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CAN Modeling and Network Simulation for School-Bus Information Integrated Control System

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***Abstract* - With the increase of the number and the complexity of School-bus ECUs (Electronic Control Units), it needs to design School-bus information integrated control system for sharing information and implementing correlative, real-time control between these ECUs. Before School-bus information integrated control system development, it is necessary to simulate and analyze system performance.**

The main advantages of using CAN as a field-bus technology are reduced wiring (CAN requires only two wires between nodes), extremely reliable communication, easy implementation and improved maintenance and service capabilities, which consequently not only produce better vehicle performance, but also help to reduce production costs.

(Society of Automotive Engineers) SAE J1939 protocol has been implemented in a broad range of vehicles and transportation systems. J1939 provides a communication protocol over a CAN network. The CAN network is comprised of two or more interconnected Electronic Control Units (ECUs). As per the SAE J1939 specification the ECUs are connected using linear shielded twisted pair wiring, with a data rate of 250 Kbits/second.

According to SAE J1939 protocol requirement, we concluded that all the messages satisfied with the system real time requirement.

Index Terms – School-Bus; CAN; SAE J1939; Model; System Simulation

I. INTRODUCTION

School-bus is one of the most important part in School students service architecture. Point-to-point link is the main electrical and electronic devices connection method in traditional school-bus. This method is impossible to implement information exchange between ECUs and causes an increase of cost and production time, reliability and maintenance problems. Thus, it needs to design school-bus information integrated control system with vehicular network for sharing information and implementing correlative, real-time control between ECUs.

Nowadays, CAN is widely applied in vehicular network control for its unique performance. Because CAN specification just defines physical layer and data link layer, the SAE J1939 has been developed by the SAE Truck & Bus Control and Communications Network Subcommittee of the Truck & Bus Electrical & Electronic Committee as a CAN application layer protocol.

Currently, many researchers focus on CAN message response time modeling and CAN protocol model with different method. But less people researches on CAN modeling and network simulation for special system. In this project, we mainly research on CAN modeling and network simulation for school-bus information. This project is organized as follows: we established CAN model including physical layer model, MAC (Medium Access Control) sub layer model, LLC (Logic Link Control) sub layer model and application layer model. Finally, we concluded and presented future work.

II. CAN MODELING OF SCHOOL-BUS INFORMATION INTEGRATED CONTROL SYSTEM

CAN network topology model of city-bus information integrated control system (single CAN bus) is shown in Fig.1. This model includes 10 ECU nodes (from ECU_0 to ECU_9), 1 statistic collection node (stat_collect) and 1 physical layer node (medium). Because every ECU node is universal and can be configured before simulation, we didn't give special name to each ECU node.

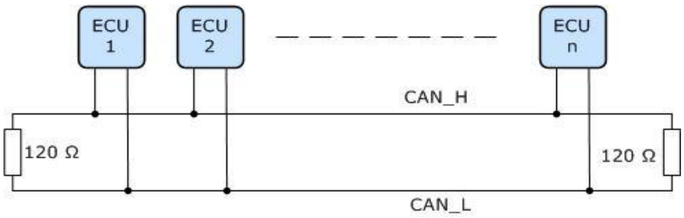

Fig.1 CAN network topology model of School-bus information integrated control system (single CAN bus)

A. Physical Layer Model

The Physical Layer defines how signals are actually transmitted and therefore deals with the description of bit timing, bit encoding, and synchronization. In CAN model,

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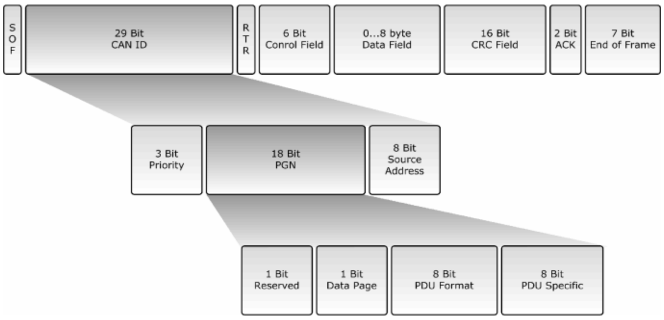
physical layer receives CAN message from ECU node and broadcasts this message to other ECU nodes. For simplifying modeling, physical layer model just transmits message to statistic collection model (stat_collect). There is frame transmission delay during bit stream transmitting process. Frame transmission delay is decided by frame length and bus transmission baud rate.

Because we use SAE J1939 application protocol in school-bus information integrated control system, we designed CAN model with 29 bits identifier and 8 bytes data field. The total frame length is 128 bits (shown in TABLE I). The SoF, Arbitration Field, Control Field, Data Field and CRC fields are Coded by bit-stuffing method. As shown in Fig.2, every 4 bits need to add 1 reversed bit in worst case. The total frame length is 157 bits in worst case.

CAN Extended frame format



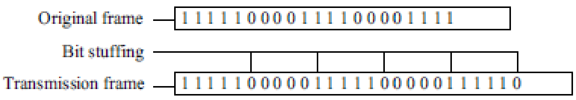


Fig.2 Bit stuffing under worst case

Calculate CRC with a given error ratio. After 157 bit time delay, it transmits the message to statistic collection mode (stat_collect) and sets bus state to “busy” persisting 160 bit time. The additional 3 bit time is interframe space which forbids transmitting message, i.e. bus “busy”.

III. Flow chart and Schematic Diagram

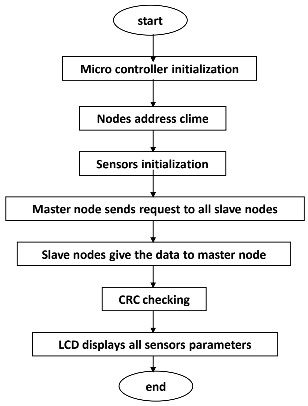


Fig .3 Flow chart of the CAN Modeling Of school-Bus Information Integrated Control System

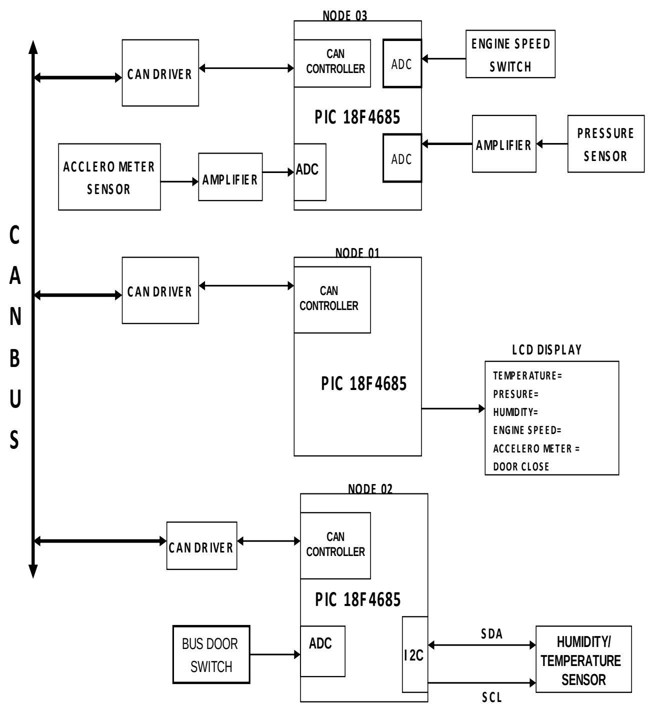


Fig .4 Proposed block diagram of the CAN Modeling Of school-Bus Information Integrated Control System

IV. J1939 Message format for Request and Data

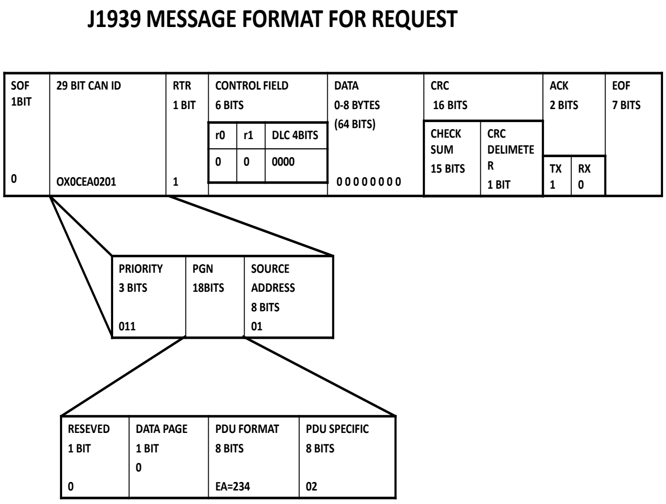


Fig .5 J1939 Message format for Request of the CAN Modeling Of school-Bus Information Integrated Control System

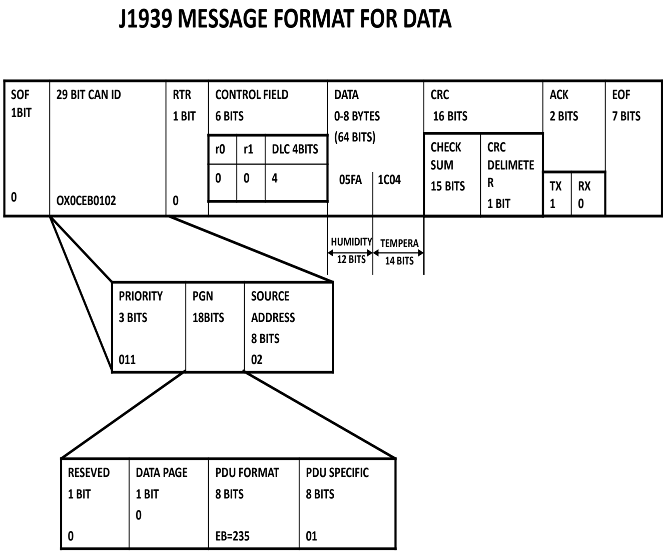


Fig .6 J1939 Message format for Data of the CAN Modeling Of school-Bus Information Integrated Control System

V. CAN analyzer Output

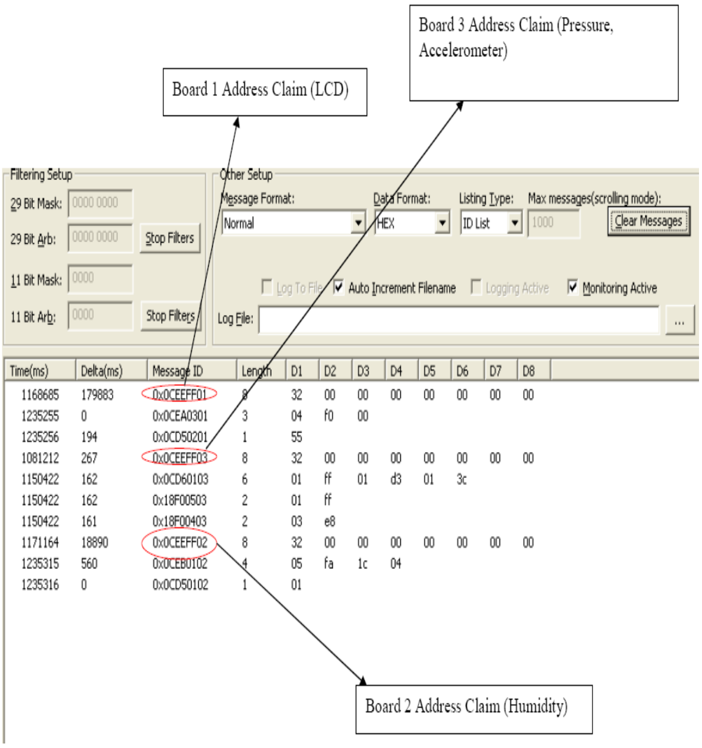


Fig.7 CAN analyzer software output, showing node addresses

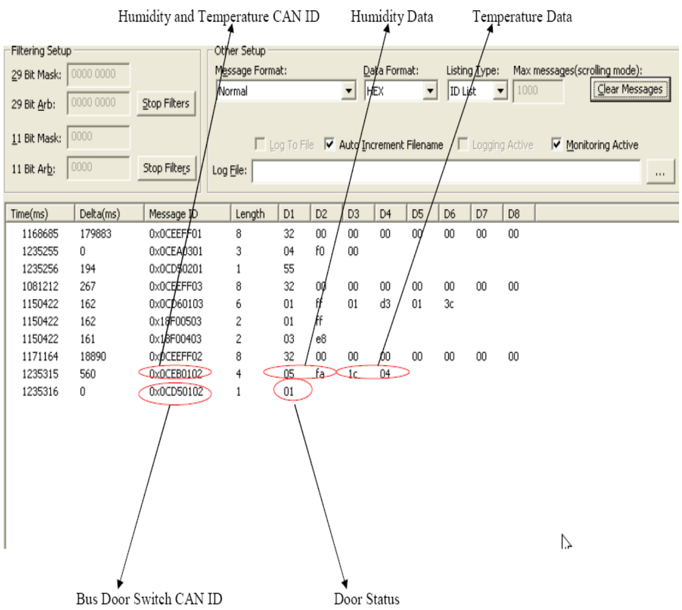


Fig.8 CAN analyzer software output, showing node addresses and data of humidity, temperature, and door status

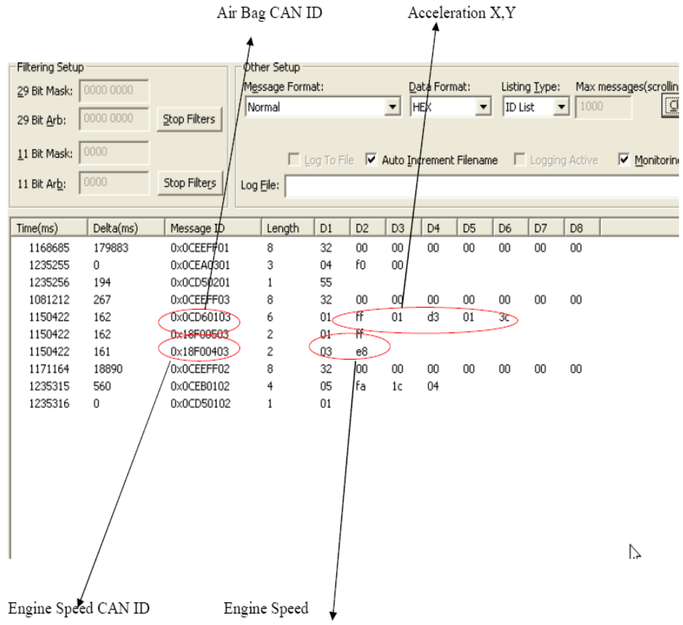


Fig.9 CAN analyzer software output, showing node addresses and data of engine speed and accelaration

VI. SUMMARY

Advances in data communications have created efficient methods for several devices to communicate using a minimum number of system wires. The Controller Area Network (CAN) is one of these methods. CAN sends and receives messages over a two-wire CAN bus. The nodes broadcast their individual messages over the CAN bus, while the receivers are setup to accept the message and anticipate an acknowledgment (ACK) signal indicating the receipt of a non-corrupted message. The protocol of the CAN has two states and the bits are either dominant (logic '0') or recessive (logic '1'). Nodes may attempt to transmit a message at the same time. To ensure that collisions do not reduce the throughput of the bus, there is an arbitration scheme in which a node will continue to transmit until a dominant bit is detected, while that node is expecting a recessive bit (in the ID field) on the CAN bus. The node(s) that lose arbitration will automatically terminate their transmission and switch to receive mode. Once the CAN bus enters an idle state, these nodes attempt to re-transmit. If the node does not lose arbitration, it completes its transmission.

The bus configuration operates by the multi-master principle and allows several node boards to connect directly to the bus. If one node board fails in the system, the other node boards are not affected. The probability of the entire network failing is extremely low compared to ring type networks. Ring type networks have a high probability failure rate, due to the fact that if one node malfunctions, the entire network becomes inoperable.

VII. CONCLUSIONS

The CAN extended model works for Maximum network length of 40 meters (~120 ft.), Standard baud rate of 250 kBit/sec, with Maximum 30 nodes (ECUs) and Maximum 253 controller applications (CAs) where one ECU can manage several CAs.

3 nodes are connected to the CANBUS, the CAN extended model is used for communication between 3 nodes, for measuring the different parameters of vehicle network like temperature, humidity, pressure, accelerations, engine speed, and door status.

Three nodes are provided with different CAN message IDs and sensors data has shown in CAN Analyzer Software, and also shown in LCD display in node1. The CAN controller seeks to solve this problem.

VIII. FUTURE SCOPE

In this Project parameters measured are Engine Temperature, Tire Pressure, environmental Humidity, Bus Accelerations, Bus Door Locking Indication, and Engine RPM.

For measuring of other required parameters in any vehicle like Tilt measuring, Fuel level indicator, Oil heat measuring, Chassis control, Braking/cooling, Speed control, Power control, etc., we have to connect the related sensors.

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