Detroit) to introduce a CAN FD transceiver roadmap supporting different bit-rates. Also STM and Freescale presented their roadmaps on the CAN FD Tech Day. Thus, it is planned to have micro-controller samples supporting CAN FD with up to 64 payload bytes in the Q1/2013. Bosch is in communication with other semiconductor manufacturers regarding this topic. Mr. Lindenkreuz also mentioned that Bosch's CAN FD micro-controllers will be integrated into company's ECUs starting from 2015 and 2016.

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