Hierarchical Automobile Communication Network using LIN Subnet with VI based Instrument Clusters and OBD-II Regulations

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Abstract— With the proliferation of electronic systems within automobiles, using CAN(Control Area Network) for all automotive electronics becomes prohibitively expensive and complex. Recently another communication standard called LIN (local inter connect network) has emerged as a viable replacement to CAN. LIN is a simple and low cost solution to reduce the complexity and the cost of the overall automotive network. A combination of CAN and LIN when required and dedicated can be used to reduce the cost of automation in industries in a significant way. Also such a hierarchical network can be used effectively in conjunction with a SCADA system based on Virtual Instrumentation for monitoring and control by a virtual control panel(Touch screen LCD) located in the instrument cluster of the vehicle according to OBD-II(On Board Diagnostics) regulations

Keywords-CAN,LIN, CAN-LIN Combination, SCADA systems, Virtual Instrumentation, Labview,Virtual control panel, OBD-II regulations

1. Introduction

Over the years CAN (Controller Area Network) Bus has emerged as a communication standard for automation requirements in various fields. Industrial automation is one such field where CAN bus is used to a large extent for distributed control systems and remote control systems in association with PLCs. Some aspects of the CAN bus that restrict its usage in the industry for certain applications. Some of these reasons are complexity and cost.CAN is a relatively complicated standard to configure and implement. It is also among the most expensive communication options available. With the proliferation of electronic systems within automobiles, using CAN for all automotive electronics becomes prohibitively expensive and complex. There is a requirement to find alternate means of reducing the complexity and cost of automotive networks. Also with increasing electronics in an automobile there is a surge of information available in the vehicle.

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As of now there is no practically viable solution to present all of the information to the user. Recently another communication standard called LIN (local inter connect network) has emerged as a viable replacement to CAN in simple applications. LIN is CAN and is also very simple to implement and configure. Devices with LIN communication tend to be very cheaper and simpler than CAN based devices. LIN can also be used in a hierarchical network configuration, where a LIN based network can server as a subnetwork to a primary CAN network[1]. LIN is a simple and low cost solution to reduce the complexity and the cost of the overall automotive network LIN can work in conjunction with the CAN network to reduce the load on the CAN network. Virtual instrumentation is used for providing a solution to provide the data from the various electronic systems within the automobile[2]. A combination of CAN and LIN when required and dedicated LIN networks when possible can be used to reduce the cost of automation in industries in a significant way.Also such a hierarchical network can be used effectively in conjunction with a SCADA system based on Virtual Instrumentation using the Labview Software. Using VI a control panel according to OBD II regulations, can be emulated to interact with such a network.On-Board Diagnostics, or OBD, in an automotive context, is a generic term referring to a vehicle's self-diagnostic and reporting capability. OBD systems give the vehicle owner or a repair technician access to state of health information for various vehicle sub-systems. Early instances of OBD would simply illuminate a malfunction indicator light, or MIL, if a problem was detected—but would not provide any information as to the nature of the problem. Modern OBD implementations use a standardized digital communications port to provide real-time data in addition to a standardized series of diagnostic trouble code, or DTCs, which allow one to rapidly identify and remedy malfunctions within the vehicle[3].

2. SIMULATED ANALYSIS ON THE AUTOMOBILE BODY ELECTRICALCONTROL SYSTEM BASED ON CAN-LIN BUS

The automobile network based on CAN-LIN bus, a system that is able to reduce the number of wiring harnesses and realize the sharing of data, is more and more widerly adopted in modern automobiles nowadays. Meanwhile, in developing of the such automobile network, to reduce the cost and save resources, the CAN analyzer software is utilized when performing simulated analysis on the electrical control system of the automobile body. The impact on the network load from the average delay time and the data transmission speed is determined by the data analysis, while the network load and the delay time are also monitored[4].

3. BASIC FUNCTIONS OF CANALYZER

CANalyzer is a general develop and analyze tool for CAN bus systems developed by VECTOR, being able to perform convenient monitor and analysis on the bus data from 32 channels at most. The application range of CANalyzer is wide, from simple demonstration to complicated analysis and simulation, and in the bus channel of LIN. CANalyzer adopts the flow diagram that demonstrates the process of data flow not only from the CAN bus through the PC card to the various access windows and log files, but also the process from the PC card through the transmission branches to the bus[5]. With CANalyzer, the CAN controllers (for instance, SJA 1000 and Philips 82C200) can be simulated with PC Board cards; the window lifter controller, the room lamp and embarkation lamp controller, the door switchcontroller and the meter detector etc. can be simulated with the generator block and CAPL block

4. DETERMINATION OF CAN-LIN NETWORK PERFORMANCE INDEXES

For CAN network performance analysis, three indexes are defined to describe the dynamic performance of CAN network, including[6]:

1. ***Network Throughput*****:** the average bits transmitted successfully through one node on the bus within a unit time. Here the normalized throughput is adopted, that is, the ratio between the network throughput and the signal channel transmission speed;

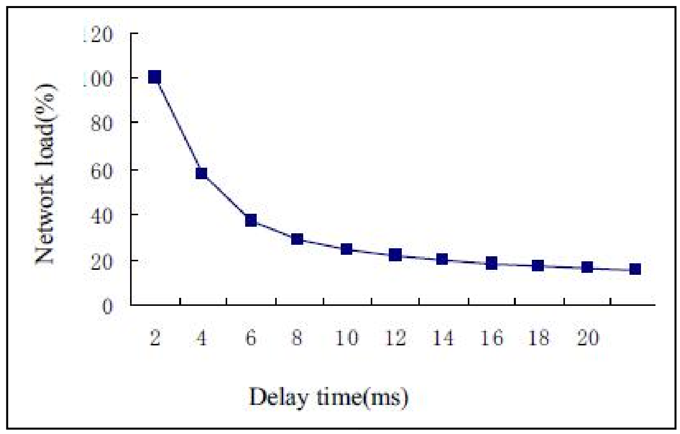
2. ***Network Load*****:** the average bits that are available to be transmitted within a unit time, comprising of the analysis load and the statistics load. The analysis load considers only the newly arrived information to the network, and no repeated information is included. In case all the information is transmitted successfully, the analysis load equals with the network throughput. The statistics load comprises all the repeated information on 237 the network.

3. ***Average Transmission Delay Time*****:** the average delay time of information (including repeated information) of a unit byte or a unit bit. Considering the different length of information frames, the situation with bit as the unit is adopted.

5. SIMULATED ANALYSIS

1. Impact on the Network Load from the Average Delay Time:

Firstly, CANalyzer is installed on PC and run, and a Windows Block is inserted into the Measurement Setup under the CANalyzer menu of configuration/options, with the setting of delay: 0ms. Then, the data transmission speed of PC Board is set as 500Kb/s. When the simulation starts, the Busload is 100%. During the simulation, only the value of delay shall be changed, the other factors remain unchanged. The relation between the two factors is shown as in Fig. 3. Therefore, it is concluded from Fig. 1 that



(Relation of delay-time and network loads)

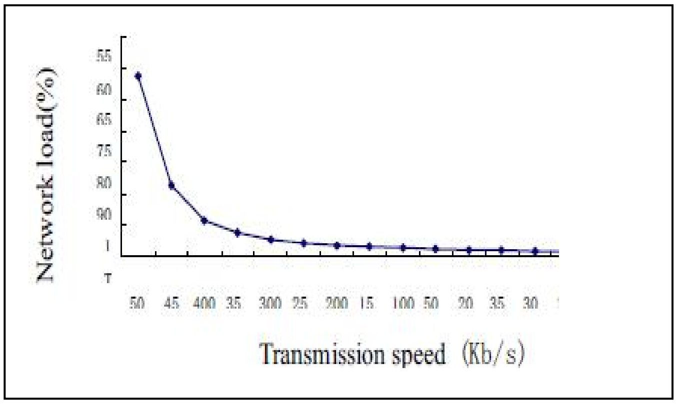
1. If the message is periodical, and its delay timeis 0, then the network load is 100%, which means that the message has taken the whole bandwidth, and therefore the reserve capacity becomes 0. Under such circumstances, if any node or message is added to the system, the system cannot execute immediately, which means that the system performs rather poorly; any change in delay time will change in different degrees the network load of the system and impact its performance.

2. The shorter the system delay time, the lighter the network load. However, the network load can only approach but never become 0. This is because when the delay time becomes longer, the fewer message frames are transmitted per second. The system design shall ensure sufficient reserve capacity for the system through setting appropriate delay time according to the actual situation.

3. The relation between the delay time and thepeak value network load is that the longer the delay time,the lighter the peak value network load, but the difference between the peak value network load and the network load is no more than 1%, which means that the system is relatively stable.

4. Impact on the network load from the data transmission speed:

The impact on the network load from the data transmission speed of the CAN and LIN bus network can be analyzed with the automobile CAN network setting file Motbus.cfg contained by CANalyzer. To start-up the main program of CANalyzer, and choose Ig.cfg under File/Load configuration, change the Baudrate value of PC Board and leave the other factors unchanged. The relation is shown in Fig. 2 and 3.



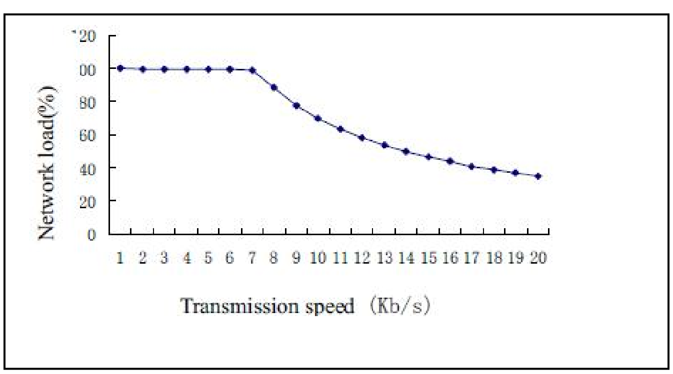
(Relation of CAN node's data transmission speed and network loads)

In the figures above, the horizontal axis shows the data transmission speed, and the vertical axis, the network load. It can be concluded from Figs that:

1. The network load decreases as the network data transmission speed (Baudrate) increases

2. In Fig. 3, no certain relation exists between the network load and the network data transmission speed, mainly because that the data transmission speed is too slow, the transmission rate is too low, and the message frames transmitted per second are rather few.

3. In Fig. 3, the data transmission speed is about 7Kb/s, and a small skip happens to the network load, which



(LIN node's data transmission speed and network loads)

means that, to avoid message transmission mistakes, the data transmission speed shall be kept above 10Kb/s in actual network configuration. The network performance can be improved when faster network data transmission speed is adopted. However, the requirements on hardware become higher when the data transmission speed increases. Therefore, the actual system design shall both guarantee the system performance and make full use of communication bandwidth to avoid wasting.

6. ON BOARD DIAGONOSTICS-II

On-Board Diagnostics, or OBD, in an automotive context, is a generic term referring to a vehicle's self-diagnostic and reporting capability. OBD systems give the vehicle owner or a repair technician access to state of health information for various vehicle sub-systems. Here VI is used to create the data base for OBD regulations in Lab –View. Sensors are employed for measuring engine related and critical emission related components. These values are compared with the database and corresponding Diagnostic trouble codes are generated(DTCs). DTCs can be analyzed by using hand held series connecter or by a PC. OBD-II is an improvement over OBD-I in both capability and standardization. The OBD-II standard specifies the type of diagnostic connector and its pinout, the electrical signalling protocols available, and the messaging format. It also provides a candidate list of vehicle parameters to monitor along with how to encode the data for each. There is a pin in the connector that provides power for the scan tool from the vehicle battery, which eliminates the need to connect a scan tool to a power source separately[7].

1. VIRTUAL INSTRUMENT CLUSTER

Lab-View software is used for designing the VI interface. It helps to implement instruments that are similar in appearance to physical instruments. The advantage of VI is the fact that since they are not present physically, they dont take up physical space in a vehicle. On a single display like an LCD different sets of Vis can be displayed for different purposes. Sensor values are accessed serially using line drivers from LIN master nodes and displayed[8].

(Virtual instrument clusture)

1. CONCLUSION

1. The number and data transmission speed of the CAN and LIN nodes shall be sensibly chosen, and the parameters in CANalyzer shall be reasonably chosen, to ensure the reasonability of the data and the correctness of the conclusions;

2. The simulation proves that the longer the message transmission delay time, the smaller the network load; the faster the message transmission speed, the smaller the network load. Therefore, to ensure the reliability of data transmission on the LIN bus, considering the performance and costs comprehensively, the LIN connectors with a transmission speed faster than 10Kb/s shall be the best choice.

3. The advantage of VI is the fact that since they are not present physically, they dont take up physical space in a vehicle.

4. OBD systems give the vehicle owner or a repair technician access to state of health information for various vehicle sub-systems.

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