

Firmware Tests with Hard Disk Simulation

➤ HIL simulation of an HDD plant with dSPACE Simulator

➤ Integration of Fujitsu's MATLAB/Simulink models

➤ Tests even before mechanism prototype exists

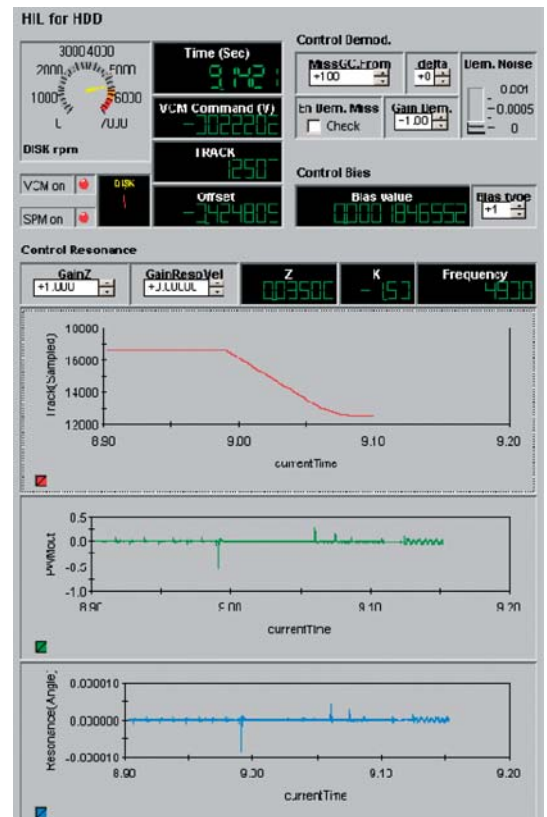


Fujitsu is one of the leading manufacturers of computer HDD units, building several million HDDs every month. In this business, with rapidly increasing requirements on HDD performance, the firmware of the HDD unit plays a key role. For example, servo controllers run by the firmware must control the arm of the HDD with a precision greater than a nanometer. Therefore, the characteristics of the mechanics and the recording magnetism cannot be neglected; they are vital factors that require thorough investigation.

At the early stage of firmware development, we use MATLAB®/Simulink® to evaluate our servo algorithm. When this work is done, we have completed about 25% of the whole firmware development process. The remaining 75% consists of generating code – taking into account the restrictions of RAM and ROM size and execution time – and thoroughly testing it. For example, we have to test whether the generated code works perfectly in extraordinary situations like defective mechanisms, shocks or vibration caused by surface unevenness. In the past, all this was done by hand. There must be a smarter way to do this kind of work – which gave Fujitsu's HDD Firmware Development Department the idea of using a hardware-in-the-loop (HIL) system.

We decided to acquire dSPACE Simulator for many reasons. The most obvious are:

- We have many MATLAB/Simulink HDD plant models that we use in the algorithm evaluation stage. Using dSPACE Simulator means we can reuse them for HIL extremely efficiently.
- ControlDesk, dSPACE's experiment software gives us an excellent platform for monitoring and capturing any state variables of our MATLAB/Simulink models.
- dSPACE Simulator is easy to operate. Although our firmware developers are experts on microcontroller code, they are not always familiar with Windows or UNIX programming. dSPACE Simulator gives them the opportunity to customize the system themselves, without complex GUI programming.



ControlDesk monitors and captures the state variables of Fujitsu's HDD simulation.

A Smarter Way for Testing Firmware Code

By testing the code with dSPACE Simulator, it is possible to save time and maintain the required precision of the HDD units, especially the arm's position. It is also possible to start the firmware development even before a mechanism prototype exists. Moreover, we can reproduce conditions of mechanical unevenness and combinations of extraordinary con-

ditions by simulation. At nanometer level, an arm and a disk appear as if they are soft and flexible, which makes it impossible to find the relative velocity between them continuously. HIL simulation enabled us to estimate the relative velocity.

However, dSPACE Simulators are usually used for simulating systems such as cars, ships, or trains, with sampling times in the range of milliseconds. When simulating a hard disk drive, you face much lower sampling times, because the plant itself is tiny. In our case, the sampling time is around 1 μ s, which was impossible to achieve, even with dSPACE Simulator. We therefore lowered the sampling time of the firmware running on the control unit to synchronize it with the simulation speed. The simulation speed is now 300 times slower than the real sampling time of 1 μ s. It greatly depends on the model size, but firmware developers say that slowing the sampling rate down three hundred times is enough.

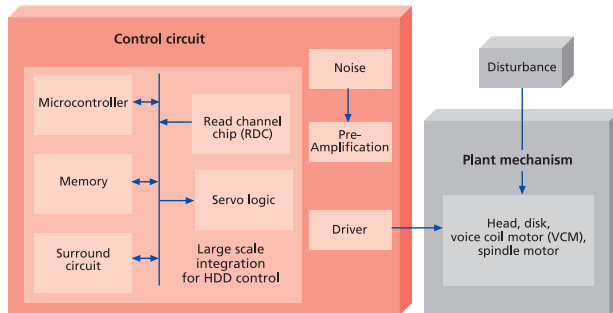
This "synchronized simulation" may be in slow motion, but it does enable us to do a time-critical simulation. dSPACE Simulator controls the firmware, for example, by waiting for acknowledge signals from it, which allows the simulation to be paused from either the simulator or the firmware side. Synchronized simulation brought us the following advantages:

- The simulation time can be set to any value.
- After a temporary program stop, for example, by an event break, the simulation can be restarted.

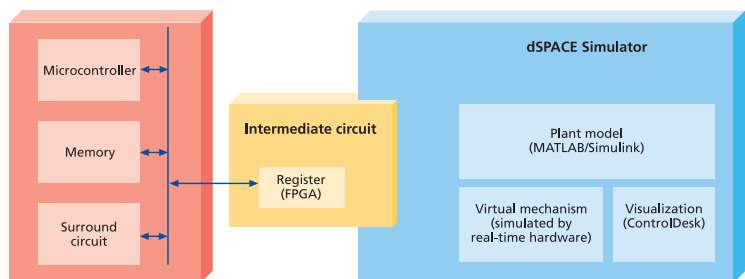
The model calculated on dSPACE Simulator is the magnetic disk model, and it is possible to add another processor board to simulate the influence of wind by calculating hydrodynamics.

Flexibility for Different Hard Disk Types

Communication between dSPACE Simulator and the microcontroller executing the firmware is via shared memory. Normally, the position information and commands to a motor for arm servo control are sent via special circuits, such as a read channel (RDC) or servo logic. But since the HIL sampling time is reduced and the firmware just requires information on the register (memory) values of the RDC and servo logic, we created our own intermediate circuit with a register. This intermediate circuit is based on

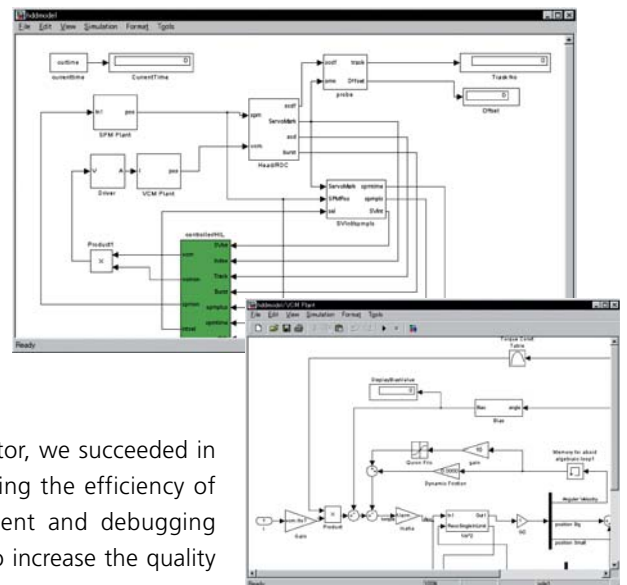


Former development method.



New development in comparison: dSPACE Simulator increases the efficiency.

FPGAs. Therefore, when switching between MCU memory maps for different targets or when changing read and write timing, it is only necessary to replace the configuration ROM of the FPGA.



The Simulink plant models used in the evaluation stage can be reused efficiently with dSPACE Simulator.

By using the simulator, we succeeded in significantly increasing the efficiency of firmware development and debugging tasks. We could also increase the quality of our production firmware. From now on we will use dSPACE Simulator in other fields, such as MO (magneto-optical) and DVD.

Yosuke Senta
Fujitsu Laboratory
Japan