

ZONE TRIGGER FOR DDR READ/WRITE SEPARATION

Debugging and verifying the DDR DRAM memory interface in a system design can be challenging. The R&S®RTP high-performance oscilloscope zone trigger is ideal for READ/WRITE separation as a basis for analyzing signal integrity.



R&S®RTP high-performance oscilloscope with high-speed modular probes connected to the DDR memory interface for signal integrity debugging and verification

Your task

Integrating a DDR memory interface gets harder as data rates and design density increase. Developers must maintain appropriate signal integrity for a reliable data exchange between the controller and the DDR DRAM memory.

An oscilloscope is important when verifying signal integrity and identifying error sources. Data (DQ) and data strobe (DQS) signals work bidirectionally, making them a real challenge. Differentiating between READ (memory sends data to processor) and WRITE (processor sends data to the memory) bursts for DQ and DQS signals is difficult. Signal integrity analysis demands separate processing of READ/WRITE signals.

Rohde & Schwarz solution

Example configuration

In our example, a PC system uses DDR4 DRAM DIMM. The data transfer is stimulated with the MemTest86 memory test software, the RANDOM test mode issues a good mix of READ/WRITE bursts.

For testing, high-speed probes are typically soldered to the clock signal and to selected DQ signals with their relevant DQS signals, as well as to command/address signals such as CS.



DDR4 DQ (C2: green) and DQS (C3: orange) signals with READ and WRITE bursts. In this example, a visual distinction between READ/WRITE bursts is possible based on the amplitude. (R: READ; W: WRITE)

Zone trigger

Rohde & Schwarz oscilloscopes have a zone trigger to define areas on the waveform diagram that MUST or MUST NOT be intersected to trigger a signal acquisition. Such zones can be used to focus signal acquisition on dedicated signal characteristics.



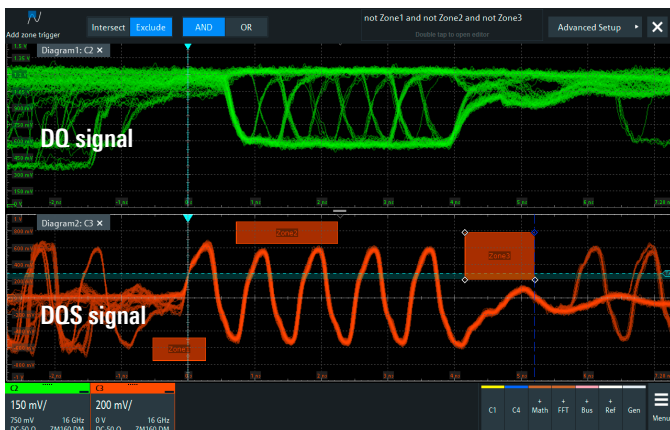
The process can be applied to the DQS signal to focus on the different preamble modes or signal amplitudes of READ/WRITE bursts to test the DDR interface.

The zone trigger always operates in combination with a standard trigger event such as EDGE or pulse width. In the example below, an EDGE is applied to the DQS signal and a first zone (excluded intersect) helps focus on the start of signal bursts. Overlaying the DQ signals (persistence on) reveals that both READ and WRITE have been acquired. The edges of the DQ signal are edge-aligned with the DQS signal for READ and center-aligned for WRITE bursts.



Zone 1 with excluded intersect on DQS signal focuses acquisition to start of READ and WRITE bursts with no activity happening before.

Additional zones let us focus on dedicated signal characteristics to help distinguish between READ and WRITE bursts. With probes connected close to the memory device, often the signal amplitude of WRITE bursts is reduced due to the transmission losses over the signal channel from the processor to the memory.



Zone 2 with excluded intersect limits the amplitude to exclude READ signals from the acquisition. Zone 3 limits the burst length to 8 bit.

Once reliably separated, other analysis tools can be applied. Examples include simple amplitude and timing measurements on both the DQ and the DQS signal or timing measurements between the DQ and the DQS signals. More sophisticated signal integrity tests are histogram measurements to determine jitter and noise or mask tests to verify open data eyes. A zone trigger for READ/ WRITE separation allows continuously running tests to detect rare signal faults in a system.



Mask test applied to a continuously running WRITE acquisition. On the DQ signal, a color table is applied to visualize the statistical distribution of the DQ data signal.

Summary

The zone trigger in Rohde&Schwarz oscilloscopes is a powerful tool for memory interface debugging and verification. Combining powerful standard trigger events with zones that require or exclude signal transitions enables reliable READ/ WRITE separation, the basis for detailed signal integrity analysis. The high acquisition rate in Rohde&Schwarz oscilloscopes ensures quick data collection and high statistical confidence.

See also

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keyword: DDR3, DDR4, DDR5 Oscilloscope software
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