Solution-Digital Circuit Testing

Research and Education Industry Solution

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深圳市鼎阳科技股份有限公司
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1 Overview

Digital circuit testing is a critical phase in digital circuit design, used to verify whether the circuit functions as intended. In digital circuit testing, oscilloscopes are typically employed to detect output signals for troubleshooting or determining circuit performance and parameters. Different oscilloscopes offer varying bandwidths and sample rates, providing suitable measurement solutions for various circuit types. This article introduces how to use oscilloscopes for debugging typical digital circuits.

2 Significance

With the advancement of science and technology, electronic circuit designs have become increasingly complex, making digital electronic circuit testing more challenging. Scientific and reasonable testing solutions are undoubtedly significant in the circuit design and manufacturing process, mainly reflected in the following aspects:

- **Verifying Circuit Function:** By inputting specific signals and observing outputs, it ensures the circuit executes its functions correctly under various operating conditions. This is crucial for ensuring product reliability and performance.
- **Identifying Design Defects:** Testing may reveal defects or errors in the circuit design, such as logic errors or component failures. Timely discovery and correction of these issues can prevent serious problems after product release, thereby improving product quality.
- **Optimizing Circuit Design:** Testing provides actual circuit performance data, such as power consumption, speed, and stability. This data is used to evaluate circuit performance and serves as a basis for optimizing the design.

3 Solution

1.1 Capturing Abnormal and Specific Events

Oscilloscopes assist engineers in quickly identifying issues, capturing abnormal waveform signals, and searching for specific events of interest during the design and debugging of digital circuits. This facilitates problem analysis and resolution by the engineer.

To find and visualize problems, you first need an oscilloscope capable of easily capturing low-probability abnormal events. It allows you to see glitches or other sporadic transient events within seconds, revealing the true nature of circuit issues. Furthermore, SIGLENT oscilloscopes feature a persistence display function. When enabled, the display is updated with newly acquired waveforms without immediately clearing previous ones. Previously acquired waveforms are displayed in a dimmer color, while new acquisitions are shown in normal color and brightness. Combining a high waveform capture rate with persistence, you

can sometimes detect waveform anomalies in a short time without complex trigger settings, improving testing efficiency. If you need to understand the frequency of abnormal signals relative to normal ones, enable the color temperature function. The warmer the color, the higher the waveform occurrence frequency; the cooler the color, the lower the frequency, helping to judge the probability of abnormal signal occurrence.

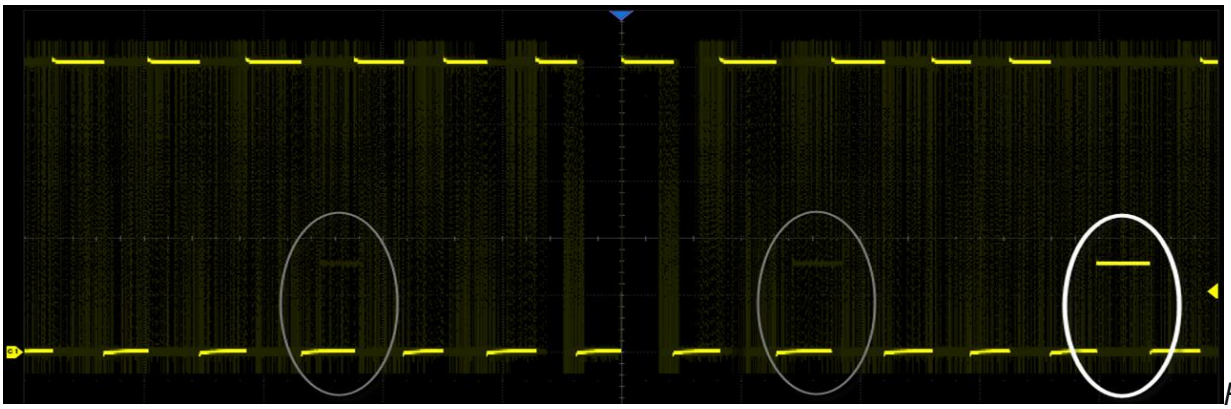

Figure 1: Rapidly Capturing Abnormal Signals

If you need to find a specific event within a long waveform record, enable the search and navigation function. By specifying conditions, the waveform is automatically searched, and events meeting the criteria are marked with white triangle symbols. Combined with navigation, you can quickly locate events of interest, saving the time and inconvenience of manual searching.

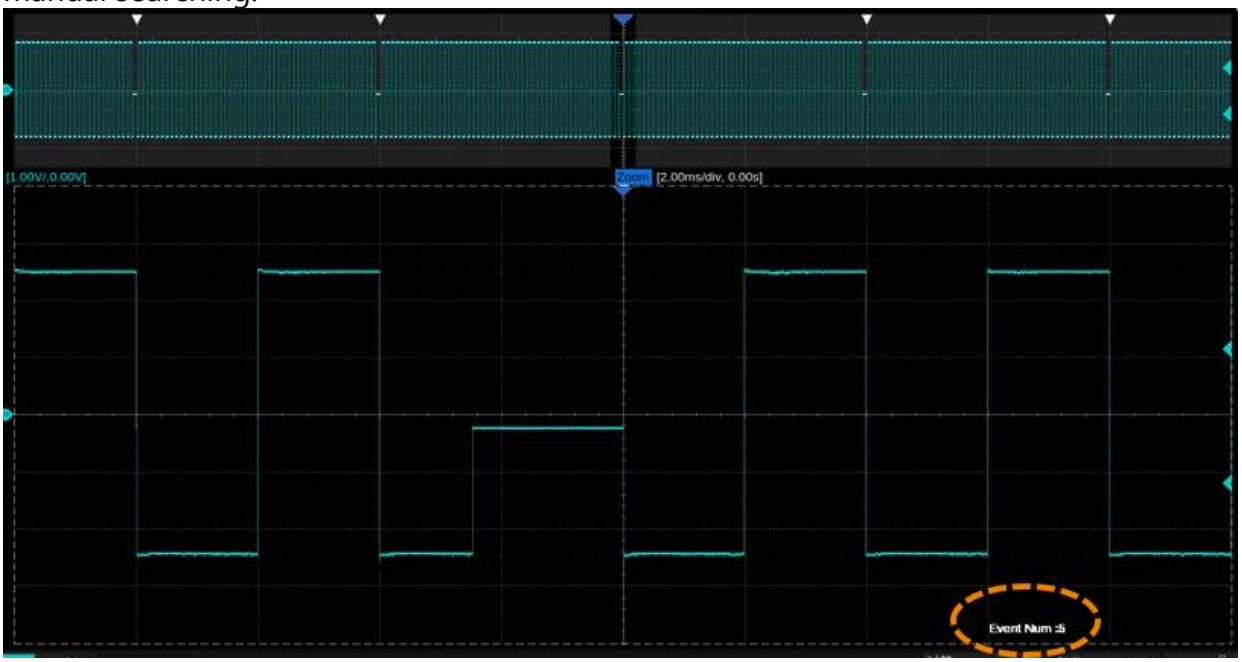

Figure 2: Quickly Finding and Marking Events of Interest

1.2 Multi-Channel Digital Signal Measurement

In complex digital circuits, you may need to capture multiple serial or parallel digital signals to observe their timing relationships. Several SIGLENT oscilloscope models can be paired

with the SPL2016 logic probe to achieve 16-channel digital signal acquisition. The 16 digital channels can be divided into two groups, each customizable with names. The threshold levels for the two groups can be set independently within the logic analyzer probe, allowing users to observe two different digital logic level signals simultaneously with the same probe.

Figure 3: 16-Channel Logic Analyzer Probe SPL2016

Digital channels can be combined with analog channels to enable mixed-signal acquisition and analysis, quickly addressing design and analysis issues in mixed analog-digital signals. In the digital channel parameter area, you can conveniently set the vertical scale and position for the digital channel waveform display area.

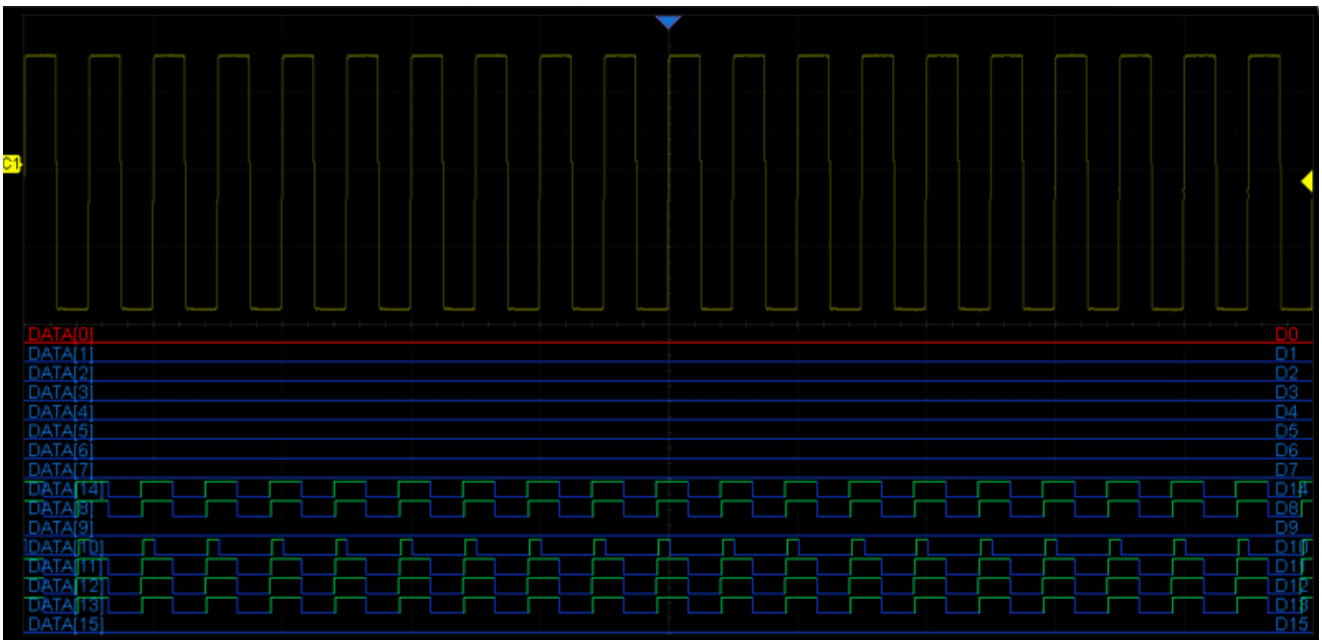

Figure 4: Simultaneous Display of Digital and Analog Channels

1.3 Digital Signal Measurement and Analysis

Digital signals convey specific digital values, with binary signals being the simplest and most common. The oscilloscope's decision process is: values below the threshold are represented as "0", and values above as "1". The threshold level determines how the input signal is interpreted.

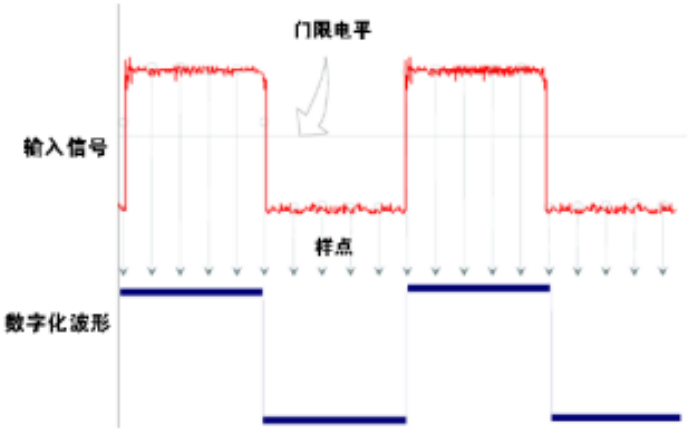

Figure 5: Digital Signal Decision Process

The digital channel functionality in SIGLENT oscilloscope product series allows for custom logic threshold settings. Additionally, settable logic levels include TTL, CMOS, LVCMOS 3.3V, and LVCMOS 2.5V.

After capturing digital signals, you need to analyze them to better understand the underlying causes. Waveform analysis tools such as automatic measurements, statistics, and cursors available on many SIGLENT oscilloscope models help you quickly understand event characteristics and diagnose problems.

1.4 Serial Bus Decoding

In digital circuit testing, decoding is the process of converting captured digital signals into a readable representation. This helps engineers better understand data transmission and processing within the circuit, facilitating analysis and evaluation of circuit function and performance. Oscilloscopes play a key role in digital circuit testing. They not only capture digital signals but also convert them into a readable format through built-in decoding functions, greatly simplifying signal analysis for engineers and improving testing efficiency.

SIGLENT oscilloscopes provide trigger and decode functionality for multiple bus protocols, such as I2C, SPI, UART, CAN, and LIN. They accurately capture electrical signals on interface buses and display them intuitively as waveforms. Multiple signal lines within a bus system can be observed simultaneously for timing relationship analysis, providing deeper insight

into interface bus communication and ensuring interface stability and performance meet design requirements.

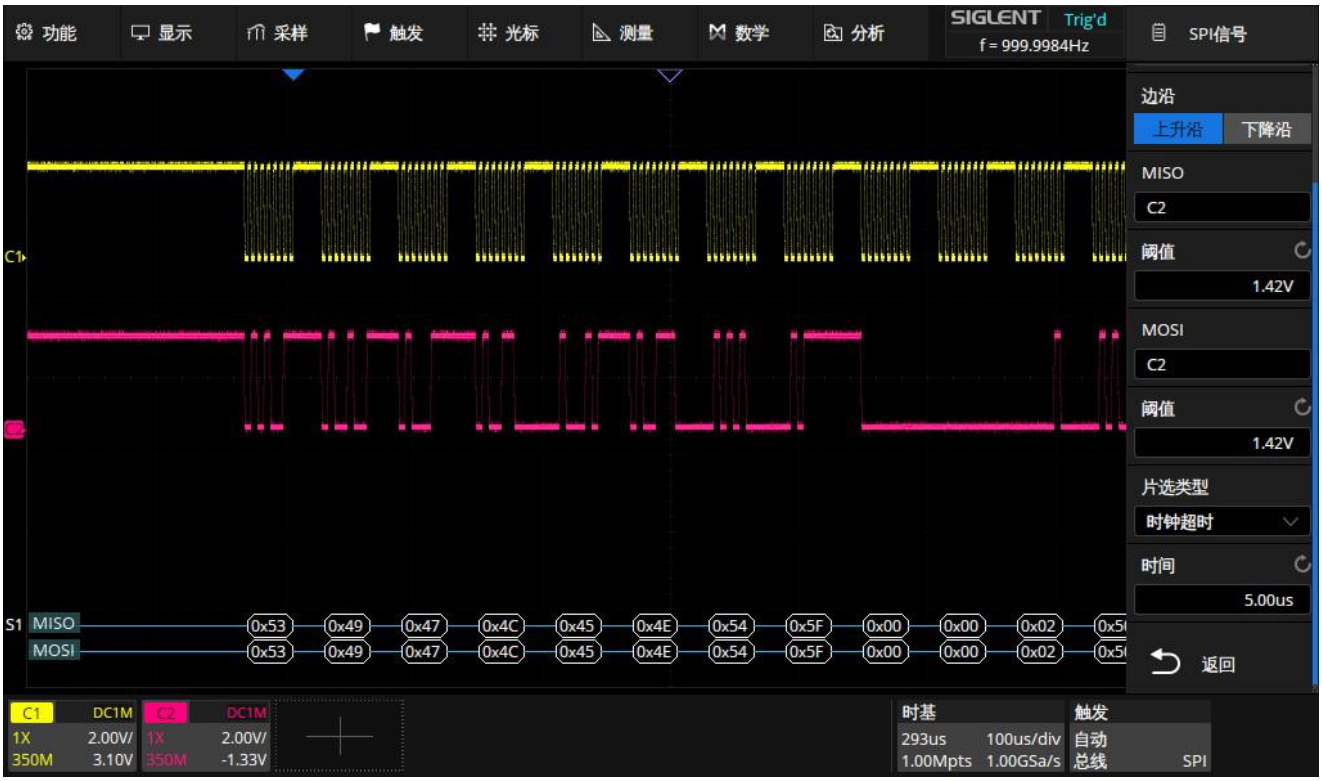

Figure 6: SPI Decode Results

1.5 Jitter Measurement in Digital Circuit Design

Jitter is the deviation of a signal edge from its ideal position. In high-speed digital circuit measurements, high-frequency jitter is typically of concern. Jitter is a very important concept for digital signals, especially high-speed ones. The higher the signal speed, the shorter its period, and the stricter the jitter requirements. For complex digital signals, besides the RMS and peak-to-peak values of jitter, its different compositional components are also of interest because different components affect digital circuits differently, requiring corresponding countermeasures. For instance, many high-speed buses further decompose and study random jitter, periodic jitter, data-dependent jitter, etc., in high-speed digital signals.

Some SIGLENT oscilloscope product series offer jitter analysis options. They can measure various jitter parameters of digital signals and decompose jitter based on Time Interval Error (TIE) data, providing time-domain and frequency-domain analysis of various jitter components.

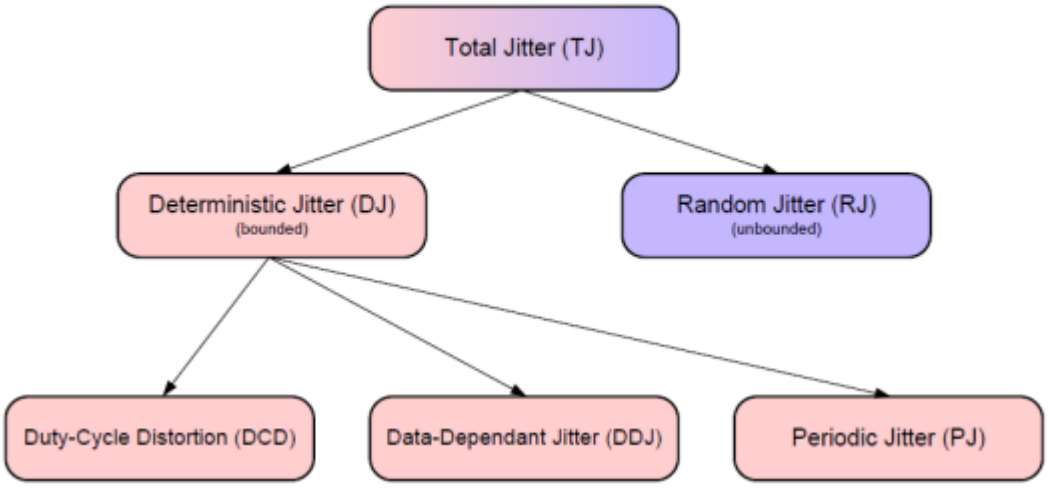

Figure 7: Jitter Decomposition

After jitter decomposition, with a correct estimation of Random Jitter (RJ), Total Jitter (TJ) at any bit error rate can be estimated from jitter measurements of a finite sample set, saving test time. Analyzing the causes of each component helps trace back to the root cause when a specific component is measured, aiding in rapid problem localization.

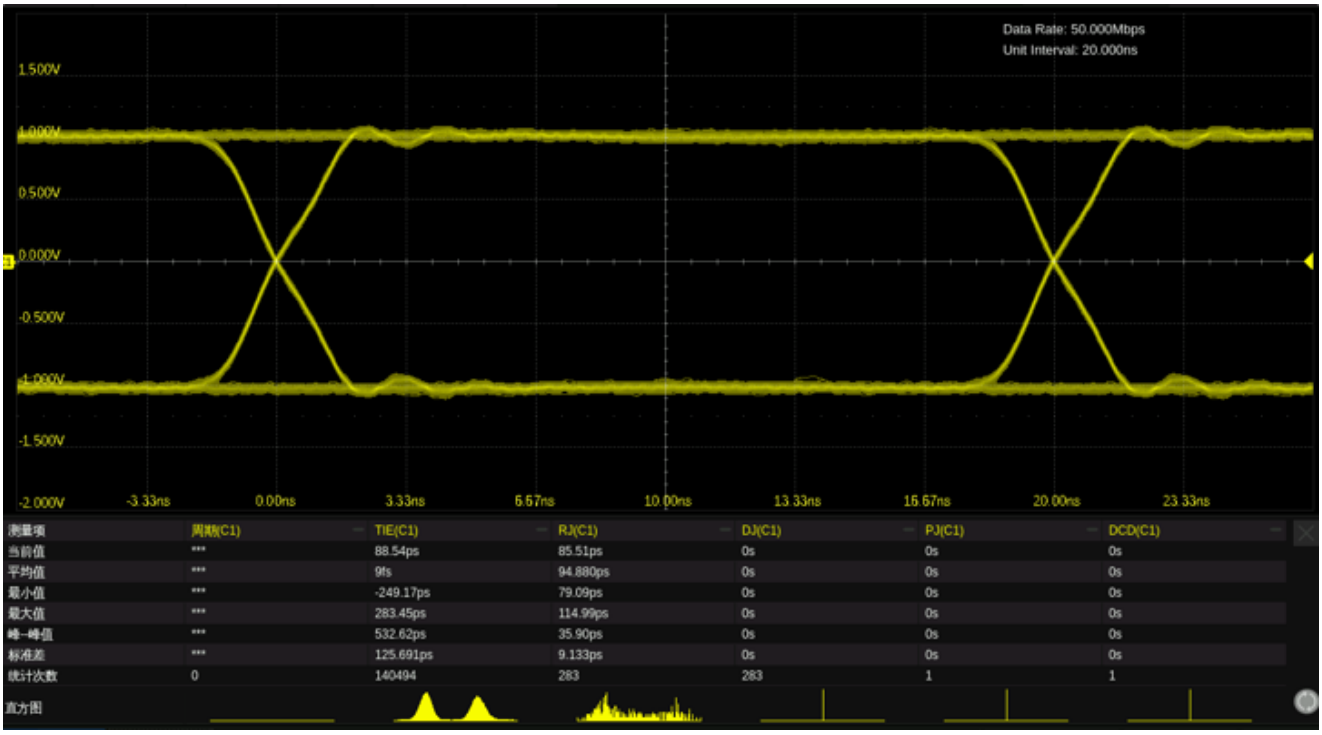

Figure 8: Oscilloscope Jitter Analysis Interface

4 Summary

SIGLENT oscilloscopes play a significant role in digital circuit testing, especially high-bandwidth, high-sample-rate products. They ensure accurate signal reproduction even when measuring high-frequency signals and capture high-speed transients, enabling rapid and precise problem identification and localization. Capabilities include capturing and analyzing abnormal and specific events, simultaneously measuring multi-channel digital signals, analyzing digital signal parameters, decoding serial bus signals, and assessing jitter characteristics in digital communication systems to improve system performance. By appropriately setting oscilloscope parameters and utilizing advanced features, the efficiency and accuracy of digital circuit testing can be greatly enhanced.

关于鼎阳

鼎阳科技（SIGLENT）是通用电子测试测量仪器领域的行业领军企业，A股上市公司。

2002年，鼎阳科技创始人开始专注于示波器研发，2005年成功研制出鼎阳第一款数字示波器。历经多年发展，鼎阳产品已扩展到数字示波器、手持示波表、函数/任意波形发生器、频谱分析仪、矢量网络分析仪、射频/微波信号源、台式万用表、直流电源、电子负载等基础测试测量仪器产品，是全球极少数能够同时研发、生产、销售数字示波器、信号发生器、频谱分析仪和矢量网络分析仪四大通用电子测试测量仪器主力产品的厂家之一，国家重点“小巨人”企业。同时也是国内主要竞争对手中极少数同时拥有这四大主力产品并且四大主力产品全线进入高端领域的厂家。公司总部位于深圳，在美国克利夫兰、德国奥格斯堡、日本东京成立了子公司，在成都成立了分公司，产品远销全球80多个国家和地区，SIGLENT已经成为全球知名的测试测量仪器品牌。

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