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Drive-by-wire of a converted into electric car Syrena 105 enabling Hardware-In-Loop tests of driving

PAWEŁ ADAMSKI[1*], PAWEŁ OLEJNIK[1]

1. Department of Automation, Biomechanics and Mechatronics, Lodz University of Technology, 1/15 Stefanowski Str., 90-924 Lodz, Poland [PO ORCID: 0000-0002-3310-0951]
* Presenting Author

Abstract: In this work, replacing an electronic throttle pedal and a driver in an electric car converted into electric by a hardware-in-loop workbench is described, highlighting the advantage of drive-by-wire feature that appeared after conversion. Drive-by-wire facilitates replacing a driver by Hardware-In-Loop (HIL) workbench, as instead of simulating a mechanical pedal depression by a servomechanism, electric signals can be transmitted directly from the workbench. Thanks to one-pedal-driving feature of the motor controller used in the car, there is a possibility of performing a variety of road tests replacing only the electronic throttle pedal. Hardware interventions in the car are described and sample HIL test results are presented.

Keywords: driving cycles, HIL driving, PID, conversion

1. Introduction

Despite the best knowledge of a car under consideration and best conversion design, to acquire the full performance of a converted car, there is a need of performing driving tests without any human error – specifically HIL drive tests. Car conversions into electric imply some changes among which exchanging mechanical throttle pedal by electronic one, which is commonly called drive- by-wire [1] and substantially facilitates any automation or HIL testing. The car under consideration is Syrena 105 family car produced in Poland in 1979, and converted into the electric vehicle.

2. Results and Discussion

Some basic parameters that can be set in the controller used in the car are: Creep torque – torque generated when stationary vehicle is ready to drive (imitation of ICE car with hydrokinetic clutch automated gearbox), Neutral torque, that stands for regenerative braking in case of releasing the throttle pedal when cruising (imitation of engine braking caused by friction od compression).

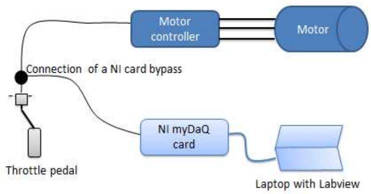

Fig. 1. Open-loop control HIL schematics

Setting the last one to big values enables achieving a car that is possible of one-pedal-driving, as throttle pedal can be used for accelerating form stationary, adjusting actual speed, and also for deceleration until stationary.

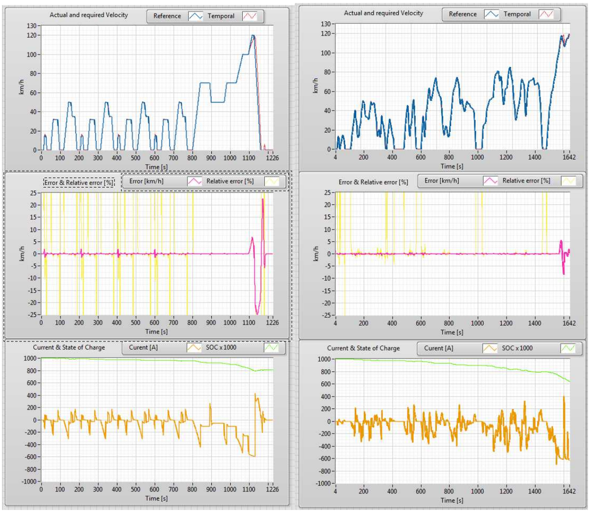

Fig. 2. Time histories of two state variables of a virtual vehicle model's drive cycles

To realise it, a mathematical model of the electric car was programmed in LabVIEW environment, and a numerical PID controller was used in the program to adjust the throttle pedal's signal in such a way, to minimise an error between the reference speed profile of a standardised driving cycle and the actual vehicle speed calculated from measurement of motor speed in a feedback loop.

Tests were carried out both in open (see Fig. 1) and closed-loop control, with HIL and fully virtually. Results of cycling a virtual car model over WLTP and NEDC drive cycles (Fig. 2) show error between reference and actual car velocity, along with battery current and State-Of-Charge (SOC) given as a percentage and multiplied by 10.

3. Concluding Remarks

It is possible to drive a converted into electric car with a one-pedal-driving. It is relatively easy technical task to substitute an electronic throttle pedal by a signal from an acquisition card attached to a laptop. It is possible to run standardised driving cycles in a HIL test procedure with a converted into electric vehicle using simple acquisition cards.

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