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Platform Construction of FlexRay Bus and Research on its Performance

Luo Jie, Bao Yue, Wang Pengjie
School of Information Engineering, Wu Han University of Technology,
Wu Han city of Hu Bei Province, 430070, China
Tel.: +8613476103111, fax: +8602787850513
E-mail: luo_jie@whut.edu.cn, 215723753@qq.com, 546639064@qq.com

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Abstract: The platform construction of FlexRay bus, a new kind of car bus, is introduced in this paper. In the actual platform, the FreeMASTER software of Fresscale is employed to develop PC test software of the test platform of FlexRay bus, by which the properties of FlexRay bus are carried out and tested, including related characteristics of the protocol, characteristics of codec and redundant reliability of communication. *Copyright © 2013 IFSA.*

Keywords: FlexRay, Auto bus, Eye diagram, FreeMASTER.

1. Preface

Among these traditional car buses, the CAN (Controller Area Network) bus and its child Networks (such as LIN (Local Interconnect Network) bus) are widely used today [1, 2]. As auto control and communication systems become increasingly complex, the require of vehicle is becoming higher correspondingly. Especially, with the increase of the X-by-wire in the Vehicle control system, it asks for higher performance, for instance, transmission speed, reliability of, distributed control [3]. Currently widely used CAN bus technology is based on the event-triggered with the highest communication rate up to 1 Mbps, which yet cannot satisfy the requirements of X-by-wire system for high bandwidth and fault tolerance. Hence, the new vehicle network bus -- FlexRAy arises as it requires.

FlexRay bus adopted the data transmission technology based on time trigger with data transfer rate of up to 10 Mbps, which improves the data transmission rate and enhances the high reliability requirement. This kind of communication system is able to satisfy the future demand of interior control application.

FlexRay protocol is developed by FlexRay alliance, initially formulated jointly by DaimlerChrysler and BMW to meet their current and future product demand. Afterwards, with the join of Bosch, NXP, Freescale, GM, Volkswagen and other companies, FlexRay protocol has been optimized and V2.1 version of FlexRay was published in 2005. Based on the ByteFlight protocol by BMW company and expanded, FlexRay gains the support of several car manufacturers once launched [4-7].

Because there has been only seven or eight years since the FlexRay protocol was released officially, its agreement, related control, and the design and production of transceiver chips of physical layer are mainly developed by developed countries. In those

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nations with relatively high development of automotive electronics research, say, America, Germany and Japan, etc., have related research achievement. However, for China failed to participate in the formulation of the FlexRay protocol standards and only a handful of universities and research institutes made some theatrical researches and experiments on protocol and its applications, the research on the FlexRay technology in china is still in bud [9].

2. The Build of Hardware Platform of FlexRay

The platform of FlexRay adopts MCU (MC9S12XF512) of integrated FlexRay protocol controller from Freescale company as the main chip and TJA1080 from NXP company as FlexRay driven chip to build the network nodes and testing platform. The function structure of FlexRay node is shown in Fig. 1.

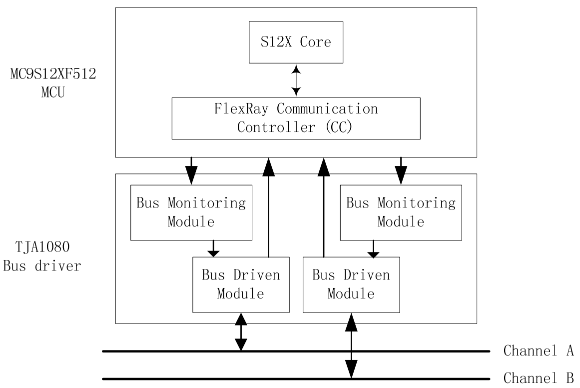

Fig. 1. The function structure of FlexRay node.

Single + 12 V power supply is employed in system node to analog the power supply environment of vehicle-mounted ECU. For the sake of the convenience of online board debugging (OBD) of FlexRay node and scalable networking capabilities, many nodes of CAN bus which have already been used in the vehicle network are designed in the FlexRay nodes, and MC9S12XF512 itself with the CAN protocol controller is adopted. Meanwhile, the PCA82C250 CAN driver from NXP company is employed as the external bus driver. The communication between system node and PC uses the currently popular USB interface whose high speed and the characteristics of supporting hot plug greatly facilitate the online capability between system and PC, while USB interface chip is PL2303HX chip from Taiwan's Prolific company. The hardware structure of node is shown in Fig. 2.

In the design of the FlexRay platform, 4 FlexRay nodes are employed to network communication and passive bus network topological structure recommended by FlexRay protocol is used, furthermore, the communication distance between nodes is about 1m. Among those 4 FlexRay hardware nodes, one as the host node is not only connected to the FlexRay bus, and a PC, but also communicates with monitoring software of FreeMaster, whereas the other 3 FlexRay nodes respectively simulated car ECU unit components. And the communication rate of the entire network platform is designed up to 10 Mbits/s with dual channels.

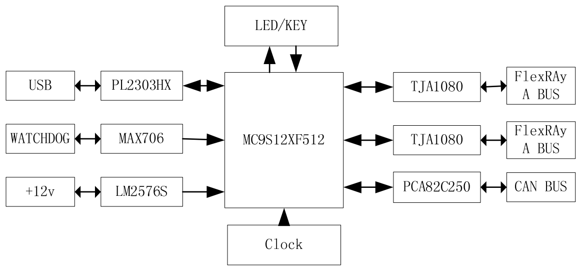

Fig. 2. The hardware structure of node.

3. The Software Design

The software of FlexRay node is mainly for initialization and parameters setting of FlexRay communication controller module of MC9S12XF512. After the initialization of MCU, it is able to enforce the MC9S12XF512 FlexRay module into FlexRay protocol configuration and start FlexRay communication controller. Once the start is done, check whether FlexRay node synchronizes to FlexRay cluster and start the normal FlexRay transceiver when finishing the synchronization. The Detail flow chart of software main program of FlexRay node is shown in Fig. 3. In addition, the communication rate, cold start node, communication channel, sending and receiving time slot, etc., a series of parameters configuration are set by the FlexRay controller. For the sake of the timeliness of node communication, communication of FlexRay is designed to base on interrupt control transceiver, in which FlexRay protocol controller and the corresponding transmit-receive of the main program will be triggered by the interrupt caused by slot.

4. The Test Platform of FlexRay Network

The test platform is designed by 4 independent FlexRay nodes (hardware circuit board), one PC (running FreeMASTER software), a digital phosphor oscilloscope of MSO4104B from Tektronix, a switching power supply with +12V / 2A and etc. The test platform is shown in Fig. 4.

The platform is designed of wake up frame with 60 bus bits of period, TXIdle with 180 bus bits of period. And the sending rate of bus is 10 Mbits/s, which means the period of bus is 0.1 μs, TxLow =

6 µs, TxIdle = 18 µs. The wake-up frames of FlexRay captured by MSO4104B are shown in Fig. 5. As shown in Fig. 5a, there are 16 frames sent by the wake-up frame according to the program setting. By the cursor function of MSO4104B, it is tested that TxLow = 6 µs (as shown in Fig. 5 b), TxIdle = 18 µs (as shown in Fig. 5c), and the total length of wake-up frame TxLow+ TxIdle = 24 µs, which all match the protocol and the demand of program design. Meanwhile, the period of FlexRray bus is 5 ms, and the network period of FlexRay captured by MSO4104B is shown in Fig. 6.

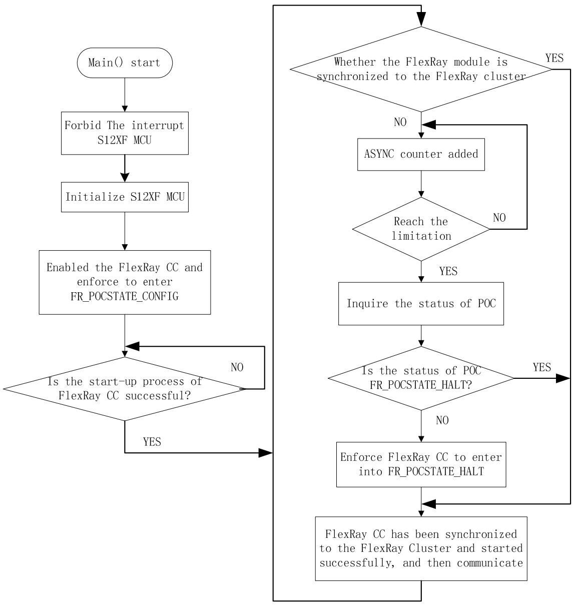

Fig. 3. The flow chart of software main program of Flexray node.

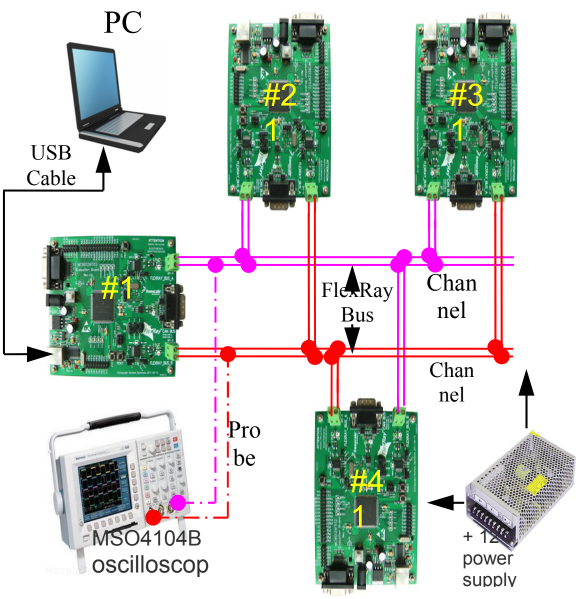

Fig. 4. The test platform of FlexRay.

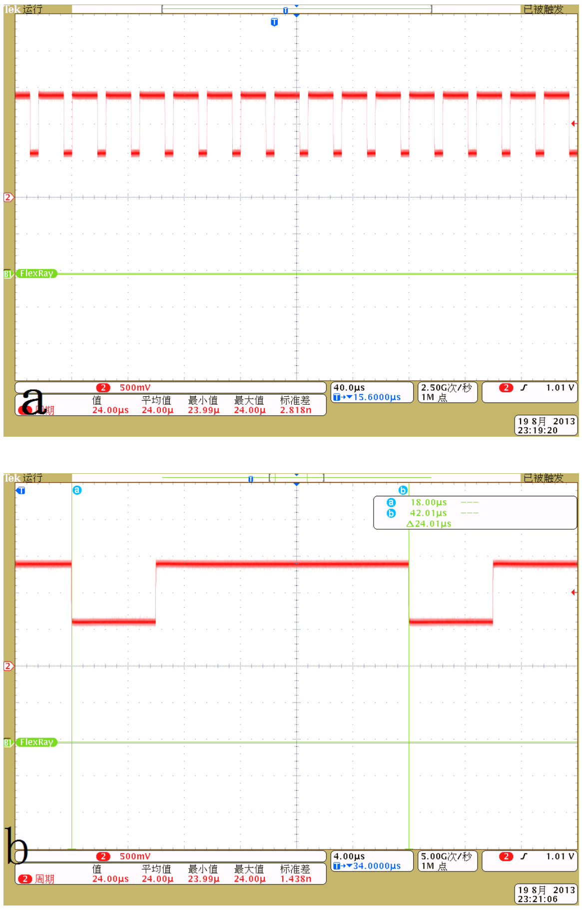

Fig. 5. The wake-up frame captured by MSO4104B.

Meanwhile, the period of FlexRay bus is 5 ms, and the network period of FlexRay captured by MSO4104B is shown in Fig. 6. As shown in Fig. 6a, the period of FlexRay bus is 5 ms measured by the MSO4104B cursor function, and one bus period includes 4 FlexRay frames corresponding to the slot of node 1 ~ 4. The full FlexRay frame captured by MSO4104B is shown in Fig. 7a. Through the cursor function of MSO4104B, the total length of the frame is 41.4 µs and the length of TSS is 1.1 µs (as shown in Fig. 7 a and 7 b). The waveform of 24 bits CRC check code is shown in Fig. 7c, in which the FES (1 bit High + 1 bit Low) at the end of the wave is a kind of static frame.

In order to monitoring signal integrity, we test the single's eye diagram at the TP4 test point(at the receiving end).The test result showed in Fig. 8, as show in the figure, the test eye map large than test template. So the platform can be decoding the signal.

The upper programming of FreeMASTER computer from Freescale is used to program the principal monitoring software of network platform of FlexRay bus. By the monitoring software, it is able to monitor the entire performance parameters of FlexRay network and communication data, and prompt alarm as well when errors and bugs happen. The monitoring software interface of FlexRay bus platform is shown in Fig. 9.

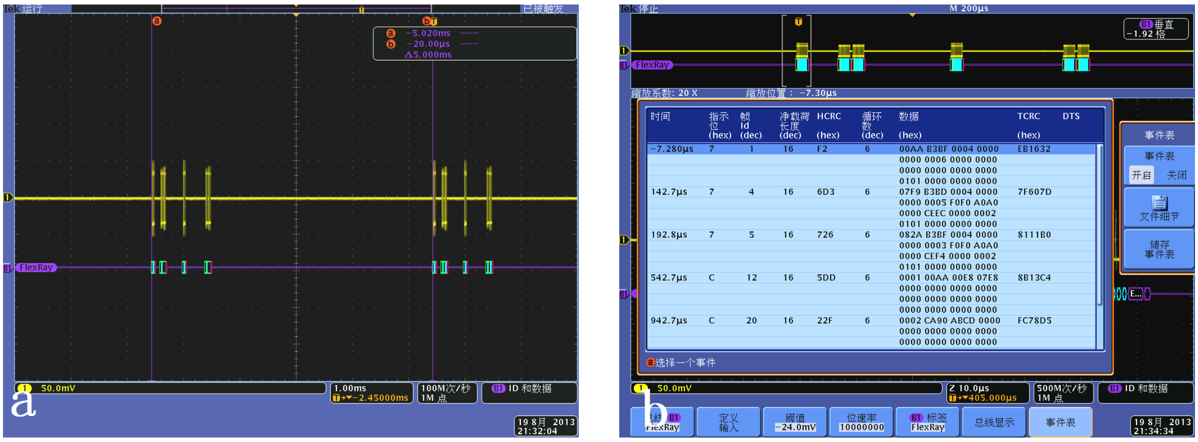

Fig. 6. The network period captured by MSO4104B.

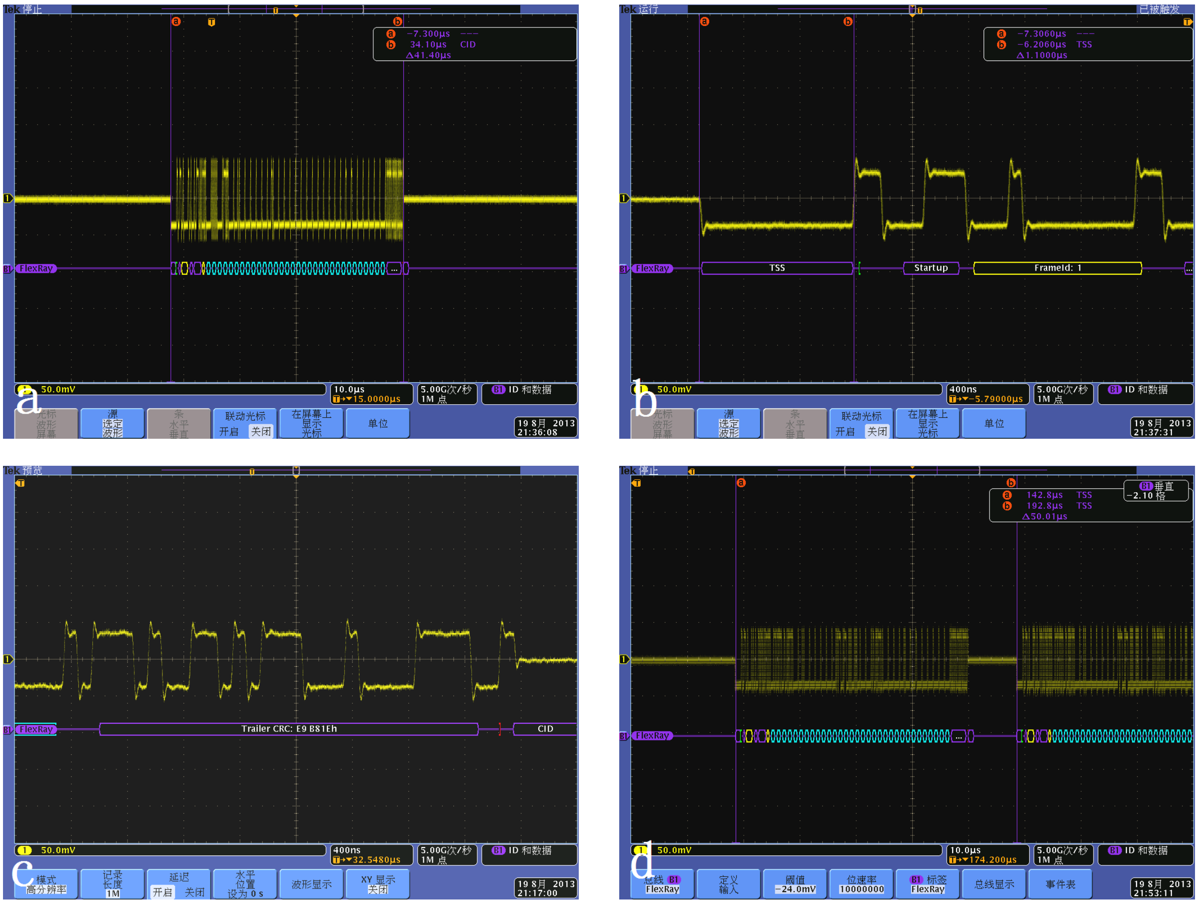

Fig. 7. The frame picture captured by MSO4104B.

Monitoring software is composed of three monitoring windows, including host control window (HCW), waveform data window (WDW) and parameters of the bus window (PBW). Firstly, the HCW is used to monitor the communication status of every node of the network and the connection status of channel A and B with the indicator lights. Meanwhile, there is a ship switch on the interface of HCW to be able to stop the communication at any time to verify the wake-up function of FlexRay network. Secondly, the WDW monitors the various parameters of bus, including the statuses of POC, wake-up, sync, MTS, real-time data of sent-received by the node and channel error counting, etc. Thirdly, PBW displays the data wave from the nodes' sensors, aiming at simulating the steering wheel and pedals, etc.

After connecting each node to FlexRay bus and the USB interface of main monitoring node to the PC's USB interface, open each node power and then start the monitoring software FlexRay bus network. The monitoring interface of each node under normal operation is shown in Fig. 10.

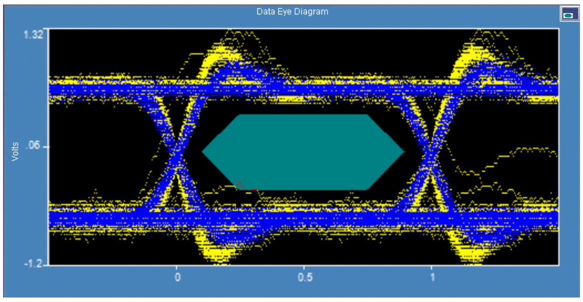

Fig. 8. The eye diagram test by MSO4104B.

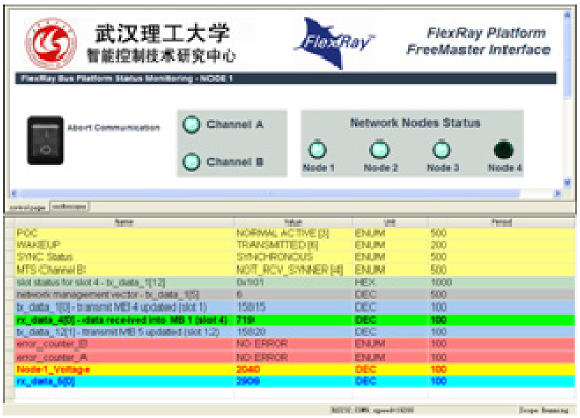

Fig. 9. The running interface of monitoring software of FlexRay bus platform.

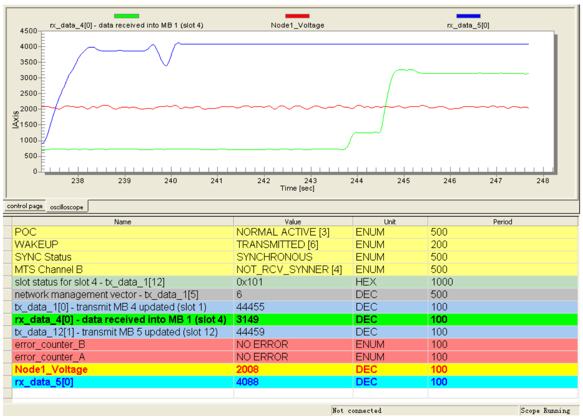

Fig. 10. The monitoring interface of FlexRay bus platform under normal operation.

Monitoring software can monitor the physical connection condition of dual in real-time and the corresponding fault alarm is given. Channel B miswires, for example, the status light of Channel B changes from green to red and the error-counter of corresponding starts counting. As shown in Fig. 11, when the Channel A is disconnected artificially, the light of Channel A on the monitoring interface turns red and error counter starts counting at the same time.

Experiments on FlexRay implementation of data communication with 10 Mbps, each node uses the ADC to acquisite corresponding sensor voltage and sent which to monitoring node. In the experiments, when any channel is disconnected physically during communication, the corresponding warm information is given and then communication is restored, due to the redundancy communication function of FlexRay bus, which validates the reliability of FlexRay communication.

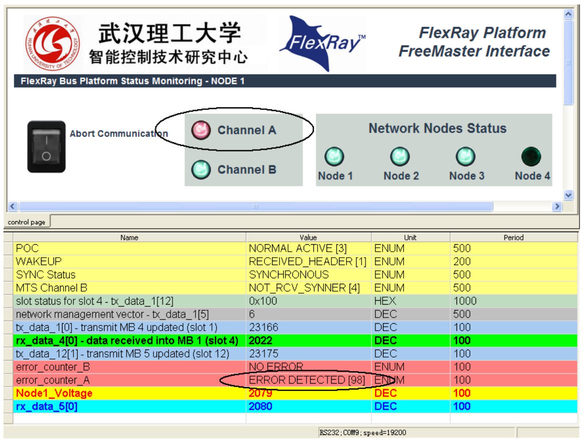

Fig. 11. The indicator interface of channel error status.

5. Conclusion

With the development of modern automotive technology, it calls for increasing high performance of automotive safety. Considerable increase of the number of electronic control unit and sensors (especially X-by-Wire system) helps the development of vehicle bus and network technology [12]. FlexRay network protocol, the next significant generation communication network, was launched by the alliance of Bosch, BMW, and Daimler - Chrysler, Volkswagen and other car manufacturers. And the FlexRay provides the development direction of new vehicle communication network. Furthermore, the deep researches on the protocol and the application theories and the establishment network platform to analyze the performance of network, all provides the essential theories and practical application value for the design of next generation of automotive electronic security and the researches on vehicle communication network system.

In this paper, the author put forward a method of designing a complete communication platform of FlexRay bus network and realized the communication platform of FlexRay bus network. The physical test and verification on the network platform of FlexRay bus prove that the platform is feasible and stable.

Compared to CAN, FlexRay bus with a wider bandwidth (single channel can be up to 10 Mbps), it can guarantee a reliable communication for the certain behavior, and be possible for the system integration and future extension, which might realize the function of drive-by-wire but without mechanical back up in the future [13-14]. Meanwhile, the FlexRay technology has incomparable advantages over traditional vehicular network and its emergence meets the requirement of some core technologies called by modern automotive industry.

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