

# **DIGITAL INTEGRATED CIRCUIT TESTING USING TRANSIENT SIGNAL FILE PDF**

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## **Digital Integrated Circuit Testing Using Transient Signal Introduction**

### **Test and Design-for-Testability in Mixed-Signal Integrated Circuits**

Test and Design-for-Testability in Mixed-Signal Integrated Circuits deals with test and design for test of analog and mixed-signal integrated circuits. Especially in System-on-Chip (SoC), where different technologies are intertwined (analog, digital, sensors, RF); test is becoming a true bottleneck of present and future IC projects. Linking design and test in these heterogeneous systems will have a tremendous impact in terms of test time, cost and proficiency. Although it is recognized as a key issue for developing complex ICs, there is still a lack of structured references presenting the major topics in this area. The aim of this book is to present basic concepts and new ideas in a manner understandable for both professionals and students. Since this is an active research field, a comprehensive state-of-the-art overview is very valuable, introducing the main problems as well as the ways of solution that seem promising, emphasizing their basis, strengths and weaknesses. In essence, several topics are presented in detail. First of all, techniques for the efficient use of DSP-based test and CAD test tools. Standardization is another topic considered in the book, with focus on the IEEE 1149.4. Also addressed in depth is the connecting design and test by means of using high-level (behavioural) description techniques, specific examples are given. Another issue is related to test techniques for well-defined classes of integrated blocks, like data converters and phase-locked-loops. Besides these specification-driven testing techniques, fault-driven approaches are described as they offer potential solutions which are more similar to digital test methods. Finally, in Design-for-Testability and Built-In-Self-Test, two other concepts that were taken from digital design, are introduced in an analog context and illustrated for the case of integrated filters. In summary, the purpose of this book is to provide a glimpse on recent research results in the area of testing mixed-signal integrated circuits, specifically in the topics mentioned above. Much of the work reported herein has been performed within cooperative European Research Projects, in which the authors of the different chapters have actively collaborated. It is a representative snapshot of the current state-of-the-art in this emergent field.

### **Digital Circuit Testing**

Recent technological advances have created a testing crisis in the electronics industry--smaller, more highly integrated electronic circuits and new packaging techniques make it increasingly difficult to physically access test nodes. New testing methods are needed for the next generation of electronic equipment and a great deal of emphasis is being placed on the development of these methods. Some of the techniques now becoming popular include design for testability (DFT), built-in self-test (BIST), and automatic test vector generation (ATVG). This book will provide a practical introduction to these and other testing techniques. For each technique introduced, the author provides real-world examples so the reader can achieve a working knowledge of how to choose and apply these increasingly important testing methods.

## **Analysis of High-power Short-circuit Test Laboratory Transient Using Digital Signal-processing Techniques**

Using the book and the software provided with it, the reader can build his/her own tester arrangement to investigate key aspects of analog-, digital- and mixed system circuits. Plan of attack based on traditional testing, circuit design and circuit manufacture allows the reader to appreciate a testing regime from the point of view of all the participating interests. Worked examples based on theoretical bookwork, practical experimentation and simulation exercises teach the reader how to test circuits thoroughly and effectively.

## **Integrated Circuit Test Engineering**

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.

## **Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits**

This is a new type of edited volume in the Frontiers in Electronic Testing book series devoted to recent advances in electronic circuits testing. The book is a comprehensive elaboration on important topics which capture major research and development efforts today. "Hot" topics of current interest to test technology community have been selected, and the authors are key contributors in the corresponding topics.

## **Advances in Electronic Testing**

Integrated circuits incorporating both digital and analog functions have become increasingly prevalent in the semiconductor industry. Mixed-signal IC test and measurement has grown into a highly specialized field of electrical engineering. It has become harder to hire and train new engineers to become skilled mixed-signal test engineers. The slow learning curve for mixed-signal test engineers is largely due to the shortage of written materials and university-level courses on the subject of mixed-signal testing. While many books have been devoted to the subject of digital test and testability, the same cannot be said for analog and mixed-signal automated test and measurement. This book was written in response to the shortage of basic course material for mixed-signal test and measurement. The book assumes a solid background in analog and digital circuits as well as a working knowledge of computers and computer programming. A background in digital signal processing and statistical analysis is also helpful, though not absolutely necessary. This material is designed to be useful as both a university textbook and as a reference manual for the beginning professional test engineer. The prerequisite for this book is a junior level course in linear continuous-time and discrete-time systems, as well as exposure to elementary probability and statistical concepts. Chapter 1 presents an introduction to the context in which mixed-signal testing is performed and why it is necessary. Chapter 2 examines the process by which test programs are generated, from device data sheet to test plan to test code. Test program structure and functionality are also discussed in Chapter 2. Chapter 3 introduces basic DC

measurement definitions, including continuity, leakage, offset, gain, DC power supply rejection ratio, and many other types of fundamental DC measurements. Chapter 4 covers the basics of absolute accuracy, resolution, software calibration, standards traceability, and measurement repeatability. In addition, basic data analysis is presented in Chapter 4. A more thorough treatment of data analysis and statistical analysis is delayed until Chapter 15. Chapter 5 takes a closer look at the architecture of a generic mixed-signal ATE tester. The generic tester includes instruments such as DC sources, meters, waveform digitizers, arbitrary waveform generators, and digital pattern generators with source and capture functionality. Chapter 6 presents an introduction to both ADC and DAC sampling theory. DAC sampling theory is applicable to both DAC circuits in the device under test and to the arbitrary waveform generators in a mixed-signal tester. ADC sampling theory is applicable to both ADC circuits in the device under test and to waveform digitizers in a mixed-signal tester. Coherent multi-tone sample sets are also introduced as an introduction to DSP based testing. Chapter 7 further develops sampling theory concepts and DSP-based testing methodologies, which are at the core of many mixed-signal test and measurement techniques. FFT fundamentals, windowing, frequency domain filtering, and other DSP-based testing fundamentals are covered in Chapter 6 and 7. Chapter 8 shows how basic AC channel tests can be performed economically using DSP-based testing. This chapter covers only non-sampled channels, consisting of combinations of op-amps, analog filters, PGAs and other continuous-time circuits. Chapter 9 explores many of these same tests as they are applied to sampled channels, which include DACs, ADCs, sample and hold (S/H) amplifiers, etc. Chapter 10 explains how the basic accuracy of ATE test equipment can be extended using specialized software routines. This subject is not necessarily taught in formal ATE tester classes, yet it is critical in the accurate measurement of many DUT performance parameters. Testing of DACs is covered in Chapter 11. Several kinds of DACs are studied, including traditional binary-weighted, resistive ladder, pulse with modulation (PWM), and sigma delta architectures. Traditional measurements like INL, DNL and absolute error are discussed. Chapter 12 builds upon the concepts in Chapter 11 to show how ADCs are commonly tested. Again, several different kinds of ADC's are studied, including binary-weighted, dual-slope, flash, semi-flash, and sigma-delta architectures. The weaknesses of each design are explained, as well as the common methodologies used to probe their weaknesses. Chapter 13 explores the gray art of mixed-signal DIB design. Topics of interest include component selection, power and ground layout, crosstalk, shielding, transmission lines, and tester loading. Chapter 13 also illustrates several common DIB circuits and their use in mixed-signal testing. Chapter 14 gives a brief introduction to some of the techniques for analog and mixed-signal design for test. There are fewer structured approaches for mixed-signal DfT than for purely digital DfT. The more common ad-hoc methods are explained, as well as some of the industry standards such as IEEE Std. 1149.1 and 1149.4. A brief review of statistical analysis and Gaussian distributions is presented in Chapter 15. This chapter also shows how measurement results can be analyzed and viewed using a variety of software tools and display formats. Datalogs, shmoo plots, and histograms are discussed. Also, statistical process control (SPC) is explained, including a discussion of process control metrics such as  $C_p$  and  $C_{pk}$ . Chapter 16 examines the economics of production testing, The economics of testing are affected by many factors such as equipment purchase price, test floor overhead costs, test time, dual-head testing, multi-site testing, and time to market. A test engineer's debugging skills heavily impacts time to market. Chapter 16 examines the test debugging process to attempt to set down some general guidelines for debugging mixed-signal test programs. Finally, emerging trends that affect test economics and test development time are presented in Chapter 16. Some or all these trends will shape the future course of mixed-signal test and measurement.

## **An Introduction to Mixed-signal IC Test and Measurement**

This book provides a comprehensive discussion of automatic testing, diagnosis and tuning of analogue, mixed-signal and RF integrated circuits, and systems in a single source. As well as fundamental concepts and techniques, the book reports systematically the state of the arts and future research directions of those areas. A complete range of circuit components are covered and test issues from the SoC perspective. An essential reference for researchers and engineers in mixed signal testing, postgraduate and senior undergraduate students.

## **Test and Diagnosis of Analogue, Mixed-signal and RF Integrated Circuits**

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.

## **An Introduction to Mixed-signal IC Test and Measurement**

This book discusses the significant aspects of thermal transient testing, the most important method of thermal characterization of electronics available today. The book presents the theoretical background of creating structure functions from the measured results with mathematical details. It then shows how the method can be used for thermal qualification, structure integrity testing, determining material parameters, and calibrating simulation models. General practical questions about measurements are discussed to help beginners carry out thermal transient testing. The particular problems and tricks of measuring with various electronic components, such as Si diodes, bipolar transistors, MOS transistors, IGBT devices, resistors, capacitors, wide bandgap materials, and LEDs, are covered in detail with the help of various use cases. This hands-on book will enable readers to accomplish thermal transient testing on any new type of electronics and provides the theoretical details needed to understand the opportunities and limitations offered by the methodology. The book will be an invaluable reference for practicing engineers, students, and researchers.

## **Automatic Testing and Evaluation of Digital Integrated Circuits**

Hurst, an editor at the Microelectronics Journal, analyzes common problems that electronics engineers and circuit designers encounter while testing integrated circuits and the systems in which they are used, and explains a variety of solutions available for overcoming them in both digital and mixed circuits. Among his topics are faults in digital circuits, generating a digital test pattern, signatures and self-tests, structured design for testability, testing structured digital circuits and microprocessors, and financial aspects of testing. The self-contained reference is also suitable as a textbook in a formal course on the subject. Annotation copyrighted by Book News, Inc., Portland, OR

## **Theory and Practice of Thermal Transient Testing of Electronic Components**

Device testing represents the single largest manufacturing expense in the semiconductor industry, costing over \$40 billion a year. The most comprehensive and wide ranging book of its kind, Testing of Digital Systems covers everything you need to know about this vitally important subject. Starting right from the basics, the authors take the reader through automatic test pattern generation, design for testability and built-in self-test of digital circuits before moving on to more advanced topics such as IDDQ testing, functional testing, delay fault testing, memory testing, and fault diagnosis. The book includes detailed treatment of the latest techniques including test generation for various fault models, discussion of testing techniques at different levels of integrated circuit hierarchy and a chapter on system-on-a-chip test synthesis. Written for students and engineers, it is both an excellent senior/graduate level textbook and a valuable reference.

## **Digital Integrated Circuit Testing from a Quality Perspective**

Enables the reader to test an analog circuit that is implemented either in bipolar or MOS technology. Examines the testing and fault diagnosis of analog and analog part of mixed signal circuits. Covers the testing and fault diagnosis of both bipolar and Metal Oxide Semiconductor (MOS) circuits and introduces . Also contains problems that can be used as quiz or homework.

## **VLSI Testing**

Este libro contiene las presentaciones de la XVII Conferencia de Diseño de Circuitos y Sistemas Integrados celebrado en el Palacio de la Magdalena, Santander, en noviembre de 2002. Esta Conferencia ha alcanzado un alto nivel de calidad, como consecuencia de su tradición y madurez, que lo convierte en uno de los acontecimientos más importantes para los circuitos de microelectrónica y la comunidad de diseño de sistemas en el sur de Europa. Desde su origen tiene una gran contribución de Universidades españolas, aunque hoy los autores participan desde catorce países

## **IC Test Using the Energy Consumption Ratio**

The increasing application of integrated circuits in situations where high reliability is needed places a requirement on the manufacturer to use methods of testing to eliminate devices that may fail on service. One possible approach that is described in this book is to make precise electrical measurements that may reveal those devices more likely to fail. The measurements assessed are of analog circuit parameters which, based on a knowledge of failure mechanisms, may indicate a future failure. . To incorporate these tests into the functional listing of very large scale integrated circuits consideration has to be given to the sensitivity of the tests where small numbers of devices may be defective in a complex circuit. In addition the tests ideally should require minimal extra test time. A range of tests has been evaluated and compared with simulation used to assess the sensitivity of the measurements. Other work in the field is fully referenced at the end of each chapter. The team at Lancaster responsible for this book wish to thank the Alvey directorate and SERe for the necessary support and encouragement to publish our results. We would also like to thank John Henderson, recently retired from the British Telecom Research Laboratories, for his cheerful and enthusiastic encouragement. Trevor Ingham, now in New Zealand, is thanked for his early work on the project.

## **Testing of Digital Systems**

This book contains the papers that have been presented at the ninth Very Large Scale Integrated Systems conference VLSI'97 that is organized biannually by IFIP Working Group 10.5. It took place at Hotel Serra Azul, in Gramado Brazil from 26-30 August 1997. Previous conferences have taken place in Edinburgh, Trondheim, Vancouver, Munich, Grenoble and Tokyo. The papers in this book report on all aspects of importance to the design of the current and future integrated systems. The current trend towards the realization of versatile Systems-on-a-Chip require attention of embedded hardware/software systems, dedicated ASIC hardware, sensors and actuators, mixed analog/digital design, video and image processing, low power battery operation and wireless communication. The papers as presented in Jhis book have been organized in two tracks, where one is dealing with VLSI System Design and Applications and the other presents VLSI Design Methods and CAD. The following topics are addressed: VLSI System Design and Applications Track • VLSI for Video and Image Processing. • Microsystem and Mixed-mode design. • Communication And Memory System Design • Cow-voltage & Low-power Analog Circuits. • High Speed Circuit Techniques • Application Specific DSP Architectures. VLSI Design Methods and CAD Track • Specification and Simulation at System Level. • Synthesis and Technology Mapping. • CAD Techniques for Low-Power Design. • Physical Design Issues in Sub-micron Technologies. • Architectural Design and Synthesis. • Testing in Complex Mixed Analog and Digital Systems.

## **Fault Diagnosis of Analog Integrated Circuits**

ITC is the World's largest premier technical conference on the testing and total quality of integrated electronics and the assenblies and systems that are based on them.

## **Essentials of Electronic Testing for Digital, Memory, and Mixed-signal VLSI Circuits**

In-Circuit Testing discusses what an in-circuit test (ICT) is and what it can and cannot do. It answers many

questions on how tests are actually carried out, with the benefits and drawbacks of the techniques. The emphasis throughout is towards practical problem solving, and many of the examples used are of surface mount printed circuit boards (PCBs). The book contains separate chapters on application—fitting ICT into a typical test strategy and into the manufacturing environment. The buying decision is fully explored—choice of system, initial and ongoing costs, and preparation of the financial proposal to Management. Then, assuming the automatic test equipment (ATE) has been purchased, additional chapters are devoted to: programming problems and solutions, interfacing problems and solutions, fault diagnosis and fault finding tools. Design for in-circuit test also merits a chapter. This covers specific design guides and the constraints which need to be placed on designers to ensure that ICT is cost effective. The concluding chapter reviews the purchase and use of the chosen ICT with the benefit of hindsight; it covers cost effectiveness; looks at alternative methods of testing, programming, and interfacing; and alternative ways of costing the testing service. This book is written for potential purchasers and users of in-circuit automatic testers who are attracted to the concept of ICT, but who may need help. This includes Test Engineering Managers who need guidance on which equipment to buy for a given application (and how to financially justify the purchase), and ATE Programmers, Test Engineers and Technicians who would welcome practical advice on how best to use the chosen ATE.

## **DCIS2002**

Integrated circuit industry has always faced the necessity of testing and verifying the fabricated ICs in order to guarantee that no faulty circuits reach the market as well as the fabricated devices function within design specifications throughout their entire service life. In the current frame, the accomplishment of this objective entangles considerable economic implications and great technological challenges. Analog and mixed-signal circuit testing becomes an even more challenging endeavor since no efficient nor systematic procedures are available. Further, these challenges are strongly related to the process variability induced by the constant feature size miniaturization as well as by circuit operating conditions (i.e. PVT variations). As opposed to the classic or specification based testing, alternate testing techniques have been lately adopted as a promising solution in such challenging scenario. In this thesis, a novel methodology to encode the pass/fail regions in the alternate measurements space is proposed. The method relies on two phases. The training phase digitally encodes the test acceptance/rejection regions in the alternate measurements space using octrees. The testing phase corresponds to the actual production testing using the previously computed octree data structure. Such digital encoding approach presents a number of benefits, specially in terms of computational efficiency since the resulting octree structures are inherently sparse, what yields to fast training and testing times. Octrees have the advantage of being generalized to an arbitrary number of dimensions without any extra issue. Regarding such generalization potential, octrees can extend their clustering capabilities to more than two clusters, therefore facilitating the proposed IC quality binning approach without any incurred overhead. Further, the octree encoding algorithm is deterministic as it does not rely on a minimization algorithm as many of the state of the art clustering methods do. This is a desirable feature since the resulting encoding does not depend on convergence issues or the considered initial conditions. The simplistic recursive implementation, both for training and testing, make them affordable and easy to implement in stand alone systems as well as convenient for BIST applications. Within the current "more than Moore" scenario, testing heterogeneous devices entangles a series of non trivial challenges which are even harder to cope than the ones existing in traditional CMOS circuits. This is so because of their inherently non electrical nature, depending on the exploited transduction principle, creates the need of complex stimuli generation. For the particular case of MEMS accelerometers, a mechanical excitation stimulus is needed in order to emulate in field operation. In this thesis, a method consisting on a variable speed vertical spinning wheel mounting the device under test has been proposed. The composition of output signals under such excitation conditions yields to an analog trace characterizing the defect level. The analog signature is used to test the device based on the octree encoding of the alternate measurements space or used for diagnosis purposes by means of a signature compaction and feature extraction procedure. The selection and acquisition of analog signatures for alternate mixed-signal testing is an issue of major concern in the field. This thesis proposes a selection algorithm based on redundancy avoidance within the selected set of indirect measurements yet keeping the

maximum information to perform the test decision. The application of such selection algorithm immediately translates into better test results.

## **Proceedings**

\''Introduces a theory of random testing in digital circuits for the first time and offers practical guidance for the implementation of random pattern generators, signature analyzers design for random testability, and testing results. Contains several new and unpublished results. \''

## **Rapid Reliability Assessment of VLSICs**

The proceedings of the 21st IEEE VLSI test symposium (VTS (2003) describing innovations in the testing of integrated circuits and systems.

## **VLSI: Integrated Systems on Silicon**

Proceedings of a spring 2000 symposium, highlighting novel ideas and approaches to current and future problems related to testing of electronic circuits and systems. Themes are microprocessor test/validation, low power BIST and scan, technology trends, scan- related approaches, defect-driven techniques, and system-on-chip test techniques. Other subjects are analog test techniques, temperature and process drift issues, test compaction and design validation, analog BIST, and functional test and verification issues. Also covered are STIL extension, IDDQ test, and on-line testing and fault tolerance. Lacks a subject index. Annotation copyrighted by Book News, Inc., Portland, OR.

## **Proceedings, International Test Conference 1996**

This book provides a detailed treatment of radiation effects in electronic devices, including effects at the material, device, and circuit levels. The emphasis is on transient effects caused by single ionizing particles (single-event effects and soft errors) and effects produced by the cumulative energy deposited by the radiation (total ionizing dose effects). Bipolar (Si and SiGe), metal-oxide-semiconductor (MOS), and compound semi-conductor technologies are discussed. In addition to considering the specific issues associated with high-performance devices and technologies, the book includes the background material necessary for understanding radiation effects at a more general level.

## **In-Circuit Testing**

Later, simple models of crosstalk and switching noise are used to give an intuitive understanding of these problems. Finally, some verification and test issues related to interconnection noise are discussed. Throughout the book, the examples used to illustrate the discussion are based on digital CMOS circuits, but the general treatment of the problems is from a fundamental point of view, so that the discussion can be applied to different technologies.

## **Mixed-signal Alternate Test and Binning Using Digitally Encoded Signatures**

Annotation This proceedings contains extended version of a selected subset of the contributions presented at the May 1999 IEEE workshop. The 27 papers share research and development (RandD) results in electronic testing. Topics include calculating efficient LFSR seeds for built-in self test, functional and structural testing of switched-current circuits, compaction of IDDQ test sequence using reassignment method, debug facilities in the TriMedia CPU64 architecture, deterministic BIST with partial scan, and using the BS register for capturing and storing n-bit sequences in real-time. Other papers address MEMs, switched capacitors, ATPG and fault modeling, fault simulation and fault coverage of analog circuits, FPGAs and regular arrays, and low

power BIST. No subject index. Annotation copyrighted by Book News, Inc., Portland, OR.

## **The Fundamentals of Mixed Signal Testing**

Lists citations with abstracts for aerospace related reports obtained from world wide sources and announces documents that have recently been entered into the NASA Scientific and Technical Information Database.

## **Developments in Integrated Circuit Testing**

Switched-Current Signal Processing and A/D Conversion Circuits: Design and Implementation describes the design and implementation of switched-current (SI) circuits with emphasis on signal processing and data-conversion applications. The work includes theoretical analysis, high-level and circuit-level simulation results as well as measurement results from a few of the author's circuit implementations. An extensive overview of the SI field of research is also given. The book contains an extensive overview of the switched-current field of research, and can therefore be used as a quick-reference to the field. The description of each design example has been organized to describe the entire design flow from system level design and simulation, to circuit simulation, layout and measurement as accurately as possible. Thus it is possible to follow each step in the design process. Switched-Current Signal Processing and A/D Conversion Circuits: Design and Implementation is an invaluable reference for researchers and circuit designers working with one-chip mixed-signal system solutions, and low-voltage analog CMOS design. It will also be appreciated by anyone requiring a quick overview of what has been done in the SI field.

## **Random Testing of Digital Circuits**

Temperature has been always considered as an appreciable magnitude to detect failures in electric systems. In this book, the authors present the feasibility of considering temperature as an observable for testing purposes, with full coverage of the state of the art.

## **Proceedings**

Collects 58 papers from the April/May 2001 symposium that explore new approaches in the testing of electronic circuits and systems. Key areas in testing are discussed, such as BIST, analog measurement, fault tolerance, diagnosis methods, scan chain design, memory test and diagnosis, and test data compression and compaction. Also on the program are sessions on emerging areas that are gaining prominence, including low power testing, testing high speed circuits on low cost testers, processor based self test techniques, and core-based system-on-chip testing. Some of the topics are robust and low cost BIST architectures for sequential fault testing in datapath multipliers, a method for measuring the cycle-to-cycle period jitter of high-frequency clock signals, fault equivalence identification using redundancy information and static and dynamic extraction, and test scheduling for minimal energy consumption under power constraints. No subject index. c. Book News Inc.

## **18th IEEE VLSI Test Symposium**

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