Troubleshoot Complex Designs in Less Time Using a Mixed-Signal Oscilloscope

Application Note 1447

Introduction

Twenty years ago, when most electronic systems were analog, engineers typically used two- and four-channel oscilloscopes for debugging their designs. Now, devices that incorporate a mixture of analog circuitry, microprocessors and digital signal processors are commonplace, and the analog and digital signals in these devices typically operate at drastically different speeds. Digital circuits are increasingly complex — the number of control lines in chip memories has more than doubled, and address and data buses keep getting bigger. As a result, debugging today's designs has become difficult — and sometimes downright impossible — with traditional two- and four-channel digital storage oscilloscopes (DSOs).

This application note explains how the increased channels, memory, and triggering of a mixed-signal oscilloscope (MSO) can help you debug today's complex designs more efficiently than you could with a DSO.

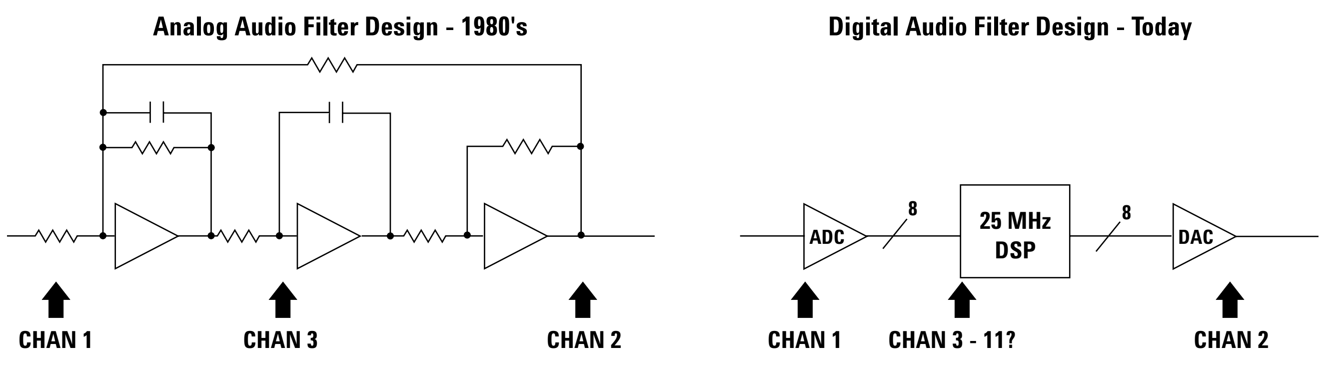

Figure 1. Evolution of Audio Filter Design

Why more channels?

With mixed analog and digital designs multiplying and digital circuit complexity increasing, the number of signals that require monitoring has jumped drastically. Limited by the 2 or 4 analog channels of a DSO, it can become both time-consuming and frustrating to find events of interest. It may take hundreds of acquisitions to trace the path between initial symptom and root cause in your design. With a DSO, each acquisition only takes you a tiny step of the way.

MSOs seamlessly integrate 16 logic timing channels with the traditional two or four analog channels, allowing you to capture, display, and analyze up to 20 signals — analog, digital, and RF baseband — in one acquisition on a single instrument display. With all 20 signals time-correlated, MSOs are particularly useful for simultaneously monitoring the digital control signals and the analog signals in mixed-signal designs. By comparison, MSOs take much larger steps on the path between symptom and root cause, minimizing the amount of troubleshooting time.

Of course, you could use a logic analyzer and a DSO together to accomplish the same task. With a logic analyzer/DSO combination, you have to hook up and configure the logic analyzer and set up a cross-triggering scheme — all of which can be time consuming, especially for first-order troubleshooting. An MSO gives you the same answer in a fraction of the time because the analog and digital channels are automatically time correlated. In other words, the digital channels use the same timebase and the same trigger as the analog channels.

Why more memory?

Mixed signal designs contain a mix of signal speeds — the digital signals are typically much faster than the analog signals. Many times it's critical to capture multiple cycles of digital signals along with the slower analog signals. In order to capture both types of signals with high resolution, deep memory is required. With deep memory, you can capture the slower analog signals and still have enough memory to zoom in on the details of the high-speed signals. Deep memory is also required if you are interested in checking the signal integrity and timing of individual cycles in complex digital-only designs.

Traditional deep memory scopes are expensive and difficult to use. Deep memory is typically implemented as a special mode, and when you turn on that mode, your oscilloscope's response slows dramatically — slowing down your productivity in turn. Because of these limitations, traditional deep memory scopes are frequently reserved for special applications where they are an absolute necessity.

MSOs eliminate those drawbacks by using innovative MegaZoom technology to provide deep memory for everyday problem solving. MegaZoom is fast and responsive, so it was not necessary to implement it as a special mode that could be turned off. Since MegaZoom deep memory is always on, it is always available to help with general-purpose debug problems. You can capture a single-shot error, see the slow analog signal, then zoom in on the fast digital signal. With the deep memory of an MSO, milliseconds of time can be captured at full sample rate.

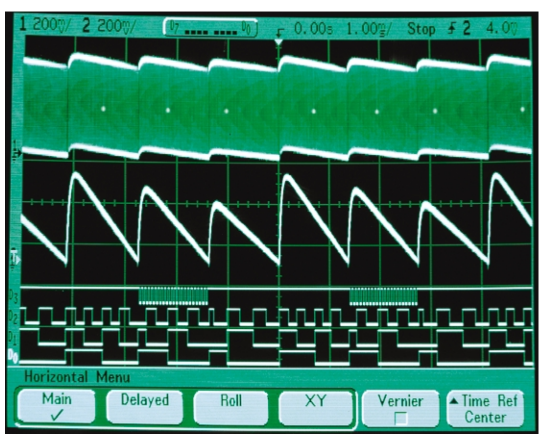

Figure 2. An MSO has the ability to display up to 20 channels time-correlated on one display. Using an MSO, we are looking at a pulse-width modulated (PWM) signal, the PWM signal after passing through a low pass filter, and the 5 digital bits that control the PWM signal.

In addition to deep memory, some MSOs also include a high-definition display system. This display system has twice the horizontal resolution of any other DSO on the market — 1000 horizontal pixel columns versus 500. The high-definition display system also enables you to view your signal with up to 32 levels of intensity — mimicking the look of an analog scope display. The various levels of intensity naturally give an indication of high and low levels of activity and slew rates of your signals. In Figure 2, the high-definition display system has brought to attention a distortion that occurring in every 1 out of 1,500 pulses in the signal on channel 1. Deep memory allows us to zoom in by a factor of 1000, bringing the distortion into detail (Figure 3).

Why more triggering?

Setting up complex triggering on an oscilloscope can quickly become a chore for many engineers. At times, when an oscilloscope does not have advanced triggering power, triggering conditions must be implemented in hardware. This may seem like more effort than it's worth, especially when you only need to view a trigger condition once! To solve complex problems, an MSOs advanced triggering can quickly help to isolate and capture specific events of interest. An MSO can be triggered on a combination of events across all analog and digital channels or perform cross-triggering between the analog and digital channels. This results in the ability to trigger on any combination of up to 20 signals. In addition to full-width triggering and cross-triggering capability, MSOs also provide the ability to trigger on serial bus protocols of interest. MSOs come standard with the ability to trigger on SPI, CAN, LIN, USB, and I2C bus protocols. Even better, you are not limited to these 5 serial bus protocols. The SPI 2- and 3-wire serial trigger can be customized for use on any 2- or 3-wire serial bus protocol.

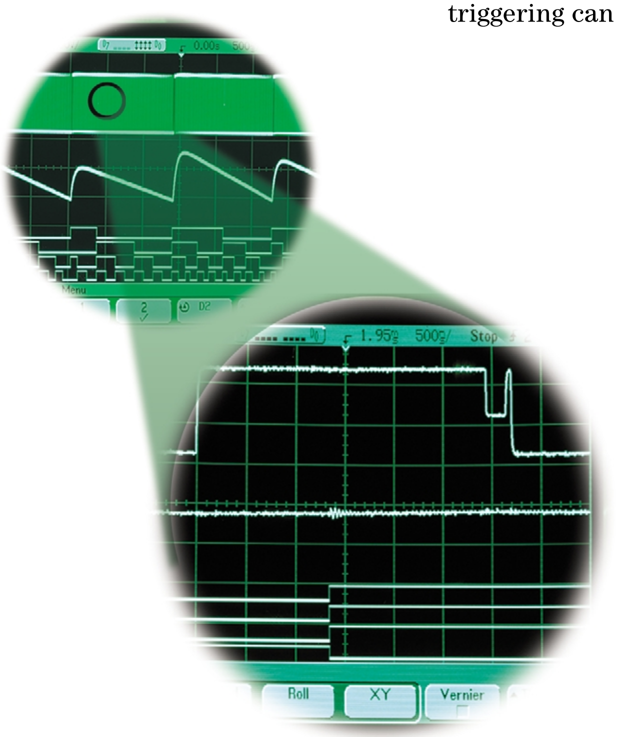

Figure 3. An MSO's high definition display system helps to bring to attention a distortion in 1 of 1,500 pulses. MegaZoom deep memory enables us to quickly zoom by a factor of 1,000 on the distortion.

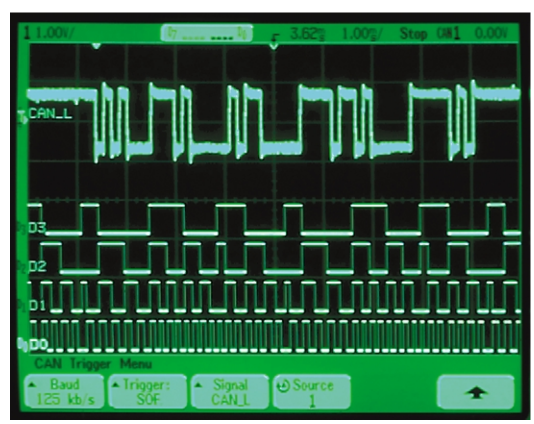

Figure 4. MSOs provide the ability to trigger on a number of serial bus protocols. This image shows an MSO triggering on the SOF of a CAN signal. The analog signal on channel 1 is being used to cross-trigger the 4 digital control signals of interest.

How all three capabilities work together to help you troubleshoot today's complex designs

Extra scope channels, advanced triggering and deep memory allow you to see more at once, so you can get from symptom to root cause using an exponentially smaller number of troubleshooting steps. The more channels that are captured in time, the fewer times you have to capture a sequence to find your problem. An MSOs extra 16 logic timing channels allow you to look across more channels in a single acquisition. MegaZoom technology gives MSOs the ability to capture a full cycle of your device's operation with the resolution needed to resolve critical time intervals of the highest-speed signals in the system. The advanced triggering capability makes it possible to trigger on a combination of events. Then deep memory can be used to capture the entire sequence of events.

MSOs incorporate more channels, responsive deep memory and advanced triggering capabilities into an easy-to-use oscilloscope interface, so you can use these features without the steep learning curve and sluggish response associated with many logic analyzers and deep-memory scopes.

Conclusion

More channels, advanced triggering and deep memory allow you to narrow in more quickly on the root cause of your circuit's problems.

Use an MSO:

- for troubleshooting designs with heavy analog content
- for first-level debug of mixed-signal and digital systems
- for all levels of debug of 8- and 16-bit microcontroller designs
- for troubleshooting DSP-based designs that are highly integrated

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