Analyzing long signal sequences with the R&S®RTM 2000 oscilloscope

The R&S®RTM-K15 history and segmented memory option is ideal for analyzing signals with long communications pauses. The large segmented acquisition memory of 460 Msample is unique in this oscilloscope class and permits long observation periods, for example when debugging serial buses. The integrated history function permits perfectly timed access to any waveform for analysis.

The challenge:
finding sporadic errors with oscilloscopes

Sporadic errors often cost valuable time during the development of new products. Debugging protocol-based buses or other pulsed signals is especially difficult and time-consuming because the communications pauses between the individual data packets can be very long (❶ in Fig. 1). In this example, a sensor transmits a protocol packet containing values over the I^2C bus every 10 ms for a duration of 400 µs. The errors that occur during this time are to be analyzed. Oscilloscopes are the instrument of choice for debugging the I^2C interface. Most oscilloscopes in this class – with the exception of the R&S®RTM 2000 – have only a very limited memory. The oscilloscope memory typically limits the record length for analyzing errors and their history to a few milliseconds.

Disadvantages of single-shot acquisition

Normally, the user acquires long recordings in two steps. The first step is to select a sufficiently long timebase, e.g. 20 ms/div, which in the example corresponds to 19 protocol packets from the sensor under test. The second step is to trigger a single-shot acquisition in order to prevent the acquired signal from being overwritten by the next trigger event.

This process has two decisive disadvantages that make the analysis of sporadic errors especially difficult for pulsed signals with steep edges. On the one hand, the large percentage of irrelevant inactivity means that only a few of the protocol packets of interest are acquired (❷ in Fig. 1). Another disadvantage arises from the necessary limitation of the sampling rate, as seen in the next example. At 2 Msample memory and 2 Gsample/s sampling rate, the maximum record length is only one millisecond, which is just enough for one protocol packet from the sensor under test. The subsequent packet would be missed because of the 10 ms communications pause. The desired 200 ms, i.e. 20 ms/div for 10 divisions, can be acquired only by reducing the sampling rate to 10 Msample/s – which is actually too low for stable decoding of the I^2C signal, never mind for finding signal integrity errors. This is why this type of analysis requires an oscilloscope with

deep memory, such as that offered by the R&S®RTM 2000 bench oscilloscope (Fig. 2). With the standard 20 Msample, the sampling rate in this example can be increased to 100 Msample/s, permitting seamless recording and analysis of all 19 protocol packets. This setup makes it possible to analyze signal errors, but the probability of isolating the error is low because only very few packets are recorded. A much better solution is the new R&S®RTM-K15 history and segmented memory option.
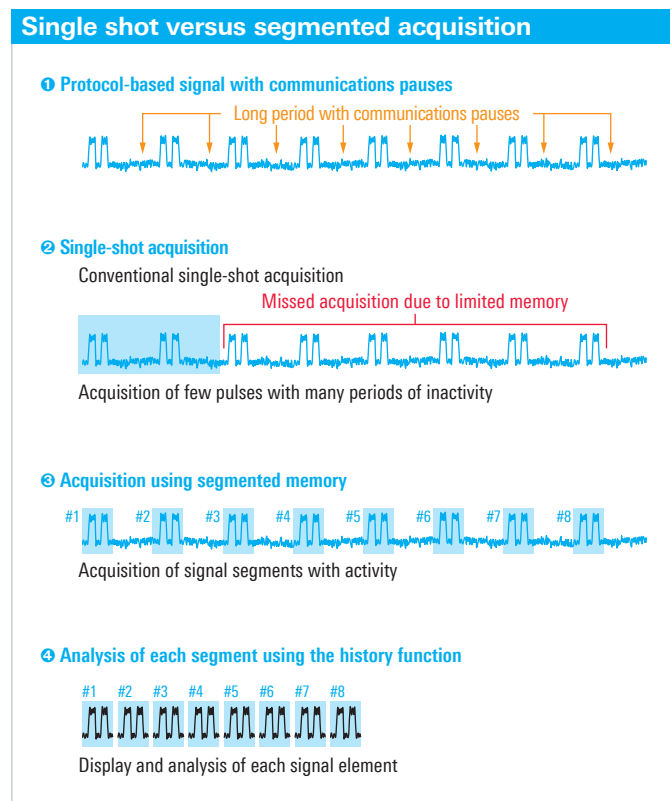

Single shot versus segmented acquisition

❶ Protocol-based signal with communications pauses

Long period with communications pauses

❷ Single-shot acquisition
Conventional single-shot acquisition

Missed acquisition due to limited memory

Acquisition of few pulses with many periods of inactivity

❸ Acquisition using segmented memory

#1 #2 #3 #4 #5 #6 #7 #8

Acquisition of signal segments with activity

❹ Analysis of each segment using the history function

#1 #2 #3 #4 #5 #6 #7 #8

Display and analysis of each signal element

Fig. 1: Examples for acquiring and analyzing short-term signals from a sensor.

Advantages of segmented acquisition

A smarter approach limits the acquisition to only the data packets. This requires the definition of a dedicated protocol trigger, for example for triggering on the start symbol of the I²C bus. Fig. 3 provides an overview of the protocols supported by the R&S®RTM 2000 oscilloscope.

The R&S®RTM-K15 history and segmented memory option supports debugging in two significant ways. It expands the available memory for analog and digital channels to 460 Msample, which is unmatched in this oscilloscope class. In addition, it divides the memory into equally sized segments. The user can modify the number of segments to meet the specific requirements of the task (Fig. 4). The R&S®RTM 2000 ensures that the memory is optimally used. For a serial protocol, for example, the maximum packet length in the signal determines the record length. Starting at the trigger point, the signal segment of interest is stored in memory. Time periods without activity are not acquired (❸ in Fig. 1). An important detail for subsequent analysis: the R&S®RTM 2000 saves the precise time of the trigger event at a resolution of 3.2 ns.

For the sensor used in this example, the desired record length is 500 µs per segment: 400 µs for the protocol packet, plus 50 µs each for a buffer before and after the event (Fig. 5). This 500 µs along with a segment length of 10 ksample – corresponding to a sampling rate of 20 Msample/s – makes it

possible to achieve stable decoding. With the 45 000 available segments, it is possible to record eight minutes of communications. "Protocol Start" is used as the trigger criterion for the serial protocol trigger.

Application	Serial standard	Option
Embedded	I²C / SPI	R&S®RTM-K1
	UART / RS-232 / RS-422 / RS-485	R&S®RTM-K2
Automotive and industry	CAN / LIN	R&S®RTM-K3
Audio	I²S / LJ / RJ / TDM	R&S®RTM-K5
Aerospace and defense	MIL-STD-1553	R&S®RTM-K6
	ARINC-429	R&S®RTM-K7

Fig. 3: Options for triggering and decoding.

Record length	Number of segments
20 Msample	23
10 Msample	46
5 Msample	92
2 Msample	230
1 Msample	460
500 ksample	921
200 ksample	2301
100 ksample	4591
50 ksample	9183
20 ksample	22 500
10 ksample	45 000

Fig. 4: R&S®RTM 2000 segmented memory setting.

Fig. 2: Providing time, frequency, protocol and logic analysis plus a digital voltmeter in a single box, the R&S®RTM 2000 is ideal for the development, production and servicing of embedded hardware.

Fig. 5: Decoded I²C signal with analog waveforms and acquisition table. The history function is accessed via the bottom menu.
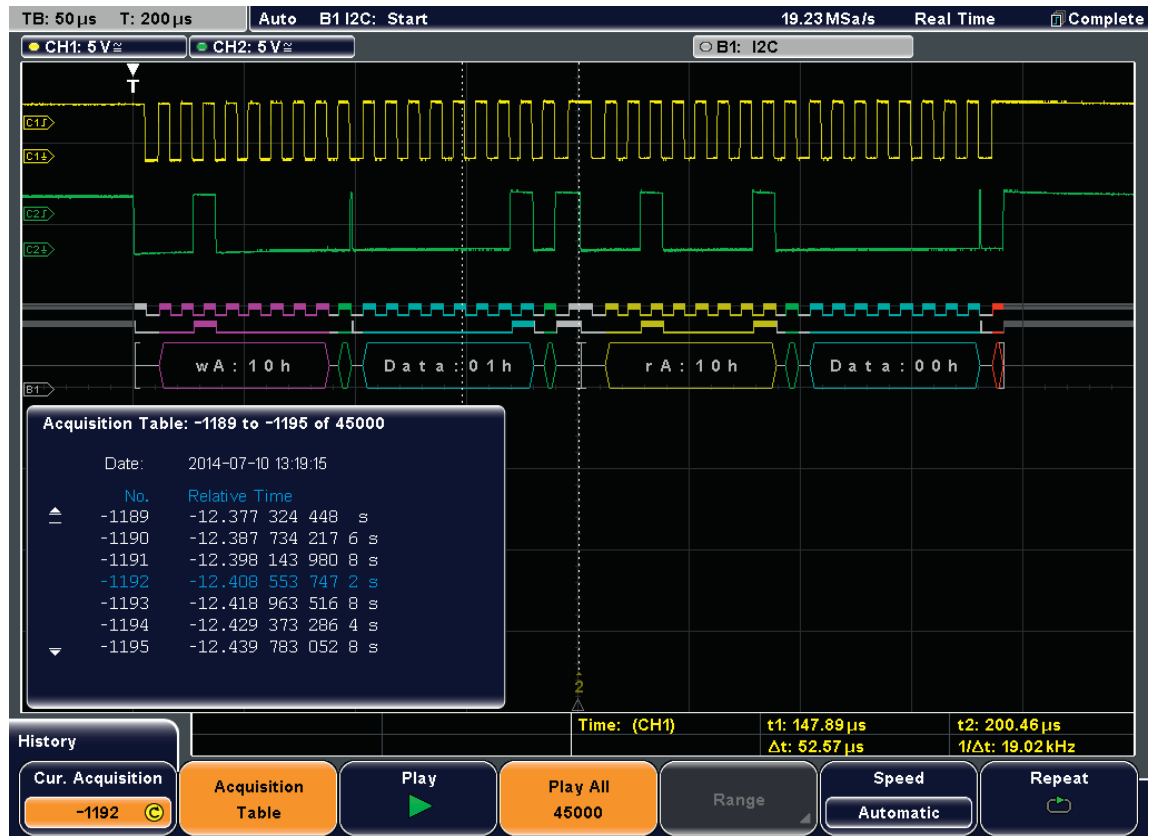
History mode for analysis

Thanks to the R&S®RTM-K15 history mode, all acquisitions can be accessed at a later time. All oscilloscope tools, including the QuickMeas function, mask tests and protocol decoding, are available for analysis (❹ in Fig. 1).

The mask test that comes as standard in the R&S®RTM 2000 is ideal for finding a deviation in the clock signal from the sensor under test, for example. Just a few keystrokes are needed to generate the mask on the R&S®RTM 2000 from a correctly transmitted clock signal, or it can be loaded from a USB flash drive. The history function's play command (Fig. 5, bottom) automatically starts a comparison of all 45 000 segments against the mask. Violations are statistically evaluated and, if enabled, the test is stopped and the segment displayed when a mask is violated.

The acquisition table that lists all segments and their time-stamps (Fig. 5, bottom left) permits fast access to the acquired segments positioned before the faulty segment. This makes it possible to isolate the effects of preceding signals quickly. Periodicities can be uncovered by means of a subsequent analysis of the trigger times for all faulty segments. All segments can be saved to a PC for offline analysis.

And if an error was detected during standard operation and viewing the history would provide the necessary information for the solution? Not a problem: When equipped with the R&S®RTM-K15 option, the R&S®RTM 2000 always saves all waveforms in segments with a timestamp so they are available via the history function at any time.

Summary

The serial triggering and decoding options together with the R&S®RTM-K15 option provide major analysis advantages. The large memory of 460 Msample (unmatched in this class) and flexible segmentation expand the effective record length from milliseconds to minutes or even longer.

The history function makes it possible to view and analyze all acquisitions at a later time. Timestamps with a resolution of 3.2 ns permit precise time correlation of signal events. Individual marked segments can be selected in the acquisition table for display. Alternatively, the history function can be used to automatically play back all segments. All R&S®RTM 2000 oscilloscope tools are available for analyzing the faulty segment, including the QuickMeas function, mask tests, FFT and protocol decoding for analyzing the signal.

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