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FlexRay communication for the high speed distributed control system

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Abstract: The FlexRay communication has been developed by FlexRay consortium which is consisted of more than 120 automotive industry companies to fulfill the requirement for the high speed communication for high performance distributed control system in the vehicle. In this paper we explain the FlexRay communication and compare the FlexRay with CAN protocol. Then we will discuss the requirement for the high speed distributed control system and consider the FlexRay protocol for this system.

1. INTRODUCTION

The joint development of the "FlexRay" standard by BMW, DaimlerChrysler, Motorola (now freescale) and Philips(now NXP) has been started in 2000 to fulfill the requirements for future in-vehicle control applications including the combination of higher data rates, deterministic behavior and the support of fault tolerance. FlexRay is a new time-triggered communication system for high-performance in-vehicle applications. Original FlexRay consortium had expired in December 31, 2005. But the consortium core members decided to continue the FlexRay Consortium until December 31, 2008. In this period, FlexRay will focus on low speed and low cost for serial product and unsolved fault tolerant features. Our company joined the FlexRay consortium in 2004.

2. KEY PRINCIPLES OF FLEXRAY

2.1 Basic feature

FlexRay protocol provides hard real-time message delivery with minimal jitter. It guaranteed that no single failure of any part of the communication system could lead to a disrupture of the communication. The protocol has been designed for highest data efficiency and minimal protocol overhead. It provides a data transfer rate of 10Mbit/s and can transfer the data per one frame up to 254bytes. Furthermore, FlexRay supports composability by its precisely defined behaviour in the value and time domain in static segment. FlexRay provides several topologies for the bus and the star topology based on dual channels for fault-tolerance.

2.2 Global time and Synchronization

All the ECUs in the FlexRay communication have to transmit and receive the frame based on global time. For this, the synchronization is necessary for every node in the system to keep a global time according to a given precision. (See Fig.1)

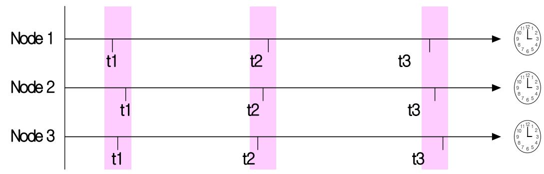


Fig. 1. Global time

There are two ways to achieve the clock synchronization, which is the single master synchronization and distributed master synchronization. FlexRay provides the distributed master synchronization to satisfy the requirement for high reliability. The clock synchronization is executed autonomously by the FlexRay communication control within each node without any interaction of the host processor.

2.3 FlexRay Frame Structure

The frame of FlexRay consists of header, payload and trailer. (see. Fig.2).

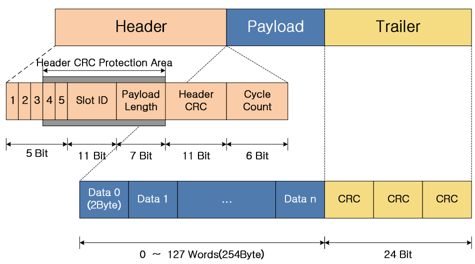
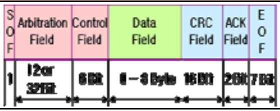
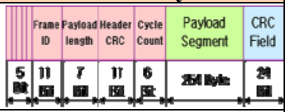


Fig. 2. FlexRay Frame Format

The header part includes the information for transmitting the FlexRay data so that communication can be accomplished properly. The payload part conveys the data up to 254byte and the trailer part is the 24 bits CRC. The comparison for frame with FlexRay and CAN described in table1

Table 1. The frame comparison with CAN and FlexRay

	CAN	FlexRay
Frame		
Header	19 bit or 39 bit (CAN 2.0B)	40 bit(5 Byte)
DATA	0 ~ 8 Byte	0 ~ 254 Byte
Trailer	25 bit	24bit (3Byte)
CRC	16Bit	24 Bit and Header CRC: 11 bit
Max. ID	$2^{11} = 2047$ or 2^{29} (CAN 2.0B)	$2^{11} = 1 \sim 2047$

2.4 Communication cycle

The communication within the nodes which are connected by FlexRay will be accomplished by repeating the communication cycle. The communication cycle consists of a static segment, a dynamics segment, a symbol window and a network idle time as depicted in figure 3.

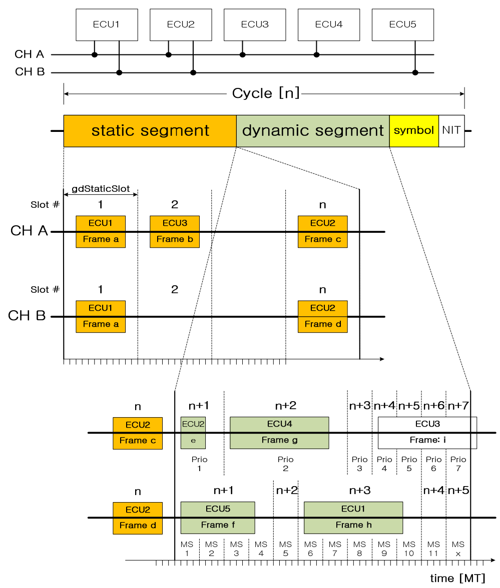


Fig. 3. FlexRay Communication Cycle

The static segment uses a TDMA (Time Division Multiple Access) - based communication. This is suitable to transmit the state message or the message which requires bounded latency and small latency jitter. All static slots have to be same payload size in communication cycle. Each node is allowed to take more than one slot ID. Each node which tries to send a message in the dynamic segment may compete for bandwidth using a priority driven mini-slotting scheme that defines dynamic communication slots. The symbol window can be used optionally and to test a physical connection of ECU. The NIT(Network idle time) is the last part of communication for global time synchronization.

3. HIGH SPEED DISTRIBUTED CONTROL SYSTEM

3.1 Distributed control system with FlexRay

Current control system in the vehicle is the networked system which is consisted of many dedicated ECUs. Each ECU has own functions for its functionality so that number of ECU can be increased if the vehicle requires more functionality. Otherwise, the ECU shares the functions in the distributed control system as depicted in figure 4. It has an advantage for reducing the number of ECU, and for increasing the fault tolerant of the system. Especially it is useful for global chassis control system and X-By-Wire system. The network based global time which is provided by FlexRay enables to control the distributed system in same time zone.

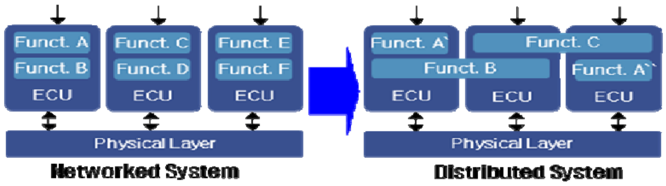


Fig. 4. Networked System vs. Distributed System

3.2 FlexRay for High-Speed Control System

As increasing the needs for the high performance of the chassis control system in the vehicle, it is necessary for a high speed communication to control the high response system like as 1 ms period control system. However, it is practically impossible for CAN protocol which was widely used for control system in the vehicle for last decade to be applied in the high response system. Although the CAN protocol provides up to 1 Mbps bandwidth, it is only available 500 kbps in automotive application because of automotive environment. If you want to transmit the 8 bytes data, then it will take at least 258us for one frame (includes overhead) because it takes 2us for one bit transmission based on 500 kbps in CAN protocol. That means only three messages can be transmitted if there is no latency jitter. However, it takes 30 us to transmit 8 Bytes data frame on FlexRay because it takes 0.1us for a bit based on 10Mbps. Then you can use maximum 33 messages of 8 Byte in 1 m sec if you assigned the messages to static segment. FlexRay is more sensible than CAN for high response communication.

4. CONCLUSION

The FlexRay Consortium has been developing the FlexRay protocol for future in-vehicle network system. In this paper we explained the FlexRay communication and compared the FlexRay with CAN protocol. Then we have discussed the possibility for applying the high speed control system. FlexRay protocol surely will be the standard protocol for future in-vehicle network to control the high speed distributed system.

- FlexRay Homepage: http://www.flexray.com