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HARDWARE-IN-THE-LOOP (HIL) SIMULATION FOR AUTOMATIVE ELECTRONIC CONTROL UNIT (ECU)

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ABSTRACT *To satisfy the to the vehicles safety environmental protection and comfort levels have become more and more complex to develop an Electronic Control Unit (ECU). Hence developing simulation and cost efficient verification tools for present and future generation of ECUdeveloping a simulation tools for automatic Hardware- In- the- Loop test environment which provides verification and calibration of state of the art sensors and ECUs*

KEYWORDS : HIL, ECU, Lab view Software.

I. INTRODUCTION

In addition, HIL systems are frequentlyused for fault tolerant studies and consistency (endurance) tests of new components.

If the controller to be tested is implemented in the controller hardware, commonly denoted the ECU, and the simulator has to run in real time, that is the simulation time develops as real time. This real time simulation is done by setting the simulation algorithm cycle time matching to the simulation time step.

Typically, the simulator communicates with the ECU via ordinary I/O (current, voltage, digital). Such a system - where the real controller is controlling a simulated process is represented asHILsimulation. HIL-simulation is used in many of the industries, e.g. automotive industry for testing clutch automation systems and in marine and aircraft industry to test autopilots of vessels.

The Figure below determines the principle of testing a control system by modifying the physical system (or process) to be controlled by a simulated system. The controller is thenassumed to be a PID controller, but the figure applicable to any controller function.

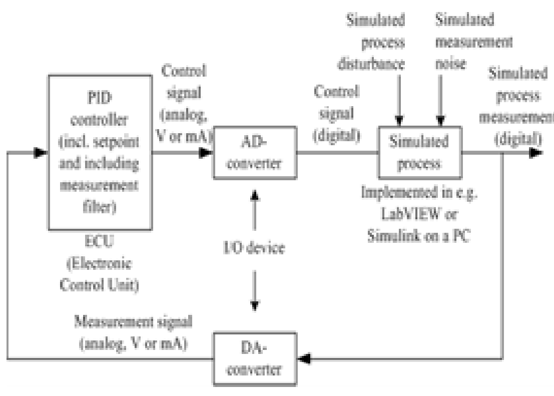

Fig.1 Principle of testing a control system by replacing the physical system to be controlled by a simulated system.

II. LITERATURE SURVEY OR RELATED WORK:

This work surveys on the complexity in the development of efficiency in testing the automotive anti-lock braking system by simulating the real time crisisusing the software implementation thereby lessen the time and money.

- Find out what is known (or not known) about a topic or research question.
- Establish the current position of the research on a topic or research question.
- Place your topic or research question into the framework of related research and information.

III. DESCRIPTION OF THE PROPOSED SYSTEM

A. Hardware-in-the-loop (HIL)

The mathematical represents are referred to as the "plant simulation". The embedded system to be tested interacts or communicates with this plant simulation. A HIL simulation must combine electrical emulation of sensors and actuators.

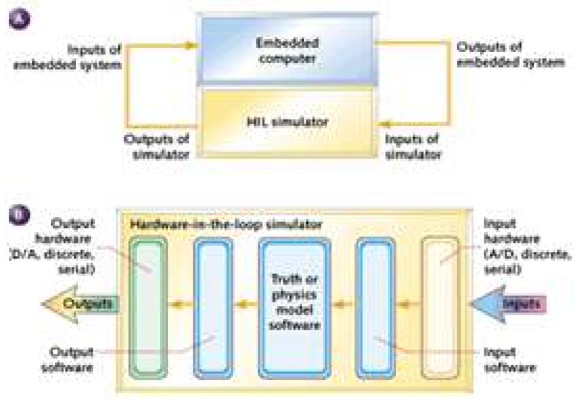

Fig 2 a) Diagram of embedded system connected to a HIL simulator

b) Components of a simple HIL simulator

A dominant powerful toolfrequently used in this situation is a HIL Simulator.. Fig 2a shows a block diagram of an embedded system that may be tested using a HILS. Fig 2b shows the simple components of a HILS.

Simulated Process

The below example determines a mathematical model of the following small-scale process is used ("Air Heater"):

Fig 3 Mathematical Model

$$T_{out} = \frac{1}{\theta_t}\{-T_{out} + [k_h u(t - \theta_d) + T_{env}]\}$$

B. Hardware

The main principle purpose with the HIL Simulation is to test the hardware device on a simulator before we implement it on the real process.

In this we use a common industrial PID controller, such as Fuji PGX5.

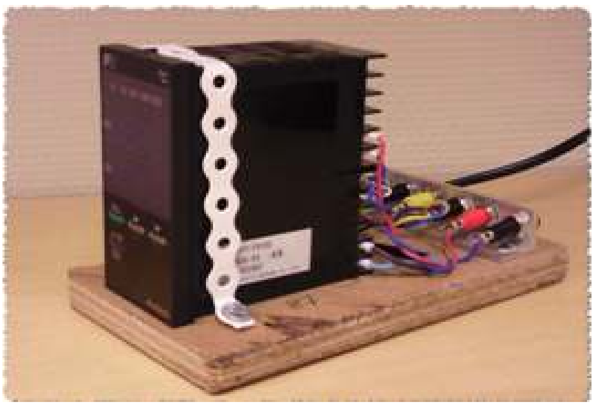

Fig. 4Hardware- in-the-Loop testing

Introduction to Hardware-in-the-Loop Simulation

In this [HIL] we use anormal industrial PID controller, such as Fuji PGX5.

We will test the **Fuji PGX5 PID** controller on a model, and if everything is correct we will implement the controller on the real system.

We willgo to use Lab VIEWin order to implement the HIL Simulation. **Lab VIEW** is a graphical programming language fromNation Instruments, and it is mostly suited for such implementation.

C. Procedure

The procedure is follows as below:

1. PID Control and Simulation in Lab VIEW (Software only). Simulate the model and implement the built-in PID controller in Lab VIEW. No hardware involved.

2. Configure the Fuji PGX5 PID controller (Hardware only). Configure and be familiar with the industrial Fuji PGX5 PID controller.

3. HIL Simulation in Lab VIEW (Software + Hardware). Test your industrial Fuji PGX5 PID controller on your simulated process.

4. PID Tuning (Software + Hardware). Find proper PID parameters, etc. for the controller based on the model.

These tasks follow the main idea with a HIL simulation. Finally you implement your hardware on the real system.

D. Control Vehicle Motion ABS in Lab VIEW

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1. Braking Dynamics

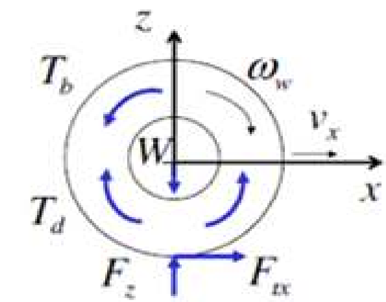


Fig 5: Free Body Diagram

Recall the rotational dynamics of the equation by

$$I_w \dot{\omega}_w = T_{drive} - T_{loss} - T_{traction} - T_{brake}$$

$$\dot{P}_x = \sum F_x = m_v \dot{V}_x$$

The two state variables, namely vehicle speed Vx and wheel speed ωw, are most important in determining the appropriate friction coefficient inbetween the tire and the ground. As it should be known that slip and skid in a single function

$$s = \frac{r\omega - V}{\max(r\omega, V)} * sign(r\omega - V)$$

E. Electronic control unit (ECU)

The new Opel Vectra was designed totally from scratch. The features include modified front seats, rain sensors and assistance, passive safety tools consisting of front side and curtain air bags should protect beside whiplash.

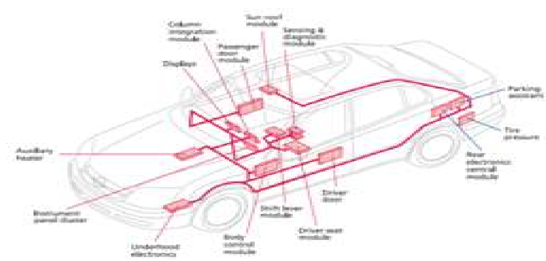
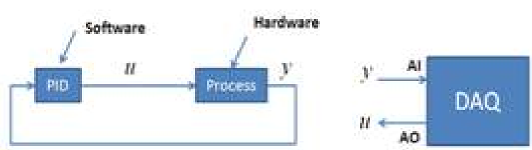


Fig 6: low-speed ECUs CAN network

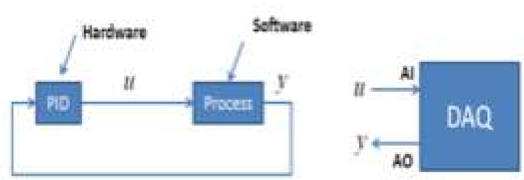
IV. Simulation

A. Traditional process system using a software program for implementing the control system:



In this case you need to scale the voltage signal you get from the process and the DAQ to a temperature value 1-5V 20-50^{0}C

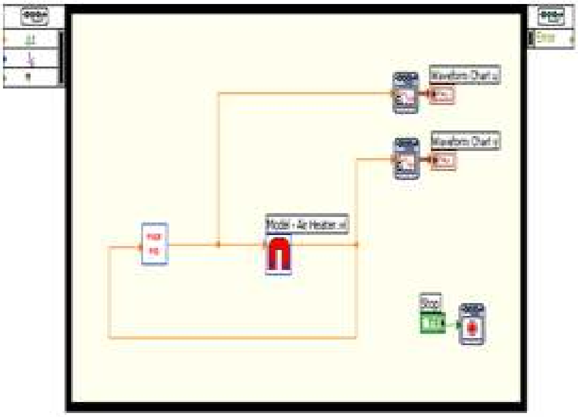
B. HIL Simulation:



In this case you need to scale the temperature value you get from the simulated process before you send the value to the Fuji PGX5 PID controller 20-50^{0}C1-5V

C. HIL Simulation in Lab VIEW

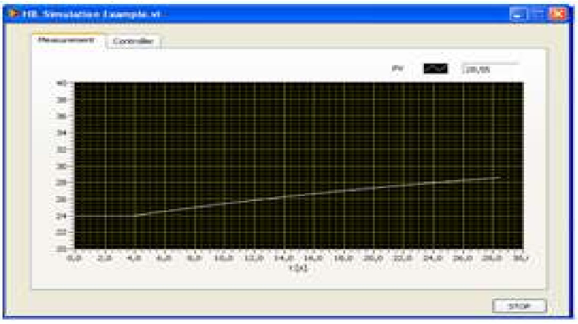
Below we see an excerpt of the program created in Lab VIEW:



In the example we have used a "Simulation Loop" in Lab VIEW, but an ordinary While Loop may also be used. The model is implemented in a Simulation Subsystem.

V. Results & Discussion

The simulation results become:



The Set Point (SP) is set on the PXG5 PID controller (in this case 30^{0}C at time=2s).

2. Simulation of Braking Dynamics

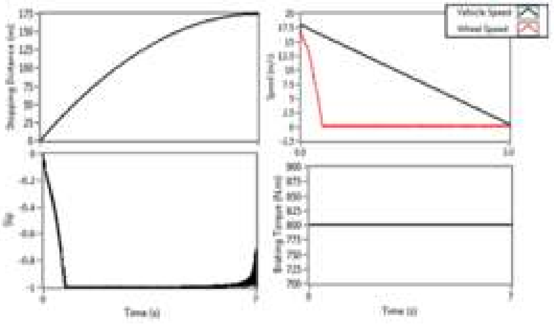


Fig 7: Simple Braking simulation results

The simulation results that are shown in Figure7show that the stopping distance is about 175m.

3. Anti-lock Braking Systems (ABS)

The base of ABS is to monitor cautiously the operating conditions of the wheels

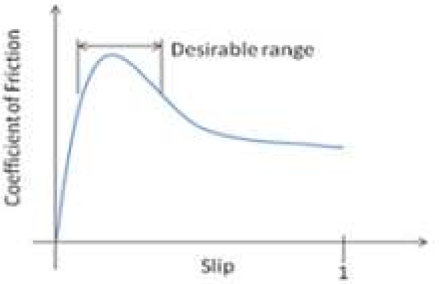
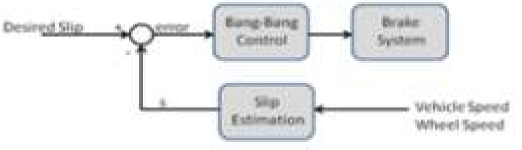


Fig8:Generic Mu-Slip Curve

A simple rule is given by,

$$u(t) = \begin{cases} U_1, e(t) > 0 \\ U_2, e(t) < 0 \end{cases}$$



ABS Formulation

4. LabVIEW ABS Simulation

The overall ABS simulation model in LabVIEW is shown in Fig 9.

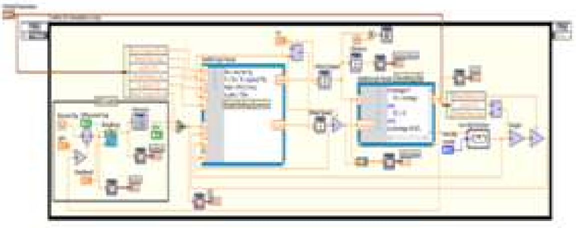
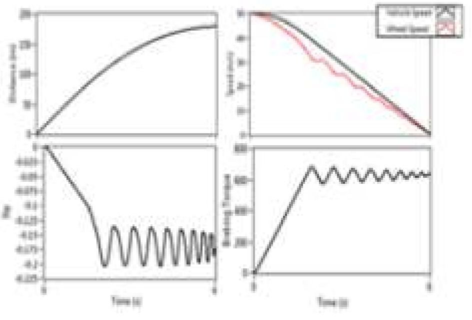


Fig9:Block Diagram of ABS Simulation



ABS Braking Simulation Results

VI. Conclusion

In summary, designers can benefit from using the HIL methodology during different stages of the design cycle.By using (HIL) test eliminated the need for using expansive real vehicle testing.National Instrumentation-lab view provides very flexible infrastructure to implement the software and hardware co-simulation of HIC capability.

VII. Acknowledgement

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