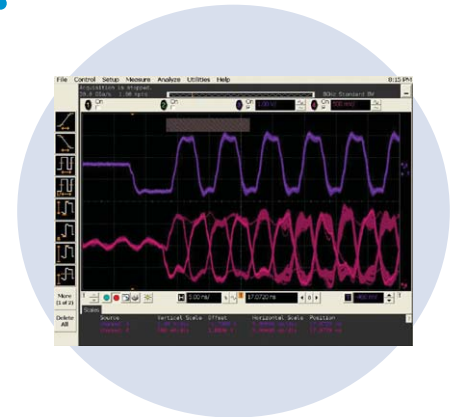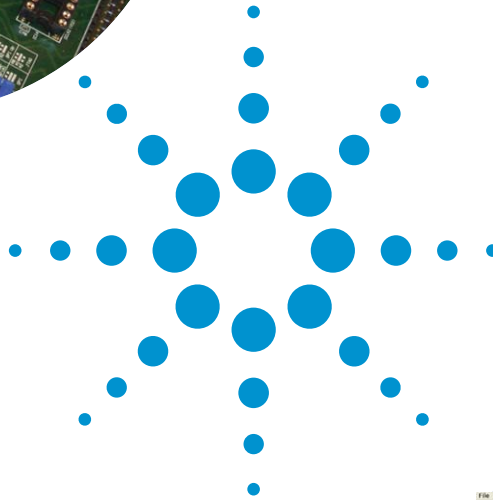# Integrated Debugging–
A New Approach to
Troubleshooting Your Designs
with Real-Time Oscilloscopes

Application Note 1605

Traditional debugging can be time
consuming and inefficient. With
Agilent Infiniium oscilloscopes,
"integrated debugging" is a reality,
and it leads you directly to the
root cause of problems.

Contents

Agilent Technologies

Introduction

In recent years, real-time oscilloscopes have become an important tool for circuit debug and analysis. A variety of software analysis features and applications are available that increase the value of these oscilloscopes for circuit debug and analysis. These applications include eye pattern, jitter analysis, compliance test, and protocol decode tools. These tools typically are used individually to debug and analyze specific circuit problems.

For the best possible circuit debug and analysis you need to start with an oscilloscope that has an extremely low noise floor that does not add impairments to your measurements. Top-notch triggering capability also is critical to your ability to debug and analyze circuit problems effectively and efficiently.

With excellent signal integrity, innovative triggering and diverse analysis software and trigger capabilities, Agilent

Infiniium oscilloscopes provide you with strong debugging capabilities. Infiniium oscilloscopes allow you to streamline your debugging process using diverse tools at the same time in the same screen, all running in real time. This application note explores two real-life debugging cases that illustrate the advantages of this "integrated debug" approach.
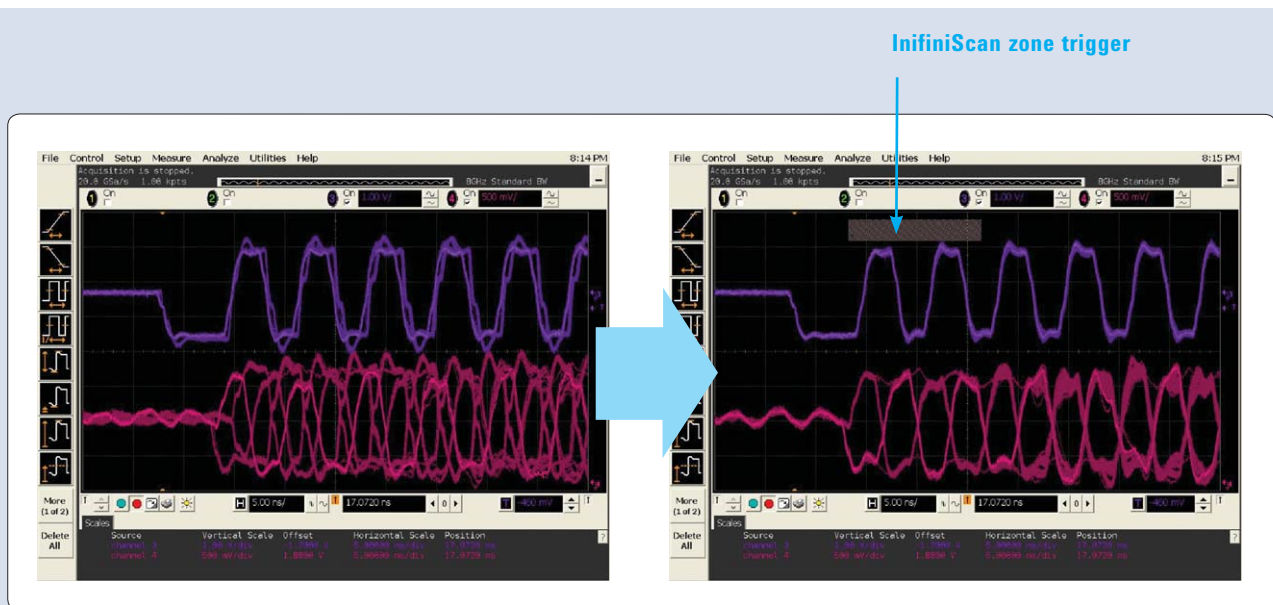
InifiniScan zone trigger

Figure 1. A complicated DDR waveform (left) has been quickly triggered with InfiniiScan utilizing zone qualifier(right).

Triggering made easy

Agilent Infiniium oscilloscopes offer a powerful trigger capability called InfiniiScan, a revolutionary tool that helps you trigger on any waveform by visually describing a trigger zone.

Drawing a zone with a mouse takes only a few seconds. This capability reduces your debugging time and improves your efficiency, accelerating time to market for your design.
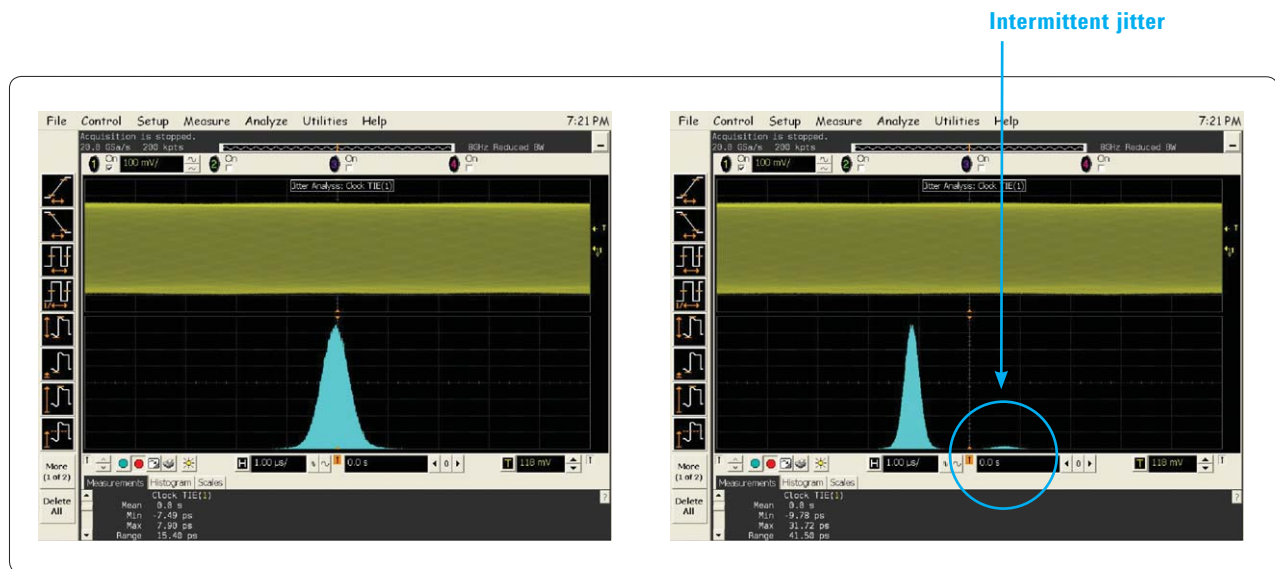
Intermittent jitter

Figure 2. Steady jitter (left) and intermittent jitter (right) of a clock signal.
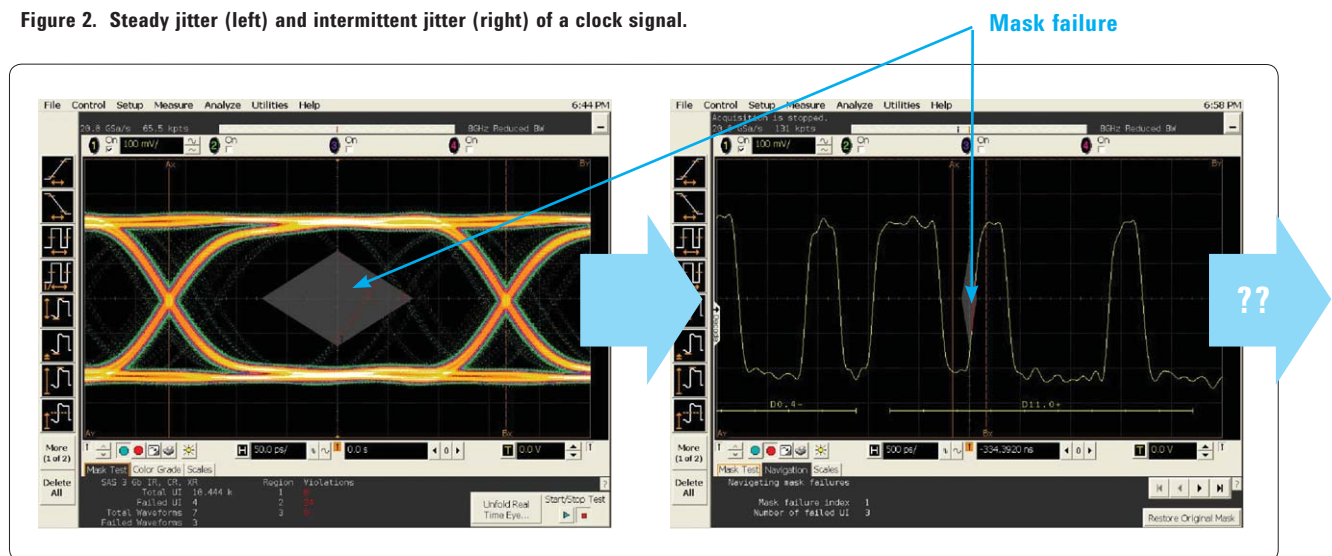
Mask failure

Figure 3. Mask unfold on eye pattern failure and 8b10b decoding. If you don't find a pattern correlation, you will be at a standstill.

Traditional debugging process

Traditional jitter analysis software provides you valuable information about jitter trends (temporal fluctuation of jitter), and the jitter spectrum (frequency component of jitter). It can also separate RJ and DJ. You can use the software to figure out how much jitter your device has, and if it meets the specification in question. But when you want to reduce jitter, you have to find out what is causing it. You may have an idea of the causes by looking at the peak frequencies of the jitter spectrum. However if the jitter is not systemic but intermittent, the root cause is difficult to determine (Figure 2).

Eye pattern tools recover the clock of the signal, make an eye pattern and make mask tests.

When the eye fails the mask test, you can unfold the waveform to see when it fails. You can also decode 8b10b coding. Using this approach you can check if mask test failures and waveform patterns have correlations. But if there is no correlation, you cannot find the cause of the mask failure (Figure 3).

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As you have seen, using features of your oscilloscope separately limits your debugging ability. These tools lack power working alone, and you need to combine them to use the full power of your oscilloscope.

Case study 1:
Combining jitter analysis tool with oscilloscope general measurements.

You know that your device has large quantities of jitter on the DDR memory clock, and this causes problems. You want to improve the situation. Using jitter analysis measurements, you pinpoint the exact value of the jitter, but you can't figure out what is behind it. You can guess that this is periodic jitter by the shape of the histogram. The jitter trend also shows that there is periodic noise on the clock (Figure 4).

Next, you use your oscilloscope's general purpose tools to look at several signal waveforms at the same time. You then probe some signals you suspect could be contributing jitter, and show them on the scope. A browser probe is convenient at times like this (Figure 5).

You check to see if the suspected signal and the clock jitter trend have any correlation. If there is a correlation, the signal you are probing is the cause of the jitter. If there is no correlation, you continue probing until you find the source of jitter.
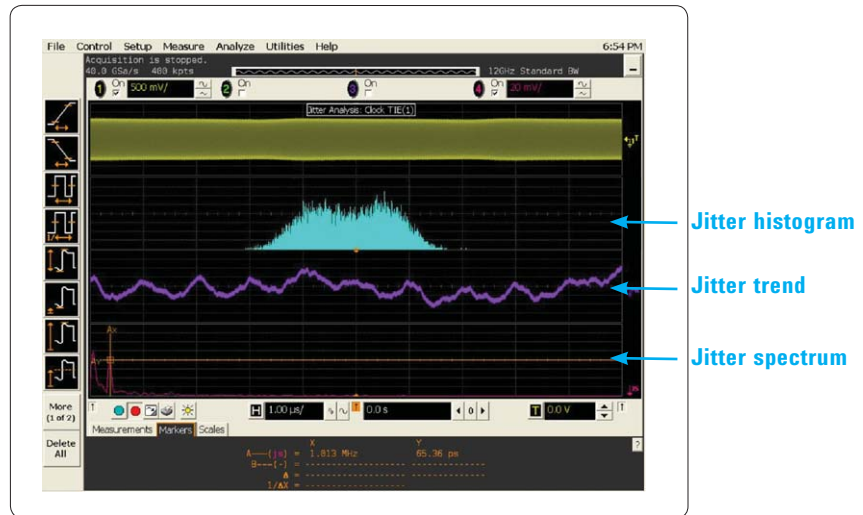

Jitter histogram
Jitter trend
Jitter spectrum

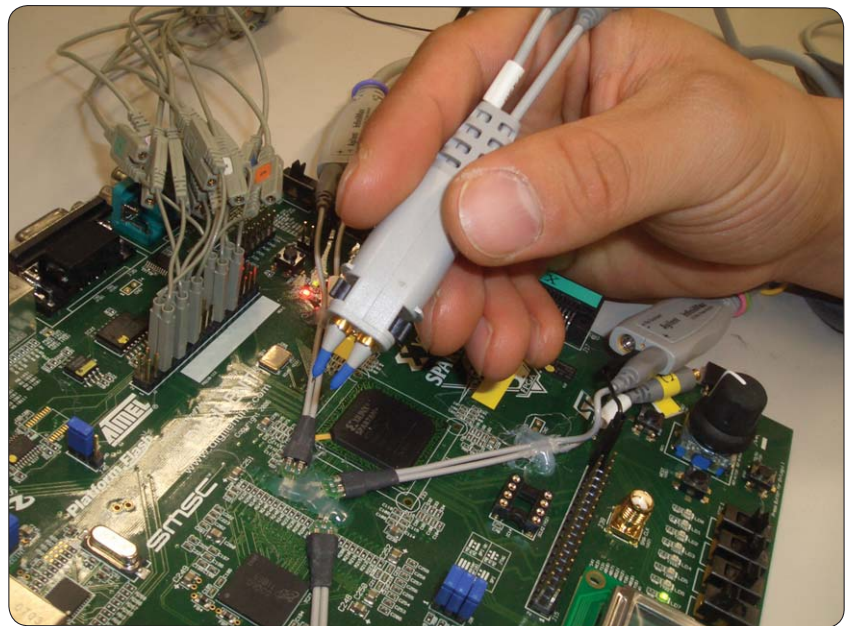**Figure 4. Clock with periodic jitter, but root cause is undetermined**

Figure 5. A browser probe is convenient to quickly check several signals

Figure 6. You can see a strong correlation between the clock jitter trend (purple) and the power waveform (pink).
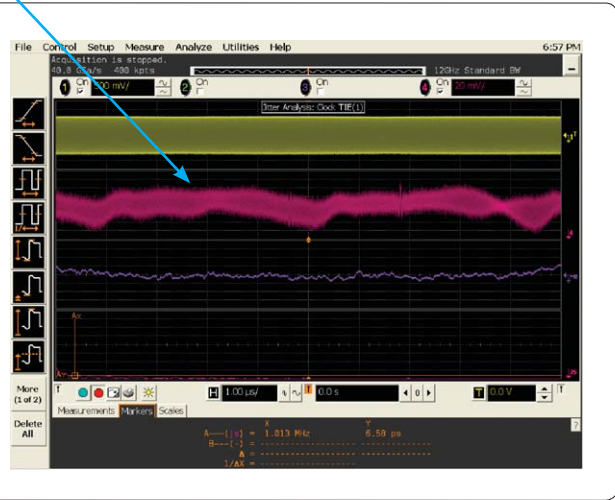
Figure 7. Both the noise emitted by the power switching and the clock jitter have dramatically decreased.

In this case the cause of jitter was the power signal. As you can see in Figure 6, there is a strong correlation between the clock jitter trend (purple) and the power waveform (pink). From both the jitter trend and the jitter spectrum, you can measure that the frequency of this periodic jitter is 1 MHz. 1 MHz corresponds to the switching frequency of the power supply. The noise emitted during the switching was affecting the DDR clock. By changing the filter capacitor, you block the noise emitted by the power supply, and the clock jitter decrease (Figure 7).

Oscilloscope test procedure 1

1. Connect the clock signal to channel 1 and start EZJIT jitter analysis software from the oscilloscope menu by choosing **Analyze>Jitter.**

2. Click **Enable Jitter Mode**, **Add Measurement** and add clock time interval jitter measurement. Check **Meas Trend** and **Jitter Spectrum** as the jitter showing.

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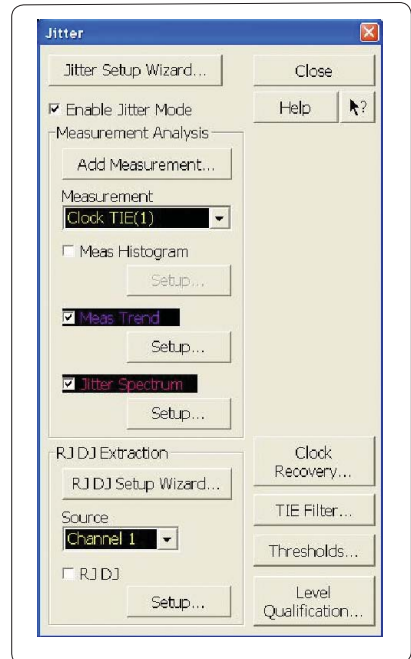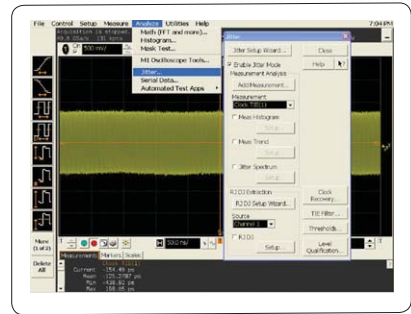
3. Display markers by selecting **Measure > Markers > Manual Placement**. Select **Meas Trend** or **Jitter Spectrum** as the marker target. Use the markers to measure the jitter spectrum peak frequencies or the jitter trend periodic cycle frequency. Then you may have some idea of the jitter causes.

4. Connect suspicious signals that can be the reason for the clock jitter, and check to see if there is correlation between the clock jitter trend and the suspected signal.

Abnormal behavior
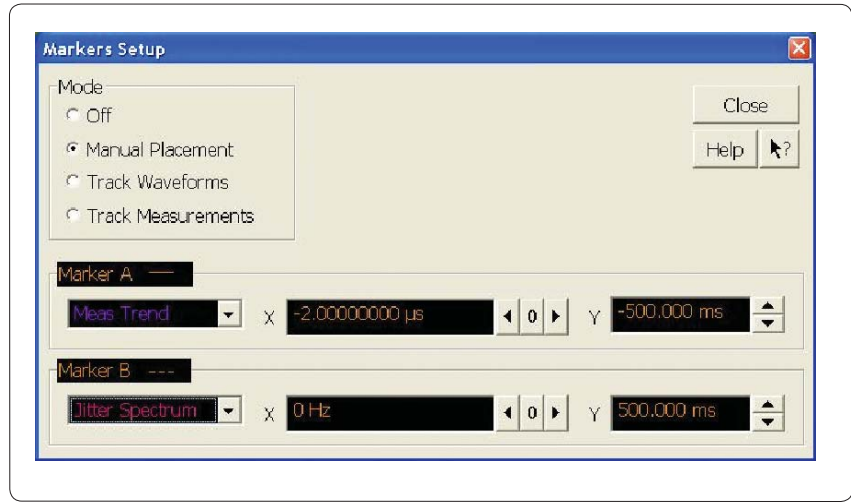
Case study 2:
Using eye pattern, jitter and trigger software together

You are running the compliance test software of a serial application, but after a number of trials you get intermittent mask test failures. You observe the signal waveform and find that it does not normally have problems, but you see some sporadic abnormal behavior (Figure 8). You want to fix this, so you need to figure out when it occurs, and why.
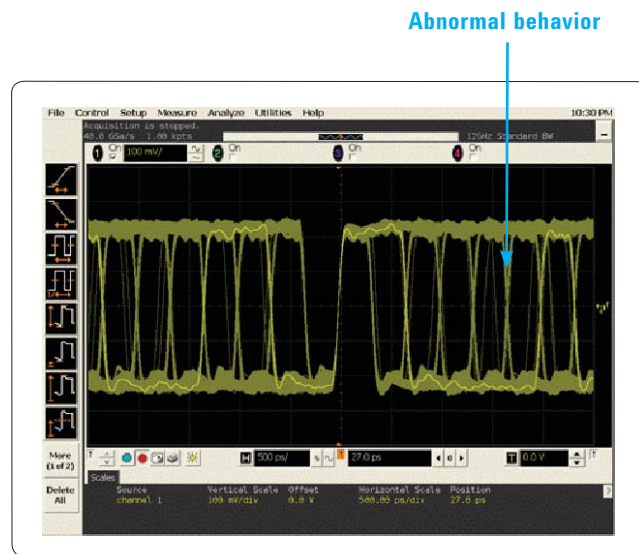

Figure 8. You see sporadic abnormal behavior in your waveform.

With the compliance test software you can only test packets of a set length. If you want to superimpose many packets, you need to use the generalized eye pattern analysis software. With this software you can run the eye pattern measurements continuously until the first failure occurs. This is a convenient feature for finding accidental failures; you don't know when they will appear (Figure 9).

The next step is to use the mask unfold feature of the software to identify exactly where the waveform has failed. For some specifications as PCI-EXPRESS®, SATA or Fibre-Channel that use 8b10b coding, the eye pattern analysis software also provides a decoding function. You can identify if there is a timing relationship between a mask failure and the protocol, or the data pattern. In this case, it seems there is no connection between the data pattern and analog failures (Figure 10).

This is the limitation of eye pattern analysis software, if there is no data pattern dependency you can't continue your debugging anymore. However, Agilent Infiniium oscilloscopes can use several analysis tools at the same time and in real-time. You can therefore activate the jitter analysis software, and look at the clock jitter in parallel.
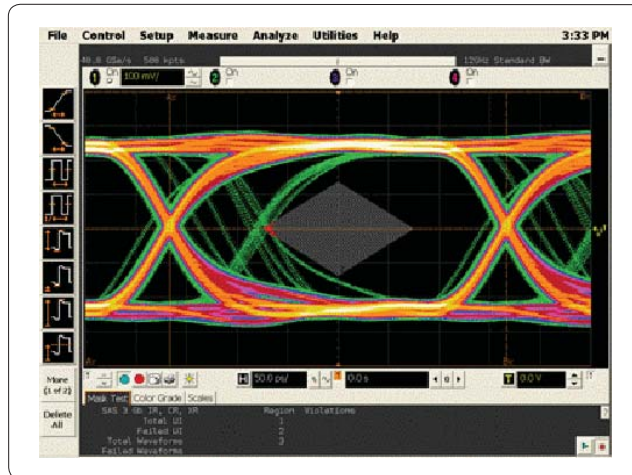

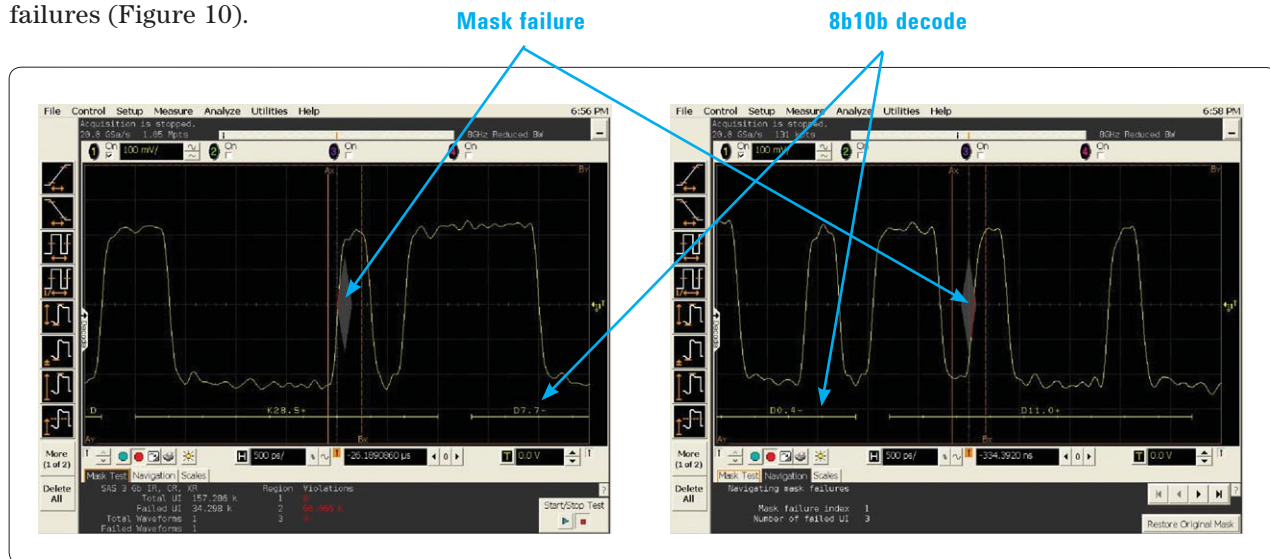**Figure 9. The application continues to accumulate eye pattern information until the first failure occurs.**

Mask failure   **8b10b decode**

Figure 10. No connection between data pattern and analog failure.

Intermittent jitter
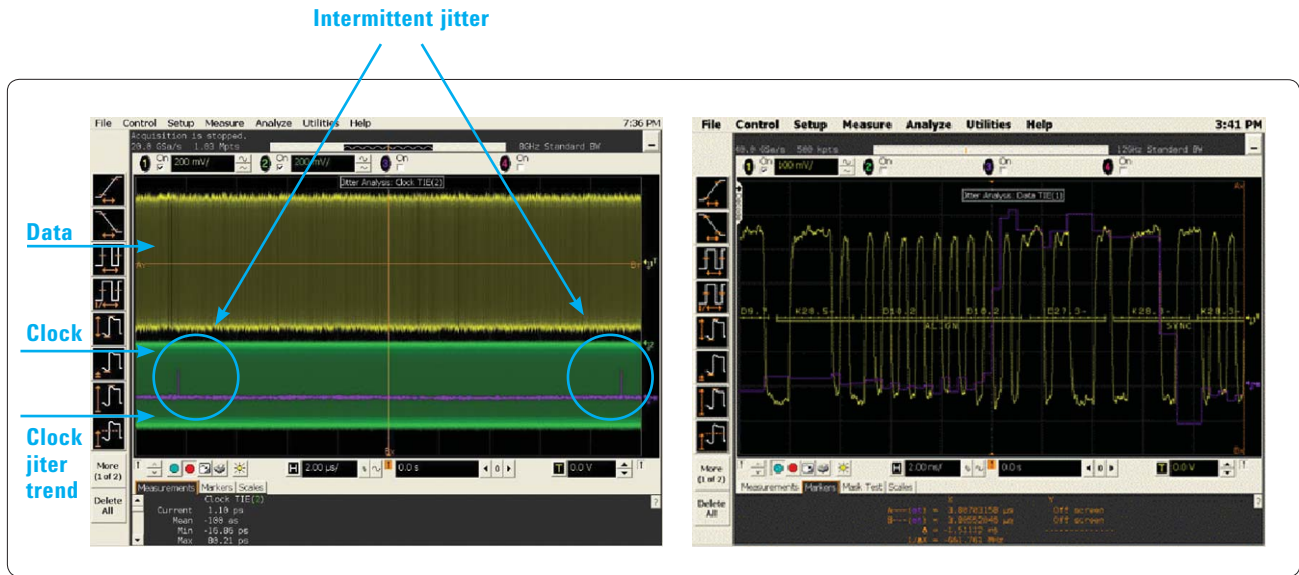
Data

Clock

Clock jiter trend

Figure 11. An intermittent clock jitter each time the data fails

Using the previous process, you find an intermettent clock jitter every time the data waveform fails during the mask test (Figure 11). So if you succeed in eliminating the unexpected jitter from the clock, there is a high probability that the mask failures won't occur. As in case study 1, you display the clock jitter trend and the possible cause of noise to find the offending one. But this time the problem is not periodic jitter. It is intermittent jitter. You don't know when the jitter will appear, and finding a signal correlated with jitter is difficult.

But there is an efficient way to troubleshoot this problem using an Agilent Infiniium oscilloscope and the InfiniiScan utility. InfiniiScan triggering

is unique in the industry and it can be used together with other Infiniium oscilloscope software. InfiniiScan can trigger signals that have already been triggered by a specific hardware function such as pulse width, rise time, period, peak voltage, etc. This utility can even trigger on jitter measurement results.

Triggering on high levels of clock jitter allows large amounts of jitter to appear in the center of the scope screen, making it easy to find the signal causing the jitter (Figure 12).
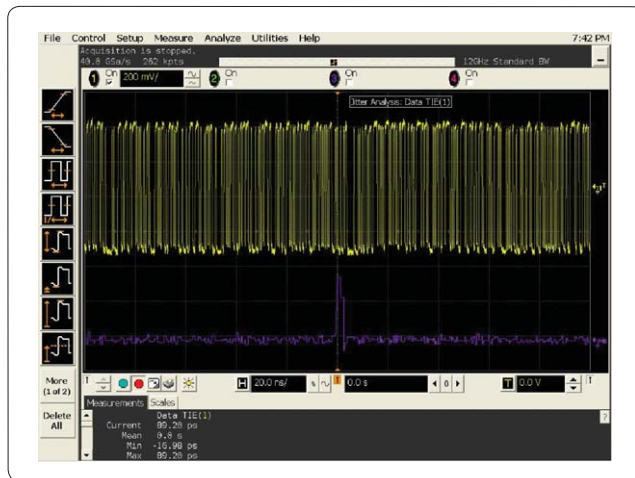

Figure 12. Infiniium triggers on high levels of clock jitter

The next step is to check if jitter occurs on some specific waveform signals such as power fluctuation, ground bounce or command signals. In this case, the clock jitter was occurring in conjunction with a command signal behavior (Figure 13). Notice that multiple measurements occur in real time and are shown in a single screen.
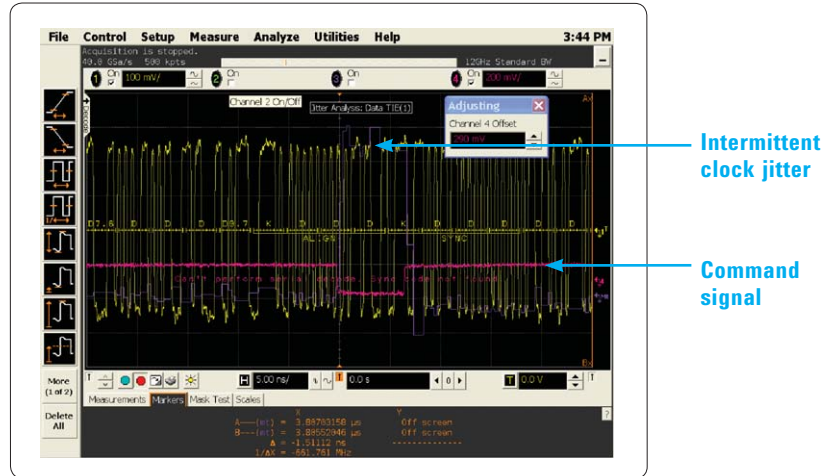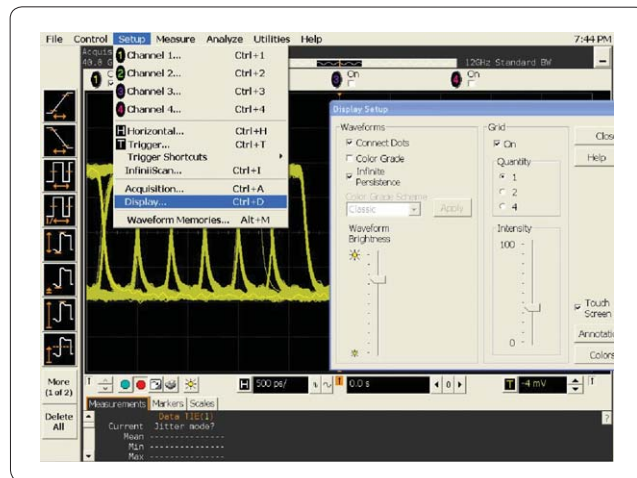

Intermittent clock jitter

Command signal

Figure 13. Clock jitter relative to a command signal

Oscilloscope test procedure 2

1. First of all, see how the signal works with infinite persistence, by selecting **Setup > Display > Infinite Persistence**.


2. To make a strict eye pattern, start the high-speed serial data analysis software or SDA Agilent eye pattern analysis software from **Analyze>Serial Data**.


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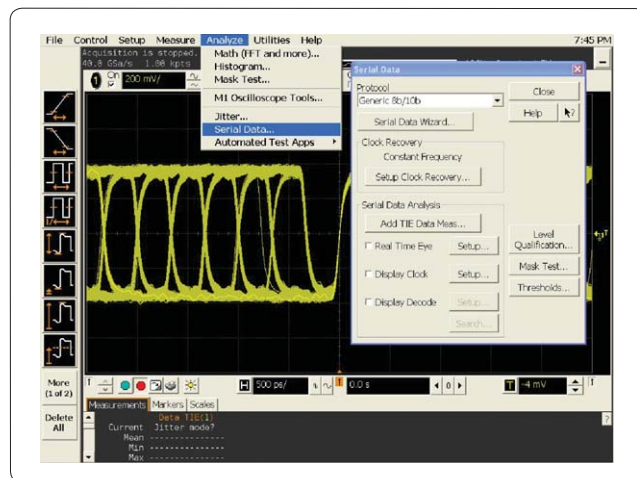
3. Next, click on **Setup Clock Recovery** and input the clock rate in the **Nominal Data Rate** field. The **Semi-Automatic** selection is recommended. Check **Real Time Eye** and click on **Mask Test**.
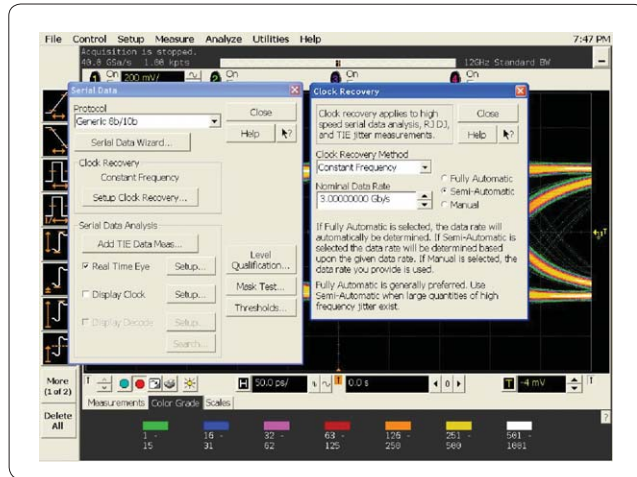
4. Check **Enable Mask Test** and **Load Mask**. Load the application-specific mask file you want to use. You can also load your own mask file.
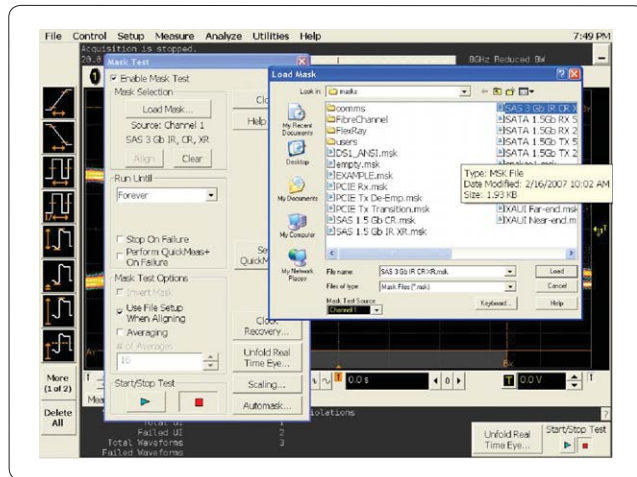
5. To use the mask unfold function, check **Stop On Failure** and **Unfold Real Time Eye**. Click the start button on the window (blue triangle), and start the mask test. The scope will continue to write the eye pattern until it fails. Then click **Position To First Failure**, and the scope will show you the first mask failure.
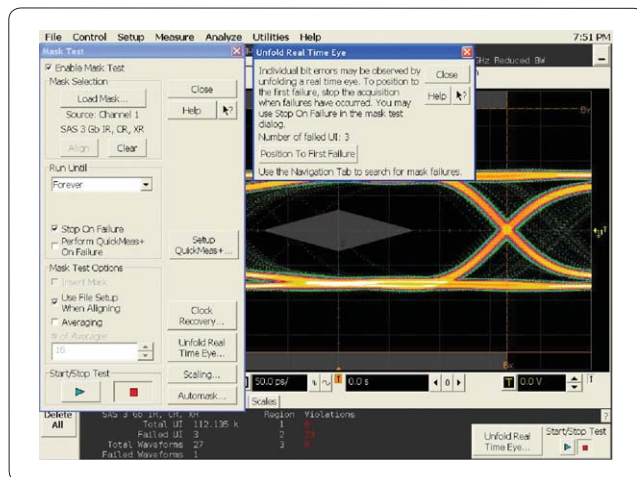
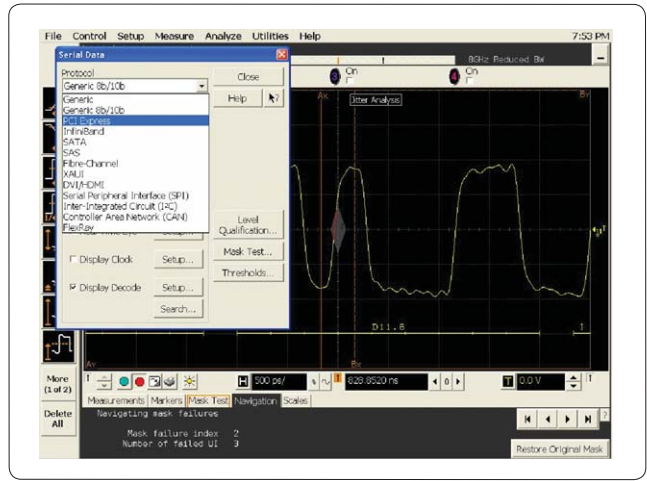6. If you encounter several failures, use the navigation tab to scroll to other failures.

Navigation tab
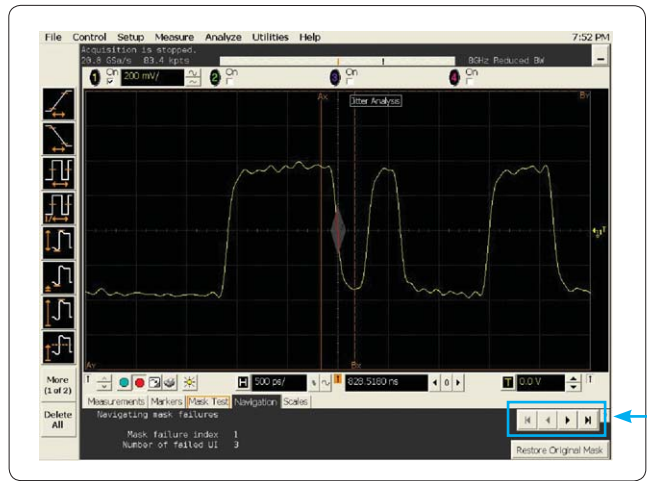
7. To check if there is a pattern dependency, use 8b10b decode. Click **Display Decode**, and choose your protocol. You can select from a variety of protocols such as PCI EXPRESS, SATA, Fibre-Channel, etc....

8. Next, you can check to see if there is a relationship between the clock jitter and the data mask test failure. Connect the clock signal to an open channel, and start EZJIT jitter analysis software by selecting **Analyze > Jitter**. Click **Add Measurement** and choose **Clock TIE (Time Interval Error)**. Check **Meas Trend**. Use the navigation tab to jump to every mask failure as in step 6. Determine if there is a correla-tion between the jitter behavior and the mask failures.
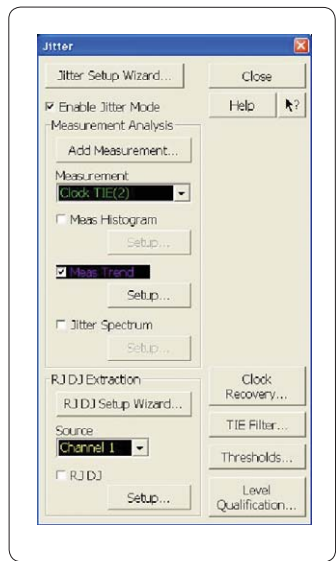
9. Next you want to trigger on jitter peaks. Start InfiniiScan from **Setup > InfiniiScan**. Choose **Measurement** as the InfiniiScan mode, and select **Clock TIE** as the measurement. You know that this clock jitter varies from -12ps to 66ps from the measurement results. So set the InfiniiScan measurement trigger as **Inside Limits: 50ps to 100ps**, and then the scope will trigger on large jitter peaks.

10. Connect a suspicious signal on another open channel, and check to see if there is any correlation on the trigger timing, which is the timing of the large clock jitter.

Clock TIE measurement result
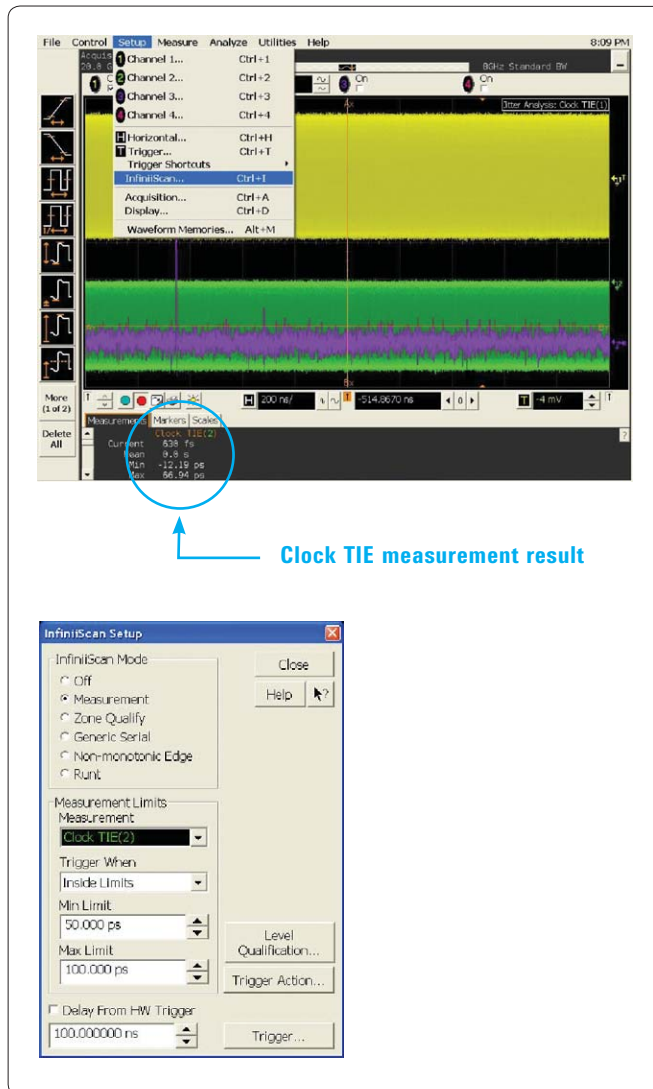
Conclusion

Traditionally a real-time oscilloscope is used to observe and analyze individual signal waveforms. But today high-speed digital engineers spend more and more time debugging their designs. As you have seen in the previous case studies, Infiniium oscilloscopes provide a strong and efficient debugging tool by combining several real-time and simultaneous analysis tools. You can save time with Agilent integrated debugging.

Instruments used

- DSO90000A Series, DSO80000B Series, DSO/MSO 8000 Series Infiniium oscilloscopes

- E2688A or Option 003, high-speed serial data analysis software (eye pattern analysis)

- E2681A or Option 002, EZJIT jitter analysis software

- N5414A or Option 009, InfiniiScan trigger software

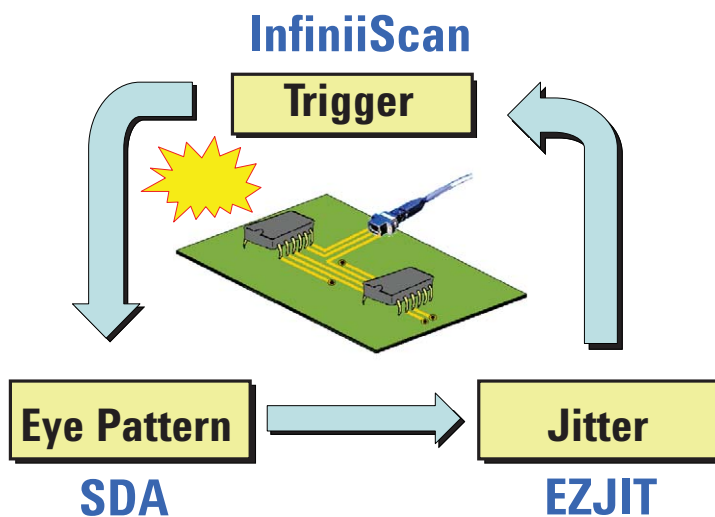- 113xA, 116xA InfiniiMax probe system and various probe heads

Figure 14. Integrated debugging process

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