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SURVEY PAPER ON CAN BUS TECHNOLOGY IN THE VEHICLE

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Abstract: This paper shows the application of Controller Area Network (CAN) that changed vehicle electrical system wiring and control mode, wiring harness and controller pin count were decreased. Therefore the cost was reduced. The comparative method is applied in this paper based on traditional vehicle circuit and CAN-bus circuit. CAN-bus not only can improve reliability and control function, but it reduces the costs and the car failure rate also.

Keywords: CAN bus, Protocol, SPI, MCP2515, MCP2551

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INTRODUCTION

Now days the automobile electronic control systems are becoming more complex because of the application of increasing number of Electronic Control Units (ECUs). The Controller Area Network (CAN) [1] is one of the most widely used networks to connect these ECUs. As more and more electrical equipments are used in automotive, automotive electrical system has formed a complex large system. CAN Bus is the advance serial bus for the microcontroller to communicate in complex environment with multiple microcontrollers.

With the development of the automotive industry, the increasing legal requirements for safety, the reduction of emissions and fuel economy are driving the market for more intelligent systems. The CAN Bus is a very powerful and fast field bus, that supports transfers with data rate up to 1 Mbits/s. Because of the higher transmission speed and the standardized functionality, CAN is a very interesting alternative to other protocols. It is analysised from the wiring perspective that most of the traditional electrical system uses a single point to point communication that is lack of contact with each other. Therefore the wiring system will inevitably lead to large. According to statistics, cable lengths are up to 2000 meters and 1500 electrical nodes in the luxury cars when traditional wiring was implemented. In terms of the efficiency or the costs of materials, the traditional wiring was not suitable for the car development. In such situation CAN bus is more suitable then other buses.

Controller area network (CAN) is a one type of serial bus that is developed by Bosch Corporation to solve the problem of data interchange between many electronic devices of future automobile in 1980s. CAN bus has the advantages of high intelligence, fault-tolerant and reliability [2], that can support distributing real-time control [3].Therefore the instance it comes into being it is popular in industry field, especially in automobile industry. Controller Area Network (CAN) is widely used in automotive, industrial, building, and aerospace domains. Its cost is low and has ability to connect multiple microcontrollers. So silicon families have made it a standard for automotive applications [4-7]. It satisfies the communication requirements of different embedded systems. Controller Area Network (CAN) is a bus standard which is designed to allow microcontrollers and devices to communicate with each other within a vehicle without a host computer. CAN bus was implemented to reduce the wiring complexity in vehicles. It is designed to enable real-time communication among vehicles ECUs. The CAN 2.0B specification has two types of data formats: (1) Standard Data Frame for standard messages which use 11 identifier bits and (2) Extended Data Frame for extended messages which use 29 identifier bits. CAN bus is one type of serial communication network that effectively supports real-time control and distributed control, any node in the network can actively interchange data with other nodes in the way of broadcast. Compared with the centralized computer control system, the hardware interface is easy and cheap with strong anti-interference ability, maintainability and extensibility, CAN-bus data communication is outstandingly reliable, flexible and immediate in comparison with other field buses.

II. CAN BUS SYSTEM

1. Capability Comparison between RS-232 and CAN Bus [8]

Industry facilities communication is often related to a lot of hardware and soft ware products. It is used to connect the protocol between standard computer flat and industry automatic application facilities. Moreover, the facilities and protocols in which were used are different. So, it is hoped that most automatic application facilities can perform simple serial orders, especially hoped that these orders are compatible with the standard serial ports in PC or accessional serial port boards. RS-232 that has widest application in PC and communication industry is one of the serial ports. RS-232 is defined as a sort of single end standard which could increase the communication distance in serial communication with very low-velocity. With the communal signal ground between sending port and sink of RS 232, it cannot use signal with two ports. Otherwise, the common mode noise will be coupling into signal system.

CAN is one of the serial field bus which is widest application internationally full named "Controller Area Network". As a sort of serial communication bus with multi-mainframe mode, the basic design criterion of CAN demands high-velocity and better capability of contradicting electromagnetism disturb, even demands to check any mistakes which are produced in communication bus. When the distance of signal communication is 10km, CAN still provide digital communication velocity with 50kbit/s. This shows that, as a sort of serial bus, CAN is more excellent than RS-232 in many aspects such as the capability of real-time, adaptive, agile and secure. When two serial-ports cannot be connected by RS-232 directly for one serial-port is away from another with long distances, we can change RS-232 into CAN realizing the connection of serial facilities.

2. The implement of CAN interface

The CAN is a serial communications protocol that efficiently supports distributed real-time control with a high level of security.

Its area of application ranges from high speed networks to low cost multiplex wiring. In automotive electronics, engine control units, sensors, anti-skid-systems, etc. are connected using CAN bus with bit rates up to 1M bit/s. The intention of this specification is to obtain compatibility between any two CAN implementations. Compatibility, however, has various aspects regarding e.g. electrical features and the interpretation of data to be transferred. To get design transparency and implementation flexibility CAN has been subdivided into different layers.

The whole CAN bus system is made up of the MCP2515 which is a stand-alone CAN controller with SPI Interface. When using the MCP2515, it is essential to initial it. Differently with other CAN controllers, the MCU communication is implemented via SPI protocol. Different commands and data are sent to the device via the SI pin, with the data being clocked in on the rising edge of SCK. Data is driven out by the MCP2515, on the SO line, on the falling edge of SCK. The CS pin should be held low while any operation is performed.

III. THE TECHNICAL FEATURES OF CONTROLLER AREA NETWORK (CAN)

1. The Characteristics of CAN bus

The different characteristics of CAN bus are reliability, real-time and flexibility, and the major are as follows:

1) Based on the priority of the non-destructive arbitration, important information frames are set with a higher priority, thus the refresh rate is improved and the completeness and accuracy of the transmitted data are guaranteed [9].

2) Multi-station structure: through the serial number of data source code identification and the destination address, the data transmission may be unicast, multicast, or broadcast [9].

3) Data fields with less than or equal to eight bytes: data encoding principle-relevant data are packed to a data frame, this method can improve the transmission efficiency and make sure that it may got a relatively greater proportion of the valid data in every data frame; as for the data need to be send quickly, it can reduce the data bits and take less time to send a data frame, therefore it can improve the real-time data transmission [9].

4) Scalability: it not only supports to add new nodes to the CAN bus but it also reserved space for the future expansion in the application protocol layer [9].

2. CAN bus communication principle

A CAN node is any type of intelligent device such as a microcontroller, smart sensor, actuator, or even a PC computer etc. which uses CAN protocol and CAN connectively for CAN communications. In general, smart sensors and actuators contain a controller in their architecture. Microcontrollers are computers that follow either Von Neumann or Harvard architecture; so, CAN nodes are basically computers, thus the CAN network is considered as a multi-computing system. Nowadays, CAN connected devices are usually microcontrollers that either has a built-in CAN controller or are connected to a stand-alone CAN controller chip. A PC computer can also be a can node. It can be interfaced to a CAN controller via a PC plug-in card, USB port, or serial port.

CAN transmission medium is formed by the two lines; one is called high-level transmission line CANH. Another is called low-level transmission line CANL, Ground voltage respectively as VCANH and VCANL. The difference between them is called difference voltage V diff. CAN bus uses two dedicated wires for communication. The wires are called CAN high and CAN low as shown in figure 1. When the CAN bus is in idle mode, both lines carry 2.5V. When data bits are being transmitted, the CAN high line goes to 3.75V and the CAN low drops to 1.25V, thereby generating a 2.5V differential between the lines.

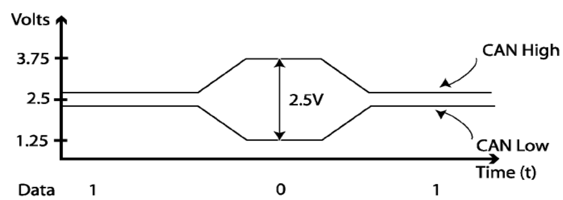
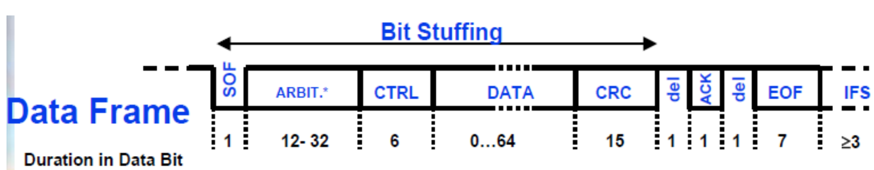


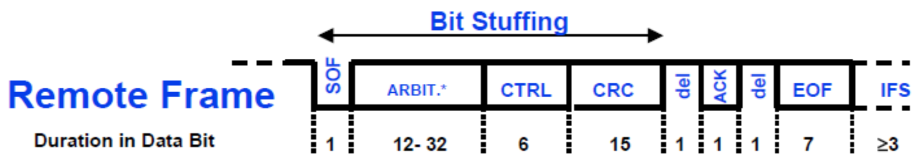
Fig.1: CAN Bus Modules Communicate [10]

3. CAN Packet Structure and Frame Type

CAN packet structure includes the four types of message frames that are Data frame, Remote frame, Error frame and Overload frame [11]. All these frames are shown in the following figure. Each CAN frame consists of the Start of Frame (SOF), Arbitration field, control field, Data Field, Cyclic Redundancy Code(CRC), Delimiter(del), Acknowledge (ACK), End of Frame(EOF), Inter Frame Spacing(IFS).



(a)



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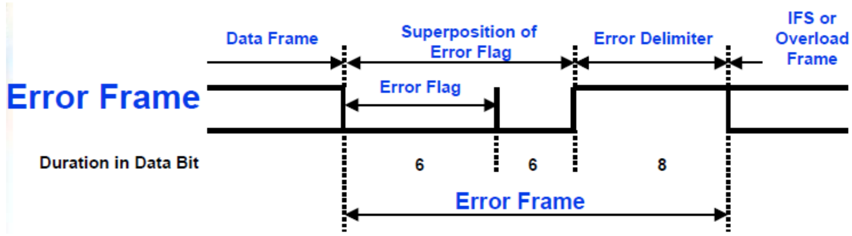

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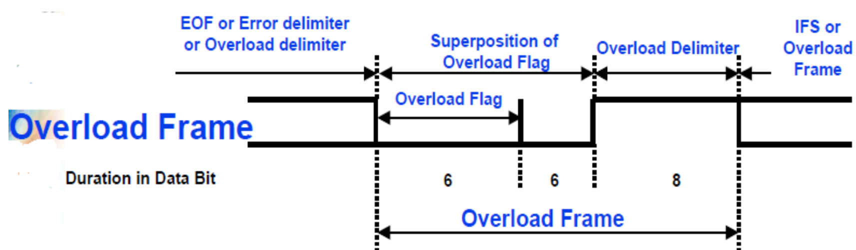


(d)

Fig.2: CAN Packet Structure (Fig. 2(a) CAN Data Frame, Fig. 2(b) CAN Remote Frame, Fig. 2(c) CAN Error Frame, Fig. 2(d) CAN Overload Frame) [11]

IV. CAN MESSAGE SENDING AND RECEIVING

1. CAN Message Sending [12]

After initialization, the single-chip MCP2551 is in working mode. The CAN message sending adopts inquiry mode. Every 20ms, it checks the data sending buffer for command packet, if there is no command packet, it will return to main program waiting for the next check, and if there is command packet, the CAN controller sending status is on, it sends data in CAN BUS to buffer, the flow of program design is shown in Figure 3.

2. CAN Message Receiving [12]

There are two ways for messages receiving: inquiry mode and interrupt mode. The design adopts the interrupt mode. It checks whether the packet is received or not and also checks whether the buffer is full or not. If buffer is full, it will return to main program waiting for the next check, and if buffer is not full, the CAN controller determines the packet type, packet data length, and the message ID. It sends data in CAN BUS to buffer. The receiving flowchart is shown in Figure 4.

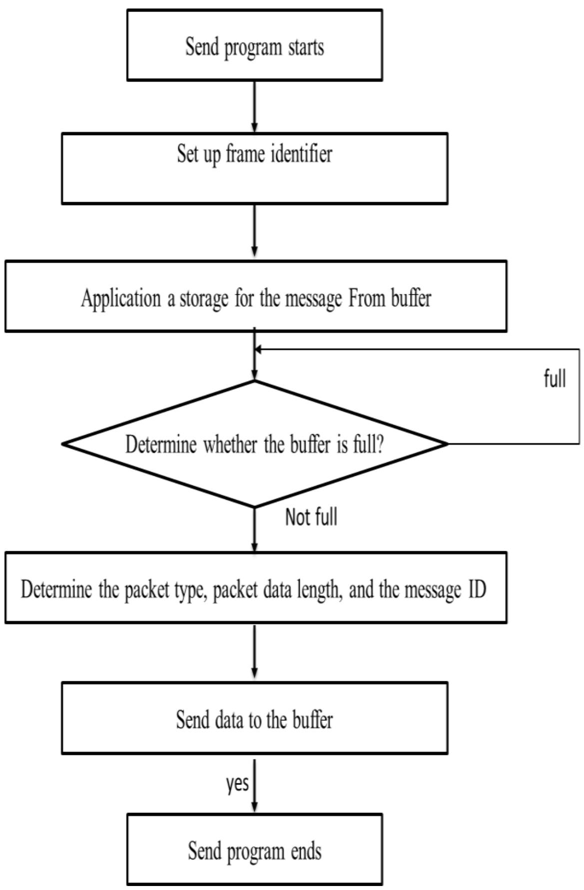


Fig.3: CAN message sending process flow

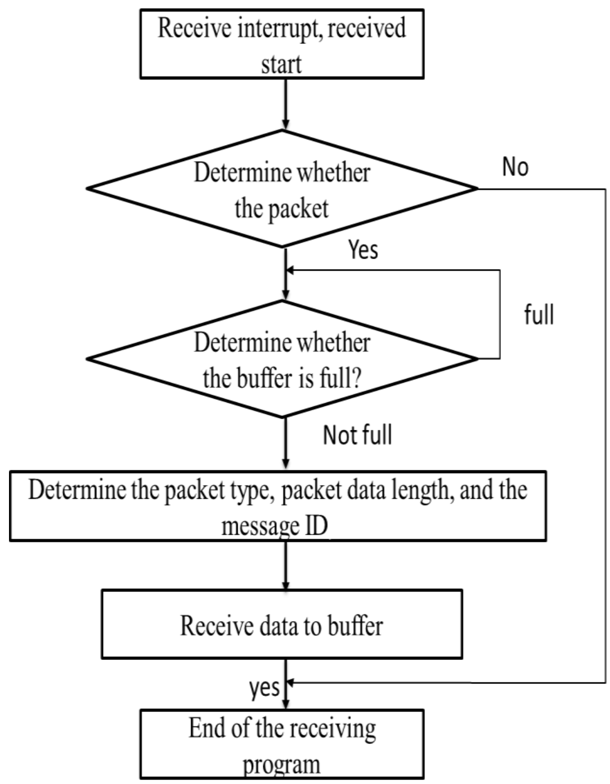


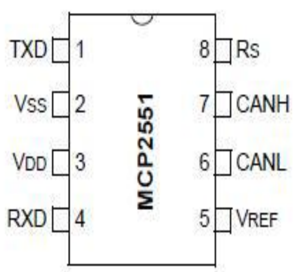
Fig.4: CAN message reception process flow

V. CHOICE OF CAN CONTROLLER

There are many types of CAN controllers, some of them are integrated in MCU, and others are independent from MCU. The performance price ration is relatively higher in MCU with integrated CAN; functionally it is much the same with independent CAN controller. The At mega 128, from the Atmel Company, is chosen as MCU in exploitation as a result of the downward compatibility in the devices, without integrated CAN controller in this MCU; we have to consider the independent CAN controller. Nowadays, both SJA 1000 from Philips and MCP 2515 from Microchip are very widely used as the independent CAN controller chips. Both are much the same in price and function, however, the communication mode between SJA 1000 and MCU is parallel data communication, which requires lots of I/O ports, the connection between MCP 2515 and MCU is standard SPI, which undoubtedly decreases the I/O ports. MCP 2515 is an independent CAN protocol controller, totally supporting the technical specification of CAN V 2.0 B, and it could send and receive standard, extended and long-distance data frames. The accepting two shield registers and six filter registers in MCP 2515 can filter some unwanted message, so that the cost of MCU is reduced a lot.

VI. MCP 2551 CAN TRANCEIVER

The CAN Bus Boosterpack for the TIVA C Launchpad evaluation board will be designed around an MCP 2551 CAN transceiver. The MCP2551 is a high-speed CAN, fault-tolerant device that serves as the interface between a CAN protocol controller and the physical bus. The MCP2551 device provides differential transmit and receive capability for the CAN protocol controller on the TIVA C Launchpad. It operates at speeds of up to 1 Mb/s. It also provides a buffer between the CAN controller and the high-voltage spikes that can be generated on the CAN bus by outside sources.



Pin Number	Pin Name	Pin Function
1	TXD	Transmit Data Input
2	Vss	Ground
3	VDD	Supply Voltage
4	RXD	Receive Data Output
5	VREF	Reference Output Voltage
6	CANL	CAN Low-Level Voltage I/O
7	CANH	CAN High-Level Voltage I/O
8	Rs	Slope-Control Input

Fig.5: MCP 2551 **Fig.6: Pin Function of MCP 2551 pins**

VII. CONCLUSION

Compared with the traditional manual operation or point-to-point interconnection, the use of CAN-bus technology can reduce wiring significantly, as well as a simple body structure. Therefore, system reliability can be improved and easier to maintain. There is a flexibility to increase or decrease the number of nodes on the CAN bus. To increase or decrease the number of nodes on the CAN bus only software modifications are required and hardware does not require any modifications, and completely universal. CAN bus is playing an important role in the vehicle network.

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