15th IMEKO TC10 Workshop on Technical Diagnostics
Technical Diagnostics in Cyber-Physical Era
Budapest, Hungary, June 6-7, 2017

EXTENSION OF TELEMETRY SYSTEM

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***Abstract* – The most important problem of electric vehicles is the energy storage. Currently the system components are ready for mass production, the cost of energy storage, and energy density is limited by the capacity of these types of vehicles. The present study aimed to implement a battery monitoring system in to an F2000 electric formula car. Based on the real-time monitoring capability, the control system can continuously check the voltage of the battery. Monitoring of battery systems is a critical importance to maintain reliable operation of electric vehicles. In addition of fault diagnosis the charge of the battery, the status of the battery cells, measure of the load (current consumption) and also the load variation in time (peaky, constant) can be monitored real-time.**

I. INTRODUCTION

The contents of: “The occurrence of loads in operating cycles during extreme conditions - a research in high speed vehicles”

Modelling of the loads during a whole operating cycle, furthermore controlling the model in an empiric way, at high speed, non-commercial road vehicles. An important part of this work is online measurement, - with large sampling, during one operating cycle, at normal track conditions - and the evaluation of the data set. Further conclusions, regarding the development of the telemetric system and drive train, can be drawn.

II. CONSTRUCTION OF VEHICLE TELEMETRY

2.1. Preparatory tasks, specifications, examination of initial system

The goal of the vehicle telemetry construction is to develop a measuring system and sensor network which is able to measure system parameters, is capable to store the gathered data, wirelessly transmit the received signals and processes them with a software.

At first, during the preparations we tested, that is it possible to create a system which can evaluate the parameters of two vehicles that were meant for completely different uses. Next we determined the type of sensors are necessary for the construction of such a system. We designed the measuring system as well.

For the highest possible sampling data had to be collected from multiple sensors: data from the intelligent controller of the car and data regarding the behavior of the vehicle. In the vehicle there are already three CAN capable components, these are connected to the electrical drive chain. Only the control unit of the electric engine and the control unit of battery were prepared for CAN communication, but these were functioning independently. Because of this the basic CAN bus of the vehicle had to be constructed as well. To measure the parameteres which are important for us, we had to extend the CANBUS system with more elements which are listed in 2.2. We did not use the CAN communication of the cooling system.[1]

Beside the mobile online data transmission, the system is capable of storing the data offline as well. The frequency of online system update is 10-15 s, offline it is more precise: 0.5 s.

2.2. Components of the measurement system

- Yasa Engine ECU
- Battery Management System
- GPS2CAN™ 5Hz
- AD2CAN™
- VDSU™
- Offline CAN data collection system
- Online CAN data transmission and collection system

III. DESIGNING OF CAN BUS NETWORK

3.1. Design considerations

By designing the CAN bus network, we had to consider the priority of each message, because there are standard 11 bit-messages and extended 29-bit messages. Standard messages always have the priority over the extended messages, so these appear first on the CAN bus. In the system the parameters of motor diagnostics and the battery voltages have the highest priority level, next are the follow-up sensor values. The order can be determined during the planning of the CAN address assignments.[2][3]

We also have to pay attention to the timing of the different CAN messages namely, how often should these messages appear on the bus. In case of the GPS2CAN™ it was set to 200 ms, in case of the AD2CAN™ it was set to

100 ms and in case of the VDSU™ it was set to 10 ms (retrofitted devices).

During the address assignment we had to adjust to the systems that were already in the car, which were using standard messages. The tools of a Hungarian Ltd. named “Inventure Autóelektronika Kft.” use extended messages.

In the industry it is standard, that the description of the CAN communication for the entire network is found in a so-called CAN communication matrix. So we have to add to the matrix any appeared change in the control unit of the CAN interface, and to filter the occurring conflicts, collisions as early as possible.

While planning, we have to investigate the busload, this will be detailed in separate sections.

Fig. 1. shows the cable layout of the above discussed CAN communication designed for the Formula 2000 based vehicle. In order to prevent incorrect connections, every unit has a different industrial connector.

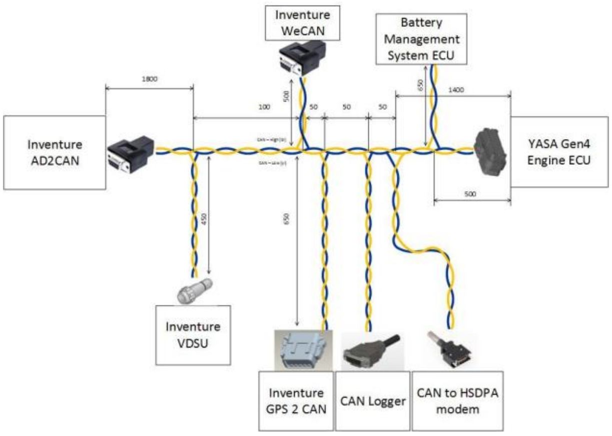

Fig. 1. Layout of the CAN system

Also the proper IP protection of the system had to be taken care of. According to the definition IP protection is a notation that indicates effectiveness of the protector of electrical circuits in technical equipments against environmental effects. Knowing the expected loads and the environmental factors the car industry uses “high” IP certified devices. Following these guidelines all the connectors of different cables are IP66 (IP6x = dustproof, IPx6 = waterproof [for a short period of time, not damaging leakage is allowed]) and IP67 (IPx7 = waterproof for a limited time [between 0,15–1 m for 30 minutes]) certified.[2]

The designed system then gets installed into the car. During instalment the narrow space (usual for formula cars) caused some difficulties and we had to careful, that the tools don’t tarnish the driving dynamics of the car. After consultation we decided that the telemetric system will be installed behind the driver’s seat.

3.2. Calculation of bus load and validation by laboratories measurements

The average load of the CAN buses found in vehicles is around 30-40%. If this value is higher, then it is possible that some messages will be delayed due message jam. Because of this it is important to evaluate the busload beforehand. It can be done with the following equation:[1]

$$Transmssion\ rate = \frac{Bits\ of\ massages}{Test\ time}\ \left[\frac{bit}{s}\right] \quad (1)$$

$$Bus\ load = \frac{Bits\ of\ messages}{Test\ time}\ [\%] \quad (2)$$

Considering the parameters of the original and the retrofitted CAN controllers in the Formula 2000, we expect an average of 17.55% of busload. This value allows for further increase of rate frequency for the individual sensors or the application of more CAN capable sensors.[4]

After indicating the parameters of the CAN bus, all the components were wired together and were tested in laboratory. (Fig.2.)

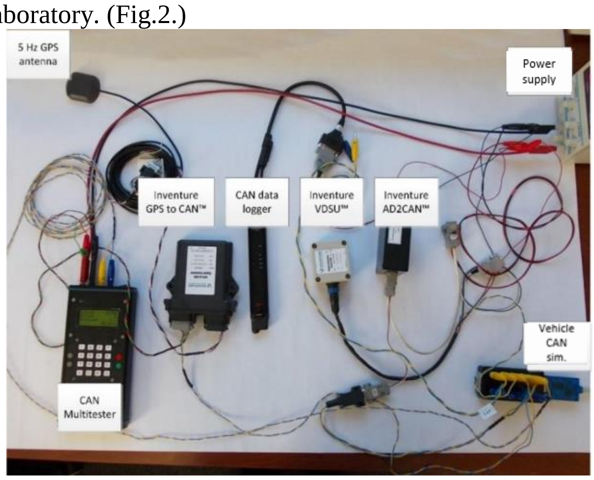

Fig. 2. Assembly of measuring equipments

With the constructed system the busload can be controlled with a preliminary calculation. For this purpose, two different methods were used. Firstly, we measured the busload with the help of the Inven-ture WeCAN PC software, which showed an average of 14-16%.

Simultaneously we connected CAN Multitester device to the network, which in CAN Monitor mode can measure the busload, as well as the bandwidth of the communication. Here it was between 14-15% and the bandwidth was 72-80 kbit/s.

According to these preliminary calculations 17,55% was validated as an upper limit.

IV. HIGH SPEED VEHICLE MODELS

The parameters of vehicle that was used in the research:

- Light frame construction used in the Formula 2000 series
- Electric drive system
- Electronic motor with low weight and high power
- The original 4 piston brake used in Formula 2000

4.1. Electrical drivetrain model

While creating the vehicle model it is very important to know the exact construction of the drivetrain. The vehicle is driven by a high power YASA electric engine. The simplified model of the engine contains the following elements:

- Electric motor
- High capacity battery pack
- ECU (engine control unit)
- Reversor
- Torque demand potentiometers

4.2. The torque and power model of electric engine

The torque and power characteristics of the YASA engine are available even at different voltage levels. The voltage of the battery that we currently use is around 200 V, so in this research we studied this voltage range. (Fig. 3-4.)

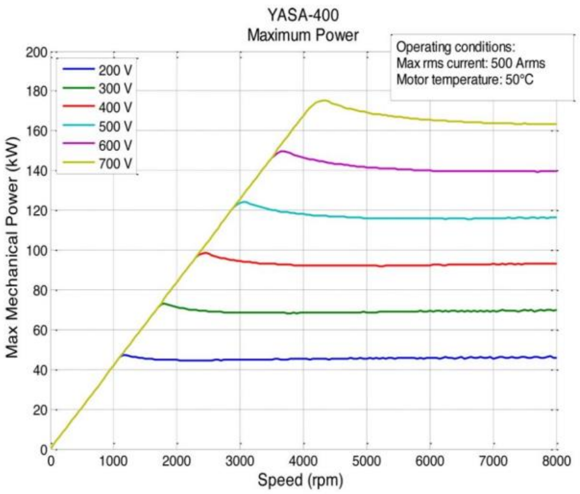

Fig. 3. Speed-Power char. of YASA 400 engine

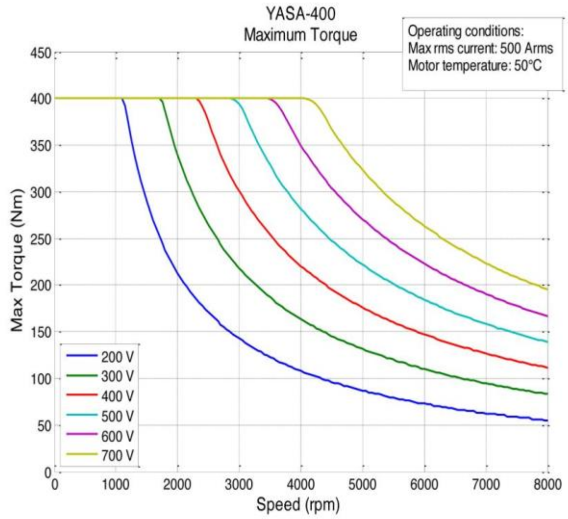

Fig. 4. Speed-Max.Torque characteristic of YASA 400 engine

Comparing the torque and power curves the maximum torque and power is optimal in one speed range. This is 1000 rpm. Here the maximum torque is 400 Nm and the maximum power is 45 kW. It is important to note, that the voltage decreases with the discharge of the battery as well as the increases of current consumption, so the optimal speed range changes accordingly. (Fig.5.)

There is no clutch and transmission in the car, so the gear ratio is constant and the vehicle can produce the maximum torque at starting. The vehicle speed is directly proportional with the engine speed.

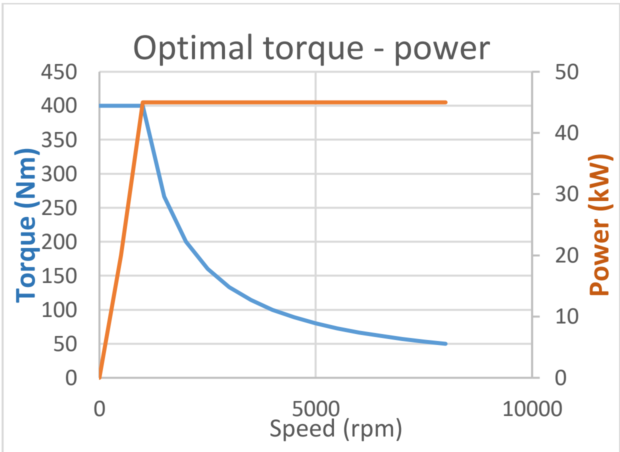

Fig. 5. Speed-optimal torque and power char. of YASA 400 engine

V. THE RESULTS

The measurements were carried out on the 13th of November 2015, in Zalaegerszeg.

5.1. The status and voltage decrease of the battery

Fig. 6. illustrated the decrease of voltage on a 10 minutes long vehicle test. The vehicle accelerated three times to 40-50 km/h during this test. These accelerations appear on the graphics as a fall of potential.

At the start of the measurement the voltage of the battery was 121 V, but after the test it was just 116 V. The trend line show us the decrease of the battery voltage, which was -5V/minute. To handle unexpected battery failure the voltage has to checked real time. Unmonitored faults would have detrimental effects on batteries. One of the common faults that occur to battery cells is the voltage abnormity including over-voltage and under-voltage. [5] Any sensors fault that are often neglected, may result in some serious consequences. For example, if there is a current or voltage sensor fault, the battery SoC estimation will be affected. [6]

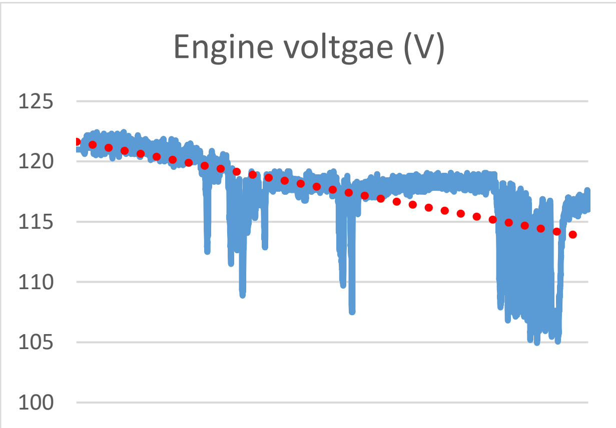

Fig. 6. Engine voltage in fucntion of time

Based on the data from the telemetry the charge of the battery, the status of the battery cells, measure of the load (current consumption) and also the load variation in time (peaky, constant) can be monitored real-time.

The remaining energy and the state-of-energy are very important indexes for the embedded BMS used in electric vehicles. Monitoring of battery systems is importance for safe and reliable operation of electric vehicles (EVs). Faulty diagnosis is responsible for discovering various faults at the battery pack and cells. Based on the collected data the system could be alerting the driver. This paper suggests a system that can measure battery system real-time to identify voltage defects during the tests. Understanding and tracking battery life span mechanisms and adapting its operation have become a necessity to enhance battery durability. Based on the voltage diagnosis the excepted lifetime can be specified according to the voltage drop comparison within the same power consumption. The under-voltage prediction can be configured to warn the Vehicle Control Unit, or the Motor Controller Unit, that the vehicle should switch to a low power mode, because the accumulator is close to the under voltage switch off limit (Drive Enable minimum voltage). According to the data that was collected from the telemetry system, the charge of the battery, the status of the battery cells, the current consumption and load variation in time can be specify.

VI. ACKNOWLEDGEMENT

Work presented here has been supported by the grants of the Highly Industrialised Region in Western Hungary with limited R&D capacity: "Strengthening of the regional research competencies related to future-oriented manufacturing technologies and products of strategic industries by a research and development program carried out in comprehensive collaboration", under grant No. VKSZ_12-1-2013-0038.

VII. LITERATURE

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