

Real-Time Digital Signal Processing in a Mixed-Signal LSI Test System

In test subsystems based on digital signal processing, the HP 9493 test system emulates the analog and digital signals of the device under test, thereby reducing test time and increasing test coverage compared to a memory-based test system.

by Keita Gunji

Complex mixed-signal integrated circuits are used more and more frequently to realize many complex functions needed for applications such as telecommunications, servo control, and image processing. Testing of these ICs is much more difficult than for traditional ICs because of the integration of complex functions and synchronized interactions between blocks. Conventional IC testing methods cannot provide both high test throughput and high test quality for these devices. At-speed signal processing by synchronized distributed subsystems is required to perform functional testing of complex mixed-signal devices. Also required is a programming style that is straightforward and allows flexible control of signal and data flow in the test subsystems.

DSP-based LSI testers can be classified as having one of two types of architecture according to the location of the signal processing units (SPUs): centralized or distributed.¹ In the distributed type, SPUs are distributed among the individual subsystems. Usually, each SPU cannot manage a large amount of data and the processing speed of each SPU is slower than that of a centralized SPU. Programming is more difficult because the SPUs are not strongly coupled to the CPU, so the control layer between the CPU and the SPUs is more complicated. On the other hand, the distributed type makes it possible to process data in the subsystems and enables at-speed emulation of IC functions, which is required to test mixed-signal devices.

To meet the needs of complex mixed-signal testing, the HP 9493 mixed-signal LSI test system is based on distributed digital signal processors (DSPs). In each test subsystem is a Motorola DSP96002 chip, which runs at 32 MHz and performs 32-bit floating-point operations. The DSP modules are connected by data transmission paths for data sharing. A flexible programming language directs the DSPs to generate and analyze test signals.

The HP 9493 architecture allows digital and analog signal processing completion times on the order of microseconds to ensure the quality and throughput of dynamic signals and data operations for the device under test (DUT). Precise timing synchronization of all subsystems makes it possible to distribute operations among the DSP modules.

Compared to a memory-based test system, the HP 9493's distributed DSP architecture reduces test time and increases test coverage for complex mixed-signal devices. To generate

an analog waveform, the conventional memory-based system must compute and store discrete time data for the entire waveforms before generating it. This takes time and may require so much memory that the functions of a complex device may not be tested completely because of the memory cost. In contrast, the DSP-based HP 9493 prepares the discrete time data in real time using a much smaller amount of waveform memory.

Architecture

Fig. 1 shows the HP 9493 system architecture, which allows synchronous and asynchronous control of the analog and digital subsystems and the distributed DSP in each subsystem. This distributed architecture consists of a tester controller, which controls all test subsystems, a master clock subsystem, two test heads, and test subsystems. The test subsystems include digital subsystems, which generate and fetch digital patterns and signals, arbitrary waveform generator subsystems, and waveform digitizer subsystems.

In each test subsystem are a DSP module, a sequencer, and a memory block. Each DSP module has a data transmission path. The DSP modules operate on data or signals according to instructions loaded from the tester controller, and the start and stop operations are synchronized by the master sequencer or tester controller. The master sequencer precisely synchronizes the timing of the other sequencers.

The DSP96002 manages the memory block. Data can also be stored in high-speed memory in the DSP module to reduce memory access time, which increases the processing speed of the DSP96002. The sequencer in each subsystem controls address generation and the timing of data fetch or generation between the memory block and the signal input or output for memory-based testing.

The advantages of this architecture are real-time signal emulation and shared signal processing. Test throughput is more than double the capability of conventional LSI testers, and ICs can be evaluated by at-speed functional tests. Data can be transmitted between DSP modules without CPU intervention, which allows synchronous and concurrent operation and sharing of signals from the DUT.

The DSP module in the digital subsystem can fetch and generate up to 32-bit digital test data. The test data is directly connected to the data bus of the DSP96002. Data can be

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Thomas Noulis



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Oscillation-Based Test in Mixed-Signal Circuits Gloria Huertas Sánchez, Diego Vázquez García de la Vega, Adoración Rueda Rueda, Jose Luis Huertas Díaz, 2007-06-03. Oscillation Based Test in Mixed Signal Circuits presents the development and experimental validation of the structural test strategy called Oscillation Based Test (OBT) in short. The results here presented allow to assert not only from a theoretical point of view but also based on a wide experimental support that OBT is an efficient defect oriented test solution complementing the existing functional test techniques for mixed signal circuits.

Computer-Aided Design of Analog Integrated Circuits and Systems Rob A. Rutenbar, Georges G. E. Gielen, 2002-05-06. The tools and techniques you need to break the analog design bottleneck. Ten years ago analog seemed to be a dead end technology. Today System on Chip (SoC) designs are increasingly mixed signal designs. With the advent of application specific integrated circuits (ASIC) technologies that can integrate both analog and digital functions on a single chip analog has become more crucial than ever to the design process. Today designers are moving beyond hand crafted one transistor at a time methods. They are using new circuit and physical synthesis tools to design practical analog circuits, new modeling and analysis tools to allow rapid exploration of system level alternatives and new simulation tools to provide accurate answers for analog circuit behaviors and interactions that were considered impossible to handle only a few years ago. To give circuit designers and CAD professionals a better understanding of the history and the current state of the art in the field this volume collects in one place the essential set of analog CAD papers that form the foundation of today's new analog design automation tools. Areas covered are Analog synthesis, Symbolic analysis, Analog layout, Analog modeling and analysis, Specialized analog simulation, Circuit centering and yield optimization, Circuit testing. *Computer Aided Design of Analog Integrated Circuits and Systems* is the cutting edge reference that will be an invaluable resource for every semiconductor circuit designer and CAD professional who hopes to break the analog design bottleneck.

Efficient Testability Design Methodology for Analog/mixed Signal Integrated Circuits Cheng-Ping Wang, 1997. **An Introduction to Mixed-signal IC Test and Measurement** Gordon W.

Roberts, Friedrich Taenzler, Mark Burns, 2012 With the proliferation of complex semiconductor devices containing digital analog mixed signal and radio frequency circuits the economics of test has come to the forefront and today's engineer needs to be fluent in all four circuit types Having access to a book that covers these topics will help the evolving test engineer immensely and will be an invaluable resource In addition the second edition includes lengthy discussion on RF circuits high speed I/Os and probabilistic reasoning Appropriate for the junior senior university level this textbook includes hundreds of examples exercises and problems

Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits M. Bushnell, Vishwani Agrawal, 2006-04-11 The modern electronic testing has a forty year history Test professionals hold some fairly large conferences and numerous workshops have a journal and there are over one hundred books on testing Still a full course on testing is offered only at a few universities mostly by professors who have a research interest in this area Apparently most professors would not have taken a course on electronic testing when they were students Other than the computer engineering curriculum being too crowded the major reason cited for the absence of a course on electronic testing is the lack of a suitable textbook For VLSI the foundation was provided by semiconductor device technology circuit design and electronic testing In a computer engineering curriculum therefore it is necessary that foundations should be taught before applications The field of VLSI has expanded to systems on a chip which include digital memory and mixed signal subsystems To our knowledge this is the first textbook to cover all three types of electronic circuits We have written this textbook for an undergraduate foundations course on electronic testing Obviously it is too voluminous for a one semester course and a teacher will have to select from the topics We did not restrict such freedom because the selection may depend upon the individual expertise and interests Besides there is merit in having a larger book that will retain its usefulness for the owner even after the completion of the course With equal tenacity we address the needs of three other groups of readers

Low-power HF Microelectronics Gerson A. S. Machado, 1996 This book brings together innovative modelling simulation and design techniques in CMOS SOI GaAs and BJT to achieve successful high yield manufacture for low power high speed and reliable by design analogue and mixed mode integrated systems

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Mixed-Signal Circuits Thomas Noulis, 2018-09-03 Mixed Signal Circuits offers a thoroughly modern treatment of integrated circuit design in the context of mixed signal applications Featuring chapters authored by leading experts from industry and academia this book Discusses signal integrity and large scale simulation verification and testing Demonstrates advanced design techniques that enable digital circuits and sensitive analog circuits to coexist without any compromise Describes the process technology needed to address the performance challenges associated with developing complex mixed signal circuits Deals with modeling topics such as reliability variability and crosstalk that define pre silicon design methodology and trends and are the focus of companies involved in wireless applications Develops methods to move analog into the digital domain quickly minimizing and eliminating common trade offs between performance power consumption simulation time verification size and cost Details approaches for very low power performances high speed interfaces phase locked loops PLLs voltage controlled oscillators VCOs analog to digital converters ADCs and biomedical filters Delineates the respective parts of a full system on chip SoC from the digital parts to the baseband blocks radio frequency RF circuitries electrostatic discharge ESD structures and built in self test BIST architectures Mixed Signal Circuits explores exciting opportunities in wireless communications and beyond The book is a must for anyone involved in mixed signal circuit design for future technologies

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