Microprocessor Communication Module Connecting On Board Diagnostic System and Personal Computer

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Microprocessor Communication Module Connecting On Board Diagnostic System and Personal Computer: *The article considers hardware and software development of a Microprocessor Communication Module Connecting On Board Diagnostic System and Personal Computer. A microprocessor-based embedded system was chosen to implement the Physical layer. The overall functionality of the physical layer is to receive and transmit frames of data between the On Board Diagnostic System on the vehicle and the Data Link Layer residing on a PC. The frame coming from the Data Link Layer is sent to the PIC18F452 microcontroller, where based on the type of protocol, it is encoded following the timing constraints.*

Key words: *communication interfaces, physical layer, microprocessor systems, on board diagnostic systems, message format.*

INTRODUCTION

One of the most important world problems is to save our planet clean and to reduce the exhausted emissions, caused by the vehicles. Development and elaboration of good testing systems for vehicles is one of the solutions of that problem.

On Board Diagnostic (OBD) systems introduced by the “California Air Resources Board” are incorporated into the computers on-board new vehicles to monitor components and systems that may affect emissions when malfunctioning. The second generation of OBD requirements, which is known as OBD II, has been fully in effect since the 1996 model year for Passenger Cars, Light Duty Trucks, and Medium Duty Vehicles with Feedback Control Systems. Title 13 of California Code of Regulations (CCR) defines the diagnostic functions to be supported by vehicles and also defines functions to be supported by test equipment that interfaces with the vehicle diagnostic functions [7].

The OBD II systems monitor virtually every component that can affect the emission performance of a vehicle. If a problem is detected, the OBD II system illuminates a warning lamp on the vehicle instrument panel to alert the driver

The Physical Layer and its associated wiring form the interconnecting path for information transfer between Data Link Layers. Typical layer elements include voltage/current levels, media impedance, and bit/symbol definition and indication of different frame timings.

The OBD II Scan Tool must be able to communicate with the vehicle control modules using the prescribed communication interfaces. The interfaces are:

- SAE J1850 41.6 Kbps PWM [6];
- SAE J1850 10.4 Kbps VPWM;
- ISO 9141-2 [8, 9, 10, 1].

NETWORK ELEMENTS AND STRUCTURE

The general format of a message frame for SAE J1850, which is transmitted over the OBD II Bus, consists of different Network Elements: Idle, SOF, DATA, EOD, CRC, NB, IFR, EOF, IFS, and BRK (Fig. 1) [5, 3].

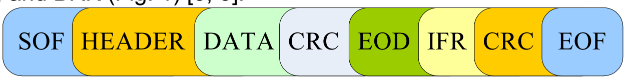

Figure 1. Structure of the message frame in SAE J1850

The preceding acronyms are defined as follows:

- Idle: Idle Bus that occurs before SOF and after IFS;
- SOF: The SOF (Start Of Frame) mark is used to uniquely identify the start of a

frame;

- DATA: Data bytes each 8 bits long;
- EOD: End Of Data (EOD only when IFR is used) is used to signal the end of transmission by the originator of a frame;
- CRC: Cyclic Redundancy Check Error Detection Byte;
- NB: Normalization bit is applicable to 10.4 Kbps implementation. The NB defines the start of the in-frame response;
- IFR: The In-Frame Response bytes are transmitted by the responders after the EOD.
- EOF: The EOF (End Of Frame) defines the end of frame;
- IFS: The IFS (Inter-Frame Separation) is used to allow proper synchronization of various nodes during back-to-back frame transmissions. A transmitter must not initiate transmission on the bus before the completion of the IFS minimum period;
- BRK: This BRK (Break) can occur any time on a network.

The ISO 9141 protocol uses a Universal Asynchronous Receiver/Transmitter (UART) serial communication at a rate of 10.4 Kbps, 1 start bit, 8 data bits, no parity bit and 1 stop bit. A simple data byte (45h) is shown in Figure 2 with Start and Stop bits. The bit time is 96 μs.

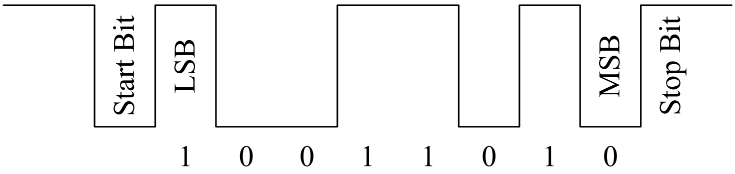

Figure 2. ISO 9141-2 sample data byte (45h)

When connected to a vehicle the OBD II Scan Tool must automatically attempt to determine which of the possible communication interfaces is being used in the vehicle to support OBD II related functions. The tool must continue to try to determine which interface is being used until it is successful in doing so. No user input can be required, nor allowed, to determine the appropriate interface.

DIAGNOSTIC MESSAGE FORMAT

The messages are limited to a three-byte header, and have a maximum of 7 data bytes, as shown in Table 1. The message format is used by all three protocols.

Table 1. Diagnostic message format

Header Bytes			Data Bytes								
Priority/type	Target Address	Source Address	#1	#2	#3	#4	#5	#6	#7	ERR	RSP

The first three bytes of all diagnostic messages are the header bytes. The value of the first header byte depends on the bit rate of the data link and the type of message. The second header byte has a value that depends on the type of the message, either request or a response. The third header byte is the physical address of the device sending the message and is generally F1h for an OBD II scan tool. SAE J1850 uses cyclic redundancy check (CRC) and ISO 9141-2 checksum, as an error detection (ERR) byte [2].

FEATURES THE PIC18F452 IN TERMS OF THE COMMUNICATION MODULE

The PIC18F family of MCU's from Microchip is some of the fastest and most feature-loaded 8-bit PIC MCU's on the market, with a maximum speed of 40 MHz and 128 kB of Flash memory [4]. These microcontrollers are powerful enough to allow a lot of complexity and freedom in the design process of an embedded system. The MPLAB Integrated Development Environment allows for a centralized interface between the programmer and all of Microchip Technology's devices. The MPLAB ICD 2 In-Circuit Debugger is the developer's most powerful and cost-efficient tool for low-cost real-time debugging of all PIC18F MCU's. The PIC18F MCU's are programmed using a device-specific PIC assembly language, but using the MPLAB C18 compiler allows to develop applications in "C".

DESIGN PROCESS OF THE COMMUNICATION MODULE

The PIC18F452 has a lot of functionality and is directly applicable to real time applications. This can be easily hooked onto a PC using the RS232 port or USB by an additional USB – SERIAL Integrated Circuit. All of this makes the PIC18F452 an ideal candidate for this research.

A microprocessor-based system was chosen to implement the Physical layer of the Scan Tool. The hardware is an embedded micro-controller system. The Physical Layer functionality is achieved by "C" code written for PIC18F452. The overall functionality of the physical layer is to receive and transmit frames of data between the OBD II system on the vehicle and the Data Link Layer residing on a PC. The frame coming from the Data Link Layer is sent to the PIC18F452 micro-controller, where based on the type of protocol, it is encoded following the timing constraints. The micro-controller system then transmits the frame to the OBD II system. While receiving a frame from the OBD II system, the frame is decoded and then sent to Data Link Layer residing on the PC.

MODULE DESIGN

The voltage levels for each of the three protocols are different. Because of that three modules were developed – one for each protocol. The main function of each module is to convert the levels between the OBD II bus and the microprocessor. For SAE J1750 VWP and ISO 9141-2, Freescale's MC33390 and MC33290 integrated circuits were used. SAE J1850 PWM voltage levels are achieved using transistors.

USB connection is more common nowadays, therefore a USB – SERIAL converter was used to connect the PIC18F452 UART module and the PC. The device used is a Future Technology Devices International's FT232BM. The circuit is simple and does not require external microcontroller or any type of firmware programming.

In Fig. 3 the block diagram of the presented module is shown.

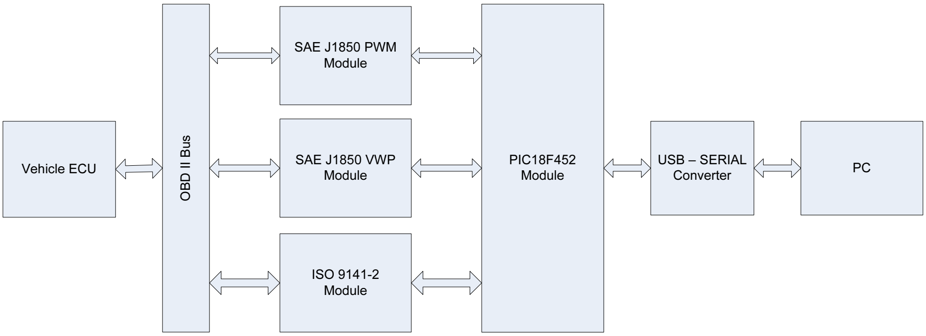

Figure 3. Block diagram of the presented module

FIRMWARE ALGORITHM (Fig.4)

The functionality of the firmware of the embedded microprocessor system in this work is to get the encoded frame from the PC and then send the frame to the OBD II. In reverse direction the firmware has to get a response frame from the OBD II, decode the frame and send it back to the Data Link Layer residing on the PC.

The protocol_find() function creates a sample request for (MODE$01 PID00). The purpose of MODE$01 is to allow access to current emission related data values. The request for information includes a Parameter Identification (PID) value that indicates to the on-board system the specific information requested. PID 00h is a bit-encoded PID that indicates, for each module, which PIDs are supported.

It then cycles through the protocols' send function. If there is a positive response from any of the protocols, the system sets to use it for further actions. The Main module then takes appropriate action, by indicating to the user whether the operation was successful or not. Once a valid protocol is detected, the control is transferred to the Transmission module. Via the Data Link Layer the user sends requests for different PIDs and receives the responses.

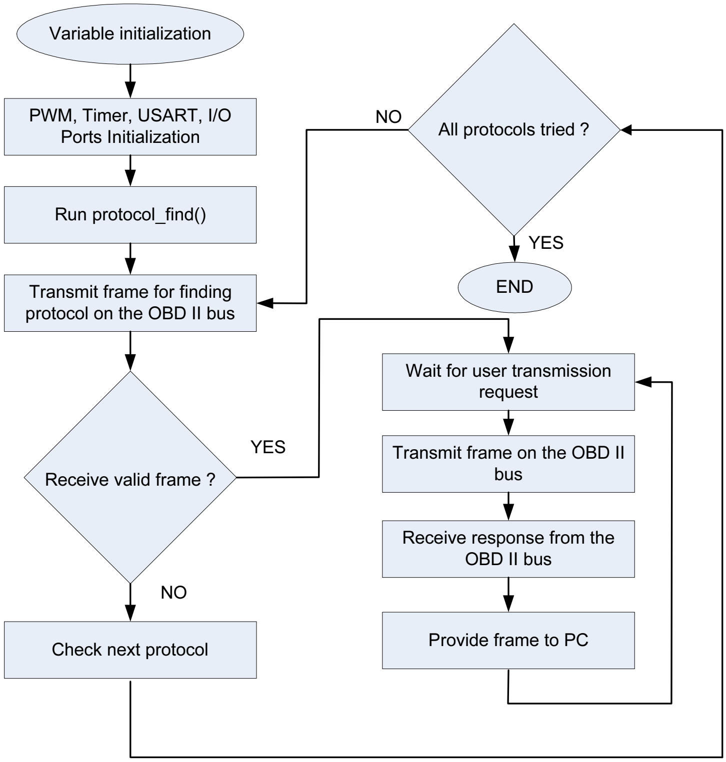

Figure 4. Flowchart of Main Module

The communication protocols were divided into three separate modules, each having a "send" and "get" function. Specific for the SAE J1850 PWM and SAE J1850 VWP is having additional elements (SOF, EOD, EOF, IFS), that need to be interpreted.

For ISO 9141-2 protocol there is also a 5 baud initialization sequence before each transmission.

CONCLUSIONS

OBD II supports three types of protocols, which are SAE J1850PWM at 41.6kbps, SAE J1850VPWM at 10.4kbps and ISO 9141-2. They were implemented in the presented communication module. The implementation and verification of the “C” code was done using another microprocessor to simulate a vehicle Electronic Control Units. The test signals were generated to simulate real-time operation of the module. The signals generated by the transmitter module indicate the functionality of the module and that the frames of data can be transmitted to the on board system for all types of protocol supported. The transmitter output is used to verify the receiver module. The wave shapes monitored by the oscilloscope are found to be slightly distorted but within the acceptable limits specified by the corresponding protocol.

The current development shows the design of the physical layer of the OBD II using the PIC18F452 is simple and cost effective, requires minimum hardware, and is more accurate at measuring the different frames and bits. The communication module can be easily connected to a PC eliminating connecting hardware and making it relatively easy for the data link layer to store the retrieved data from the vehicle.

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The paper has been reviewed.