Formula Student variable geometry intake manifold and telemetry unit development using NI-cRIO and NI-PXI hardware and LabVIEW and DIAdem software

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Products Used:

NI LabVIEW 2012
NI DIAdem 2012
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

Industry:

Automotive

Application Area:

Data Acquisition, Generation

The Challenge:

Development of a relatively complex engine's system such as continually variable geometry intake manifold. Collecting data from the engine's ECU and other on-vehicle mounted sensors for later analysis in order to improve the engine's and the vehicle's performance.

The Solution:

Using NI CompactRIO and NI PXI hardware with NI DIAdem and NI LabVIEW system design software, we are able to acquire and generate all relevant data which are important in the development, testing and optimization process of a various subsystems of the racing car.

Description:

Formula Student is a global student engineering competition, which rules are prescribed by Society of Automotive Engineers (Formula SAE) and individual amendments to the rules or competition organizer (Formula ATA, FSA, FSG, FSH, etc.). “Road Arrow” team very successfully represents the University of Belgrade for the fourth consecutive year. The majority of vehicle systems are designed and built by students, which makes this competition very useful for each engineering career of participants. From the very beginning, and construction of our first car, National Instruments equipment was used. Because of that, we would like to share part of our success with NI.

In order to improve performance of a racing engine for new 2014 Formula Student season, students from the Internal Combustion Engines Department (ICED), Faculty of Mechanical Engineering, University of Belgrade has developed a prototype of continually variable geometry intake manifold (CVIM). This system is very technically advanced and can only be seen within the most exotic and prestige vehicle powertrain systems. Also, the upgrade and improvement of telemetry unit are done. Data acquisition is significantly improved so the post-processing and decision-making processes are way faster.

The main idea beside designing and development of continually variable intake manifold was the improvement of the engine effective torque curve over the particular RPM range at wide open throttle (WOT). Beside this, development of such a system is a great engineering challenge. Generally, various CVIM concepts were considered regarding the way of actuation, control and production complexity. At the end, we opted for a concept that has telescopic intake runners inside of a fixed volume plenum. Total runner stroke is 96 mm and maximum speed is 0.1 second for full stroke. Intake runners are activated using two high power servo motors and by system of a liner and levers.

Figure 1: Formula Student team "Road Arrow" at the competition in Italy, September, 2014.

The whole system is the integration of different platforms and programing approaches. We are using at the first place NI products, but for some specific systems (or parts of it) we are using platforms such as MikroE, Arduino and XBee products (based on STM and ARM microcontroller). The most important of all is that the whole system operates in a kind of symbiosis without any problems. During projecting, physical model validation, calibration and testing process and for every other "want to know how" activity, NI PXI platform was engaged.

The main advantage of NI products, especially LabVIEW, is easiness and flexibility during application making and adapting. Permanent usage of NI PXI during designing various vehicle systems requires frequent application changes. Every time when you try to make something new, there is no straight-forward plan, but improvisation is largely present, and the LabVIEW is practically intended for that. By using NI-cRIO and NI-PXI platforms which we have at our disposal, we were able to design and test various control algorithms at stationary and quasi-stationary operating regimes. Utilization of LabVIEW graphical programing interface, as well as DIAdem software for test results analysis greatly contributed to the rapid and effective development of a system as a whole, and especially during resolving of control strategies for pairing of two interdependent dynamic systems – Internal Combustion Engine and variable intake manifold.

Also, a telemetry unit for wireless transmission of engine's sensor readings and applied control values for ignition, gasoline injection and other engine's systems was developed. These informations are available via ECU's high-speed CAN stream (such as RPM, TPS, MAP, AFR, Oil temp, ignition timing, injection duration, etc.), and also various on-vehicle mounted sensor readings (brake temperatures, suspension behavior, wheel angular speed, GPS position, etc.). Using NI VISA coupled with the state machine programing approach we have come to clear and adjustable applications solutions. On-vehicle mounted sensor readings and whole CAN data stream was sent to pit-lane PCs running LabVIEW application developed for data graphical interpretation and logging for later analysis. With such an approach, students were able to monitor the engine's and vehicle's behavior in Real-Time during the race.

Guided by the desire to use as much as possible NI-cRIO processor power, our future plan is to integrate NI-cRIO platform even more in our vehicle for actuating components of the vehicle that we want to be on-track adjustable (variable intake manifold, suspension, differential settings, traction control, etc.). Overcoming these engineering challenges in cooperation with NI will, for sure, put our FS team in a higher position at the world ranking list.

Thanks to National Instruments Serbia and National Instruments South East Europe office that provide generous support, University of Belgrade and it's Formula Student team gained new skills and better results at the global level. NI hardware and software properties, such as modularity, robustness and reliability, allow us to improve almost every part of our vehicle. That gives us a chance to achieve even better results in the upcoming races.

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