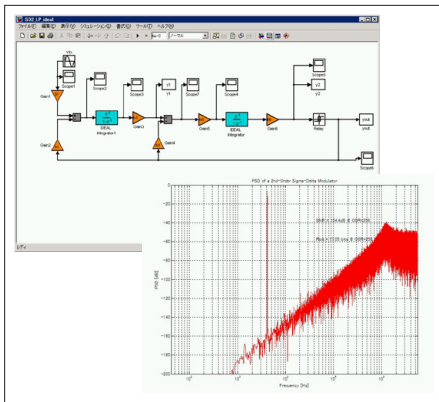


Epson Toyocom Designs and Verifies Mixed-Signal Integrated Circuit in Two Months



Simulink model of the delta-sigma ADC with power spectral density plot.

As manufacturers strive to pack more functionality into ever smaller devices, the demand for compact yet highly accurate crystal devices has increased. Crystal devices are essential to many of the advanced features in today's consumer electronics—for example, they are used to implement clock functions, mobile TV tuners, surface acoustic wave filters, and gyro-sensors used in cell phones, digital cameras, and automobiles.

As components are miniaturized, it becomes much harder to deliver stability and precision at high frequencies using purely analog designs. To solve this problem, engineers are turning to mixed-signal integrated circuits (ICs) that combine analog and digital circuits on a single chip.

Epson Toyocom used MATLAB® and Simulink® to develop a 16-bit delta-sigma analog-to-digital converter (ADC) for a mixed-signal IC. Modeling and simulation in Simulink enabled Epson Toyocom engineers to make informed design decisions, verify their design early in development, and reduce the number of hardware prototypes, helping the team complete the project within a two-month deadline and saving Epson Toyocom millions of dollars.

The Challenge

When Epson Toyocom engineers began developing the delta-sigma ADC, they had no existing design that could be adapted or reused. Without a reference design, the team would have to evaluate a wide range of parameters, including input capacitance,

output voltage, operational amplifier (op-amp) gain, and slew rate. “We needed to run numerous simulations to sufficiently explore all the alternatives,” explains Jun Uehara, QI project, Epson Toyocom.

The team had just two months to design and lay out the ADC, which meant the specification had to be completed in the first two weeks. There was not enough time to use circuit-level or Verilog-A-level simulations to explore design options. Furthermore, to meet the project deadline, the team would need to rapidly simulate and verify any design changes as soon as they received the first IC prototypes.

The Solution

Epson Toyocom used MathWorks tools for Model-Based Design to model, simulate, and verify the 16-bit delta-sigma ADC.

The engineers used Simulink to model the system architecture and the initial system design. The input capacitance, op-amp gain, and other key characteristics were implemented as modifiable design parameters.

After verifying the basic functionality of the Simulink model via simulations, the engineers developed MATLAB scripts that programmatically updated the system parameters in the model. They then performed numerous simulations in which parameter values were systematically varied across their ranges to identify the combination of values that minimized thermal noise and maximized the signal-to-noise ratio.

The Challenge

Develop a mixed-signal integrated circuit with a new 16-bit analog-to-digital converter in two months

The Solution

Use MathWorks tools for Model-Based Design to model, simulate, verify, and improve the system-level design

The Results

- Simulation time reduced from days to minutes
- Development time cut by 33%
- Millions of dollars saved

“Circuit-level simulations took three days. With Verilog-A they took 20 minutes—still too long to enable sufficient exploration of design alternatives. Using MATLAB and Simulink, we reduced simulation time to just one minute.” —JUN UEHARA, EPSON TOYOCOM

They used MATLAB to visualize the simulation results, such as power spectral density as a function of frequency. They also evaluated design tradeoffs using MATLAB. For example, the team weighed using a higher input capacitance to improve noise reduction against the additional expense of the high-quality amplifier that would also be needed.

Once they had identified parameter values that fulfilled all the system requirements while minimizing costs, Epson Toyocom produced engineering samples of the design. Lab testing of these IC prototypes revealed a higher level of harmonic distortion than expected, which was reducing the signal-to-noise ratio.

The engineers used Simulink to diagnose the problem, identify its cause, and gain deeper insight into the behavior of their design.

Using MATLAB, they developed a compensation algorithm to address the distortion problem. They incorporated this algorithm as a functional block in the Simulink system model. After running simulations to verify that the distortion had been sufficiently reduced, they updated the IC design with this fix.

The Results

Simulation time reduced from days to minutes. “Using our conventional approach, the simulation of a system model took days when performed at the circuit level,” says Uehara. “Simulink enabled us to simulate the entire design at the system level and complete the simulation in one minute.”

Development time cut by 33%. Epson Toyocom completed the mixed-signal IC development within the two-month deadline. The engineers estimate that the project would have taken three months using their conventional development approach.

Millions of dollars saved. After identifying a problem in the first IC samples, the engineers implemented a fix in Simulink. They verified this fix in minutes. Using the team’s previous simulation methods, it would have taken an entire day. Verification via Model-Based Design enabled Epson Toyocom to reduce the number of IC samples built, saving millions of dollars in mask and prototyping costs.

Industry

- Electronics and semiconductors
- Communications

Application Areas

- Algorithm development
- System design and simulation
- Verification, validation, and test
- Digital signal processing

Products Used

- MATLAB®
- Simulink®

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