PERFORMANCE EVALUATION OF CONTROL AREA NETWORK WITH INTELLIGENT VEHICLE BLACK BOX SYSTEM

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Abstract
The main purpose of this paper is to develop reliable and affordable tools and methodologies for the design, simulation, and fault analysis of Control Area Network (CAN). Some of the undesired situation may occur such as bus line short circuits, power supply fault, transceiver over temperature must be correctly modeled and detected. Therefore the test and fault diagnosis of network are strongly required to ensure that all the CAN bus devices are able to correctly and reliably interact as specified. CAN networks, including a large number of ECUs working in different operating conditions, require a special attention regarding the convergence in transient analyses. Error checking techniques is used to detect the error in the data frame transferred along the CAN bus. The proposed automotive Black Box design intends for storing and retrieving the data of various ECU on standard CAN protocol frame. The data stored and retrieved can be used for introspection of cause of failure or unfortunate miss happening in the vehicle.
Keywords: CAN: Controller Area Network, VHDL: Very High Speed Hardware Description Language, fault simulation analysis, signals integrity analysis.

1. INTRODUCTON

The Controller Area Network (CAN) network application domain has been increasing significantly over the last several years. Moreover, the growing diffusion of CAN in safety- or mission-critical applications (e.g., automotive and biomedical systems) asks for suitable techniques to assess the dependability of CAN networks. The continuous increase in the integration level of electronic systems is, indeed, making more difficult than ever to guarantee an acceptable degree of reliability. Therefore, test and fault diagnosis of network integration are strongly required to ensure that all CAN bus devices are able to correctly and reliably interact as specified.

The design and validation process of CAN networks is time consuming and expensive, as some iteration steps between design and validation are needed. Validation by measurements on prototype vehicles is not exhaustive; in fact, corner or faulty conditions can be hardly configured. Moreover, worst case configurations are usually not available during the early stages of development process, and tolerance values are distributed randomly among networked devices. In order to propose an effective solution, specific aspects concerning CAN network characteristics must be taken into account. In particular, the following properties and issues must be carefully dealt with by the proposed solution.

1) Signal integrity: A reliable representation of bus-line electrical signals permits the optimization of the entire system considering many variables, for instance, different operating temperatures for each transceiver, different input impedances in the case of hybrid networks, the device parameter variation within the specified range, etc.

2) One of the main aspects of accurately representing electrical bus signals is the related amount of electromagnetic emission (EME). Mainly in automotive systems, which are well

known as noisy electromagnetic environments, EME investigation must be addressed.
3) Test and fault diagnosis of network integration are strongly required to ensure that all CAN bus devices are able to correctly and reliably interact together as specified.
4) The verification of CAN networks must ensure that the worst case combination of parameters (i.e., corner analysis) and tolerances assures sufficient signal integrity.
5) A network diagnosis considering whether any electronic control unit (ECU) is working properly has an important and direct impact on the network reliability assessment.

Modern automobile units include many microcontrollers and their number is growing continuously. Driver's comfort and safety is of utmost importance in today's heavy competitive world. This has also made it possible to introduce & integrate new, wide & advanced range of products in vehicles for e.g. Breaking & stability control, anti-collision systems, parking aids, engine injection i.e. advanced safety systems, exhaust & emission management system, body control. Many state-of-the-art methodologies in vehicle communication technology exist within vehicles, as well as between vehicles which are referred as Intra-Vehicular communication & Inter-vehicular communication respectively**.**

In this paper, present results of VHDL code of CAN Protocol and have also presented FPGA synthesis results of CAN bus which will be used for designing of proposed Vehicle black box. The proposed Vehicle black box will be lead to simulate the emergency conditions i.e. accident situations the vehicle have encountered.

1.1 CAN OVERVIEW

Controller Area Network (CAN) was initially created by German automotive system supplier Robert Bosch in the mid-1980s for automotive applications as a method for enabling robust serial communication. The goal was to make automobiles more reliable, safe and fuel-efficient while decreasing wiring harness weight and complexity. It specifies a maximum signaling rate of 1M bit per second (bps). Since its inception, the CAN protocol has gained widespread popularity in industrial automation and automotive/truck applications.

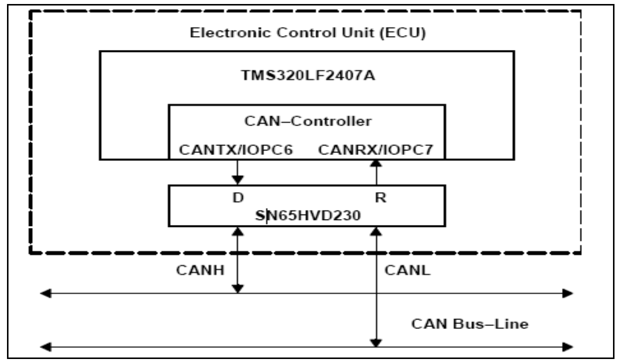

Fig1. Details of an Electronic Control Unit

The data link and physical signaling layers of OSI model, which are normally transparent to a system operator, are included in any controller that implements the CAN protocol, such as Texas Instruments' TMS320LF2407 3.3-V DSP with integrated CAN controller. Connection to the physical medium is then implemented through a line transceiver such as TI's SN65HVD230 3.3-V CAN transceiver to form what the ISO–11898 standard refers to as an electronic control unit (ECU) in Figure.1.

1.2 CAN FRAME

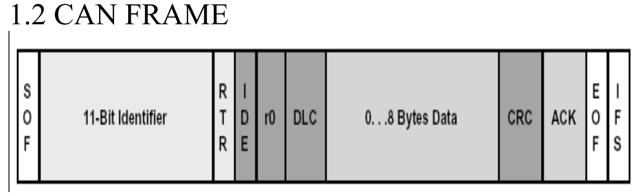

Fig2. 11-bit Identifier

The frame transmitted along the CAN bus. The bit fields of frame are in the Fig 2.
□SOF—The single dominant start of frame (SOF) bit marks the start of a message, and is used to synchronize the nodes on a bus after being idle.
Identifier—The Standard CAN 11-bit identifier establishes the priority of the message. The lower binary value, the higher its priority.
RTR—The single remote transmission request (RTR) bit is dominant when information is required from another node.
IDE—A dominant single identifier extension (IDE) bit means that a standard CAN identifier with no extension is being transmitted.
r0—Reserved bit (for possible use by future standard amendment).
DLC—The 4-bit data length code (DLC) contains the number of bytes of data being transmitted.

Data—Up to 64 bits of application data may be transmitted.
CRC—The 16-bit (15 bits plus delimiter) cyclic redundancy check (CRC) contains the checksum (number of bits transmitted) of the preceding application data for error detection.
ACK—indicating an error-free message has been sent.
EOF—This end-of-frame (EOF) 7-bit field marks the end of a CAN frame (message) and disables bit–stuffing, indicating a stuffing error when dominant.
IFS—This 7-bit inter-frame space (IFS) contains the amount of time required by the controller to move a correctly received frame to its proper position in a message buffer area.

2. METHODOLOGY

Automotive black box will be installed in vehicle and will be used to store the data supplied by CAN host downloaded on FPGA. The data thus stored in Black box can be retrieved and can be used for simulating any external or internal emergency situation which has lead to cause of accident. The design methodology is shown in Figure 3.

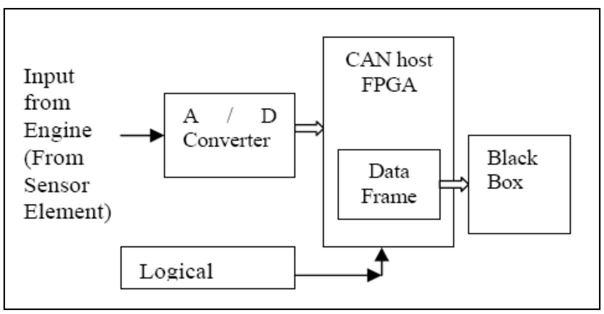

Fig3. Block diagram of design methodology

The digital signal thus derived from output of ADC is given as input to CAN host FPGA which holds Data frame and directs it to Black box. The black box will store the frame and will make available as and when required. The 8-bit input from the analog to digital converter is used to form the complete data frame by the CAN Host which will be transmitted to the black box. The data frame that is to be transmitted by the CAN-Host will consist of the following fields: Identifier field, control field, data field and CRC field. Obviously all of these fields will vary according to the system. The emergency situation in Vehicle i.e. output of sensor element from the Engine of a car can be simulated using ADC converter in which the Analog input is varied by potentiometer or the same can be simulated by XILINX software. The digital signal is given as input to CAN aspects regarding e.g. electrical features and the interpretation of data to be transferred.

3. DISCUSSION

A. Signal Integrity Analysis

It is the process of analyzing the unity of the signal. The signal integrity verifies whether recessive-to dominant and dominant-to-recessive bit transmission transitions are properly done. In both cases, transceiver power supplies have typical values, and no bus error has been injected. A first signal feature is the transmission delay from a TxD event and the delay from a bus-line event detection to the RxD change. In general, the signal timing characteristics are strongly influenced by conditions is useful in order to validate CAN systems operating at high bit rates. Moreover, the signal timing analysis is essential for the bitwise arbitration of the CAN protocol.

B. Fault Analysis

The model capability of accurately modeling faults is very useful during CAN systems ‘early development stages. The fault occurs in the frame transmitted along CAN bus may be detected using Cyclic Redundancy Check technique. CRC,
is a technique for detecting errors in digital data, but not for making corrections when errors are detected. From this check we can able to find out whether the transmitted data is corrupted or not. The following is the procedure for sending the data below with the given polynomial generator. For (e.g.) Data to be sent: 11011. Polynomial generator: x4 + x2 +1

1. Take the polynomial generator and work out its corresponding binary representation by identifying the absent powers its Divisor = 10101 ;this is the digital representation of the polynomial generator.
2. A Frame Check Sequence (FCS) which equates to the highest power of the polynomial generator – (4 in the example above and represented as four zeros -0000).
3. The CRC is calculated by dividing the binary representation of the polynomial into the DATA + FCS using modulo-2 arithmetic.

So we calculated the CRC by dividing the binary representation of the polynomial into the data and the FCS. So we end up with 1001 which is the CRC. So it's easy enough to find the CRC. Now we have the CRC for the data which has been sent all theirs left to do is check the CRC and find out if the data has been received correctly. We do this exactly like the CRC Generator. If the remainder is all 0s, the CRC is dropped and the data is not corrupted, if the remainder is not = 0s, the data is corrupted If the remainder is all 0s, the CRC is dropped and the data is not corrupted, if the remainder is not = 0s, the data is corrupted. Thus the occurrences of error in the frame have been detected and store the data in the automotive black box.

4. SIMULATION AND SYNTHESIS RESULT

The design is implemented in VHDL and is tested for simulation and FPGA synthesis on XILINX MODEL SIM tool. The results presented in this section are simulation results of various sections of design.

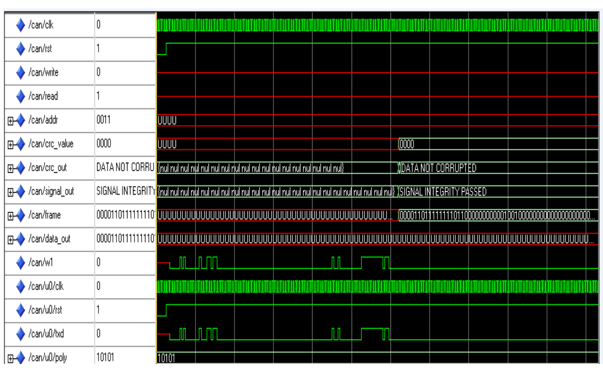

Fig4. Data without error

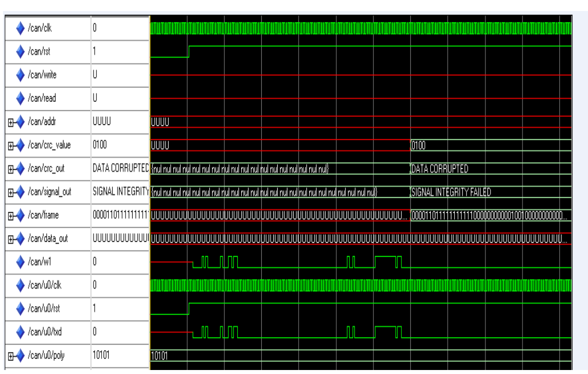

Fig5. Data with error

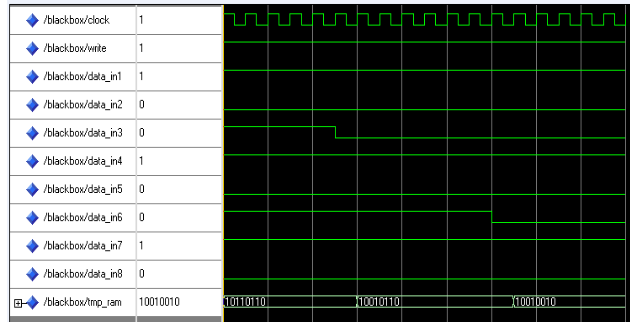

Fig6. Data stored in Black Box

5. CONCLUSION

The presented modeling methodology allows one to check functional behavior and fault analysis of the CAN bus networks. Special attention was given to fault condition analysis. The occurrence of fault in the CAN data frame was detected and transmitted along the CAN bus successfully. The proposed automotive Black Box design intends for storing and retrieving the data of various ECU on standard control frame. The data stored and retrieved can be used for introspection of cause of failure or unfortunate miss happening in the vehicle.

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