Introduction to Mixed Signal Test Solutions

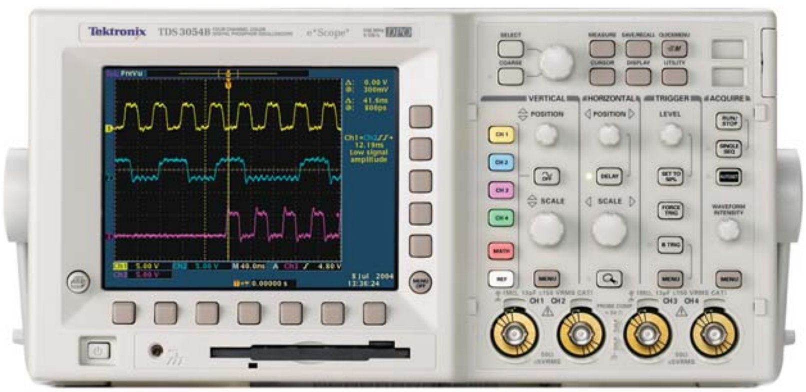
Tektronix
Enabling Innovation

Contents

Introduction

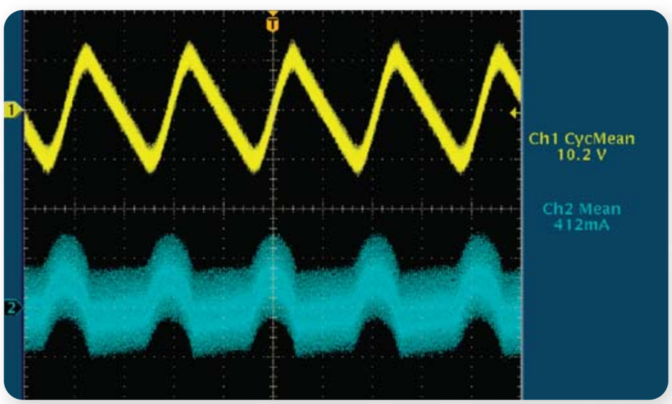
As the complexity of today's electronic designs rises with the increase in digital and serial content, the boundaries that define the optimum piece of test equipment can become unclear. Engineers are working with "mixed-signal" designs, which contain a substantial mix of both analog and digital technology. Designers increasingly want equipment that allows them to time-correlate both the analog and digital domains in a single instrument. Traditionally mixed-signal analysis was accomplished by using a stand-alone oscilloscope and a logic analyzer; a two-box solution. This solution is often unwieldy and it can be difficult to get optimum results. The need to correlate analog and digital waveforms has led to the development of the mixed signal oscilloscope.

There are similarities and differences between oscilloscopes, mixed signal oscilloscopes and logic analyzers. To better understand how these instruments address their respective applications, it is useful to take a closer look at their individual capabilities.

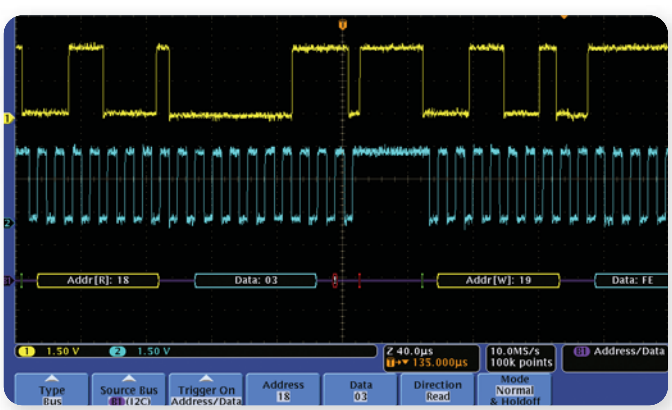


The Digital Oscilloscope

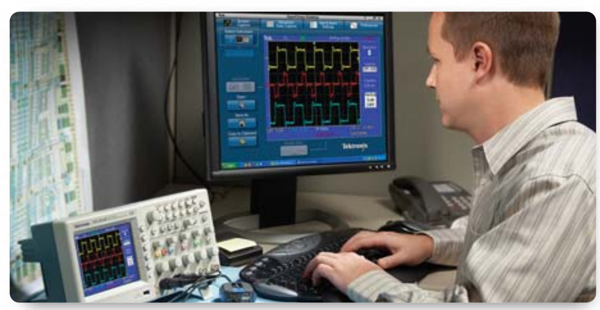
The digital oscilloscope is the tool of choice used by electronic engineers worldwide. Designers are confident in the way it operates and they trust the results.The oscilloscope's high sample rate and bandwidth enable it to capture a high-resolution view of the signals of interest. Oscilloscopes are ideal for displaying and measuring the analog characteristics of all types of electrical signals. Oscilloscopes generally have two or four input channels and can time-correlate a small number of analog, digital and serial signals.



▶ **Figure 1.** *Analog debug using a Tektronix TDS3000B Series oscilloscope.*

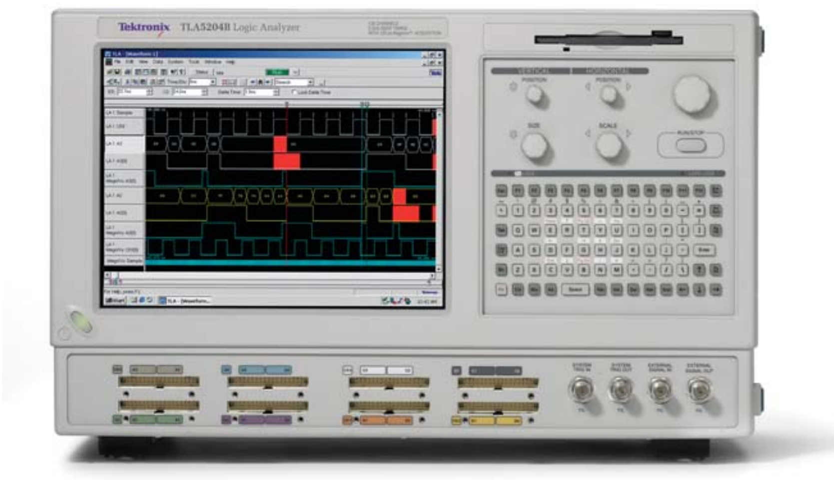


▶ **Figure 2.** *Serial decode using a Tektronix DPO4000 Series oscilloscope.*



Digital Oscilloscope Applications

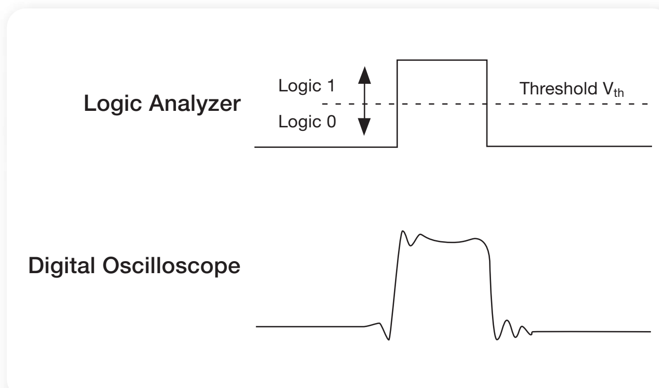
- Measure signal amplitudes and timing parameters
- Measure signal edges and voltages to evaluate timing margins
- Measure current
- Detect transient faults such as glitches, runt pulses, metastable transitions
- Characterize signal integrity



The Logic Analyzer

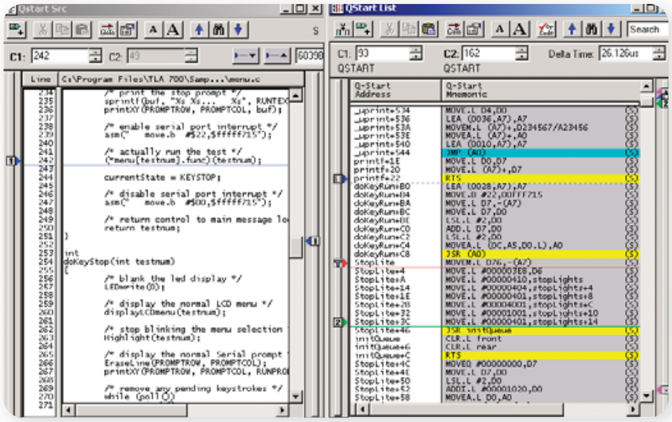
Logic analyzers are ideal tools for verifying and debugging complex digital designs. The most obvious difference between a logic analyzer and an oscilloscope is the number of channels. Logic analyzers have anywhere from 34 to hundreds or even thousands of channels, while a typical oscilloscope has only 2-4 channels.

More fundamentally, though, logic analyzers acquire signals different than oscilloscopes. Oscilloscopes typically sample the signal with an 8-bit analog-to-digital converter (ADC) to faithfully reproduce the signal with all its analog subtleties on the oscilloscope display. A logic analyzer, however, simply compares the input signal to a user defined threshold. If the signal is greater than the threshold then it is considered a Logic 1, if it is lower than the threshold it is considered a Logic 0. These fundamentally different acquisition approaches lead to the same pulse being displayed in different fashions as shown in Figure 3.



▶ **Figure 3.** *Waveform displays on logic analyzers and oscilloscopes.*

Another difference between an oscilloscope and a logic analyzer is triggering. Oscilloscopes offer basic trigger modes focused on isolating anomalous analog characteristics (glitches, runt pulses, slew rates, etc…) as well as basic digital conditions such as a setup/hold violation or a single logical pattern defined over the two or four input channels. On the other hand, logic analyzers provide extensive logic resources such as numerous word comparators, counters and timers, enabling the user



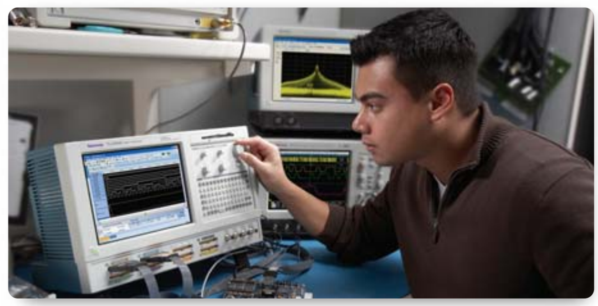
▶ **Figure 4.** *Source code linking on a Tektronix TLA Logic Analyzer.*

▶ **Figure 5.** *Timing analysis using a Tektronix TLA Logic Analyzer.*

to define complex, multi-state, IF-THEN-ELSE type triggering to isolate problems in complex system environments.

Logic analyzers also host a full complement of microprocessor support packages. These packages typically provide a hardware and software element. The hardware provides a physical connection to the front-side microprocessor bus, whereas the software disassembles the acquisition into readable software execution.

Another benefit of a logic analyzer is its ability to monitor and time-correlate multiple system buses on a single instrument. For example, a designer may want to trace the execution of software across the front side bus while monitoring reads and writes to memory. The expandability of logic analyzers makes them ideal for solving complex applications where broad visibility, advanced triggering and software analysis is required.



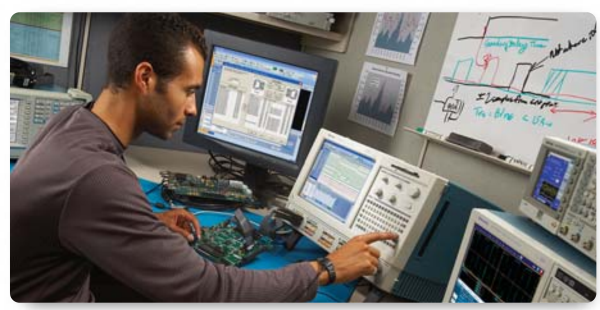
Logic Analyzer Applications

- Broad multi-channel verification of digital system operation
- Advanced multi-state triggering is needed to isolate problems
- Trace software execution
- System timing validation
- System margin testing
- High speed memory applications

The Logic Analyzer with Oscilloscope Modules

One of the first attempts to provide a true mixed-signal solution was done by creating digital oscilloscope modules for logic analyzers. These modules plug directly into the logic analyzer providing oscilloscope functionality. The oscilloscope's acquisition is time-correlated with the digital channels on the logic analyzer display.

However, these oscilloscope modules have their limitations. Because they are part of a logic analyzer, they are primarily single-shot devices, unlike standalone oscilloscopes that operate in real-time. They are fairly expensive, lack the performance of a standalone oscilloscope, and don't offer the familiar oscilloscope user interface. Finally, because they are integrated into the logic analyzer, they are unavailable for general oscilloscope use in day-to-day debug tasks.



Logic Analyzer with Oscilloscope Applications

- Mixed analog and digital design
- A/D, D/A converters
- Digital signal quality measurements
- Time correlation of analog and digital events
- System power on characteristics

A Logic Analyzer used in Conjunction with a Bench-top Oscilloscope

Oscilloscopes can be found in virtually every engineering lab. They are ideal for applications where a high-resolution analog view of your signal is required. In applications where broad observation of system bus activity is needed, oscilloscopes often fail to have enough channels. This is where designers regularly use logic analyzers.

What do you do when you need to acquire many digital channels and obtain high resolution analog at the same time? The mixed signal nature of today's complex problems often requires the designer to view both analog and digital at the same time. This requires using both an oscilloscope and logic analyzer.

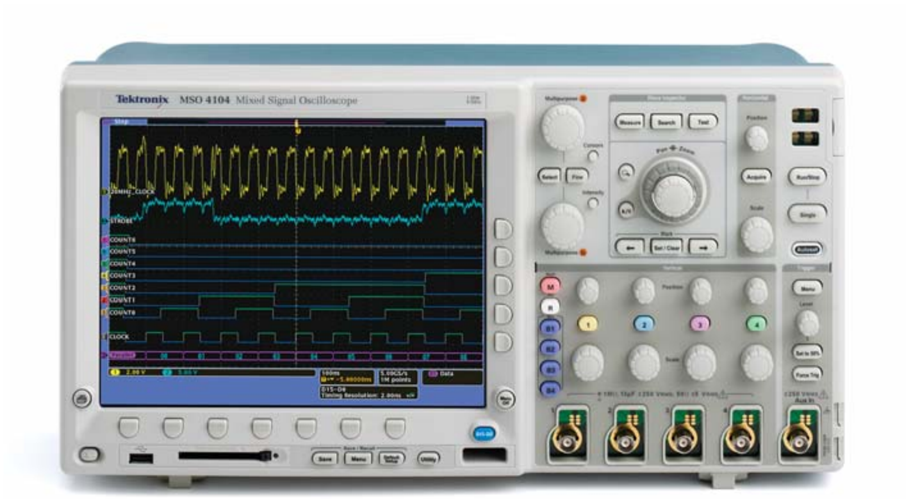
One advantage of this two-box solution is performance. As design margins decrease, the analog characteristics of signals increasingly affect design integrity. Designers need to simultaneously measure the characteristics of high-speed digital and analog in their designs. Technologies like PCI Express, HyperTransport,™ and DDR all provide measurement challenges. The bus speeds are simply too fast for integrated logic analyzer oscilloscope modules.

However, high performance bench top oscilloscopes are ideal for these applications. Realizing the need to correlate data acquired on a bench-top oscilloscope with data captured on a logic analyzer prompted Tektronix to develop iView™ (Integrated View).

iView™ integrates and automatically time-correlates data from a bench-top Tektronix oscilloscope and logic analyzer. Data acquired on the oscilloscope is transferred to the logic analyzer offering a time-correlated display. Unlike the integrated oscilloscope solution discussed previously, iView™ makes it possible to use any Tektronix oscilloscope in conjunction with a logic analyzer. This integrated two-box solution provides the power of a fully-functional logic analyzer and an oscilloscope acting as one. The power of iView™ comes by matching the performance and price of the instrumentation to the application.

A Logic Analyzer used in Conjunction with a Bench-top Oscilloscope Applications

- Digital and high-speed serial
- Low speed serial
- Memory design and validation
- System design validation
- Server design
- High speed interconnect validation
- Microprocessor front side bus analysis
- Graphics



The Mixed Signal Oscilloscope

Oscilloscopes are the tool of choice for the vast majority of mixed-signal designers. However, the traditional two- and four-channel digital oscilloscope is often inadequate to solve today's mixed-signal problems. Consider the A/D or D/A converter. These devices can be found in various embedded devices from MP3 players to automobiles. If a designer wants to analyze the A/D's input while monitoring the 8-bit output, his oscilloscope will run out of channels. All too often, we find ourselves thinking, *"If my oscilloscope only had more channels...."*

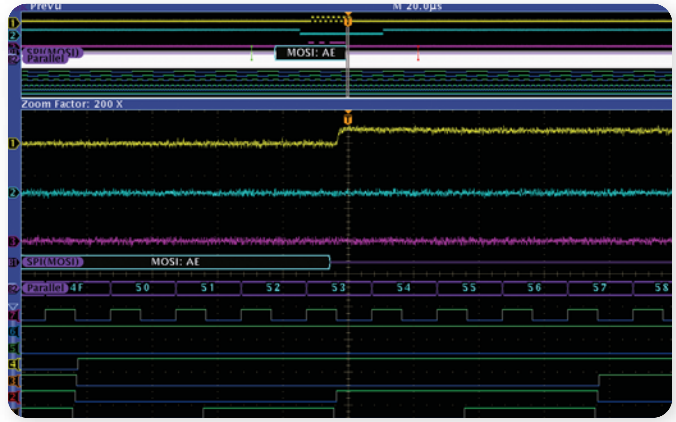
Mixed Signal Oscilloscopes (also referred to as MSOs) utilize the same form factor and user interface of a traditional oscilloscope. The oscilloscope is enhanced for mixed-signal analysis by the integration of basic logic analyzer functionality. MSOs operate like oscilloscopes but with the added advantage of 16 digital channels.

Mixed Signal Oscilloscopes Offer a Tool You Already Know How to Use

How often have you heard someone say, *"I'm tired of having to get the manual out every time I use this piece of equipment?"*. Mixed Signal Oscilloscopes primarily operate like an oscilloscope. However, unlike your oscilloscope, MSOs provide 16 digital channels. The simplicity and utility of mixed signal oscilloscopes make them the ideal instrument for your lab. They are simple to use and easy to setup. This is not to say MSOs do not offer a full complement of powerful features, they just operate as your current oscilloscope does. Features like Autoset automatically position and set the right scale factors for both the analog and digital waveforms. All of the menus stay the same, but now the 16 digital channels show up in the channel selection. This tight integration between the oscilloscope and 16 digital channels creates the ultimate all-in-one tool for embedded design.

Figure 6. *Wave Inspector® allows you to efficiently view, navigate and analyze analog and digital waveform data.*

▶ **Figure 7.** *Analog and digital waveforms acquired with a single instrument - The MSO4000 Series.*



▶ **Figure 8.** *Simultaneous decoded parallel and SPI serial bus displays on the MSO4000 Series.*

Mixed Signal Oscilloscopes Offer Peace of Mind

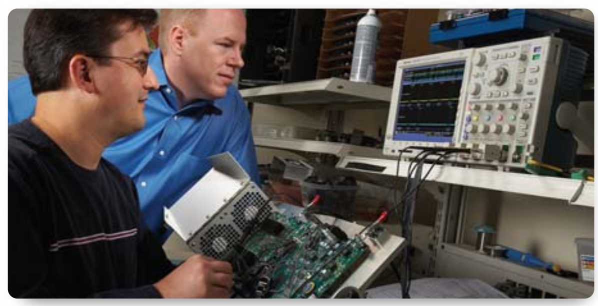
For many designers, Mixed Signal Oscilloscopes offer a form of digital insurance. There is a peace of mind knowing you have more than four channels when your application requires them.

Mixed Signal Oscilloscopes, the Ideal Mixed Signal Tool

Mixed Signal Oscilloscopes are a tool unlike any other. You get a high performance portable oscilloscope and a basic logic analyzer, all in a single portable box. This tight integration between analog and digital makes it possible to display, trigger and analyze both types of signals in the same instrument.

Unlike the logic analyzer mixed signal solution, Mixed Signal Oscilloscopes operate in real-time allowing continuous updates of the analog and digital waveforms. How often have you seen something that just did not look right when using logic analyzer? Next thing you knew you were looking for your oscilloscope to verify what was going on. With an MSO if things don't look the way you expect, you have the analog channels at your disposal all the time.

Another attribute of Mixed Signal Oscilloscopes that make them the ideal tool for mixed signal design is their ability to trigger on serial buses. Unlike logic analyzers that primarily focus on parallel buses, MSOs can trigger on and decode buses like I^{2}C, SPI, RS-232 and CAN. Combine this with the MSO's parallel bus triggering and no bug will go unfound.



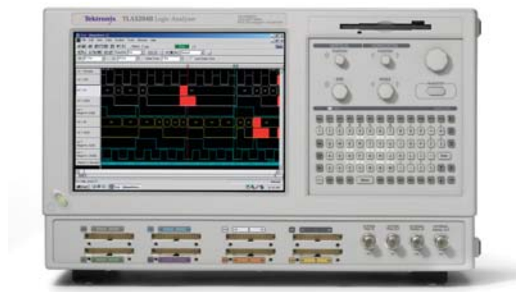
Mixed Signal Oscilloscope Applications

- Embedded design and validation
- Systems engineering
- Serial debug
- A/D, D/A debug
- FPGA design and validation
- Automotive

Choosing the right tool for your Mixed Signal Application

Choosing the right piece of test equipment is largely dependent upon your application. Table 1 breaks down the key features of each product solution based on a common set of user needs to help determine which type of instrument is right for you.

▶ Need more help deciding which mixed signal test solution is best for your particular needs? Ask the Mixed Signal Product Advisor at: www.tektronix.com/mixedsignaladvisor



▶ **Table 1: Comparison Chart**

	Mixed Signal Oscilloscope (MSO)	Logic Analyzer (LA)
Ease of Use	MSOs share the same platform as an oscilloscope, the tool engineers already know how to use.	The LA provides a specialized, more analytical and in-depth environment, enabling the debug of complex digital systems.
Channel Requirements	MSOs offer the traditional 2 or 4 analog channels plus 16 digital channels.	LAs start at 32 and can be expanded to thousands of digital channels. To acquire analog and digital requires a standalone oscilloscope or scope module.
Triggering Needs	MSOs offer a broad range of triggering options focused on analog and digital applications. These triggers often include Edge, Pulse Width, Runt, Logic, Setup and Hold, Rise / Fall time and Video.	LAs offer multiple state triggering. LAs can monitor for conditions that require multiple events to be true. LAs also offer triggering resources like counters and timers.
Asynchronous or Sychronous Acquisition	MSOs only provide asynchronous sampling. Like an oscilloscope, the MSO uses its internal clock to sample the data. MSOs are ideal for application where accurate timing measurements need to be made.	LAs provide both synchronous and asynchronous sampling. The LA can clock data into the instrument using your system clock or its internal clock.
Correlation of Analog and Digital Data	MSOs are ideal if your application requires the ability to correlate both analog and digital on the same instrument.	LAs offer the ability to correlate analog and digital domains by using an embedded oscilloscope module or external bench top oscilloscope.

Summary

Solutions for mixed signal applications vary based on your particular application. It is important to evaluate your measurement needs to make sure the solution you choose is adequate to solve your problem. There are similarities and differences as well as strengths and weaknesses of each mixed signal solution. In some cases, you may find more than one mixed signal solution meets your needs. Balancing your current measurement needs with the individual capabilities of the measurement solution will assure your success.

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