Formula Student racecar Real-Time telemetry unit based on cRIO and LabVIEW

By:

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Description:
We are using the NI cRIO-9025 controller and other NI cRIO products in order to create a real-time data acquisition system for our Formula Student race car. This acquisition system is used for acquiring information about the engine speed, load, temperatures, pressures etc. via ECU's (Engine Control Unit) high speed CAN (Controller Area Network) port. Also we have idea to control some engine's and vehicle's subsystems using the National Instruments cRIO platform and LabVIEW software.

Products Used:
NI LabVIEW 2012
NI DIAdem 2011
NI cRIO 9025 controller
NI 9118 chassis
NI 9853
NI 9205
NI 9401
NI 9505
NI PXI-8186
NI PXI-5401
NI PXI-4070
NI PXI-6229
NI PXI-6123
NI PXI-6602
NI PXI-8461
NI BNC-2110
NI TB-2715

Category:
Industrial Control Systems and Embedded Design Applications

The Challenge:
Acquiring data from a Formula Student race car ECU and other on-vehicle mounted sensors in order to improve the engine's and vehicle's racetrack performance.

The Solution:
Using NI CompactRIO hardware with NI LabVIEW system design software, we are able to acquire a vast amount of relevant data to aid us in the never-ending quest for maximum performance extraction from every component of the vehicle.

Introduction
The Road Arrow Formula Student team is a project of the University of Belgrade's students, challenging them to design and build a single-seat race car to be put to the test at the Formula Student competitions worldwide.

Figure 1: Formula Student team “Road Arrow” at the competition in Italy, September, 2013.

Using cRIO during Formula Student testing and developement
Data acquisition systems are of great importance to the teams involved in the Formula Student competition, so that with every next iteration of the project the vehicle can be improved and be more competitive with other team’s vehicles.

In order to design, prototype and build a successful Formula Student car, it is important to carefully design and conduct tests on newly developed subsystems that can only be appropriate if there is an insight into their behavior during on-track racing and that’s where Real-Time telemetry unit based on cRIO and LabVIEW comes in.

One of the main goals this season was to gather as much data as possible from the engine and vehicle subsystems. Indeed, we have designed and implemented an NI CompactRIO-based telemetry unit in our vehicle, which gave us complete control of our data acquisition system and provided a versatile controller for data logging. This unit was implemented also because of its reliability and ruggedness that were required to endure harsh on-track conditions.

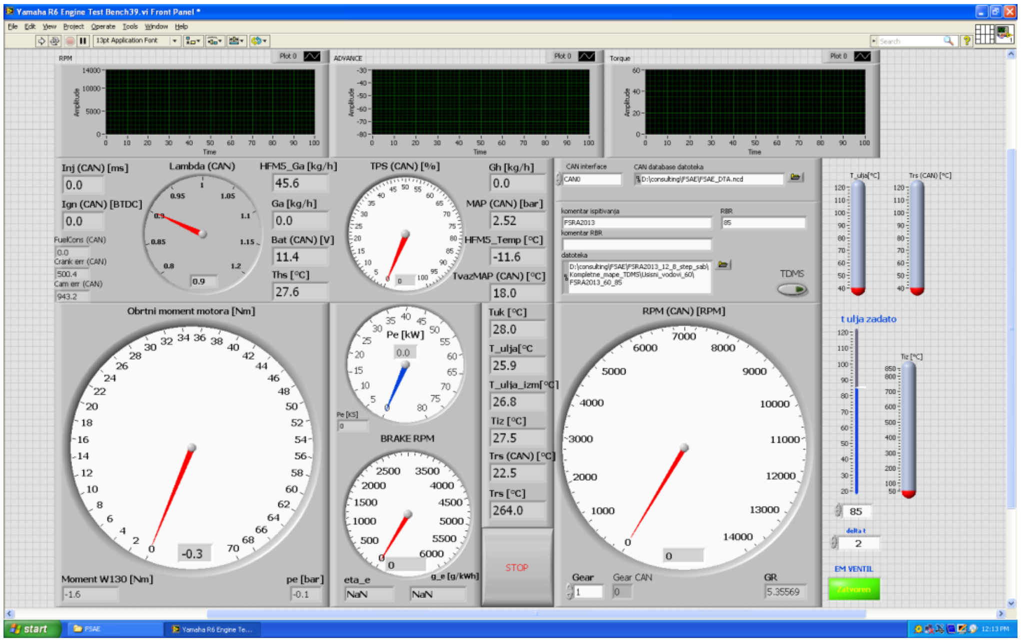

Figure 2: labVIEW Application for engine test bench monitoring and data logging.

The NI CompactRIO system allows us to acquire various information about the ECU's sensor readings sent via ECU's high-speed CAN stream (such as RPM, TPS, MAP, AFR, Oil temp, applied control values for ignition timing, gasoline injection and other engine's systems) directly to NI 9853 module, and also various on-vehicle mounted sensor readings (brake temperatures, suspension behavior, wheel angular speed, GPS position, etc.). This unit is also used in such a manner that, besides acquisition, we are able to send relevant data packages via a wireless access point to a PC. For this purpose was particularly used NI cRIO-9025 Controller. The pit-lane crew can monitor behavior of specific subsystems in real-time and, if necessary, suggest the driver via a radio connection to adjust his driving style. This is essential, because it means better time score at the end of the race.

The acquired data is processed using NI DIAdem, which gave us the possibility to precisely pinpoint the subsystems that need to be re-evaluated, recalibrated, or eventually redesigned. For instance, we have changed the engine intake runner length, and conduct the engine testing on various RPM and load defined operating regimes. Intake runner length has direct influence on the engine torque characteristic over RPM and load, and selected value depends on track configuration and type of the race. This testing was carried out in a quick and efficient way thanks to application of NI PXI hardware and applications for digital acquisition developed within the LabVIEW programing environment.

Also, with the acquired amount of data, we have the opportunity of determining the on-track driving cycle, the engine's and vehicle's dynamic characteristics which are used for later analysis, research and development of new subsystems. Estimation of the driving cycle, transient regimes and response of the engine, greatly contribute to the IC Engine control parameter optimization in terms of effective power and fuel consumption.

We succeeded to decrease development time and as well as overall cost savings because of using NI embedded systems and a programming approach that abstracts low-level of complexity.

Plans for the future

In the future, we are planing to integrate NI cRIO even more in our vehicle, in the manner of try to use every bit of its potential in actuating components of the vehicle that we want to be on-track adjustable (variable intake manifold, suspension, differential settings, traction control, etc.) and that will take us one step further in the Formula Student competition. We would also like to redesign telemetry streams acquisition, so the engine and vehicle on-track behavior can be monitored not only via PC, but on the other OS-es (Android, iOS, etc) as well.

Conclusion

Thanks to National Instruments hardware and software properties, such as modularity, robustness and reliability, that allow us to improve almost every part of our vehicle, as long as we devise it. That gives us a chance to achieve even better results in the upcoming races.