Development of CAN Bus Converter for On Board Diagnostic (OBD-II) System

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Abstract. CAN-bus technology is adapted in various vehicles to reduce the wiring harness and controls the vehicle exploitation physical system. In this paper, Control Area Network (CAN)-bus protocol is enforced employing a Single Board Computer (SBC) and access with each other by set a sender and receiver to get the data transmission. A special CAN-bus application layer protocol is intended for the high reliable and high period management network of the vehicle system. However not all microcontroller that used for Computer module in vehicle network had CAN-bus communication port. Thus the CAN-bus Converter is used as tool for converting data from a computer into an understandable language. The CAN-bus converter can also be used in various ways to obtain the final results of the data sent to it. Although different methods may be used, the most appropriate method cannot be identified. This project is therefore designed to find and evaluate which method is suitable for obtaining accurate data results and for avoiding abnormal data and data transfer speed.

1. Introduction

The Controller Area Network (CAN) was developed in the early 1980s by Bosch as a serial bus communication protocol. It sets the standard for efficient and reliable communication in real - time applications between sensor, actuator, controller and other nodes [1]. On-board diagnostics (OBD-II) is an automotive term that refers to the ability of a vehicle to diagnose itself and report. OBD systems provide access to the status of different vehicle subsystems to the vehicle owner or repair technician. OBD System. OBD is a computer-based system originally designed to reduce emissions by monitoring the performance of major components such as the engine, catalytic converter, particulate filter, oxygen sensor, emission control system, fuel system, and exhaust gas recirculation (EGR) [2]. In some cases, some of the microcontroller cannot communicate with can bus due to the communication converter protocol. It means that communication converter protocol consists of variety of protocol such as serial, serial peripheral interface (SPI) and inter-integrated circuit (I2C).

Therefore, this study will analyse the data packet transferring over conversion of difference communication protocol. Another case is mostly the converter of integrated circuit (IC) come in the form of chips and not fully support the protocol to communicate, so that the project needs to develop electronic circuit for data protocol conversion. Since this project will be implemented at the car, there are lots of method that can be used to get the data from electronic control unit (ECU) to on board diagnostic (OBD-II). Hence, this project needs to determine best protocol conversion method. This experiment focuses on communication protocol which is to develop can bus converter that can communicate with communication converter that consist of Serial and Serial Peripheral Interface.
This study will use two types of communication converter which are MCP2515 and CAN-bus shield V2 (MCP2551) to test the performance on latency and data loss of this project and determine which type of communication converter provide more efficient result.

2. CAN-bus protocol framework
The frame is the data link layer transmission unit [3]. In the CAN protocol, it is consists of four different types of frames [4-5]. The data frame and remote frame send messages during the transmission of error frames and overloading frames. The data frame is the format of the standard message. As shown in Fig. 1 Start-of-Frame (SOF’s) indicates the frame start. The field of arbitration contains an identifier and Remote transmission request (RTR) bit indicating whether the message is a remote application [6]. The control field specifies the length of data while the current content is stored in the data field [7]. A Cyclic redundancy check (CRC) sequence is included in the CRC field to verify the integrity of the message received [8]. The Acknowledge slot (ACK) field acknowledges that at least one of the nodes successfully receives the transmitted message.

![Frame Format](image)

**Figure 1. Frame Format.**

The End-of-Frame (EOF) marks the end of the seven-bit frame. The remote frame is a message sent by any node to request a different node to send the identical identifier to a data frame [9]. Data frame format differs in that the RTR bit marks 0 and the data field is empty.

3. Experiment Setup
To test which CAN-bus communication method is better, a hardware system needs to be setup as shown Figure 2. Where the OBD-II port in vehicle is connected to CAN-bus converter module and Microcontroller Arduino Uno. Then for the firmware to test performance of CAN-bus communication with different method, algorithm flow as displayed in Figure 6 is needed based on four stages to communicate the data between OBD-II and Arduino Uno. Stage 1 focuses in examining three bitrate and design electronic circuit for data transferring from ECU to sensor node device. Then, for the second stage, mathematical algorithm for converting different base number in data packet is applied. Next, the latency and data loss is analysed based on two different CAN-bus converter. Lastly, from the analysis of the result, high performance communication device for connecting ECU to sensor node is determined.

![Communication node hardware setup](image)

**Figure 2. Communication node hardware setup that will receive data from communication node.**
Figure 3. Flowchart.

Based on two different can bus converter analyse the latency and data loss.

Determine high performance communication device for connecting ECU to sensor node.

START

Examine bitrate and design electronic circuit for data transferring from ECU to sensor node device.

Vehicle OBD-II

Arduino receiver

Mathematical algorithm for converting different base number in data packet.
CAN-bus data packet formation
CAN-bus data conversion

Comparing experiment result. Is it same with calculation theories result?

YES

Comparing converted ECU (Arduino sender) data through electronic circuit and data in software.

YES

END
4. Experiment Result and Discussion

Based on 20 samples of data, the latency result from communication converter experiment is separate to three different baud rate 250kbps, 500kbps and 1000kbps as in Figure 4. The result shows decreasing trend of latency corresponding to the increasing of baud rate.

![Diagram A]

![Diagram B]
Figure 4. A, B and C are latency data for two different communication converter with different of baud rate at A=250kbps, B=500kbps and C=1000kbps.

Based on 20 samples of data, the data loss result from communication converter experiment is separate to three different baud rate 250kbps, 500kbps and 1000kbps as in Figure 5. The result shows decreasing trend of percentage of data loss corresponding to the increasing of baud rate.

Figure 5. Percentage of data loss between MCP2515 and CAN Bus shield V2.

5. Conclusion
From the experiment result it can be concluded that the best way to collecting data from ECU is by using the CAN-bus shield V2 CAN-bus converter board due to data clocking for every frame of data packet. From the CAN-bus data collection it can be concluded that the use of CAN-bus shield V2 CAN-bus converter will increase system performance due to fast clocking data packet collection. It’s easier to segregate the data into sub packet in two byte of data for data conversion method. Then for the CAN-bus data conversion it’s more accurate by using string to long integer converter because it will directly convert the hex data without SOF. Besides that, from the result of latency between
MCP2515 and CAN-bus shield V2 showed that CAN-bus shield V2 converter have average low latency than MCP2515. From the study, it has been proven that CAN-bus shield less data loss then MCP2515 due to the previous calculation result.

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