# USING OF dSPACE DS1103 FOR ELECTRIC VEHICLE POWER CONSUMPTION MODELING

*T. Haubert, J. Bauer, P. Mindl*

Czech Technical University in Prague, Faculty of El. Engineering, Dept. of El. Drives and Traction

**Abstract**

**This paper presents the using of dSpace DS1103 for the electric vehicle power consumption modeling. The dSpace is a part of control system where the main controller is an embedded module G400-D from the GHI Electronics company. The G400-D module communicates with a GPS receiver used for the actual point on the known track showing.**

## 1 Introduction

Increasing of living standards increased needs for people transport. Gas emissions and fossil fuel consumption are actual problems for global environment quality on the Earth. Gas emission of car internal combustion engines (ICE) brings many ecological problems in big cities specially. Electric vehicles are tackling this problem, because they do not produce gas emissions. On the board needed electric energy can be stored in batteries, but their disadvantages are limited capacity and inconvenient ratio capacity to mass. Due to driving area of electric vehicles (EV) is lower to compare with vehicles equipped by ICE [1].

## 2 G400-D Module and dSpace DS1103

The G400-D Module is a DIMM socket System on Module (SoM) that runs the .NET Micro Framework software platform, the most compact version of Microsoft .NET framework. The value of the G400-D Module is not only in the hardware capabilities such as the ARM926EJ-S core processor,memory and peripherals, but also is in the integration between the hardware and the embedded software. This provides high level features such as a FAT file system, TCP/IP stack, Graphics and Threading to the developer through .NET APIs [2].

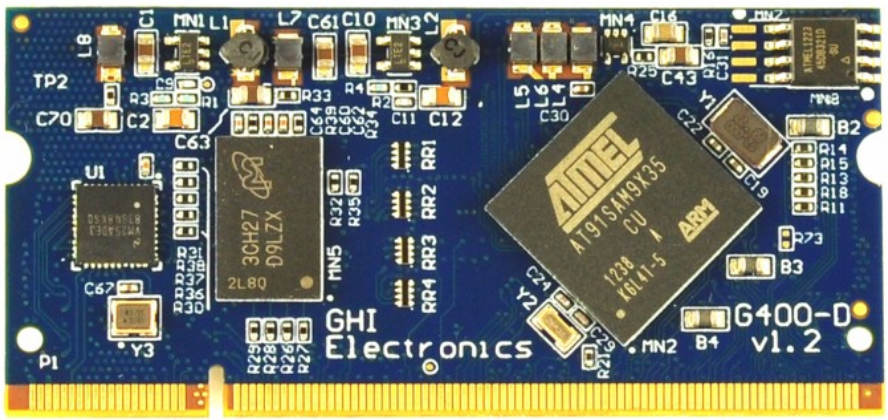


Figure 1: G400-D Module

The G400-D Module is shown in the Fig. 1 and the specification is presented in the table 1. The developing board was designed in the Department of Electric Drives and Traction. The board includes SD card connector, Ethernet connector, 3x USB connector, 2x CAN connector and 1x RS232 connector.

Table 1: G400 MODULE SPECIFICATION

| | |
|---|---|
| Processor | Atmel SAM9X35 |
| RAM | 128 MB |
| Flash | 4.5 MB |
| Interfaces | USB Host/device, 2xSPI, 6xUART, I2C, 2xCAN, Full TCP/IP with Ethernet, WiFi support |

dSpace DS1103 is single-board system with real-time processor and comprehensive I/O. It is used for the modern rapid control prototyping and it should be used for:

- Induction motor control
- Automotive applications
- Robotics

The dSpace DS1103 board is included in an expansion box called AutoBox. The AutoBox (Fig. 2 ) is dedicated for using in car. The AutoBox supply voltage is 12 V.


Figure 2: dSpace AutoBox

## 3 Mathematical Model of Electric Vehicle

It is possible to write the equation 1 for the mechanical force of the electric motor.

$$F_{elmotor} = F_{car} + F_{air} + F_{road} \tag{1}$$

$F_{car}$ is the force applied on the car. This is Newton's second law of motion where the car receives the force with the acceleration. $F_{air}$ represents the air resistance and the $F_{road}$ represents the road angle. For these coefficients we can write:

$$F_{elmotor} = m_{car}a + \frac{1}{2}c\rho Sv^2 + m_{car}g \cdot sin\alpha \tag{2}$$

where:

- $m_{car}$ is the mass of car
- $a$ is acceleration of car
- $c$ is air resistance coefficient
- $S$ is frontal area
- $v$ is the car speed
- $\alpha$ is the road angle

The equation 3 represents the calculation of the actual mechanical power of electric motor in electric vehicle. The transfer from the electrical power into the mechanical power is represented by the power electronics and electric motor efficiency. This efficiency is for modern electric drive about 95%.

$$P_{elmotor} = F_{elmotor} \cdot v \tag{3}$$

The model (Fig. 3) in MATLAB/Simulink was created based on the equation 2, equation 3 and respects the electric drive efficiency. This model is running in dSpace DS1103. The block "Serial Receive" receives every 4 bytes from G400 module, where the first byte is a command or a parameter name and the next three bytes are data. The block "RXDataProcessing" includes a switch/case structure and splits the data to the outputs. The block "ElectricVehicleDynamic" calculates the actual electric power consumption of electric vehicle in accordance with the inputs. The last two blocks "TXNumBytesCalc" and "Serial Transmit" enables the data transmission back to the G400 module.

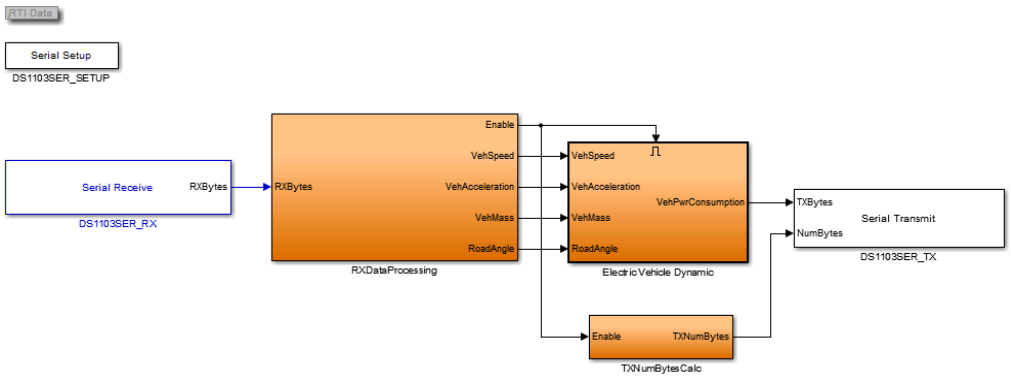


Figure 3: Simulink Model

## 4 Communication Structure

The structure is shown in the Fig. 4. The DS1103 communicates with the G400 module using serial communication. The electric vehicle dynamic model is running in the DS1103 and the model parameters are controlled by the G400 module.

# 5 Results

The simple algorithm was used for the result presenting. The electric vehicle acceleration is zero, the road angle is 2 degrees, electric vehicle is 1200 kg. The speed is changed from the zero to 108 km/h. These conditions represents the vehicle motion with no acceleration for different vehicle speeds. The result is shown in the Fig. 5. The red points represents the actual vehicle power consumption and the black points represents the actual vehicle speed.

# 6 Conclusion

This article presents how it is possible to use the dSpace DS1103 with the different control system based on programmable module G400. G400 enables the Internet connectivity, GPS data processing, data logging etc. The result of a project which part was presented in this article will be the creation of expert system for electric vehicle. The expert system will know the future track characteristic (altitude profile, curves, maximal speed, etc.) and will calculate the range of the electric vehicle in accordance with the actual weather.

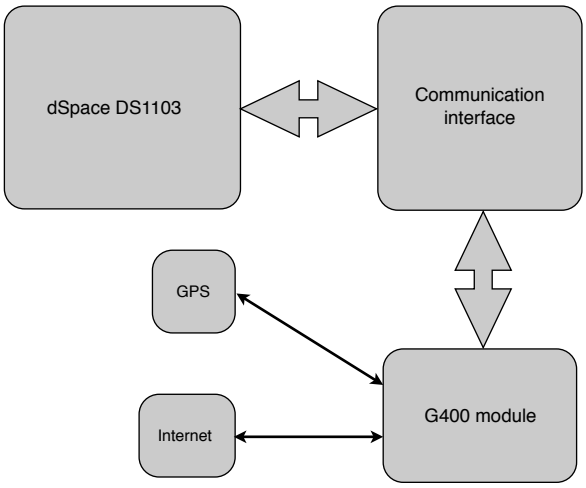


Figure 4: Schematic of the Communication Structure based on the DS1103 and G400 module

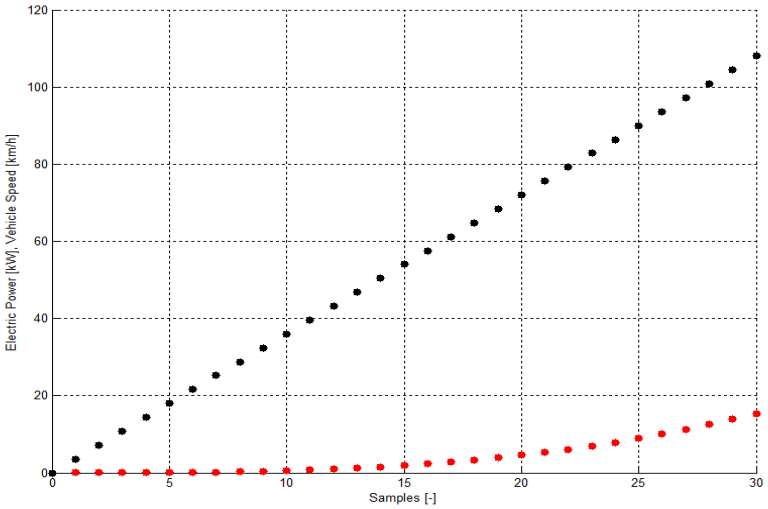


Figure 5: Simulink Model

## 7 Acknowledgement

This research has been realized using the support of Technological Agency, Czech Republic, programme Centres of Competence, project TE01020020 Josef Bozek Competence Centre for Automotive Industry. This support is gratefully acknowledged.

## References

[1] T. Haubert, P. Mindl: Optimization of DC/DC Power Converter for Super-capacitor Charging and Discharging. In *TRANSCOM 2013 - 10th European Conference of Young Researchers and Scientists - Section 4*. Zilina: Technical University of Zilina, 2013, p. 43-46. ISBN 978-80-554-0693-0.

[2] GHI Electronics LLC: G400-D Module Preliminary Specifications. [on-line]

---

Tomas Haubert
Czech Technical University in Prague, Faculty of Electrical Engineering, Department of Electric Drives and Traction: tomas.haubert@fel.cvut.cz

Jan Bauer
Czech Technical University in Prague, Faculty of Electrical Engineering, Department of Electric Drives and Traction: bauerja2@fel.cvut.cz

Pavel Mindl
Czech Technical University in Prague, Faculty of Electrical Engineering, Department of Electric Drives and Traction: mindl@fel.cvut.cz