BEÁGYAZOTT RENDSZER KIEGÉSZÍTŐ KÁRTYÁJÁNAK FEJLESZTÉSE JÁRMŰ KOMMUNIKÁCIÓHOZ

DEVELOPMENT OF EMBEDDED SYSTEM EXTENDER CARD FOR VEHICLE COMMUNICATION

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ABSTRACT

The SZEnergy Team have been developing light-weight concept cars since 2005. Our current vehicle communication system is based on different protocols used in the vehicle industry such as CAN, LIN, SPI and UART. As the main control unit of the vehicle we use an embedded controller produced by National Instruments, which sometimes struggles with UART driver loading and incompatibility which makes our communication system unreliable. In this case our car cannot start, and we need to restart the whole system, which is not permissible under competition situations. As a solution we decided to create our own function specific extender card, a special CAN to LIN transceiver, and a CAN to SPI transceiver to bypass all UART related actions. With the designed boards we can cope with cabling issues, analog signal routing and previous incompatibility problems. We designed the boards to be modular, so the two communication transceivers are capable to work as a standalone device as well. With the self-designed boards, we could not only reduce the cost of the communication system but also optimize our signal and power routing.

1. INTRODUCTION

The main goal of our work aims the reliability of our internal communication system and the space saving of the control module. Power line communication [1] and the standard of CAN 2.0 [2] is available since the beginning of the 90s. These communication standards are still in use in the automotive industry and are implemented in our concept car as well. With these communication protocols we can control the motor, read sensor values, and operate all the different peripherals around the car. Our main controller unit is a NI myRIO – 1900 [3] which does not have dedicated CAN[1] or LIN[2] communication connector. Users must implement software and hardware connection on different available ports to be able to use these communication protocols. The current and upcoming communication model of our concept car is shown in *Figure 1*.

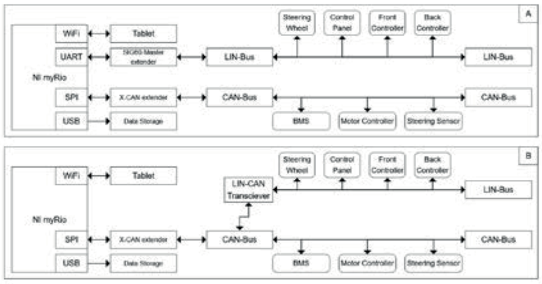

Figure 1
A: SZEmission communication model - 2019
B: SZEmission communication model - 2020

2. CAN-SPI GATEWAY

The default CAN expander card offered by National Instruments is an X-CAN named module [4] which is shown in *Figure 2*. This module is a hardware gateway between the CAN bus and the SPI[3] bus of the NI myRIO. It consists of few parts but takes up a lot of space next to the myRIO, while only a fraction of the outputs is used. Most of the unused connector pins are routed to socket headers, which provide unreliable connection, therefore these are not safe to use in automotive applications.

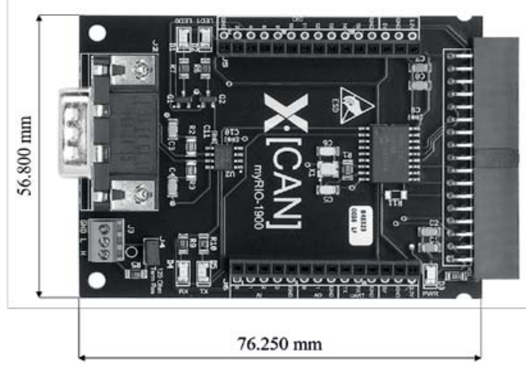

Figure 2. X-CAN module produced by National Instruments

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[1] Controller Area Network

[2] Local Interconnect Network

[3] Serial Peripheral Interface

2.1 *Schematic design of the CAN-SPI module*

The new circuit has the same function as the X-CAN module, but in a smaller package and has the capability to work individually. For the CAN bus controller, a MCP2515 named IC[4], produced by Microchip is used [5]. It works with both high speed and low speed CAN and capable of using the standard and extended CAN message frames as well. The microcontroller also has several modes of operation such as sleep mode and listen-only mode to reduce energy consumption. It has an SPI interface, to communicate with the myRIO, and it is available in small UQFN packaging. The transceiver for the CAN bus is also a Microchip product, a MCP2652 coded IC. The circuit (*Figure 3*) also includes the CAN bus termination, which must be chosen for the actual application. For inline modules 1.5 kohm resistors, for end point modules 120 ohm resistors should be used as termination.

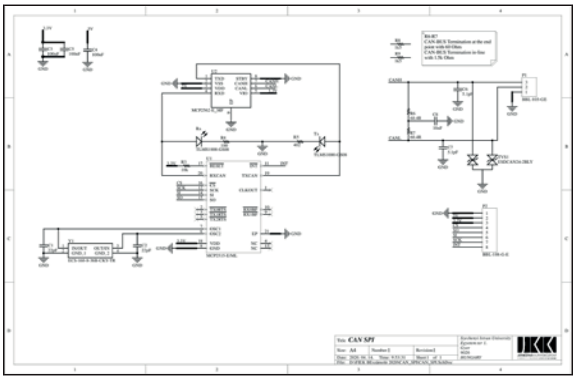

Figure 3 Schematic of the CAN-SPI module

2.2 *PCB design of the CAN-SPI module*

During the designing of the PCB[5] we focused on size reducing therefore every part is placed as close to each other as possible, considering the ease of manufacturing. To achieve this every component is 0402 size and the IC-s are chosen in the smallest QFN package available. To minimize routing, every component is placed and oriented in the correct way. Because of this communication protocol does not need high current supply, we could design the board with 8 mil routing width, which also helped our design goals. The headers on the edge of the PCB have a pitch of 2.54 mm, hence it is easily implementable not only in our but in other applications as well. The circuit inherits its power supply directly from the myRIO, through the lower extender board. As a result, the final product is 13 times smaller than the original X-CAN module, while keeping the same functionality (*Figure 4*).

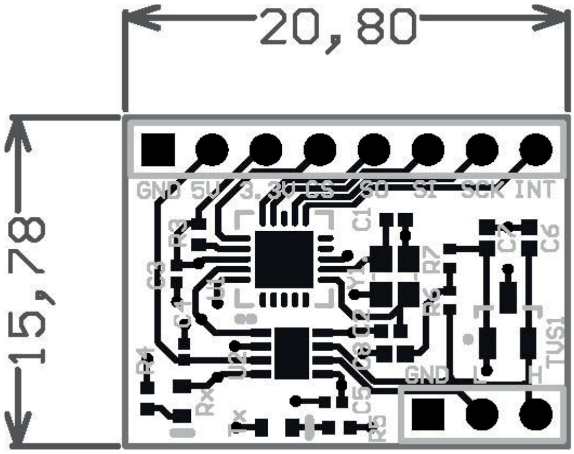

Figure 4 PCB plan of the CAN-SPI module

After the assembly procedure of the CAN-SPI gateway, we could test it via temporary cabling with the myRIO instead of the X-CAN module to check our vehicle communication with the newly designed communication board. On *Figure 5* the myRIO sends necessary data for the motor controller via the new CAN-SPI gateway. The test and therefore the new communication module succeeded.

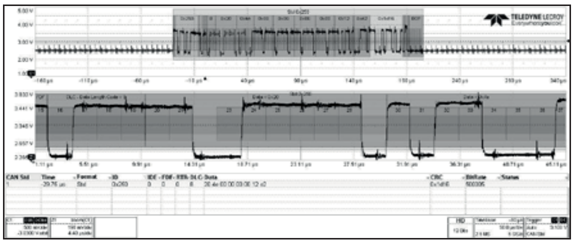

Figure 5 CAN message inspection on the new CAN-SPI gateway

3. CAN-LIN GATEWAY

Since the SIG60 coded integrated circuit, can cope with the coding and decoding of LIN communication as master unit, is only capable of UART[6] communication [6], that gives no choice for developers, they must work with that. Even with dozens of hours invested to optimize UART communication for the NI myRIO and the SIG60, we struggled to create a reliable and robust communication and that is why we decided to design our own module. We solve the UART communication problem via leaving this port unused on the myRIO, and insert a specific microcontroller, which will cooperate with the SIG60 integrated circuit, then translate all the

[4] Integrated Circuit

[5] Printed Circuit Board

[6] Universal Asynchronous Receiver-Transmitter

messages to the CAN bus. In this scenario our main controller does not have to work with UART at all, and a dedicated microcontroller can easily handle this communication translation.

3.1 Schematic design of the CAN-LIN module

The custom circuit is built up by the references of the manufacturer, and some custom added parts, for easier debugging and optional settings. We also made pinout for the "*Command*" pin of the SIG60 IC (*Figure 6*) for future programming options, which are currently not in use, but probably would be useful if we would like to take full advantage of all the features the IC has. All the parts used in the schematics are chosen to save as much space as possible, and to create an easy to assemble board. The controller IC have been chosen to a low power type manufactured by Microchip, which also has the minimal number of pins and functions what is needed. The controller IC powered from 3.3 VDC source, and capable of 100 MIPS[7], although in our case it will only run around 15 MIPS to save power. This complex module will also connect to the custom expander card via two low-profile headers, which card will be described in detail in the 4th section.

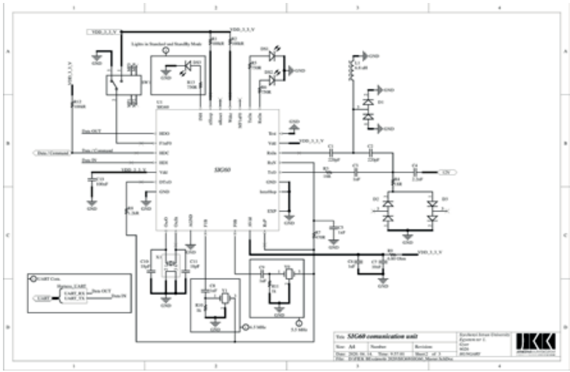

Figure 6 Schematic of the SIG60 IC.

3.2 PCB design of the CAN-LIN module

The biggest challenge during the design of the printed circuit board was the routing [7]. We wanted to organize all the parts to the physical minimum therefore in some cases we had to use 0201 sized capacitors. Even with the difficulties of the manual manufacturing, overall board size was prioritized. Some components were recommended by the manufacturer and caused some extra problem for our design e.g. not having proper PCB footprint for design or being much larger for other components. Exception to this were all the headers we design on the board to ensure the ease of connectivity to the expander card, or any further applications (*Figure 7*).

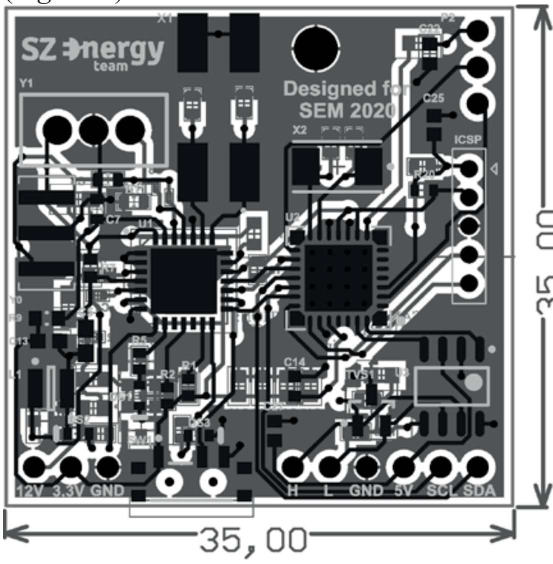

Figure 7 PCB plan of the CAN-LIN module

4. CUSTOM EXTENDER CARD

National Instruments offers extender card for the myRIO, which can be used in any desired application, however it also has the same socket headers as the X-CAN Module, which are not suited for automotive applications. It also lacks the ability to house many custom components on the board due to the small available place.

The new design uses both output ports of the myRIO, offers much more freely available space, and houses the two communication interfaces. Also, in our application a 12V line was implemented for power line communication. The extender card has two standard DSUB-9 connectors for CAN communication, and several plugin terminals for secure connection of analog and digital signals from other electronics. Several output pins from the myRIO are routed to the plugin terminals for easy access. The two-dimensional view of the PCB plan could be seen below, on *Figure 8*.

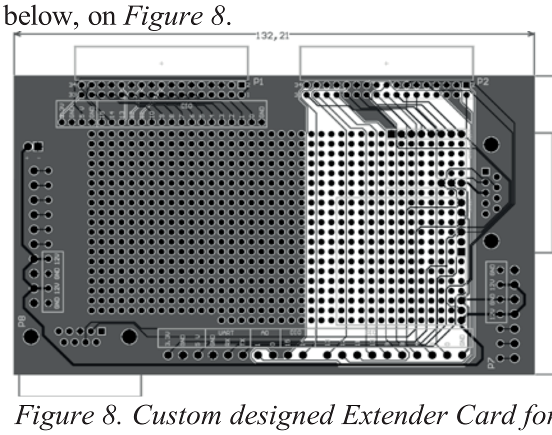

Figure 8. Custom designed Extender Card for myRIO.

[7] Million Instructions Per Second

5. CONCLUSION

We managed to create a complex extender card with two communication gateways for the myRIO embedded system, to solve our previous issues around the power line communication and space utilization. We successfully reduced the size of the X-CAN module by 13 times, and within the original size of the extension card, we added a custom CAN-LIN gateway. This way we created spare place for other electronics on the extender side of the myRIO. Moreover, we designed the Extender Card such way, our cable management needed all the connections for the best fit in our electric vehicle. The assembled and connected PCB-s are shown in *Figure 9*.

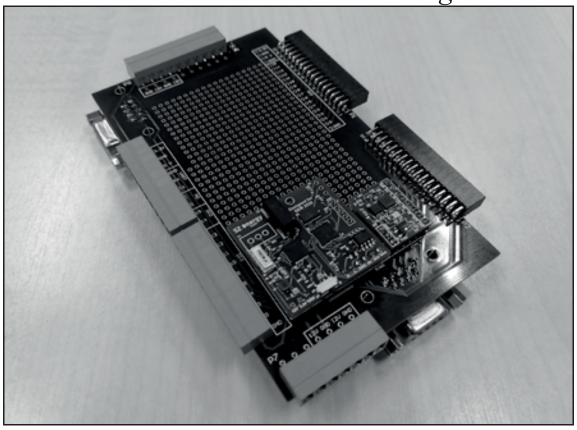

Figure 9 The completed Extender Card for myRIO

6. FUTURE DEVELOPMENT

Currently only two specially designed interfaces are installed on the board. However, with further analysis more communication protocols can be implemented in the same way, even as interchangeable devices. Modularity is a key word here, as every device can work individually. The myRIO itself can be used for many applications, such as motor controlling, data logging etc., therefore there are many possibilities for further development.

7. ACKNOWLEDGMENT

The research presented in this paper was carried out as part of the “Autonomous Vehicle Systems Research related to the Autonomous Vehicle Proving Ground of Zalaegerszeg (EFOP-3.6.2-16-2017-00002)” project in the framework of the New Széchenyi Plan. The completion of this project is funded by the European Union and co-financed by the European Social Fund.

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