

On-Board Bus Powertrain Parameters and Position Data Logging Solution for Driving Cycle

Determination and Energy Efficiency Analysis

by

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Products used:

LabVIEW 2009

NI Vision Acquisition Software 2009.11

NI DIAdem 2010

NI cRIO-9025

NI 9118

NI 9853

Category:

Research

The Challenge:

Developing an on-board data acquisition system for bus real-world driving cycle determination and powertrain parameters logging for the purposes of conducting an energy efficiency analysis involving the implementation of a hybrid powertrain.

The Solution:

Using the LabVIEW Graphical Development Environment to build a logging application utilizing an NI 9853 module for J1939 powertrain traffic monitoring, an RS232 GPS module for vehicle tracking along with an IP camera on a platform consisting of the rugged NI cRIO-9025 controller with the NI 9118 FPGA reconfigurable chassis.

Body Text:

Introduction

As members of the Internal Combustion Engines Department at the Faculty of Mechanical Engineering – University of Belgrade, we are committed to doing research on solutions for raising the internal combustion engine energy efficiency and lowering its impact on the environment.

Lately, we have been investigating on the prospects of a hydraulic hybrid system implementation on a heavy-duty vehicle, as part of our government-funded project. One of the first analyses that we needed to be focusing on was assessing the baseline fuel economy of a bus circulating on Belgrade's transportation system and determining the level of improvements that would be achieved with the implementation of certain green technologies like the start-stop system, hydraulic hybridization, etc.

It was evident that one of the conditions for the aforementioned requirements to be fulfilled was gathering GPS' NMEA tracking data for extracting the bus' real-world driving cycle. This would help us determine the optimal hybrid powertrain configuration for minimizing the fuel consumption and pollutants emission in vehicle simulation software packages. On the other hand, for obtaining the baseline performance figures, access to the J1939 bus and its multitude of powertrain messages containing essential data (fuel mass flow, actual engine torque, engine speed, etc.) was needed. It was thought that a windshield-mounted camera grabbing images at a predetermined capture rate, which would allow us to pin down the reasons of vehicle braking phases, would also be beneficial for later analysis.

Given the positive experiences gained during the elaboration of our Engine Testing Laboratory's acquisition system using PXI hardware and LabVIEW's programming environment, it comes as no surprise that we chose NI's hardware and software solutions for accomplishing our data-logging project. Due to its ruggedness and small form factor, it quickly became evident that the best hardware platform for our needs was NI's CompactRIO.

Data-logging application

The connection to the CAN bus was achieved with an NI 9853 module configured to operate at the J1939's standard 250 kbit/s baud rate. Because we wanted to capture all messages on the bus, even

those we were perhaps not particularly interested in at the moment of project planning, and due to simple needs of logging CAN frames without actually parsing them at the acquisition level, we chose the NI-CAN Frame API Concept. Thanks to readily available VIs in the excellent NI Example Finder database for LabVIEW, the CAN Logging application, consisting of a VI operating at FPGA level, grabbing CAN frames and transporting them to the FIFO buffer, and a Host VI dequeuing the FIFO buffer and logging CAN frames, was only slightly modified to suit our needs. A Network-Published Shared Variable was created to permit live monitoring of bus' parameters on a remote notebook through Wi-Fi. For J1939 messages containing data greater than 8 bytes, the J1939 Transport Protocol Reference Example VI was used to assemble frames in accordance with BAMs (Broadcast Announcement Messages).

For vehicle's GPS tracking data logging needs, a roof-mounted, 5Hz high-accuracy Garmin RS232 GPS receiver was used. Implementation into the logging application was carried by means of the NI-VISA programming interface which allowed us to log a couple of NMEA sentences broadcasted at 200 ms intervals containing, among longitude and latitude information, the elevation data that is crucial for driving cycle's slope definition. Needless to say, the flexibility of NI solutions has proven to be a great advantage, allowing successful implementation of non-NI based instrumentation hardware functionalities into the LabVIEW application environment.

Another handy LabVIEW feature used in our application is the possibility to interface with cameras through the NI Vision Acquisition Software. The sub-portion of the logging application dedicated to camera frames capturing was constructed using the NI-IMAQdx drivers with great simplicity and success. By taking advantage of the IMAQ Flatten Image to String function to store captures to a binary file, we were able to contain camera log files to small sizes.

Monitoring application

The monitoring LabVIEW application (Fig. 1) was built from fragments of applications available in the NI Example Finder database and by assembling VIs from Function palettes, enabling parsing of crucial CAN messages and GPS sentences via Network-Published Shared Variables. This allowed us to gain valuable initial experience regarding certain powertrain parameters' behavior in changing traffic and occupancy conditions while providing assurance that the main loop in the logging application was being executed.

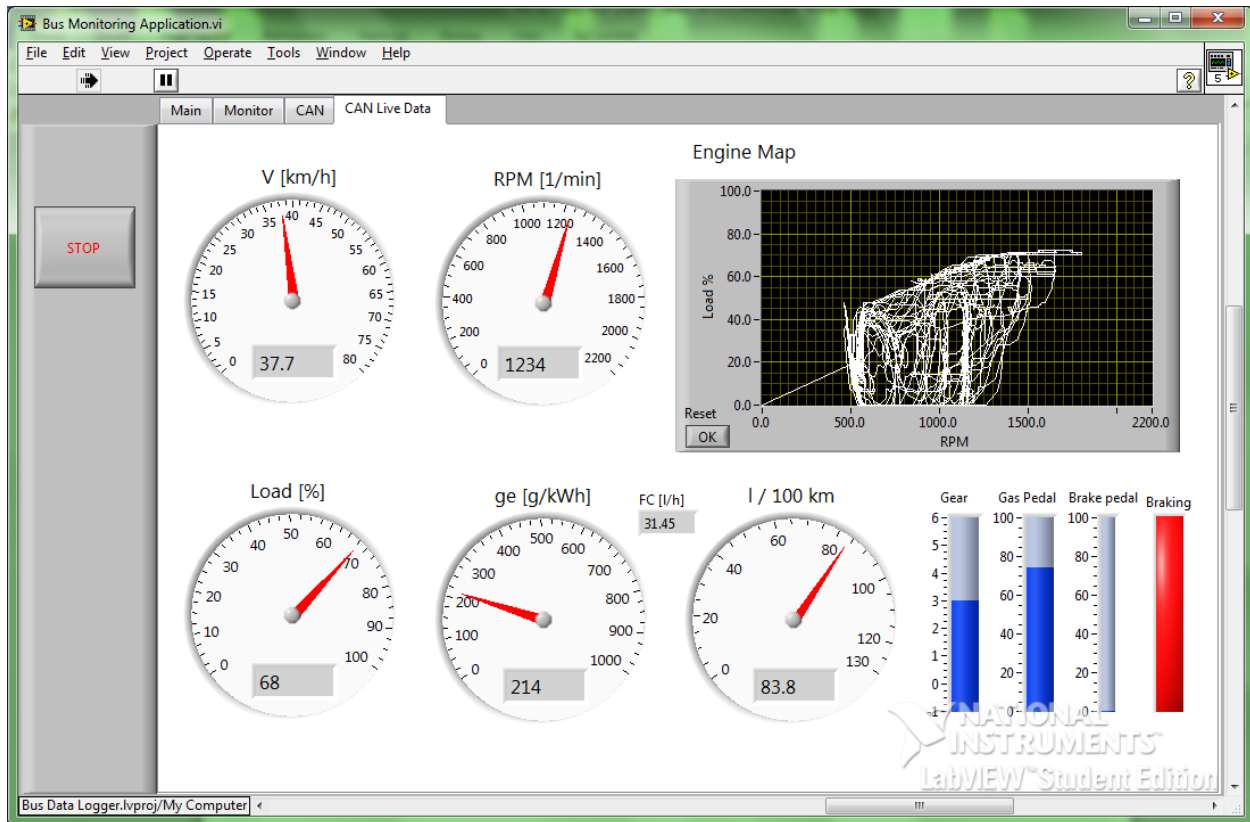


Figure 1: The Monitoring Application

Data-logger installation

Due to cRIO's compact dimensions, we were able to easily install and conceal it in the bus' roof compartment (next to vehicle's ECU and fuse box) with no signs suggesting that the vehicle was carrying any acquisition equipment, which allowed for regular bus service to be assumed while data was gathered. Thanks to cRIO's wide voltage supply range, it was powered by the bus' 24V accumulator which meant that neither supplemental PSU nor additional space was needed.

Data analysis

For visualization and data analysis needs, NI's DIAdem 2010 Data Management software was used. The CAN converter function, converting *.ncl* CAN logs into *.tdm* files, has been extremely useful for parsing CAN messages using Vector's J1939 *.dbc* database file. NMEA sentences were also taken care of within DIAdem, being converted into dedicated longitude, latitude, elevation and other channels. The binary log files containing frame captures were previously extracted using functions from the IMAQ Image

Management and AVI palettes into .avi files, ready to be imported into DIAdem to be simultaneously presented along with powertrain data and a GPS map of the driving cycle for detailed analysis (Fig. 2).

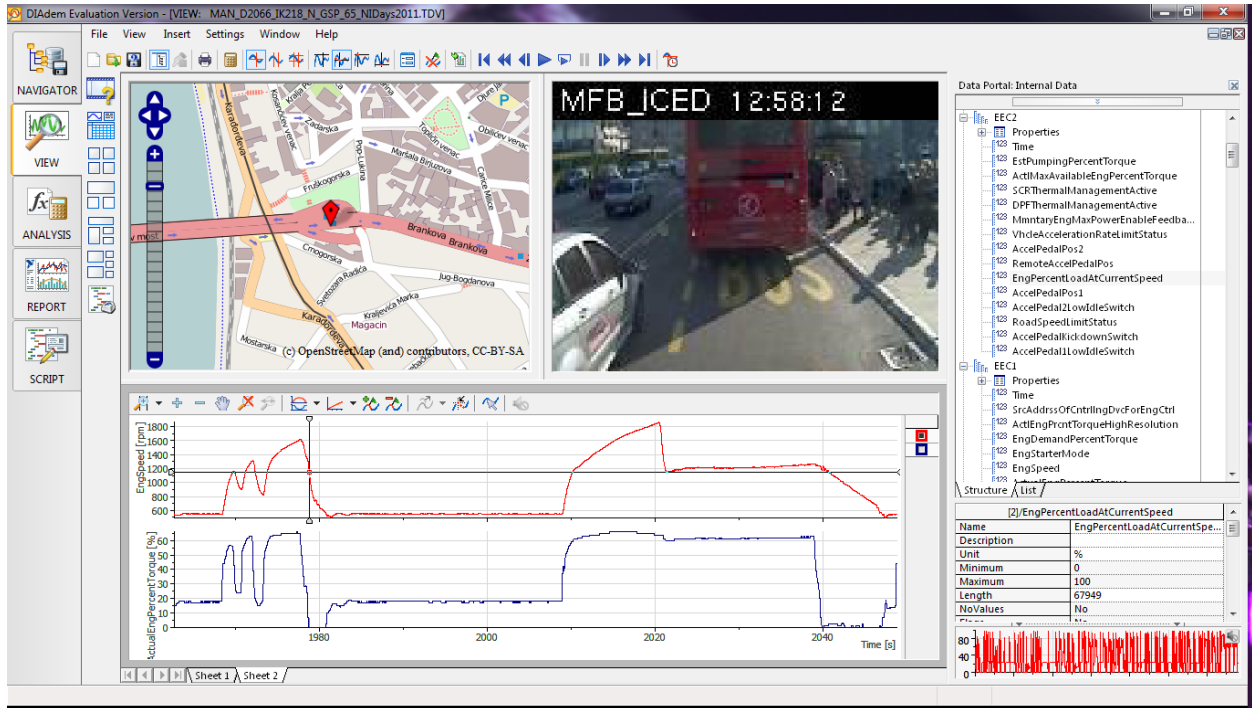


Figure 2: Visualization and Data Analysis in NI DIAdem 2010

Conclusion

The graphical concept of LabVIEW programming, its compatibility with practically all types of acquisition devices and the ruggedness and compactness of the NI CompactRIO platform have greatly helped us develop an acquisition system in a very short time frame that has allowed us to complete the measurements essential for our research.

Acknowledgements

We would like to acknowledge the invaluable support of the local NI representatives, in particular Mr. Dusan Vukasinovic, who gave us the opportunity to try out the CompactRIO platform.