RESEARCH ON FLEX RAY BUS TECHNOLOGY IN VEHICLE ELECTRONIC SYSTEM

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Abstract: In order to ensure the driving safety of the car, the on-board electronic system is studied based on Flex Ray bus technology. Firstly, the structure of Flex Ray vehicle electronic system is optimized according to the operation requirements of vehicle electronic system, and Flex Ray application protocol is set up to complete the control and management of vehicle electronic system according to the settings of Flex Ray application protocol. Finally, the experiment proves that the application effect of Flex Ray bus technology in vehicle electronic system is obviously improved compared with the traditional method.

1. Introduction
In recent years, electronic information technology has gradually matured and improved, and people's requirements for the safety and functional diversity of automobiles have become higher and higher. As a result, the number of corresponding on-board electronic control units and the like have also increased greatly, increasing the construction cost of automobiles. In order to reduce the construction cost and strengthen the stability of communication, it is very necessary to optimize the communication form between ECU, among which the research on bus mode inside the vehicle is very important. Many scientific research institutions pay close attention to and study the in-car bus mode, and point out that the development of today's automobile industry depends on the research status of the in-car bus mode. The wide application of high-speed electronic information technology in automobiles has improved the electronic process of automobiles. Due to the increasing number of modern automobile ECU, this requires that in multiple subsystems, information sharing and transmission should be increased, thus realizing real-time signal scheduling and improving signal utilization rate [¹]. At the same time, with the continuous improvement of multi-function and intelligence of automobiles, traditional bus communication technologies such as LIN, CAN, RS485, etc. have gradually failed to meet the future needs in on-board electronic systems [²]. LIN bus communication technology is a low-cost serial communication, which has the advantages of low cost and simple protocol. However, LIN bus as a whole belongs to an auxiliary bus communication technology, and its security is still difficult to meet the world requirements. In contrast, CAN bus communication technology has to design multiple bus structures in order to meet the needs of reducing the number of wire harnesses and carrying out high-speed communication of large amounts of data through multiple LANs. The number of wire harnesses also increases, resulting in heavy operating burden and slow operation. RS485 bus technology usually has only one host, so this bus mode is a typical centralized-decentralized control
system. Once the host fails, the communication of the whole system will be limited to a paralyzed state, and its practicability is relatively poor. In this context, Flex Ray bus technology is applied, and Flex Ray bus technology is mainly used to assist in the design of network communication indexes of modules in the network structure of the car that need fast communication speed, and is an additional high-speed protocol for the in-car system. The technology has high transmission rate, real-time transmission, high reliability, flexibility and convenience, can well solve the problems of multiple safety of automobiles, and can help automobiles realize the goal of developing to high-speed control and distributed control [3]. Therefore, the research on FlexRay technology plays an important role in the application of advanced electronic control system for automobiles. In-depth study of network scheduling algorithm and communication scheduling management and control, analysis of network resources how to more reasonable configuration, to ensure that the information in the transmission process is correct and timely, so that the control system is stable and reliable, high speed, high efficiency to meet the requirements.

2. Application of Flex Ray bus technology in vehicle electronic system.

2.1 Structural optimization of Flex Ray on-board electronic system

The use of Flex Ray in future automobiles has revolutionized the traditional communication system and created a communication management system based on a new type of network, namely, distributed communication management system[4]. Flex Ray bus network not only has bus topology, but also usually has star topology and hybrid topology. Each topology structure has two channel types, namely, single channel and double channel, which can be divided into active and passive channels and contains cascade mode. It should be noted that in a dual-channel system, its nodes do not have to be connected to both channels[5]. In Flex Ray bus topology, all nodes in its network are connected to the central network nodes in a point-to-point manner using cables, and the information transmission form is also transmitted from the central node to each node. The central node in this structure has the most complex structure and high load, and the communication management strategy is centralized. In this type of structure, information transmission between nodes is completed through the central node[6]. The schematic diagrams of the star topology structure of the bus single channel and the bus double channel are shown in the figure respectively.

According to the above figure, Flex Ray network topology has the following advantages: on the one hand, the interface transceiver is connected in a point-to-point manner, which has better transmission effect in networks with high transmission rate or long lines. On the other hand, error separation can be carried out, i.e. information transmission between normal nodes and other nodes will not be interrupted as shown in the figure.
The data comes from the main processor and is transmitted by Flex Ray communication controller. The number of channels depends on the Bus Driver and busguardian and is connected to the controller or microprocessor. The bus has relatively independent monitoring logic from other controllers\cite{7}. Bus Driver is usually connected to the Communication Controller and the bus, or to busguardian and the bus\cite{8}. Flex Ray controller's allocated time slot is processed by the main processor, and data can be transferred after issuing commands to the bus monitor, and the time for data to be accepted is not limited.

Examples of node communication flow:

(1) Host sends out information data, which is accepted and encoded by the Communication Controller, converted into a data bit stream, and then transmitted to the designated channel by Bus Driver.

(2) After receiving the data information, Bus Driver will access the stack, then send it to the Communication Controller for decoding, and part of the converted data will be transmitted to Host.

According to the above steps, in-vehicle communication management of the system is carried out. In order to improve the speed and reliability required in the communication management process, Flex Ray application protocol needs to be further set up.

2.2 Flex Ray application protocol settings

As a communication management protocol, Flex Ray protocol has certainty and fault tolerance. Due to its high bandwidth and high reliability, Flex Ray protocol has been gradually applied as an ideal protocol in the backbone network communication module of automobiles\cite{9}. The use of Flex Ray bus technology will be very beneficial to the future performance of automobiles in terms of safety, reliability and entertainment. In order to realize in-depth research on Flex Ray bus protocol and better practical utilization, its main contents will be explained in detail. The six operating states of Flex Ray nodes are shown in the figure below:

![Diagram of Flex Ray internal communication management module of on-board system](image-url)
The communication management of vehicle-mounted electronic system is carried out in combination with Flex Ray application protocol. In the actual application process, Flex Ray related initialization is mainly divided into module initialization and protocol initialization. The module initialization process is divided into two parts: Flex Ray module configuration and enabling. The module configuration includes the configuration of MCR control bits and the configuration of system memory base addresses in SYMBADHR and SYMBADLR. After the parameter configuration is completed, set MEN in MCR to 1 to enable Flex Ray module[10]. The application protocols of different module state functions are:

1. Configuration state application protocol: initialization definition of various parameters, including the communication cycle size and data rate;
2. Ready state application protocol: define internal communication state;
3. Wake-up state application protocol: wake up nodes that are not in communication. The wake-up object is the power management system. Normally, a node will enter a "power saving" mode when it is not in an operating state, so the node must be "woken up" when it is switched to an operating state. The group can be awakened by a single node; The host can use the communication channel to communicate the wake-up command. The transceiver wakes up the node when receiving the wake-up information; After receiving the wake-up feature, the node first turns on the host processor and the communication controller, and then wakes up other constituent units.
4. Start state application protocol: start the hour hand synchronization feature and prepare to transmit information. This link is usually realized after the node is awakened. The initialization of the startup process is called "cold-start" and only a limited number of nodes can be cold-started. The start-up of the whole system can be divided into two steps: the first step is the start-up of the cold start node, and the second step is the start-up of other nodes through the joint action of the cold start node and the start-up frame.
5. Normal State Application Protocol: A node is in a state where it can transmit data at any time.
6. Interrupt state application protocol: accept the protocol and transmit port information.

When the module enters Normal mode, the application program starts to initialize the protocol. The protocol initialization step includes configuring the protocol engine, configuring the message cache and FIFO. The steps of CONFIGuring the protocol engine are: sending config command...
through POCR;  Waiting to reach POC: config state in PSR0;  Configure all protocol parameters in PCR0 to PCR30.  The step of configuring that message cache and FIFO are as follow: setting the number of message caches use and the message cache partition in MBSSUTR;  Defining the size of message cache data in register MBDSR;  Setting the values of registers MBFIDRn, MBCCSRn, MBCCFRn, MBIDXn to configure each message cache;  Configure receive FIFO;  Send CONFIG_CMPLETE comm via POCR;  Wait for POC:ready state in PSR0.  The above protocol operation steps can effectively control and manage the communication safety of the vehicle-mounted electronic system and improve the safety performance and effect.

2.3 Application of Flex Ray bus technology

Reasonable selection of scheduling algorithm plays a vital role in the efficiency of vehicle-mounted network. Therefore, selecting an effective scheduling algorithm can improve the use efficiency of network communication, allocate network resources more efficiently, and well control the time delay caused by the system.  The upper computer needs to store the operation information and acquisition information at different times, which can be recorded as \((t_1, a_1, b_1)\) and \((t_2, a_2, b_2)\), where \(t_2\) is greater than \(t_1\).  According to the continuous operation characteristics of the on-board management equipment, assuming that the equipment performs stable linear motion during this period of time, the operation parameters of the on-board management equipment at this moment are predicted as follows:

\[
V_a = \frac{a_2 - a_1}{t_2 - t_1}, \quad V_b = \frac{b_2 - b_1}{t_2 - t_1} \tag{1}
\]

The algorithm for estimating the reliability of equipment operation is as follows:

\[
S = \left( t_3, b_2 + V_a (t_3 - t_2), b_2 + V_b (t_3 - t_2) \right) \tag{2}
\]

According to that current moving speed and position of the mobile device at the moment.  According to the above conditions, the multi-vehicle electronic system management model can be obtained as follows:

\[
\varphi = f(t) \sum_{i=1}^{f(t)} S(Y + X) \tag{3}
\]

Where \(f(t)\) is the set of vehicle information centers, \(x\) is the center of each constraint parameter, and \(y\) is the safety parameter for configuration application.  After the above configuration steps, the Flex Ray module can be configured as a node in the Flex Ray communication cluster to be integrated into the network, as shown in the figure for the initialization process of the Flex Ray module.
The module configuration register is added in the application process of Flex Ray vehicle-mounted electronic system, and the module therein is initialized, and the module is enabled after the initialization setting of the module is completed. Initializing the communication controller is the main aspect of bus communication cluster protocol parameter setting, which includes the setting of communication cluster protocol parameters and the initialization configuration of Flex Ray driver data structure. When designing parameters, certain requirements must be met, including the definition of system parameters in Flex Ray communication protocol and the restrictive conditions met between parameters, so as to realize the reasonable application of Flex Ray bus technology in vehicle electronic systems.

3. Analysis of experimental results
In order to verify the application effect of Flex Ray bus in vehicle electronic system, a simulation test was carried out. In order to ensure the validity of the research results, the experimental environment is set up. Firstly, the distribution of Flex Ray, LIN, CAN and RS485 bus technologies is tested by using the Vector company Da Vinci Network Designer Flex Ray tool. For the convenience of memory, the following are represented by the initials F, L, C and R respectively. Under the same experimental environment, carry out overall planning and network design; The FIBEX file exported by this software is imported into ENO.link software, which is a simulation verification tool, to establish and simulate the model.

Vehicle state data acquisition scheme: assume that four sub-nodes are placed near four wheels and respectively acquire the rotation speed, triaxial acceleration, wheel temperature and tire pressure of the respective wheels through wheel speed sensors, triaxial acceleration sensors, temperature sensors and pressure sensors, and each sub-node should have four data quantities input to the main node; At the...
same time, when the master node controls the sub-nodes, it needs to drive the electronic control module of each sub-node, and it should also have a data output to output to the sub-nodes, and the sub-nodes themselves should also have a data volume indicating their status in the network. In the simulation experiment, we can design the data structure of network transmission, and use 6 groups of specific data to represent the models of the four collected physical quantities and one output quantity. The safety and effectiveness of the four methods are verified by simulation experiments in the above-mentioned environment, and the experimental results are recorded and plotted as follows:

![Fig. 5 comparison test results](image)

It is not difficult to find by observing the above comparative test results that Flex Ray bus technology is relatively superior to traditional LIN, CAN and RS485 bus technologies in vehicle electronic systems. In the research, it is found that RS485 bus technology has the lowest safety effect and accuracy in traditional methods. LIN bus technology resigned, but the overall operation effect tends to be stable but there is still a downward trend. The integrity of CAN bus technology is relatively good in the application process, but the stability of curve has certain fluctuation. However, Flex Ray bus technology in the actual application process, the overall curve area rises steadily, and its safety and accuracy have reached the current highest requirements, fully meeting the current research objectives.

4. Concluding remarks
Electronic automobile is the inevitable trend of current automobile technology development. Following the wide application of electronic technology in engine, transmission, steering gear, suspension and other systems, the automobile braking system has also developed rapidly. The future braking system will be transformed into a brake-by-wire system without mechanical and hydraulic backup and completely driven by electricity. It has the advantages of fast and accurate response, light weight and convenient maintenance. It is one of the research hotspots and cutting-edge technologies in the current development of automobile technology. Therefore, in combination with Flex Ray technology, the network transmission information of the vehicle electronic system is collected and transmitted, and the corresponding Flex Ray bus application layer definition is formulated, so that each node receives the information of Flex Ray network, completes the brake-by-wire function, and finally realizes the safe and reliable transmission of data.
References
[1] Anonymous. Simulation study of automobile line control braking system based on Flex Ray bus [J]. Power supply, 2018, 35 (10): 6-10+23.
[2] Dai Xiaochen, Zhang Fengdeng, Zhang Yuhui. Design and research of control system based on Flex Ray bus line [J]. Electronic measurement technology, 2017, 57 (12): 6-10.
[3] Guo Chao, Zhang Fengdeng. Design of Vehicle Line Control Brake System Based on Flex Ray Communication [J]. Software Guide, 2017, 16 (10): 116-118.
[4] Application of Flex Ray Bus in Ship Automatic Navigation System [J]. Ship Science and Technology, 2017 (06): 97-99.
[5] CHARACTERISTICS AND APPLICATIONS OF Zhao Ying, Mengxiang. Flex Ray BUS IN ON-LINE CONTROLLED BRAKE SYSTEM [J]. Machine Tools and Hydraulics, 2017, 45 (6): 69-71.
[6] Anonymous. Design and Implementation of Flex Ray Bus Security Protocol on Vehicle [J]. Journal of Xi’an Jiaotong University, 2018, 52 (12): 63-69.
[7] Liu Biao, Bai Weiwei, Zhong Wei. Flex Ray network monitoring platform based on three-level queue cache [J]. Computer measurement and control, 2017, 25 (8): 139-142.
[8] Meng Xiang, Zhao Ying. Design of Fault Testing System Based on Flex Ray Bus [J]. Coal Mine Machinery, 2017, 31 (24): 237-238.
[9] Li Yan, Chen Xin, Li Chuntao. 4-channel Flex Ray Bus Communication and Redundancy Management Design for UAV Flight Control Computer [J]. Information and Control, 2017, 46 (3): 318-327.
[10] Ren Bank, Zhang Jianlong, Yin Chengliang. Implementation of ECU calibration system based on XCP protocol supporting multi-bus [J]. Application of electronic technology, 2018, 44 (5): 78-82.