

## Deep-Memory Oscilloscopes Illuminate Hard-to-Find Problems

Modern embedded systems that utilize a mix of analog and digital technologies call for a new breed of oscilloscope.

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If you have ever debugged a mixed-signal embedded system, you know the frustration of trying to get a big picture of the various signals while maintaining enough resolution to focus in on details. When designing complex state-of-the-art systems such as electromechanical or biomechanical products, you must simultaneously acquire both slow analog and fast digital signals. Design complexity is increasing as you use advanced microcontrollers, DSPs, and FPGAs to deliver smarter products to your customers. Limitations in simulation tools and the inability to provide real-world stimulus to the simulated environment require you

to execute rapid prototyping and debugging cycles. The debugging problems you face during these cycles can be intermittent, infrequent, and difficult to reproduce.

Fortunately, deep-memory oscilloscopes are available for intermittent problems and any others requiring large timecapture windows at high resolution. In the early stages of debugging, problems in the design prototype are not well understood. You often try to capture as much of the target system execution as possible and then peruse the data to see if you can find any clues as to what might be going wrong. Some problems occur intermittently or under very rare conditions and often cannot be duplicated at will.

Some failures carry detrimental financial implications during product development, as when an expensive component is inadvertently destroyed during a test. When this happens, accumulating as much data as you can each time a failure occurs is highly desirable. Even if a problem can be reliably duplicated, capturing the effect of the problem (such as a target system crash) without having captured

enough data to view the cause, which occurred much earlier, can be a very frustrating experience. Deep-memory oscilloscopes are invaluable for situations like these. Two examples of how deep-memory oscilloscopes can help solve some of your mixed-signal and other debugging problems are described below.

**EXAMPLE 1:  
A Low-Power, Spread-Spectrum  
Data Acquisition System**

The first example is a Motorola MC68HC11K1 microcontroller being used to collect temperature data from an array of remote sensors. The collected data is transmitted to a central computer via spread-spectrum radio transceivers (figure 1). This low-power system turns on briefly every 60 seconds to make its measurements and then is designed to sit quietly and conserve power for the remainder of the 60-second cycle. The problem is that intermittently, the system is showing activity during the quiet period. This added, unwanted activity is consuming power at a higher-than-acceptable rate. The engineer needs to know where in the 60-second window the

problem is occurring and what precise system activity is happening at that point. The long time window makes this a good application for a deep-memory scope.

**Good Measurements Start  
with Quality Probing**

It should go without saying, but a high-quality probing solution is required for high-quality measurements. This is a surprisingly easy area in which to make mistakes. A poor probing setup can mask real problems or create problems that are not actually present. Either situation can result in a significant loss of time and add a significant

amount of frustration. In this example, a high-precision “wedge” probe is used to reliably connect to the closely spaced pins of some of the QFP components. Also, every effort is made to maintain a short ground lead to minimize probe inductance. Low-mass, low-loading probes designed for and calibrated with the scope being used are employed in the setup.

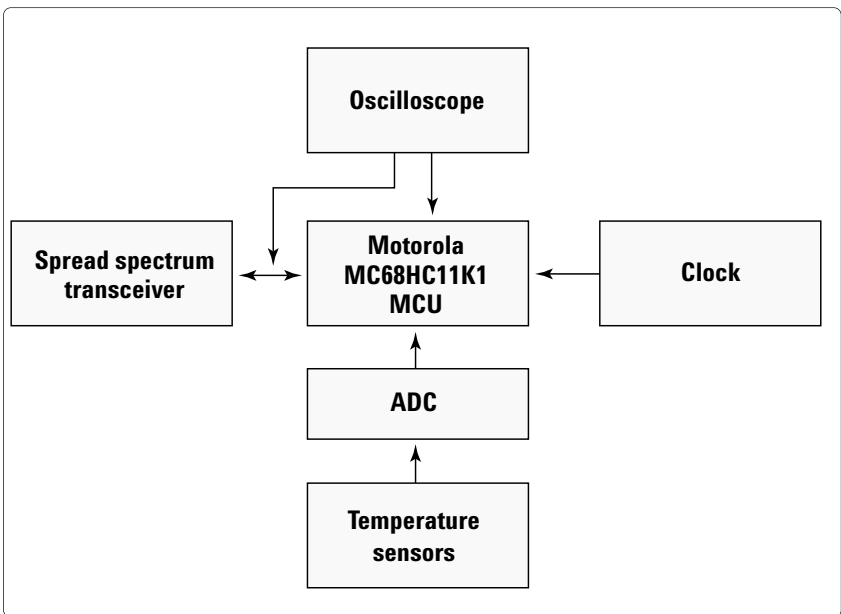


Figure 1. Block diagram of the wireless data acquisition system. One analog input of the scope monitors power-up on the MCU while the other monitors the carrier-detect signal feeding the transceiver.

**Capturing Long Time Windows with Sustained Sample Rate**

The ability to sustain high sample rates over long time windows is the classic benefit of a deep-memory oscilloscope. With a shallow-memory oscilloscope, a lower sample rate must be used as the time-base setting is increased in order to display an entire screen of data. Thus a shallow-memory oscilloscope with a higher maximum sample rate at fast sweep speeds may actually deliver lower sample rates at slow sweep speeds than its deep-memory counterparts.

The benefit of a sustained high sample rate is that you do not miss any signal details due to digital under-sampling of the waveform. Long time windows allow you to view an entire execution cycle or an entire range of motion of the device under test. In this example, the entire 60-second execution cycle is captured at a resolution of 16.7k samples per second (one sample every 60 ms) due to the 1 megasample of deep acquisition memory behind every channel. This is sufficient resolution to capture the 2-ms glitch that occurs 15 seconds after the trigger event and causes power-consuming activity (figure 2).

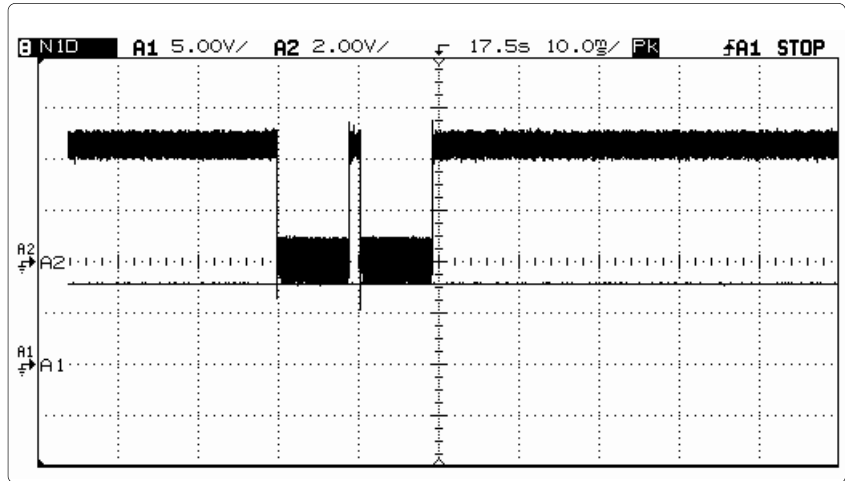


Figure 2. The glitch causing the unwanted system activity

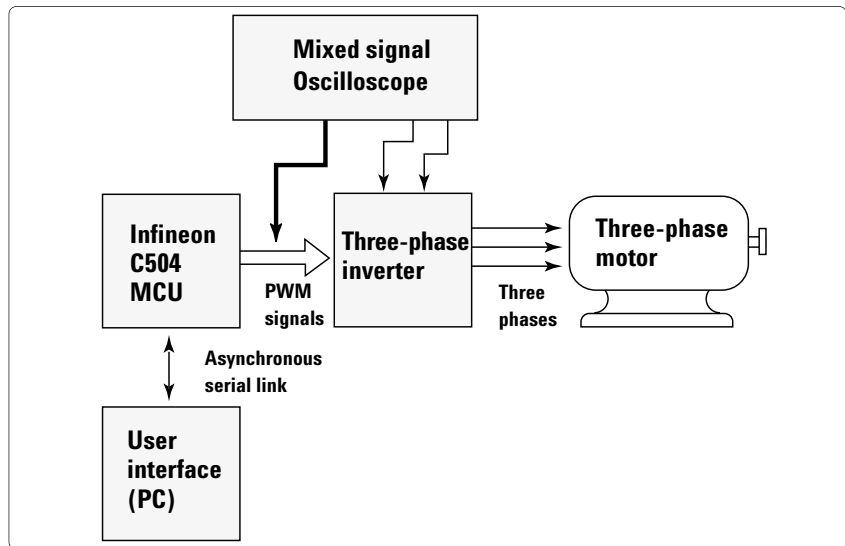


Figure 3. Block diagram of the PWM motor control system

**EXAMPLE 2:  
A Motor Controller Utilizing Pulse-Width Modulation Circuits**

The second example is an Infineon C504 microcontroller controlling an AC motor. The AC motor is driven by a three-phase inverter controlled by

digital pulse-width modulation circuits (figure 3). The three-phase inverter uses MOSFET power switches to convert the digital PWM control signals to the amplified phase signals needed to drive the motor.

This is an efficient design, but it is tricky to make sure that both sides of the push-pull switches do not conduct at the same time. If this occurs, the three-phase inverter will be destroyed. The engineer must determine whether potentially destructive operation can occur during variations to motor loading and operating temperature. Measuring both the inputs and the outputs of the three-phase inverter simultaneously can be a challenge because the inputs have a cycle time in the nanosecond range and the outputs have a cycle time in the millisecond range – a million to one difference in resolution.

#### **Image Processing – Getting the Big Picture of All that Data**

So how can over one million data points be displayed on an oscilloscope screen that has only six hundred display pixels across its horizontal axis? A simple decimation scheme that eliminates all but one of every two thousand data points would result in the loss of a great deal of signal information. Clearly, some very intelligent display processing algorithms must be employed to produce a final display image that is not misleading. The desired result is that any variation in the signal's characteristics is clearly

projected so that even a casual glance at the display will identify that something is wrong.

The most effective, modern deep-memory oscilloscopes can display entire megasample-length acquisition records on the display without missing a single variation in the data patterns. In the previous example, this allows the engineer to correctly identify a 2-ms glitch on a display showing 60 seconds' worth of activity. In this example, the user can view the slowmoving three-phase inverter outputs while monitoring the high-speed digital inputs for any data pattern variations or dropouts.

#### **Avoiding Scroll and Zoom Frustration**

Anyone who has had the frustrating experience of trying to use a computer to scroll through a file of large photo images can identify with the problem of a tool that has become unresponsive to its user because it has too much data to deal with. Some deep-memory oscilloscopes can leave you with the same frustrated feeling. With deep memory enabled, the scope can become very unresponsive when you are trying to scroll through or zoom in and out of the acquired data. This can leave you with

an unpleasant tradeoff: having to choose between a scope with deep memory or one that is responsive to commands. The latest deep-memory scopes are both responsive and deep, so you don't have to choose between the two.

In this example, the engineer must zoom out to observe the quality of the analog output signals and then zoom in to verify that the digital control signals do not cause the power switches to conduct at the same time. The engineer's next step is to scroll to the next transition of interest and use measurement cursors to determine the timing margin in the desired non-overlapping switching operation. This can be either a painless or painful sequence of events depending on whether the oscilloscope is responsive to its controls when deep memory is enabled.

#### **Specifying a Trigger – Focusing on the Event of Interest**

As stated previously, an advantage of deep-memory oscilloscopes is that you don't necessarily need to know what to trigger on in order to start solving the problem. However, once you understand the problem better, the ability to trigger on specific events of interest can be quite useful in determining whether undesir-

able events ever occur or in making very specific measurements. Mixedsignal oscilloscopes with deep memory allow you to trigger on a wider variety of target system events due to their 16 extra, integrated digital channels. In this example, the time-qualified trigger mode allows the engineer to synchronize the scope's display to the desired dead-time measurement (figure 4).

The complexity of the latest embedded systems that utilize mixed-signal technologies can present debugging and verification problems that are best solved by deep-memory oscilloscopes. These scopes are a valuable resource for locating small or intermittent problems, which is particularly difficult for complex embedded systems that use a combination of analog and digital signals.

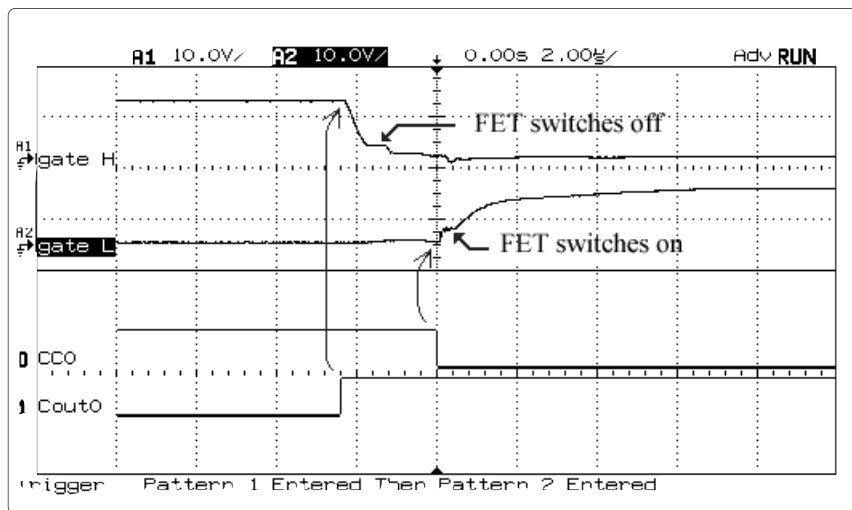


Figure 4. Verifying the dead time between the high-side and low-side PWM outputs

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